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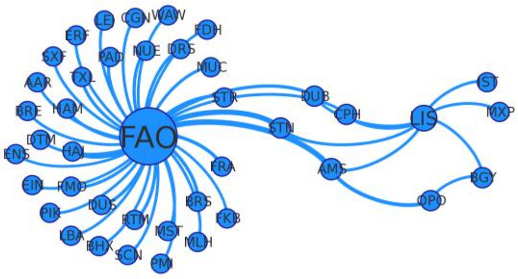

Airport Competition and Aviation Network Evolution

An exploratory study on continental Portugal

by

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When you look at an ordinary map you think there's no more airports,

in actual fact the place is absolutely awash with airports.

Michael O'Leary, Chief Executive, Ryanair

in "No Frills" by Simon Calder (p. 110)

Airport Competition and Aviation Network Evolution

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Abstract

Airports have been traditionally considered as natural monopolies. This perspective is being challenged by market deregulation in the aviation industry. The airlines' freedom to choose the airports they use, privatisation and commercialisation of airports, and the growth of low-cost carriers contribute to create competition between airports.

A literature review on network analysis reveals that most of the work has been done on airline networks using schedules data. The opportunity to use real traffic data in the analysis of the entire aviation network, including all the routes operated by commercial airlines from the airports under study, is explored in this work. An additional review on airport competition shows a lack of agreement regarding the ways in which airports compete. Moreover, the available literature on network analysis of airport systems does not extensively consider the subject of competition, while the literature on airport competition normally does not take into account that airports are part of a networked system.

Those gaps are addressed with the exploratory study proposed in this work. The dissertation examines the evolution of the aviation network of the three largest airports in continental Portugal – Lisbon, Faro and Porto – during the first decade of the 21st century. One of the main purposes of the network analysis performed in this study is to evaluate the influence that decisions taken in a given airport have over decisions made in other airports in the network. Another objective of the research is to show the relationship between airport competition and the changes occurring in the aviation network during the period of study.

To support these objectives, a conceptual framework on airport competition is presented. This framework defines the different ways in which airports compete, and explores the relationships between them. In the network analysis, we evaluate the degree of concentration of the aviation network for the Portuguese airports, using the Network Concentration Index (NC) and its evolution over time. Similarly, we analyse some of the most important planning documents produced by the operator of the three airports – ANA Aeroportos de Portugal, in order to assess its level of awareness of airport competition and the strategies proposed for its airports.

Our work suggests the existence of five different categories of airport competition and relates those categories to three types of customers of the airport product. Besides providing examples of each kind of competition, our analysis shows evidence of airport competition extracted from the aviation network, both for the Portuguese and for other European airports. The network analysis also illustrates the growth of the low-cost airlines in the Portuguese market and its implications for airport competition. Additionally, we conclude that ANA Aeroportos de Portugal is somehow aware of competition, but not in all the dimensions and aspects suggested by our research. Airport marketing arises as a tool to deal with competition; however, a tighter relationship between marketing and infrastructure planning departments should be pursued to properly satisfy the needs of the diverse customers and to be more competitive.

Key words: aviation network, network analysis, network evolution, network concentration, airport competition.

Concorrência entre aeroportos e evolução da rede de aviação

Um estudo exploratório sobre Portugal continental

Resumo

Os aeroportos têm sido tradicionalmente considerados monopólios naturais. Esta perspetiva está a ser desafiada pela desregulação da indústria da aviação. As companhias aéreas têm maior liberdade para escolher os aeroportos que utilizam; cada vez há mais aeroportos a serem privatizados ou comercializados; as companhias low-cost continuam a ter um crescimento importante. Tais aspetos contribuem para a existência de concorrência entre aeroportos.

A revisão feita da literatura sobre análise de redes mostra que a maioria dos trabalhos na área diz respeito a redes das companhias aéreas e baseiam-se nos dados dos horários previstos pelas mesmas. Este trabalho explora a oportunidade de analisar a rede de aviação na sua totalidade (incluindo todas as ligações operadas por companhias comerciais a partir dos aeroportos estudados), usando dados reais do tráfego aéreo. Esta dissertação também faz uma revisão da literatura sobre concorrência entre aeroportos, a qual sugere uma falta de acordo sobre o tópico. Para além disso, os estudos examinados na área da análise de redes de sistemas de aeroportos normalmente não têm em conta a questão da concorrência, enquanto a literatura sobre concorrência entre aeroportos não considera o fato de serem parte de um sistema em rede.

Esta dissertação propõe um estudo exploratório para superar as limitações encontradas na literatura. Para isso, a tese analisa a evolução da rede de aviação dos três maiores aeroportos de Portugal continental – Lisboa, Faro e Porto – durante a primeira década do século XXI. Um dos principais objectivos da análise da rede é o de avaliar a mútua influência que podem ter as decisões feitas em diferentes aeroportos da rede. Um outro objectivo é o de demonstrar a existência de concorrência entre aeroportos a partir das alterações experimentadas na rede de aviação ao longo do período de estudo.

Para atingir esses objectivos, apresenta-se um enquadramento conceptual para definir as diferentes maneiras em que os aeroportos concorrem entre si e as possíveis relações entre tais tipos de concorrência. A análise de rede aqui proposta avalia o grau de concentração da rede de aviação dos aeroportos portugueses através do *Network Concentration Index (NC)* e a sua evolução no tempo. De maneira semelhante, são analisados os mais importantes documentos de planeamento produzidos pelo operador dos aeroportos – ANA Aeroportos de Portugal, para fazer uma avaliação do nível de conhecimento da empresa relativamente à concorrência entre aeroportos e às estratégias seguidas pelos aeroportos.

Esta pesquisa sugere e caracteriza cinco categorias de concorrência entre aeroportos que estão relacionadas com três tipos de clientes para o produto do aeroporto. Para além de proporcionar exemplos de cada modo de concorrência, mostra-se evidência de concorrência para os aeroportos portugueses e para outros aeroportos na Europa, a partir da análise da rede de aviação. A mesma análise mostra o crescimento que têm experimentado as companhias low-cost no mercado português e o que isto implica para a concorrência entre aeroportos. Adicionalmente, o trabalho indica que a ANA Aeroportos de Portugal tem conhecimento da concorrência, embora não seja o caso em todos os tipos de concorrência encontrados nesta investigação. O marketing aeroportuário surge como uma ferramenta para tratar a concorrência entre aeroportos; no entanto, falta estabelecer uma relação mais forte entre os departamentos de marketing e planeamento da infraestrutura para atender adequadamente as necessidades dos diversos clientes.

Palavras-chave: rede de aviação, análise de redes, evolução de redes, concentração, concorrência entre aeroportos.

Competencia entre aeropuertos y evolución de la red de aviación

Un estudio exploratorio sobre Portugal continental

Resumen

Tradicionalmente, los aeropuertos han sido considerados monopolios naturales. Esta perspectiva está siendo desafiada por los efectos de la desregulación en la industria de la aviación. La libertad que tienen las aerolíneas para escoger los aeropuertos desde los que operan, la privatización y comercialización de aeropuertos y el crecimiento sostenido de las compañías *low-cost* han contribuido al surgimiento de competencia entre aeropuertos.

Una revisión de la literatura sobre análisis de redes revela que la mayoría de trabajos en el área se refieren a redes de aerolíneas y utiliza datos provenientes de los horarios de las compañías. En consecuencia, este trabajo explora la oportunidad de analizar la red de aviación en su totalidad (todas las rutas operadas por aerolíneas comerciales a partir de los aeropuertos en estudio), usando datos de tráfico reales. Una revisión semejante sobre la competencia entre aeropuertos demuestra la falta de acuerdo en relación al tema. Así, la literatura disponible sobre análisis de redes de sistemas de aeropuertos no considera especialmente la competencia; mientras que los trabajos sobre competencia entre aeropuertos no toman en cuenta el hecho de que estos son parte de un sistema en red.

En esta disertación se propone un estudio exploratorio para subsanar tales limitantes. Este trabajo estudia la evolución de la red de aviación de los tres mayores aeropuertos de Portugal continental –Lisboa, Faro y Oporto– durante la primera década del siglo XXI. Uno de los principales propósitos al analizar la red consiste en evaluar la influencia que las decisiones que se toman en un aeropuerto tienen sobre las decisiones tomadas en los otros aeropuertos de la red. El otro propósito es el de encontrar evidencia de la existencia de competencia entre aeropuertos a partir de los cambios que ocurren en la red de aviación a lo largo del periodo de estudio.

Para favorecer el desarrollo de tales objetivos se ha desarrollado un marco conceptual que define las diferentes maneras en que los aeropuertos compiten y las relaciones que existen entre ellas. En el análisis de la red de aviación se evalúa la evolución del nivel de concentración por medio del *Network Concentration Index (NC)*. Igualmente, los documentos de planeación más importantes de ANA Aeroportos de Portugal, el operador de los tres aeropuertos, son analizados para evaluar el nivel de conocimiento que la compañía tiene sobre la competencia entre aeropuertos y las estrategias que propone para hacerle frente.

Esta investigación propone y caracteriza cinco categorías de competencia entre aeropuertos, en relación a tres tipos de clientes del producto ofrecido. Además de proporcionar ejemplos de cada categoría, el análisis muestra evidencia de la competencia existente, tanto en los aeropuertos portugueses como en otros de Europa, a partir de lo encontrado en la red de aviación. El estudio de la red también ilustra el crecimiento alcanzado por las compañías *low-cost* en Portugal y las implicaciones que esto tiene para la competencia entre aeropuertos. Adicionalmente, los documentos de ANA Aeroportos de Portugal dan cuenta de la existencia de competencia, pero no en todos los ámbitos señalados por esta investigación. El concepto de marketing aeroportuario aparece allí como una herramienta para hacer frente a la competencia; sin embargo, hace falta una relación más fuerte entre los departamentos de marketing e desarrollo de infraestructura, de manera que se puedan satisfacer adecuadamente las necesidades de los diversos clientes.

Palabras clave: red de aviación, análisis de redes, evolución de una red, concentración de una red, competencia entre aeropuertos.

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1 Introduction

Deregulation of the air market in the United States, started in 1978, generated the concentration of the airline routes into few airports creating the famous *hub and spoke* networks (Guillaume Burghouwt, 2007, p. 38). This type of network is intended to increase efficiency by taking advantage of scale and density economies. Airlines were at the time competing in a liberalized environment and passing these economies to their passengers.

In Europe, however, most airlines were (and still some are) owned by national governments and tied to the main national airports (Richard De Neufville & Odoni, 2003, p. 97; A. Graham, 2003, p. 5). Hence their networks were already, at least geographically, of a *hub and spoke* style. Therefore, when deregulation started in the 1990's, network concentration was not its most important result. On the contrary, a de-concentration effect is noticeable (G. Burghouwt, Hakfoort, & Ritsema van Eck, 2003, p. 320) mainly due to the appearance and rapid growth of Low-Cost Carriers (LCC).

LCCs disrupted the market and increased competition between airlines, pushing flight fares down. But also, their preference for airports that are cheap, simple and free of congestion introduced a new ingredient in the European air market: competition between airports, this being propelled in addition by other effects of deregulation and the economic environment; such as major airlines bankruptcy and mergers, and airport ownership transition towards privatisation (Richard De Neufville & Odoni, 2003, p. 14, 2003, p. 98).

Of course LCCs are also playing a similar role in the United States and in fact, Southwest Airlines is commonly recognized as the initiator of the low-cost model (Chambers, 2007, p. 24). However it is in the European context where they have shown a tremendous growth rate in a very short period. Besides that, the war periods in Europe have left behind plenty of airfields formerly used for military purposes that allow the creation of airports at relatively low investment costs (Forsyth, Gillen, Müller, & Niemeier, 2010, p. 31).

In this new context, more than ever, airports need to remain competitive if they are to survive and be profitable, or at least sustainable, in a market with increasing volatility. Especially when airports have the most fixed of assets – runways and buildings – while airlines have the most mobile of assets – aeroplanes, so they can literally fly away to any other airport (Bush, 2010, p. 117).

In Portugal the majority of commercial airports are owned and managed by a state-owned company, *ANA Aeroportos de Portugal*. Its largest airport, in terms of passengers, is serving as the home base for the country's flag carrier, *TAP Portugal*, also a state-owned company. Although competition might not be the biggest issue at first sight, they are both in the context described above. In this context, more carriers are more strongly competing in the

Portuguese airports, as will be seen along this study, and more airports outside the ANA regular network are willing to take international operations, such as those in Beja and Bragança, South and North of Portugal respectively. Therefore, to analyse the Portuguese network gains relevance; especially when both national companies, TAP and ANA, are planned for future privatisations (Lusa, 2010a, 2010b).

As an exploratory study, this dissertation is focused on the three main airports in continental Portugal (this is, excluding the overseas regions of Madeira and Azores): Faro’s Algarve Airport (IATA code FAO), Lisbon’s Portela Airport (LIS) and Porto’s Francisco Sá Carneiro Airport (OPO). In this work, the network comprised by the airlines serving passengers departing from these three airports and their destinations is analysed over a time span between 2001 and 2010 to asses the evolution and the impacts that the deregulated environment poses over the network, and its implications for airport competition, not only in Portugal, but in the rest of Europe. This time span was chosen due to the availability of detailed data, and to the relevance of the phenomena under analysis along the decade.

During that period there is a clear evidence of the events that have introduced higher volatility to the aviation market, such as the establishment of LCCs as key players in the business and the bankruptcy/merge of several carriers. Additionally, during the period of analysis the three airports studied have implemented important investments in their facilities to increase capacity. Consequently, there is an opportunity to analyse whether such investments have been used in a correct way, considering airport competition.

1.1 Research questions

As previously mentioned, in this work the three Portuguese airports are analysed as a dynamic network system. Such analysis is intended to provide insights on the following research questions to be addressed by this dissertation:

- Are airport manager’s decisions influenced by analogous decisions in other airports?
    - How are these decisions reflected on the aviation network characteristics (geographical distribution and demand allocation)?
    - Is there empirical evidence that changes on the network are related to the airport decisions?
- In the same way, can signs of competition for the Portuguese airports be traced in the network and its evolution over time?
- If so, in which ways are these airports competing and how are their management facing competition?

By addressing those questions, this dissertation aims not only at applying network analysis to the Portuguese aviation system, but also at generating a framework to define competition for airports in general. Even though this work is centred on the three airports of LIS, FAO and OPO, thus limiting its scope and results; it is intended also as a base for future more general research.

1.2 Key definitions for a common understanding

Across the dissertation some terms that may seem confusing or similar are frequently used. Hence, their definition is presented next, to allow a clear reference and avoid misunderstandings.

Most of the definitions are related to the concept of *network*. The structure of a network is often represented by a *graph*, especially in the context of graph theory. Basically, a graph is a set of vertices, the nodes, and a set of edges, the links, connecting pairs of vertices. Consequently, a network can be defined as a graph containing information on the vertices or the edges (Tampubolon, 2009, pp. 6-7). Essentially, a network is a practical instance of a mathematical graph (Gergana Bounova, 2009, p. 31).

An instance one may think of as an example is a pair of airports in cities A and B respectively, with one company flying a route between A and B. Let us assume the airline carries 1000 passengers in a given period over this route, regardless of the direction; or, more specifically, that 500 people travel from A to B and the remaining 500 go in the opposite direction. There are at least two ways of representing this graphically as a network. Figure 1.1 a) shows an *undirected* graph with one *edge* between the nodes; while Figure 1.1 b) shows a *directed* graph with two *arcs*, one for each possible direction.

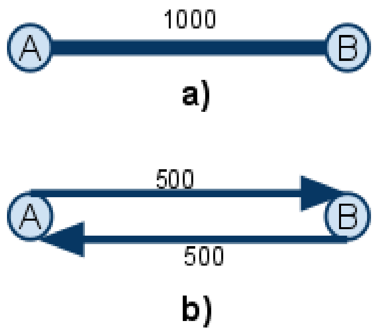

Figure 1.1 Two representations of a very simple network.

As for this dissertation, airports are represented as nodes, and routes connecting pairs of airports, operated by commercial airlines, are represented as arcs, this is, directed links between the nodes. There are, however, multiple possibilities and further clarification is needed.

Taking airports as the main study object, an *airport network* can be defined. In this case, the links may not only represent physical flights but also organizational or hierarchical information. Let us take the example of ANA Aeroportos de Portugal. The company itself manages three airports in continental Portugal and four more in the Azores Islands, but it also owns shares in a subsidiary company, *ANA Aeroportos e Navegação Aérea da Madeira* (ANA Madeira), which runs two airports in the Madeira Islands. Such information can be summarized in a network representation of ANA airports as shown in Figure 1.2. Even though they are not all geographically interconnected with direct flights, they are all part of the ANA Group. The company also manages other airports around the globe, through another subsidiary (ANA, n.d.). This information might as well be part of the network.

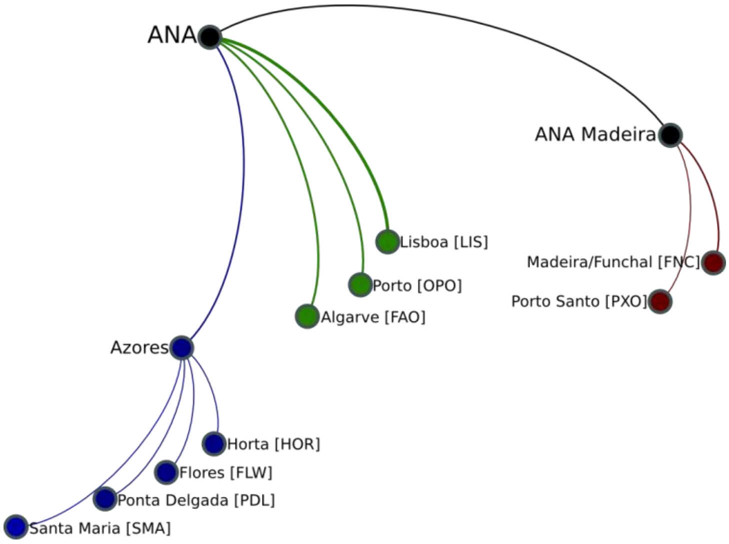

Figure 1.2 ANA airport network.

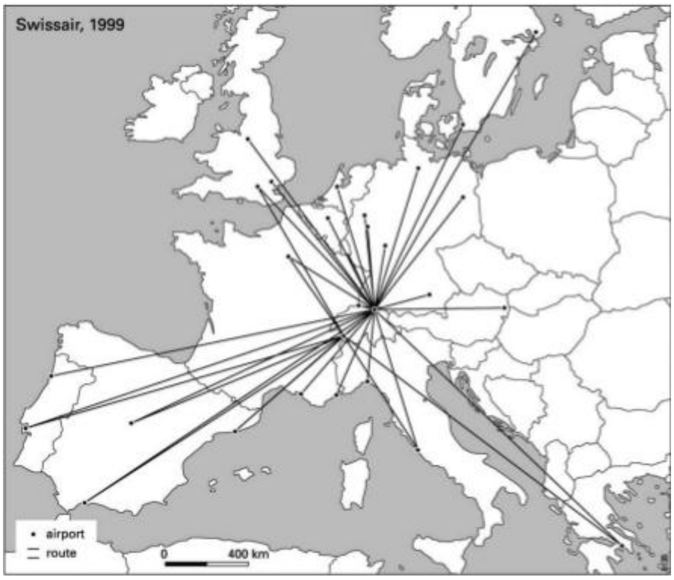

Figure 1.3 Swissair intra-European network in 1999. Source: (G. Burghouwt et al., 2003, p. 322).

If airlines are now the main concern, *airline networks* can also be defined. In this case, the focus is on single carriers and the destinations they offer in a given period. Figure 1.3 shows in a geographical layout the network of Swissair as of 1999 for its intra-European connections, taken from Burghouwt et al. (2003, p. 322). As it can be seen, the network includes all the airports being connected by routes offered by Swissair, not including code-sharing agreements. Airline networks are useful to analyse the strategies followed by carriers, especially in what concerns hubbing or point-to-point operations. Burghouwt (2007, p. 12) argues that airline networks are not only about geographical configuration, but there is a need to analyse the temporal arrangement of flights, especially to study connectivity on hubs. For the sake of this work, the geographical scope is enough.

If a broader picture is desired then it is the turn for the *aviation network*. While Burghouwt (2007, p. 34) defines it as "the aggregation of all individual airline networks", there is still the need to establish some borders. Since it is necessary to take into account all the single airlines, it seems clear that airports naturally define the limits for a given aviation network. Therefore, the definition proposed for aviation network is as follows: *the set of routes (links) and the resulting destinations (airports as nodes) offered by all the airlines operating in an airport or a group of airports in a given moment*.

Figure 1.4 Aviation networks of the three main airports in Continental Portugal during Summer 2006. Data Source: ANA.

This way, an aviation network can be further limited according to selected characteristics of airports or airlines. For instance, the aviation network formed by all the intra-European scheduled services offered in airports located within the European Union in 1999; exactly as the example presented by Burghouwt (2007, p. 34). Another example directly related with the scope of this work is shown in Figure 1.4 with the aviation network of all destinations flew by airlines operating at FAO, LIS and OPO during the IATA Period of Summer 2006.

1.3 Dissertation roadmap

The dissertation is structured in seven main chapters. The first one is an introduction to the subject under analysis, followed by the description of the methodology to be used for the study, in the second chapter. Afterwards, in chapter 3, there is an extensive literature review to present previous works in which network analysis has been the basis to study airport systems.

Such studies are grouped in two categories according to their methodologies, one for those works based on graph theory grounds, and another for those more related with air transportation. Chapter 4 presents up-to-date discussions regarding airport competition, from the origins of the concept to the role of aeronautical fees in competition, going through the definition of who is the customer of the airport product. The chapter also contributes to the discussion by proposing a conceptual framework to identify the possible ways in which airports compete with each other.

Chapter 5 presents our exploratory study on Portugal's aviation network. In this analysis there is a description of the way the network has evolved during the first decade of the present century; from the physical developments in the airports to the commercial evolution of demand and supply both in the network and in the airports. Chapter 6 discusses how airport competition is related to that particular evolution of the aviation network in Portugal and in other European airports. It analyses whether the airports' managers are aware of the effects of competition and how they tackle the matter. Finally, the chapter describes how airport marketing, as a way to pro-act before competition, is not correctly linked to airport infrastructure development.

Chapter 7 summarizes the main findings of the dissertation, points out the limitations of the results and opens the door to future work on the subject of network analysis applied to airport systems and its relation to airport competition. In the end, some appendices have been added to the document for more detailed reference, and the bibliography of all the studies and documents used across the dissertation are presented.

2 Methodology

This chapter presents the theoretical grounds in which the dissertation is based and describes the methodology applied in the network analysis of the aviation network for continental Portugal. Additionally, it shows how the evaluation of the network is related to the study of competition amongst airports and how the two aspects contribute to addressing the research questions presented in the previous chapter. We start by explaining why this work is called an exploratory study.

2.1 Exploratory study

An *exploratory study* is often used when there is little or null knowledge about the problem under research. Normally, this lack of understanding comes from the fact that the subject has never been studied before; or even if studied, there are still plenty of doubts regarding the characteristics of the subject, either in general or for a particular instance or context (Sampieri, Collado, & Lucio, 2006, p. 99).

Traditionally, airports have been considered as natural monopolies (Forsyth et al., 2010, p. 31) therefore competition between them is a rather new subject, yet to be understood in many aspects. Moreover, the available literature on network analysis of airport systems does not extensively consider the subject of competition, while the literature on airport competition normally does not take into account that they are part of a networked system.

Consequently, the exploratory approach is seen as a valuable alternative to address the research questions proposed. In this way, the analysis performed in this work remains open to new questions that may help clarifying the interaction between different airport's decisions, and finding evidence of airport competition in the aviation network.

Even though there are clear limitations of an exploratory study, such as the conclusions bounded to the scope of the analysis; the use of real data to build the network and the complementary approach described in the next section are intended to minimize these negative impacts.

2.2 Methodological approach

In order to properly address the research questions previously stated, the analysis is focused on the evolution of the aviation network formed by the three main airports in continental Portugal (FAO, LIS and OPO) and the routes of all the airlines departing from these airports. Based on data provided by *ANA Aeroportos de Portugal*, a network analysis tool is used to create a visual model of the network with the airports represented as nodes and the routes operated by the different airlines as the links. The analysis on how the network has evolved within a time span is concentrated in the aviation network as a whole and in the evolution of the three aforementioned airports.

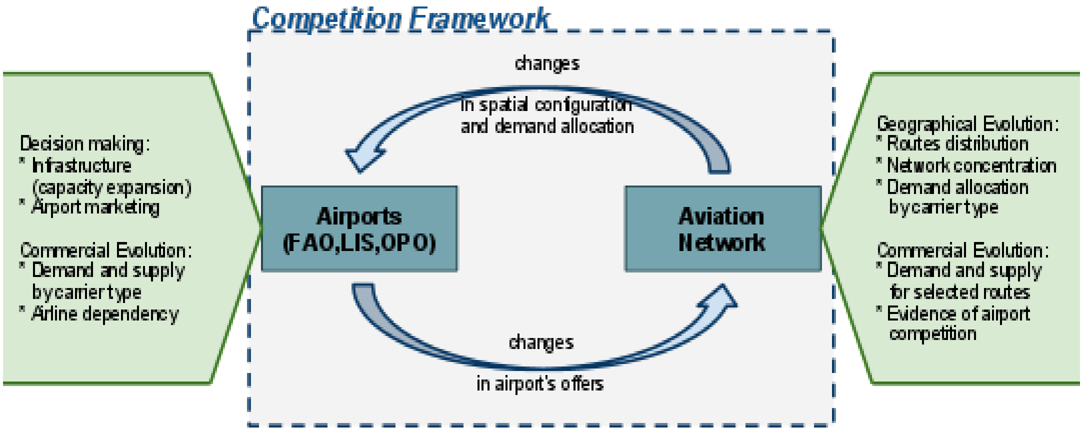

Figure 2.1 Methodological approach.

As shown in Figure 2.1, each of the two main components of the analysis is examined for particular details. For the aviation network they are categorized in two groups describing the way it has evolved geographically and commercially. The first one is considered a *dynamic network analysis.* It is concerned mainly with what are the destinations served, i.e. what routes appear or disappear in every period of study, and what is the type of carrier (Full-Service Carrier, Low-Cost Carrier, Charter operator or Regional airline) with the largest share in each route, namely in terms of the demand allocation. Additionally, using the Network Concentration Index (G. Burghouwt et al., 2003) the way the network has expanded or contracted is also studied. The commercial evolution, on the other hand, consists of a more detailed analysis over a group of selected routes for which there might exist evidence of airport competition. Such analysis is concerned with the behaviour of demand (passengers) and supply (seats offered) of every type of carrier along the time span.

For the Portuguese airport themselves, the details can also be grouped in two categories: decision making analysis and, again, commercial evolution. The former consists of a review of planning documents from the airport's operator, by looking for decisions related mainly with changes in the airport infrastructure which, in turns, affects the capacity offered; and with airport marketing that defines the way the managers are selling the airport's services. The commercial evolution, once more, is concerned with the behaviour of demand and supply for every type of carrier over time. An additional element is included, the share of major airlines in each airport, that gives an insight on whether they are being more or less dependent on single carriers.

The analysis of these two components provides an understanding on how the changes in one or the other are mutually affecting each other. Should a relation exist, it may show that airport's decisions are also mutually influenced.

There is still one element missing, however. All such interactions between the airports and between the airports and the aviation network may be occurring in a context of airport competition. Hence, there is a need of defining the way this competition arises, what are its drivers and how are exactly airports competing. Therefore, the analysis done in this work will be framed by a *competition framework*, which is to be defined hereby through a comprehensive literature review and the evidence presented in the aviation network.

By presenting a coherent synthesis of the current developments in the area, the competition framework aims at clearly identifying the specific ways in which airports compete with each other and the possible interrelationships that may arise between such diverse forms. It presents a schematic view of the traditional perspectives combined with the insights provided by the network analysis and the author's achievements. Moreover, it is intended to relate competition with key costumers for an airport and, by doing so, it will help airport managers to define strategies to become more competitive.

Nonetheless, this framework is not intended to be a fully extensive tool built upon competition concepts and existing frameworks in the fields of economics and strategic management, even though some results in those areas are here taken into account. The idea of the competition framework for airports rather arises as a need to better understand the findings in the analysis of the aviation network and the airport's decisions and is presented here to support further discussions and encourage future research work.

2.3 Network analysis

As described before, one of the components of our methodological approach is related to a dynamic network analysis. In order to evaluate the evolution of the aviation network, there are two main tools to be further explained in this section. They refer to the visualization of the network itself, and the network concentration index (NC).

2.3.1 Network visualization

The Portuguese aviation network has been modelled using *Gephi* as a network analysis tool (Bastian, Heymann, & Jacomy, 2009). This software allows the use of several graph drawing algorithms to define the spatial layout of the network. When a complex and overwhelming amount of information is included in large graphs, visualization layouts facilitate the analysis by providing an easy way to extract the most relevant data. Current developments in this area brought up the birth of a new field of research: visual analytics (Kielman, Thomas, & May, 2009).

Three visualization layouts are used in the network analysis. The first one provides a geographical layout based on the actual location (latitude and longitude) of every airport. The geographical coordinates represent the Airport Reference Point (ARP), which is the geometric centre of all usable runways[1]. That information is retrieved from the Great Circle Mapper database[2] and converted to planar positions in the screen using a Mercator projection through the proper layout algorithm available in Gephi. Figure 1.4 shows an example of the aviation network visualized using this geographical layout.

The other two layouts are based on *force-directed algorithms*. Such algorithms model the graph as a “physical system of bodies, with forces acting between them” (Hu, 2005, p. 37). Nodes, subject to attraction and repulsion forces, are placed by moving them according to the direction of the forces by successive iterations until the energy of the system is minimized. These methods allow for better representations of large graphs and facilitate the analysis of the relationship between the network components.

The two algorithms provided by the software are *Force Atlas* and *Yifan-Hu*. In both models the repulsion force, hence the separation of the nodes, is proportional to the degree of the nodes, i.e. the number of connections. Accordingly, high-degree nodes tend to be separated from each other. For the aviation network under analysis, this feature provides a clear differentiation of the three airports on focus (FAO, LIS and OPO).

The attraction force, on the other hand, is proportional to the weight of the arcs. Normally, across all the representations of the aviation network in this work, the weight is directly proportional to the number of passengers travelling over a given route, meaning that popular destinations may appear closer to their origin than others. Such attraction is more powerful in the Force Atlas than in Yifan-Hu algorithm. Both of them show a characteristic star shape, though.

Force-directed algorithms tend to fall in local minima when executing the optimization process (Hu, 2005). The Force Atlas algorithm converges towards a particular network layout, but it never stops since there are still some tiny improvements in the objective function (minimizing the energy of the system) that do not change the network visualization. The Yifan-Hu algorithm, on the contrary, includes an adaptive cooling scheme to avoid local minima and, consequently, stops itself at a given layout. This is the main difference between both models; thus Yifan-Hu is preferred for dynamic analysis, since it brings more stable layouts over different periods.

Figure 2.2 and Figure 2.3 provide examples of these visualization algorithms. Yifan-Hu models are used primarily to compare different instances over time of the entire aviation network. In contrast, Force Atlas models are used to compare the aviation network offered by type of carriers, and to show how it evolves. Occasionally, the results of both layouts may be subsequently altered to adjust the positions of the labels (the airport IATA codes or names) in the final representation, increasing readability of the network.

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[1] See http://www.ngs.noaa.gov/AERO/arpcomp/arpframe.html for more details.

[2] Great Circle Mapper, http://www.gcmap.com, by Karl L. Swartz.

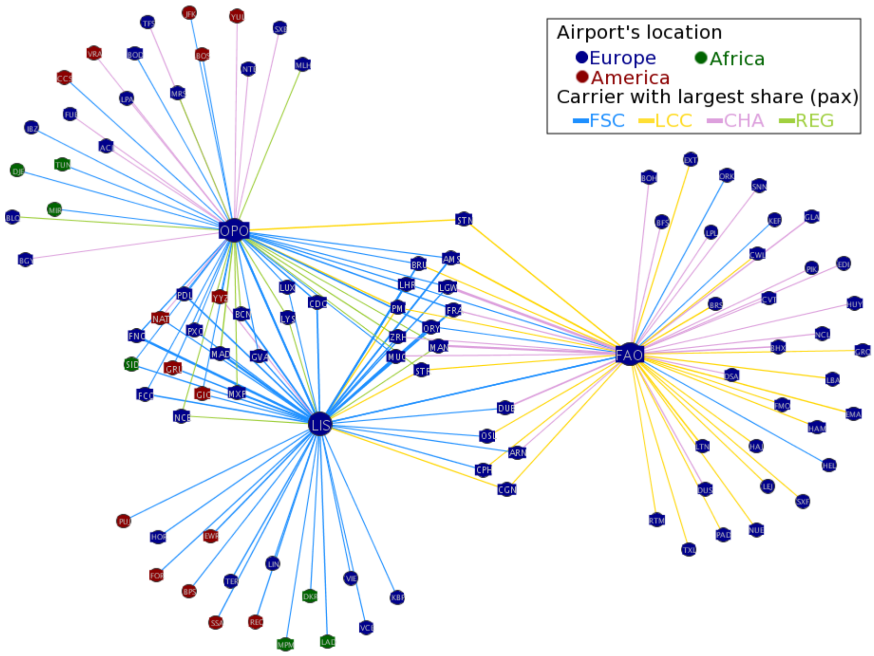

Figure 2.2 An example of a Yifan-Hu layout for the Portuguese aviation network in Summer 2005.

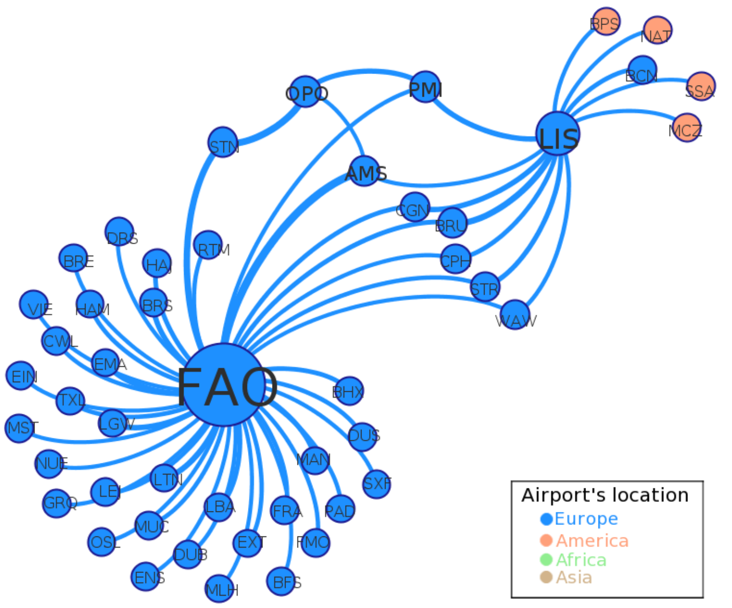

Figure 2.3 An example of a Force Atlas layout for the Portuguese aviation network of LCC carriers in Summer 2005.

2.3.2 Network concentration index

Burghouwt (2007, p. 41) makes a brief summary of the different measures for spatial concentration in airline networks or other airport/airlines related studies. Supported mainly by Reynolds-Feighan (2001) he concludes that the Gini Index is best suitable to measure the level of spatial concentration of a network, since it "is not sensitive to the distribution of the population and reacts quite well to changes in all parts of a given population".

The *Gini Coefficient* was originally developed by the Italian statistician Corrado Gini in 1912 to measure inequality in a distribution. The easiest way to understand its meaning is by using a *Lorenz curve* as the one shown in Figure 2.4. The Lorenz curve plots the cumulative share of traffic (*y* axis) held by all the airports in the population ordered from the smallest to the largest, in relative terms (*x* axis). The 45° line of equality shows the case in which all airports equally share the traffic, i.e. all routes have the same traffic. The Gini coefficient thus measures how big is the area between both lines (marked A in the figure) in relation to the total area under the line of equality (A+B in the figure).

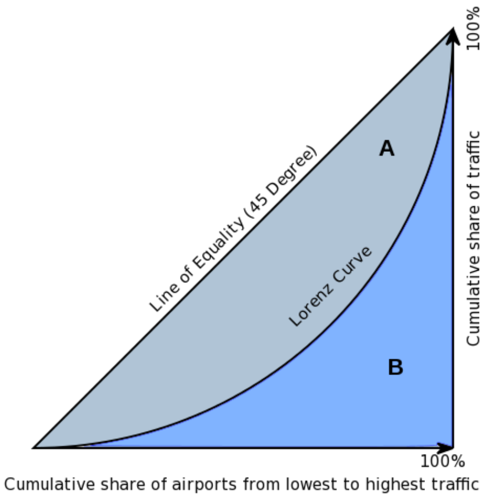

Figure 2.4 The Gini Coefficient: G = A/(A+B).

The Gini index (*G*) ranges from 0 to 1. A value of 0 (nonexistence area A in Figure 2.4) means the completely equal case aforementioned in which all airports handle the same amount of passengers. A theoretical value of 1 would mean one single airport handles all the traffic, hence A=A+B.

Nonetheless, any route includes at least two airports. Thus, as Burghouwt (2007, p. 42) points out, the Gini index can never reach its theoretical maximum value of 1. Moreover, assuming an equal distribution of incoming and outgoing traffic in any given airport, he concludes that "the maximum Gini score increases with the number of airports" in the network, since no airport is part of the network without sharing at least a small fraction of the traffic. Such maximum value (G_{max}) is computed as:

$$G_{max} = 1 - \frac{2}{n} \qquad (1)$$

Where *n* is the number of airports in the network. G_{max} is then used to normalize the Gini index, creating the Network Concentration Index (NC):

$$NC = \frac{G}{G_{max}} \qquad (2)$$

This new index is defined as the level of network concentration and accounts for a correction for the size of the network, making it possible to compare measures obtained from networks of different scale. NC again varies between 0 and 1, with 1 for a single radial network with traffic concentrated on one route. A decline in NC indicates a more even spread of traffic over the airports (a de-concentration effect) and the opposite for an increase in NC (a concentration effect). As before, an NC of 0 corresponds to the case in which all airports have equal shares of traffic (Guillaume Burghouwt, 2007, p. 42).

In this setting, there is, however, a difference to underline between this dissertation and the work by Burghouwt (2007), which is the input for the NC index. Since he worked with OAG data[3], the input for his model is the seat capacity resulting from the schedule offered by the diverse airlines. In contrast, the analysis presented here is based on data collected by the airports operator (ANA) and includes the real figures of the actual traffic flow for all the routes. Thus, the input in the current study can be viewed as the actual passenger demand.

The fact that such difference hinders comparison between both studies should not be seen as a major problem, since there is a bigger structural difference in analysing only airline networks against the entire aviation network. As a consequence, we consider real traffic flows to be more valuable than comparability with other studies, for achieving the objectives of this dissertation. At the same time, it helps us to overcome the drawbacks of using OAG data, namely the variability between airline schedules and reality and the lack of information regarding actual demand.

The definition of the Gini index described previously is not rigorous enough to be applicable for NC calculations, though. Considering the input discussed above, i.e. the passenger demand for each route (y_i), the Gini index (*G*) for the aviation network of a particular airport can be calculated as follows (where *n* is the total number of airports in the network):

$$G = \frac{2 \sum_{i=1}^{n} i y_i}{n \sum_{i=1}^{n} y_i} - \frac{n+1}{n} \qquad (3)$$

This simplified version of the Gini index (simplified because it does not require a definition of a function for the Lorenz curve to integrate) holds true for a uniform population on y_i (i= 1 to n), meaning the y_i have no null values, and are arranged in non-decreasing order ($y_i \leq y_{i+1} \leq y_n$). Both conditions are easily achievable with the available data set.

[3] OAG Aviation is a company providing information on global flights schedules for over 1000 airlines, including historical data since 1976 (http://www.oagaviation.com). Such information regards only scheduled data and not necessarily reflects the real operations that took place; however it is widely used as a base to define airlines networks.

3 Network analysis in airport-airlines systems

Studies on network analysis applied to airports or airlines systems can be divided in two broad categories: either they take a strict network theory point of view or have an air transportation field perspective[4]. The first group is normally more interested in analysing the topology of the networks and their performance according to graph statistics. Usually, they also deal with other types of networked systems, such as Internet routing connections or biological systems, using the same methodology. Conversely, the second group uses some network-related parameters either to classify business strategies of both, airports and airlines; to perform economic analysis or to evaluate technical features of the systems.

3.1 Network theory perspective

Bounova (2009) studied the evolution of airline networks in the United States between 1990 and 2007. She analysed topology transitions, such as *stars* to *non-stars* shapes, and concluded that such transitions are more usual in early stages of growth for airlines, more clearly for LCCs in expansion, while legacy carriers (also known as Full-Service Carriers, FSC) show a more stable structure, subject to changes revealing market fluctuations, like network downsizing after bankruptcy.

She also found that Southwest, the largest and oldest American LCC, is clearly an outlier, among all airlines, regarding network topology. However, their highest frequency flights resemble the hub-spoke shape of most FSCs. This is interesting given the maturity of Southwest in the market and might give a clue to future trends in the low-cost segment.

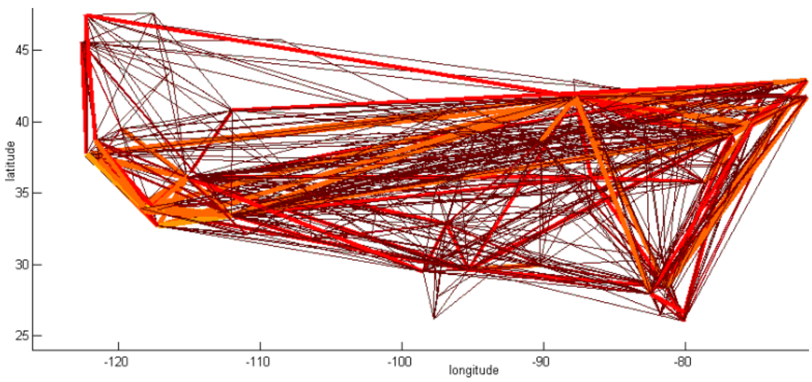

Figure 3.1 Southwest network in August 2007. The thickness of the edges is proportional to the number of seats offered. Source: Bounova (2009, p. 128).

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[4] Bounova (2009, p. 94) propose three categories in her review, considering also an econometric perspective for the work of Burghouwt et al (2003). Its context, however, fits better in the air transportation category.

Bounova et al. (2006) analysed the Chinese airline network for the 20 largest domestic operators using diverse graph theory metrics, like network diameter that measures how far are nodes (in this case cities or their corresponding airports) from each other; this is, how many hops are necessary to travel from one airport to another. Despite the apparent complexity of airline networks, they found the Chinese case to be a *small world*. In other words, a network with a small diameter in which it is rather easy and quick to access any particular node regardless the origin. This is found to be common in transportation networks, especially when dealing with passengers as noted by Bounova (2009, p. 42).

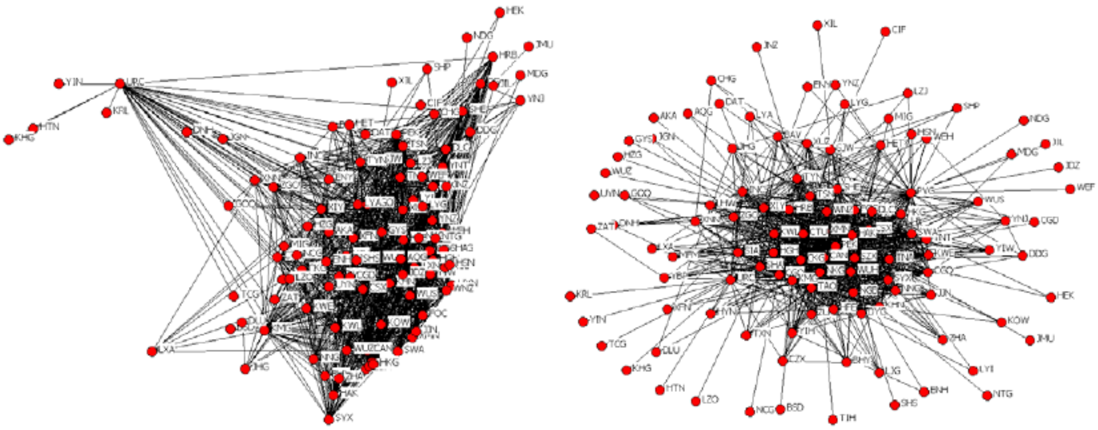

Figure 3.2 Chinese aviation networkin geographical (left) and force-directed (right) layouts. Source: (G. Bounova et al., 2006, p. 7)

They also apply optimization techniques to reconfigure the network for each carrier in order to minimize the diameter, eliminating excessive flight changes (connections), and maximize the passengers flow on each route, in order to increase airline revenues. Even though such reconfiguration might be subject to more complex technical or economic constraints, the use of graph theory for a more prescriptive analysis proves to be an interesting exercise indeed.

Similar findings of air transport networks as *small worlds* appear in Guimera et al. (2005). They analyse a world-wide aviation network using measures of node centrality to propose an airport classification regarding their role in the network as hubs, connectors or peripheral airports. *Degree* and *betweenness centrality* are mainly used as metrics. The former refers to the number of edges, in this case routes, coming to and leaving from each node; the latter to the number of shortest paths between two given nodes that go through a particular node.

Burghouwt (2007, p. 8) briefly summarize a set of studies from a graph theory perspective. The main contribution of these studies has been on the conceptualization of airline networks, particularly, the characterization of their graph structure. Some of them date back to the 1970's and define the very basics of network theory applied to different transportation systems (Tinkler, 1977).

Other examples on the border of graph theory and applied air transport research can be found in Fleming and Hayuth (1994) and Chou (1993). The first analyse multi-modal hubs based on centrality and betweenness measures with an application on the US passengers air transport. The second proposes another measure, also based on graph theory, to define spatial concentration in airline networks.

3.2 Air transportation perspective

Capitani (2009) makes a review of different studies proposing different alternatives to compute network concentration in air transportation networks. Most of the works reviewed take some distance from traditional network theory and introduce other econometric or social-related indices. The use of the *Gini coefficient* – originally a measure of income disparity, widely used in economics and social science – as a base for those measures deserves particular interest. The computations used to differentiate hubs and non-hubs airports are also an interesting aspect of these studies.

Burghouwt (2007) and Burghouwt et al. (2003) have made and extensive analysis on the evolution of airline networks in Europe after market deregulation. In relation to the network analysis itself, their main contribution regards the introduction of the *Network Concentration Index* (NC) to identify the level of concentration of European carriers and define their strategy as hub-spoke or point-to-point airlines. The NC is a normalized Gini Coefficient designed to avoid some of its flaws when dealing with networks of different size.

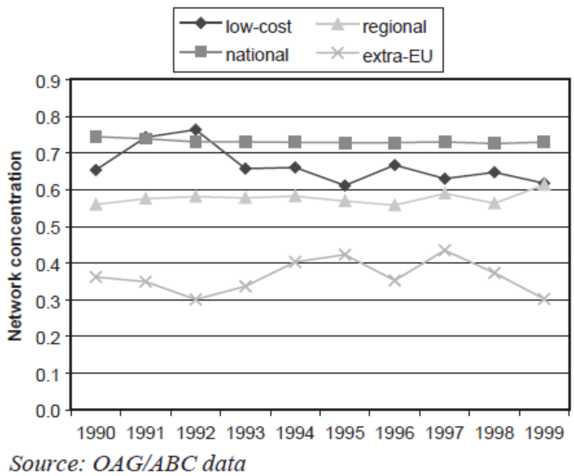

Figure 3.3 Evolution of the NC for different types of carriers. Source: Burghouwt et al.(2003, p. 313).

Burghouwt (2007) also analyses the temporal configuration of airline networks. Since connection opportunities are essential to hubbing activities in airports, the geographical concentration alone is not enough to characterize an airport as a hub or an airline as a user of a hub-spoke strategy. Surprisingly, not so many European airports provide a time coordination suitable for such operation, according to his methodology. Temporal configuration of airline schedules is not part of the scope of this dissertation, though.

As noted also by Burghouwt (2007, p. 8), there is a lot of research dealing with the *hub location-allocation problem* that analyse airline networks to identify best alternatives to place their hubs and how to assign the resulting traffic. Optimization techniques are used to minimize the total transportation cost in the network, resulting in traditional hub and spoke configurations.

Attention has also been paid to airport categorization as the object of other studies, dealing mainly with the concentration of the spatial layout of airline networks and their incidence in airports. Beside the Gini index, other measures have been used for this purpose, such as the *Herfindahl index* and *Theil's entropy index* (Reynolds-Feighan, 2001) or the *Hubbing Concentration Index* (Martín & Voltes-Dorta, 2009).

As for these studies, it is implicitly accepted that those concentration indices define better indicators for hub identification than pure graph theoretic measures (Guillaume Burghouwt, 2007, p. 9). Despite the analysis of Martín and Voltes-Dorta (2008), the Gini index being the most advantageous indicator for geographical concentration, especially in the normalized version of the Network Concentration Index as defined by Burghouwt et al. (2003).

Concentration measures are used as well to differentiate the strategies of FSCs and LCCs, especially because the first are normally linked to hub and spoke operations, while the latter opt for point-to-point networks. However, when analysing the European LCCs, Dobruszkes (2006) introduces a different methodology by performing a *Principal components analysis* (PCA) with 10 variables related to LCCs volume of supply (number of flights and seats and available seats kilometres) and the characteristics of the networks of these carriers (such as the use of the *freedoms of the air* granted by the market liberalisation, the resemblance of charter routes or the exclusivity in some origin-destination pairs). He argues (Dobruszkes, 2006, p. 263) "that it is precisely the concentration of FSCs on a limited number of hubs that has facilitated the rise of LCCs, which could create many direct connections bypassing the hubs and avoiding constraining connections." As a consequence, LCCs create parallel networks that trigger competition between secondary airports and the traditional ones. This is a very important conclusion, for the sake of this dissertation.

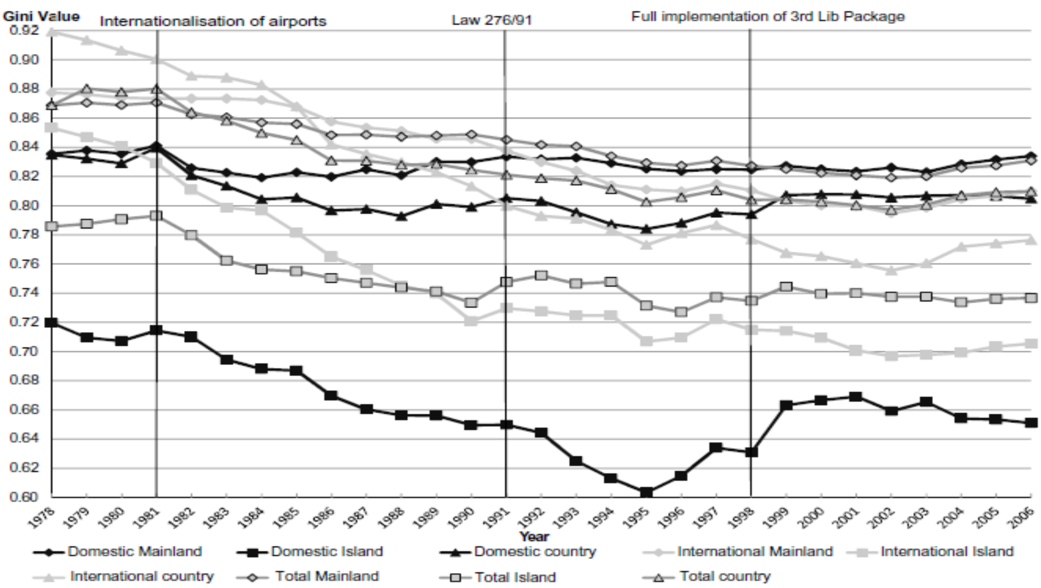

Figure 3.4 Evolution of the Gini index in the aviation network of Greece. Source: (Papatheodorou & Arvanitis, 2009, p. 407)

Papatheodorou and Arvanitis (2009) explore the evolution of the aviation network in Greece between 1978 and 2006. They mainly use the Gini index to analyse the changes in the geographical concentration of traffic and the asymmetry in the use of the different airports in mainland and the islands. Despite liberalisation, the Greek aviation network remained highly concentrated and with low levels of LCC shares in traffic, the authors argue. Nevertheless, there is a drop in the Gini index values during the 1980's which is related to the internationalization of the airports on the one hand, and the increase in the number of airports operating in the country, on the other. The number of airports, however, is assumed to be constant for the calculations of the Gini Index, i.e. they do not use measures independent from the network size, as the one proposed by Burghouwt et al. (2003).

3.3 Key findings

The majority of the studies in this field take an airline network perspective. Clearly, airlines have the most important role in defining their own networks and their strategies to operate them. Perhaps available data is naturally aggregated by airlines (many studies rely on OAG databases containing scheduled flights for most regular airlines). Although there are other studies concentrating on airports, either for specific case studies or to analyse the role of airports as hubs, only the paper on Greece (Papatheodorou & Arvanitis, 2009) does analyse the entire aviation network of the country. Consequently there is a clear need to further study the behaviour of the aviation network as a whole, and not only its development airline by airline.

Nonetheless, the literature review confirms that the methodology proposed in the previous chapter is appropriate to address our research questions. Even though with some particular variations and different contexts, it seems clear that network analysis tools and methods contribute to a better understanding of air transportation related problems.

Moreover, there is a contribution of this dissertation in approaching the analysis with actual figures regarding network flows for both demand (passengers) and supply (seats available). In this sense, it takes a step apart from other studies that work with airline schedules information.

However, no evidence was found regarding the use of network analysis to study airport competition. Consequently, the attempt to link both (airport competition and network analysis) in this dissertation is also seen as a valuable contribution to the area, given the fact that airports are clearly part of a networked system. Additionally, there might be an opportunity to tackle competition when there is an airport network managed by a single company, as in the case of Portugal.

4 Airport competition – a literature review

This chapter presents a review of the currently growing literature on airport competition. Since this dissertation is focused on the Portuguese aviation network, there is a natural bias to European studies in such review. This option is also supported by Forsyth et al. (2010, p. 8) who argues that “Europe provides the best case study of airport competition”. Additionally, aided by the discussion on the literature and insights from the study on the particular case of Portugal, a new framework to define airport competition is proposed at the end of the chapter.

4.1 A rather new concept

Airports have been traditionally considered as natural monopolies (A. Graham, 2003, p. 180), with no real competition between them. This lack of competition is normally associated to two reasons: a) nonexistence of close substitutes in the same location; and b) economies of scale in airport provision. The first reason assumes that airports are restricted to passenger demand in their own catchment area, then in attractive locations there are already airports and it is very difficult to build a new one. The second reason views the natural monopoly as being more efficient, since two or more airports would lead to higher costs and, in the end, the airport able to attract more traffic would force the others out of the market (Forsyth et al., 2010, p. 1).

This concept was further supported in early stages of air transport market growth when airlines were also in a non-competitive environment. The Chicago Convention on International Civil Aviation in 1944 structured the market in a hardly contestable way, through bilateral agreements in which airlines had no incentive to compete. This was reflected in high fares, high costs and low productivity (Barrett, 2000, p. 13).

In this context airports were plain providers of the air side infrastructure, very often as a public service, responding to airline requests and facilitating the access of passengers to the airline networks trough terminal buildings. Deregulation of air transport around the world brought about a competitive pressure for airlines which, in turn, created competition for airports, especially due to the fact that airlines were then free to choose the airports they wanted to operate, without being constrained by bilateral restrictions (Richard De Neufville & Odoni, 2003, p. 112; A. Graham, 2003, p. 178).

Deregulation also pressured for a change in airport ownership towards privatisation (Richard De Neufville & Odoni, 2003, p. 100). New owners with different perspectives force airports to be more focused on costs and commercial revenue and the need to attract and retain airlines (Bush, 2010, p. 114). Private ownership implies an increasing concern for regulators on policy issues to control monopolistic behaviours, this being an implicit recognition of airport competition (Forsyth et al., 2010, p. 6).

A free market for aviation services was in place since 1978 in the United States. There were several airports serving large cities and densely populated areas in North America long ago. Airports located near the Canada-USA border (such as Vancouver and Seattle or Toronto and Buffalo) competed for international traffic. Major airports around the world may be thought of competing for transfer traffic as hubs as well, like Singapore, Kuala Lumpur and Bangkok or London/Heathrow, Frankfurt, Paris/Charles de Gaulle and Amsterdam (Forsyth et al., 2010, p. 8). However, most of the literature on airport competition is quite recent.

Nevertheless, the great majority of commercial airports used to be owned and operated by diverse forms of national or local government agencies or institutions (Richard De Neufville & Odoni, 2003, p. 94). In many cases common ownership of closely located airports hindered competition, as for New York airports. Moreover, competition between airports was simply not an issue for regulators while states continued to fund airport infrastructure (European Commission, 2002, pp. 1-1).

It was the entire privatisation of the British Airports Authority (BAA) in 1987 that somehow started the trend towards privatisation of airport infrastructure (Richard De Neufville & Odoni, 2003, p. 94). Kapur (1995), in a study for the World Bank, analyses the diverse forms of privatisations and suggests that airports would do better if they were run as companies; however, he assumes they are natural monopolies (Kapur, 1995, p. 22). Airport privatisation, in turn, has triggered additional concerns on competition issues, as said before.

By the time BAA was on its way to be privatized, as Barret (2000) suggests, there was a public discussion on whether the airports should be privatized as a single entity or as independent competing airports. At the end, arguments for the first choice won and BAA plc. was formed to take over three airports in London (Heathrow, Gatwick and Stansted), four in Scotland (Aberdeen, Edinburgh, Glasgow and Glasgow/Prestwick) and Southampton Airport. Later on in 1991 Glasgow/Prestwick was sold after transatlantic flights were transferred to Glasgow (Reference for Business, n.d.).

In 2008, after BAA plc. had been sold to a consortium led by the Spanish Grupo Ferrovial (The Economist, 2007), the new BAA Limited was forced by the UK Competition Commission to sell two of its three London airports and either Glasgow or Edinburgh Airport. The decision was based on the grounds of promoting competition between the airports (Forsyth et al., 2010, p. 1). I.e. competition has clearly become an issue for airport systems.

The case of BAA is similar to other decisions of different regulators for which airport competition has been a justifying reason. One of the most interesting cases was the dispute between the European Commission and the Walloon Region in Belgium regarding the aid provided by the Brussels South Charleroi Airport, owned by the regional authorities, to Ryanair, the largest European LCC in terms of passengers. In 2004 the Commission had banned the discounts and payments issued by the airport to the airline, alleging they constituted illegal subsidies and distorted competition. In 2008, however, Ryanair saw the case overturned by the European Court of First Instance (Barbot, 2006; European Commission, 2004; Forsyth et al., 2010). In a similar way, other airports have been involved in legal disputes regarding subsidies to LCCs (Morrell, 2003).

As another example, the Slovak Anti-monopoly Office ruled against the sale of Bratislava Airport in 2006. The airport was about to be sold to a consortium led by the operator of the neighbouring Vienna Airport. The Slovak government agency decided that this would prevent the development of competition between the two airports, especially considering the role of Bratislava as a Low-Cost attractive airport (Bratislava City, 2006; Forsyth et al., 2010).

In fact, the steady growth of LCCs in deregulated markets has become an incentive for the creation of Low-Cost airports. As De Neufville (2008, p. 37) notes, "Low-cost airports largely develop in competition with major airports, either as secondary airports in a metropolitan multi-airport system, or as destinations that bypass the use of a centralized metropolitan hub." At the same time, Graham and Shaw (2008) argue that environmental costs caused by the increase in air transport demand, generated by LCCs, are not internalized by the industry, thus the Low-Cost air transport model is unsustainable. This may pose a threat to airport competition if the trend for LCC growing gets reversed.

Summing up, so far it seems clear that competition between airports exists and it is becoming increasingly important. Air transport market deregulation can be identified as the main driver for such competition. Especially because, among other aspects, it triggered the change in airport ownership and the steady growth of traffic coming from LCCs. Exactly how, in practical terms, and to what extent are airports competing is a different matter though. Before dealing with the types of competition in which airports may be engaged, another question of paramount importance needs to be answered – if they are to compete, what are they competing for? The answer, however, may not be straightforward.

4.2 Who is the client?

As with competition, in recent times, the discussion regarding who is the real client for airports implies changing perspectives and having a broader view on the problem. Francis et al. (2003, p. 267) summarize the matter in a useful way, as presented next:

> *Traditionally airports have viewed airlines as their primary customers partly because of the legally binding agreements between the two parties and because airlines pay a variety of charges such as landing fees and charges per passenger or tonne of freight handled. So far there has been little vertical integration between the airports and airlines. Airlines have legally binding agreements with passengers and see passengers as their primary customers. In today's commercialised and privatised environment, where airports place more emphasis on non-aeronautical revenues from retail and concessions, the traditional airline – airport – passenger relationship has become more complicated.*

Airports can be seen solely as infrastructure providers that sell aeronautical services to facilitate the interchange between air and surface transport. Thus they provide runways, air traffic control, taxiways, aprons and terminals for the use of airlines, which in turn sell seats to passengers and cargo space to shippers. However, airports take advantage of the passenger throughput to offer a variety of non-aeronautical services, such as shops and car parks to their users (European Commission, 2002, pp. 4-1; Kapur, 1995, p. 8).[5]

In the last decades non-aeronautical revenues are becoming increasingly important for airport operators. In many cases they represent, proportionally, a higher income for the airports than aeronautical revenues, especially in North America where aeronautical services contributes with less than half the total revenues on average. In Europe and Asia airports are more or less balanced between the two sources, while Africa, the Middle East, Latin America and the Caribbean show more dependency on aeronautical revenues, mainly due to the lower population income and the existence of smaller airports with fewer opportunities to offer non-aeronautical services (Richard De Neufville & Odoni, 2003, p. 268; A. Graham, 2003, p. 56).

This trend towards a greater importance of non-aeronautical revenues is to blame for the increasingly ambiguous definition of the airport's clients. Moreover, it may pose some conflicts of interests, since airport operators are interested in offering a good level of service to both, airlines and passengers, by providing quick and easy access to aircraft; while at the same time they want passengers to spend more time, and thus money, enjoying the non-aeronautical facilities (Francis et al., 2003, p. 267).

Macario (2008, p. 171) highlights the need to include all the stakeholders involved in the airport processes when assessing the relationship between aeronautical and non-aeronautical activities. She refers to the stakeholders as *external* (passengers, freight forwarders, accompanying people) *or internal* (employees, suppliers, etc.) clients. Moreover, the interaction of the airport with those customers allows it to develop activities inside and even outside the perimeter of the airport.

Trade	***Passengers***	***Others***
Airlines	Scheduled (FSC and LCC)	Tenants and concessionaires
Tour operators	Charter	Visitors
Travel agents	Business	Employees
Freight forwarders	Leisure	Local residents
General aviation	Transfer	Local businesses

Table 4.1 The airport's customers. Source: Graham (2003, p. 183).

Graham (2003, p. 182) simply disregards the airline – passenger dichotomy and states that airports have several different costumers. “For the airport product, demand comes from a variety of markets each with their own specific requirements” she adds. In this wide perspective, she makes an effort to classify the clients in three categories as shown in Table 4.1. Those in the *trade* group directly buy the airport facilities and can be more or less associated to aeronautical services. The *passengers* group includes the travellers who consume or utilize the airport product, a portion of the non-aeronautical services, and are in the airport thanks to those in the *trade* category. The third group includes other stakeholders that cannot only be viewed as so, but as clients, since they may play a significant role in non-aeronautical revenues and cost.

[5] See De Neufville and Odoni (2003) for a more extensive explanation on aeronautical vs. non-aeronautical services and charges.

Vancouver airport, for instance, promotes itself as a sort of touristic destination for local residents and visitors offering self-guided tours (Vancouver Airport Authority, n.d.). Even though they are for free and do not represent direct revenues to the airport, they attract people that may consume non-aeronautical services and, over all, enhances the airport public image. Munich airport, on the contrary, sells guided tours around the airport for interested individuals or groups (Munich Airport, n.d.).

All that sort of customers are easily found in established airports. For new entrants, however, the fact that they have no flights to offer prior to entry simply means that airlines have a bigger weight than the other clients. In other words, airlines continue to be those who offer what passengers want to find in an airport: flying alternatives. De Neufville and Odoni (2003, p. 124) put it this way when explaining competition for transfer traffic at hubs: “in a deregulated environment, airlines compete with each other for the same customers (...). As one airline succeeds at the expense of the others, so does its hub airport compared with its competing hubs”.

From a simplistic point of view, airlines attract passengers that can provide the airport with other sources of revenues. Therefore, a close cooperation and a clearly commercially defined relationship between the airport and the airlines seems to be a condition for a successful business (A. Graham, 2003, p. 132). This has a great impact in airport competition, since a wrong assessment of the needs of the airlines – as prime customers – would make them less interested in using a specific airport, limiting the existence of other types of competition for other customers.

In brief, the diversity of clients consuming what an airport has to offer means airports can compete in satisfying the needs of all those customers. Defining their priority is therefore of paramount importance in strategic terms.

4.3 How do airports compete?

4.3.1 The common ways

In a more traditional view, airports compete in mainly two different ways: overlapping catchment areas and transfer traffic at hubs (Richard De Neufville & Odoni, 2003, p. 124; Forsyth et al., 2010, p. 8). In this perspective passengers are seen as the main customers for airports, hence they can decide what airport to choose if they have several nearby alternatives or the airport of their preference to transfer for a longer journey. By this reasoning, people departing from London may start their trip either at Heathrow, Gatwick, Stansted, Luton or London City airport. While people travelling from the USA to Europe may choose to spend some time at London/Heathrow, Amsterdam/Schiphol or Paris/Charles de Gaulle, just to cite some examples, in order to get better fitting schedules.

However, very often passengers are not confronted with those kinds of choices regarding airports but rather concerning airlines. According to Morrell (2003, p. 3) “airports compete with other airports to attract airlines". Once the airlines are there, the airports are able to offer other services to passengers, such as their desired destinations. As a consequence, the airlines will choose which airport to serve in a multi-airport system (several airports serving a single urban area[6]) and which airports to use as their connecting hubs.

The traditional view is being expanded according to the evolution of the airport businesses (Bush, 2010, p. 117). In this sense, the Airports Council International Europe identified six types of competition between airports (ACI Europe, 1999; cited by European Commission, 2002, pp. 4-3):

1. Competition to attract new airline services - passengers and freight.
2. Competition between airports with overlapping hinterlands.
3. Competition for a role as a hub airport and for transfer traffic between hubs.
4. Competition between airports within urban areas.
5. Competition for the provision of services at airports.
6. Competition between airport terminals.

As discussed in Forsyth et al (2010, p. 15), types 5 and 6 are actually forms of competition within a given airport (*intra-airport* competition) and not between different airports (*inter-airport* competition). Nonetheless, as airports continue to engage in more operations and activities outside their own limits, it is perfectly feasible that such services could be provided by another airport. In fact, some *airport companies* are exercising management contracts in other airports which are not owned by them and are located all around the globe (Richard De Neufville & Odoni, 2003, p. 20). Therefore, it would not be surprising if one airport manages its own terminal or runs some services in another airport.

Additionally, types 2 and 4 do actually refer to the same way of competition based on overlapping catchment areas, that is to say, geographical proximity. As a matter of fact, the term *catchment area* is confusing, since different airports have different definitions of it. The essential idea is to determine an area surrounding the airport "within which most of the existing or potential traffic of an airport lies" (European Commission, 2002, pp. 4-7). It can be defined in terms of time to reach the airport using surface transport (normally a private car), or in terms of distance from the airport, or even as plain as a geographical region, for instance an entire country in the case of Luxembourg.

Moreover, the catchment area can also be a dynamic concept since passengers and journeys are not homogeneous. An intercontinental leisure flight may benefit from a larger area to look for potential travellers than a short-haul business flight. Consequently, airports offering long-haul services may enjoy a bigger catchment area than a regional airport offering only short-haul flights.

[6] See De Neufville and Odoni (2003) for further details on multi-airport systems.

In the same way, airport connectivity with surface transport networks can also extend the airport catchment area. “Airport services are provided in the context of the door-to-door transport network, whether for passengers or freight. Air service will always be ‘consumed’ in conjunction with one or more sectors provided by other transport modes.” (Forsyth et al., 2010, p. 12). Therefore, the better the airport is connected with those other modes, the easier for passengers is to reach it from a far location.

Type 3 (Competition for a role as a hub airport and for transfer traffic between hubs) defines the more classic way of competition for transfer traffic or, better said, the competition between airports to become the hub of an airline. There are a number of reasons why airlines concentrate their operations either spatially or both, spatially and temporally (Guillaume Burghouwt, 2007, p. 26). In general terms, a hub allows an airline to operate more frequent and less expensive services (Richard De Neufville & Odoni, 2003, p. 118). Accordingly, airports must provide certain characteristics in order to be attractive for hubbing activities, such as a location that does not impose a great detour on the direct route, and enough peak capacity to handle high demands for the successive waves of landings and take-offs[7] and to process the passengers through their connections.

Even though many major airline hubs in Europe have developed in the capital cities of the airline’s national country (Forsyth et al., 2010, p. 15), there are plenty of examples of this type of competition around the globe (R. De Neufville, 2008; Richard De Neufville & Odoni, 2003). Not only in what regards the establishment of a hub (as Munich instead of a second terminal in Frankfurt for Lufthansa), but also in relation to moving an existing hub from one airport to another (like Delta moving most of its operations at Dallas/Fort Worth to Cincinnati or US Airways from Pittsburgh to Philadelphia) or even the disappearance of a hub due to the bankruptcy of an airline (such as Sabena in Brussels or Swissair in Zürich).

As discussed before, Morrell (2003) considers type 1 (Competition to attract new airline services) to be, strictly speaking, the only real form of competition between airports. According to the European Commission (2002, pp. 4-4) study, the airport can influence the decision of an airline to start new services by offering a good deal. Therefore, competition appears “if there is another airport serving the same catchment area, the airport's offer can rightly be considered to play a part in the airline's decision to introduce the service at all, and to use that airport in particular”.

4.3.2 The airport’s perception

The European Commission (2002) study included the results of a survey in which some airports were asked to rank their major competitors according to some traffic categories, namely low-cost airline services, scheduled long-haul and transfers, scheduled short-haul, charter and

[7] A wave-system at a hub provides the ideal connectivity in such a way that passengers in all incoming flights have the opportunity to connect to all outgoing flights without wasting too much time in the operation. See chapter 4 in Burghouwt (2007) for a more detailed explanation.

all cargo. The survey reveals considerable awareness of the airport operators regarding competition. As expected, some consistency in the selection of competitors for transfer traffic is visible. Amsterdam/Schiphol, London/Heathrow, Paris/Charles de Gaulle and Frankfurt are the most cited cases. The result for short-haul services is not surprising as well, with most airports citing other airports in close proximity. In cargo services, Liège airport in Belgium is cited as the major competitor for nearby airports, such as Amsterdam/Schiphol and Luxembourg.

Charter services were scarcely included in the answers of the airports. The number of respondents for low-cost traffic was also surprisingly low. Perhaps by the time of the survey airport managers were not envisioning the steady growth of this segment. Brussels/Zaventem and Brussels/Charleroi cite themselves mutually and London/Luton cited London/Stansted, but no other London airport saw each other as competing in the low-cost market.

In Portugal, only Lisbon was part of the survey. It cited Madrid/Barajas as its major competitor in all of the traffic categories, even short-haul and charter, despite the airports are not so near each other and the cities are not connected by high-speed rail. At the same time, the Lisbon airport considered Porto as the second most important competitor for short-haul scheduled services.

Despite the lack of awareness of the competition triggered by the rise of LCCs in the survey, de Neufville (2008, p. 38) argues that "competition between 'legacy' and 'low-cost' airlines leads to competition between 'legacy' and 'low-cost' airports". The business model of most LCCs demands for cheap infrastructure without congestion problems. Without congestion, the airports allow the airlines to have quick turnaround times, and LCCs are able to keep their aircraft flying as much as possible. This has created opportunities for under-used airports or former military airfields to embrace the development of LCCs.

4.3.3 The role of LCCs and low-cost airports

According to de Neufville (2008, p. 40), there are three major ways in which low-cost airports can compete with the major airports:

1. As alternative secondary airports in a metropolitan multi-airport system. This corresponds to the competition between airports within the same urban area, as previously described in the assessment of ACI Europe (1999). The difference in this case is that these airports may prove to be more convenient not only for the low-cost airlines, but to the passengers. Possibly because the low-cost airports are located closer to the origin/destination of the trip, or they provide cheaper parking facilities and other inexpensive services, or simply because passengers are willing to use a simpler airport that is quieter and easier to reach.

2. As an alternative to hub connections. LCCs are characterised by their point-to-point network configuration. Normally, they do not sale connecting tickets and they do not offer coordinated schedules at central hubs (some exceptions, such as Air Berlin, also exist). Therefore, low-cost airports offer the opportunity for passengers to bypass the

major hubs and get directly, non-stop, to the destination they want. E.g. holidaymakers can reach the Algarve, in Portugal, by flying an LCC to Faro, instead of using a legacy airline, such as TAP, that implies a layover in its hub at Lisbon.

3. As an alternative parallel network. By putting together the airports served by LCCs, these airlines create a network that competes in origin/destination with the networks of Full-Service Carriers (FSC). For instance, Ryanair provides service between London, Brussels, Frankfurt and Paris, using the low-cost airports of Stansted, Charleroi, Hahn and Beauvais; or Southwest serving Boston, Washington and Miami through Providence, Baltimore and Fort Lauderdale.

There is a clear common feature in those three ways of competition. Low-cost airports compete with 'legacy' airports because LCCs avoid the use of hubbing practices. However, as Burghouwt (2007, p. 27) suggests, LCCs may present connectivity opportunities to their passengers by *self-help hubbing;* introducing competition between low-cost and legacy airports *for* transfer traffic.

The self-help hubbing concept refers to the fact that a transfer process may be in place without needing a wave-system structure (incoming and outgoing flights coordinated in time). By increasing frequencies in point-to-point services – through quick turnarounds and extensive aircraft utilization, and increasing the acceptability of waiting times – through low prices; connection opportunities naturally appear. As a consequence, a cheaper and less complex hub model arises. In this way, small airports such as Brussels/Charleroi, Paris/Beauvais or Frankfurt/Hahn can effectively turn into hubs for LCCs passengers wishing to travel between East and West Europe.

That is not only an opportunity for LCCs to compete with FSCs in medium-haul markets, but for the airports themselves, since such random connectivity may arise between different carriers. For example, one may travel between Portugal and Poland using a combination of LCCs, like Ryanair and Wizzair, via Paris/Beauvais, without incurring cost penalties for the airline change, as it would otherwise be the case in a FSC.

Self-help hubbing is not exclusive to LCCs, though. One of the main well-known world hubs, London/Heathrow, is not so, strictly speaking. British Airways has not implemented a wave-system structure at the airport. However, given the large frequencies, the airport is highly used to connect short and medium-haul flights to long-haul services. In fact, the large number of connections happening in practice, allow us to consider the airport as a *continuous hub* for British Airways (Guillaume Burghouwt, 2007, p. 83).

LCCs have not only propelled competition by catalysing the development of low-cost airports, but have also forced legacy airports to *compete back* with the newcomers. As de Neufville (2008, p. 49) explains "the point is that competition now exists between the low-cost and the legacy airports, in a way it did not when the [LCCs] were marginal. Many legacy airports have lost their previous virtual monopolies. This fact has to motivate their management to build facilities that will be more competitive with low-cost airports".

In this sense, LCCs have challenged the power of FSCs and, more importantly, their influence in airport planning. As a particular case, the planning process of future expansion for the Amsterdam/Schiphol airport – presented by Burghouwt (2007) in the ninth chapter of his book – shows the change in the mindset of airport planners: from a starting point of «we do not want LCCs because we want to be a first class airport», to «LCCs would be tolerated as far as capacity would permit» and ultimately to «we want LCCs and we are willing to build flexible facilities, adaptable to their particular needs». Their metamorphosis does not only show the decision of the airport managers to compete with other airports that are embracing the low-cost segment, but, to a larger extent, the divorce – at least partially – from KLM as the main costumer of the airport and the only one to care about.

4.3.4 The not so common ways

Competition for funding

Other sources of competition can be identified beyond those already mentioned. Despite the discussion on airport privatisation held previously, most of the airports are still owned by some form of local, regional or national governmental agency, institute or company. In this way, they can compete with each other for attracting state funds or grants to invest in the expansion of the airport infrastructure, turning it into a more competitive one. Airports can also compete for subsidies and tax alleviation (European Commission, 2002, pp. 1-1) leaving them in a better position to offer lower costs to the users, especially to the airlines.

This kind of competition is under strong scrutiny in Europe. The Treaty Rules on State Aid for the European Union does not allow any form of state-aid (i.e. subsidies) to support operational costs. At the same time, state-aid for construction and expansion of air transport infrastructures cannot be ruled by the European Commission. However, the application of such subsidies to sunk costs may result in preferential conditions for some users (the state-owned flag carriers, for instance). Therefore, the aid is subject to the condition that all possible users have equal access to the infrastructure (European Commission, 2002, pp. 1-1).

Nonetheless, some airports are taking advantage of taxpayer's money to offer special agreements to the airlines in order to attract new services and promote their growth. Normally, they expect to compensate their support, by promoting regional development, especially in the form of greater employment and tourism attraction. One of the most well-known cases was already mentioned for the Brussels South Charleroi Airport in Belgium, in which the Walloon Regional Government, owner of the airport, offered a support worth well over 3 million Euros to Ryanair in order to open new routes (Morrell, 2003, p. 9).

In a broader sense, such kind of aid does not have to come from the state, or at least not in a direct form. Some airports may benefit from funds coming from other sources, such as tourism authorities interested to promote a particular region. For instance, Porto Airport had in place an incentive scheme to support new routes which was sponsored by the local tourism promoter (ANA, 2007a, p. 75). The plan has been extended to most of the Portuguese airports, supported by Turismo de Portugal, the official tourism promotion office in the Country.

Scope competition

As a final remark, there is another way in which airports can compete that is not commonly referred in the literature, although Chapter 9 of Forsyth et al (2010) briefly refers to it as *destination competition*. However, the Marketing Plan for Faro's Algarve Airport, which is part of its master plan, outlines it this way: “Faro airport becomes, inherently, a competitor of all the airports that serve tourist destinations which compete with the Algarve” (ANA, 2007b, p. 102). For airports in which inbound traffic outweighs outbound (more people are coming to the airport than inhabitants of the catchment area going out) the attractiveness of similar regions in other locations represents, indeed, a key factor in competition. Passengers going for holidays to the Algarve region can easily choose another destination that offers beaches and sun, not even in Portugal or Spain. This kind of competition is particularly challenging to the airport, since its managers have little or null control over what the region has to offer, even if they can explore it in marketing terms.

Other modes

The review conducted so far is entirely focused on competition between different airports. This does not mean that other airports are the only competitors, however. Competition between air transport and other modes also has an impact on airports (Forsyth et al., 2010, p. 120). The expansion of high speed rail networks in Europe has proven an effective way of competition between surface and air transport. In France, for example, a 7% decline in domestic air traffic is noticeable between 2000 and 2007, mostly due to the growth of the TGV network (International Transport Forum, 2009, p. 20). In relation to airports, train stations are normally better located and provide a more efficient boarding process that increases passenger throughput and decreases wasted time. But again, since the aim of this chapter is to analyse only inter-airport competition, other modes are let aside for now.

Based on the discussion presented along this chapter, intended to provide a clearer perspective on how and why airports compete, the next section aims at proposing a scheme to synthesize the different types of competition identified, and the way they are related with each other and with the clients of the airport product.

4.4 Towards a competition framework for airports

Graham (2004) performs a competitive analysis for the airport industry based on the five forces framework developed by Porter (1979) . Porter’s framework considers the threats of new entrants and substitutes, the bargaining power of buyers and suppliers, and the rivalry within the industry, hence Graham (2004) analyses airport competition on these aspects. She concludes that the existence of more than one key customer for the airports, among other factors, hinder the analysis of competitive strategies under this framework.

Consequently, a perspective more focused on the clients and other particular aspects of the airport industry has been chosen to propose a framework to define airport competition. This framework may be viewed as one of the main contributions of our work. The literature referred so far usually focuses on few kinds of competition, or describes only in a shallow way how particular types of competition arise; hence our effort to put everything together and provide for a deeper analysis of the interactions between the different ways in which airports compete.

Figure 4.1 shows a schematic view classifying competition between airports in five general types. For each type, a key customer is also identified using the three groups defined previously as in Graham (2003, p. 183). This gives an insight on specific ways of competition according to the kind of client that is being attracted.

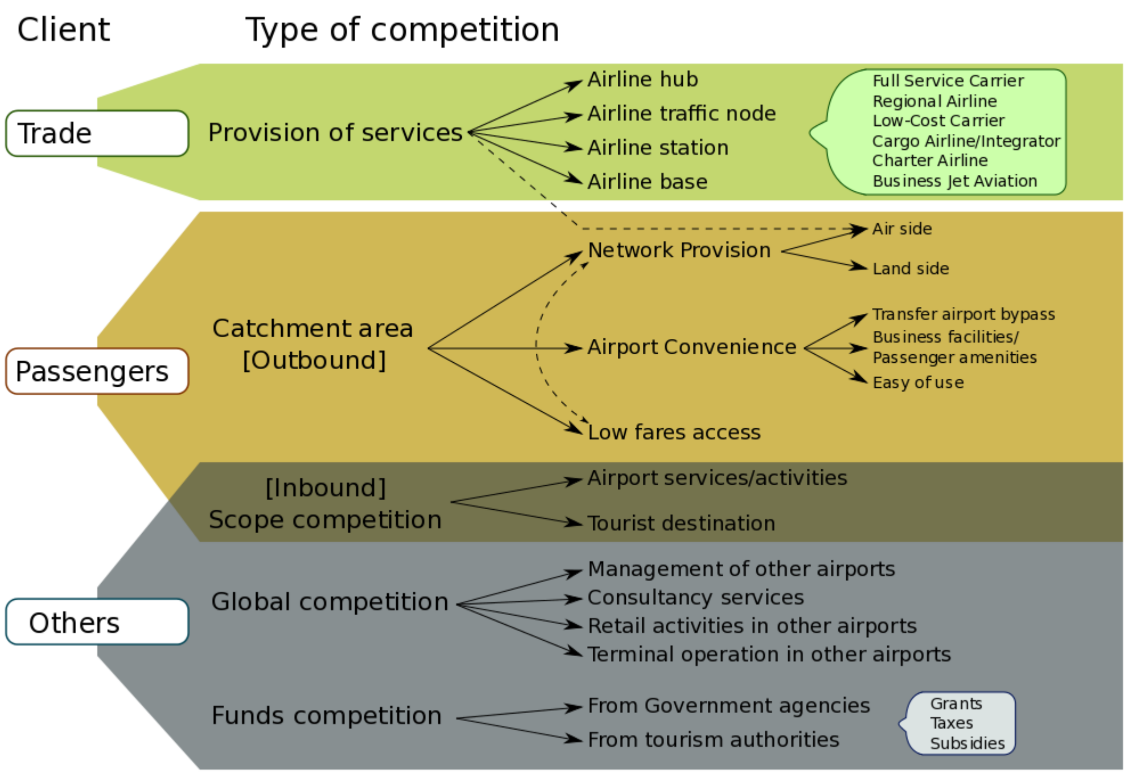

Figure 4.1 Conceptual framework for competition between airports.

As expected it is very hard to draw a line that clearly separates competition for one client type from the other. This is reflected in the scheme proposed in Figure 4.1 by overlapping areas. Additionally, the diverse types of competition can be subdivided into more specific ways in which airports compete according to their own characteristics. This means that not necessarily all airports are able to compete in each and every way, provided the diversity of the customers. Thus the requirements to attract one client may be opposite to those to attract another. For example, not many airports can compete to become a hub for a major Full-Service airline and, at the same time, a base for a Low-Cost carrier. In the first case, the airport may need to deploy fancier facilities with a high level of service; while in the second case, the airline may prefer inexpensive facilities and accept a lower level of service. Only if the airport has enough space, capacity and a well oriented planning process will probably be able to simultaneously satisfy both.

An explanation on each of the components of this framework is given in the next section. Examples are presented to show the existence of the proposed types of competition.

4.4.1 Provision of services

For the sake of simplicity, the different clients in the group of *trade* (see Table 4.1) can be basically seen as airlines, whether they are in charge of passengers, cargo or both. In fact, tour operators and general aviation clients can also be included in the group of airlines since their main interest, in what concerns the airport, is to operate aircraft using the infrastructure of the airport. In this way, airports compete with each other by providing different services to the airlines so they can *be* at the airport and offer their own services to passengers or other clients.

Airline strategies

It is important to notice that airlines can be established at a given airport with different kinds of operations. To distinguish those operations Burghouwt (2007) classifies the role of the airports within the airline network in three categories. Thus airports compete with each other to provide an airline hub, a traffic node or an airline station.

As Burghouwt (2007, p. 14) states "at a hub an airline concentrates its flights not only spatially, but also temporally" by the means of a wave-system structure. Thus a hub exists only when indirect connectivity comes from a conscious coordination of the incoming and outgoing schedules. A traffic node is a central airport in the airline network that concentrates a large share of the airline's traffic. It provides for some indirect connectivity, even though the airline does not have a wave-system structure in place. Finally, an airline station is an airport "from which only air passenger flows can originate and into which only flows that are destined for that [airport] can enter", this definition can of course be extended to cargo. The airline station can be seen as a feeder for a traffic node, a spoke for a hub or an origin/destination in a point-to-point route.

Beside those three categories, one additional has been included in order to make an explicit reference to the fact that an airline can base one or more airplanes at the airport. The concept of airline base gains relevance for the LCCs, since most of them do not operate coordinated schedules and can have a significant number of flights from/to an airport without basing any aircraft, as Ryanair did in Faro before it based 6 planes in March 2010 (Ryanair, 2009a). Although Burghouwt (2007) considers LCCs in his definition of airline stations, within the context of this dissertation an airline base is different in the sense that it brings the airport the opportunity to have larger revenues that can be translated into profits, the ultimate reason to compete.

An airline base, however, is not restricted to LCCs. Regardless of its business model, any airline can decide to position one or several airplanes at a given airport to gain economical benefits from aircraft maintenance and crew recruitment, for example. Moreover, this option is not restricted to passenger airlines, since freight forwarders and cargo integrators are also becoming increasingly important in total air traffic (European Commission, 2003).

Services to airlines in relation to services to passengers

The provision of services to airlines is inextricably intertwined with the provision of an aviation network to passengers. To show it, there is a dashed arrow between the competition for the provision of services and the competition for the air side network provision in Figure 4.1. Therefore it is very important for the airport to provide services to airlines, so that the air companies are able to offer the destinations in which passengers may be interested. In other words, attracting airlines means attracting passengers who have now the opportunity to fly where they want to go ultimately.

Although one may think that airlines are naturally attracted by the demand in the catchment area, it is clear that airports also have the power to attract airlines to serve a latent or previously nonexistence demand. Such emerging markets have been in the core of the success for LCCs. Low-cost airlines are interested in establishing bases to increase their dominance or importance in a given airport. This allows them to offer lower fares to price-sensitive passengers, increasing their propensity to fly (Barbot, 2006; Malighetti, Paleari, & Redondi, 2009).

This relationship between the air services provided by the airlines attracted by the airports and the services offered to the new passengers is expressed in the "virtuous circle" presented by the Civil Aviation Authority (2005) and shown in Figure 4.2. According to Graham and Shaw (2008, p. 1445) airports are now "actively seeking additional carriers so that both aeronautical but especially non-aeronautical revenue growth allow the cycle to continue". As seen in the figure, LCCs play an important role when they are attracted to previously "unknown" airports that gain visibility afterwards.

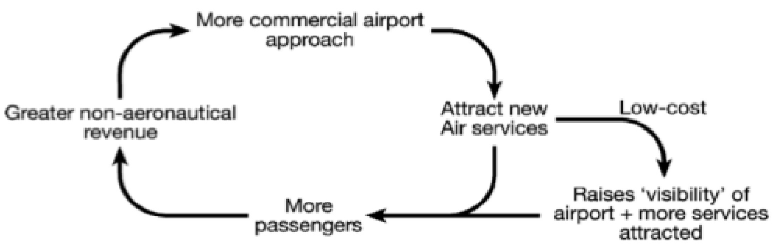

Figure 4.2 CAA "virtuous circle". Source: Graham and Shaw (2008, p. 1445).

Airport characteristics

The idea of dividing the competition for provision of services to airlines in the four categories already described (hub, traffic node, station and base) is related with the different characteristics that the airport has to offer in order to attract an airline to operate one model or the other. For example, peak capacity is a crucial factor for a hub, but it is less important for a traffic node or a base. In the same way, the attractiveness of the catchment area, in terms of potential demand, is less important for an airline interested in having a pure transfer hub than for an airline station or a traffic node in which a high origin/destination market makes it possible to operate high frequencies. Airport fees and efficiency to guarantee quick turnaround times are primordial for LCCs when deciding where to establish a base; while FSCs may demand larger spaces and business lounges for a traffic node.

Summing up, it is up to the airport operator to clearly identify the particular needs of their *trade* customers and respond to them accordingly with the right infrastructure and services. Burghouwt (2007, p. 31) synthesises the more relevant aspects that airlines look for when establishing their operations at the airports, while Barret (2004, p. 37) reviews the selection criteria for Low-cost airlines, as seen in Table 4.2.

Although the competition for the provision of services from airlines was somehow discussed as a part of the previous section, more examples on the specific ways presented here are given next.

For an airline hub it is clear that Munich Airport was able to attract Lufthansa to form its second major hub at the expense of an underused Terminal 2 in Frankfurt Airport (R. De Neufville, 2008, p. 55).

For an airline traffic node, TAP handles most of its operations at Lisbon, but it could also do it in Porto or in the new Lisbon airport, when built, or even its services could be reduced if the airline is sold to another carrier operating large hubs elsewhere.

For an airline station Morrell (2003, p. 4) presents a hypothetical example in which an Asian airline desires to introduce a new service to Europe. Multiple airports then compete to show themselves as a more attractive destination, either in terms of its local market, connection opportunities with other airlines in the same alliance or both.

For an airline base EasyJet provides the example when deciding to open its twentieth base in Lisbon Airport. According to the airline, it "selected Lisbon over a number of other European cities because of its market potential" (EasyJet, 2010), being this just one of many reasons carriers may state to position their aircraft in an airport.

4.4.2 Catchment area

The catchment area of an airport refers to the geographical location of most of the existing or potential demand. I.e., the area where the airport is able to catch passengers to fly using the services provided by the airlines already attracted. By its name and definition, the catchment area is mainly associated to outbound traffic, namely people who use the airport as the origin for their air trips.

	Airline station	*Traffic node*	*Hub*	*Low-cost*
Airport	• Safety of the airport and destination • Efficiency on ground (turnaround times), baggage and terminal handling • Airport charges and other airport related costs (visit costs)	• Capacity • Airport amenities according to airport size • Efficient airport layout that minimizes taxi times • Opportunities for future growth • Opportunities for aircraft maintenance	• Peak-hour capacity of airport • Transfer facilities minimizing minimum connecting time • Facilities for connecting passengers • Gate-positions hub carrier • Opportunities for operating dedicated airline terminal(s)	• Low or no airport charges • Quick (25 minutes) turnaround times • Single storey airport terminals • Quick check-in • Good catering and shopping at the airport • Good facilities for ground transport • No executive-business class lounges[8]
Airport context	• Size of solid origin-destination market, which is determined by: ○ Population size and growth ○ Personal disposable income in catchment area ○ Level and nature of economic activity in catchment area ○ Social environment (length of holidays, attitudes to travel) ○ Level of tourist attraction ○ Historical/cultural links ○ Earlier population movements ○ Migrant labour flows • Travel restrictions • Land side accessibility in relation to airport size • Reliability of runway system in various weather conditions • Flying (sector) time to hub(s) (in case of a spoke) • Competitive position: degree of market dominance that is likely to be achieved in direct and onward markets • Level of competition of other transport modes	• Degree of market dominance that is likely to be achieved by the hub-carrier in both direct and to a lesser extent indirect markets • Location with respect to global time zones and night curfews	• Geographical location of hub with respect to the major traffic flows • Existence of commuter feeder	

Table 4.2 Key drivers for airport selection in airline networks. Source: (Barrett, 2004, p. 37; Guillaume Burghouwt, 2007, p. 31).

The catchment area sometimes represents the population living in the area surrounding the airport. The absolute number of people is not the only important aspect, though. The economical characteristics of the population, such as the Gross Domestic Product that may indicate the existence of disposable income to spend for air travelling, or the presence of

[8] As a general rule, not all the LCCs adopt the same strategies. EasyJet (N.d.) for example offers airport lounges in selected airports for a premium fee.

international companies that favour the existence of business passengers are just some examples of other key aspects.

As already discussed in previous sections, the catchment area is a dynamic concept varying according to the type of services offered by the airport and the particular characteristics of the passengers. Thus the specific ways in which airports compete for demand within their catchment area reflect this dynamic aspect.

Network provision

Firstly, airports compete for the network provision in two ways: a) the aviation network, i.e. the air side network provided to passengers; and b) the connectivity with surface transport networks, or the land side network provision. In the air side it is obvious that airports compete to offer the most desired destinations. Porto airport compete with its Spanish neighbour at Vigo because it is able to offer more direct connections (destinations) or higher frequencies to the same destinations offered by Vigo. Conversely, the aerodromes in Bragança or Vila Real are not yet able to strongly compete with Porto because they lack most of the air services that passengers can be interested in. The same happens with the airport in Beja for Lisbon or Faro (Algarve).

In the land side, competition occurs because, as mentioned before, air transport is only one leg of a longer trip that always includes a surface part. Therefore, the connection with the surface transport network makes an airport more easily accessible from longer distances, widening its catchment area. Porto airport can compete with Vigo not only because of its destinations, but also because it has a rapid motorway connection with Galicia, coach companies with services to and from the same region in Spain and also a metro (light rail) station that connects directly to the main train station at Porto which, in turn, also offers international trains to Vigo. From the point of view of passengers, the cost of this land side access is, of course, very important in the choice of an airport, since it plays a role in keeping the general cost of the journey at an affordable level. In this sense, it would be interesting to analyse how the introduction of tolls in the motorways that link the North of Portugal with Galicia affect the competitive position of Porto airport in relation with its counterparts in Spain, such as Vigo, Santiago de Compostela and La Coruña. This question is, however, outside the scope of this dissertation.

Low fares

Secondly, and in direct relation with the network provision in both the air and the land side, there is the competition for passengers willing to have access to low fares in their flight tickets. Airports that attract LCCs gain a competitive advantage in the sense that these airlines can offer remarkably low prices for their flights, especially if booked in advance (Malighetti et al., 2009), expanding the catchment area by attracting price-conscious passengers. Porto airport, for instance, can compete with Lisbon airport by catching people willing to travel with the cheap fares of Ryanair, since the company does not fly to Lisbon. Again, this is reinforced if the airport, or the airline itself, is able to complement the low fares with easy and affordable surface transport. Many low-cost airlines also sell bus or train transfers to/from the main cities served by the airports they operate in.

Airport convenience

Thirdly, airports sharing similar catchment areas can compete for outbound traffic by providing a more convenient service to some passengers. As stated by de Neufville (2008, p. 40) airports served by LCCs offer the opportunity to bypass bigger hubs and avoid transfers, delivering a higher quality service, in terms of travel time. Additionally, the airport can offer differentiated products that are more convenient for business travellers for example, or it can be viewed as an easier alternative for passengers wishing to stay away from the confusion caused by very large airports. These aspects are obviously more under the control of the airport operator.

4.4.3 Scope competition

Tourism attraction

The so-called scope competition refers to the possibility that airports have to attract passengers or other users solely by the characteristics of the airport itself and its surrounding environment. To some extent, scope competition occurs in airports with a large share of inbound traffic in the total throughput. That is, the airport is serving mainly as a destination (Forsyth et al., 2010, p. 123). Normally these airports are located in or nearby tourist destinations.

Faro's Algarve airport is a perfect example of this case. Crowds of tourists, mainly from the UK, Germany and the Netherlands, fill the airport during summer, looking for some holidays in the Algarve region, and then leave. Other locations offering sun, beach and golf courses can indeed compete with the Algarve for those tourists. In fact, competition can even come from any other tourist destination, as tourists may change their mind from one year to the next. Consequently, the airports located at those other destinations compete with Faro to receive the holidaymakers. As a matter of fact, Faro's marketing plan establishes the need to link the name of "Algarve" to the airport brand because it is the demand for the touristic attractions there that drives the demand for the airport (ANA, 2007b, p. 105).

The scope competition framed by touristic destinations suggests that airports should have a close relationship with either private or governmental authorities in charge of promoting the tourism for their regions. LCCs are also playing an important role in this respect, since they promote their destinations for tourism and normally offer free tourist guides on their websites.

Airport services

Another specific way of competition regarding the scope of the airport relates to complementary services or supplementary activities that they can offer to be more attractive, again to passengers or other customers (such as local inhabitants, for example). Those services and activities can go from hotels and convention centres in a more conventional point of view (Forsyth et al., 2010, p. 123), to concerts, sport events and airport tours (as the example of Vancouver airport) in a broader perspective.

As an example, Figure 4.3 shows a portion of the Munich Airport Centre (MAC) at Munich Airport (MUC), a special area that serves as a connection between terminals 1 and 2. It also serves as a field for expositions and sport or cultural events; it hosts the airport's own «Biergarten» where beer brewed only at the airport is available; it includes a convention and a medical centre too. MAC is part of other strategies of the airport to attract visitors and entertain passengers (Munich Airport, n.d.).

Figure 4.3 - Munich Airport Center at MUC connects terminals 1 and 2.

4.4.4 Global competition

The airport industry is becoming increasingly composed by international groups working across the world. That means there is a well-established process of globalization for the airport industry, increased substantially with airport privatisation, but not limited to private companies (Richard De Neufville & Odoni, 2003, p. 18; A. Graham, 2003, p. 37). This expansion has led airports also to compete for the services they are offering at a global scale. Figure 4.1 highlights four forms in which this competition can be expressed. The global airport companies can compete in a bid to buy or earn a contract for the management of other airports; they can compete with their consultancy services in areas such as engineering, economics or construction; they can operate retail facilities in other airports and, finally, they can compete by operating a separate terminal in other airport.

Graham (2003) provides a number of examples in which airport companies, such as BAA, Aéroports de Paris, Aer Rianta, Schiphol Group, Fraport and many others have involvements or interest in airports around the globe. The sample is not restricted to companies previously related with the airport businesses. In this way, many property developers, construction companies, financial investors and other transport companies also have interests and large shares in airports. Not surprisingly, airlines have also shown interest in airport operations, such as EasyJet unsuccessfully trying to buy London/Luton airport, Ryanair proposing the construction of its own low-cost passenger building at Dublin, or Lufthansa successfully partnering with Munich Airport to build terminal 2. In Australia and in the United States, however, the relationship between airlines and airports has been traditionally more direct, since the carriers can lease terminals from the airports.

4.4.5 Competition for funding

Public expenditure

The last type of competition identified in this work is related to the attraction of funds to develop airport expansions or upgrades leading airports to a more competitive position. In a general way, the funds can be in the form of grants with special conditions, such as very low interest rates, tax reductions or subsidies, not necessarily in the form of state-aid but in some kind of payment made to the airport. These funds can come from governmental or private institutions. As an example, Figure 4.1 shows government agencies and tourism authorities. Both can be interested in providing funds to the airport as a mean to impulse economic development, tourism and employment in the airport's surrounding area. Additionally, some governments may be keen to invest in regional airports in order to reduce the pressure of congestion or environmental constraints in major airports (Davison, Ryley, & Snelgrove, 2010, p. 179).

In a paper by Bel and Fageda (2009, p. 5), they show evidence of the Spanish airports competing to attract public expenditure. According to their analysis, between 1994 and 2003 Madrid received 60% of the total investments made by AENA[9], at the expense of the other 46 airports managed by the Spanish authority. Curiously, their purpose was to demonstrate how common ownership has prevented competition in Spain for the sake of a non-existent solidarity (cross-subsidisation across airports).

Airline support

Funds can also be used to enhance the competitiveness of an airport, by preparing it to compete in any of the other forms of competition already described, even if the money is not directed to the airports but to the airlines. For instance, in Forsyth et al. (2010, p. 20) there is a summary of airports in which Ryanair has received money as an incentive to increase the number of routes the airline operates, such as Ostend and Charleroi in Belgium, Strasbourg in France, Stockholm/Skavsta in Sweden, Girona in Spain, Birmingham and London/Stansted in the UK and Aarhus in Denmark. Even though the results have been different in each case, it is

[9] Aeropuertos Españoles y Navegación Aérea (AENA) is the Spanish state-owned company in charge of managing most of all the commercial airports in the country.

clear that this support for route development expands the aviation network that the airports are able to offer to their customers.

In a similar way, ANA Aeroportos de Portugal, sponsored by the Portuguese tourism agency – Turismo de Portugal, has implemented an incentive plan to promote the Country as a tourist destination by favouring inbound traffic in the Portuguese airports through new routes or higher frequencies. Currently, the plan is limited to Lisbon, Porto, Faro, Azores and Madeira airports (ANA, 2010a). However, those airports with interesting slots available (e.g. during morning and evening peaks) and a more efficient operation are more likely to have a higher share of the financial support, since their marginal costs for new routes is lower than in congested airports.

Even though the funds of the incentive plan go straight to the airlines, there is no doubt that the airports attracting those airlines would enjoy a more competitive position because they would be able to offer a wider network to passengers. Faro and Porto airports, serving as an LCC base, seem to have and advantage, given that low-cost airlines can more easily start new routes between their many bases.

Although this form of airline sponsoring at particular airports has been strongly criticised, mainly by legacy airlines (Lufthansa, n.d.), de Neufville (2008, p. 40) presents a counter-argument by saying that "these deals (...) follow the pattern of airport development that prevailed for most of the last century". Indeed, airports have benefited from access to large amounts of capital from national and local governments under very good conditions. That capital has normally been used to build highly expensive architectural monuments.

It is important to note that privatisation and commercialisation[10] of airports expand their opportunity to raise funds from their private owners or operators. In consequence, this is expected to "remove airports form a position where they compete for public expenditure" (Davison et al., 2010, p. 180). On the other hand, airports that are not privatised in the sense that local, regional or national forms of government maintain the ownership, but that have been delivered as a concession to private operators, are able to raise private funds more easily to gain competitiveness.

4.5 Competition and airport pricing

In the world of legacy airlines (FSCs), airport charges normally account for a very small proportion of air fares charged to passengers (European Commission, 2002, pp. 4-2). In a regulated market that prevented airline competition, a 'cost-plus' environment existed to guarantee airline success and, at the same time, generated a sort of inefficiencies along the business chain, such as extraordinary wages and working conditions for airline employees (R.

[10] A commercialised airport here refers to those transformed in commercial companies in which the state (in a local, regional or national form) is the only shareholder.

De Neufville, 2008, p. 39). In this context, differences in airport fees were not reflected in the airline's ticket prices.

Economic deregulation poses a completely different environment. Not only price competition between traditional airlines was now possible but LCCs appeared with a different model that provided for much lower costs per seat-kilometre that were passed on to the passengers. Dobruszkes (2006) presents a very detailed summary of the methods used by low-cost airlines to reduce its production costs. Labour costs account for over 30% of the difference between LCCs and FSCs costs (Franke, 2004, p. 17) in direct opposition of common practices for legacy carriers. This, in turn, forced FSCs to review their models. "As airlines faced bankruptcy and disappearance, employees confronted the choice of losing the airline and their jobs, or lowering their pay packages" as de Neufville (2008, p. 39) explains.

In this new context, airport charges gain relevance and prove that airports can be engaged in price competition. As an example Barret (2000, p. 17) describes the discount scheme for airport charges implemented by Aer Rianta in its airports at Dublin, Cork and Shannon during the 1990s. The Irish airports reduced charges consisted of:

- a discount for new routes and traffic growth, of up to 90%;
- a 25% discount on low-fare routes to Britain;
- a 50% winter landing charge discount;
- a £ 1.50 discount for use of a low-cost pier.

By the end of the discounted period, Ryanair had benefited from discounts of £23 million, and Aer Lingus £21 million. At the same time, traffic at Dublin Airport doubled between 1993 and 1998, clearly showing that reduced airport fees were passed on to the passengers and contributed to the competitiveness of the airport. Not only the increase in the number of passengers, but also the increase in the airport profits, can be associated to the discount scheme. However, this scheme also brought significant congestion problems to Dublin terminals and car parks.

Ryanair was seeking further discounts to promote new routes to mainland Europe and proposed to build its own terminal at Dublin Airport. But in another clear example of competition between airports, the airline got a better deal at London/Stansted and shifted its route development to there. To illustrate the influence of airport fees in competition Barret (2000, p. 25) declares that "in a competitive airport environment airport managers will have to engage in price negotiations with airlines rather than present a fixed set of charges on a take it or leave it basis".

Normally, airports offer reduced fees aiming to increase the number of passengers going through their facilities and providing larger non-aeronautical revenues, as shown in Figure 4.2. In this way, airports can expect a higher general profitability. However, as Francis et al. (2003, p. 272) suggest "if reduced aeronautical charges are to be offered then there is a need to ensure adequate retail facilities are in place to generate commercial revenue". In their analysis of two different airports offering discounts to LCCs one airport successfully recovered the reductions in aeronautical revenues with other services, while the other saw the airline flying away after six months when the airport managers wanted to renegotiate the agreement. For this second case, there were no retail stores available for passengers that had already gone trough security, and tourist were not spending money in the airport surroundings, but travelling further by land modes to an alternative destination. In such cases, airport fees are paramount for the business of airports.

Forsyth et al. (2010, chap. 6) argue that price competition through aeronautical charges is not always welfare enhancing (as competition is expected to be) and may lead to a sub-optimal allocation of traffic among the airports. When competition occurs between a major airport and a secondary one located nearby, and the major airport has spare capacity, the marginal cost of handling extra flights there may be minimal and lower than for the secondary airport. Consequently, the allocation of those new services to the secondary airport would result in higher overall costs and less general welfare.

Nevertheless, secondary airports are able to offer lower fees because of several reasons (Forsyth et al., 2010, p. 81). Particularly, major airports are required to cover their costs, including sunk costs for the provision of a very expensive infrastructure (especially runways and buildings) and this is reflected in their prices. On the other hand, secondary airports normally come from former military bases or underused facilities sold to local authorities or privates for a low nominal price, therefore capital costs have been written off and airport fees do not have to reflect high sunk costs.

Efficiency related reasons can also be raised. In this case, price competition from the smaller airport acts as an incentive for the major airport to improve efficiency. Especially since airports and airlines are still bearing burdens of a former regulated era that affect their price structures to support inefficient operations. Competition then helps by changing mindsets and pushing for new and more efficient methods.

Price competition through low airport fees may work so well that it may lead to significant congestion problems, as seen previously in the Dublin case. In the long run, the strategy may end up leading the airport towards a less competitive position, since congestion makes it less attractive to provide certain airline services (A. Graham, 2004, p. 5). Therefore airport marketing strategies must be closely linked to infrastructure planning in such a way that they both pursue the achievement of common goals.

As a final remark it is worth noting that regardless of the weight of airport charges in overall costs for the airlines, the carriers do obviously consider all costs incurred when operating at an airport to assess and make their choice. In this way, other elements such as fuel provision, baggage handling or catering also influence the airline decisions. Consequently, the level of *intra-airport* competition and whether external companies, the airlines or the own airports are engaged in those operations, are also relevant when analysing *inter-airport* competition.

4.6 Conclusion

This chapter reviewed the current trends in airport competition and presented different points of view from several authors. The conceptual framework to identify the diverse types of competition between airports developed here is used as the base to analyse the evidence of this phenomena in the evolution of the aviation network that is performed in the following chapter and, with more detail, in chapter 6.

As expressed at the beginning of this chapter competition between airports triggers a wide concern regarding how the industry should be regulated. Regulation comes about as a means to compensate for market failures but there is still a lack of understanding as to what extent regulation encourages efficiency. Regulators normally focus on price for airport charges. However, as seen throughout this chapter, other important issues arise such as the use of public expenditure to support airport operations.

Some of the references in the bibliography are suggested for further reading on the subject of airport competition and regulation. Especially the study of the European Commission (2002), part D of the book by Forsyth et al. (2010) and the papers by Bush (2010) and Kapur (1995).

5 Portugal's aviation network

This chapter presents the exploratory study we have performed to show the evolution of the aviation network provided by the three most important airports, in terms of passengers, in continental Portugal (Lisbon, Faro and Porto) over the period comprised between Summer 2001 and Summer 2010. The aviation network has been modelled using Gephi (Bastian et al., 2009), an open source software for the exploration and manipulation of networks. The data provided by ANA Aeroportos de Portugal was aggregated by IATA period[11]. Therefore an instance of the network was created for each of the periods (summer and winter), within the time span of the analysis.

5.1 Scope of the analysis

The data gathering process supporting the construction of the network model strongly depends upon the scope chosen for the exploratory study. Such scope can be expressed in terms of time and space. Regarding the spatial or geographical boundaries of our work, it was decided that keeping the analysis for continental Portugal would take advantage of existing knowledge of the local environment and might facilitate the collection of the required data. Consequently, the study is focused on the three major airports that provide regular commercial services in continental Portugal (this is, excluding the overseas regions of Madeira and Azores): Faro's Algarve Airport (IATA code FAO), Lisbon's Portela Airport (LIS) and Porto's Francisco Sá Carneiro Airport (OPO). The network is then constructed by linking these airports to the destinations offered by all the airlines operating during the time span.

In terms of the time scope the study is precisely focused on the period starting on March 31st, 2001 and ending on October 30th, 2010. Even though the data collected comprised a wider time series, from January 1st, 1992 to November 1st, 2010; data before January 1st, 2001 did not contain the same level of detail on a by route basis, hindering the model for a proper network system. Moreover, the IATA periods of Winter 2000 and Winter 2010 were not considered in the analysis because the data available for these periods did not show their entire duration, hindering comparability with the other periods.

The data set was kindly provided by the Documentation and Information Centre (*Centro de Serviços Partilhados/Informação e Documentação*, in Portuguese) of the airport operator – ANA Aeroportos de Portugal. The original data for the selected period contains information for

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[11] The International Air Transport Association (IATA) defines two periods for air transport related measures or activities: Summer and Winter. The Summer period starts on the last Saturday or Sunday of March, comprising approximately 7 months; while the Winter period starts on the last Saturday or Sunday of October, lasting more or less 5 months.

each of the three airports under analysis, referred by ANA as AFR (standing for *Aeroporto de Faro*) for Faro Airport, ALS (*Aeroporto de Lisboa*) for Lisbon Airport and ASC (*Aeroporto Sá Carneiro*) for Porto Airport. Such information records the following details:

- airline or aircraft operator (in case of a non-commercial airline);
- IATA period;
- number of aircraft movements (per airline - period - destination);
- number of passengers (per airline - period - destination);
- number of seats offered (per airline - period - destination);
- destination airport;
- type of movement (either a normal movement (MOV) or a technical scale (ESC) in which no passengers leave or board the plane).

The fields of destination airport and IATA period were the ones used for data aggregation. This way, a typical record for Lisbon Airport (ALS as in the original data) looks like the example in Table 5.1 in which S05 stands for Summer 2005.

Airline	*IATA period*	*Movements*	*Passengers*	*Seats offered*	*Destination airport*	*Type*
TAP Portugal	S05	651	92 537	112 241	London/Heathrow	MOV

Table 5.1 A typical record from the database. Source: ANA.

Initially, the database was entirely reviewed in order to correct typos and use standard values for the airlines and airport names. Since the original data included any kind of aircraft operator, and accounted for nearly 40 000 individual records, a preliminary filtering was performed to match the objectives of the study. Accordingly, the records matching the following criteria were removed:

- no passengers flown (0 in the passengers field);
- no seats offered (even with passengers flown);
- less than 19 seats offered (regardless of the passengers carried).

These criteria were selected in order to eliminate non-commercial flights, such as fire-fighters, ambulances, pilot academies, air taxis and general aviation mainly. The first two criteria attempt to account also for cargo flights, since the focus of the study is on passenger transport and there is no additional available information regarding cargo loads to use in the network analysis. The last criterion is intended to remove most of general aviation, including helicopters and recreational flights (like sky-diving, for instance). It was selected based on the capacity of a Beechcraft 1 900 type of aircraft, which was found as the smallest aeroplane used by regional carriers or private jet rental operators (according to the information about their fleets available on their web sites). Other operations such as flights from private companies, official state's air forces and other air services like mapping, topography or photography were also excluded, based on the aircraft operator information.

With a standardized and filtered form in place, for which 15 580 individual records remained[12], the database was expanded to include two new fields: Origin airport and type of carrier. The origin airport field is intended to facilitate automated data functions to handle the large amount of records when combining information from the three airports. The type of carrier, on the other hand, is used to classify and group data for the network analysis. Six types of carrier were used in the classification:

- FSC: Full-Service Carrier;
- LCC: Low-Cost Carrier;
- CGO: Cargo airline;
- REG: Regional airline;
- CHA: Charter airline;
- BJA: Business Jet Airline or private jet operator.

Several sources were used to identify the airlines so that they could be assigned to a particular type of carrier. The airline's membership in one of the following associations was a key criterion for identification: Association of European Airlines (AEA), European Low Fares Airline Association (ELFA) and European Regions Airline Association (ERAA)[13]. Additionally, the airlines own website and other references, such as Dobruszkes (2006), were also used for the classification.

Major cargo airlines were not entirely removed from the database following the first filtering process, so they were considered individually. Additionally, especial cases were taken into account, such as Europe Airpost that operates a fleet of Boeing 737-300 Quick Change aircraft. These planes can quickly change their configuration by entirely removing the seats, enabling the airline to carry on passengers during the day and cargo during the night. Consequently, for the passenger flights the charter type was chosen in cases like this.

As for the regional airlines, there is a huge impact in the database since the major regional Portuguese carrier, PGA – Portugália, was acquired by TAP Portugal by the end of 2006 (Publico, 2006). As a consequence, the records for the airline changed starting in the Summer 2007 period, even though many routes are still operating with PGA livery and fleet but with the regular services from TAP.

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[12] It is important to highlight that many records (rows) in the original data corresponded to blank spaces between the airlines, subtotals and minor airfields destinations for non-commercial flights (like Cascais or Sintra for helicopters or flight academies). That explains the big difference between the number of records before and after the filtering (from ~ 40 000 to ~ 15 000).

[13] See http://www.aea.be/about/memberairlines/index.html, http://www.elfaa.com/members.htm and https://ei.eraa.org/ei/cm.esp?id=26&eiscript=06IMDS8DR&cd=36859&pageid=MEMDIR&type=MAIR.

The main criterion to differentiate between charter and business jet airlines was their fleet's composition, with a clear focus on luxury aircraft layouts for the latter. However, given the small proportion of BJA carriers within the total population, those that showed a significant amount of regular services were subsequently included as charter and the rest were filtered.

As explained before, the Winter 2000 and Winter 2010 periods were also removed for the sake of comparability. In the end, the working database includes 13 801 individual records for the 19 IATA periods between Summer 2001 and Summer 2010 with information on the operations of 442 different airlines classified as Full-Service Carriers (FSC), Low-Cost Carriers (LCC), Regional Airlines (REG) or Charter Airlines (CHA). In total, the filtered database accounts for 98,5 % of the passengers, 97,7 % of the seats availability and 93,5 % of the aircraft movements included in the original database from ANA. This difference is mostly explained by the removal of three months of operations in the two periods not taken into account; except for the aircraft movements, in which the small aeroplanes used for non-commercial activities account for several individual operations. Information on the number of aircraft movements is not used for the network analysis, though. Demand and supply are expressed always in terms of passengers and seats respectively.

5.2 The airports

This section provides a brief description of the three airports under analysis and the relevant developments they have had during the studied period. The information provided here is mostly based on the airports Master or Expansion Plans (ANA, 2006, 2007a, 2007b) and the ANA RouteLAB website[14].

Figure 5.1 Location of the three airports in Portugal.

[14] See http://routedevelopment.ana.pt/DRD/ for more information.

5.2.1 Faro airport – FAO

Faro Airport is located in the coastline in the South of Portugal (see Figure 5.1), 4 km West of the city centre of Faro, the capital of the Algarve region. It is identified by the IATA code of FAO and ICAO code of LPFR, while ANA Aeroportos de Portugal, the current airport operator, refers to it as AFR, Faro Airport or Algarve Airport in its documents.

The airport started commercial operations in July 1965 with two runways and 5 aircraft stands. The second runway was abandoned due to prevailing winds. The airport overcame major expansions in 1976 and 1989 when a new terminal building was completed. This building was further expanded and refurbished in 2001. This was the only major development in the airport that is relevant during the period of analysis.

Currently the airport has a single runway (10/28) with 2 490 m length in asphalt surface and a full-length parallel taxiway. The declared capacity in the airside is estimated at 22 aircraft movements (arrivals and departures) per hour or 8 movements in a peak 15 minutes period (5 movements when considering only arrivals or only departures). The three aprons account for 22 aircraft stands, 6 provided with air-bridges and 16 being remote stands. The passenger building has 68 500 m^2 in total, with 60 check-in desks, 36 boarding gates, 8 emigration control positions and 5 belts for baggage claim. The nominal capacity amounts to 6 million passengers per year or maximum 2 400 passengers per hour (either arrivals or departures) and the baggage system is able to handle up to 4 500 pieces of baggage an hour.

Figure 5.2 A view over the apron and terminal building at FAO. Source: http://en.wikipedia.org/wiki/File:FaroAPoverview.jpg by BabyNuke, cc-by-sa.

Although the airport is not subject to any environmental restriction or curfew to operate during the 24 hours, it actually operates only from 06:00 to 24:00. It is worth noting, however, that Faro airport is almost entirely surrounded by the Natural Reserve of Ria Formosa, which poses a strong constraint for future expansions.

The airport is connected to surface transport networks only by a single arterial road (N125-10) with four lanes, 2 per direction. This road connects the airport to the N125 highway that goes to Faro centre and to the A22 motorway that links to other destinations in the Algarve. Additionally, the same road N125-10 gives access to the beaches South of the airport. Therefore, it is often congested during Summer time.

One route of urban bus service links the airport with the city centre. Additionally, the airport leases 33 000 m^2 of its property, adjacent to the passengers building, to eight different car rental companies for car service and storage. These facilities play an important role, since car renting provides easy and affordable transportation, especially for foreign tourists. Four public parking lots are also available and two additional parking facilities are dedicated to coaches and mini-buses.

Faro Airport defines its catchment area in terms of travel time by private car. In this sense, the airport counts 500 000 inhabitants living at up to 60 minutes from it, in an area that covers part of the Algarve region in Portugal and Huelva in Spain. Indeed, the airport advertises itself as the gateway to both regions.

Regardless of this definition, FAO is a typical inbound leisure airport given that a significant proportion of its passengers come to visit the Algarve region (93% according to ANA). Since the main tourist product of the Algarve is traditionally sun and beach, the airport reflects this with a particularly high seasonality. As an example, in 2005, 80% of the traffic was registered during the IATA period of Summer (between April and October) with almost half of these passengers traveling between July and September.

The high seasonality puts a big pressure on the airport operator, since it has to provide enough infrastructure to cope with high Summer peaks, but the same facilities are mostly underused in the Winter season. Within a given Summer day high hourly peaks can also be observed since airlines (especially charter operators) organize their schedules in such a way that they take the passengers leaving the region in the same planes they use to bring new tourists. That is the reason why the most congested hour in a year is often over the declared capacity of 22 movements per hour (e.g. 24 for 2005 and 27 for 2007). This means that such peak hours are likely to have occurred with a particular mix of aircraft using visual flight rules procedures.

The marketing plan for FAO established the need of attracting all-year round services to decrease the pressure for peak demand and favour outbound traffic. Accordingly, Ryanair (2009a) based 6 aircraft in March 2010 at the airport, being the first airline with a regular operating base in FAO.

5.2.2 Lisbon airport – LIS

Lisbon Airport is located North of the Portuguese capital, 7 km away from the city downtown. With the city expansion throughout the last decades, the airport is now completely surrounded by urban development. It is identified by the IATA code LIS and ICAO code LPPT, named Lisbon Portela or Lisbon Portela de Sacavém for the parish in which it is located; it is also referred as ALS by ANA Aeroportos de Portugal.

The Airport was opened in October 1942. It is the largest airport in Portugal in terms of passengers, often accounting for more than the traffic of OPO and FAO together. Given the historical ties with former Portuguese colonies, Lisbon sees itself as a main hub to connect Europe with Brazil and Africa. The headquarters of ANA Aeroportos de Portugal, the operator of Lisbon and the other airports in this study, are located at this airport.

Lisbon is the home base and operation centre of the Portuguese flag carrier, TAP Portugal. It is (or has been) also a main traffic node for other Portuguese airlines, such as SATA International, PGA – Portugália, Air Luxor or White Airlines. Starting in 2011 EasyJet is to operate Lisbon as yet another one of its bases (EasyJet, 2010).

Currently the airport has two runways with 3 805 m (runway 03/21) and 2 304 m (17/35) length respectively, with runway 35 being used alternatively as a taxiway. The airside infrastructure provides a declared capacity of up to 37 movements (arrivals + departures) per hour with a maximum of 26 arrivals or departures in 60 minutes. For a peak period of 15 minutes capacity stands for maximum 12 mixed movements or 10 arrivals or departures.

During the period of analysis LIS engaged in a € 350 million expansion program to increase its overall capacity from 10 million passengers per year to around 15 to 17 million. The investments attempt to increment the airside capacity to 40 movements per hour, the apron's stand positions from 46/51 to 57/64 (depending on the use of dual parking positions) and the boarding gates from 26 to 47. The most relevant developments of the expansion plan are:

- the building of a new "Terminal 2" and its corresponding aprons (see Figure 5.3);
- the expansion and refurbishment of the main "Terminal 1" by building a South and a North pier.

Figure 5.3 Render of Lisbon's Terminal 2 and adjacent aprons. Source: ANA (2006, p. 13).

The expansion plan is intended as a partial solution to cope with an ever increasing demand meanwhile the new Lisbon airport is built. This new airport is expected to start operating by 2017 (according to the current plans). This is, of course, under the assumption that

Lisbon/Portela would be abandoned when the new airport becomes available. Closing an airport conveniently located near a city centre has proven a very difficult task, however (A. Graham, 2003, p. 182).

Terminal 2 at LIS was opened on August the 1st, 2007, and operates only for departures (it does not have a luggage pick-up area) of domestic and Schengen flights, but also for charter and low-cost airlines and passengers transferring to domestic flights. As a matter of fact, Terminal 2 can be considered as a low-cost facility for some of its characteristics, such as a single storey layout and walking access to the aircraft.

The North pier extension of Terminal 1 has been in place since December 2009, including 10 boarding gates with air-bridges. The expansion of the South pier was planned to be finished by the end of 2010 with other 3 new gates to access the planes trough air-bridges. The effects of this last expansion are therefore not measurable in the analysis period. Table 5.2 summarizes the major developments already described. Other investments are related to the expansion of the baggage handling areas in Terminal 1, a new bus gate also in Terminal 1, improvements in the taxiway system, a new multi-functional apron and new facilities for cargo and freight integrators.

Date	*Development*	*IATA Period*
August 2007	Terminal 2 opening	Summer 2007
December 2009	Terminal 1 North pier opening	Winter 2009
By the end of 2010	Terminal 1 South pier expansion	Winter 2010

Table 5.2 Most relevant expansions in Lisbon Airport during the analysis period.

As of 2010, the airport offers 105 check-in desks in its Terminal 1 and 22 more in Terminal 2, 38 boarding gates in T1 and 12 (only Schengen) in T2. It has 20 security control positions for departures in T1 and 10 in T2, 17 and 14 emigration passport control positions in T1 and T2 respectively – Including automated border control system – and 21 passport control positions for arrivals in T1 (including automated positions). The baggage system can handle 4 300 bags/hour in T1 and 1 200 bags/hour in T2, both for departures; for arrivals, the airport has 7 belts in Terminal 1 with a capacity of 3 500 bags/hour.

Lisbon Airport enjoys a convenient location (for travellers, perhaps not so for local inhabitants) inside the city, something uncommon in major European capitals. Thanks to that, it has several connections with surface transport by regular urban – Including especial airport shuttles – and inter-urban buses; the airport is linked to many local roads and to the 2ª Circular motorway that goes around Lisbon and connects with the main North-South motorways to access other regions.

An extension of the metro (Lisbon's underground) red line to link the airport is under construction (Metropolitano de Lisboa, n.d.), expected to offer a 15 minutes journey to the city centre. In fact, part of the expansion plan for the airport already mentioned included the access to the underground metro station in Terminal 1. The metro will also provide a connection between the airport and *Gare do Oriente*, an intermodal station that offers national and international trains and coaches. Additionally, there is an airport bus connecting Terminal 2 with the departures curbside in Terminal 1.

The airport offers four different parking lots with free shuttle services from those lots located farther away. Valet parking is also available and a differentiated tariff is in place for the three airports (FAO, LIS and OPO). Parking on-line booking is available in the airports operator website. Terminal 2 does not have a dedicated parking area nor taxi bays, since it is intended only for departures.

Lisbon Airport has a rather wide definition for its catchment area. As in Faro, LIS uses travel time distance from the airport by private car to delimit an area in which the airport is accessible. LIS calls this its *outer* catchment area, which accounts for 5 million people living within 2 hours driving. Under this definition, the Lisbon catchment area overlaps those at Faro and Porto airports. Given its area of influence, the airport is used for both, inbound and outbound traffic. It serves the Lisbon area and Portugal in general as a tourist destination. It also provides for direct connectivity with major airports in Europe, North America, Brazil, Africa and few in Asia.

LIS operates 24 hours a day, but given its location within the city it has environmental restrictions for operations during the night. No more than 91 aircraft movements weekly or 14 daily are allowed in night hours.

5.2.3 Porto airport – OPO

Porto Airport is located 11 km Northwest of Porto's city centre in a place known as Pedras Rubras between Maia, Matosinhos and Vila do Conde municipalities. It is identified by the IATA code OPO and ICAO code LPPR. It is named after former Portuguese Prime Minister Francisco de Sá Carneiro, who died in an air accident when heading towards the airport, but it is sometimes referred as Aeroporto de Pedras Rubras and identified internally by ANA Aeroportos de Portugal as ASC and frequently called Porto Airport.

Porto airport was opened for commercial aviation in December 1945, shortly after Lisbon's Portela Airport and two decades before Faro. Nevertheless, over most of its existence Porto airport has been, and still remains, the third busiest airport in Portugal, in terms of passengers, precisely after Lisbon and Faro. However, over time the gap between Faro and Porto airport in traffic figures has been reducing in a systematic way. In 2010 the number of passengers in OPO was just 1,2% below the total in FAO. In fact, Porto shows the highest growth figures from the three airports in the period analysed. Traffic at the airport has almost doubled between 2000 and 2009 (INAC, 2010).

Such steady growth has been propelled by the entire renovation of the airport, specifically regarding its passenger building. At the beginning of the analysis period, a development plan for the airport, known as ASC2000, was in place. This plan was divided in three phases according to the capacity goal of each one. The first, already completed, intended to increase capacity up to 6 million passengers per year; the second, named "master phase", includes mainly airside improvements in the runway - taxiway system and air traffic control to increase capacity up to 11 million pax/year; while the "last phase" is aimed to achieve a capacity of 12 to 15 million pax/year by further expansion in the terminal area and aprons.

The brand new passenger building for OPO opened on October 18, 2005; followed by the opening of the "Northern bus-gates" which are, in fact, not being used as bus-gates since this part of the building is used by LCCs (namely Ryanair) to board passengers by walking to the plane. The terminal was built to deliver a capacity that has been significantly above the demand. As a study made by IATA for the airport master plan (ANA, 2007a, p. 126) says "It is evident (...) that the passenger terminal at [OPO] has been designed with substantial future capacity expansion in mind. Selective elements of the equipment installation, including check-in desks, outbound security and baggage reclaim carousels, have only been provided at 50% of the maximum system configuration afforded by the respective areas."

Thanks to that, the level of service delivered by the airport is very high. As a consequence, the airport has been consistently in the top European positions of the Airport Service Quality Survey made by Airports Council International. In 2007 OPO was awarded the best European airport in the Service Quality awards and it achieved the third place in the 2009 edition (ACI, 2008, 2010).

Figure 5.4 Underused check-in desks in OPO's passenger building.

Table 5.3 shows the most relevant developments at OPO during the analysis period, including the establishment of the first Ryanair base in Portugal by July 2009. Although not shown in the table, Porto airport has been actively expanding cargo facilities, both by developing a logistic centre in the West side of the runway, and by catching cargo traffic from Galicia in Spain.

Date	*Development*	*IATA Period*
October 2005	New passenger building opening	Summer 2005
December 2005	Northern “bus-gate” opening	Winter 2005
May 2006	Metro station opening	Summer 2006
July 2009	Ryanair base 2 aircraft at OPO (increased to 4 in 2010)	Summer 2009

Table 5.3 Most relevant expansions in Porto Airport during the analysis period.

Currently, Porto airport has one asphalt runway (17/35) with 3 480 m length. Together with the taxiway system (parallel taxiways do not extend across the full length of the runway), they account for a declared capacity of 20 movements per hour, either arrivals and departures exclusively or mixed, with a peak capacity of maximum 7 movements in a 15 minutes period, again mixed or only arrivals/departures. The aprons include 35 stands, 9 of them served by air-bridges.

The terminal building includes nearly 70 000 m^2 for arrivals and departures, including almost 20 000 m^2 for the “boarding lounges” or the space after security clearance for departing passengers, 60 check-in desks, 4 belts in the baggage claiming area, 6 security control positions for departures, 16 passport control positions for arrivals and 11 for departures. This accounts for a throughput of maximum 6 million passengers per year (although as mentioned before, there is ample space for expansion in the terminal; main capacity constraints are related to the runway-taxiway system and air traffic control).

As its counterparts of Faro and Lisbon, Porto Airport also defines its catchment area in terms of the number of people living at a given travel time by private car from the airport. For a 90 minutes ride that means nearly 4 million inhabitants, while for 120 minutes it represents around 5,5 million people. In this definition the catchment area of Porto extends to the South of Galicia in Spain, particularly the city of Vigo. Moreover, no other major airport exists in the interior part of North Portugal and the West of Spain. Even though these regions are beyond the 2 hours ride limit, it is natural to consider them as part of the airport’s own catchment area.

Accordingly, OPO promotes itself as the airport for all the Galician. For a 90 min travel time, the catchment area of Porto overlaps those of Vigo (VGO), Santiago de Compostela (SCQ) and La Coruña (LCG) and for 120 minutes it also overlaps Lisbon’s catchment area. However, the Galician market has been very attractive for OPO provided that the region has shown constant growth in its GDP over the last years.

Regarding surface transportation, Porto airport has a metro (light rail) station with regular services that take passengers to the city centre in around 25 minutes or to the main train station in 30 min. It is also served by urban bus lines and coach routes to Vigo. For private transportation, it is connected to the A41 motorway which, in turn, connects to the A28 and to the A3 to Spain and to other motorways of the Portuguese highway network. Four parking lots are available according to cost and length of stay. Additionally, a car rental *park* has been built to provide services required by car rental agencies.

Figure 5.5 Metro station at Porto Airport.

Porto Airport operates 24 hours a day and has no environmental restriction for night hour's movements. It serves both outbound and inbound traffic without a significant difference. The growth in passenger figures has been mainly propelled by the rise of LCCs operating at the airport, as described in the next sections.

5.3 Aviation network evolution

The network model has been constructed with the airports as nodes and the air routes linking the airports as arcs (directed links). Accordingly, a small database containing information on 236 airports in 59 different countries was developed representing the nodes used as a basis for the analysis in each of the periods studied. The arcs, on the other hand, come from the database created from the original data provided by ANA Aeroportos de Portugal, divided for every period.

The nodes are normally identified by the IATA code of the airports, unless otherwise stated. Each node contains information regarding the airport location by city, country, continent and geographical coordinates. The airport's name, or names if applicable, is also included in the database; however, for the modelled version, the most usual name has been chosen.

The links in the network are directed since only departures were considered to model the services provided by the three airports. It is normally accepted that the distribution between incoming and outgoing passenger traffic is even[15], that is, both flows are approximately equal (G. Burghouwt et al., 2003, p. 311). Given that assumption, departure traffic is considered to reflect more accurately the ability of the airports to compete according to the discussion presented in Chapter 4.

[15] Not to be confused with inbound and outbound traffic that relates to the nature of the origin of a round-trip journey.

Across the different network models, the arcs contain information on the number of passengers or seats offered and the type of carrier that has the largest share in the same route, in terms of passengers. This share does not refer to individual airlines but to the categories identified earlier in this chapter (namely FSC, LCC, REG and CHA). Therefore, if there are several airlines serving the route they all add up to the type of carrier they belong to in order to define which of the four types has the largest share.

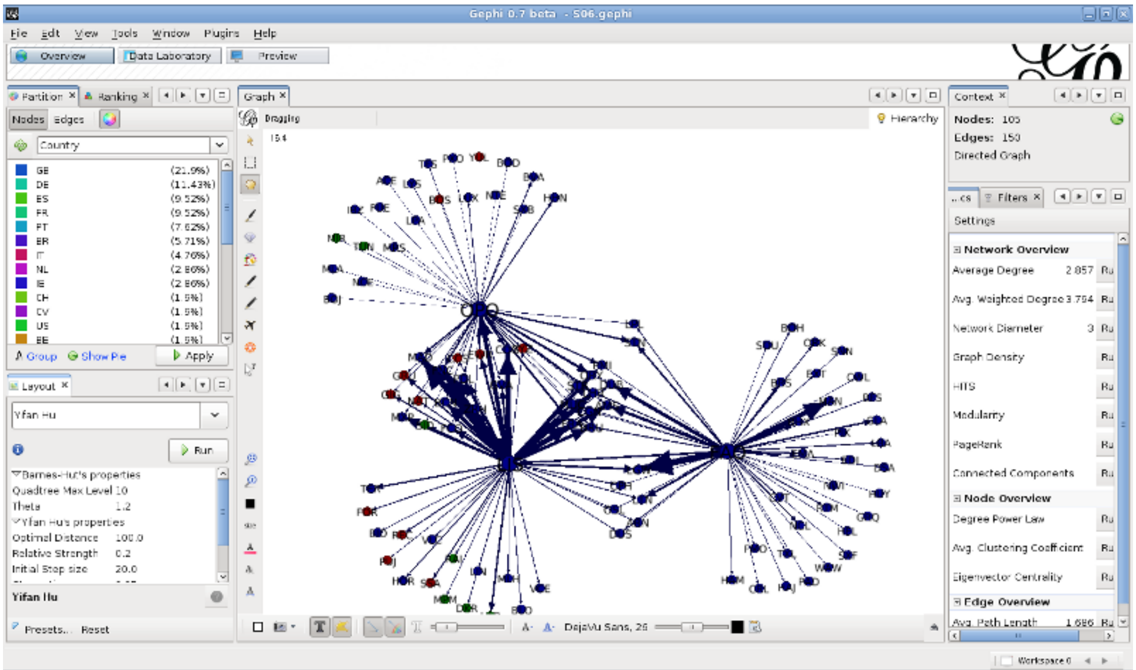


Figure 5.6 Screenshot of the Gephi application running the aviation network model for the Summer 2006 period.

Figure 5.6 illustrates the use of Gephi, the network analysis software used to model the aviation network. The network corresponding to the Summer 2006 IATA period appears in this particular instance using a Yifan-Hu layout. A weight proportional to the number of passengers in every route is associated to each link and subsequently represented by the thickness of the line.

For the sake of clarity and readability in this dissertation, the visual analysis of the aviation network evolution presented here is limited to the 50 major routes per airport. That is 150 routes per total in each period, which represents in every case more than 90% of the total passenger flow for the entire network. As shown in Figure 5.7, this share is lower towards the end of the analysis period; that means the network has been expanding and, in subsequent periods, 150 routes explain less of the entire network.

The entire database was the base for numerical analysis elsewhere in the dissertation, though. Additionally, given that the summer IATA season contains 7 months while the winter contain the remaining 5 months of a year, only the summer periods were chosen to be represented in the so-called Top 50 Summer routes network, in order to avoid a zigzag pattern if combined with the winter data and convey the evolution trends.

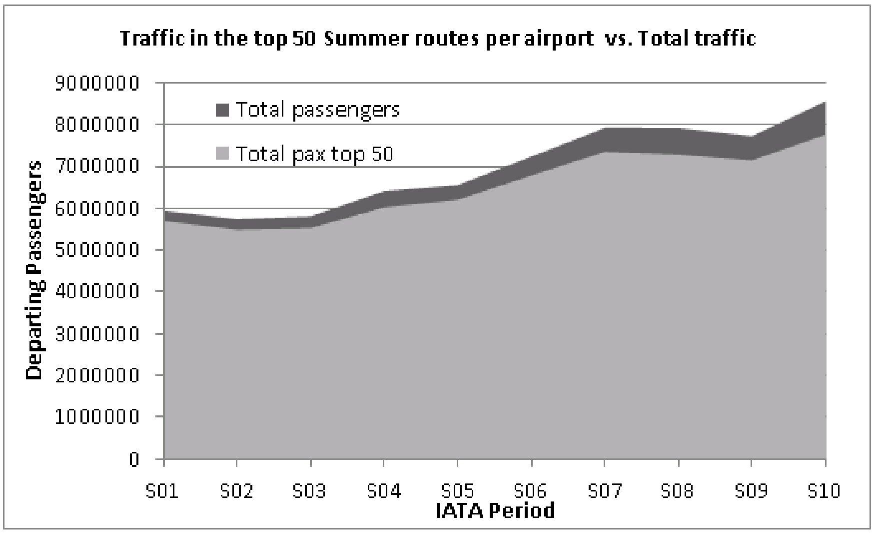


Figure 5.7 Comparison between total passenger flow and traffic of the 50 routes with more passengers per airport in each of the summer periods.

This section also presents an analysis with some detail on the intra-European aviation network. The reason for this choice comes from the fact that most of the evidence for airport competition that may lie in the network occurs in the European destinations, as many services outside Europe are still governed and regulated by bilateral agreements, hindering competition.

5.3.1 Top 50 summer routes

As explained before, 150 routes per season were chosen for a visual representation that provides an insight on how the aviation network of the three airports evolved during the first decade of the 21st century. The 150 routes come from the top 50 destinations (those with the largest number of passengers) for each airport in each Summer period. Therefore, they do not show the same routes each season. A similar analysis, regarding main routes evolution, for OPO appears in INAC (2010) and for FAO and LIS in the yearly traffic reports of ANA. However, those statistics show routes in terms of cities as destinations (e.g. “London” may include five different airports: Heathrow, Gatwick, Stansted, Luton and London City). For the current analysis the destinations are related to airports, allowing for a deeper analysis on airport competition and not just markets served.

One of the most remarkable aspects in the network evolution regards the nature of the type of airline that carries most of the passengers in each route. This shows a strong competition between airlines, but also the strategy of most LCCs to use smaller airports in which they have less direct competition from FSCs. It is therefore easier for LCCs to have the largest share in a route, since many times they are the only carrier operating the origin-destination pair, especially for Ryanair. On the other hand, competition between LCCs and charter airlines seems to be more direct.

As seen in Figure 5.8, low-cost airlines show the biggest growth in passengers share over the 150 routes, mainly to the expense of charter operators. By Summer 2001, LCCs were the major carrier in 10% of the routes. This share grew to over 50% in Summer 2010, while charters go down from over 30% to some 2,7% in the same periods. It is worth noting, however, that these figures do not reflect the number of passengers carried in total by each type of carrier (that is shown later on in the Airport's evolution section in this chapter), but the extent to which every kind of airline remains the stronger in a given route.

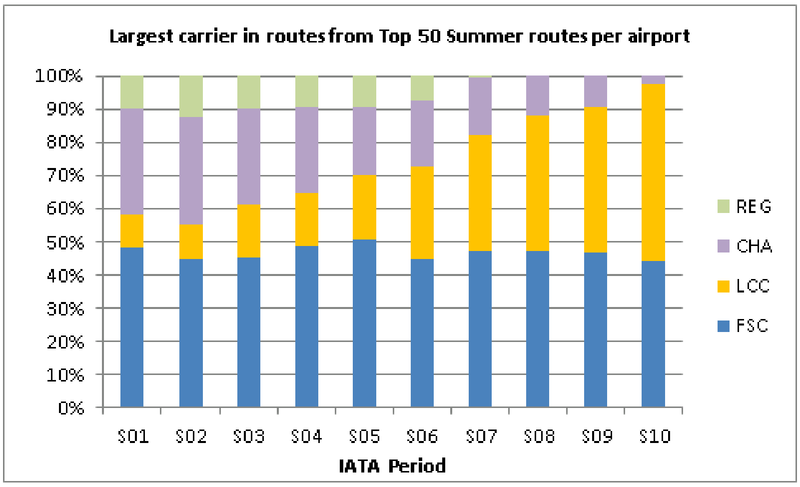


Figure 5.8 Evolution of the type of carrier with the largest share per route in the Top 50 Summer network.

Figure 5.8 also shows the drop in the participation of regional carriers as dominants in some routes. This is mainly due to TAP taking over PGA-Portugália in 2006 (Publico, 2006) with all the former flights of the Portuguese regional airline being branded as TAP by the airport operator since IATA Winter 2007 season. Most of the other regional airlines operating at the three airports are too small to be the major carrier in any of the Top 50 Summer routes.

It is interesting how TAP could not retain the dominant position of PGA in some routes, either because the routes were dropped or other carriers, mainly LCCs, reached the first positions. Hence the share of regional airlines does not go directly to add up the share of FSCs after Summer 2006. FSCs, on the other hand, remain more or less stable between 40% and 50% of the Top 50 Summer network as the major carriers. This reflects FSCs dominant position in their established network of major airports, but also shows that LCCs are holding most of the growth in demand.

Beginning of the 2000's

Some of the changes discussed here can be further explained from a network analysis perspective by using the Yifan-Hu visualization layout algorithm to represent the Top 50 Summer aviation network. In Figure 5.9, for the Summer 2001 season, the nodes colour is associated to the geographical location of the airports in Europe, Africa or America. The links colour represents the type of carrier with the largest share in the route, in terms of passenger flow, as in the chart of Figure 5.8 but in a route by route basis.

The first aspect to notice in Figure 5.9 is how clusters or groups of airports can be easily distinguished. Each airport (LIS, FAO and OPO) has its own exclusive services or specific destinations that are not directly served by the others. There are a small number of *major* airports that have direct connections with the three Portuguese airports so they act as their feeders or hubs. Finally, some other airports share connections with only two of the three airports under study; with Lisbon and Porto sharing a larger number of destinations, especially outside Europe.

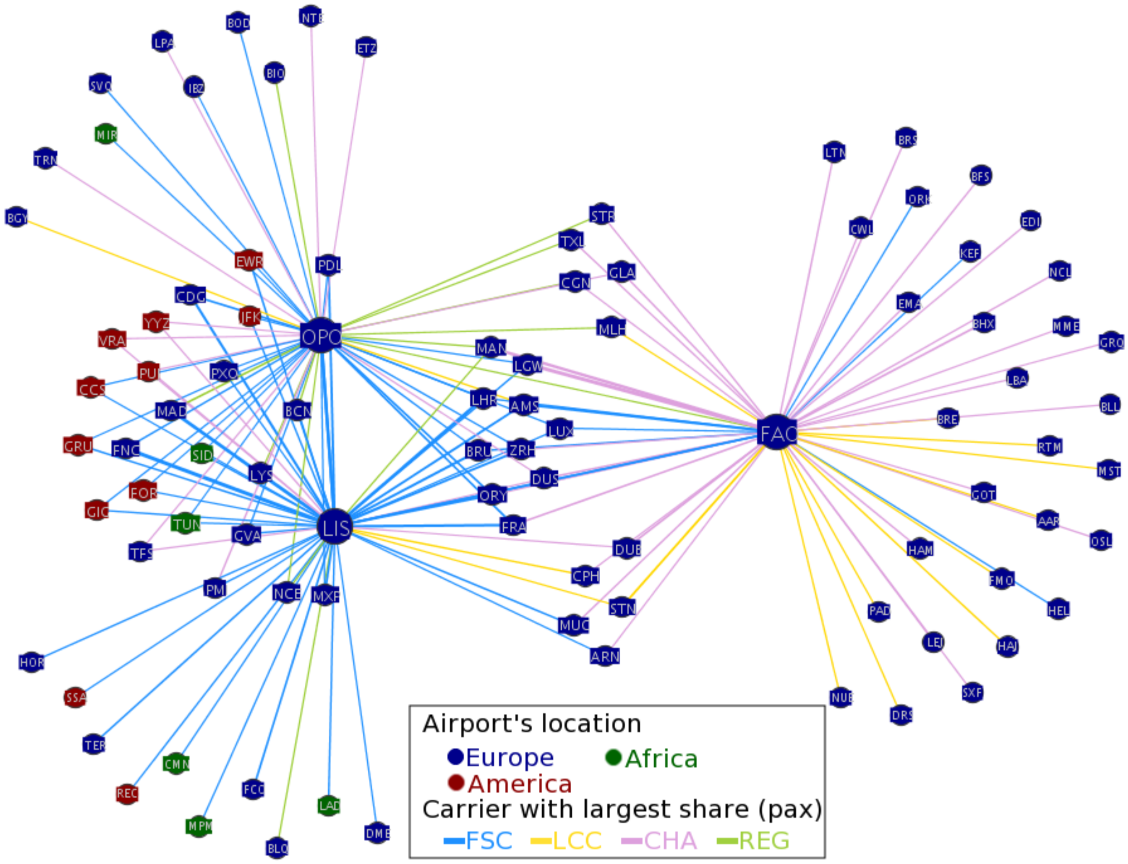


Figure 5.9 Yifan-Hu layout for the Top 50 Summer network in Summer 2001 period.

It is clear how in the beginning of the time span analysed charter airlines were mainly focused on FAO and to a lesser extent on OPO, sharing some holiday destinations with LIS, such as Varadero (VRA) and Punta Cana (PUJ) in the Caribbean or Tenerife (TFS) in the Canary Islands. FSCs, on the contrary, were more tied to LIS as expected, firstly for being the home base for TAP (and other Portuguese airlines) and secondly for providing an established feeder to the networks of other legacy carriers; and also to a lesser extent to OPO. Porto, at the same time, provided more opportunities for regional airlines to be the major carriers in some routes. In this early stage LCCs were also more focused on FAO, serving mainly airports in the UK and Germany; especially because Faro provided a large enough inbound market for point-to-point services.

All destinations from FAO are located in Europe, leaving all the intercontinental connections to Lisbon and Porto airports. This reinforces the idea that Faro is a holiday destination for European holidaymakers. Creating a general picture for Summer 2001, one may say that FAO was clearly a charter-preferred leisure destination in which tour operators take advantage of selling flights as part of bigger tourist packages. LIS, on the contrary, was a *legacy* airport serving as the main gateway to the country and being served mainly by FSCs. Finally, OPO was a regional airport with a mix of the different types of carriers and intercontinental connections with tourist destinations and areas of strong migrant flows.

The middle of the decade

Even though no major expansions or changes in the infrastructure of FAO took place during the analysis period, the part of the network linked to this airport shows a dramatic change, especially in what regards the type of carrier with higher dominance per route. As seen in Figure 5.10 for Summer 2005, many of the routes from FAO have gradually changed to have LCCs as their major airline. The stronger competition between charter and low-cost airlines in Faro is more related to structural changes in the way tourists accessed the Algarve. LCCs were not only offering cheap flights, but the opportunity to book the trip and the accommodation through their websites, providing more flexibility to travellers. Additionally, many holidaymakers developed a sort of loyalty to the destination and bought a second home there (ANA, 2007b). As a consequence, LCCs offered a better deal since they no longer needed the entire holiday package.

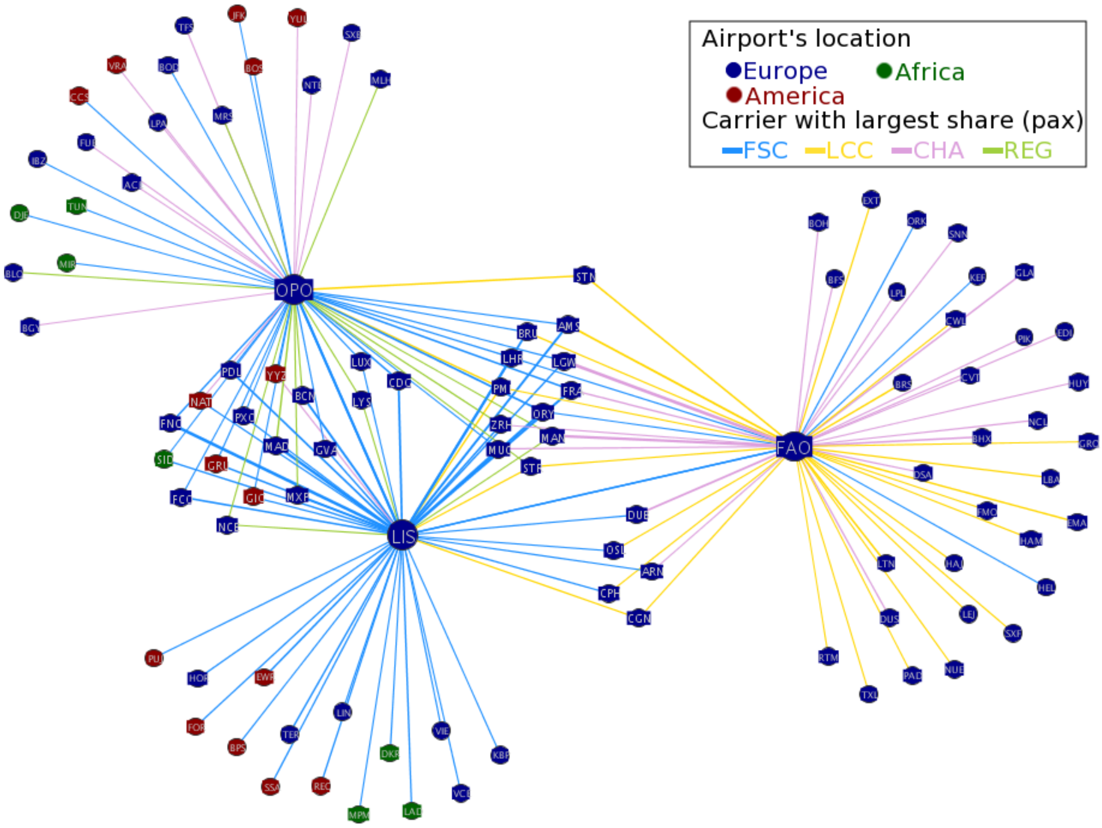


Figure 5.10 Yifan-Hu layout for the Top 50 Summer network in Summer 2005 period.

Since the largest market for the Algarve continued to be in the UK and in Germany, the aviation network also reflects the many LCCs existing in these two regions, such as Jet2.com, bmi baby, Eurowings, Germanwings, Go Fly and so on, with easyJet (the second largest European LCC in terms of passengers) offering six routes to Faro in Summer 2005 (three of them are to/from London, using Luton, Stansted and Gatwick) and Ryanair (the largest European LCC in terms of passengers) offering one single route between Dublin and Faro by

Summer 2005. However, the network shown in Figure 5.10 also marks three important moments for the expansion of LCCs in Portugal.

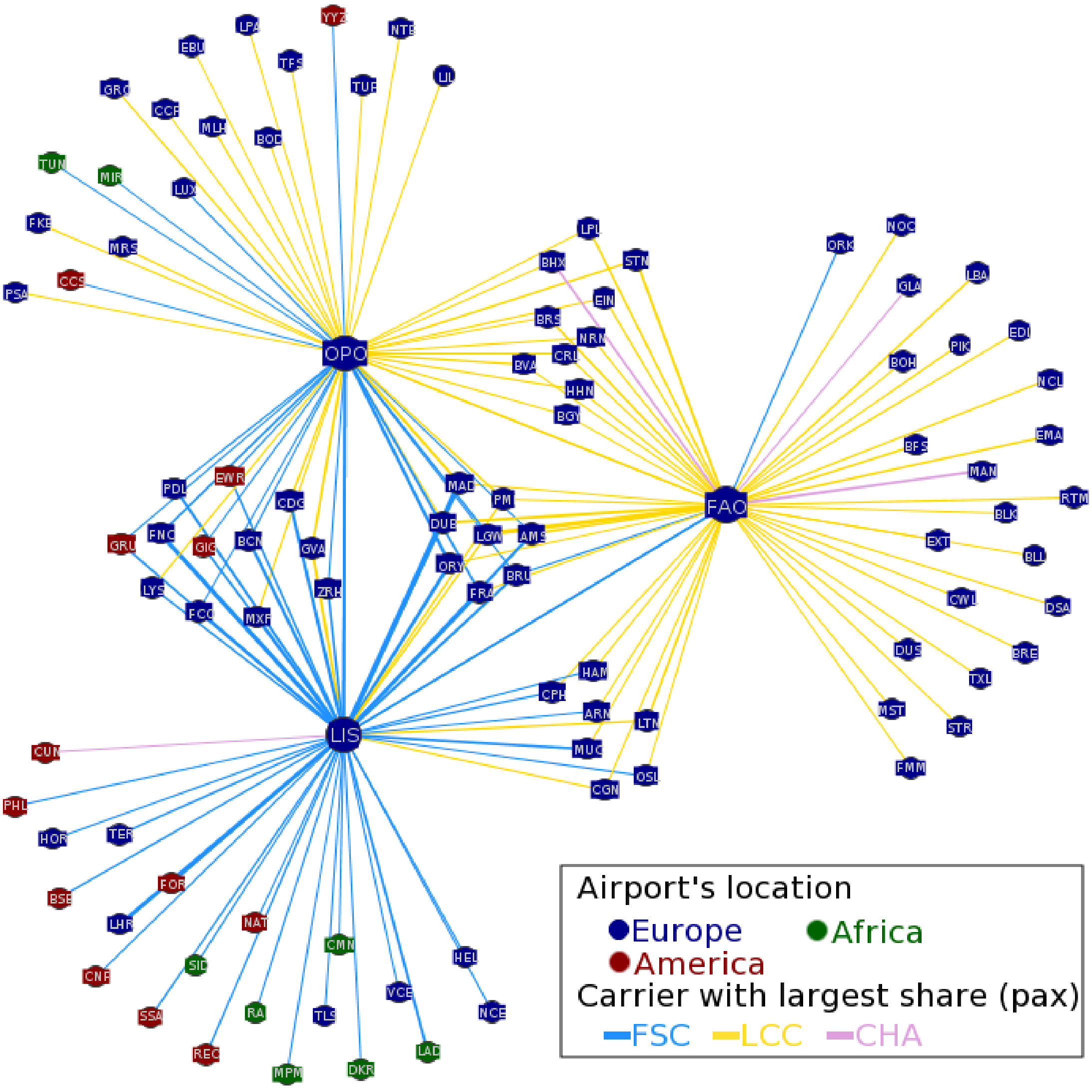


Figure 5.11 Yifan-Hu layout for the Top 50 Summer network in Summer 2010 period.

Firstly, Ryanair started flying earlier in 2005 (still in the Winter 2004 period) the route London/Stansted (STN) - Porto, thus by Summer 2005 the route was clearly noticeable with a large amount of passengers and appears as the arc between OPO and STN, the only airport shared exclusively with FAO. Secondly, easyJet officially started operations at LIS, although its service was only consolidated in the Winter 2005 season, so it does not appear in the network yet. Thirdly, by the first time in the period of study Air Berlin gained a dominant position in its three routes from the Portuguese airports to Palma de Mallorca (PMI)[16]. The relevance of this fact is that PMI enters the group of *major* airports that offer service to the three Portuguese

[16] Even though Air Berlin is one of those hard to classify carriers and it is half way between LCCs and FSCs, it has been included in this study as a low-cost airline following statements on its website referring itself as a low-fares or a low-cost carrier. However, it follows *unusual* practices for an LCC, such as hubbing (in the sense of geographical concentration and selling connections), a global alliance membership (planned for 2012) and business-class in selected routes.

airports, thus directly competing for transfer opportunities with other airports in the same group, such as Amsterdam/Schiphol (AMS), London/Gatwick (LGW) or Frankfurt (FRA).

The end of the decade

Figure 5.11 shows the network in Summer 2010. The consolidation of LCC's own networks is evident. FAO shows itself as a low-cost airport with few routes dominated by FSCs, as Lisbon for the feeder services of TAP. By this time LCCs have clearly overcome charter airlines, which remained dominant in only three routes to Manchester (MAN), Glasgow (GLA) and Birmingham (BHX).

Lisbon remains a legacy airport but clearly shows the strong presence of easyJet in routes like London/Gatwick (LGW), London/Luton (LTN) and Geneva (GVA); Air Berlin in Palma de Mallorca (PMI) and Germanwings in Cologne-Bonn (CGN); charters remain dominant only for the Caribbean destination of Cancun (CUN).

Porto, on the other hand presents an interesting mix between FSCs and LCCs, with a clear reference to the network of Ryanair, sharing with Faro destinations such as Paris/Beauvais (BVA), Brussels/Charleroi (CRL), Frankfurt/Hahn (HHN), Milan/Orio al Serio (BGY, also known as Milan/Bergamo) and so on; but also Geneva (GVA), Milan/Malpensa (MXP), Paris/Charles de Gaulle (CDG) and Lyon (LYS) as some examples of the expansion of easyJet and other LCCs like Transavia; and at the same time keeping FSCs connections in Europe and other continents. Also interesting is the regular link between FAO and OPO that appears for the first time in the decade, served by Ryanair.

Evolution overview

The group of airports shared by FAO and OPO reflect marketing decisions at both airports that allowed Ryanair to base two aircraft in Porto in Summer 2009, expanded to four precisely for the S10 season, and six planes in Faro by the end of Winter 2009 (Ryanair, 2009b, 2009a). As discussed by Malighetti et al (2009) and Barbot (2006), the existence of LCCs bases and their dominance in those base airports allow them to offer even lower fares for their flights. In this sense, the direct regular connection between FAO and OPO arises not only as an example of that, but as an evidence of the airport manager's desire to expand the airport's aviation network.

However, a relationship between decisions that affect the capacity of the airports and the changes seen in the aviation network is not straightforward. For OPO it is interesting how part of the network expansion, the one provided mainly by the growth of Ryanair (see section 5.4.2 for further details), is concentrated in the so-called "Northern bus gates", which are not operated with buses. Thus, even though this scenario was not explicitly part of the forecast, the airport is being able to cope with this *new reality*. Perhaps, the provision of traditional facilities allows OPO to keep the FSC part of the network, and not showing an entire shift in the demand as in FAO.

In Lisbon, however, the opening of Terminal 2 in Summer 2007 can be translated to the aviation network when the connection to Geneva (GVA) is dominated by low-cost traffic by the first time, while allowing other routes, namely London/Gatwick, to shift to this type of carrier in subsequent seasons as in Figure 5.11.

The group of airports in the middle, with connection to FAO, LIS and OPO simultaneously, also show an interesting evolution. In the beginning of the decade, FSCs dominated the routes to that group of airports (Figure 5.9). in the end, only Brussels/Zaventem (BRU, also known as Brussels/National) retained FSCs as the major carrier in the three links (Figure 5.11). The remaining airports in this cluster are also major *hubs* such as Madrid/Barajas (MAD), Frankfurt (FRA), London/Gatwick (LGW), Amsterdam/Schiphol (AMS), Paris/Orly (ORY), Dublin (DUB) and Palma de Mallorca (PMI). Interestingly, most of them have an FSC dominance in the routes from Lisbon (and, to a lesser extent, Porto), and an LCC dominance in the routes from Faro. Porto, on the other hand, shows LCCs as the dominant carriers in the route to MAD, one of the largest destinations in terms of passengers. In the same way, LCCs dominate in the route from LIS to LGW.

Other important European airports, such as London/Heathrow (LHR) and Paris/Charles (CDG) de Gaulle show a particular behaviour. Probably their focus on becoming intercontinental hubs is the reason for their disappearance from the cluster described in the last paragraph. This is especially true for LHR, which ends up the analysis period connected only to Lisbon, although with a very high volume of traffic. For Porto, on the contrary, FSC traffic to Heathrow was transferred to Gatwick. Paris/CDG suffered a similar transformation, with intra-European connections transferred to Orly (ORY). However, spare capacity (as it is not the case in LHR) allowed for low-cost operating in CDG in the routes from LIS and OPO, putting the airport in direct competition for this segment with Paris/Beauvais (BVA) in the link with Porto.

Top 10 evolution

In the figures above, the thickness of the lines is associated to the total number of passengers carried by all type of companies, but this representation is not clear enough to provide a proper picture of the main routes within the Top 50. Hence, in order to have a better perspective, Table 5.4 shows the evolution for the main 10 routes from each airport during the period of analysis. The behaviour on the type of carrier with the largest share per route somehow restates what has been told above: FAO moved towards a low-cost airport, LIS remains the flag ship for FSCs in Portugal and OPO accommodates both types of companies almost evenly.

This table also calls the attention to the fact that some destinations for FAO have drastically reduced their flows, especially Manchester (MAN) and Amsterdam/Schiphol (AMS). This may show competition induced by LCCs using more convenient airports that are either better located for the traveller's sake, or have a simple layout or just offer cheaper flights. Perhaps this contributes to the rise in the ranking of Liverpool (LPL, in direct competition with Manchester), Bristol (BRS), East Midlands (EMA) and others that are not visible in the table. At the same time, Lisbon (LIS) fell dramatically and disappeared from the Top 10 by 2010, showing also that LIS is competing with other airports in the other extreme of the journey and LCCs enable passengers to bypass the *hub*. Even if the information is limited, we might think that the drop in the number of passengers for Frankfurt (FRA) and AMS is associated with a shift in the preference of some holidaymakers there, putting Faro in competition with the airports at other tourist destinations. What is true, however, is that 9 of the top 10 routes link Faro to the UK or to Ireland.

As for Lisbon, it is evident how the route to Porto fell down in the rank, while most of the others were growing in terms of the number of passengers. Nevertheless, the fall in the level of traffic for LIS – OPO (and vice versa) is more dramatic after 2005, so it can be associated to the expansions developed at Porto airport that allowed it to have better (more and more frequent) connections of its own, thus relying less on Lisbon as a transfer point.

Period		Summer 2001			Summer 2005			Summer 2010		
#	Origin	Destination	Pax	Carrier	Destination	Pax	Carrier	Destination	Pax	Carrier
1	FAO	LGW	277504	CHA	LGW	272599	CHA	LGW	270431	LCC
2	FAO	MAN	200166	CHA	MAN	202516	CHA	DUB	138167	LCC
3	FAO	AMS	152307	FSC	AMS	123082	LCC	MAN	116973	CHA
4	FAO	STN	97811	LCC	DUB	122148	CHA	STN	113391	LCC
5	FAO	DUB	92912	CHA	BHX	85138	CHA	BHX	86593	CHA
6	FAO	LIS	83849	FSC	LTN	77130	LCC	AMS	83614	LCC
7	FAO	BHX	72669	CHA	STN	72080	LCC	LTN	79957	LCC
8	FAO	DUS	68367	CHA	LIS	68922	FSC	LPL	67102	LCC
9	FAO	FRA	63648	CHA	GLA	65806	CHA	BFS	66916	LCC
10	FAO	GLA	42904	CHA	EMA	63132	LCC	BRS	66160	LCC
1	LIS	FNC	292354	FSC	FNC	265490	FSC	MAD	369545	FSC
2	LIS	MAD	258448	FSC	MAD	229896	FSC	FNC	287501	FSC
3	LIS	LHR	211196	FSC	LHR	203538	FSC	LHR	250902	FSC
4	LIS	OPO	208295	FSC	OPO	174057	FSC	ORY	200168	FSC
5	LIS	FRA	158731	FSC	ORY	173787	FSC	CDG	172288	FSC
6	LIS	CDG	149569	FSC	FRA	166614	FSC	FRA	163660	FSC
7	LIS	ORY	135588	FSC	AMS	153829	FSC	BCN	158532	FSC
8	LIS	BRU	125297	FSC	BCN	138453	FSC	AMS	152527	FSC
9	LIS	AMS	111338	FSC	BRU	130064	FSC	OPO	143969	FSC
10	LIS	PDL	111222	FSC	CDG	120504	FSC	BRU	130420	FSC
1	OPO	LIS	180543	FSC	LIS	171366	FSC	ORY	163210	FSC
2	OPO	CDG	79096	FSC	ORY	108363	FSC	LIS	136758	FSC
3	OPO	ORY	77854	FSC	FRA	77398	FSC	MAD	130765	LCC
4	OPO	FRA	74102	FSC	CDG	71218	FSC	GVA	102417	LCC
5	OPO	MAD	63833	REG	STN	69147	LCC	FRA	98509	FSC
6	OPO	FNC	50051	FSC	MAD	59741	REG	FNC	74701	FSC
7	OPO	LHR	48239	FSC	FNC	55488	FSC	LGW	72465	FSC
8	OPO	ZRH	30899	FSC	PMI	53536	LCC	BVA	63480	LCC
9	OPO	AMS	29095	LCC	LHR	42251	FSC	STN	60045	LCC
10	OPO	BRU	29062	FSC	LGW	25489	FSC	CDG	49982	LCC

Table 5.4 Evolution of the Top 10 routes from each airport. The column "Carrier"indicates the type of carrier with the largest share in the route.

The same can be concluded when looking at the evolution in OPO, for which all routes in the top 10 show a significant growth, regardless of the destination. It is noticeable the drop in Paris/Charles de Gaulle (CDG), especially since Air France abandoned the airport leaving demand on the route to CDG in the hands of LCCs. At the same time, TAP relocated its services to Paris/Orly (ORY). Competition in the market for Paris was further increased with the entrance of Beauvais (BVA) that, even though it is served only by Ryanair, accounts for more passengers than CDG in Summer 2010. The growth of Geneva (GVA) propelled by easyJet is also surprising. Madrid/Barajas (MAD) also doubled since the new passenger building was opened in 2005. Frankfurt (FRA) holds as one of the main destinations with Lufthansa and the airport seeing competition from Ryanair in Frankfurt/Hahn.

5.3.2 Intra-European network

As seen in the previous section, the large majority of the most important routes for the aviation network of Continental Portugal are within the boundaries of Europe. Intercontinental routes are reserved mainly to Brazil, Africa (former Portuguese overseas territories and tourist destinations in Northern Africa) and North America. This section then provides a brief overview of the Intra-European network, extracted from the Top 50 Summer network. Information is graphically depicted in a geographical representation, as a way to support the analysis.

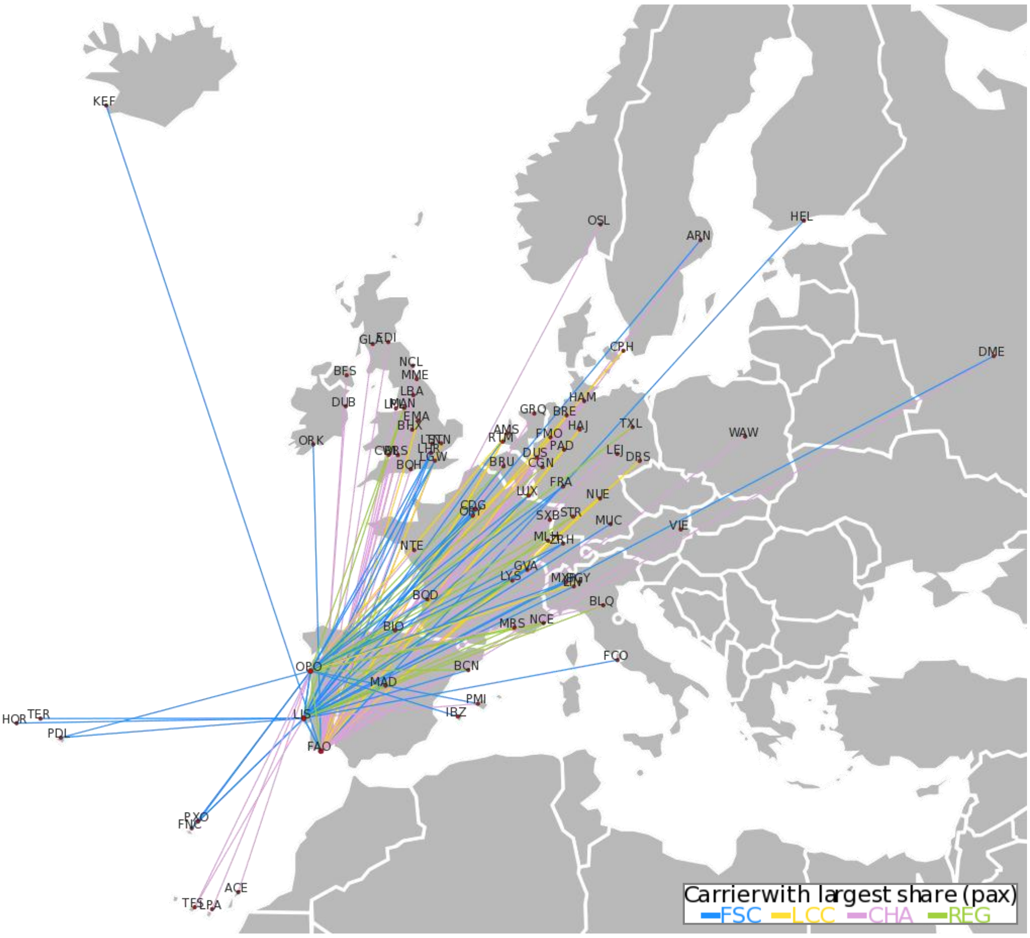


Figure 5.12 Intra-European aviation network for the Summer 2002 season.

Figure 5.12 and Figure 5.13 show two instances of the network, in Summer 2002 and Summer 2010 respectively. Besides the steady growth of low-cost carriers already described, the geographical layout shows the densification in the number of airports in some areas. Since the LCC phenomena started in the South of the UK, the Great Britain presents some areas that are already dense enough, in terms of the number of airports, at the beginning of the time lapse analysed. By the end of the period (Summer 2010 season) there is further densification, though. Glasgow/Prestwick (PIK) appears in the same area where Glasgow (GLA) and Edinburgh (EDI) operate; Exeter (EXT) in the Southwest and Blackpool (BLK) in a region where Manchester (MAN), Leeds/Bradford (LBA) and Liverpool (LPL) already showed some competition.

Outside the UK there are also new entrants for the Portuguese destinations. Paris/Beauvais (BVA) stands out in the Paris area (even though it is located 80 km from Paris centre); Lille (LIL) and Brussels/Charleroi (CRL) near Brussels; Eindhoven (EIN) and Maastricht (MST) in the Netherlands, which are also close from Niederrhein/Weeze (NRN) and Dusseldorf (DUS) in Germany; Frankfurt/Hahn (HHN) near Frankfurt and Memmingem (FMM) in the vicinities of Munich; Basel/Mulhouse (MLH), also known as the Euroairport between France, Germany and Switzerland; Milan/Orio al Serio (BGY) near Milan/Malpensa (MXP), and finally Girona (GRO) relatively close to Barcelona (although Ryanair dropped the route OPO – GRO and started OPO – BCN in Winter 2010). With all these airports the LCCs are in fact providing an alternative and parallel network to that of FSCs.

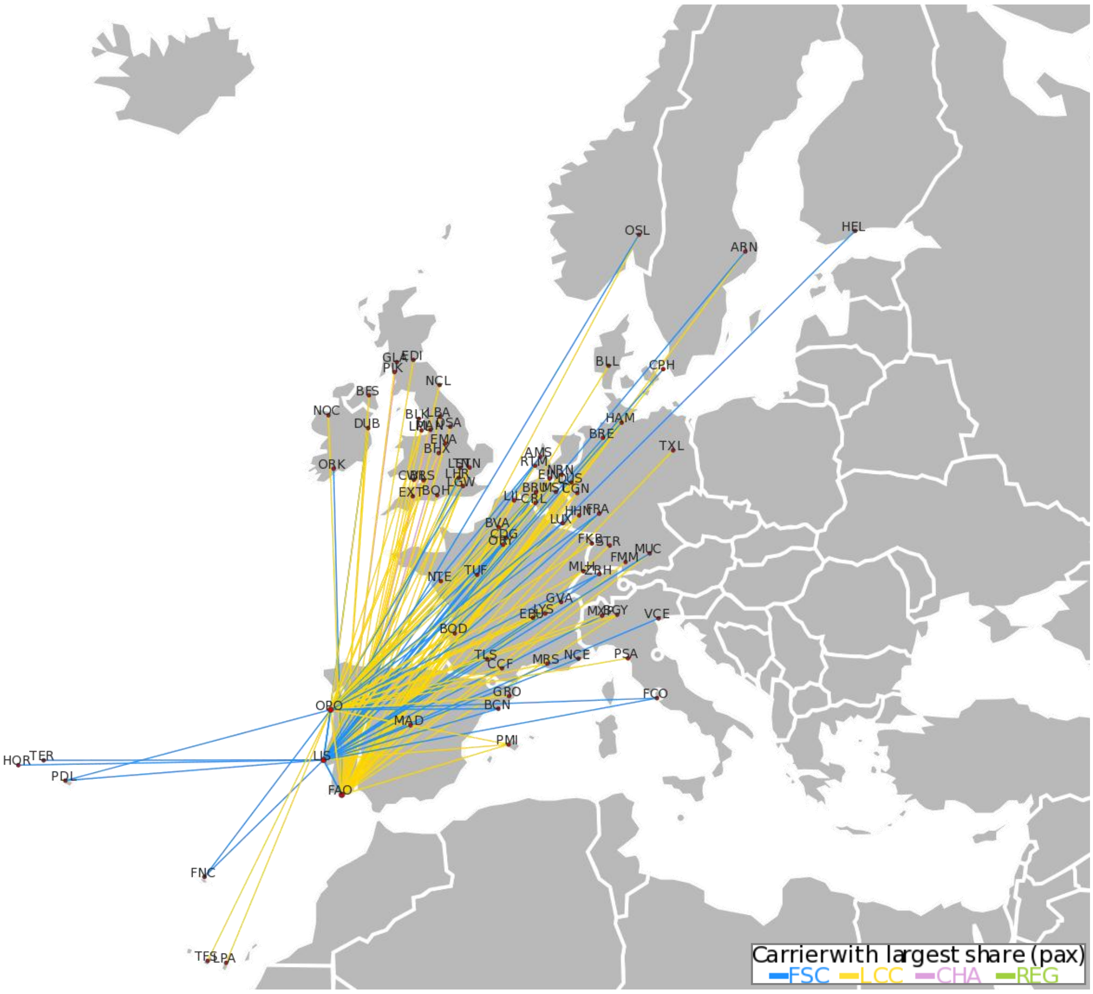


Figure 5.13 Intra-European aviation network for the Summer 2010 season.

Another aspect that is clearly visible in the geographical versions of the aviation network is the fact that LCCs remain in the short-haul routes, while FSCs engage in longer lasting segments. Only Faro – Oslo (OSL) and Faro – Stockholm/Arlanda (ARN) appear with LCC dominance in Summer 2010 and they are very likely supported by a very strong origin-destination market during summer. We can also remark the hub of Air Berlin in Palma de Mallorca (PMI) and its convenient location for this kind of operations in relation to the German market.

5.3.3 Network concentration

The Network Concentration Index (NC) described in section 2.3.2 is used here to analyse the evolution of the spatial distribution of demand (passengers flow) for each of the airports under study. The value of the NC for every season is computed using the entire filtered database including all scheduled and non-regular routes and not only the Top 50 Summer network described previously in this chapter. The total number of routes per airport has an unusual peak, especially for routes from Porto and Lisbon, in Summer 2004 that is produced by the increase in charter flights due to the Euro2004 football championship in Portugal. Nonetheless, the NC is a normalized measure, thus the comparison between different networks is independent of their size.

Burghouwt et al. (2003) propose the NC as a valuable tool to categorize the structure of airline networks by analysing their morphology (also referred by the same author as *network configuration*, the morphology is basically the shape of the network, i.e. the topology). However, since the aviation network defined for this dissertation is focused on the airports and includes all their direct connections, it is obvious that the shape of the network would resemble a star. Indeed, the values for the NC found for the Portuguese case in all the periods range between 0,65 and 0,85. These values are associated by Burghouwt (2007, p. 44) to radial or multi-radial route networks, as confirmed by the network representations shown along this chapter.

Consequently, it is not meaningful to use the NC to evaluate the shape of the network. For the spatial distribution of the demand, however, the NC proves more valuable in addressing the objectives of this dissertation. In this way, the NC measures the level of concentration within the route structure of the network. That is, whether the passengers flow is evenly or unequally distributed across all the routes available.

According to Burghouwt (2007, p. 44), NC values between 0,61 and 0,70 indicate concentrated networks, while values of 0,71 and above are associated with very concentrated networks. As shown in Figure 5.14, for the summer periods the three airports (FAO, LIS and OPO) developed very concentrated networks. This means that a few number of routes accounted for a large part of the traffic, in terms of passengers.

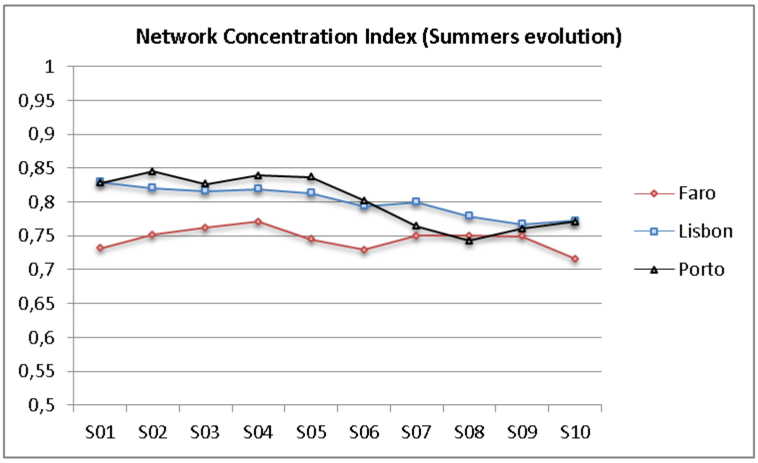


Figure 5.14 Network Concentration Index evolution for the Summer periods.

However, it is noticeable how the level of concentration diminished for Porto airport. Moreover, the decrease in the route concentration can be associated to the physical improvements developed by the airport in the year 2005 allowing for a stronger service on a wider number of routes. The growth of LCCs in OPO and LIS can also be a factor contributing to a lower level of network concentration in three ways: offering the opportunity to expand the network, increasing demand in new routes and switching demand from established routes to the new ones. The latter alternative (switching demand) is not evident though, since most of the LCC traffic comes from an emergent demand (so the LCCs mainly take new travellers, or the same passengers travelling more frequently), but these airlines are not yet able to gain a significant amount of current demand for FSCs (this topic is treated with more detail in section 5.4.1). In Faro, on the other hand, a de-concentration effect is not visible since most of the demand shifted from charters to LCCs operating in similar networks.

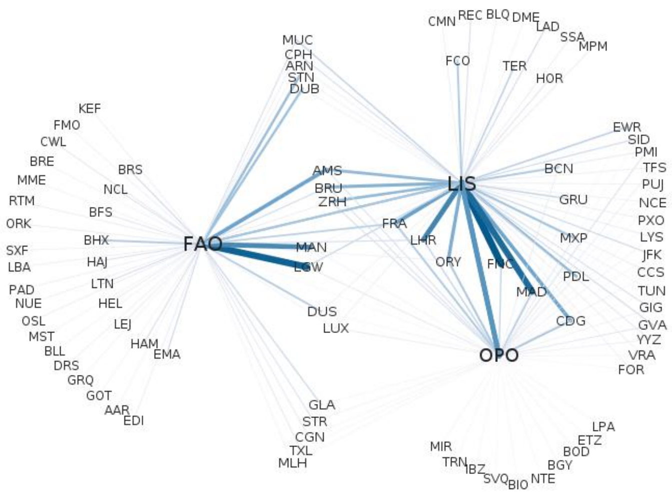


Figure 5.15 Top 50 Summer aviation network in Summer 2001.

To further explain the evolution of the Network Concentration, Figure 5.15 shows the aviation network (only the top 50 routes per airport) in the Summer of 2001, a season in which Lisbon and Porto airports had similar levels of very high concentration and Faro, although very concentrated as well, had a lower level of concentration. Figure 5.16, in turn, shows the network

(Top 50 routes again) for Summer 2009 when the three airports showed a similar level of concentration, as seen in Figure 5.14. These two network representations are based on a Yifan-Hu layout in which the colour and thickness of the arcs are proportional to the traffic in each route. Hence the bolder and thicker the line, the higher the number of passengers using the link.

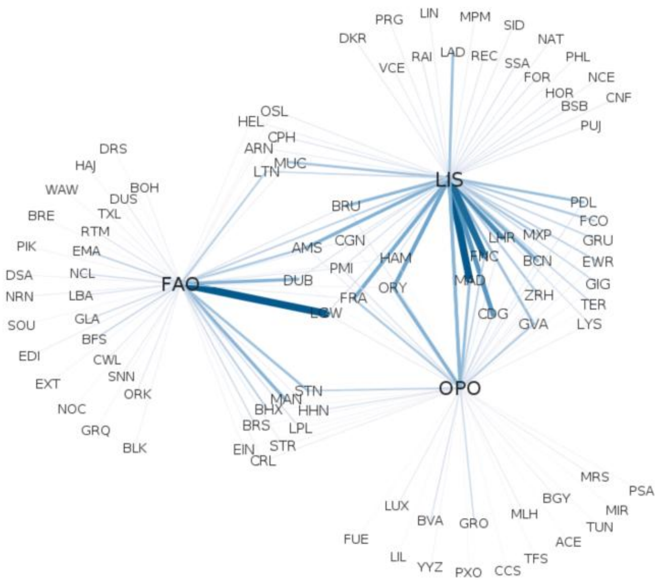


Figure 5.16 Top 50 Summer aviation network in Summer 2009.

By Summer 2001, OPO was very concentrated in the LIS – OPO route and had no other strong links, i.e., links with high flows. Although LIS had more strong routes, the aggregated demand in those routes was too high when compared with the distribution through all the other destinations. For Faro, although there were three very strong routes, the remaining routes shared more similar levels of traffic.

In contrast, by Summer 2009, Porto and Lisbon reduced the relative significance of their mutual route (LIS – OPO) while traffic figures grew more evenly in the other routes. Faro, on the contrary, was by then more concentrated in its route to London/Gatwick (LGW), since the other top routes dramatically declined in the number of passengers, and the growth in the remaining connections was not enough to compensate inequalities in the largest destinations.

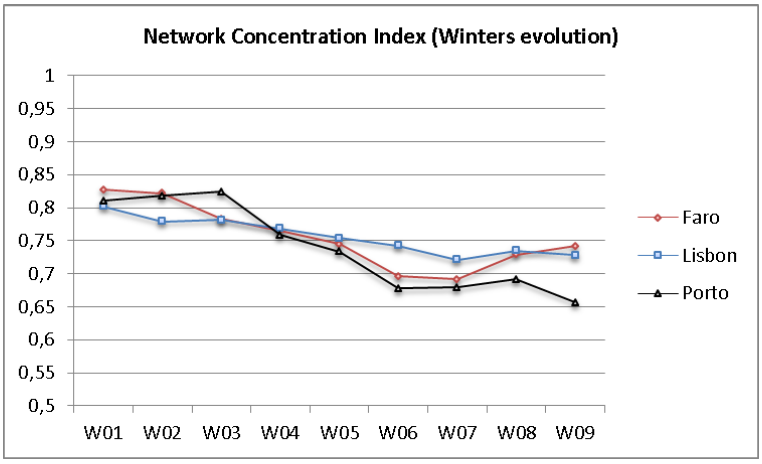


Figure 5.17 Network Concentration Index evolution for the Winter periods.

Figure 5.17 shows the evolution of the NC during the winter IATA seasons, for which the de-concentration effect is more evident. Indeed, since Winter 2006 Porto airport consistently shows values below 0,7 that imply a concentrated network (without the «very» adverb) in the scale of Burghouwt described in the beginning of this section. The reason for a higher de-concentration during the winter seasons is explained by the growth of LCCs and their responsibility in keeping all-year-round routes, thus creating demand for previously seasonal destinations. This also explains why the effect is more noticeable in OPO and FAO and how FAO reaches values of Summer in the Winter seasons. The last two periods for Faro show a re-concentration due to a generalized fall in the traffic level for those seasons. The following summer (S10 in Figure 5.14) shows again a lower level of concentration, probably associated to the establishment of the Ryanair base by the end of Winter 2009.

5.4 Airports evolution

In the beginning of this chapter we made a brief description on the history of the three airports including the most relevant developments in terms of physical infrastructure introduced during the first decade of the current century. Now, the analysis turns towards a more commercial description of the evolution during the same period. Accordingly, this section presents more detail on what regards demand and supply aggregated by airport (i.e. adding up all destinations). Again, demand corresponds to passengers flow and supply to seat capacity offered by the airlines. Additionally, the changes in dominant airlines for each airport are examined, given that the future of an airport may be strongly tied to what happens to the major carrier or carriers in a clearly uncertain world.

5.4.1 Demand and supply evolution

If we consider passengers flow (demand) and seat capacity offered by the airlines (supply) in all the available routes, in absolute terms, Porto and Lisbon airports show some growth but Faro shows a sort of stagnation during the analysis period. Figure 5.18 presents the evolution of the demand and supply for departing flights in Faro; the summer periods are shown on the left and winters on the right. Although there is some growth in the figures for the 2006 and 2007 seasons, that trend is reversed in 2008 and 2009; a more significant growth is experienced in Summer 2010, most probably associated wit the establishment of the Ryanair base at the airport. Beside the absolute numbers, the high seasonality of the airport is clearly visible with the traffic in winter seasons being just around one quarter of that in summers. It is also noticeable that load factors are higher for Faro since the bars for demand and supply in Figure 5.18 do not account for a major difference.

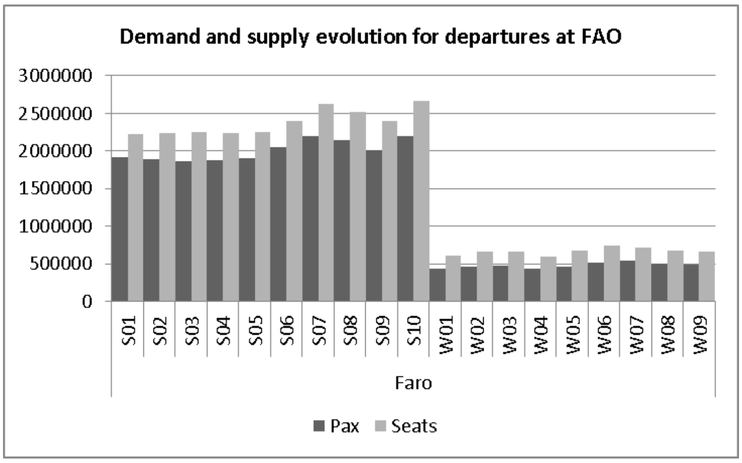


Figure 5.18 Departing passengers and seat capacity of Faro Airport.

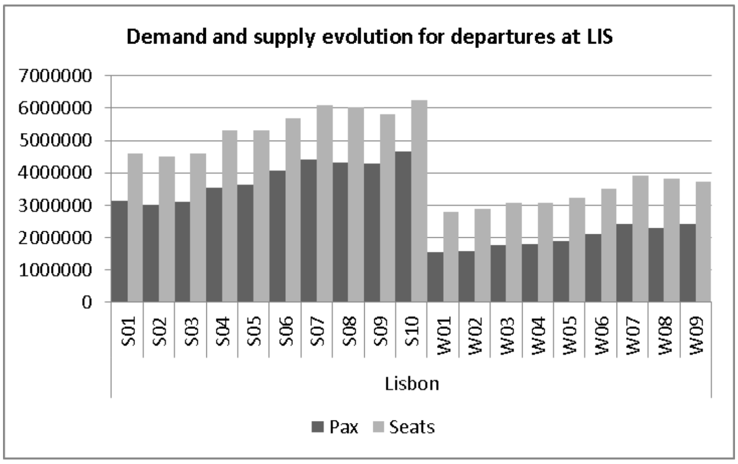


Figure 5.19 Departing passengers and seat capacity of Lisbon Airport.

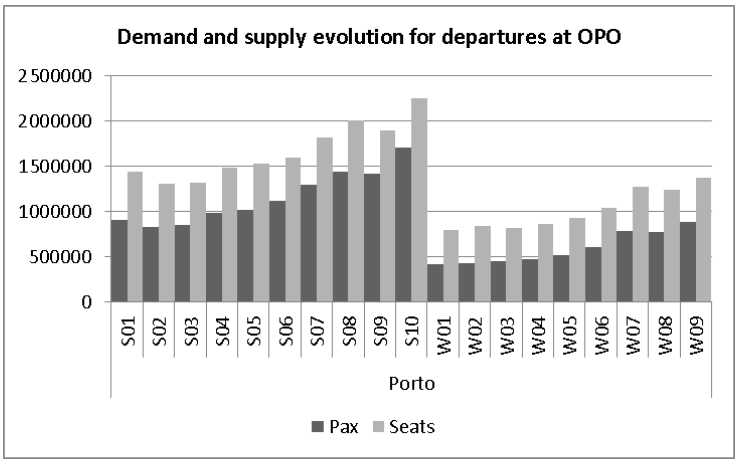


Figure 5.20 Departing passengers and seat capacity of Porto Airport.

Figure 5.19 shows the evolution in the same terms for the Lisbon airport and Figure 5.20 for Porto. In both cases the general trend is similar with a slight decrease in the traffic for the summers of 2002 and 2003 and a sustained growth afterwards, except for a drop in the levels of Winter 2008 / Summer 2009. The growth rate is much more significant in OPO, where traffic almost doubled at the end of the decade. Seasonality is less strong in both airports as well, and winter figures are normally over half of summer numbers. Load factors are comparatively low in relation to Faro, with an interesting behaviour in Porto thanks to the rise in the number of passengers.

Tables Table 5.5 and Table 5.6 show the evolution of load factors (the ratio between the number of passengers and seats offered) for each airport across the entire analysis period and distinguishing by type of carrier. The numbers are formatted on a green shade to increase readability, the darkest green indicating load factors over 80% and the lightest green (almost white) below 50%. Average values per season, airport and type of carrier are also displayed (in terms of total passengers divided by total seats in each case, not the average of the values presented since that would not be representative).

Load	Faro					Lisbon					Porto				
factor	CHA	FSC	LCC	REG	Mean	CHA	FSC	LCC	REG	Mean	CHA	FSC	LCC	REG	Mean
Mean	**85%**	**75%**	**82%**	**57%**	**82%**	**74%**	**66%**	**76%**	**51%**	**66%**	**75%**	**63%**	**79%**	**57%**	**66%**
S01	89%	83%	81%	55%	86%	70%	70%	69%	50%	68%	68%	66%	75%	51%	63%
S02	88%	80%	81%	66%	84%	78%	68%	61%	51%	67%	79%	65%	63%	57%	64%
S03	86%	78%	79%	72%	83%	74%	68%	72%	55%	67%	78%	65%	47%	60%	65%
S04	86%	78%	83%	53%	84%	77%	67%	75%	54%	67%	79%	68%	62%	59%	67%
S05	87%	80%	85%	45%	85%	74%	69%	80%	51%	68%	76%	67%	79%	56%	66%
S06	87%	81%	86%	56%	85%	75%	72%	79%	59%	72%	75%	68%	84%	65%	70%
S07	85%	82%	84%	84%	84%	75%	72%	78%	58%	73%	76%	69%	80%	58%	71%
S08	87%	78%	86%	66%	85%	77%	71%	78%	61%	72%	77%	66%	81%	79%	72%
S09	86%	76%	85%	84%	84%	80%	72%	83%	66%	74%	77%	69%	82%	72%	75%
S10	85%	75%	83%	79%	82%	81%	73%	82%	68%	74%	79%	70%	82%	71%	76%
All airports average: Carrier CHA **82,71%** FSC **66,17%** LCC **79,61%** REG **53,35%** General average **69,54%**															

Table 5.5 Load factors per airport, type of carrier and summer periods.

Load	Faro					Lisbon					Porto				
factor	CHA	FSC	LCC	REG	Mean	CHA	FSC	LCC	REG	Mean	CHA	FSC	LCC	REG	Mean
Mean	**85%**	**75%**	**82%**	**57%**	**82%**	**74%**	**66%**	**76%**	**51%**	**66%**	**75%**	**63%**	**79%**	**57%**	**66%**
W01	80%	61%	72%	42%	72%	59%	57%	48%	46%	56%	76%	53%	50%	51%	53%
W02	80%	57%	71%	54%	70%	70%	56%	47%	44%	55%	74%	51%	59%	49%	51%
W03	75%	62%	75%	-	72%	71%	58%	63%	46%	57%	65%	55%	74%	53%	54%
W04	74%	67%	76%	-	73%	49%	59%	74%	45%	58%	53%	56%	73%	50%	55%
W05	68%	61%	73%	78%	69%	63%	59%	69%	45%	58%	73%	53%	70%	52%	56%
W06	75%	56%	72%	71%	70%	64%	60%	70%	45%	60%	63%	53%	73%	55%	58%
W07	78%	67%	77%	48%	75%	73%	60%	73%	48%	62%	66%	56%	71%	59%	62%
W08	80%	58%	78%	68%	74%	70%	59%	71%	50%	60%	69%	53%	77%	59%	62%
W09	81%	55%	78%	-	74%	70%	63%	76%	61%	65%	68%	56%	76%	59%	65%
All airports average: Carrier CHA **82,71%** FSC **66,17%** LCC **79,61%** REG **53,35%** General average **69,54%**															

Table 5.6 Load factors per airport, type of carrier and winter periods.

As proposed before, Faro shows the higher load factors due to the bigger proportion of charter and low-cost airlines, the two types of carrier that are normally more eager to fill their aircraft (for LCCs more passengers mean more chances of selling in-flight catering and services, for instance). Of course, the big demand for summer trips in Faro accounts for high load factors in general for all carriers.

Lisbon and Porto, on the other hand, show lower load factors. However, it is clear how the whole picture changed for Porto after Summer and Winter 2005. Load factors increased in a way that can be related to the expansions performed in the airport and the associated new services, mainly with LCCs. This trend was further aided by the restructuration of the PGA –

Portugália network after its acquisition by TAP, revealing a surprising increase in the load factors for regional carriers in the three airports after 2007.

A closer look at the evolution in demand for each airport highlights what was previewed in the aviation network – see Figure 5.21 that shows the market share of every type of carrier, in terms of passengers for the summer periods. All routes in the filtered database are accounted for. The left part of the chart, corresponding to Faro airport illustrates the entire shift from a major charter destination to a low-cost airport. Since the growth of traffic at FAO was not outstanding, as explained before, it is valid to state that LCCs took almost all of their new passengers from charter airlines, in a gradual way. Moreover, the strong presence of Low-cost companies also had an impact on legacy carriers, reducing their share to half of their participation in the beginning of the decade.

For Lisbon and Porto, in contrast, one may argue that LCCs have caught most of the growth in demand, if not all, thus increasing their own market share. Although LIS continues as a legacy airport in which FSCs remain with over 80% of the traffic there (TAP alone accounts for over half the passengers in the airport), LCCs are making their way to hold almost 14% of demand by Summer 2010, even after most of the share of regional airlines went to FSCs when all PGA-Portugália flights started to be registered to TAP.

In Porto the growth of LCCs is evident since Summer 2005. Again, this is explained by LCCs catching the new demand, while FSCs retain similar levels of traffic along the analysis period. Since traffic almost doubled at Porto, LCCs reached a dominant position by the first time in Summer 2010, with almost half of the total passengers, meaning also that Ryanair overcame TAP as the major carrier in the airport. Regional carriers also lost most of their share when TAP took over PGA – Portugália.

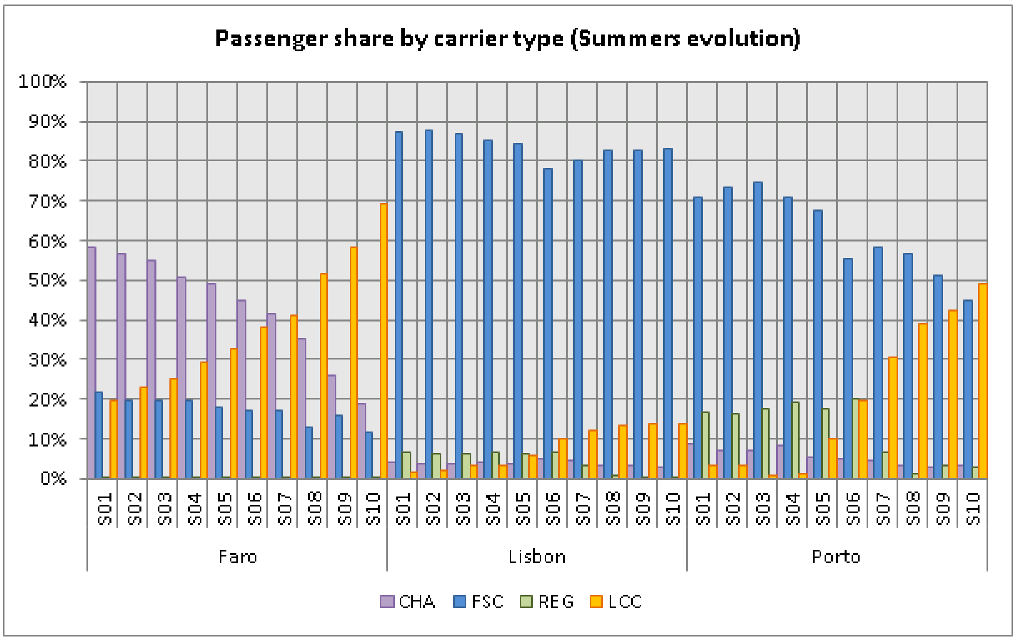


Figure 5.21 Demand evolution by type of carrier during the Summer IATA seasons.

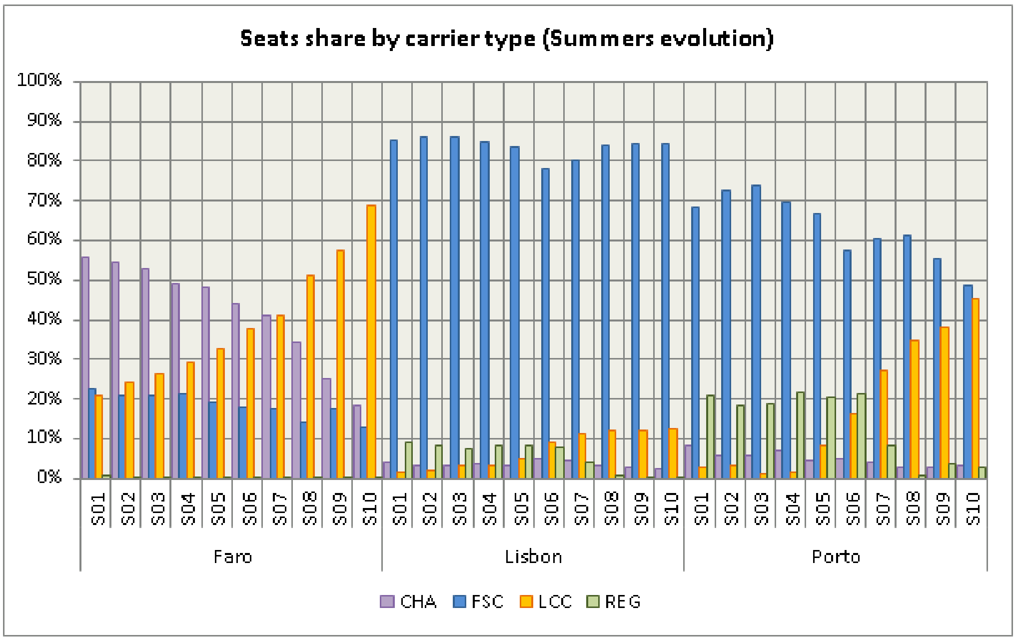


Figure 5.22 Supply evolution by type of carrier during the Summer IATA seasons.

Figure 5.22 shows a similar picture that looks almost *copy-pasted* from the one above it. It represents the evolution of supply expressed in terms of seat capacity provided by all the airlines operating at the airports. Even though the general trends are the same, there are some worth noting differences. For example, the low load factors of regional carriers account for their higher visibility in this second chart. Additionally, it is interesting to see how FSCs still remain dominant suppliers of seats in OPO, even though LCCs are carrying more passengers. The TAP route between Lisbon and Porto has a big impact in this aspect, given that it offers a very high frequency (7 daily flights on weekdays all year round for 2010) with very low load factors.

5.4.2 Airline dependency

It seems now clear that LCCs have gradually gained a strong position in the airports under analysis, even in Lisbon although to a lesser extent. This may have contributed to the offer of a wider network, and a pattern of traffic more evenly distributed across different routes. Nevertheless, it may also imply that fewer airlines are taking control over larger market shares making the airports more dependent on the future of particular carriers. That is, if an airline is responsible for a big proportion of the traffic, anything happening to that airline will have a bigger impact on the global airport business.

With airlines bankruptcies or mergers and the abandon of routes not so unusually occurring, the dependence on single or few airlines leads to higher uncertainties for airport operators. This is not just something to fear, but also an attention call for the managers to build a stronger relationship between airports and airlines. A closer understanding of the airlines' needs would make them keen to stay at the airport and provide it with a good level of passengers to develop enough non-aeronautical revenues.

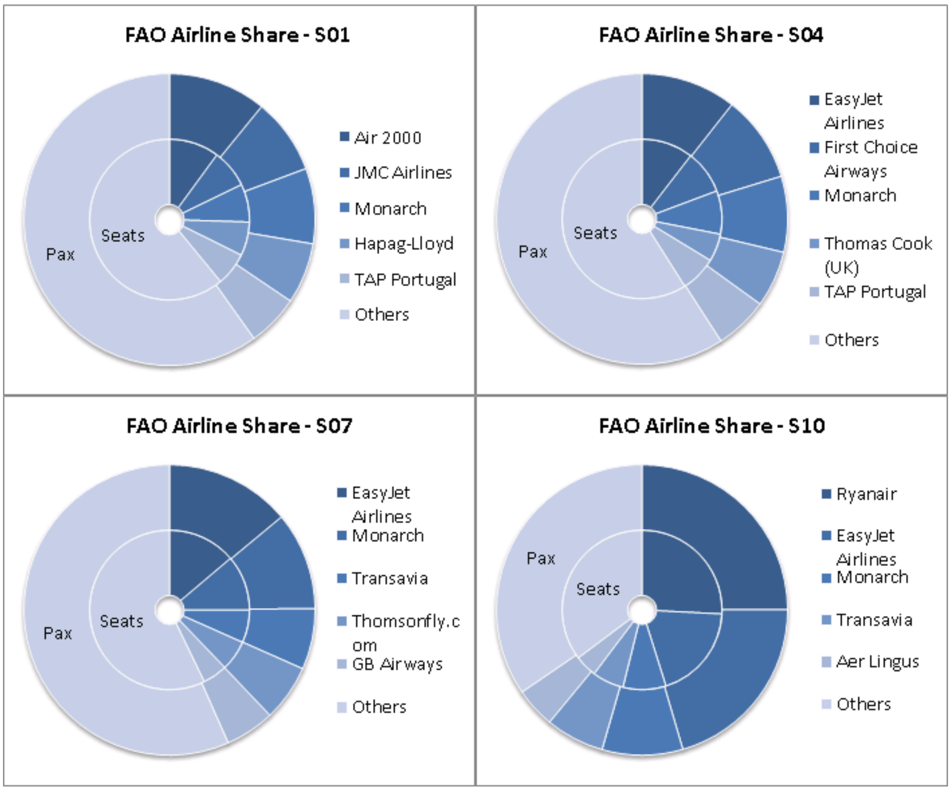


Figure 5.23 Demand and supply share for the five major carriers in FAO.

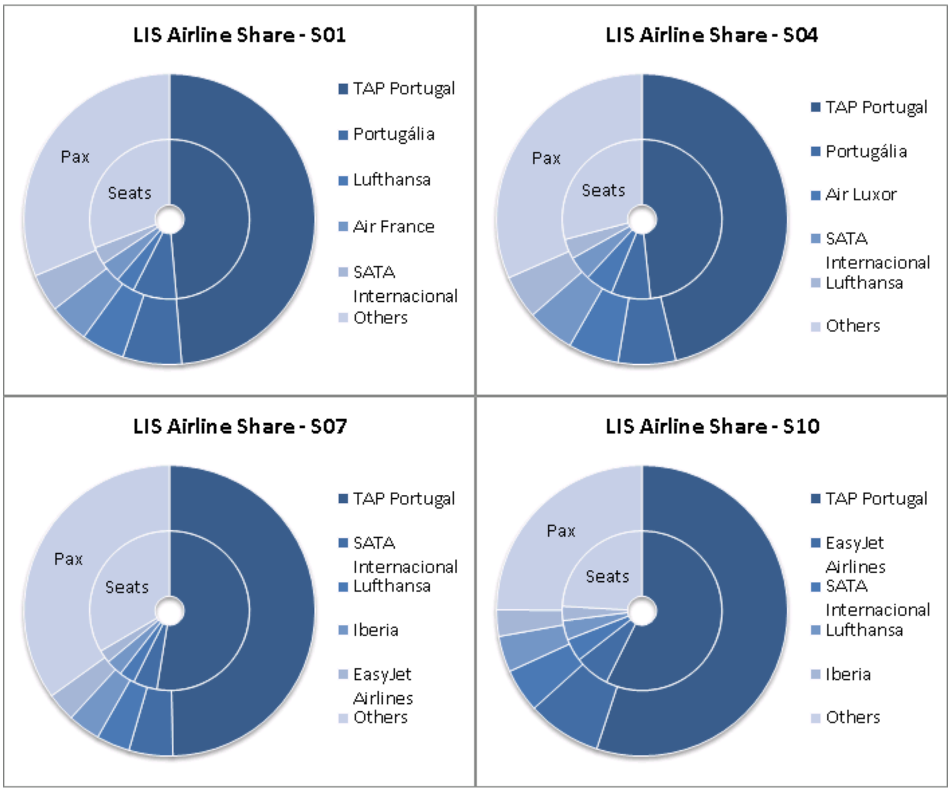


Figure 5.24 Demand and supply share for the five major carriers in LIS.

So, how strong is the dependence of the three airports on single or few airlines? Figures Figure 5.23, Figure 5.24 and Figure 5.25 show the evolution of the five major carriers in Faro, Lisbon and Porto, respectively, and how are they sharing the «cake» in terms of passengers (pax) and seats offered. The pie charts show four different periods in the time span considered (Summer 2001, Summer 2004, Summer 2007 and Summer 2010), with two years between each other to highlight the evolution.

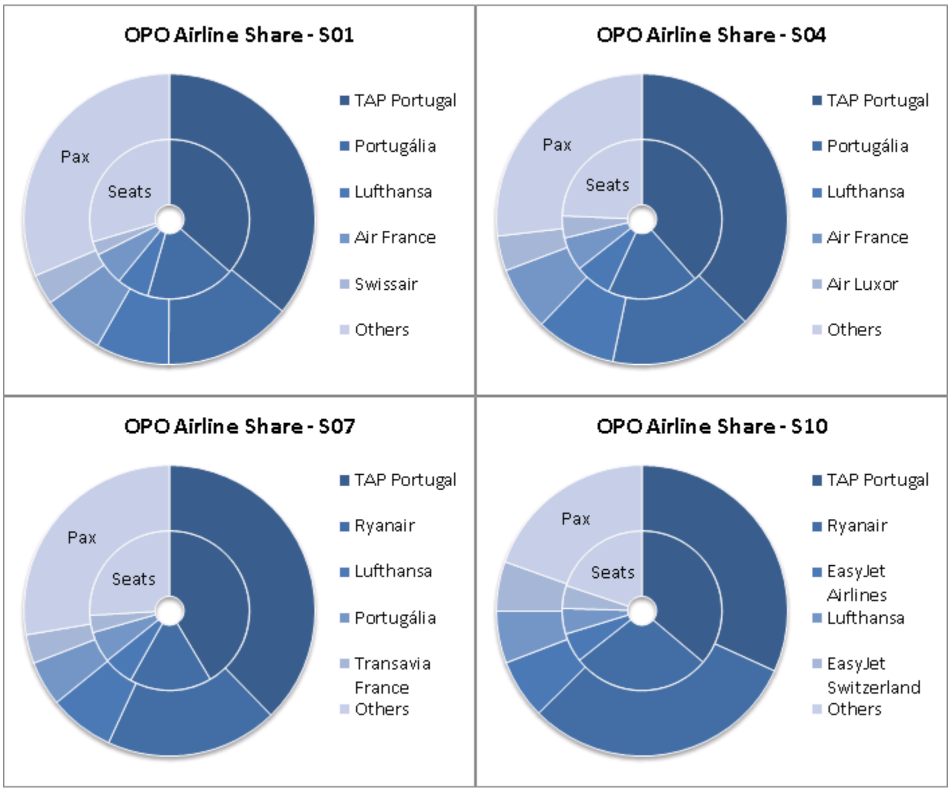


Figure 5.25 Demand and supply share for the five major carriers in OPO.

Faro airport

As for Faro, when many charter airlines were the main players in the beginning of the century, the five major carriers accounted for some 40% share in both passengers and seats capacity at the airport, and there was not a single clear dominant airline. Since easyJet bought Go Fly and bigger LCCs started to establish in FAO, these companies gradually displaced charter operators, with some space still for FSCs like TAP and GB Airways. Ryanair was in the "others" part for most of the decade, but when the airline decided to have a stronger presence in Faro it quickly appeared among the top five carriers in Summer 2009, and after basing 6 aircraft it made it to the first place. Hence, at the end of the decade, Ryanair and easyJet together made for as much as 45% (25% for the first and 20% for the second) in both demand and supply, more than the top 5 airlines in Summer 2001. The share of the other carriers outside the top five went to almost half that in the beginning. There are no significant differences in the share of seats offered and passengers carried to account for.

Lisbon airport

In the case of Lisbon, TAP has been always and very clearly the major carrier, especially after 2007 when it took part of the shares of PGA – Portugália, the second largest before, and reached virtually half of the market. By the end of Summer 2010, TAP was responsible for 55% of the passengers, with 57% of the capacity offered. Surprisingly, easyJet made its way along the other FSCs in the top positions and by the end of the decade it was placed second with 8% of the passengers and 7% of the seats offered. SATA Internacional, the airline from Azores, gets third with almost 5% of the market. From the other non-Portuguese carriers Lufthansa is the only one always present in the top 5 with a share between 3% and 5% in both passengers and seats, but always with a higher proportion in the demand than in the supply side, although without huge differences. Only one quarter of the total remains for all the other airlines operating at the airport.

Porto airport

As for Porto, there are no major changes in the first half of the decade, except for the bankruptcy of Swissair. However, after TAP bought PGA-Portugália it was Ryanair taking its part of the pie. Thus in the last period, TAP and Ryanair shared virtually the same amount of traffic, around 30% of the total, but with the low-cost offering 28% of the seat capacity, while the Portuguese flag carrier offered 36%. EasyJet appears in third and fifth place[17], adding up to 12% of the market, with almost 11% in seat capacity. As in Lisbon, Lufthansa is the only non-Portuguese FSC with a permanent position in the top 5 and again having a bigger share in passengers than in seats offered. Unlike in Lisbon, however, the German carrier holds its position with one single route to/from Frankfurt (FRA). The commercial evolution in Porto has made it the airport most dependent on few airlines (4 indeed and not 5 given the case of easyJet) from the group of three, leaving only 20% of the total for all the other airlines.

Beyond the implications for airport planning and design, the evolution of demand and supply in the Portuguese airports studied account for an aggressive competition between airlines. As discussed in chapter 4, the liberalisation of the air market brought about a strong competition between the diverse air companies. It was precisely this liberalisation, together with the airlines' freedom to choose airports, which triggered a real competition between airports. And the Portuguese market has not been exempted from it.

5.5 FSCs versus LCCs

So far, it is clear that LCCs had a significant impact on the way the aviation network for the three Portuguese airports evolved, during the first decade of the current century. When looking at the entire picture, the effect of LCCs can hide the developments of the FSCs, and the dimension of the own LCCs evolution is not fully visible. That is why this section briefly recalls the difference between the characteristics of the networks from the two different types of carriers and the way they have developed over time. All available routes are accounted for in here.

[17] Although EasyJet and EasyJet Switzerland are, in practical terms, the same airline, they are nominally two different companies so easyJet can operate the same brand in Switzerland, a country which is not part of the European Common Aviation Area, thus the liberalisation packages do not apply there.

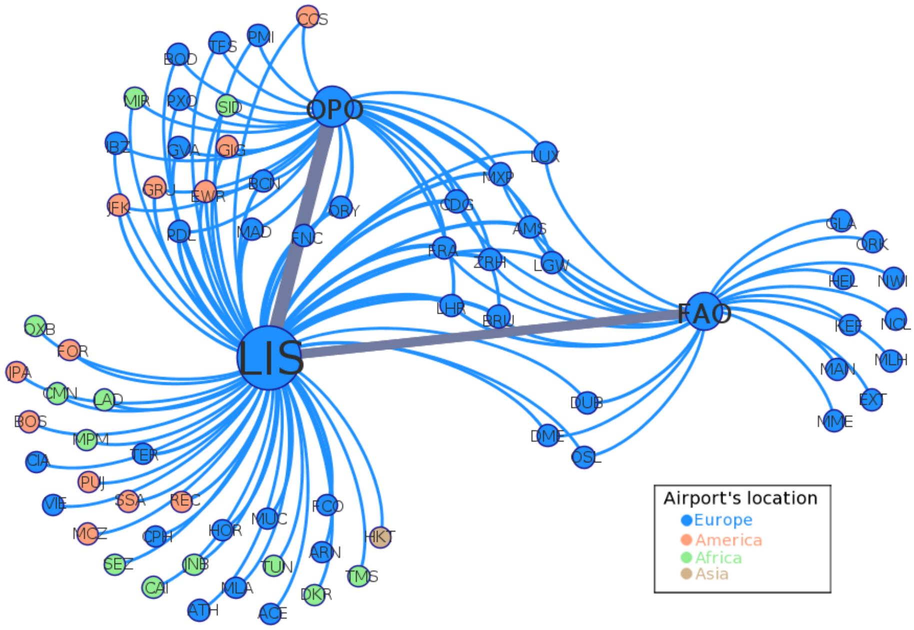


Figure 5.26 Force atlas layout for the aviation network of Full-Service Carriers in Summer 2001.

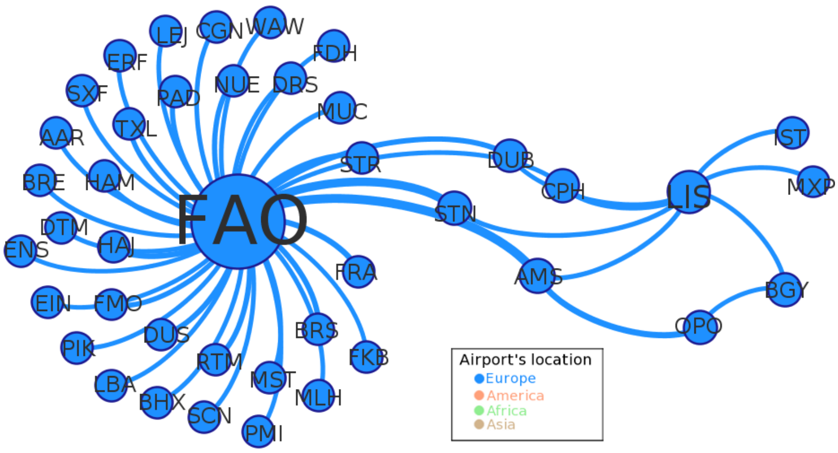


Figure 5.27 Force atlas layout for the aviation network of Low-Cost Carriers in Summer 2001.

Figure 5.26 and Figure 5.27 depict the shape of the networks, for FSCs and LCCs respectively, in Summer 2001. The thickness of the straight lines somehow exaggerates (in comparison with the other arcs) the number of passengers in the mutual connections between the three airports under study. These links also reflect almost exclusively the feeder services of TAP to its base in Lisbon. That is the reason for not having such lines in the LCCs network.

When comparing such early stages of both networks with the instances corresponding to the Summer 2010 season, presented in Figure 5.28 for FSCs and Figure 5.29 for LCCs, it is interesting to see how the small *creature* of Figure 5.27 evolved into the multi-radial network of Figure 5.29. Even more interesting if it is noticed that many of the *new* airports are actually new entrants in the market, provided that they were neither present in the early versions of the low-cost network nor in previous instances of the FSC network.

That fact is most likely linked to the growth of Ryanair's own network, which is the best example of an LCC using secondary airports, where the airline turns into the dominant carrier (with near 100% of all the traffic in some airports, like Girona) and is able to offer exclusive routes without direct rivalry from other airlines (Barbot, 2006, p. 198; Dobruszkes, 2006, p. 256). This also represents a high risk for the airports if the airline decides to leave. As an example, Girona's Costa Brava airport (GRO) in Spain appears as a destination for OPO as a rather important route (see Figure 5.16 earlier in this chapter). However, the route disappeared by Winter 2010 when Ryanair moved part of its operations from GRO to El Prat in Barcelona (BCN).

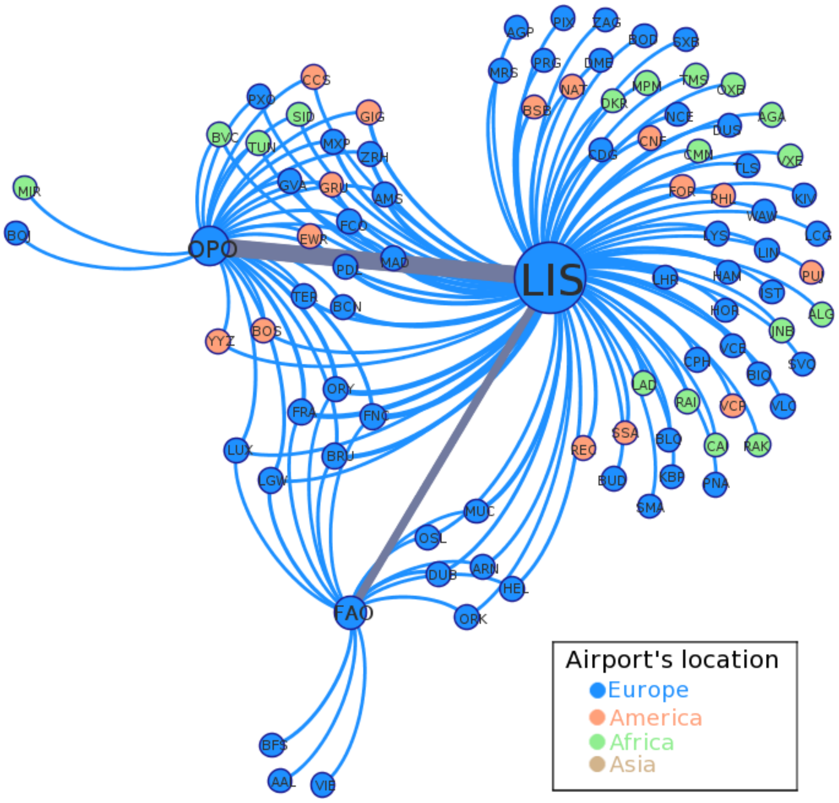


Figure 5.28 Force atlas layout for the aviation network of Full-Service Carriers in Summer 2010.

Besides that, the evolution of the LCC network in Portugal proves that low-cost airports and low-cost airlines compete with their legacy counterparts by providing an entirely alternative network, at least in the market of European destinations. As seen in Figure 5.29, almost all nodes for the LCCs are located within Europe. In fact, the only airport shown outside Europe is Antalya (AYT) in Turkey, so it is not quite an intercontinental journey.

It is also worth noting how the evolution of the aviation network for LCCs was propelled by the developments at OPO and the subsequent agreement to embrace more low-cost airlines. To illustrate this, the corresponding network for Summer 2005, just before the new Porto's passenger building opening, is shown in Figure 5.30.

The evolution of the FSC network, on the other hand, illustrates the expansion of TAP and the development of its traffic node in Lisbon, especially for intercontinental connections. Porto also gained more direct connectivity, although not in such an impressive way like for Low-cost destinations. Given the high frequency between Porto and Lisbon and the spare capacity available in OPO (at least in the passengers building), it seems reasonable to think of a further expansion for FSCs, especially TAP, in the airport. Faro, on the contrary, looses many of its exclusive *legacy* connections while FSCs ceded space for LCCs at the airport. Additionally, the FSC network is composed almost exclusively by legacy airports and it is visible how London/Heathrow (LHR) and Paris/Charles de Gaulle (CDG) were replaced by London/Gatwick (LGW) and Paris/Orly (ORY) respectively in concentrating the Portuguese connections for their own countries (at least for FSCs, of course).

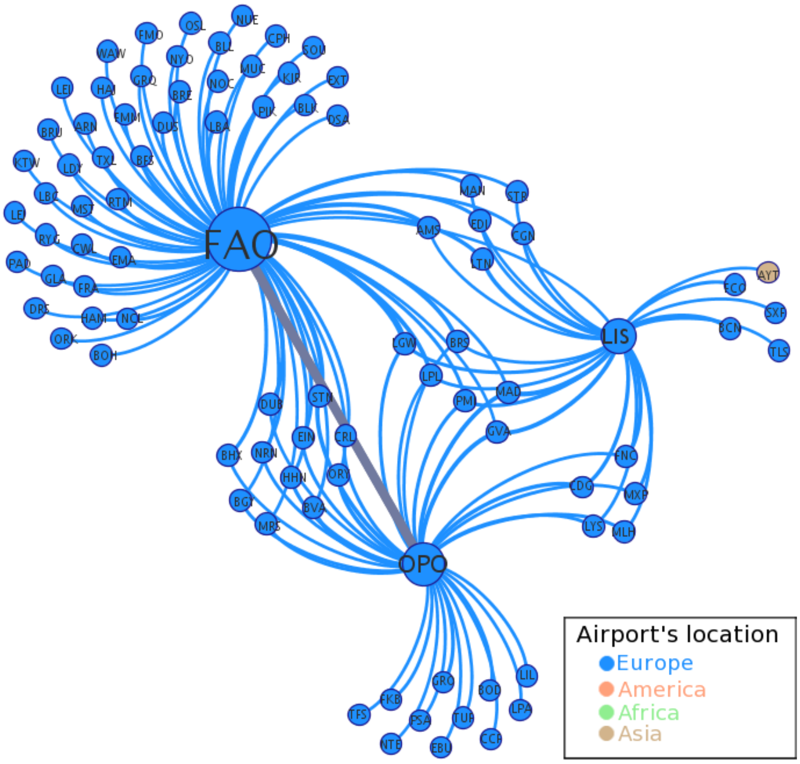


Figure 5.29 Force atlas layout for the aviation network of Low-Cost Carriers in Summer 2010.

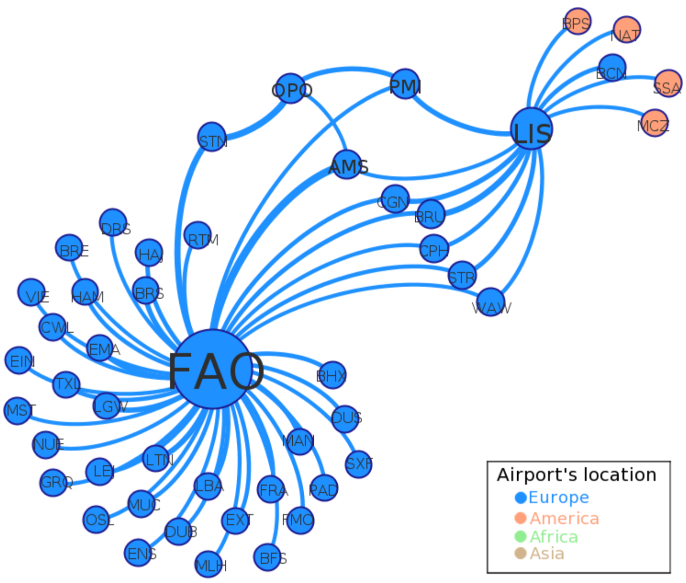


Figure 5.30 Force atlas layout for the aviation network of Low-Cost Carriers in Summer 2005.

5.6 Conclusion

The aviation network of Lisbon, Porto and Faro has evolved in a way that clearly offers evidence of the development of the low-cost revolution in the Portuguese market. LCCs have found new customers for air transportation and encouraged old travellers to fly more frequently. They have generated a fierce competition between airlines that is driving charter operators out of the intra-European market. They are responsible for the growth in passenger figures for Porto airport and for a big proportion of the growth in Lisbon. They are carrying most of the tourist coming to Algarve and possibly providing Faro airport with an opportunity to increase the number of residents flying abroad.

The three Portuguese airports are increasingly more dependent on fewer airlines and their ability to attract passengers. LCCs are occupying the place of traditional airlines as those dominant carriers in the airports, even challenging the former comfortable position of TAP. The new entrants are flying people to new and previously unknown destinations. LCCs are also requiring different standards and facilities for airport operations.

Summing up, the changes in the aviation network described in this chapter stand as an attention call for the airport operator, ANA, to recognize the importance of assessing the real needs of airlines as key customers, while taking care of passengers and other clients as essential part of the airport business too. The next chapter recalls the findings of the current chapter regarding airport competition in the aviation network, and makes them more explicit. It also analyses the role of ANA in a more competitive environment.

6 The network, the operator and the impact of competition

The previous chapter described the evolution of the aviation network for the three Portuguese airports under study. Across that description different examples of competition between airports were highlighted, either within the Portuguese airports or between other airports that are connected to the Portuguese airports. This chapter further explores the evidence of airport competition in the aviation network, with a deeper analysis on a set of destinations with an interesting behaviour regarding demand allocation among the airports served. Additionally, a review of some key planning documents for the Portuguese airports has been conducted to investigate whether ANA, as the manager, was aware of competition for its airports and how does the operator tackle the issue. It seems that ANA is strongly developing the concept of Airport Marketing; however, it does not appear to be properly linked to infrastructure development plans. Thus the chapter concludes with a discussion on the relationship between both areas and on how this relationship can improve the airport competitiveness.

6.1 Competition in the aviation network

The way the aviation network has evolved reflects the existence of competition between airports, namely with the appearance of new destinations served mainly by low-cost carriers. However, there is more interesting information in the network that is not visible in some of the graph-like layouts presented so far. Therefore, this section presents a deeper analysis on particular examples of airport competition that also show how decisions in some airports are affecting the outcome in others.

6.1.1 Portuguese airports

Although Faro, Lisbon and Porto airports are all owned and operated by the same company, it seems that common ownership does not prevent competition. Even though they all set similar prices for aeronautical fees, there are ways of competition (see section 4.4) that are not entirely dependent on airport prices for airlines or for which other aspects are more relevant. Common ownership, on the contrary, might be an opportunity to tackle competition with networked decisions using all the airports to accomplish joint goals. Bel and Fageda (2009), however, argue that common ownership of most airports in Spain has indeed prevented competition on the grounds of a non-existent inter-territorial solidarity. At the same time they show how the Spanish airports compete among them to attract public funds.

The three Portuguese airports present similar levels of prices, fixed by the Portuguese government, as shown in Figure 6.1 for landing fees, and in Figure 6.2 for passenger fees. As we can see, there is no direct price competition regarding landing fees, but passenger fees favour Porto before Lisbon and Faro before both[18]. However, airport prices alone do not explain the evolution experienced by the three airports. Figure 6.3 shows how the passenger traffic shares have evolved during the period of study for FAO, LIS and OPO. Even though the Lisbon airport has retained over half the demand for Continental Portugal, Porto has succeeded more than Faro. During the same period LIS and OPO have implemented higher levels of investments in capacity expansion.

	LISBON	PORTO	FARO	AZORES
LANDING/TAKE OFF - per tonne				
Aircrafts up to 25 tonnes, per tonne	4,35	4,35	4,35	3,07
25 to 75 tonnes, per tonne above 25 tonnes	5,28	5,28	5,28	3,76
over 75 tonnes, per tonne above 75 tonnes	-	-	-	4,42
75 to 150 tonnes, per tonne above 75 tonnes	6,21	6,21	6,21	-
over 150 tonnes, per tonne above 150 tonnes	5,28	5,28	5,28	-
Technical Stops - value per tonne	4,04	4,04	4,04	3,33
Minimum charge per operation - up to 10 tonnes	106,64	-	-	-
Minimum charge per operation - 11 to 25 tonnes	170,63	-	-	-

Figure 6.1 Landing fees for ANA airports (all prices in Euros). Source: ANA (2010b)

	LISBON	PORTO	FARO	AZORES
PASSENGER SERVICE CHARGE				
Flights inside Schengen Area	7,45	7,43	7,25	5,95
Intra EU flights outside Schengen Area	9,50	9,45	9,19	9,47
International flights	12,66	12,62	12,32	12,64

Figure 6.2 Passenger fees for ANA airports (all prices in Euros). Source: ANA (2010b)

It should be noted that the growth of Porto's share is higher after the new terminal was opened by the end of 2005, and that this share increased later with the establishment of LCCs and the decision of ANA to market the airport in the Galicia region in Spain.

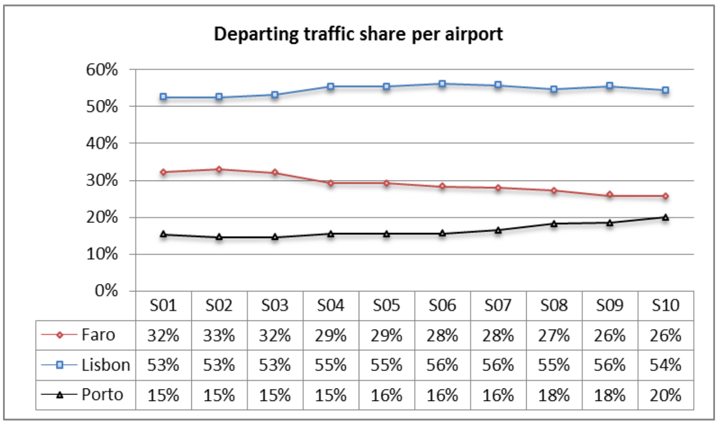


Figure 6.3 Evolution of the traffic share for the Portuguese airports.

[18] It is worth noting that landing and passenger fees are not the only charges that account for airlines costs in an airport.

The way in which airlines influence the competition between airports is clear for the analysed aviation network. Figure 6.4 shows the evolution of services to London/Heathrow from the three airports while Figure 6.5 illustrates the same in relation to London/Gatwick. It is clear that the Lisbon airport had the best results in what regards to direct connections to Heathrow while routes to Gatwick are dominated by Faro. This is an example of how decisions regarding the role of the airports in London impact the outcomes for the Portuguese airports.

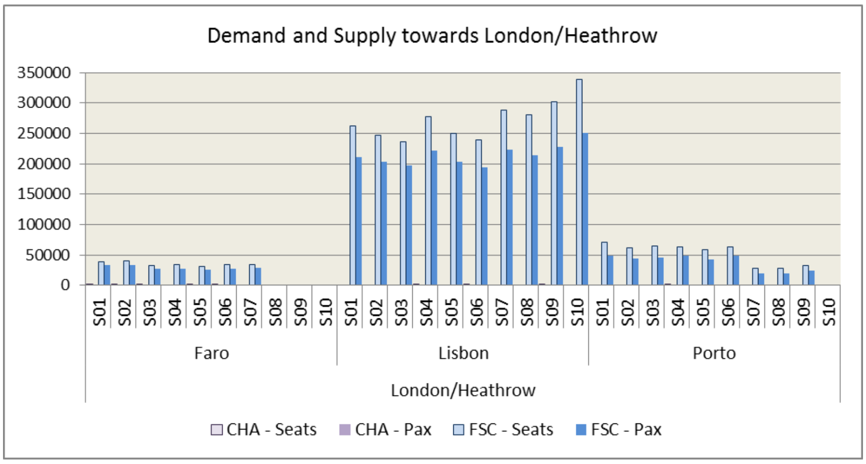


Figure 6.4 Passengers and seats level evolution in the routes to London/Heathrow.

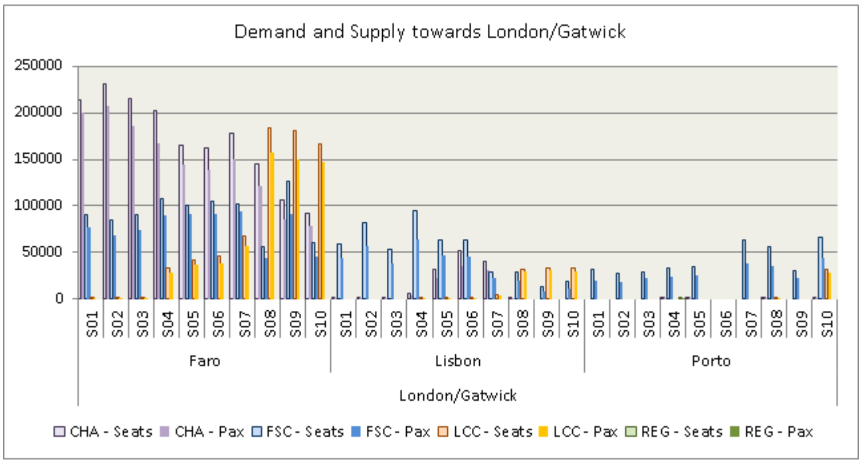


Figure 6.5 Passengers and seats level evolution in the routes to London/Gatwick.

In a similar way the decision of an airline, such as Air Berlin, and an airport, such as Palma de Mallorca (deciding to become a hub for the German carrier), affect the traffic pattern in the Portuguese airports (as seen in Figure 6.6). In this case, the increased demand produced by the new airline reached a similar level in the three airports (FAO, LIS and OPO), although to a lower extent in Faro, surprisingly, where the airline did not have any strong competitor.

There was no available information to analyse how the three airports are competing for passengers in their catchment areas (for instance whether passengers in Coimbra prefer Lisbon or Porto). Nevertheless, some insight was gained on the matter through the planning documents from ANA analysed in section 6.2. And the available dataset allows an evaluation of airport competition for other European airports in the network, as shown next.

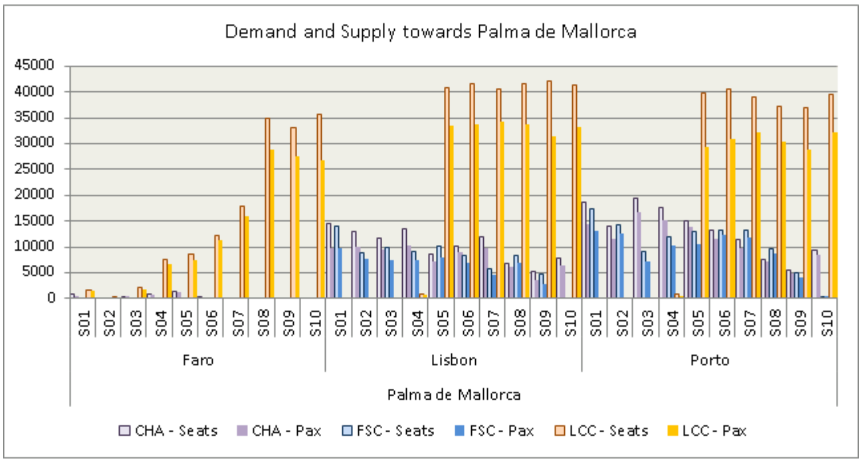
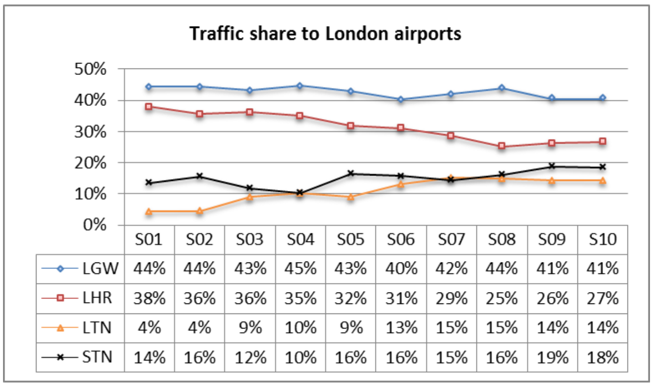


Figure 6.6 Passengers and seats level evolution in the routes to Palma de Mallorca.

6.1.2 Other European airports

The effect of airport competition is clearly visible in some European destinations. In fact, the traffic from Continental Portugal experienced a transition to less traditional airports. The existence of several low-cost and legacy airlines in England, along with a long history of privatised or commercialised airports, is a good example to show, as seen in Figure 6.7 and Figure 6.8. The first of this figures refers to the change in traffic shares for passengers utilising the routes connecting the Portuguese airports (FAO, LIS and OPO) to the London area[19]. It can be seen how Heathrow (LHR) has lost over 10% of the market by remaining only with the routes to/from Lisbon as described previously; Gatwick (LGW) has also lost part of its participation while Stansted (STN) and Luton (LTN) have grown by embracing LCCs more avidly. This is especially true with Luton that was able to catch the growth experienced by easyJet in Lisbon.



	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
LGW	44%	44%	43%	45%	43%	40%	42%	44%	41%	41%
LHR	38%	36%	36%	35%	32%	31%	29%	25%	26%	27%
LTN	4%	4%	9%	10%	9%	13%	15%	15%	14%	14%
STN	14%	16%	12%	10%	16%	16%	15%	16%	19%	18%

Figure 6.7 Evolution of traffic shares in London airports for routes from FAO, LIS and OPO.

Figure 6.8 shows a similar yet more dramatic situation for the airports of Manchester (MAN), Liverpool (LPL) and Leeds/Bradford (LBA), all of them located in North West England and near the Greater Manchester. As Barret (2000) states, Manchester airport changed its policy of attracting LCCs in 1999. This favoured a shift of such airlines to Liverpool and Leeds/Bradford. Indeed, LPL had been a stronger player for the low-cost segment earlier than

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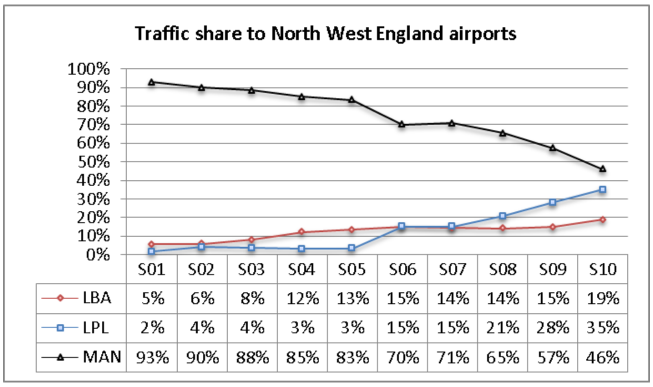
[19] London City Airport is not included given its very low participation in the market and the particular niche of business traffic that it serves.

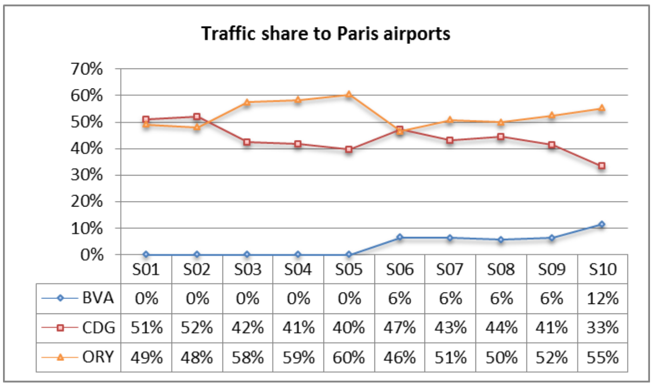
LBA and it is located half the distance from MAN than LBA, explaining a bigger share for Liverpool. Additionally, Manchester airport has been among the top routes from Faro for the entire period of analysis and it is largely served by charter operators. As a consequence, the growth of LCCs in FAO proved to be an opportunity to increase competition between the English airports.

The big leap between Summer 2005 and Summer 2006 stands out for the start of the Ryanair service OPO–LPL and easyJet service FAO–LPL while at the same time PGA – Portugália abandoned the OPO–MAN route. At the end, Manchester airport ended the decade with half the quasi-monopolistic share it had in the beginning. Liverpool grew from a minor 2% to the second position with 35%, and Leeds/Bradford increased its share in the Portuguese market in almost four times.



	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
LBA	5%	6%	8%	12%	13%	15%	14%	14%	15%	19%
LPL	2%	4%	4%	3%	3%	15%	15%	21%	28%	35%
MAN	93%	90%	88%	85%	83%	70%	71%	65%	57%	46%

Figure 6.8 Evolution of traffic shares in North West England airports for routes from FAO, LIS and OPO.



	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
BVA	0%	0%	0%	0%	0%	6%	6%	6%	6%	12%
CDG	51%	52%	42%	41%	40%	47%	43%	44%	41%	33%
ORY	49%	48%	58%	59%	60%	46%	51%	50%	52%	55%

Figure 6.9 Evolution of traffic shares in Paris airports for routes from FAO, LIS and OPO.

Outside England there are other interesting examples, also with the participation of low-cost airports as new entrants. The airports serving the Paris region[20] are one of those examples, illustrated in Figure 6.9. Charles de Gaulle (CDG) and Orly (ORY), both owned and operated by Aéroports de Paris, show a remarkable behaviour of substitute products with similar share's trends, until the appearance of Beauvais (BVA) that accounted for a deeper fall in ORY's participation in the short run and CDG in the long run. Additionally, Air France, by

[20] As with London/City, Paris/Le Bourget was not included for the same reasons stated in that case.

abandoning the route to CDG from OPO, and TAP, by changing its focus from CDG to ORY in the route from OPO, have also accounted for the loss of dominance of the largest French airport in the Portuguese market. Interesting to note how BVA gets 12% of the share with one single airline, Ryanair, serving two routes in FAO and OPO. In fact, the share doubled after the LCC opened its base in Faro and created the route for Summer 2010.

Frankfurt/Hahn (HHN) in competition with Frankfurt (FRA) stands out as another example. Despite its name, HHN is located 120 km away from the city of Frankfurt, the same distance from Luxembourg, a country with strong migration flows from Portugal. As shown in Figure 6.10, HHN quickly gained a significant participation when Ryanair started its route from OPO in Winter 2005 and a further step up with the route from FAO in Summer 2007.

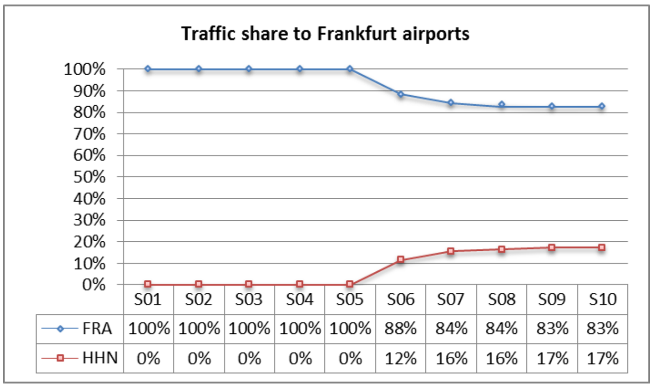


Figure 6.10 Evolution of traffic shares in Frankfurt airports for routes from FAO, LIS and OPO.

Figure 6.11 Terminal 2 at Frankfurt Hahn.

Frankfurt/Hahn comes from a former military base and the investments made to turn it into civilian operations were supported by Fraport, the owner of Frankfurt Airport. Therefore, for most of the period of analysis, both airports also shared common ownership without preventing them from competing. Actually, HHN is engaged in a very strong price competition, since it does not charge any landing fee for most of the aircraft used by LCCs, provided that the turn-around time is no higher than 30 minutes (Frankfurt Hahn Airport, 2006). The airport is also a prototype of low-cost airports, with very simple and inexpensive facilities, as shown in Figure 6.11. In 2009 the Fraport share was sold to the German state of Rhineland-Palatinate that owns now 82,5% of the airport, the rest being owned by the state of Hesse (Frankfurt Hahn Airport, n.d.). The change in ownership is not reflected in the traffic evolution.

6.1.3 Some routes

The evidence of airport competition can be further supported by looking at a selection of routes in which traffic demand has had considerable changes along the analysed decade. Most of the examples provided in here are related to Faro and Porto airports. This is explained by the fact that Lisbon has kept its position as a legacy airport, thus serving traditional airports across Europe and the world, as described in chapter 5. Nevertheless, the decreasing trend in passengers and seats figures in domestic routes from Lisbon to Faro and Porto presented in Figure 6.12 may be related to the network expansion experienced especially in Porto. There is no information regarding how many of those passengers were transferring to or from another flight in Lisbon, though.

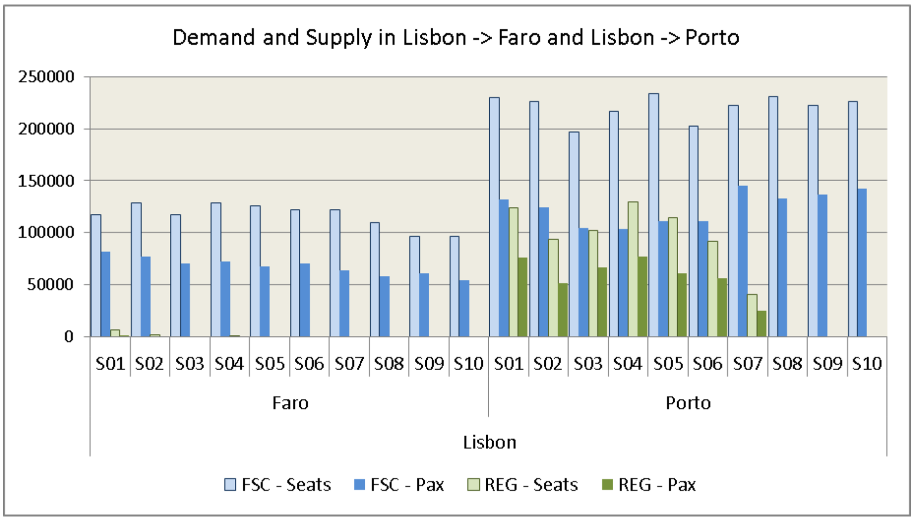


Figure 6.12 Demand and supply evolution in routes from LIS to FAO and OPO.

A clear example of new entrants strongly competing with established airports can be seen in Figure 6.13 for London airports and Figure 6.14 for Paris airports in relation to Porto. Additionally, it shows how the low-fare availability in OPO accounts for the largest proportion of the growth in demand to both destinations. As a matter of fact, Stansted enters the market and gets as much as the joint traffic of Heathrow and Gatwick together after the first full summer of operations. Some 10 thousand passengers are lost by Stansted in Summer 2010 when easyJet started its route to Gatwick; at the same time Heathrow was abandoned by FSCs and its capacity and demand were transferred to Gatwick as well.

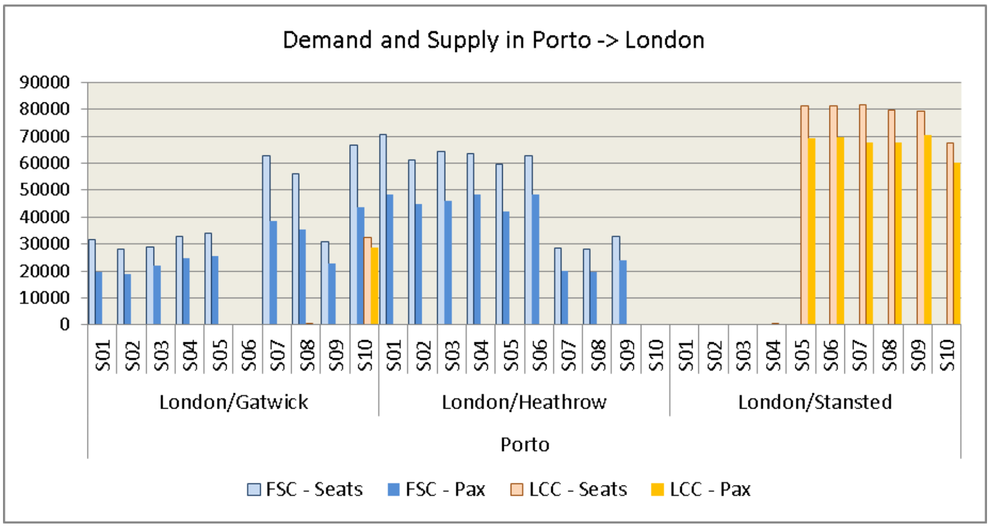


Figure 6.13 Demand and supply evolution in routes from OPO to London airports.

A similar trend is observed in Paris airports where Beauvais enters in 2006 with a total demand of over half the total traffic to Charles de Gaulle and nearly 40% that of Orly. This happened one year after Air France abandoned Porto as a destination and PGA – Portugália was not able to satisfy the same level of demand to Charles de Gaulle for Summer 2006. The following year Transavia started operations to Orly, providing a higher share to the airport and reducing the share of Charles de Gaulle. However, CDG recovered when easyJet opened its route there, but also suffered because TAP redirected its flights to Orly.

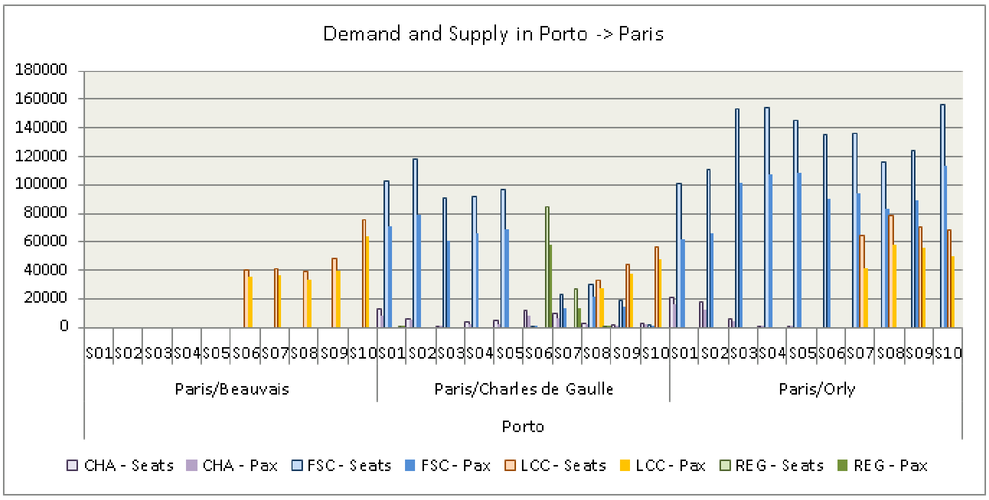


Figure 6.14 Demand and supply evolution in routes from OPO to Paris airports.

Similar findings are presented in the routes from Faro to Brussels airports in Figure 6.15, and London in Figure 6.16. The case of Brussels, besides competition with Charleroi, also shows the change in the mix of traffic to Brussels (Zaventem) after the bankruptcy of Sabena in 2001, which reappeared only in 2007 as Brussels Airlines. This is why there are no FSCs in the route during the period in between. Precisely during that time charter airlines and the low-cost Virgin Express filled the space left by the Belgian flag carrier, only until Virgin Express went bankrupt too and its share was replaced by JetAir (the former charter company TUI Belgium, turned low-cost and rebranded). It seems that Ryanair has been more successful in its route to

Charleroi. For Summer 2010 it was able to carry 19 629 passengers, compared to 28 726 by all carriers in Brussels. Moreover, the LCC offered only 23 960 seats, compared to 45 818 offered by the other airlines in the competing airport.

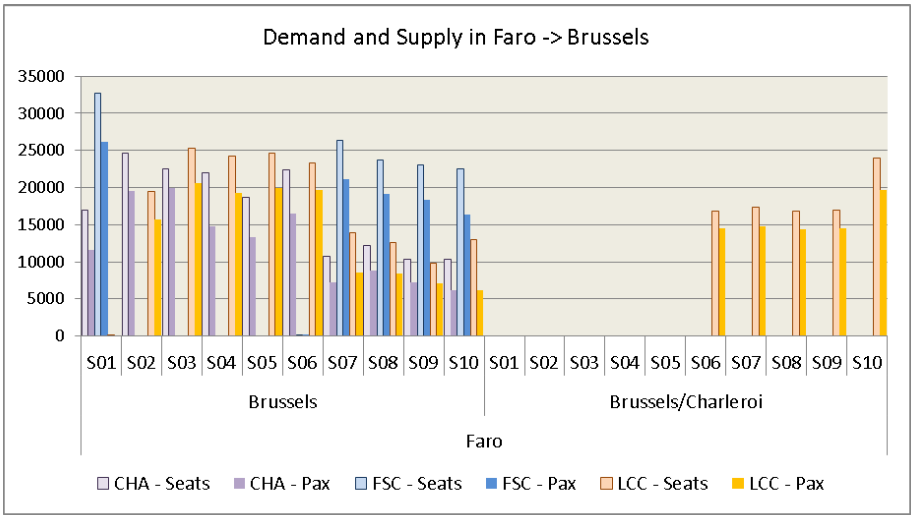


Figure 6.15 Demand and supply evolution in routes from FAO to Brussels airports.

Concerning the routes to London, it should be noted that Faro was the only one (in the three Portuguese airports) offering regular services to the four largest airports in the English capital, until TAP abandoned the direct connection to Heathrow in the Summer of 2007. For the remaining three airports a strong struggle among LCCs and charters is noticeable, with participation of FSCs as well in Gatwick, making it the most important destination for Faro during the entire decade and yet one of the largest routes in terms of passengers for the Portuguese airports.

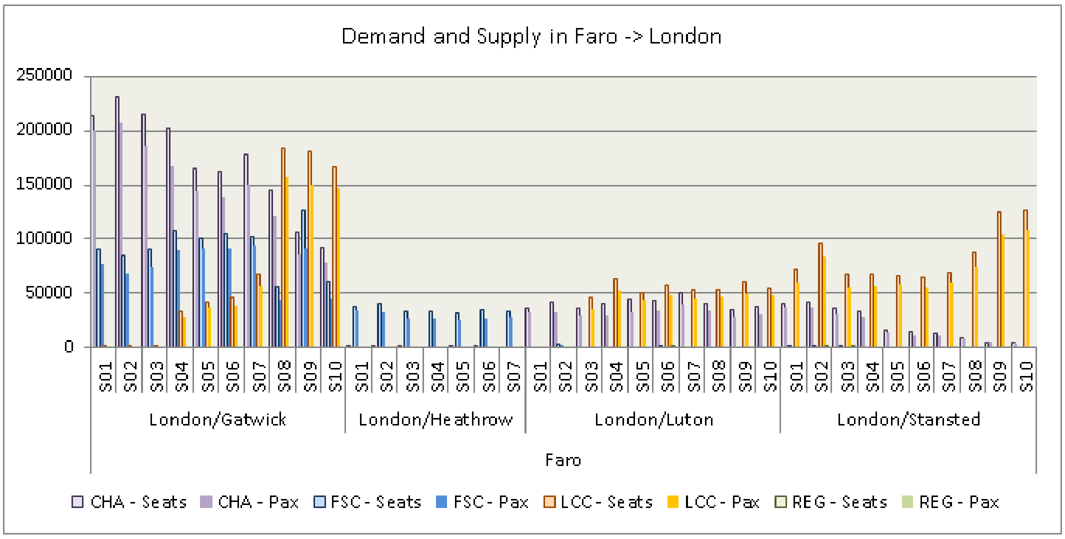


Figure 6.16 Demand and supply evolution in routes from FAO to London airports.

Despite the evidence of airport competition that may be found in the aviation network, it is important to know to what extent the airport operators were aware of it and what line of action have they followed to face their competitors. In this line, the following section aims at understanding how the Portuguese operator, ANA, has been dealing with this matter.

6.2 ANA and the competition

ANA Aeroportos de Portugal SA is a fully state-owned company. Inside its organizational structure, each of the three airports under study works as a business unit, directly depending upon the management board. However, there are some corporate centres associated to activities with implications in all the airports, such as the Directorate of Planning and Management Control or the Directorate for Airport Marketing and Strategy. As an example, the Master Plan for Algarve Airport (ANA, 2007b, p. 19) states that the local management in Faro plays a “passive role” regarding non-aeronautical activities, since they are centralised in the Retail, Real State and Special Projects Directorate in ANA’s headquarters at Lisbon.

Nevertheless, the most important documents referring airport competition come from the airports in Porto and Faro. Indeed, it is again Faro’s Master Plan (ANA, 2007b, p. 79) that summarizes what has been discussed across this dissertation in a simple way: “The changes in the air transportation industry, resulting, in part, from its liberalization in Europe, had a profound impact on intra-European air transportation and on tourism. Airports are currently facing a highly competitive environment, competing amongst each other to attract new air transportation capacity that companies, mainly the low cost carriers, place on the market.” Later on, the document adds that airport marketing is recognized as an effective tool to tackle airport competition. Actually, the marketing plans contained in the master plans for OPO and FAO (ANA, 2007a, 2007b) are the main base for any fruitful discussion to follow regarding the level of awareness of the airport operator on the subject.

6.2.1 Porto airport

Throughout the entire marketing plan for Porto airport, we can verify a high level of concern regarding the airports in Galicia, namely Vigo, Santiago de Compostela and La Coruña. In this sense, OPO recognizes competition with the Spanish airports in terms of demand within the catchment area. Particular attention is devoted to the competition in the connections that all the airports offer to Madrid and Barcelona, especially due to the character of feeders or spokes of the Galician airports in the airline networks of Spanish carriers, such as Iberia and Spanair.

Within this context, Porto airport recognizes Santiago de Compostela (SCQ) as the main competitor in the area. SCQ is not only conveniently located in the middle of Galicia, but it also holds the higher levels of traffic from the three Spanish airports mentioned before. In fact, the marketing plan mentions the fact that “AENA seems decided to bet in one single airport for the entire Galicia. In fact, the recent announcement for the construction of [new infrastructure investments] shows its willingness to centralize operations in Santiago [de Compostela].” (ANA, 2007a, p. 66) Such investments for around € 135 millions (according to ANA) “may pose a threat to Porto”.

Interestingly, Santiago de Compostela was the only one of the three Spanish airports in Galicia offering low-fare flights with services of Ryanair since 2005 (Ryanair, 2005). However, the Irish airline is to withdraw from the airport by 2011. In its official announcement (Ryanair, 2010), the LCC encourages its clients to change their tickets to routes from alternative airports, such as Porto or Madrid.

The marketing plan for Porto highlights the airport as more competitive than its Galician competitors in terms of capacity offered by their infrastructures, both in the air and the land sides. As a matter of fact, by 2005 OPO had almost as much traffic as the three Spanish airports altogether. Additionally, in a comparison of prices in place by 2006, OPO is found to be cheaper regarding landing fees and traffic control costs inside the airport. However, the airport management shows a big concern because passenger handling and security fees were much higher than in Spain, despite parking costs were significantly reduced after the new developments in the airport (ANA, 2007a).

Although Porto's management did not have enough information to compare air fares for passengers in all routes, significant differences were found only in the routes OPO–MAD and VGO–MAD with almost half the price in Vigo (VGO). Nevertheless, this comparison was made in a time when LCCs were still developing in Porto, thus ticket fares were to be lower in the following years.

Precisely in that direction, the marketing plan for OPO calls the attention for the need to adapt actions to the different requirements of FSCs and LCCs, and to show that the airport was able to handle both demand segments. In fact, its traffic forecast provides for a growth of around 68% in the low-cost share between 2006 and 2011, while only 2% for FSCs in the same period. Even though the actual figures confirmed a higher increase in the low-cost segment, and a small decrease for the FSCs (as seen in Figure 6.17), it is important to note that the document shows the willingness to embrace a mixed traffic to support the airport development and increase it competitiveness.

It is a pity that the marketing plan was done after the first phase of the investments to expand the capacity in the airport was already completed. In this way, Porto built traditional *legacy* (i.e., expensive) facilities into its new passenger building. An award-winning terminal that is now being extensively used by low-cost companies that normally demand for lower standards.

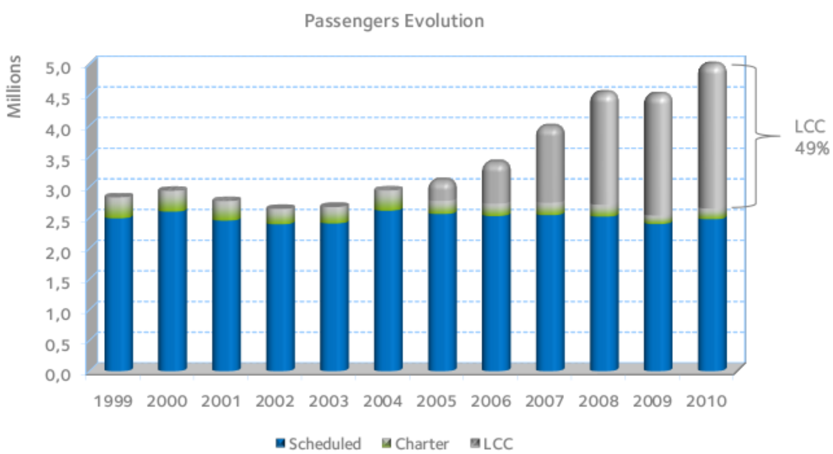


Figure 6.17 Total passengers evolution (1999 - 2010) in Porto airport. Source: ANA (2011).

In a more recent document (ANA, 2011) Porto airport withdrew La Coruña from its direct competitors, but included Lisbon in the list. According to OPO's management, it remains in competition with Vigo and Santiago de Compostela for the network provision to passengers, as explained in section 4.4 (see Figure 4.1 for quick details). The competition with Vigo has been more directly and strongly stated since the launch of the *voyporoporto.com* campaign in 2010, especially directed to the passengers residing in Galicia. In this website, the airport performs a comparison on a by route basis with the services offered in Vigo and advertises exclusive services, such as a waiting room dedicated to Galician passengers with access to local media.

Additionally, OPO recognizes itself as competing with Lisbon for the provision of services to airlines, given the constrained operational conditions and limited slots availability in LIS; but also competing for passengers in an extended catchment area in the form of airport convenience and low-fares access (again, refer to Figure 4.1 for these types of competition), based on what they call "catchment area passengers reluctance in using Lisbon Airport".

6.2.2 Faro airport

Regarding Faro Airport, its marketing plan contains an entire section devoted to airport competition. However, since FAO is identified as a leisure inbound airport, competition for outbound traffic residing in the catchment area is not the main subject. On the contrary, the airport is a very good example of the *scope competition* identified in section 4.4.3 and the management recognizes that any airport serving tourist destinations with similar characteristics to those of the Algarve region accounts as a potential competitor. In this sense, Table 6.1 shows the most relevant airports identified by FAO as competitors; they are classified in three categories related to the geographical context of each group.

Type of competing airport		Airports competing with Faro
I	Airports with overlapping catchment areas.	Seville; Jerez de la Frontera
II	Airports without overlapping catchment areas that serve nearby tourist destinations with similar characteristics.	Malaga; Almeria; Alicante; Valencia
III	Airports that serve other tourist destinations competing within an extended geographic area –benchmark perspective	South Tenerife ; Nice; Naples; Tunis; Antalya; Marrakech.

Table 6.1 Competing airports for FAO as identified by the airport operator. Source: ANA(2007b, p. 103).

Although Seville and Jerez de la Frontera are located nearby and also serve the Spanish region of Huelva, which is an integral part of what Faro offers as a destination, FAO operator underlines the fact that the Portuguese airport is the closest to the sea, thus being more competitive in relation to tourism. Additionally, FAO is the largest of the three airports, in terms of passengers. However, Seville still handles over 4 million passengers a year and Jerez de la Frontera has experienced large growth, overcoming one million passengers by 2004. The three airports show a similar trend to host low-cost carriers.

The other airports mentioned in Table 6.1 are not geographical substitutes for Faro's Algarve airport. However, according to the airport's marketing plan (ANA, 2007b), most of the stagnation in the traffic suffered along the decade is explained by changes in the tourism patterns of European visitors regularly coming to the Algarve region for holidays. This way, the airport operator has been increasingly engaged in promoting the region as a destination and not just to provide the infrastructure for tourists. A desire to increase the proportion of outbound traffic is also noticeable in the marketing strategies.

Such strategies account for a diversification in the low-cost routes offered across Europe in order for the airport to break the dependence on the British market and open up to further possibilities. Additionally, the marketing plan established the creation of a strong direct connection to Madrid/Barajas as a priority to make the airport more accessible to indirect markets. Both objectives were seen as achievable by getting the “loyalty” of a company, an airline that would like to be based at the airport, preferably a low-cost company, able to offer high frequency and low fares to increase the potential for outbound traffic by widening its catchment area.

The goals seem to have been achieved in the Winter 2009 IATA season, after Ryanair chose Faro for its 39th base and showed its “loyalty” with 6 aircraft in the airport. The immediate results in terms of the direct connection with Madrid/Barajas and a growth in traffic for Summer 2010 were presented in sections 5.3 and 5.4. In the long run, however, it is not yet possible to fully assess the impact of the strategies and the loyalty of a company that is constantly opening and closing or down-sizing its bases, as another example of competition amongst airports for the provision of services to airlines.

6.2.3 Airline support

It seems cleat that ANA understands now that a close relationship with the airlines as key customers to develop revenue opportunities for the airports is essential to improve their competitiveness. Faro airport refers to it as Airport to Airline (A2A) strategies, in comparison with business to business marketing components and extended to Airport to Passengers (A2P) in relation to business to consumer (ANA, 2007b, p. 80). As part of such strategies, ANA Aeroportos de Portugal (also with ANA Madeira), in a partnership with the Portuguese tourism promotion office, Turismo de Portugal, created a common incentive plan to support airline’s route development programs. The plan is called “initiative: pt” and applies to the three continental airports (FAO, LIS and OPO), as well as those in Azores and Madeira (ANA, 2010a).

The initiative consists of financial support for airlines or tour operators willing to operate previously non-served or under-served air routes that prove efficient to attract inbound traffic to increase tourism in Portugal. This support is referred as a “marketing co-investment model” and, in a general way, includes the components shown in Figure 6.18. The support is given under the condition that the routes have at least two years of all-year-round weekly frequencies and minimum 10000 arriving passengers each year. Unfortunately, the agreements made with the airlines are confidential, thus there is no information available to assess their impact.

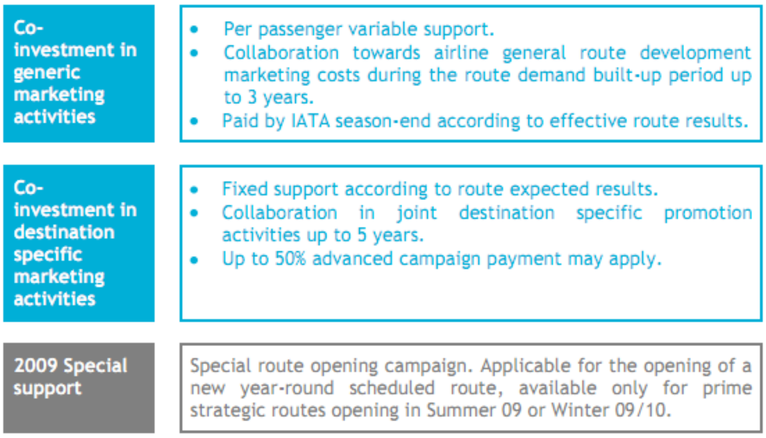


Figure 6.18 Components of the co-investment model of ANA, ANA Madeira and Turismo de Portugal to support airline's route development programs. Source: ANA (2010a).

6.3 Airport marketing and airport development

The concept of airport marketing was practically non-existent when airports were monopolies in fully-regulated markets. Airports considered that it was the airlines' job to look for new opportunities of development, as well as the promotion of the air services provided at the airports. Since the 1980s, however, "airports have developed a wide range of increasingly sophisticated techniques for meeting the demands of their complex mix of customers" (A. Graham, 2003, p. 178). In Portugal, airport marketing emerged at the end of the 1990s as a mean to increase "air traffic by attracting new routes and developing those which already exist, contributing, at the same time, towards accommodating the airport and its respective services to the needs of airline companies and passengers." (ANA, 2007b, p. 79).

In a deregulated environment in which airlines – especially LCCs – are free to choose any airport they find convenient and global alliances desire more visibility in airport terminals, airport marketing helps the management to find the right strategies to sell the airport and its services. However, airlines are not the only clients of airports (see section 4.2 for a wider discussion). Thus marketing departments of airport operators must also look for new ways to attract different kinds of passengers and all the other segments interested in the airport, such as retailers or local businesses. The strategy of Porto airport to convince Galician passengers of the advantages of using OPO described before is an example of applied airport marketing.

Despite the development of the airport marketing concept and its application in the Portuguese airports under analysis, the review presented in the previous section indicates that there is a missing link between the marketing strategies and the infrastructure development plans. That is, marketing plans seem to go in one direction and airport development in the opposite one. Most of the decisions encouraged by the marketing plans have been more aligned with the way the aviation network has evolved, especially in relation to LCCs, but infrastructure expansion went in a more traditional way.

The development of a second terminal in Lisbon seems to be more related to the fact that the airport needed a quick solution (not disturbing normal operation without reducing capacity or comfort for passengers (ANA, 2006)), and less to an explicit decision of actively embracing the growth of LCCs in terminal 2. Despite its low-cost characteristics, such as the inexpensive and simple single-floor layout, the terminal works only for departures; thus arriving passengers and baggage have to be transported to the arrival area in terminal 2 and airlines have to pay for the bus and higher complexity of the manoeuvre. Nevertheless, that decision also accounted for a more simplified design and construction of the passenger building and constrained space for short-term parking and taxi queuing.

The expansion of Porto airport during the first half of the decade included the construction of an expensive and monumental passenger building. Nevertheless the traffic forecast of the marketing plan was surprisingly close to the actual figures, and the predicted mix of FSCs and LCCs was also not so wrong. In terms of architecture, the terminal is considered an exceptional work, and the airport has been awarded a prestigious recognition for its beautiful steel structure. What happens is that half of the passengers using the building nowadays are flying with airlines that are not willing to pay for this huge investment. Therefore, future expansions should consider more flexibility to be adaptable to an uncertain future demand.

In a similar situation, the short term expansion plan for Faro airport (ANA, 2010c) proposes a refurbished passenger building that do not follow the same ideas proposed in the master plan (ANA, 2007b). Despite both documents call the attention on the shift towards low-cost traffic – moreover, the master plan declares "positioning Faro Airport as a low-cost outbound airport" as one of its marketing strategies, the new proposed design seems to present a less efficient layout for low-cost operation. As seen in Figure 6.19, the new terminal would provide for less aircraft being near the building, hindering walk access to the planes, increasing turn-around times and costs of buses operations, leading to less use for the jet-bridges and to more disruptions while in construction.

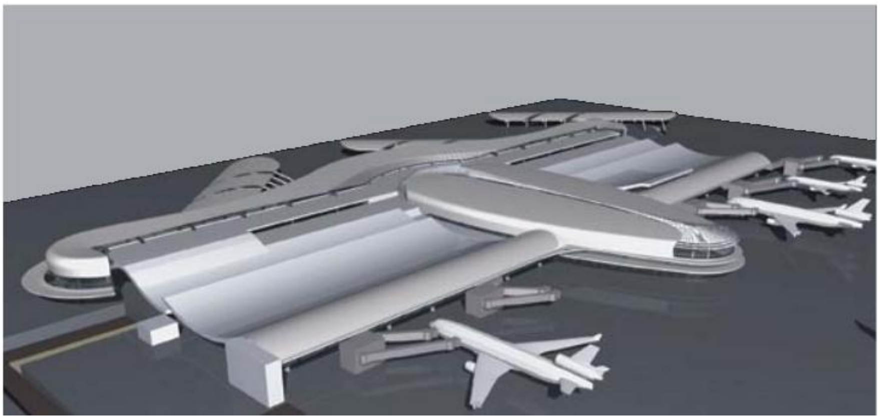


Figure 6.19 Render of the Faro Airport passenger building with the developments proposed in the expansion plan. Source: ANA (2010c).

The phase of the expansion plan in which the terminal refurbishment is included has not yet started. Thus it is still time for the airport operator to rethink the communication between marketing and infrastructure planners, so they both work together to achieve the satisfaction of the real needs of the airport customers, but guaranteeing enough room for adaptation, should new types of clients with different, not foreseen, requirements arrive.

6.4 Conclusion

This chapter has demonstrated that Portugal is not indifferent to the phenomenon of airport competition. In fact, the competition may take place either between the airports in the continental part of the country and between them and their Spanish neighbours, or between the airports in the markets they are serving. In that sense, we have shown how ANA was partially aware of this matter and saw airport marketing as an alternative to tackle competition. Nevertheless, there is still much room for improvement by relating marketing strategies with infrastructure development.

7 Final remarks

7.1 Conclusions

Three main topics were proposed in the research questions that guided this work and were addressed throughout this dissertation:

- the mutual influence of airport decisions, as part of a networked system, and the evidence of such interactions in the aviation network and its evolution over time;
- the evidence of competition for the Portuguese airports and its impact in the aviation network; and
- the types of competition in which airports are engaged, and the response from the airport operators to that competition.

7.1.1 Airport decisions

Regarding the first of these aspects, the network analysis seems to indicate that marketing and commercial decisions made by the airport operator are more related to the way the Portuguese aviation network evolved, during the decade analysed in this work, than those decisions regarding capacity expansion. However, spare capacity appears as a vital factor to satisfy the airport clients' needs. In fact, available capacity in the Porto airport has been essential to support the marketing campaigns (with airlines, passengers and other customers) that propelled the growth in terms of passengers evidenced for the last half of the decade.

Perhaps the extent to which decisions regarding infrastructure development affect the evolution of the aviation network would have been larger if they were more aligned with marketing plans. That is, a tighter relationship between the marketing and planning departments is needed to link their goals and increase airport competitiveness.

Nevertheless, the exercise of applying network theory to evaluate the evolution of the aviation network in continental Portugal found more evidence of changes appearing as a product of commercially-oriented decisions in other airports; such as the establishment of airline bases (especially LCCs) or the change in the role of hubs from long-haul to medium-haul or vice versa.

The growth in the importance of the connections between the airports in continental Portugal and low-cost airports in Europe, such as Brussels South Charleroi (CRL), Paris/Beauvais (BVA), London/Luton (LTN), London/Stansted (STN) on Frankfurt/Hahn (HHN); demonstrates that the decisions of those airports to become LCC bases had an impact in Porto (OPO), Faro (FAO) and, to a lesser extent, Lisbon (LIS). Indeed, the commercial decisions in the Portuguese airports reflect the desire to support the low-cost expansion. However, as mentioned before, the impact on capacity expansion decisions has not been as strong as it should, at least in the sense of supporting LCC development.

Other airports in the aviation network show the willingness to promote the activity of LCCs, without giving away their services to FSCs, such as Amsterdam/Schiphol (AMS), Paris/Charles de Gaulle (CDG) and Madrid/Barajas (MAD). An evaluation of their planning processes to provide infrastructure that satisfies the new clients' requirements might prove valuable for implementation in the Portuguese airports.

The change in the role of some airports regarding the Portuguese market, as said above, is also found in the aviation network. The decision to use Lisbon (LIS) as a feeder for London/Heathrow (LHR) and Paris/Charles de Gaulle (CDG) in long-haul routes had a visible impact in the connections from the other Portuguese airports. In fact, Porto (OPO) and Faro (FAO) reacted by having stronger routes to London/Gatwick (LGW) and Paris/Orly, respectively.

7.1.2 Airport competition and aviation network

Regarding the second main topic – the evidence of competition for the Portuguese airports and its impact in the aviation network, it is interesting to note that the evidence of airport competition, found in the network analysis, is not restricted to the Portuguese airports. As it is demonstrated across this dissertation, airport competition, in general, not only exists but also takes several forms. Many of those forms differ from traditional views in which airports compete, through airlines, by catching demand in their surroundings, or by hosting airlines with network strategies that favour one airport at the expense of others.

Airport competition, in a wider perspective, has been boosted by the steady growth of low-cost carriers, and a trend towards privatisation and commercialisation of airports that force them to pursue goals beyond the exclusive provision of infrastructure. Both the growth of LCCs and the privatisation trend are favoured by a deregulated environment in which airlines are free to choose any airport to fly.

Low-cost carriers have made air transport become a mode for the masses, far away from the glamour of its initial days. Their ability to attract emergent demand for air traffic called the attention of many airport operators. There are many «new» airports that are increasingly eager to attract LCCs in order to improve their passenger figures and, in turn, be more attractive to other customers. This phenomenon is widely visible in Europe where several war-time airfields are now being used for commercial operations.

The network analysis performed in this dissertation not only shows the appearance of such new entrants, but also illustrates the growth of low-cost airlines in Portugal. In the IATA season of Summer 2010, LCCs accounted for nearly 70% of passengers departing from Faro, almost half of those travelling from Porto, and over 10% of the demand from Lisbon. This trend has also favoured a more intense competition between the three airports, even if they are owned by the same organization.

7.1.3 Airport competition and airport management

Regarding the third aspect – the types of competition between airports, this dissertation presents some contributions for a conceptual framework defining five ways in which airports effectively compete with each other, according to the different clients that demand the airport product. For the Portuguese airports under analysis, the network provision in the air side (the range of available destinations), together with the access to low fares, seem to drive a big proportion of the competition between the airports (especially between Lisbon and Porto) and between them and their Spanish neighbours. Additionally, the scope competition (for tourism attraction) is the strongest form of competition faced by the Faro airport.

In what concerns airport management, airport competition seems to be a rather new concern. Although airports are strongly affected by the uncertainty of the aviation industry, they have been traditionally more reluctant to accept competition with other airports, while delivering the burden of market development solely to airlines.

In a shift of strategy, the airport operator (ANA, Aeroportos de Portugal) has been implementing the concept of airport marketing to adequately address competition, especially with the Spanish neighbours of Porto and Faro. We think Porto is the airport that has been more engaged in marketing strategies to attract new airlines, routes and passengers. Nevertheless, at a national level, ANA is also implementing an incentive scheme to support airlines in their route development activities. Even if the operator is clearly aware of airport competition, there is still the need to provide adequate infrastructure according to the different requirements of the customers.

To summarise, commercial and physical decisions in one airport can both affect decision making in other airports. If managers are aware of the different kinds of competition arising between airports and if they are able to match good commercial deals with the proper, efficient, infrastructure, they will make airports clearly more competitive.

7.2 Limitations

Given that this dissertation is based on an exploratory study geographically bound to three airports in continental Portugal, it has some clear limitations that result from the adopted methodology and the scope of the analysis. As an exploratory study, the research is intended more to raise and design questions rather than being entirely conclusive and affirmative. Given its geographical scope, the outcomes of the network analysis are limited to the areas studied; hence they do not necessarily apply to any airport. However, the review on airport competition was performed in a more general perspective (at least at a European level). Additionally, even though the information for the network analysis comprised a lot of data related to other airports outside Portugal that was used to draw some conclusions, they always relate to the Portuguese market and not to those airports in a generalized way.

In particular, the fact that the database was constructed only with the information provided by ANA on the Portuguese side is seen as another limitation. It hinders the analysis about direct competition with the Spanish airports located near the border with Portugal. The lack of access to comparable data to build up the aviation network of the Spanish airports during the same period of study (2001 – 2010) was the cause for this drawback.

It is worth mentioning that the conceptual framework for airport competition was developed as a tool to assist in the analysis of which customers airports are competing for and in which categories of services they may face competition, i.e., it is not concerned with exactly what actions airports may pursue, in each or in all of the categories identified, in order to gain competitiveness. In this sense, it differs from more general frameworks developed in the fields of economics and strategic management. Such frameworks aim at understanding the firm's environment and the dynamics of competition. Most of them are based on the *structure-conduct-performance* model (SCP), dating back to the 1930s. Within this model, the *conduct* refers specifically to the actions that a given firm can implement to produce competitive advantage (Barney, 2007).

Porter's five forces framework builds upon the SCP model to identify the environmental threats in the structure of an industry. In a similar way, Porter and others also have analysed the opportunities in a firm's environment that allow it to be competitive within its industry. However, the example of successful firms in industries with numerous threats and few opportunities favoured the study of organizational strengths and weaknesses in this context. This led to another framework known as *resource-based view of the firm*. Its main idea is that a firm can gain a competitive advantage by exploiting its unique resources (Barney, 2007). More recently, another framework to define competitive advantages based on the firm's *dynamic capabilities* has been proposed (Winter, 2003).

The objective of the framework proposed in this work is to assist managers in analysing what are the classes of services that airports may be competing in and which clients play the main role in each of those classes, so that they can then be more effective in developing strategies to gain competitive advantage and avoid competitive disadvantage. Thus the development of precise strategies remains as a future task for additional research.

Regardless of the aforementioned limitations, this dissertation provides a valuable analysis applied under a clear methodology that can be replicated for wider temporal and geographical scopes.

7.3 Future work

There are some interesting topics for potential future research that derive form the analysis performed in this dissertation. The list below presents some of these topics:

- The first logical choice would be to increase the geographical scope in order to include a wider network. Perhaps the most interesting initial step would be to analyse the aviation network of the Spanish airports of Vigo, Santiago de Compostela, Seville and Jerez de la Frontera, as well as other Portuguese airports in mainland and, especially, the overseas territories of Madeira and Azores. Additionally, analysing the aviation network of the Iberian Peninsula seems quite relevant, given the relative importance of the Lisbon – Madrid and Porto – Madrid routes, as well as the start of a regular Faro – Madrid link, and the role of Madrid/Barajas as a regional hub for the Peninsula.

- It would be equally interesting to perform a series of interviews to decision makers in the airports to know their perception of airport competition. Such interviews would also allow a deeper analysis on how decisions in one airport affect those in other airports.
- The conceptual framework of airport competition can be further developed, namely by analysing the strength of the agents involved and their inter-relations. The idea is to unveil the complexity of the interactions between the different customers of the airport product and how they support the growth of the airport business, whether in terms of traffic (aeronautical) or non-aeronautical operations. Particular attention should be devoted to the Airport to Airline and Airport to Passenger marketing components. In this way, the framework could be the base to propose strategies that airport managers can implement, especially when negotiating services with airlines in route development conferences or when "selling the airport" using innovative channels, such as *The Route Shop* (www.therouteshop.com).
- Flexible design and real options are making their way to transform traditional master planning in airports. Therefore, a deeper analysis on how can flexibility improve competitiveness appears as another interesting alternative.

These suggestions for future research close this dissertation that has hopefully contributed to the use of network analysis in the field of air transportation, and to a better understanding of airport competition.

8 Appendices

8.1 List of airports and their IATA codes

Continent	Country	City/Airport	IATA Code
Africa	AO	Luanda	LAD
Africa	CV	Boa Vista	BVC
Africa	CV	Praia	RAI
Africa	CV	Sal/Espargos	SID
Africa	CV	Sao Vicente	VXE
Africa	DZ	Algiers	ALG
Africa	EG	Aswan	ASW
Africa	EG	Cairo	CAI
Africa	EG	Hurghada	HRG
Africa	EG	Luxor	LXR
Africa	GM	Banjul	BJL
Africa	GW	Bissau	OXB
Africa	MA	Agadir	AGA
Africa	MA	Casablanca	CMN
Africa	MA	Marrakech	RAK
Africa	MA	Oujda	OUD
Africa	MZ	Maputo	MPM
Africa	SC	Mahe Island	SEZ
Africa	SN	Dakar	DKR
Africa	ST	São Tome	TMS
Africa	TN	Djerba	DJE
Africa	TN	Monastir	MIR
Africa	TN	Tunis	TUN
Africa	ZA	Johannesburg	JNB
America	AG	Antigua/V.C. Bird	ANU
America	BR	Belo Horizonte	CNF
America	BR	Brasilia	BSB
America	BR	Fortaleza	FOR
America	BR	Joao Pessoa	JPA
America	BR	Maceio	MCZ
America	BR	Natal	NAT
America	BR	Porto Seguro	BPS
America	BR	Recife	REC
America	BR	Rio de Janeiro	GIG
America	BR	Salvador	SSA
America	BR	São Paulo/Garulhos	GRU
America	BR	São Paulo/Viracopos	VCP
America	BS	Providence	NAS
America	CA	Montreal	YUL
America	CA	Montreal/Mirabel	YMX
America	CA	Toronto	YYZ
America	CU	Havana	HAV
America	CU	Varadero	VRA
America	DO	Puerto Plata	POP
America	DO	Punta Cana	PUJ
America	DO	Samana	AZS
America	JM	Montego Bay	MBJ
America	MX	Cancun	CUN
America	US	Boston/Logan	BOS
America	US	New York/JFK	JFK
America	US	New York/Newark	EWR
America	US	Philadelphia	PHL
America	VE	Caracas	CCS
Asia	IL	Tel Aviv	TLV
Asia	KW	Kuwait	KWI
Asia	MV	Male	MLE

Continent	Country	City/Airport	IATA Code
Asia	PK	Islamabad	ISB
Asia	TH	Phuket	HKT
Asia	TR	Antalya	AYT
Asia	TR	Istanbul/Sabiha Gokcen	SAW
Europe	AT	Innsbruck	INN
Europe	AT	Linz	LNZ
Europe	AT	Salzburg	SZG
Europe	AT	Vienna	VIE
Europe	BE	Brussels	BRU
Europe	BE	Brussels/Charleroi	CRL
Europe	BE	Liege	LGG
Europe	BG	Bourgas	BOJ
Europe	BG	Sofia	SOF
Europe	CH	Geneva	GVA
Europe	CH	Zürich	ZRH
Europe	CY	Larnaca	LCA
Europe	CZ	Prague	PRG
Europe	DE	Berlin/Schonefeld	SXF
Europe	DE	Berlin/Tegel	TXL
Europe	DE	Bremen	BRE
Europe	DE	Cologne-Bonn	CGN
Europe	DE	Dortmund	DTM
Europe	DE	Dresden	DRS
Europe	DE	Dusseldorf	DUS
Europe	DE	Erfurt	ERF
Europe	DE	Frankfurt	FRA
Europe	DE	Frankfurt-Hahn	HHN
Europe	DE	Friedrichshafen	FDH
Europe	DE	Hamburg	HAM
Europe	DE	Hannover	HAJ
Europe	DE	Karlsruhe/Baden-Baden	FKB
Europe	DE	Leipzig	LEJ
Europe	DE	Lübeck	LBC
Europe	DE	Memmingen	FMM
Europe	DE	Muenster	FMO
Europe	DE	Munich	MUC
Europe	DE	Niederrhein/Weeze	NRN
Europe	DE	Nuremburg	NUE
Europe	DE	Paderborn/Lippstadt	PAD
Europe	DE	Saarbruecken	SCN
Europe	DE	Stuttgart	STR
Europe	DK	Aalborg	AAL
Europe	DK	Aarhus	AAR
Europe	DK	Billund	BLL
Europe	DK	Copenhagen	CPH
Europe	EE	Tallinn	TLL
Europe	ES	Alicante	ALC
Europe	ES	Almeria	LEI
Europe	ES	Barcelona	BCN
Europe	ES	Bilbao	BIO
Europe	ES	Fuerteventura	FUE
Europe	ES	Gerona	GRO
Europe	ES	Ibiza	IBZ
Europe	ES	Jerez de la Frontera	XRY
Europe	ES	La Coruna	LCG
Europe	ES	Lanzarote	ACE
Europe	ES	Las Palmas	LPA

Continent	Country	City/Airport	IATA Code
Europe	ES	Madrid/Barajas	MAD
Europe	ES	Malaga	AGP
Europe	ES	Menorca	MAH
Europe	ES	Oviedo/Asturias	OVD
Europe	ES	Palma de Mallorca	PMI
Europe	ES	Pamplona	PNA
Europe	ES	Seville	SVQ
Europe	ES	Tenerife	TFS
Europe	ES	Tenerife Norte	TFN
Europe	ES	Valencia	VLC
Europe	ES	Valladolid	VLL
Europe	ES	Vitoria	VIT
Europe	ES	Zaragoza	ZAZ
Europe	FI	Helsinki	HEL
Europe	FR	Basel/Mulhouse	MLH
Europe	FR	Bordeaux	BOD
Europe	FR	Carcassonne	CCF
Europe	FR	Lille	LIL
Europe	FR	Lyon	LYS
Europe	FR	Marseille	MRS
Europe	FR	Metz/Nancy/Lorraine	ETZ
Europe	FR	Nantes	NTE
Europe	FR	Nice	NCE
Europe	FR	Paris/Beauvais	BVA
Europe	FR	Paris/Charles de Gaulle	CDG
Europe	FR	Paris/Orly	ORY
Europe	FR	St-Etienne	EBU
Europe	FR	Strasbourg	SXB
Europe	FR	Toulouse	TLS
Europe	FR	Tours	TUF
Europe	GB	Aberdeen	ABZ
Europe	GB	Belfast	BFS
Europe	GB	Birmingham	BHX
Europe	GB	Blackpool	BLK
Europe	GB	Bournemouth	BOH
Europe	GB	Bristol	BRS
Europe	GB	Cardiff	CWL
Europe	GB	Coventry	CVT
Europe	GB	Doncaster/Sheffield	DSA
Europe	GB	Durham Tees Valley	MME
Europe	GB	East Midlands	EMA
Europe	GB	Edinburgh	EDI
Europe	GB	Exeter	EXT
Europe	GB	Glasgow	GLA
Europe	GB	Glasgow/Prestwick	PIK
Europe	GB	Humberside	HUY
Europe	GB	Leeds/Bradford	LBA
Europe	GB	Liverpool	LPL
Europe	GB	London/Gatwick	LGW
Europe	GB	London/Heathrow	LHR
Europe	GB	London/Luton	LTN
Europe	GB	London/Manston	MSE
Europe	GB	London/Stansted	STN
Europe	GB	Londonderry	LDY
Europe	GB	Manchester	MAN
Europe	GB	Newcastle	NCL
Europe	GB	Norwich	NWI
Europe	GB	Nottingham	NQT
Europe	GB	Southampton	SOU
Europe	GR	Athens	ATH
Europe	GR	Heraklion	HER

Continent	Country	City/Airport	IATA Code
Europe	GR	Thessaloniki	SKG
Europe	HR	Dubrovnik	DBV
Europe	HR	Zagreb	ZAG
Europe	HU	Budapest	BUD
Europe	IE	Cork	ORK
Europe	IE	Dublin	DUB
Europe	IE	Kerry County	KIR
Europe	IE	Knock	NOC
Europe	IE	Shannon	SNN
Europe	IE	Waterford	WAT
Europe	IS	Reykjavik	KEF
Europe	IT	Bologna	BLQ
Europe	IT	Cagliari	CAG
Europe	IT	Catania	CTA
Europe	IT	Milan/Linate	LIN
Europe	IT	Milan/Malpensa	MXP
Europe	IT	Milan/Orio al Serio	BGY
Europe	IT	Naples	NAP
Europe	IT	Palermo	PMO
Europe	IT	Pisa	PSA
Europe	IT	Rome/Ciampino	CIA
Europe	IT	Rome/Fiumicino	FCO
Europe	IT	Turin	TRN
Europe	IT	Venice	VCE
Europe	LU	Luxembourg	LUX
Europe	MD	Chisinau	KIV
Europe	MT	Malta	MLA
Europe	NL	Amsterdam/Schiphol	AMS
Europe	NL	Eindhoven	EIN
Europe	NL	Enschede	ENS
Europe	NL	Groningen	GRQ
Europe	NL	Maastricht	MST
Europe	NL	Rotterdam	RTM
Europe	NO	Bergen	BGO
Europe	NO	Moss/Rygge	RYG
Europe	NO	Oslo	OSL
Europe	NO	Stavanger	SVG
Europe	NO	Trondheim	TRD
Europe	PL	Katowice	KTW
Europe	PL	Krakow	KRK
Europe	PL	Warsaw	WAW
Europe	PT	Bragança	BGC
Europe	PT	Faro	FAO
Europe	PT	Horta	HOR
Europe	PT	Lisbon	LIS
Europe	PT	Madeira/Funchal	FNC
Europe	PT	Pico Island	PIX
Europe	PT	Ponta Delgada	PDL
Europe	PT	Porto	OPO
Europe	PT	Porto Santo	PXO
Europe	PT	Santa Maria	SMA
Europe	PT	Terceira	TER
Europe	PT	Vila Real	VRL
Europe	RO	Bucharest/Baneasa	BBU
Europe	RU	Moscow/Domodedovo	DME
Europe	SE	Gothenburg	GOT
Europe	SE	Malmo	MMX
Europe	SE	Stockholm/Arlanda	ARN
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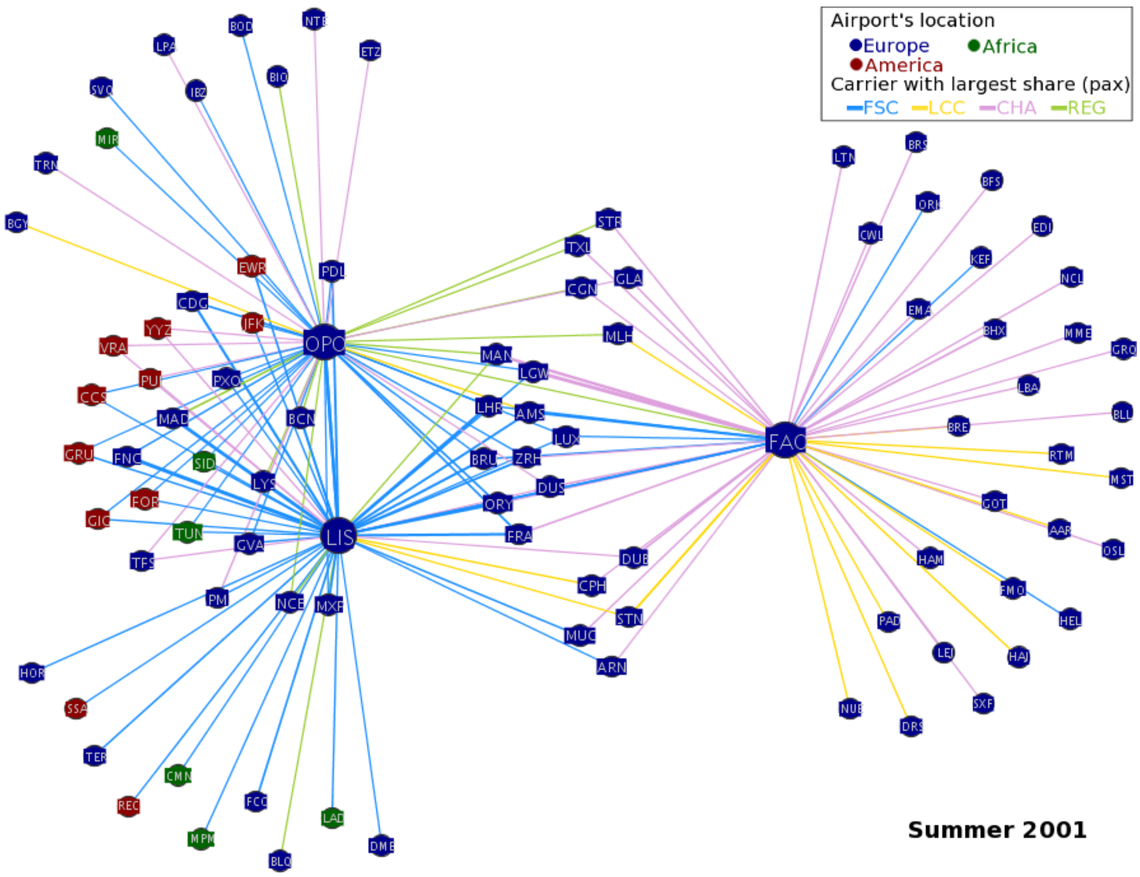
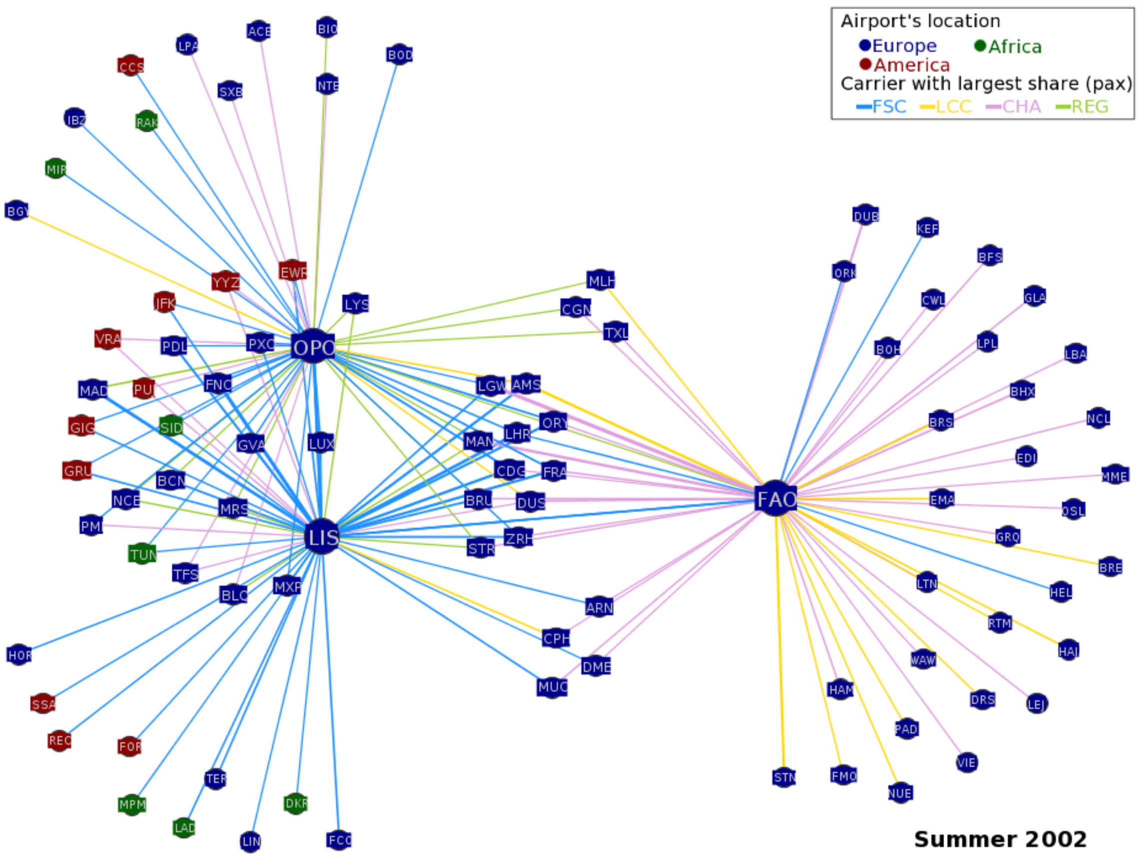
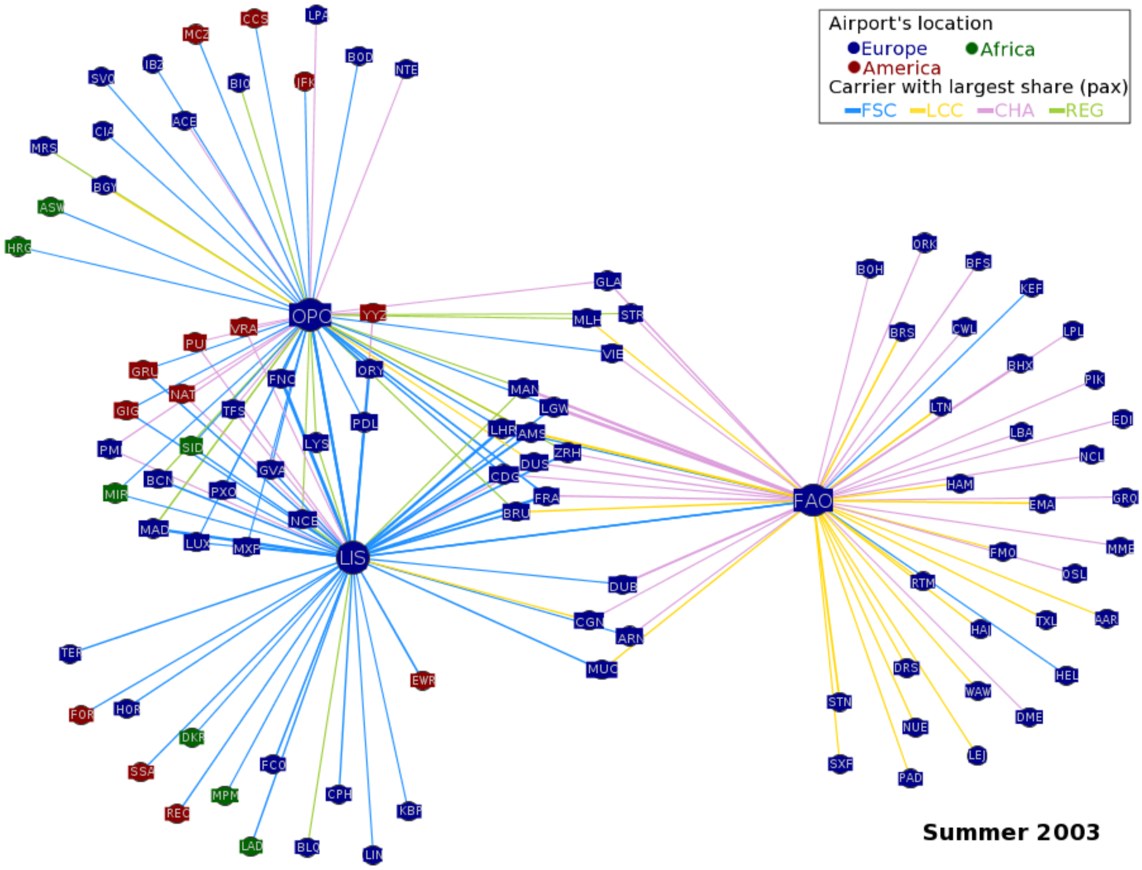
Europe	UA	Lviv	LWO

8.2 Top 50 Summer network evolution






Airport's location
Europe
Africa
America
Carrier with largest share (pax)
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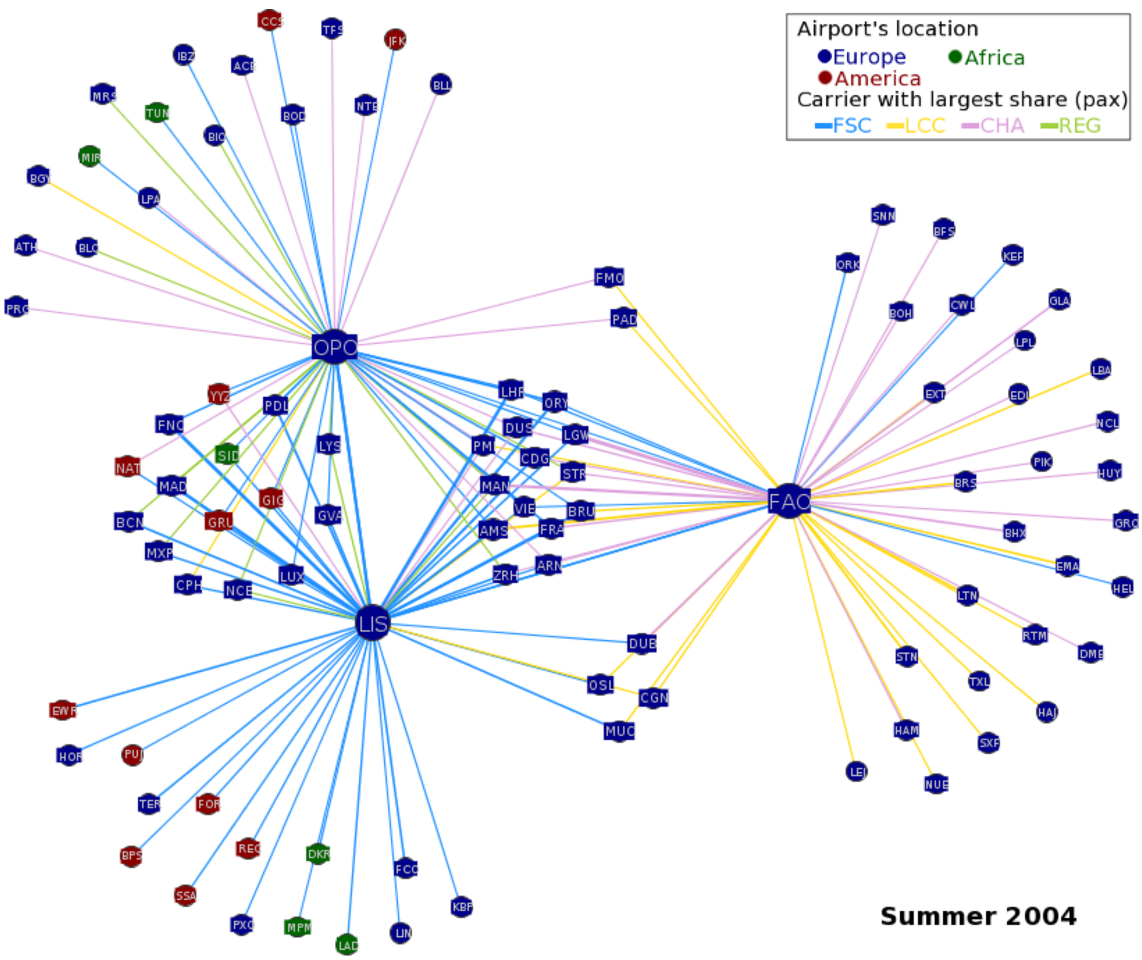
FAO
Summer 2003


Airport's location
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Africa
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Carrier with largest share (pax)
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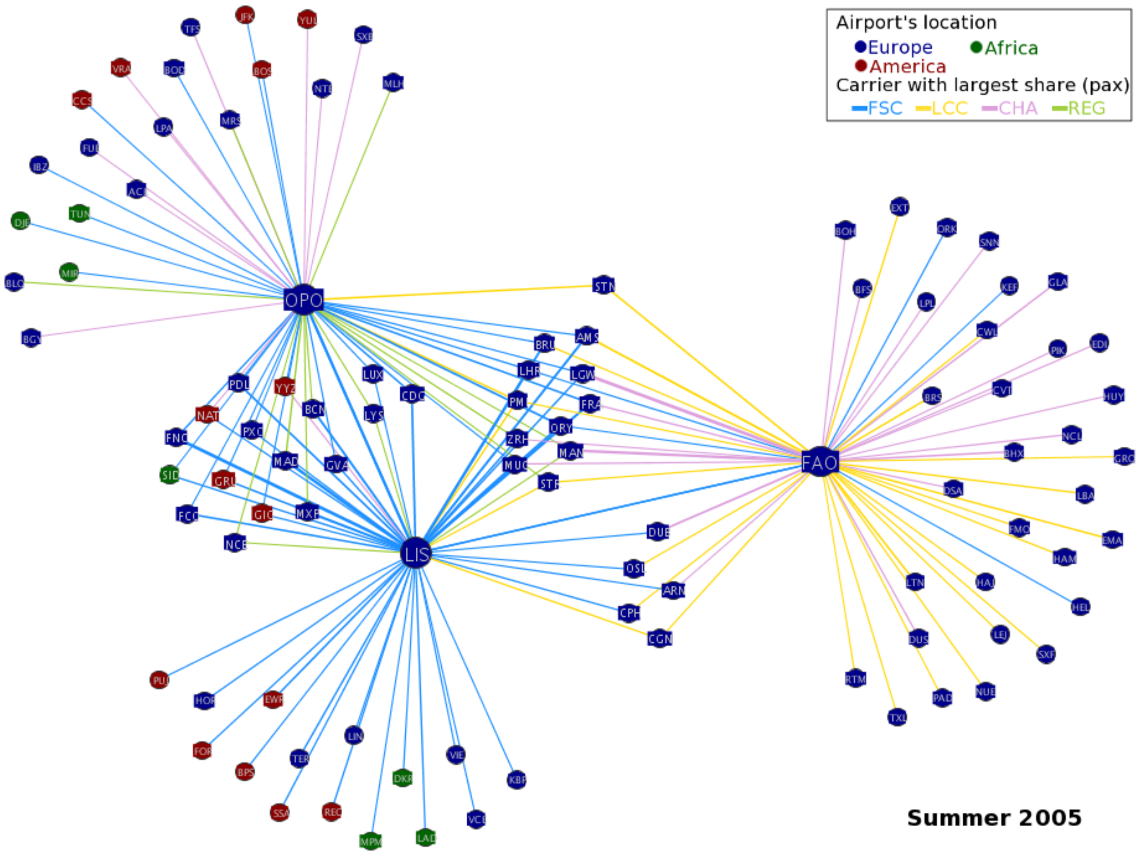
LIS
FAO
Summer 2004


Airport's location
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Africa
America
Carrier with largest share (pax)
FSC LCC CHA REG
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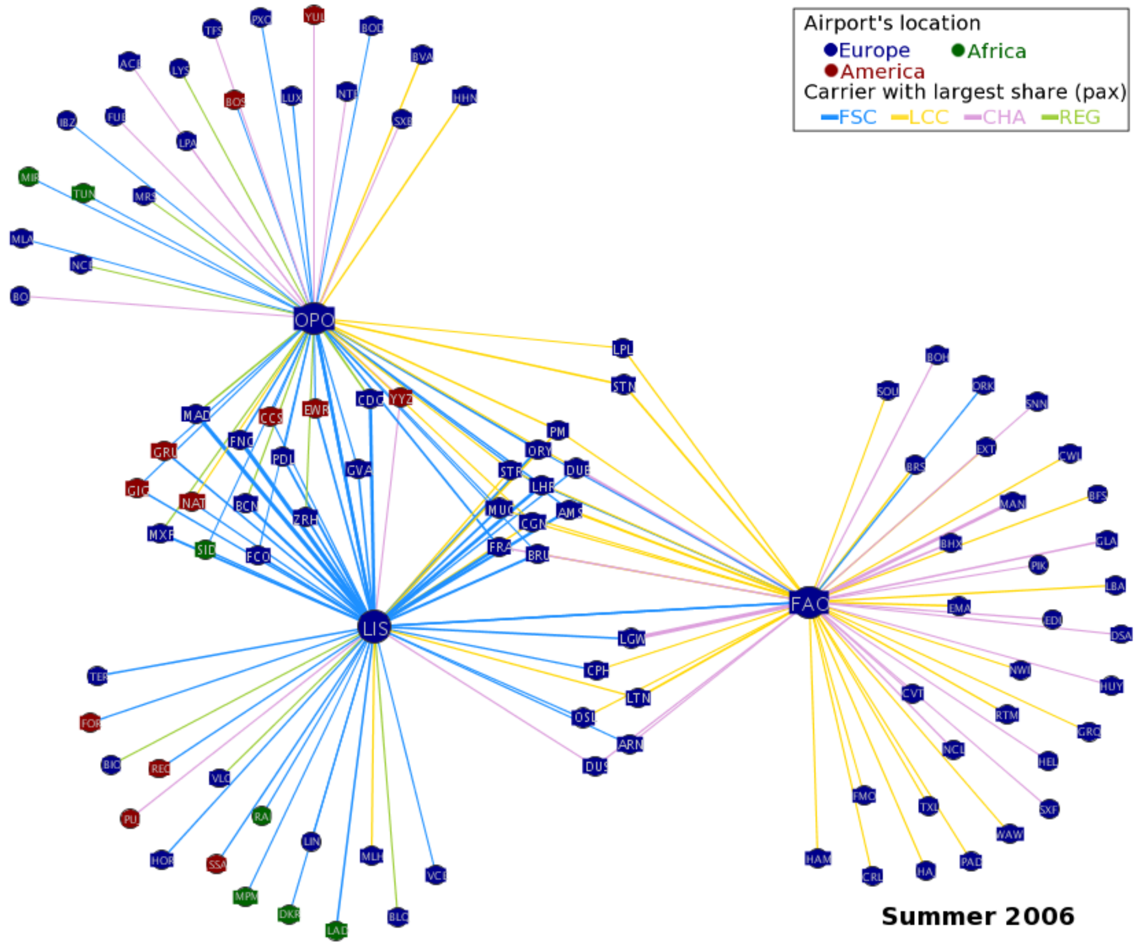
FAO
Summer 2005


Airport's location
Europe
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Carrier with largest share (pax)
FSC LCC CHA REG
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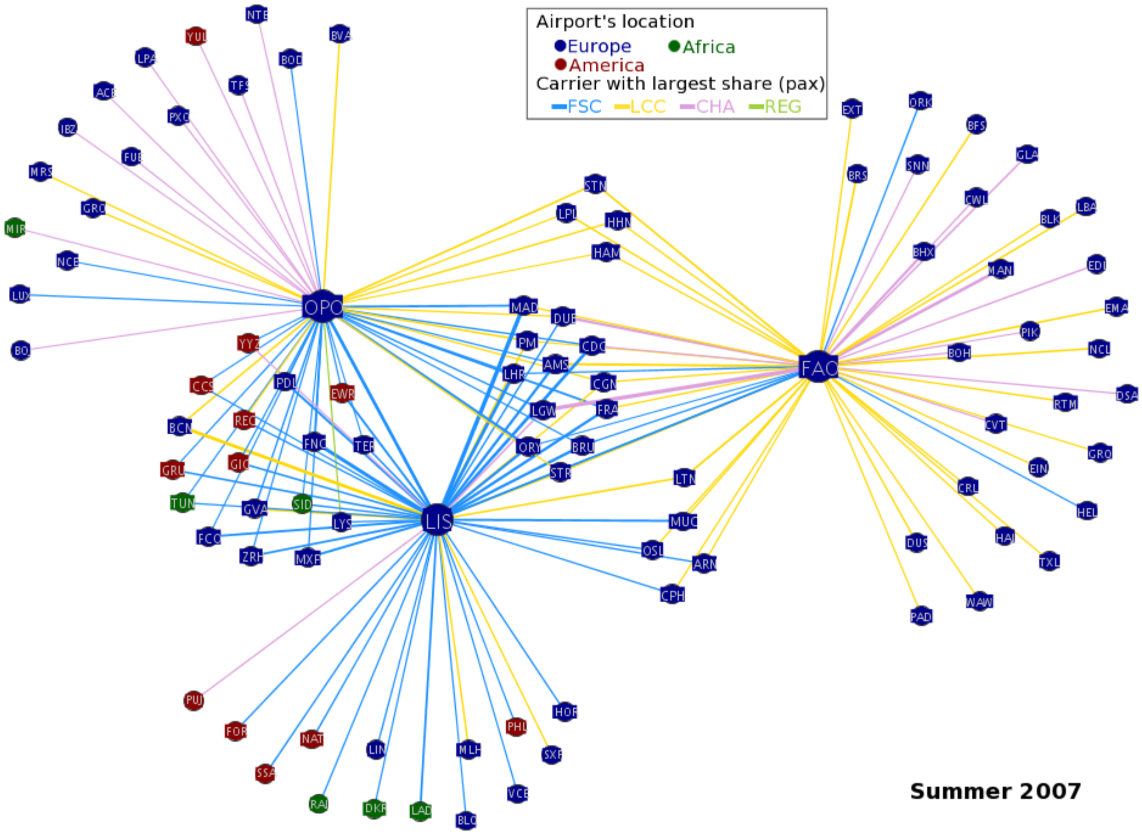
FAO
Summer 2006


Airport's location
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Carrier with largest share (pax)
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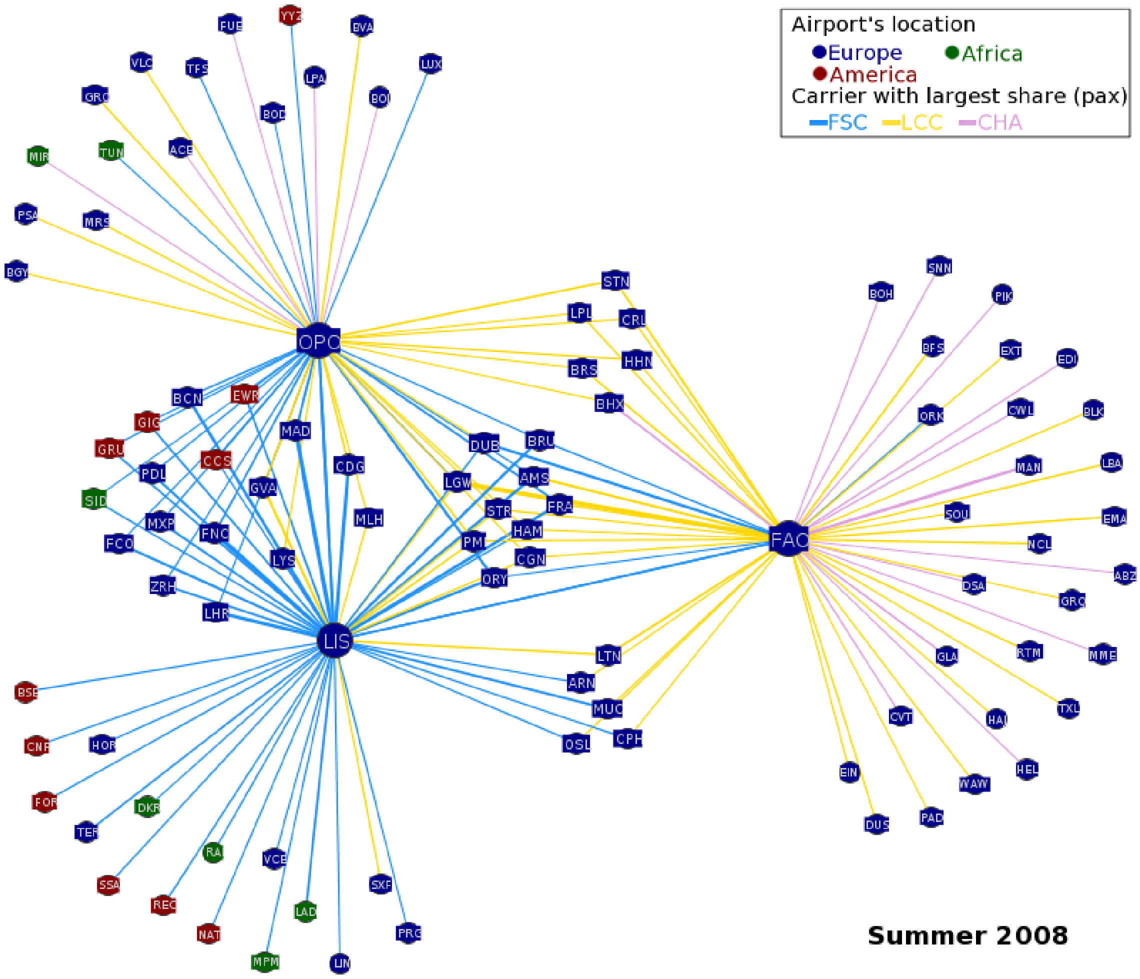
Summer 2007


Airport's location
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Carrier with largest share (pax)
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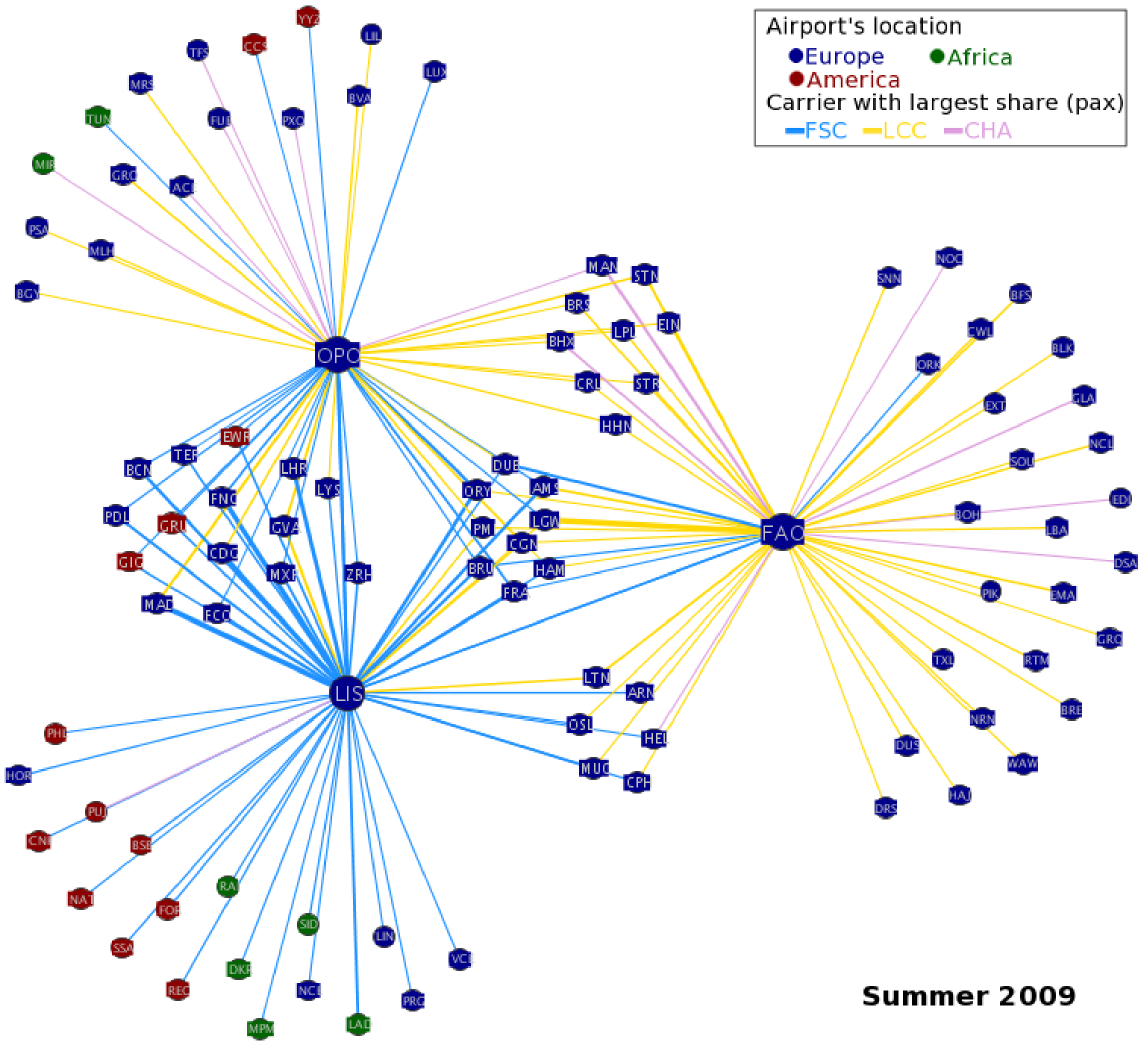
Summer 2008


Airport's location
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Carrier with largest share (pax)
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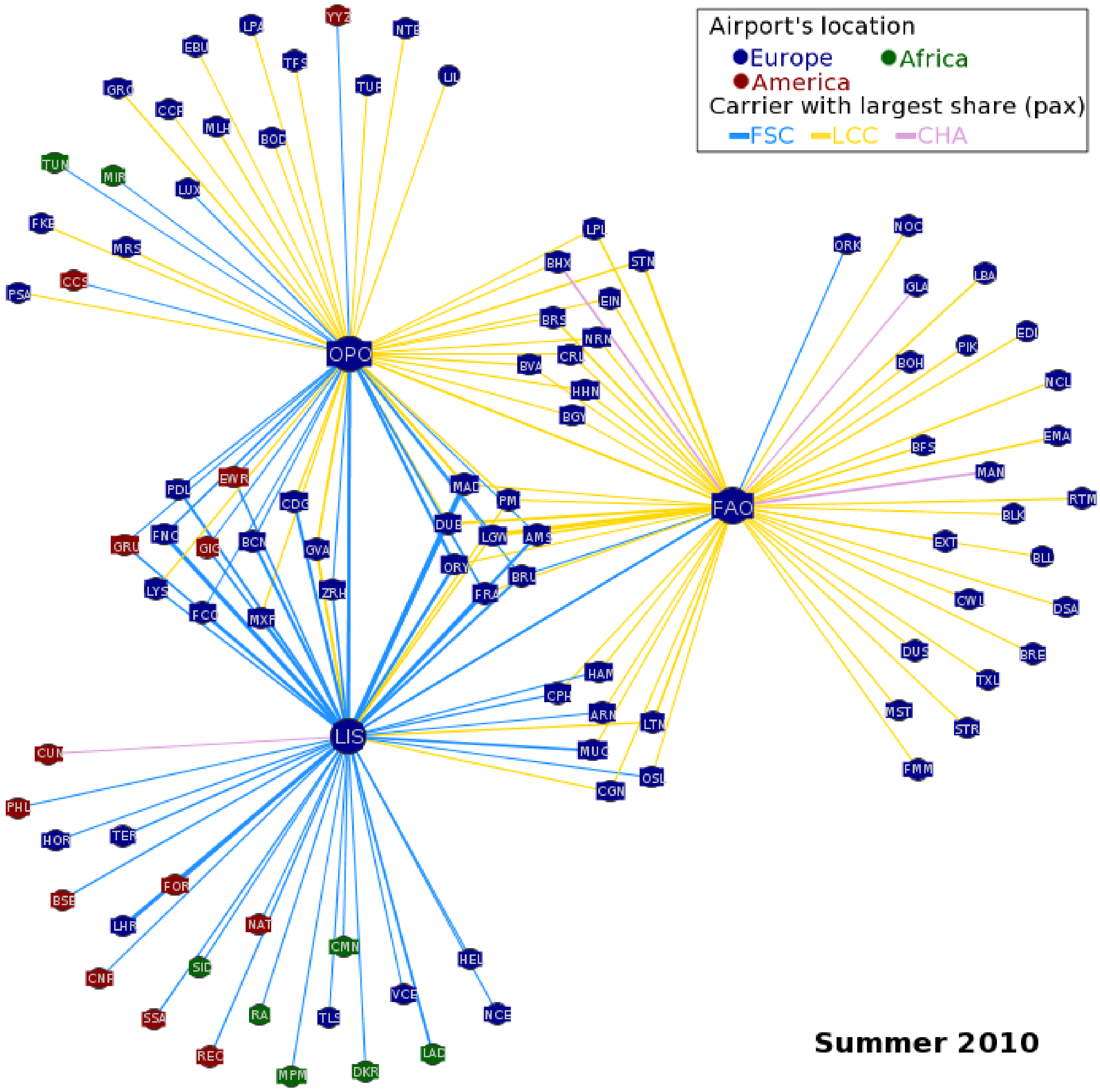
Summer 2009


Airport's location
Europe
Africa
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Carrier with largest share (pax)
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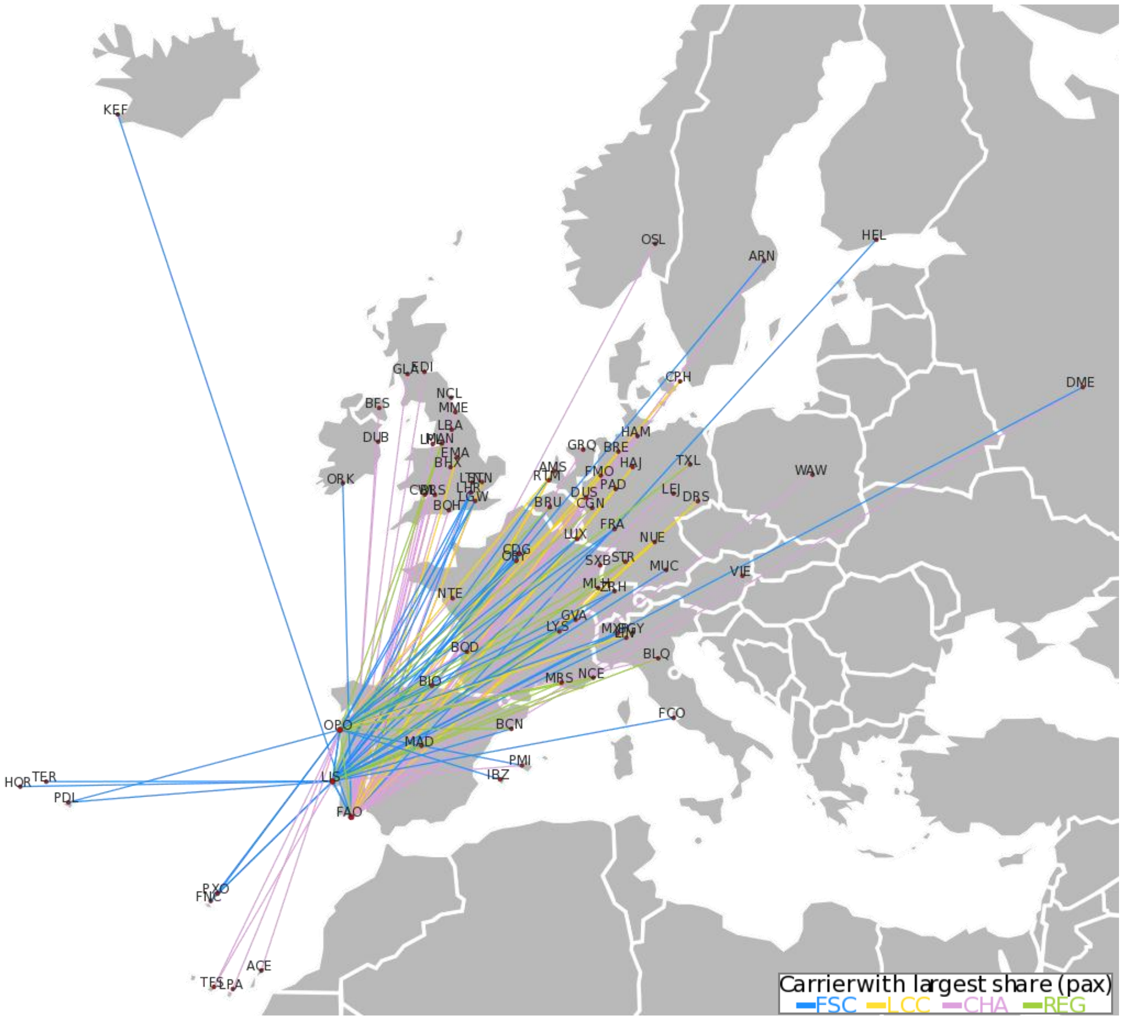
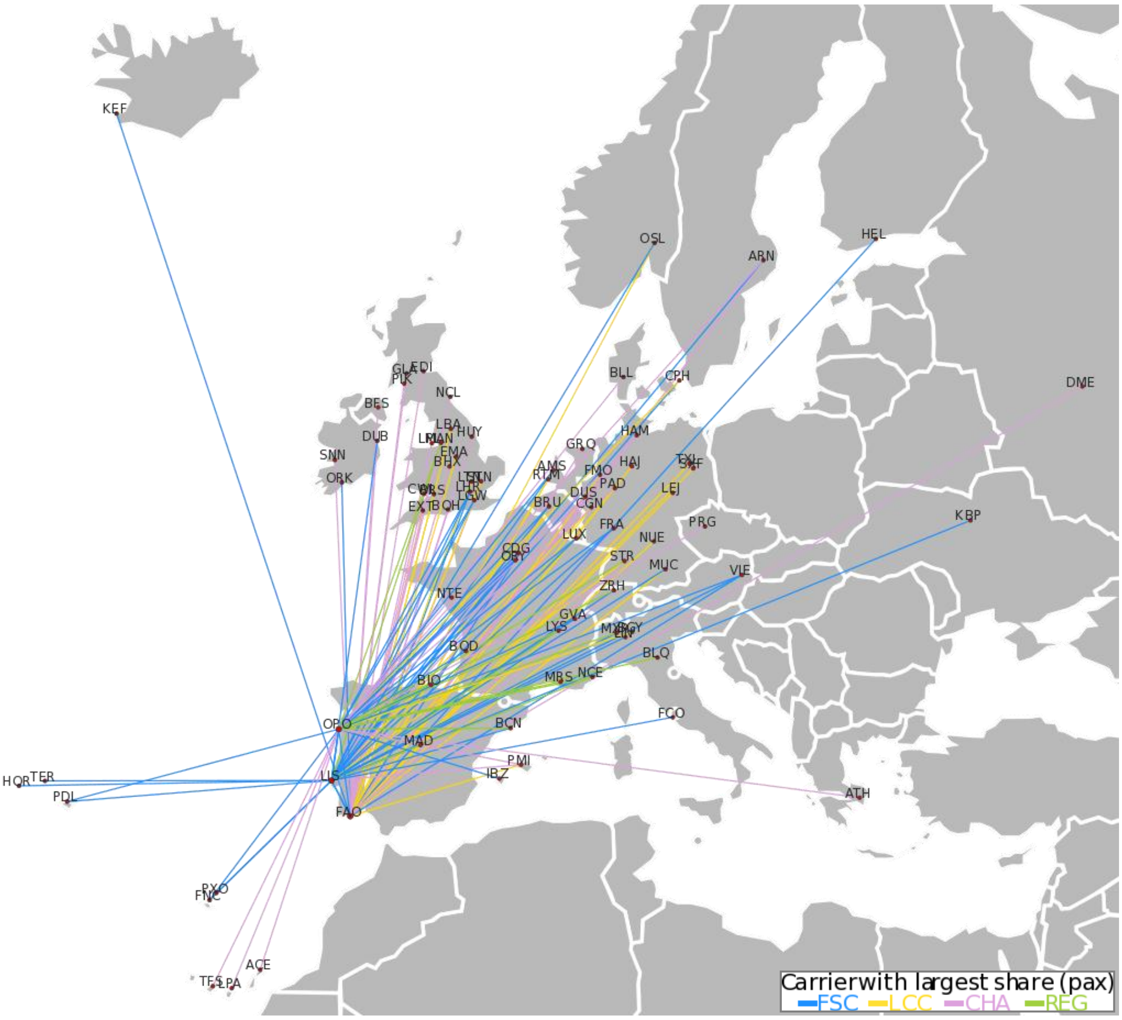
Summer 2010

8.3 Top 50 Summer intra-European network evolution



Summer 2002


KEF
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HEL
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KBP
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HAJ
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DUS
CGN
BRU
FRA
LUX
PRG
NUE
CDG
STR
MUC
VIE
ZRH
GVA
LYS
BLQ
NCE
MRS
FCO
BCN
PMI
IBZ
ATH
MAD
BIO
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PXO
FNC
ACE
LPA
EDI
NCL
BFS
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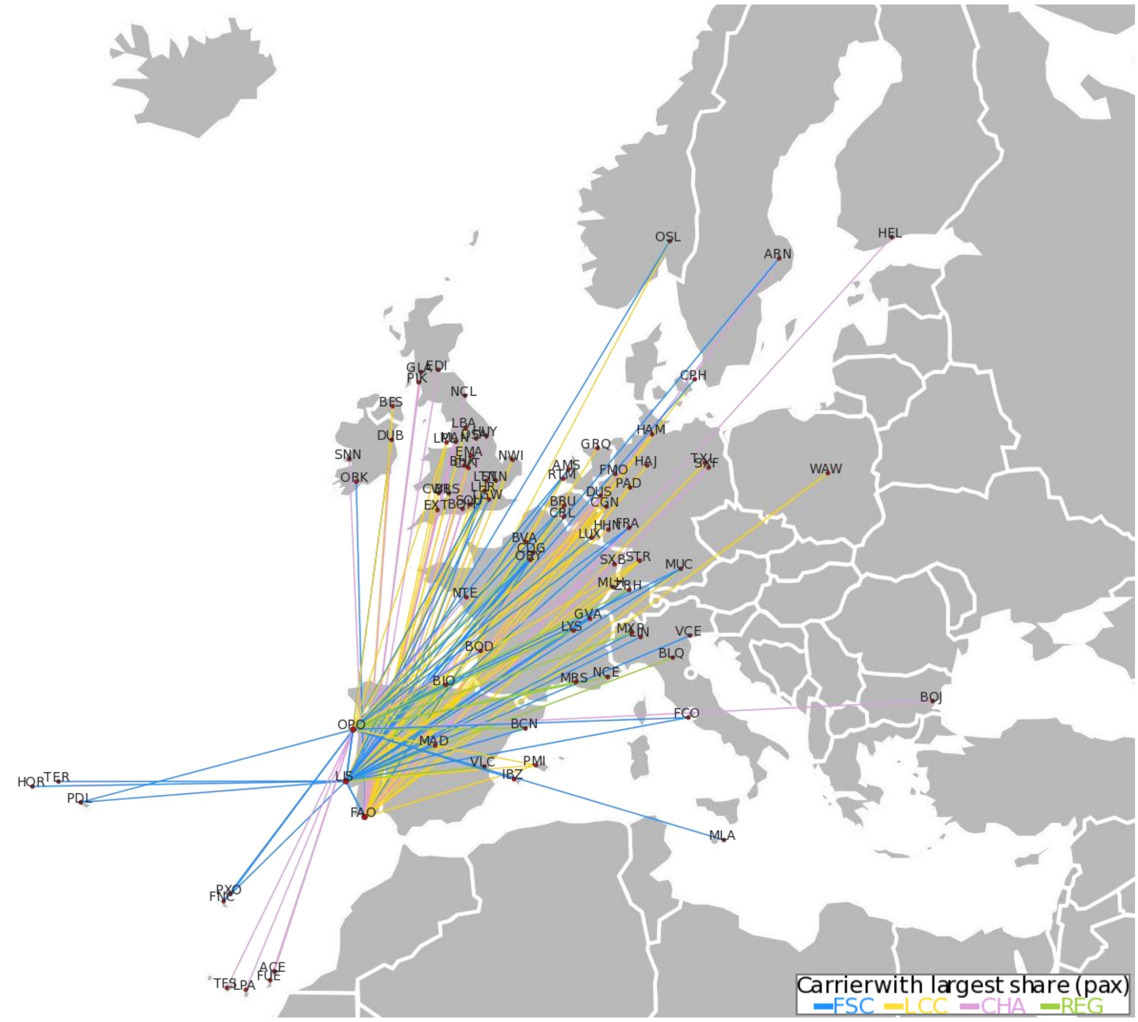
LGW
Carrierwith largest share (pax)
FSC
LCC
CHA
REG

Summer 2004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FMO
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TXL
SXF
WAW
PAD
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CGN
BRU
CRL
HHN
FRA
LUX
BVA
CDG
ORY
SXB
STR
MUC
NTE
MLH
ZRH
GVA
LYS
MXP
LIN
VCE
BLQ
BOD
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Carrier with largest share (pax)
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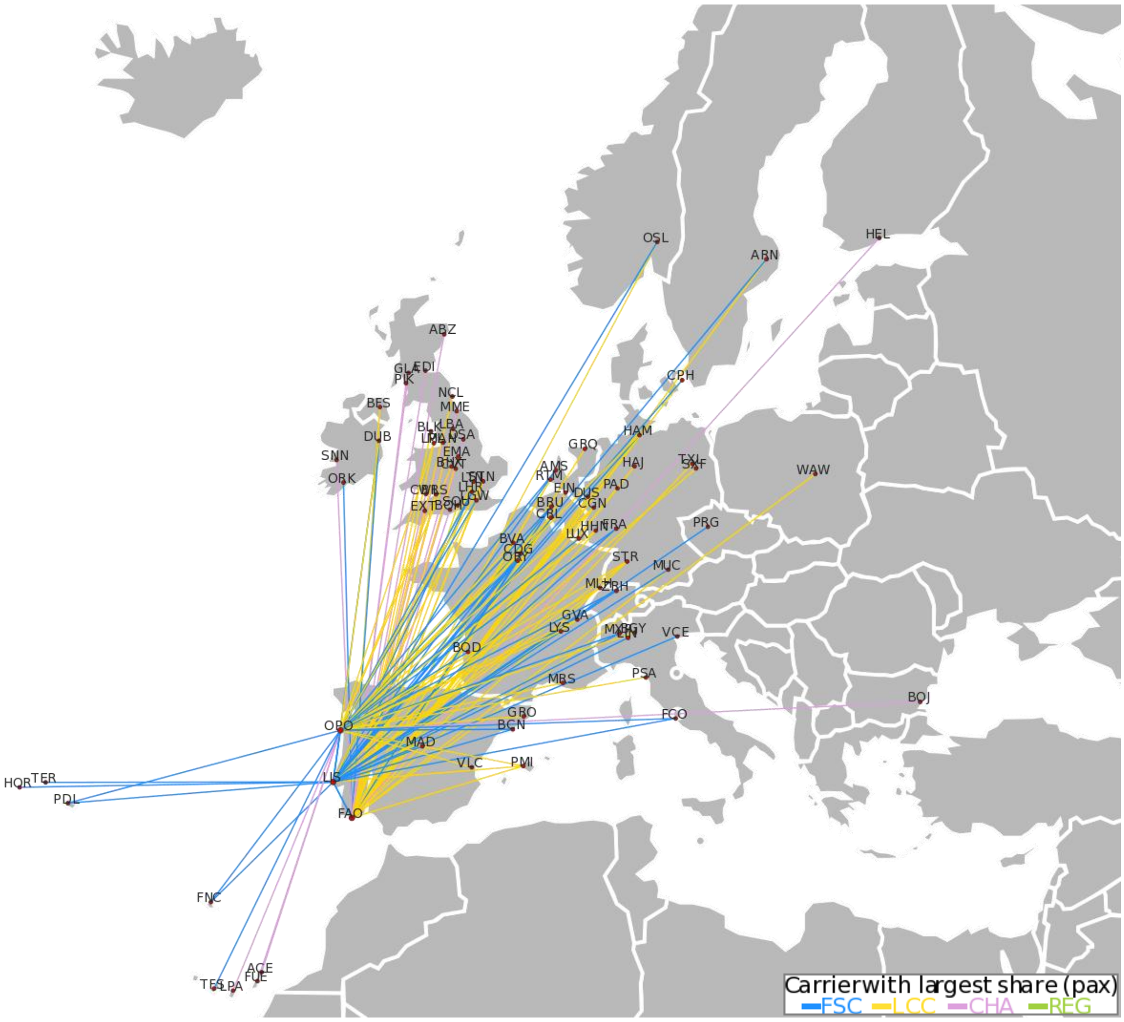
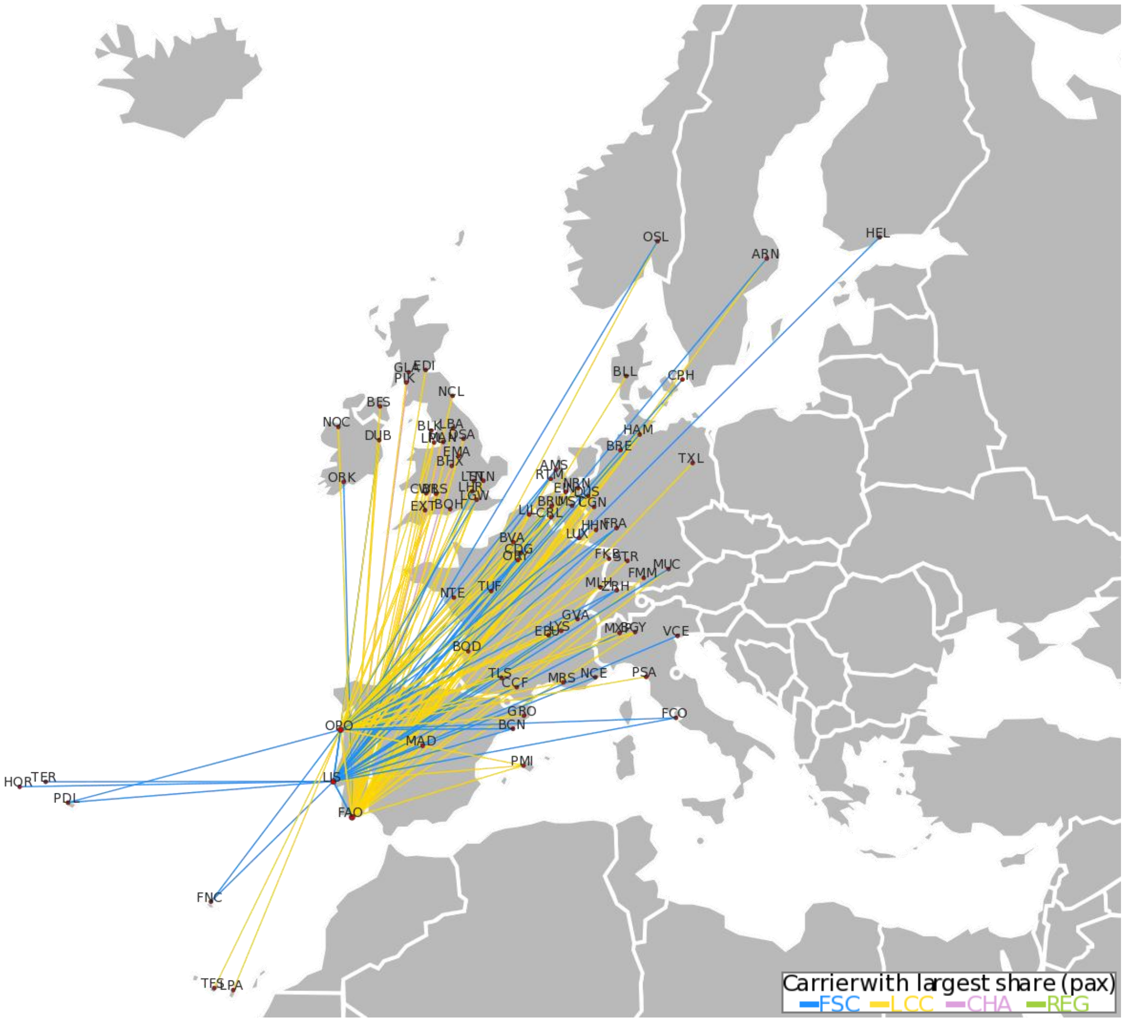
Summer 2006



Summer 2008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CGN
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CDG
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MUC
FMM
NTE
TUF
ZRH
GVA
LYS
VCE
BOD
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PMI
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LIS
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FAO
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Carrierwith largest share (pax)
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LCC
CHA
REG

Summer 2010

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