LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTER

INTERNATIONAL ECONOMICS AND EUROPEAN STUDIES

MASTER'S FINAL WORK

PROJECT

AIR CONNECTIVITY AND ECONOMIC GROWTH

BY MARIA INÊS FERNANDES CASTRO

NOVEMBER – 2020

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SUPERVISION:

PROFESSORA DOUTORA MARIA PAULA FONTOURA

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Abstract

This Master's thesis aims to study the correlation between air connectivity, and some economic variables, which contribute to economic growth already mentioned in previous researches. In order to achieve this goal, and regarding the air connectivity data, the Netscan model was used, developed by SEO Aviation Economics, in partnership with ACI (Airports Council International), World Bank, and Eurostat provided the economic variables' data.

The empirical results of this thesis and the conclusions presented in the literature survey allow determining that there is a cause-effect relationship between air connectivity and the economic variables. Therefore, air connectivity can contribute to increase economic growth.

In comparison with previous research, this thesis distinguishes the different impacts that both airport connectivity and hub connectivity can have in economic variables related to growth. This distinction appears to be relevant as the correlation between Hub connectivity and Gross Domestic Product (GDP) is becoming stronger.

In addition, this study is conducted using data for specific airports in the European Union. In the case of Portugal, we observe a very significant difference between Portugal/Lisbon and the main European hubs. With that in mind, it is clear that Portugal should increase its Hub connectivity, which could be achieved by taking advantage of its geographic position, mainly regarding the American and African continents. By doing so, it could be an exceptional opportunity for Portugal to achieve a higher economic development and growth.

[**Keywords:** connectivity; economic growth; economic variables; Gross Domestic Product (GDP); Netscan Model; European Union; Portugal]

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Introduction

The aim of this thesis is to analyze the correlation between air connectivity, which is divided in Airport connectivity and Hub connectivity, and some economic variables that have been put into evidence in previous research (inflows and outflows of Foreign Direct Investment, Goods imports and exports, International tourism expenditure, Passengers carried by air and Gross Domestic Product). By doing this study impact, we aim to analyze if air connectivity can influence this variables' values and hence influence a country's economic growth.

The combined understanding between the empirical results of this thesis and the conclusions presented in the literature survey will allow concluding about the cause-effect relationship between air connectivity and the economic variables, which in turn means that air connectivity can contribute to increase economic growth. An alternative to this correlation test would be to build a multi variable model for each one of those economic variables based upon their determinants, which would be the only way to guarantee that other effects are being correctly controlled. Nevertheless, the extension of this alternative is not compatible with the goal of this study.

Why is it pertinent to study the relation between air connectivity and economic growth? The aviation sector, in a worldwide level, generates more than 2.7 trillion US dollars, which means 3,6% of the world's GDP created in 2016. The European Union aviation industry is accountable for 14% of total jobs generated in the world. Therefore, this especially critical knowing is dealing with one of the most severe economic crisis due to the proliferation of the COVID-19 virus.

This unprecedented situation has had major negative impacts on the aviation industry. The global airline industry is estimated "to lose $315 billion in passenger revenue in 2020" (McKinsey, 2020). Hence, the world's air connectivity is critically threatened with major implications for economies worldwide, especially the ones that are very dependent upon tourism.

Consequently, this work will show which variables are correlated and the intensity of this relation which could also be helpful in order to understand some of the variables that may be affected by the COVID-19 effects in the aviation sector with serious repercussions in the economic activity overall.

In comparison with previous research, this thesis brings some important contributes to the literature which can be explained by two main reasons. First, and far as it is known, past works did not distinguish the different impacts that Airport connectivity and Hub connectivity had in economic variables. In fact, the effects that Hub connectivity has in some economic variables were not even accounted before and now it is clear, in the empirical results section, that hub connectivity should be seen as a country's strategic tool. Also, this study is conducted using data from specific airports in the European Union and, unlike other authors it is presented a more exhaustive correlation study between Airport and Hub connectivity and all the economic variables mentioned in several researches that will be described in the Literature Survey.

After clarifying the context and goals of this thesis, it is important to explain the structure and organization of this work. In Chapter I it is demonstrated how aviation is a very important sector in European and Portuguese economies. Chapter II introduces the definition, types and determinants of air connectivity as this will be crucial, namely the Results' chapter. Chapter III presents some previous research conducted regarding the relation between air connectivity and some economic variables. Chapter IV reveals different methodologies to calculate air connectivity with a major focus in the Netscan model which is used in the Results' chapter. Chapter V demonstrates if air connectivity can be related with some economic indicators and therefore tries to conclude if enhanced air connectivity can in fact contribute to improve economic growth within the European Union. Chapter VI finalizes this thesis with some conclusions and comments regarding the limitations that were encountered throughout this work.

I. Importance of air transport

When studying Economics we are confronted with the requisite to answer the dilemma of satisfying human needs, which are unlimited, and knowing that the resources available to satisfy these wants are scarce. That is why the goal of Economics is to try to maximize the resources available in order to have an optimum response to fulfil human needs. Therefore, aviation can also be seen as being part of economics because air transport geography "is limited to the use of predetermined corridors" (Senguttavan, 2006). Further, aviation associates very deeply movements in the global, regional and local economy and, as it happens in economics, aviation also relates with society and political environment. That is why any development regarding economic globalization and liberalization has automatically repercussions on the air transport sector (*ibid*.).

Between 1960 and 1970, air traffic grew rapidly and in consequence, there were significant developments in the air transport industry led by the intersection of four processes (Senguttavan, 2006):

- **Technical advances:** technology made it possible to have a broad range of aircrafts that were able to fly overseas, so aircrafts could fly up to 18 hours uninterruptedly;
- **Lower fares:** technical enhancements, higher demand and competition made it possible for airfares to reduce substantially;
- **Globalization:** it is directly connected to the "demand for greater mobility and access (...) for different types of passengers and cargoes, to different places, and over different distances than was the previous norm" (Button, 2008);
- **International tourism:** income and economic output growth can highly explain the growth of air transportation. The high increase of trips originated in developed countries made it possible to have a greater amount of income available for leisure.

Regarding the last process, in 2018 Europe received 716 million international tourists, which means a 6% growth when compared to 2017. If we

look at Figure 1, this means that tourist arrivals in Europe represented 51% (716 million) of the worldwide number (1.407 million).

Figure 1: Global and Regional Tourism Performance in 2018

Source: https://www.unwto.org/global-and-regional-tourism-performance

It is important to clarify that all the expenditure done by international tourists is accounted as an export in the destination country and an import in the tourists' country of residence. Hence, tourism can play a major role in order to produce a tourism trade surplus in countries' Balance of Payments (BoP). In 2016, the EU trade surplus of 27 billion euros (international tourism receipts of euro 342 billion euros and expenditure of euro 315 billion euros) is mostly due to Southern and Mediterranean countries, which accounted for 83 billion of euros of travel trade surplus (WTO, 2018). Therefore, it is possible to conclude that European countries play an important role when it comes to foster tourism

Within Europe, the 28 countries of the European Union (EU) welcomed the highest volumes of international arrivals in Europe. In 2016 the EU represented 40% of international tourist arrivals (500 million in 1.243 million worldwide) and 31% of international tourism receipts (342 billion USD in total of 1.253 billion USD worldwide) when compared to the rest of the world (WTO, 2018).

In 2016, 84% (521 million) of arrivals originated from European source markets were to European destinations (intraregional tourism), of which 417 million to European Union destinations. The Schengen Area and the Euro Zone facilitate greatly the number of travels between the majority of countries in the European Union (WTO, 2018).

According to the European Commission, tourism has an overall positive impact on economic growth and employment within the European Union.

1.1 Economic impacts of tourism

Tourism is undoubtedly dependent upon the aviation industry, hence any efficiency adjustment in aviation will greatly impact tourism development (Dimitrios et al., 2017). Regarding the European Union area, this is seen as “the largest international free market in air transport services in the world since 1997” and this will grow as the Union expands geographically (Button, 2008).

It is clear that aviation “provides air access for companies that must meet the demands of supply, competition and expanding marketing areas” (Oktal et al., 2006). This is why aviation is seen as “one of the most global industries” because it is able to join people, cultures and business across countries (IHLG, 2019).

The economic impacts of air transport industry can be divided as follows (see Annex 1) (Oktal et al., 2006):

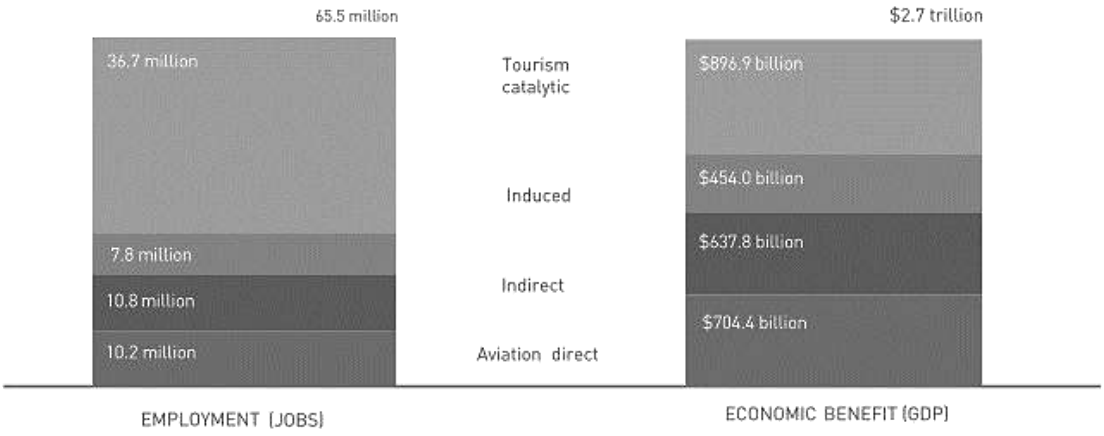
- **Direct impacts:** includes jobs and activities that are part of the air transport industry, such as the aviation sector and the civil aerospace sector (airline and airport operations, aircraft maintenance, for example) (Oktal et al., 2006);
- **Indirect impacts:** includes jobs and activities that are related with air transport industry supply chain (aviation fuel suppliers, for example)
- **Induced impacts:** includes spending of direct and indirect employees “that support jobs in industries such as retail outlets, companies producing

consumer goods and a range of services industries" (banks and restaurants, for example);

- **Catalytic impacts:** all the effects that the air transport industry has on the performance of other industries and that it contributes as a key driver of these industries' growth (trade, tourism, consumer welfare, productivity, etc.).

According to ATAG (Air Transport Action Group), in 2016 all of these economic impacts are translated in 2.7 trillion US dollars which means 3,6% of the world's gross domestic product generated in that year. This impact brought an economic benefit on GDP of 897 billion USD that is the largest benefit when compared to the other economic effects (see Figure 2).

Figure 2: Aviation's global employment and GDP impact (2016)



Source: Industry High-level Group (IHLG), 2019

Regarding employment, the European Union is accountable for 14% of total jobs created which generated a total of 691 billion dollars of economic benefits in GDP, which means 26% weight worldwide. In Portugal were generated 322 thousand jobs with a 13.4 billion USD impact on GDP (see Figure 3).

Figure 3: Aviation's employment and GDP impact in UE28 and Portugal (2016)

Source: Air Transport Action Group (ATAG), 2019

The economic impacts are even more evident in the current context where the world is facing one of the worst health pandemics in the History. The real impacts that the COVID-19 pandemic will have in the world's economy remain uncertain, but whatever the final scenario, the consequences will be catastrophic in both GDP values and unemployment rates, especially for countries were tourism depends greatly upon aviation. The latest forecasts of ACI Europe predict that in 2020 airports will lose 69% of passengers (1.69 billion of passengers), in comparison with 2019, which means a loss of approximately 31 billion euros in airport revenues.

II. Definition and meaning of air connectivity

Previously we saw that increasing the number of connections to the global air transport network can be an important tool to enhance “productivity and growth of economies by providing better access to markets, [amplify] links within and between business and providing greater access to resources and to international capital markets” (IATA, 2007).

According to ICAO air connectivity can be defined as “an indicator of a network’s concentration and its ability to move passengers from their origin to their destination seamlessly”. This concept is especially relevant because many governments worldwide are looking at air connectivity as an asset that can foster the worldwide competition between cities, regions and/or countries (Burghouwt, 2017). Furthermore, ACI stated that Europe’s air connectivity plays a crucial role in its competitiveness and it is an important input for both economic growth and job creation (ACI Europe, 2014).

Additionally, air connectivity is seen as intrinsic to international mobility and it is the core of a globalised world where it essential to have national and regional accessibility and development (ACI, 2018).

In what follows we present the main types of air connectivity.

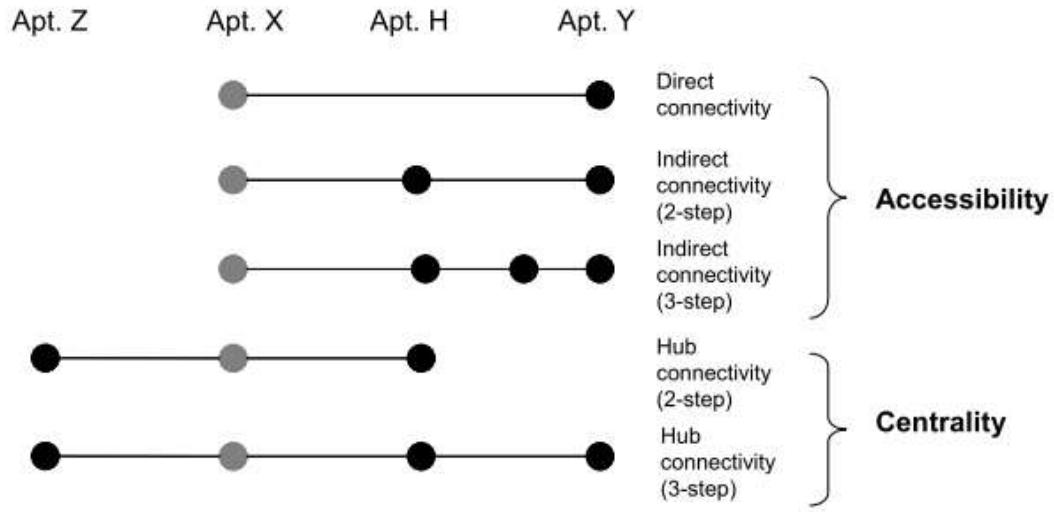
2.1 Different types of air connectivity

In order to further understand the importance of air connectivity as a “key to unlocking a country’s economic growth potential” it is relevant to distinguish two basic perspectives on connectivity: accessibility *versus* centrality (Morphet & Bottini, 2013).

The accessibility perspective is linked with direct and indirect connectivity whereas centrality is related with Hub connectivity (see Figure 4). This differentiation is paramount because accessibility only measures the “number and quality of direct and indirect air travel connections available to the consumer

at a certain airport" and centrality considers the "number of transfer opportunities available via a specific airport" (Burghouwt & Redondi, 2013).

Figure 4: Types of connectivity at airport X



Source: (Burghouwt & Redondi, 2013)

Therefore, and according to ACI (2019), within the accessibility perspective it is possible to distinguish between direct and indirect connectivity:

- **Direct connectivity:** direct air services that are provided from a specific airport measured in terms of destinations and frequency of flights to the same destination;
- **Indirect connectivity:** this assesses the number of places that passengers can fly to, via a connecting flight at hub airports, originated from a specific airport. Then, the larger the number of available onward ("beyond") connections between airports X to Y (Figure 4), the greater is the range of destinations available from the airport of origin.

Hence, **Airport connectivity** is defined as the sum of both direct and indirect connectivity. This way it is possible to compute the gross level of connectivity of a specific airport regarding the rest of the World either through direct or indirect flights.

The centrality perspective in air connectivity brings out an extremely important type of connectivity – the **Hub connectivity**. It measures the number of connecting flights that can be enabled by a specific hub airport. This accounts for minimum and maximum connecting times and also measures the quality of the “connections by the detour involved and connecting times". Hub airports work to create economies of scale by pooling demand. Therefore, airlines are able to maximise passenger numbers by filling flights with those using the hub airport which makes the route viable (ACI, 2019).

Most of the literature focus only on the impacts that Airport connectivity has on economic growth. In this study, we will try to go further on the empirical analysis by regarding the benefits of Hub connectivity to boost economic growth. Thus, the hub connectivity definition will be crucial for understanding the conclusions of this work.

2.2 Determinant of air connectivity

According to Morphet and Bottini (2013), there are four major determinants that can be seen as enablers of air connectivity: geography, airport infrastructure, airline models and a country’s regulatory and economic frameworks.

Regarding geography, a country’s location can help developing their capability to enhance their network connections. For instance, if we look at Europe, it is possibly to realize how its geographic location can capture intra and inter-regional flows because “within a four-hour radius, the EU’s main hubs can draw mainly from European and possibly North African destinations”. Also, for long-haul routes, EU is an advantageous intermediate location for passengers originated from East Coast North America to Asia destinations (Morphet & Bottini, 2013).

A strengthen airport infrastructure combined with a well-developed and large network can decrease travel costs not only for passengers, but also for air

cargo. This happens because fares are lower, time travel is decreased and connections are more seamless. In order to achieve this strengthen airport infrastructure it is paramount that the airport has the necessary capacity not only to evolve but also to mature its operation which require a substantial capital investment (Morphet & Bottini, 2013).

Airlines' business models can also play a crucial role as it has a direct impact on air connectivity. These business models can be aggregate in three major categories: low-cost (e.g. Ryanair), network (e.g. TAP Portugal) and hybrid (e.g. Blue Air) carriers (see Annex 4) (Morphet & Bottini, 2013).

Low-cost carriers spot mainly the leisure passengers segment and can be very appealing because offer very low fares which captivated a large group of consumers that previously did not have the necessary income to fly. (Morphet & Bottini, 2013). Network carriers mostly operate "radial network centred on their main base or hub". This type of carriers supply a wide range of routes combined with very regular and flexible services that answer the needs of both business and leisure travellers (Morphet & Bottini, 2013).

According to Morphet and Bottini (2013), countries that depend on "strong network carriers that use their hubs efficiently are more likely to achieve greater air connectivity than countries served only by LCCs".

A country's regulatory and economic framework can also be used as a tool to enhance air connectivity. An example of this situation is the "open skies agreement" signed in 2007 between the European Union and the United States. The goal of this agreement was to "open access to markets and maximize benefits for consumers, airlines, labour and communities on both sides of the Atlantic" (European Commission, 2017).

III. Literature Survey on Air Connectivity and Economic Growth

In this chapter it is presented several researches conducted throughout the years that explains how air connectivity can be related with some economic variables.

3.1 Efficiency and Innovation

In a survey conducted by the International Air Transport Association (IATA) in 2006, on a total of 600 companies that were inquired, 50% confirmed that air transport is vital to efficiency. For 70% of these firms, aviation allowed them to improve their efficiency through economies of scale via access to export markets which consequently will promote higher investment (Oxford Economics, 2008).

According to the 2007 R&D Scoreboard, all the successful innovation in the aviation industry have important repercussions in all of the industry's supply chain and that is why the social return of the aerospace expenditure in R&D is estimated to be 70%. For instance, an investment in R&D of 100 million US dollars made by the aviation sector would "add 70 million US dollars to the GDP level year-after-year." (Oxford Economics, 2008).

Therefore, increasing air connectivity will be helpful not only for the flow of new ideas, but also to the spread of significant benefits in all economic sectors. This is explained by the fact that increasing air connectivity will reduce distance which, in turn will stimulate the development of social and businesses networks (Oxford Economics, 2008).

3.2 Labour mobility and productivity

The air transport industry can promote the movement of labour both domestically and internationally (Oxford Economics, 2008). This matter becomes

especially relevant within the European Union as labour mobility is seen as an important element for the success of the Eurozone (Oxford Economics, 2008).

Moreover, studies undertaken by IATA (2006) and InterVistas (2006) concluded that increase air connectivity will consistently produce considerable growth in labour productivity (Oxford Economics, 2008). The capitalised gains of such event can be seen in the Cork Airport Business Park. “International travellers can be at their desk within ten minutes of landing without the customary delays associated with rental cars, parking, traffic, etc.” and can also choose to stay at the hotels that are placed on the Cork campus (Cork Airport Business Park Ireland, n.d.). The Cork Airport Business Park has already produced considerable benefits, namely the 83% growth on employment, since 2000 until 2006, and the fact that Cork’s output has surpassed by 0.5% annually the growth of all of the Irish economy (Oxford Economics, 2008).

Another example of how the aviation sector can contribute, at least partly, to the rise of productivity can be seen by looking at the high rate of investment in air transport services at United Kingdom (UK) airports. In this regard, in 2012, investment in air transport services represented 25.4% of total gross value added (GVA) in United Kingdom, which means that the investment in this sector is “5.6 percentage points higher than in the whole economy”. According to Oxford Economics (2014), increasing air connectivity can contribute to enhance productivity, which in turn, will contribute to the progress of the overall economic performance.

During 2005 and 2006 there was also three studies carried out by EUROCONTROL and Oxford Economic Forecasting where it is estimated that a 10% increase in connectivity (relative to GDP) will raise the level of productivity in the economy by a little under 0.5% in the long - run. Additionally, these studies also state that air connectivity can also increase the long run level of GDP through its effects on increasing investment. In consideration of the foregoing, if we account for this investment channel, the total impact of a 10% increase in

connectivity relative to GDP can increase the long run level of GDP to over 1% (Oxford Economics, 2014). More specifically, Oxford Economics (2014) calculated that a 10% increase in UK's air connectivity (relative to GDP) would be translated in a £890 million increase in the long-range level of GDP annually.

3.3 Foreign Direct Investment (FDI)

Some studies that prove how enhanced air connectivity can have major positive impacts on FDI will be subsequently presented:

Oxford Economics studied the relation between foreign direct investment and air connectivity index (created by IATA). As it was reported, countries with high levels of air connectivity could, in general, attract more foreign direct investment.

The annual survey ("European Cities Monitor") made by Cushman & Wakefield showed some evidence on how connectivity can be a key element for a company's location decision ("the transport links with other cities and internationally and ease of access to markets, clients and customers"). Additionally, this survey reveals that European cities that have major airports' hub are considered as preferential locations for firms. In 2011, London, Paris, Frankfurt and Amsterdam were in the top of this list (Oxford Economics & York Aviation, 2013).

The Oxford Economics Forecasting undertook a research during 2006 where 25% of the companies enquired stated that access to air services is important in determining where they locate their operations in the UK. In addition, another study done by Oxford Economics for IATA (2006) proved that "a 10% increase in (air) connectivity is associated with a 3.5% increase in the level of fixed investment in the long run" (Oxford Economics & York Aviation, 2013).

In 2008, Bel & Fageda studied how intercontinental flights can determine the location of a firm's head office. They found out that "a 10% increase in the

supply of intercontinental flights involves around 4% increase in the number of headquarters of large firms located in the corresponding area" (Oxford Economics & York Aviation, 2013).

3.4 Trade

Aviation is crucial for firms to engage in international trade is seen as an important tool for countries to develop their competitive advantage(s).

International trade is an important opportunity for exporters to "meet wider market demand" outside their domestic market which will allow them to take advantage from economies of scale and therefore increase productivity (Oxford Economics & York Aviation, 2013). That being said, air cargo can be the most efficient way to transport goods worldwide, especially living in a world where *"time is money"*, so distance matters more than ever. Accordingly, improving air connectivity can play a key role in reducing costs associated with time travel between geographically distant markets. (Oxford Economics & York Aviation, 2013).

There is some literature that support relation between air connectivity and trade. For instance, in 2011, the Frontier Economics prove that "UK businesses traded 20 times as much with countries where there are at least daily flights (…) and that UK trade could be increased by around £1.2 billion per annum if there were sufficient capacity at Heathrow to accommodate viable routes to emerging markets" (Oxford Economics & York Aviation, 2013).

In addition, during 2013 CBI Trading Places report estimated that if the UK increased a daily service "to each of the World's largest high growth economies" it would have a positive impact of around £1 billion on their trade balance.

3.5 Tourism

The existence of air services makes it easier and faster for potential visitors to travel to their destination country. That being said, developing and broaden air connectivity will increase the number of visitors that enter into a country. In consequence, this increase the opportunities of the opening of new markets, which will bring new visitors (Oxford Economics & York Aviation, 2013).

In 2004 an ACI Research undertaken by York Aviation stated that “even for major European cities, where other transport modes are more effective competition, air connectivity can account for a third or more of foreign visitors” (Oxford Economics & York Aviation, 2013).

According to a research conducted by the Great London Authority (GLA) in 2011, inbound tourism is crucial in order to reinforce a country’s export revenues. This is explained when looking to the tourism balance because increasing the inbound tourism can also increase the level of consumption in the domestic economy, which can make the export revenues rise and overall have a positive impact in a country’s GDP (Oxford Economics & York Aviation, 2013). It is clear that increasing air connectivity will increase both inbound and outbound tourism which can be beneficial to a country if their combined effect, and including other impacts described above, can be able to increase productivity and economic growth (Oxford Economics & York Aviation, 2013).

IV. Different methodologies to calculate air Connectivity

There are many different ways to measure air connectivity. Within this wide research, four of the most common and acknowledged connectivity measures that are broadly used in the aviation industry are going to be highlighted: York Aviation, World Bank (representing the gravity models), IATA and ACI.

4.1 York Aviation – Business Connectivity Index (BCI)

The York Aviation is an air transport consultant that provides services regarding aviation policy advice, economic impact assessment, air traffic forecasting and advice on airport capacity assessment and planning (York Aviation LLP, n.d.). Taking into account their knowledge and capabilities within the aviation industry, a business connectivity index (BCI) was developed. This index "measures the extent to which airports can support the economic benefits associated with connectivity". Hence, the air connectivity value of an airport is assessed not only by the economic significance of the destinations served (based on the Globalisation and World Cities network research), but also by the number of frequencies for those destinations that are originated in that airport (Oxford Economics, 2017).

The main goal of BCI is to realize "the relative value that different airports or groups of airports" can provide to businesses through the offer of economically advantageous destinations. Thereupon, this index aims to understand how airports can deliver economic benefits by developing their routes' network and hence their connectivity (Oxford Economics & York Aviation, 2013).

4.2 Gravity models – The World Bank Air Connectivity Index

Gravity models were inspired by the Law of Universal Gravitation of Isaac Newton, which indicates that the attractive force between two objects is positively

determined by masses of objects and negatively by distance between them. These models are commonly used in international trade theories that aim to explain trade flows between different countries (“nodes”) (Blonigen et al., 2018).

Regarding air transport research, the application of gravity models is limited but has already shown that can be successfully used to describe the movement of people and goods between city-pairs concerning income and distance. These models usually count on GDP measures (economic variable) and the “great circle distance between two countries” (transport variable) (Oxford Economics & York Aviation, 2013).

According to Baier and Bergstrand (2010) the gravity models are gaining popularity within air transport research because of their “strong theoretical economic foundations, strong empirical explanatory power, and policy relevance for analysing many free trade agreements” (Blonigen et al., 2018). Therefore, this type of models can demonstrate how an improved airport infrastructure can positively affect trade. For instance, an airport that is capable of providing a large number of new routes and frequencies of commercial flights where it is simultaneously possible to carry cargo, can have a positive impact on the time that is necessary to store the inventory which will reduce trade costs (Oxford Economics & York Aviation, 2013).

One example of a connectivity measure that was formulated using a gravity model is the Air Connectivity Index developed by the World Bank in 2011.

World Bank’s definition of connectivity relates with the assessment of the “overall pull” that a country wields within the network. In order for a country to have a high connectivity score, the cost from moving to another country has to be relatively low cost and the dispersion of those costs must be low. Therefore, it is clear that a global airport hub that has a large number of connections to many other countries in the network will have a high connectivity score (Arvis & Shepherd, 2011). Hence, the World Bank Air Connectivity Index values a route

based on the quantity of onward connections that exist in an airport which focus mainly on hubs advantages (Morphet & Bottini, 2013).

4.3 IATA Air Connectivity Index

The International Air Transport Association (IATA) was created in 1945 in Cuba with 57 airlines as the founding members. Nowadays, IATA represents approximately 290 airlines spread by 120 countries, which represents 82% of the world's air traffic (IATA n.d.) IATA's mission is to "represent, lead and serve the airline industry by working together to shape the future growth of a safe, secure and sustainable air transport industry that connects and enriches our world" (*ibid.*)

IATA developed an air connectivity index that accessed the "number and economic importance of destinations served the frequency of service to each destination and the number of onward connections available from each destination" by using OAG (Official Aviation Guide) airline schedule data. The goal was to relate airport connectivity with long run investment and productivity for European Union countries by using the following formula (Oxford Economics, 2017):

$$\frac{Number\ of\ destinations\ \times frequency\ \times seats\ per\ flight\ weighted\ by\ the\ size\ of\ the\ destination\ airport}{scalar\ factor\ of\ 1000}$$

Hence, the higher the number of destinations and/or frequencies, the higher will be the IATA air connectivity indicator. Thereupon, this result will indicate that a specific airport has a substantial access to the global air network (Oxford Economics, 2017).

4.4 ACI – the SEO Netscan connectivity model

The ACI Europe in partnership with SEO Aviation Economics developed an air connectivity model (the SEO Netscan) in order to measure connectivity among European airports since 2004.

The SEO Netscan connectivity model main goal is to assess the "overall network performance [by measuring] how well two points (countries/airports) are connected by air" (ACI, 2018). In order to achieve this goal, the Netscan model is both quantitative and qualitative as it measures not only the number of direct/non-stop connections and indirect connections through other airports, but also the quality associated with these connections " (*ibid.*).

For the quantitative part, the input used is the airline schedule data, which gives the number of weekly frequencies (both direct and indirect). The quality part of this model is seen as how fast a flight connection can be and it is basically a specific index as it measures detour and connecting times, ranked from 0 (when exceeds predetermined flight time limits) to 1 (shortest travel time). Then, if we multiply the number of weekly frequencies with this quality index, we will have the overall air connectivity index (ACI, 2018).

It is important to point out that this model will be used in Chapter IV due to the fact that in the aviation industry, the Netscan model is very popular and reliable. Many researchers apply this model in order to test their studies, such as, the global air connectivity assessment in 2000 by the Air Transport Association (IATA). Also, nowadays the Airport Council International (ACI) uses the Netscan model to yearly evaluate airports' air connectivity index (Sopadang & Suwanwong, 2016); the hub performance of Amsterdam Airport Schiphol is monitored by using this same model (ACI Europe, 2014).

There are mainly three reasons that explain why the Netscan model is considered very reliable and popular among researchers. First, it shows the most important connection elements (frequency, travel time and connecting time) together into one single indicator (ACI Europe, 2014). Also, the Netscan model is

rated as one of the most sophisticated network quality models as it includes weights for each connection in order to evaluate its quality on a continuous scale. In addition, network quality models can identify all the connections that are available on a specific airport or group of airports. (International Transport Forum, 2018).

In Chapter IV, the ACI Europe Airport Industry Connectivity Report applies the Netscan model to compute both Hub and Airport connectivity for each airport.

V. Results

In the final chapter, the analysis of the contribution of Airport connectivity and Hub connectivity to economic growth will be performed through the study of some economic variables presented in the Literature Survey. In order to do so, we shall conclude if the correlation between Airport and Hub connectivity with these economic variables is positive and significant. An alternative to this correlation test would be to build a multi variable model for each one of those economic variables based upon their determinants, which would be the only way to guarantee that other effects are being controlled correctly. This was the case, for example, of EUROCONTROL and Oxford Economics presented in the Literature Review when studying the relation between connectivity and productivity. Nevertheless, the extension of this alternative is not compatible with the goal of this study.

This thesis analysis is different from other authors studies as, in this case the aim is to understand the relation between Airport and Hub connectivity with a vast number of variables and not only one. This method does not allow identifying the causality direction, however in accordance to what was stated in the Literature Review it is logical to assume that it is Hub or Airport connectivity that influence the variables' behaviour and not the other way around.

The evidence presented in the Literature Survey shows that a positive and significant correlation between airport and hub connectivity is expected with the economic variables mentioned in the preceding chapter. In addition, it is important to notice that most of the literature regarding this topic does not reveal the great benefits that Hub connectivity has on these economic variables and thus on economic growth. However, hub connectivity deserves special attention because it is a way to create economies of scale by "combining demand for destinations and regular flights" particularly for long-haul destinations (Heathrow 2014). In addition, this is an important tool to any airport success in a globalized and interconnected world as "the better is global connectivity, the more attractive it is to passengers" (Frankfurt Airport 2017).

For airlines, hub airports are very important in order to increase their efficiency*,* as this is a way to replace large numbers of empty seats with fuller ones, making a higher number of routes viable. Also, airports can benefit with hubs specially when they have extra capacity because interconnections between flights will be easier and less conducive to delays. In addition, airports that have a large variety of flights can easily respond to a much bigger demand (Elledge 2014). For passengers there is also a large number of benefits, namely: “easier access to and from the airport due to more infrastructure surrounding it” (e.g. transportation); wider choice of destinations; higher flight frequencies; airlines’ competition will decrease airfares, making airplanes ticket price cheaper (Heathrow 2014).

Therefore, this thesis aims to improve knowledge on the topic also by estimating if hub airports can be considered as a major tool to boost economic growth through the impact that they have on the economic variables under study. This is why during this chapter the difference between testing the correlation of the economic variables will be made with Hub connectivity and with Airport connectivity. Hence, after realizing the great impacts that Hub connectivity has on both airlines and airports, it is expected that Hub correlations will be higher than when compared with Airport correlations.

This chapter will be divided in two sections: the first one will present the methodology and variables used in the empirical evidence and the second one will show the final results.

5.1 Methodology used in the empirical study

The time period under analysis is between 2008 and 2019 for the 27 European Countries (excluding United Kingdom) and it was used air connectivity data sourced by SEO Aviation Economics that developed the Netscan model explained in the last section. The variables chosen to be studied in this chapter were already mentioned in chapter III (Literature Survey). They are namely the

value of Foreign Direct Investment (FDI) net inflows and outflows, the value of Goods exports and imports, International tourism expenditure, the number of Passengers carried and the GDP value. The World Bank Open Data, except for the number of Passengers carried was provided by EuroStat, supplied all this economic data. It is important to notice that there is still no information regarding the value of International tourism expenditure for 2019, so this variable will not be considered for the analysis in that year.

The above-mentioned variables will be correlated with Airport connectivity and Hub connectivity for each European country within the time period in question, with the data restrictions already mentioned. In addition, the European countries used to study the correlation with Hub connectivity are considered the "leading European Airport Hubs" which means that its hub connectivity value was higher than 10 000 during 2019. Hence, these countries are: Germany, Netherlands, France, Spain, Italy, Austria and Finland. Portugal also appears in this Hub correlation study in order to compare its relative position with these "leading European Airport Hubs".

Before presenting the results, it is important to define each variable that will be correlated with both airport and hubs connectivity. Therefore, as reported by the World Bank Open Data:

- **FDI net inflows:** refer to direct investment equity flows in the reporting economy. It is the sum of equity capital, reinvestment of earnings, and other capital. Direct investment is a category of cross-border investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is resident in another economy. Ownership of 10% or more of the ordinary shares of voting stock is the criterion for determining the existence of a direct investment relationship." The data presented is current U.S. dollars;

- **FDI net outflows:** this series shows net outflows of investment from the reporting economy to the rest of the world. The data presented is current U.S. dollars;
- **Goods exports:** “refer to all movable goods (including nonmonetary gold and net exports of goods under merchanting) involved in a change of ownership from residents to non-residents.” The data presented is current U.S. dollars;
- **Goods imports:** “refer to all movable goods (including nonmonetary gold) involved in a change of ownership from non-residents to residents.” The data presented is current U.S. dollars;
- **International tourism expenditure: “**expenditures of international outbound visitors in other countries, including payments to foreign carriers for international transport. These expenditures may include those by residents traveling abroad as same-day visitors, except in cases where these are important enough to justify separate classification. For some countries they do not include expenditures for passenger transport items.” The data presented is current U.S. dollars.

According to Eurostat:

- **Passengers carried:** passengers who travel by plane, including arrivals and departures.

5.2 Empirical evidence

In this section, it is going to be presented the empirical evidence regarding the correlation between airport and hub connectivity with the *above-mentioned* economic variables for the 27 European countries (excluding United Kingdom) since 2008 until 2019. Next, those variables we will also be correlated with the EU hubs airports.

Before presenting the results obtained, we highlight some of the benefits that increasing air connectivity is expected to have for economic growth, already mentioned in section II:

- a “10% increase in the supply of intercontinental flights involves around 4% increase in the number of headquarters of large firms located in the corresponding area” (Bel & Fageda, 2008);

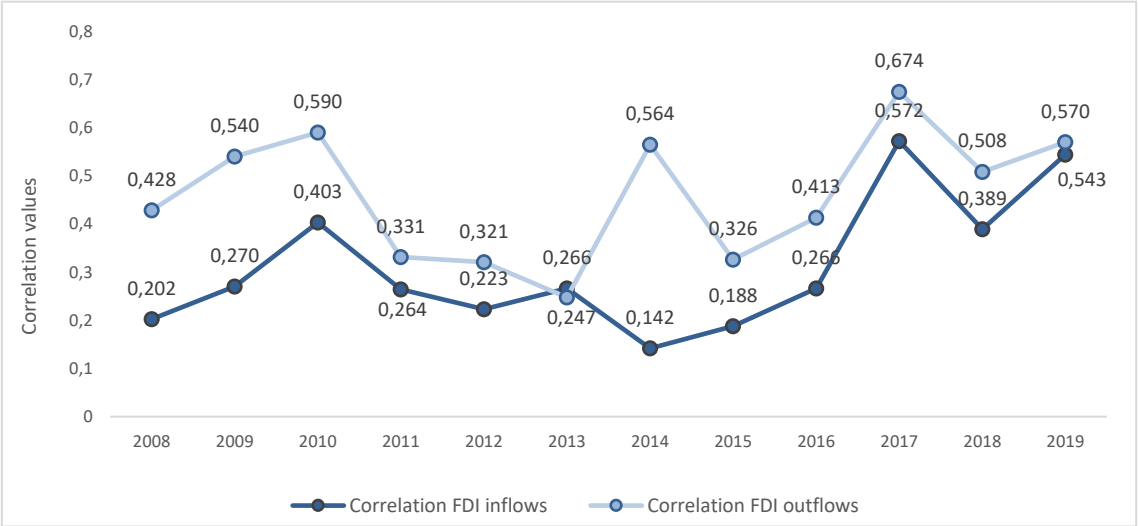
- Improving air connectivity can play a key role in trade by reducing costs associated with time travel between geographically distant markets (Oxford Economics & York Aviation, 2013);

The correlations obtained confirm the importance of separating the analysis between airport and hub connectivity as the impacts can in fact be different as shown below.

5.2.1 Airport Connectivity correlation for the EU27

As explained in Chapter II, airport connectivity is the gross level of connectivity of a specific airport regarding the rest of the World either through direct or indirect flights.

Chart 1: Correlation Airport connectivity with FDI inflows and outflows (2008-2019)



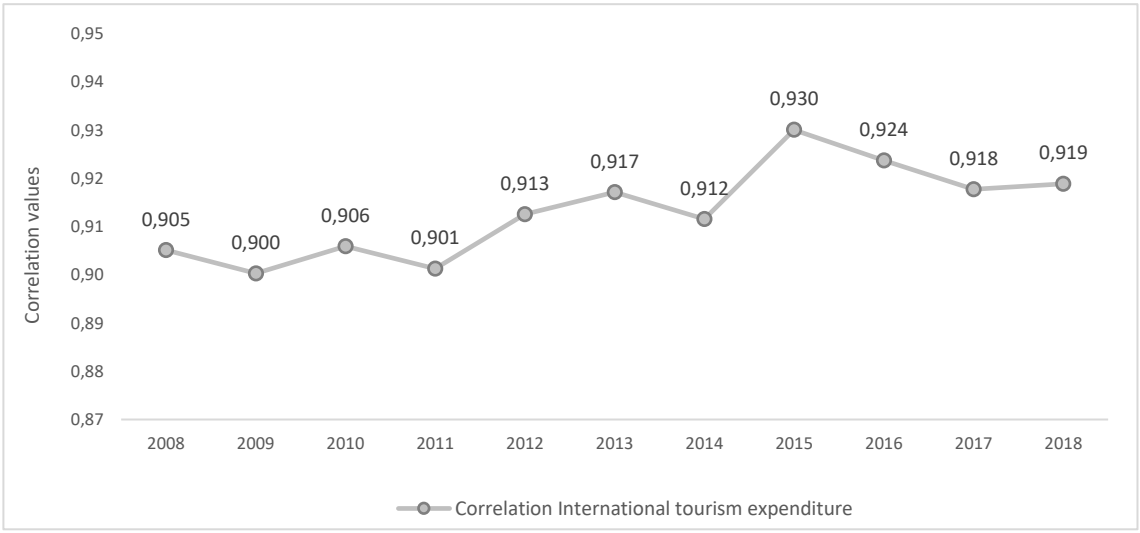
Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

The correlation between Airport connectivity and FDI inflows and outflows has the lowest values when compared to the rest of the variables. In Chart 1 shows that the correlation values had a very high variation since 2008 until 2019, but the overall trend is positive. Under the period of analysis, it is possible to affirm that FDI outflows have a higher correlation with Airport connectivity than FDI inflows, but both variables follow the same trend. However, between 2013 and 2014 the correlation value for FDI outflows more than doubled and correlation value for FDI inflows decreased 43%. Even though these correlation values are not as close to 1,0 as the other variables, it is still possible to conclude that Airport connectivity and FDI inflows and outflows have a low degree of dependency.

These results are quite unexpected after what was described in the Literature Survey, as it was predictable that the correlation between Airport Connectivity and FDI (inflows and outflows) would be much higher than the results presented in Chart 1. Namely, Oxford Economics reported that countries with high levels of air connectivity could, in general, attract more foreign direct investment and also that “a 10% increase in (air) connectivity is associated with a 3.5% increase in the level of fixed investment in the long run”.

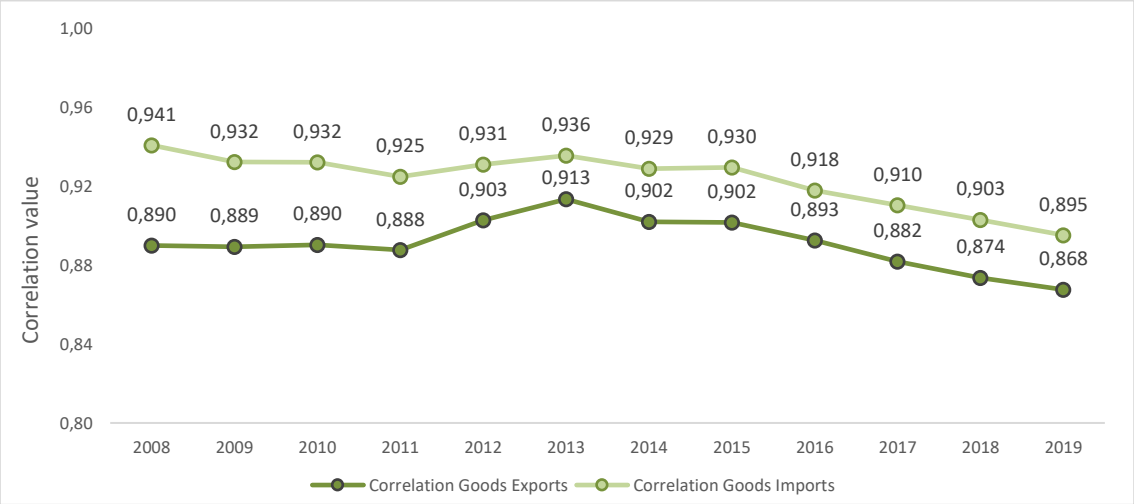
The difference in the results can be explain due to the fact that Oxford Economics used IATA's connectivity index and, in this work, we are using the Netscan model. Hence, we may conclude that by using IATA's connectivity index probably the correlation results between Airport connectivity and FDI (inflows and outflows) would be higher than by using the Netscan's connectivity index. This can be explained because the Netscan Index has a quality measure that is not address in IATA's index which could in fact the connectivity results. In addition, in this correlation study we are analyzing all the 27 European countries and not only the countries that have the highest levels of air connectivity as presented in the Oxford Economics' analysis. In consequence, countries that have low Airport connectivity values could be negatively influencing the correlation values.

Chart 2: Correlation Airport connectivity with International tourism expenditure (2008-2018)



Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

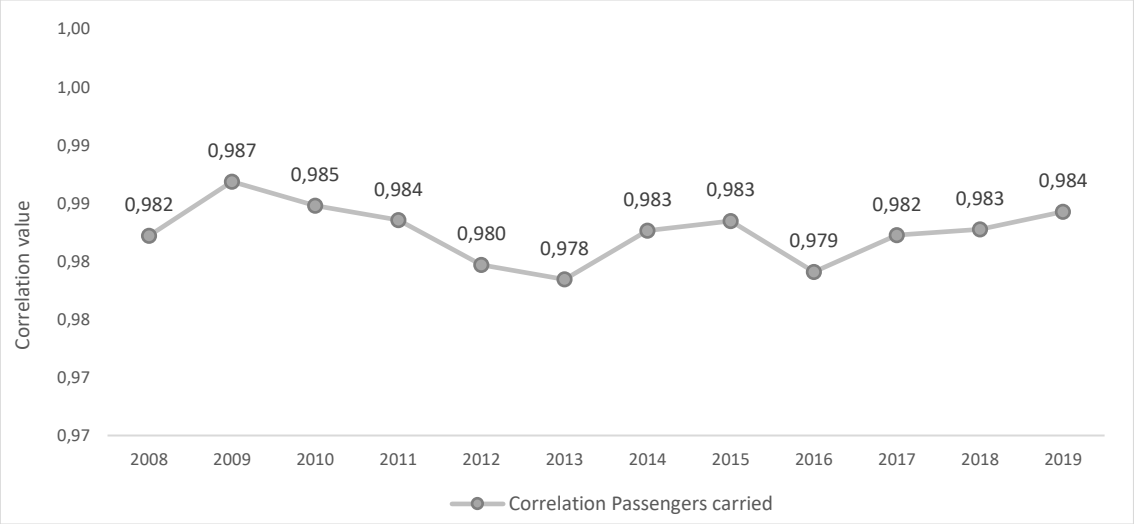
Chart 3: Correlation Airport connectivity with Goods exports and imports (2008-2019)



Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

The correlation between Airport Connectivity with International tourism expenditure (Chart 2) and the Commercial Balance (Chart 3) show very high values (close to 1,0) although in the International tourism expenditure the values are higher. These results can be explained because it is expected that high airport connectivity brings many passengers who will have some expenditures in the host country (e.g. airplane ticket, accommodation, food and beverage). These can be related with the results presented for Goods imports and exports. As it was mentioned in the chapter of the Literature Survey: “the inbound tourism can also increase the level of consumption in the domestic economy which can make the export revenues rise and overall have a positive impact in a country’s GDP (…) on the other hand, outbound tourism has the opposite effect” (Oxford Economics & York Aviation, 2013). In fact, the correlation value between Airport connectivity with Goods imports and exports is very high, varying only from 0,890 to 0,941 (Chart 2). Further, these results can also be related with the number of exports and imports that are carried by air (air cargo).

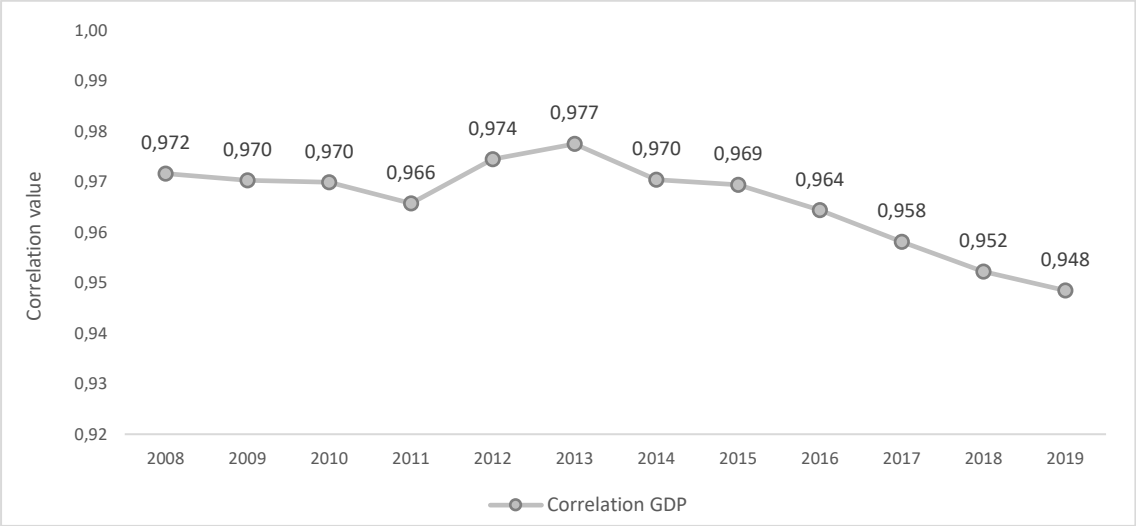
Chart 4: Correlation Airport connectivity with Passengers carried (2008-2019)



Data source: SEO Aviation Economics & ACI and Eurostat
Calculations: the author

After the analysis, it is possible to conclude that the numbers of Passengers Carried (Chart 4) is the one that indicates almost a perfect correlation (very close to 1,0) with Airport Connectivity. In addition, between 2008 and 2019 there are much reduced variations and in 2019 the correlation value is the highest (0,984). These values are very logical because high connectivity means that airports have a large route offer which is intended to carry (in both arrivals and departures) a large number of passengers. Moreover, these results are very coherent with what was presented in the Literature Survey regarding tourism, as air transport is the preferred mode of transportation for potential visitors, so high airport connectivity must be related with number of Passengers Carried. In addition, these results can be very beneficial for the international tourism expenditure because as more passengers arrive to a certain country, the higher will be the value of the international tourism expenditure in that country because these visitors will have several disbursements during their stay, as it was above described.

Chart 5: Correlation Airport connectivity with GDP (2008-2019)



Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

The Airport connectivity correlation with GDP (Chart 5) has also very significant values, which means that these variables are correlated; they have, in fact an almost perfect correlation. However, it is important to notice that since 2013 there is a downward trend in the correlation values regarding these two variables reaching in 2019 the value of 0,948, which represents a reduction of 3% when compared to 2013. Therefore, apparently the correlation between Airport Connectivity and GDP is slightly decreasing its importance for the past six years.

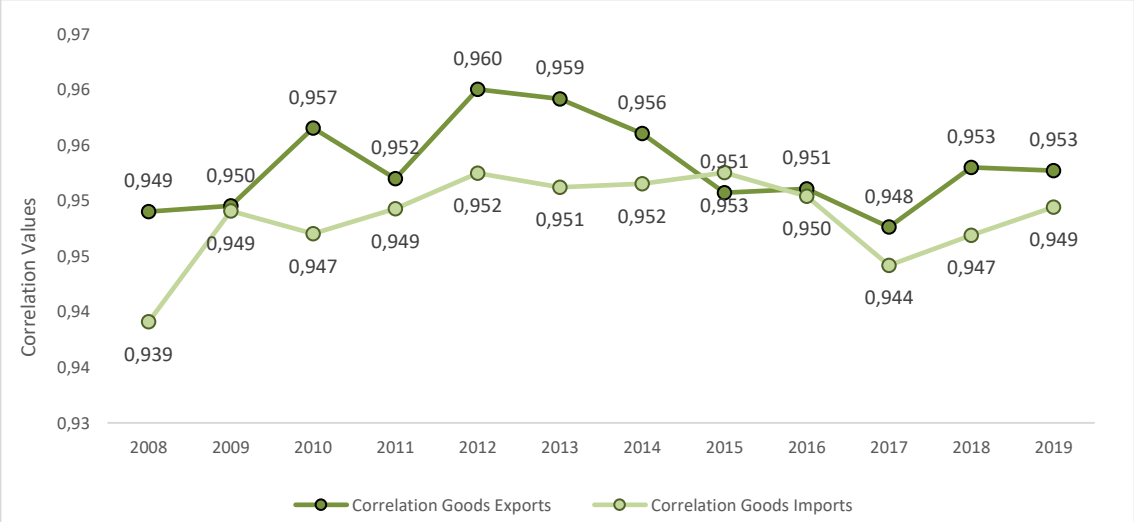
5.2.2 Hub Connectivity correlation for the EU27

As it was explained in Chapter II, hub connectivity measures the “number of connecting flights that can be facilitated” by a specific hub airport. This accounts for minimum and maximum connecting times and also measures the quality of the “connections by the detour involved and connecting times" (Heathrow 2014). Hub airports work to create economies of scale by pooling demand. Consequently, airlines are able to maximise passenger numbers by filling flights with those using the hub airport, which makes the route viable (*ibid.*). Thus, hub airports are extremely beneficial not only for airlines but also for airports as it is a way to make its infrastructure more efficient. This is the reason why it becomes

very relevant to analyse the correlation between Hub connectivity and some economic variables the same way that it was performed with the Airport connectivity in the previous subsection. It is expected that, after realizing the importance of hub airports, the correlation between Hub connectivity and some economic variables will be higher than the Airport connectivity.

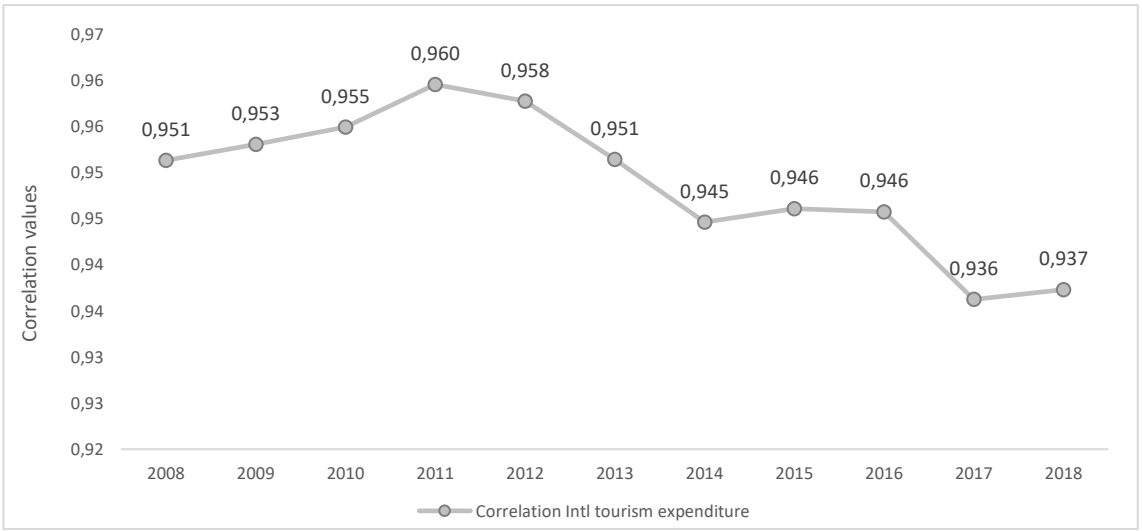
Next, it will be presented the Hub connectivity correlations with economic variables that have higher/similar correlation values than the Airport connectivity values provided in the previous subsection.

Chart 6: Correlation Hub connectivity with Goods exports and imports (2008-2019)



Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

Chart 7: Correlation Hub connectivity with International Tourism expenditure (2008-2018)



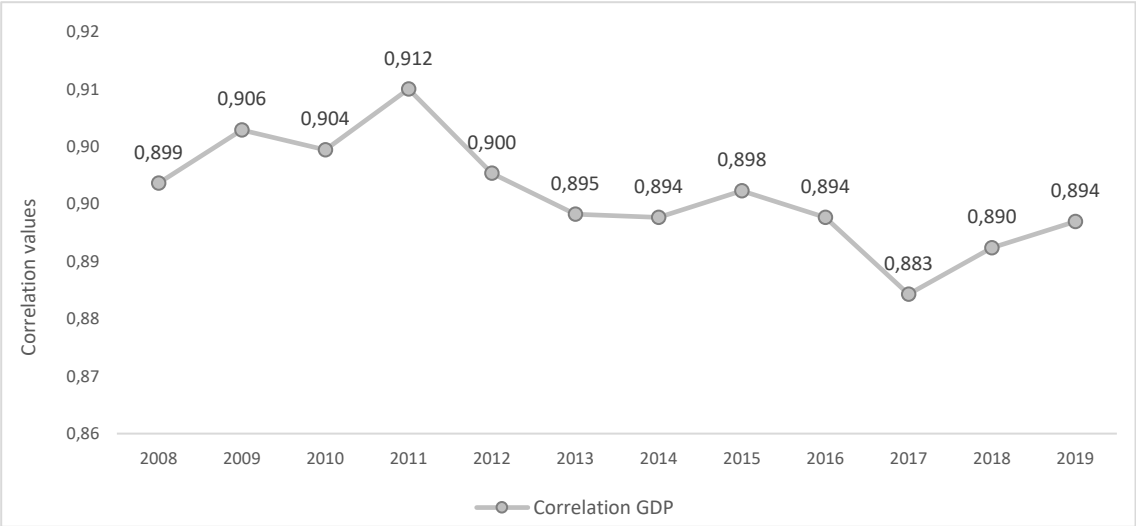
Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

Regarding the correlation between Hub connectivity with Goods exports and imports (Chart 6) it is clear that the values are high and very close do 1,0. Moreover, if we compare these values with the ones of the Airport connectivity, it is clear that will Hub connectivity the correlation with Goods exports and imports is higher throughout the years under analysis. Also, in the Airport connectivity there is a downward tendency since 2015 whereas in Hub connectivity there is a upward tendency since 2017.

These results can be explained by two main reasons. First, it is usual that the airline that has a “hub operation” in a hub airport can also have a Cargo owned subsidiary that operates in this hub airport, like Lufthansa Cargo or Air France KLM Cargo which can affect a country’s Commercial Balance. In addition, airlines that have “hub operation” can also promote Stopovers in the “hub country”. This Stopover is defined as a “stay or a break in a journey of more than 24 hours” and usually happens in the “hub country” (Lufthansa, 2020). These Stopover trips happen typically with long-haul routes, for example a flight from Bangkok via Frankfurt to Havana. Hence, by doing a Stopover of at least 24 hours in Frankfurt airport, the tourists will have some expenditures in the Stopover country. This could also be a reason to explain the fact that the correlation between Hub

connectivity and International Tourism expenditure (Chart 7) is also higher than with Airport Connectivity. It is important to notice that usually passengers of long-haul routes have a higher purchasing power than, for example, passengers of intra-European routes.

Chart 8: Correlation Hub connectivity with GDP (2008-2019)



Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

There is a high correlation between Hub connectivity and GDP throughout the period under analysis for EU27 with slight variations and reaching 0,912 in 2011 (Chart 8). Since 2017, an upward trend that contrasts with the downward trend that was seen in the correlation between Airport connectivity and GDP in Chart 5. This upward tendency seen with the correlation values of Hub connectivity and GDP can be explained by the fact that some of main European airport hubs are increasing their capacity, which is the case of Schipol and Frankfurt airports. Also, in recent years Lufthansa is increasing some of its hub operation to Munich airport that is also expanding its infrastructure.

That being said, it is clear that several factors that can affect the correlation between Hub connectivity and GDP, such as “airport capacity constraints, terminal infrastructure developments and the fate of their home-based carrier” have a high influence in this correlation (ACI Europe, 2014). In any case, the higher and increasing correlation between Hub connectivity and GDP, compared

to what was obtained for airport connectivity, illustrates the importance of hub connectivity in the context of air connectivity to improve economic growth. This result, in turn, suggests the importance of extending this study to the Airport Hubs, subsequently presented.

5.2.3. Analysis for EU27 Airport Hubs in 2019

In this subsection, the goal is to study the behaviour between hub connectivity and some variables presented above for the EU 27 "leading European Airport Hubs" by computing a regression chart and consequently analyse the R^2 results of each chart. These airport hubs are associated with network airlines that, as previously described in chapter II, work mainly in a hub-and-spoke model. We present the results for the last year of the period analysed, namely 2019.

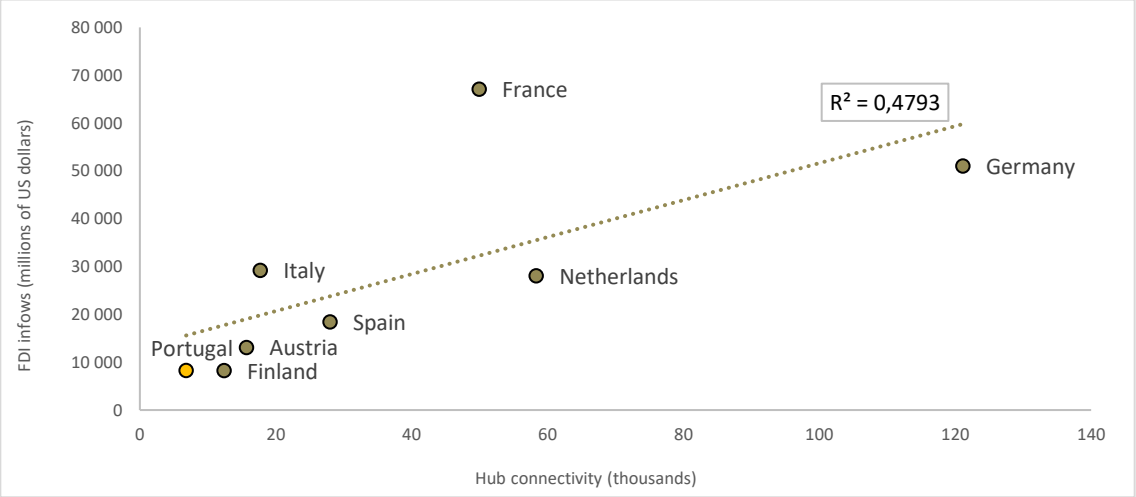
The definition of "leading European Airport Hubs" adopted in this study refers to countries that have a hub connectivity value higher than 10 000 during 2019. Therefore, the countries presented next are: Germany (Frankfurt Airport that is Lufthansa Hub), Netherlands (Schiphol Airport that is KLM Hub), France (Charles de Gaulle Airport that is Air France Hub), Spain (Madrid-Barajas Airport that is Iberia Hub), Italy (Fiumicino Airport that is Alitalia Hub), Austria (Viena Airport that is Austrian Airlines Hub) and Finland (Helsinki Airport that is Finavia Hub). For comparison purposes, we also include Portugal.

The European airport hubs are acknowledged to be between the best-connected hubs in the world, which is explained by their geographic location, high population density, and strong economic position, especially due to the strengths of the European aviation market (Frankfurt Airport 2017). According to ACI Europe, in 2019 "Europe continues to dominate the global league of hub airports".

The following analysis will not be conducted for International tourism expenditure because there is no data available for 2019, which is the year under

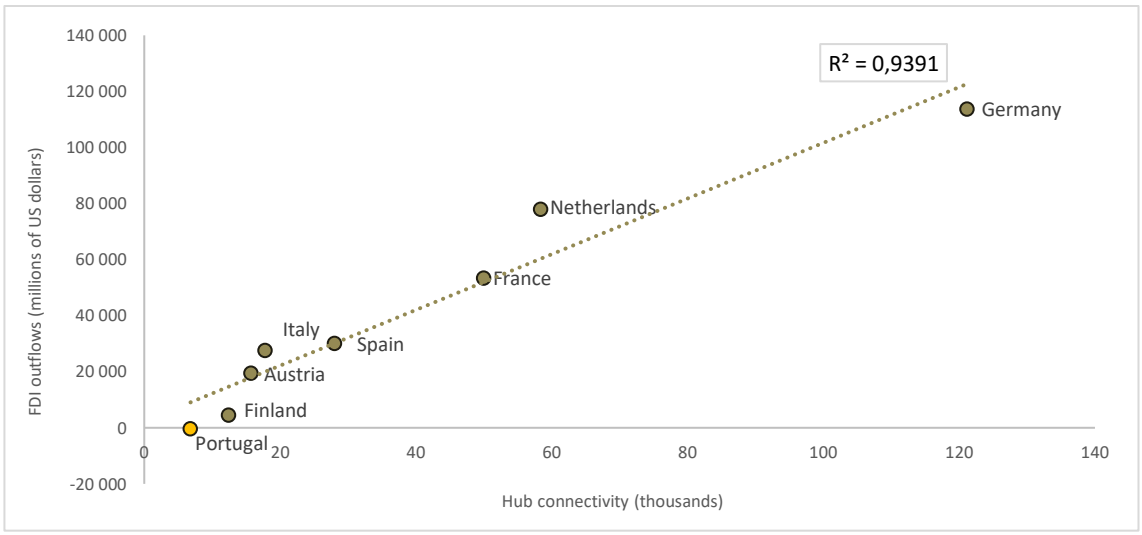
study. Further, the Passengers Carried is not going to be considered as in this subsection only economic variables are being analyzed.

Chart 9: Relation between Hub connectivity and FDI inflows of "leading European Airport Hubs" and Portugal (2019)



Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

Chart 10: Relation between Hub connectivity and FDI outflows of "leading European Airport Hubs" and Portugal (2019)

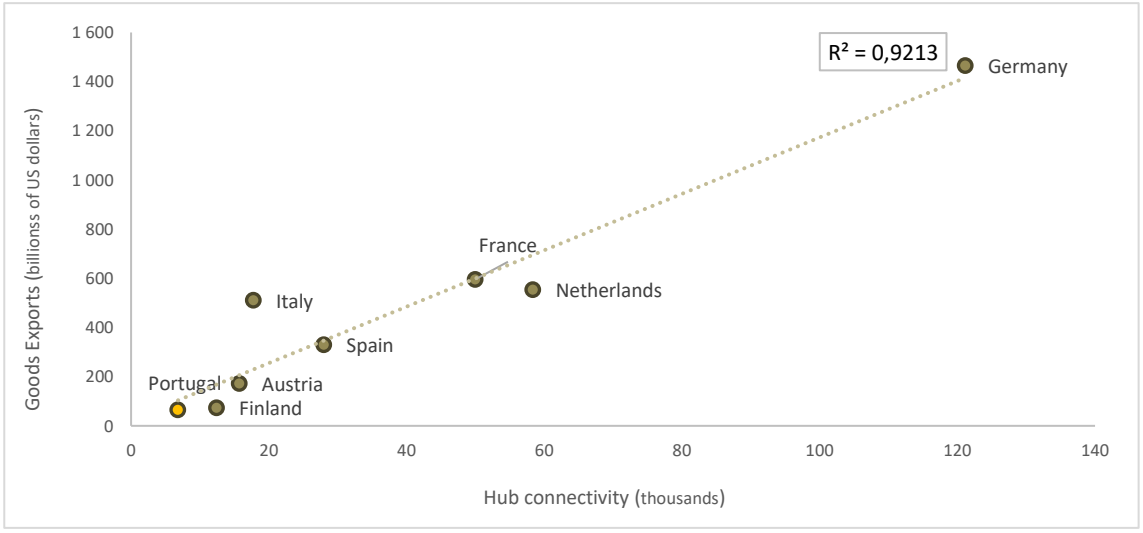


Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

It is clear that the R^2 value for Hub connectivity and FDI outflows shown in Chart 10 is significantly high and very close to 1,0. Hence, we can conclude that the FDI outflows and Hub connectivity are directly proportional. In 2019, countries like Austria, Spain and France have an almost perfect relation between Hub connectivity values and FDI outflows values as their positioned in the regression line of Chart 10. These results are very coherent to what was described in the literature survey because according to Oxford Economics and York Aviation (2013), European cities that have major airports' hub are considered as preferential locations for firms. In fact, in accordance with this study during 2011, London, Paris, Frankfurt and Amsterdam were in the top of this list.

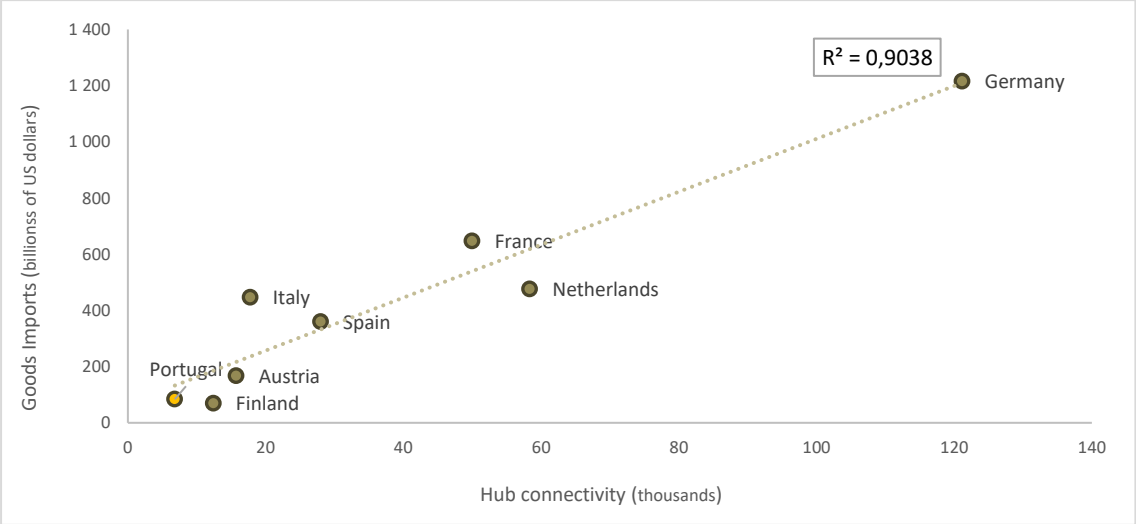
Looking at the value of the R^2 computed in Chart 9, it is very low, especially when we compare it to the R^2 of Chart 10. This value is being influenced by France as it clearly an outlier and if we remove this country from the chart, the R^2 changes from 0,473 to 0,833. The fact that France has a higher level of leisure air traffic than business air traffic might explain this scenario.

Chart 11: Relation between Hub connectivity and Goods exports of "leading European Airport Hubs" and Portugal (2019)



Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

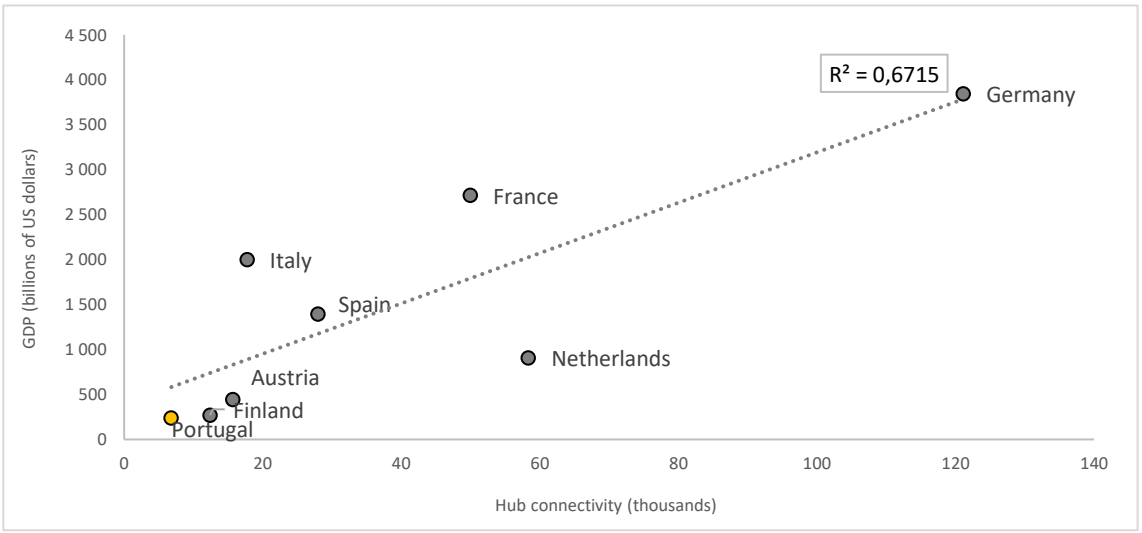
Chart 12: Relation between Hub connectivity and Goods imports of "leading European Airport Hubs" and Portugal (2019)



Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

The relation between Hub connectivity and the value of Goods imports and exports for the "leading European Airport Hubs" is very significant which can be seen by looking at the R^2 value. In Chart 11 and in Chart 12 it is possible to understand that Goods exports and imports are directly proportional with Hub connectivity. In consequence, the Commercial Balance of Germany, Spain, Austria, France and Portugal can be influenced by their Hub connectivity value.

Chart 13: Relation between Hub connectivity and GDP of "leading European Airport Hubs" and Portugal (2019)



Data source: SEO Aviation Economics & ACI and World Bank
Calculations: the author

According to the R^2 value shown in Chart 13, the relation between Hub connectivity and GDP is not very significant, especially when compared to the majority of the graphs presented above. However, the R^2 value can increase to 0,791 if we remove Netherlands from this chart. This can be explained by the fact that there are some items in Netherlands' GDP that are more relevant for this country's GDP than other variables that we have already seen that can be influenced by the aviation industry (such as FDI inflows and outflows and Goods imports and exports).

In accordance with ACI Europe, in 2019 (and in the previous 15 years) Frankfurt Airport was the world's number one hub airport. Indeed, in the graphs presented above, Germany (Frankfurt Airport in specific) stands out with the highest value of hub connectivity. Interestingly enough, this airport also shows an almost perfect linear relation with Goods exports, FDI outflows and GDP values, which points to the importance of hub connectivity to improve those economic variables and therefore, to boost economic growth.

Globally speaking, results for major European Hubs reaffirm that Hub connectivity can contribute to enhance the economy's performance and to improve economic growth. Moreover, Germany and Netherlands have a very central position in Europe, so by combining this situation with high levels of efficiency, Frankfurt and Schiphol airports are bigger contributors for the outstanding economic performance of these countries.

Turning now to the case of Portugal, correlations above allow to conclude that the country should increase its hub connectivity, which could be achieved by taking advantage of its geographic position. As a result, Portugal has a unique advantage in comparison with other European countries. Its location on the western coast of the Iberian Peninsula, that divides the inland Mediterranean Sea from the Atlantic Ocean, can be envisaged as the entry door for American and African passengers in Europe. In 2019, the passengers that flew to and from the American continent and Africa represented only 8% and 4%, respectively, of

the total passengers in the Portuguese airports. Consequently, if Portugal fully exploits this geographic advantage in terms of hub connectivity, its future economic development and growth may redeploy in long-term benefits.

VI. Conclusions

The main goal of this work is to recognize if air connectivity can be related with economic growth in the case of the EU27 by analyzing the relation between Airport and Hub connectivity with some economic variables that contribute to economic growth. The understanding of the relations that were tested can provide interesting guidelines on the relevance of air connectivity in general and, more specifically, Hub connectivity, as a tool to increase countries' economic growth, at least in the case of the EU27.

Several researches have already demonstrated that in fact air connectivity can improve a country's economic performance by enhancing efficiency. Also, air connectivity can play an important role in the labour market as it can influence "individuals' decisions around where and how much labour to supply" (Oxford Economics & York Aviation, 2013). Countries with high levels of air connectivity also appear to attract more foreign direct investment. Further, aviation is crucial for firms to engage in international trade, which is an important tool for countries to take advantage of their competitive advantage(s), and to increase FDI outflows.

In the Results' chapter, it is clear that the correlation between Airport connectivity and the vast majority of the variables analyzed is high. Therefore, airports and governments should make a joint effort in trying to incentivize airlines to increase and diversify the number of air connections.

This study also made a special focus on hub connectivity, as it can be a way to create economies of scale. The large majority of the studies regarding air connectivity do not distinguish the different impacts that Airport and Hub connectivity have on economic variables. However, during the empirical analysis addressed in the last chapter, it is clear that since 2017 the correlation with Hub connectivity, especially regarding GDP, is becoming stronger. This contrasts with the downward tendency seen between airport connectivity and GDP since 2013. Knowing that the European airport hubs are between the best-connected hubs in

the world, the distinction in the analysis between airport and hub connectivity became even more relevant.

We also concluded that there is a very significant difference between Portugal/Lisbon and the main European hubs, especially comparing to Frankfurt Airport. In 2019 (and in the last 15 years), Frankfurt has been the world's number one hub airport and results show that it has a very strong influence in Goods exports, FDI outflows and GDP values. Therefore, the high hub connectivity of this airport should have contributed significantly to the economy performance of Germany.

Contrasting significantly with the case of Germany, the results obtained show that Portugal should increase its hub connectivity, which could be achieved by taking advantage of its geographic position, mainly regarding two continents America - an economic leading area; and Africa - a promising and fast-growing region. By doing so, it could be an exceptional opportunity for Portugal to achieve a higher economic development and growth.

The lack of data regarding the economic impacts of the aviation industry led to some limitations in this work, which explains why a vast number of information merely dates back to 2016. In addition, it was not possible to have the 2019 values for the International tourism expenditure. Also, the air connectivity index used does not include some determinants (geography, airport infrastructures, airline models and a country's regulatory and economic frameworks) that influence air connectivity overall, and therefore can have impacts in both Airport and Hub connectivity index values.

As a path for future work, it would be noteworthy to build a multi variable model for each one of the economic variables presented based upon their determinants, in addition to air connectivity, which would require taking into consideration specific literature for each one.

In the case of Portugal, it would be interesting to investigate the instruments, which could be used in order to help the country achieve a higher hub connectivity, mainly regarding American and African continents as previously mentioned.

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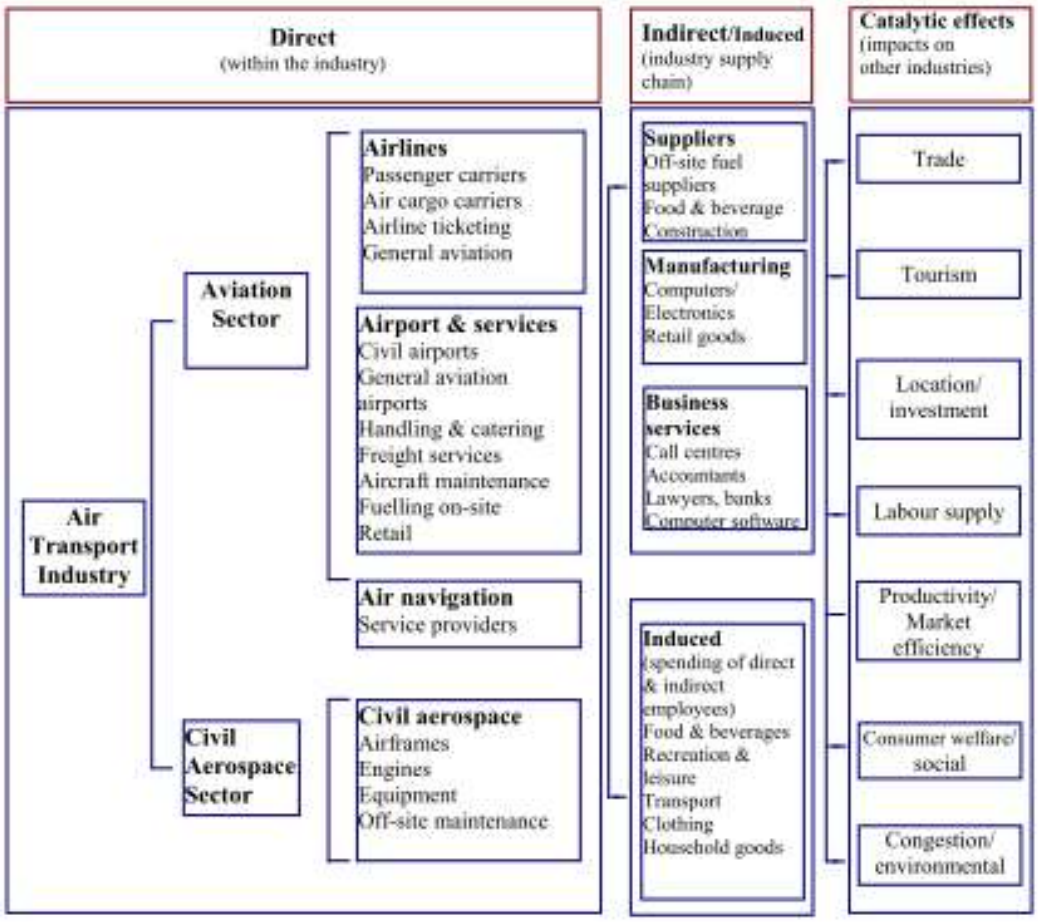
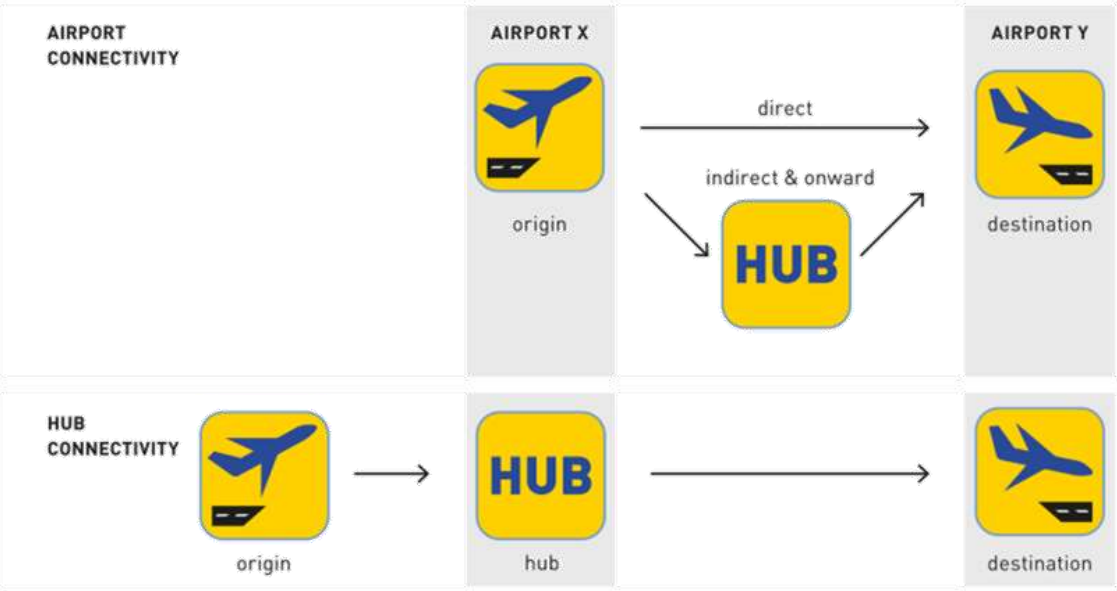
Annex

Annex 1: The air transport industry and its economic impacts



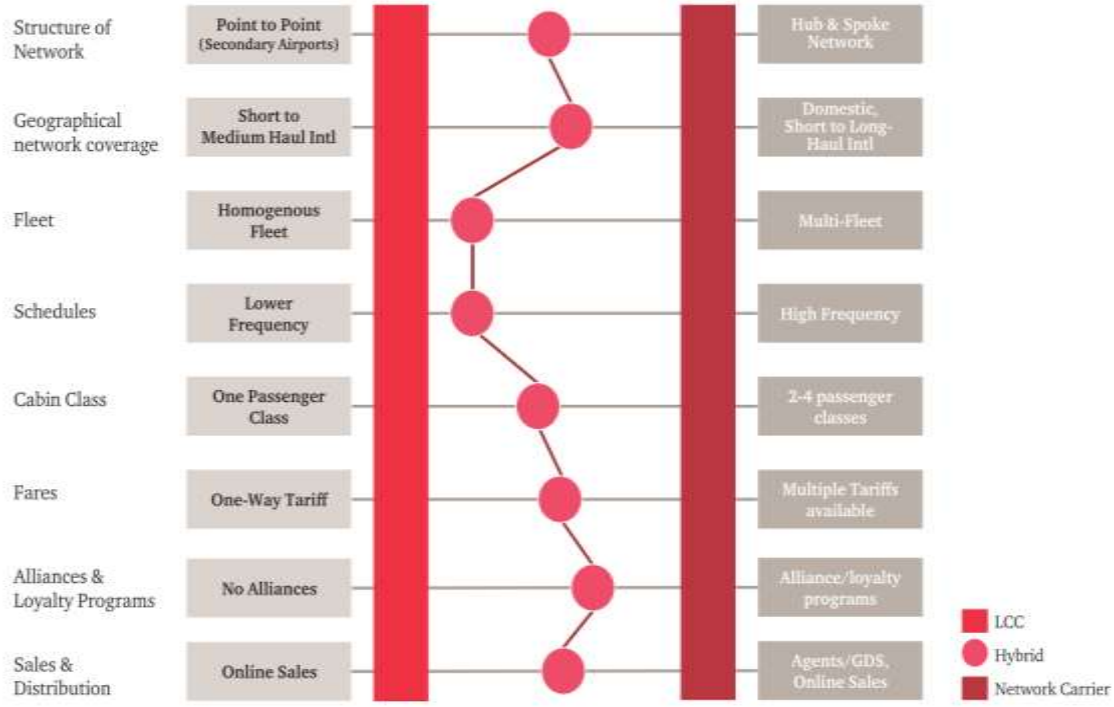
Source: ATAG: 2005: 5.

Annex 2: Different types of air connectivity



Source: SEO

Annex 3: Different types of airlines' business models



Source: (Morphet & Bottini, 2013)

Annex 5: Airport Connectivity values for the 27 European countries (2008-2019)

EU27 countries	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Austria	10 437	9 280	10 083	10 278	9 954	9 844	10 279	10 909	10 668	10 690	11 537	12 252
Belgium	7 225	7 483	7 797	8 233	7 993	7 964	8 462	8 903	8 951	8 684	9 132	9 280
Bulgaria	1 832	1 842	2 079	2 059	1 856	1 800	1 969	2 205	2 439	2 631	2 836	3 046
Croatia	2 359	2 277	2 498	2 690	2 839	2 795	3 019	3 424	3 708	4 133	4 881	5 316
Cyprus	1 195	1 191	1 365	1 367	1 422	1 324	1 239	1 511	1 503	1 845	2 310	2 234
Czech Republic	4 552	4 251	4 456	4 676	4 214	4 301	4 328	4 595	4 842	5 125	5 747	5 908
Denmark	8 204	7 674	8 547	9 157	8 829	9 074	9 379	9 800	10 068	10 421	10 773	10 711
Estonia	1 094	689	949	1 071	1 364	1 171	1 344	1 685	1 540	1 593	1 830	1 751
Finland	7 834	6 450	7 511	8 313	7 391	7 226	7 391	7 256	7 368	7 863	8 671	8 840
France	38 946	37 041	38 300	39 508	40 483	40 159	40 103	43 247	42 424	43 130	44 947	46 135
Germany	58 695	56 344	60 614	62 526	64 452	63 863	63 105	68 385	67 104	67 884	72 350	73 851
Greece	8 451	9 211	9 677	9 518	8 653	8 202	9 268	11 009	12 039	12 566	14 498	15 498
Hungary	3 353	3 438	3 484	3 527	2 972	2 956	3 121	3 427	3 533	3 809	4 175	4 385
Ireland	6 916	6 405	5 919	6 183	6 171	7 218	7 787	8 818	9 152	9 862	10 087	10 411
Italy	33 135	31 362	33 686	34 571	34 747	34 339	34 495	38 658	38 206	39 556	41 479	43 465
Latvia	1 102	1 185	1 257	1 437	1 397	1 490	1 501	1 871	1 782	1 979	2 137	2 292
Lithuania	1 096	681	862	937	914	864	953	1 123	1 159	1 511	1 647	1 660
Luxembourg	1 614	1 491	1 720	1 819	1 909	1 864	1 890	2 057	2 012	2 176	2 529	2 505
Malta	641	727	838	822	805	906	1 083	1 310	1 422	1 794	2 042	2 185
Netherlands	13 919	12 939	13 635	13 623	13 705	14 508	14 868	16 670	16 027	17 011	17 005	17 602
Poland	6 568	5 946	6 659	6 598	7 091	7 446	7 074	7 540	7 992	8 628	10 279	10 780
Portugal	7 586	7 076	7 989	8 509	8 472	8 500	9 104	10 211	10 793	12 016	14 503	14 773
Romania	3 943	4 086	4 471	4 082	4 153	4 234	3 913	4 044	4 462	4 765	5 179	4 943
Slovak Republic	365	211	189	139	122	116	111	141	165	167	236	209
Slovenia	1 244	1 149	1 142	1 172	1 155	1 029	937	1 026	1 127	1 170	1 375	1 384
Spain	39 977	38 584	39 782	41 543	37 998	35 872	38 472	42 471	43 581	46 825	50 921	53 451
Sweden	10 557	8 981	10 381	11 569	11 156	11 202	11 588	11 278	14 315	13 388	13 750	13 473

Source: SEO Aviation Economics and ACI

Annex 6: Hub Connectivity values for the 27 European countries (2008-2019)

EU27 countries	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Austria	14 511	12 310	13 328	13 773	13 194	12 635	13 070	13 329	13 442	13 838	15 256	15 698
Belgium	3 580	5 712	5 587	6 333	6 589	5 358	6 464	6 972	6 579	6 734	7 025	6 399
Bulgaria	52	37	45	69	44	48	38	27	38	46	49	48
Croatia	8	7	5	7	9	8	6	9	12	67	125	114
Cyprus	100	98	139	86	65	35	29	15	24	39	56	33
Czech Republic	3 211	3 206	2 927	2 667	1 476	1 256	1 543	1 246	1 460	1 919	2 025	1 678
Denmark	7 819	6 268	6 730	7 789	6 039	6 065	6 234	5 759	5 859	5 432	5 670	6 103
Estonia	7	5	4	8	50	11	8	17	13	15	20	6
Finland	6 644	5 165	6 201	7 411	7 015	6 799	7 644	8 096	8 513	9 986	11 587	12 397
France	52 351	54 331	53 672	60 209	55 005	52 910	52 156	55 359	50 190	49 386	50 757	49 972
Germany	95 013	90 974	99 266	103 827	108 416	106 345	104 485	110 304	104 955	107 966	120 910	121 141
Greece	1 425	1 796	1 447	1 405	1 569	1 390	2 059	2 817	2 998	2 883	3 302	3 404
Hungary	1 095	1 147	894	1 210	53	51	72	77	97	110	197	223
Ireland	1 152	275	955	1 040	1 181	1 498	1 999	2 651	3 279	3 850	4 229	4 416
Italy	13 580	12 452	14 999	15 656	14 740	14 726	14 643	14 807	15 380	14 895	16 363	17 755
Latvia	153	349	424	614	378	290	8	196	267	445	705	907
Lithuania	27	0	6	1	1	7	12	7	5	6	6	11
Luxembourg	30	32	33	37	39	37			0	67	80	82
Malta	30	34	45	29	47	48	42	49	13	32	75	79
Netherlands	37 086	33 738	38 975	40 002	43 280	45 829	49 449	50 718	52 175	56 609	57 860	58 354
Poland	1 600	1 470	1 755	1 826	2 068	1 861	2 320	2 242	3 105	3 810	5 370	6 426
Portugal	3 353	2 656	3 787	4 099	3 940	3 962	4 479	4 510	5 336	6 017	6 912	6 807
Romania	308	353	408	376	279	239	270	261	281	305	343	354
Slovak Republic	18	10	2	1	0	1	0	3	4	5	11	9
Slovenia	177	175	152	158	94	94	99	105	70	150	311	167
Spain	24 867	23 695	23 976	25 261	20 795	15 794	18 783	20 897	21 386	21 801	25 631	27 994
Sweden	2 569	1 502	2 037	2 381	2 599	2 805	3 053	2 503	3 572	3 916	4 011	3 458

Source: SEO Aviation Economics and ACI