MSc Economic Geography
Master thesis

Evolving business models of low-cost carriers and their influence on connectivity and accessibility of regions in the United Kingdom

Name: Tim Boelens
Student Number: 1764713
Date: Tuesday, September 15th, 2020

Abstract

Low-cost carriers are increasingly competing with legacy carriers at major airport hubs. Low-cost carriers (LCCs) play a vital role at secondary and regional airports, providing them with point-to-point services and providing less densely populated areas with viable connections. Are low-cost carriers changing their focus to major hubs or are the new services complimentary to the offerings of legacy carriers? LCCs shift focus to the metropolitan areas of the United Kingdom, where periphery regions lose or see stagnation of development of connectivity and accessibility.

List of abbreviations

CAA	- Civil Aviation Authority of the United Kingdom
EU	- European Union
FSNC	- Full-service network carrier
GDP	- Gross domestic product
IATA	- International Air Transport Association
LCC	- Low-cost carrier
NLC	- Network legacy carriers
PAX	- Passengers
UK	- United Kingdom

't is lukt

Table of Contents

Chapter 1 5
Introduction 5
1.1 Context and relevance 5
1.2 Research Question 9
1.3 Sub questions 9
1.4 Geographical demarcation 9
1.5 Methodology 9
Chapter 2 10
Theory and application 10
2.1 Airports 10
2.1.1 Deregulation and airports 10
2.1.2 Congestion 11
2.1.3 Accessibility and regional air connectedness 13
2.2 Airlines 15
2.2.1 Airline business models 15
2.2.1 Deregulation and airlines 15
2.3 Relationship between airports and airlines 16
2.4 Conceptual model 17
2.5 Resume 17
Chapter 3 18
Methodology 18
3.1 Introduction 18
3.2 Geographical demarcation 19
3.3 Selection of airlines 19
3.4.1 Data and material to assess connectivity 23
3.4.2 Accessibility of UK airports methodology 23
3.5.1 Data and material to assess accessibility and catchment area of UK airports 25
3.6.3 Correlation between passenger numbers, population size and gross domestic product per capita 26
3.6.4 Hypotheses for OLS model 27
3.7 Resume 27
Chapter 4 28
Data analysis and results 28

4.1 Network development at British airports 28
4.2 Passenger numbers 30
4.3 Quality of the network 34
4.4 Regional Air Connectedness 39
4.5 Statistical relationship between economy, population and passenger numbers 40
Chapter 5 42
Conclusion and discussion 42
References 46
Appendix 51

Chapter 1

Introduction

1.1 Context and relevance

The aviation industry grew steadily in the last two decades [figure 1.1], in particular due to the growth of low-cost carriers or LCCs. From 2004 to 2018, the airline industry doubled in size (IATA, 2018) and this made air transport accessible to the general public in most consumer markets as prices of air tickets fell. The revolution in the air transport industry is enforced by the innovation in business models adopted by airline companies, in which the largest revolution came from scrapping unnecessary elements of the products and the standardization of fleets (Klophaus, Conrady & Fichert, 2012). This growth means higher pressure on both constituents of the infrastructure. Airports get congested and airports face more competition (Redondi, Malighetti and Paleari, 2011).

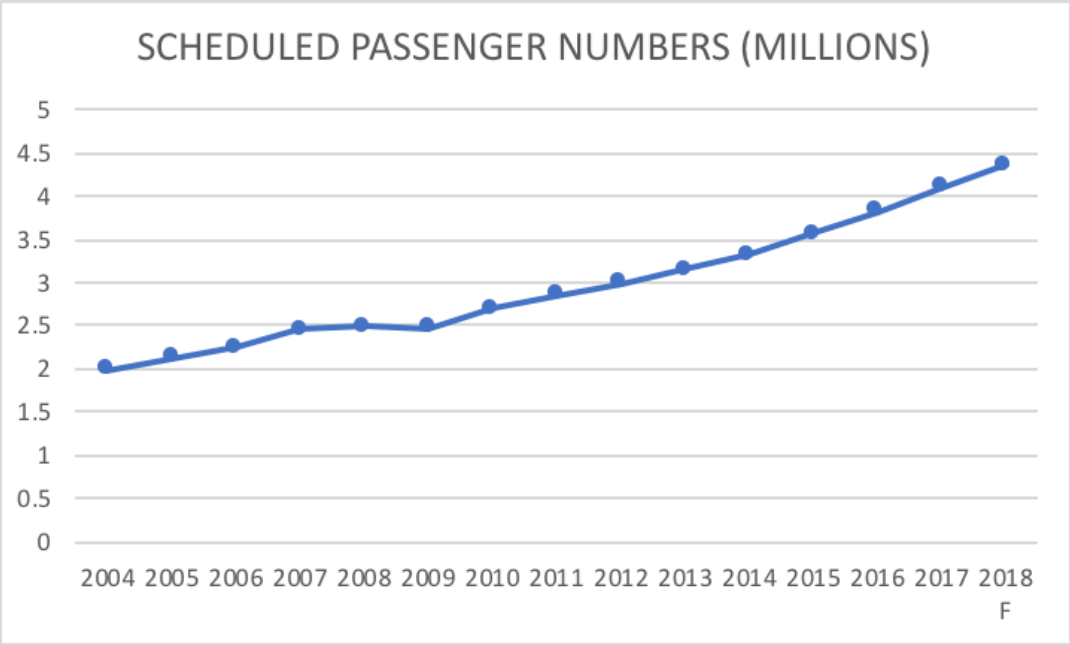


Figure 1.1: scheduled passenger numbers (millions) (source: IATA factsheet June 2018).

Airline companies in general adopt one of the three types of business models in the industry (Belobaba, 2016). There is the network carrier (NLC, after network legacy carrier), which adopts a hub-and-spoke business model. This type of airline has one central hub from which it operates connections outward to other cities. Economies of scale are the result of this strategy. Another strength of this strategy is the capability to make combinations of city pairs which would not have been economically viable served with a direct service. Through a hub it is possible. Downside is the lack of service at secondary airports. NLCs might only provide service to their hub where there might be demand for other destinations (Klophaus, Conrady

& Fichert, 2012). The second type of business model is the low-cost carriers (LCC). These carriers generally operate on a node-to-node basis, serving city pairs with direct flights which generate enough traffic to make the connection economically viable. It solely serves routes through which the LCC is able to make a profit. It generates economies of scale with a large, homogenous fleet, serving numerous city pairs (Doganis, 2009). The third strategy is a combination of the low-cost strategy and the network strategy, called the hybrid model. Most LCCs adopt a hybridized model, incorporating aspects from NLCs (Klophaus, Conrady & Fichert, 2012). This model tries to combine aspects of both strategies (Belobaba, 2016). Airlines and airports are involved in a symbiotic relationship. The strength of their relationship depends on the adopted strategy as well as on external factors as size of the market and economic prosperity. NLCs have a stronger dependency on one airport in comparison with LCCs. This is due to their dependency on the hub function as core of their strategy. LCCs tend to multiple airports as bases from which they operate their flights. The size of the airports also determines the bargaining position of the airport and the airlines which in recent years became stronger in favor of the airlines (Francis, Fidato and Humphreys, 2003).

Airports come in different sizes, from big, international hubs such as Amsterdam-Schiphol or London-Heathrow to small, regional airports such as Southampton and Durham Tees Valley Airport. The airports council Europe, representing airports in most European countries, defines a regional airport as one with a capacity of 0-10 million passengers a year (ACI Europe, 2019). The growth of airline companies with a low-cost business model also lead to a growth of regional and secondary airports in Europe (Dziedzic and Warnock-Smith, 2016). However, this is not the case at every regional airport. The Economist (2016) even warned that despite the growth in demand for air travel shown in graph 1, regional airports are facing hard times. The airports of Plymouth, Kent-Manston and Blackpool even closed in recent years. This despite subsidies from regional and the national government of the United Kingdom. ACI Europe (2019) nevertheless states that regional airports are a vital link for regions and play a large role in the consideration process of international companies. Visible is the maturation of the air services market in Europe which means a slower growth pace (Klophaus, Conrady & Fichert, 2012).

The move of LCCs to large airports is a recent strategic move (Atallah, 2018; Dobruszkes, Givoni and Vowles, 2017). Traditionally, LCCs operate from secondary airports near big cities and at smaller, regional airports as this results in comparative advantages. The LCC business model concentrates on providing point-to-point services. This in contrast with NLCs which provide services with the application of a hub-and-spoke system. The operation of LCCs is much more dispersed with operations at multiple smaller hubs where a number of aircraft is based. NLCs typically have one central hub, where all aircraft are based. This central hub provides the NLC with the necessary scale that generates economic advantages. LCCs need to find other solutions to make the business economically viable. Operation out of smaller airports and secondary airports is cheaper. Smaller airports and secondary airports are also less congested, making it easier to shorten the time at the ground. Short turnaround times improve aircraft utilization. Another advantage of LCCs is the relative young average age of their labor force in comparison with legacy carriers. This provides the firm with labor advantages, making

the LCCs cheaper and more flexible. LCCs also in general only operate a few aircraft types or just even one like Ryanair, making maintenance cheaper, by providing them with economies of scale (Belobaba, 2016). A homogenous fleet has several positive implications for the airline. First, the firm has a stronger bargaining position towards the aircraft producer. A larger order of any type of aircraft generally will reduce the cost price per aircraft. Secondly, a uniform fleet implies standardization of training for cockpit as well as cabin crew. It reduces training costs and it improves the efficiency of the operations. Thus, the firm becomes more agile. Thirdly, planning and sales becomes more efficient as even a change in aircraft due to unforeseen circumstances as defects will not result in deployment of another type or different seat lay-out. Fourth and last are the maintenance costs which will be reduced as parts can be bought in larger quantities and the maintenance department itself only copes with one type of aircraft (Belobaba, 2016). The implications of a homogenous fleet imply a strategic shift to larger airports as these advantages can be realized more efficiently. The advantages however are not bounded by the regional and secondary airports they serve, but are a linked to the airline business model, making it relatively easy to shift to other types of airports.

LCCs have a comparative cost advantage over NLCs (Gillen and Lall, 2004). This comparative cost advantage in combination with a business model that is focused on operating economically viable routes makes the airline more flexible. The airline can relatively easy decide to abandon routes and shift operation elsewhere. NLCs are attached to their hubs and their home country. They serve as flag carrier and mostly establish operations at the most important airport of their respective country. NLCs focus on routes that will contribute to the functioning on the hub and the network as a whole. Routes that might be economically viable but are not contributing to the hub will not be operated (O'Kelly and Bryan, 1998). One can think of hubs that suffer from congestion such as Schiphol where slots (landing and take-off rights at a designated time) are scarce and not all routes can be operated. One can also think of a lack of financial resources or a lack of fleet to operate certain routes. Routes to periphery regions with a challenging economic prospect or lack of purchasing power will be abandoned first. This abandonment will have consequences for connectivity of the region involved. The airports involved which solely rely on one carrier have a weaker bargaining position (Gillen and Lall, 2004). LCCs with their higher flexibility of operation and a different target market can at relatively low-cost operate the necessary service. This will enhance the connectivity of the periphery region even if the region has a challenging economic prospect or a lack of purchasing power to justify a service to the region (O'Kelly and Bryan, 1998). The market served has to have a vigorous demand for transfer to other destinations than the destination operated by the NLC. E.g. there has to be a market not only for flights from Bristol to Amsterdam, but also from Bristol to virtually all destinations served by the respective flag carrier. LCC focus solely on the demand from Bristol to a market that is large enough to be economically viable such as Bristol – London, enhancing the connectivity of the Bristol region. So, the cost advantage of LCCs can enhance the connectivity or periphery regions if LCCs operate out of these regions.

Periphery regions however often cope with less favorable economic circumstances. These derive from aspects of the physical environment (e.g. mountains) or distance to regions with better economic circumstances. Furthermore, regions with stronger comparative advantages

tend to attract more activities in general as they have a stronger pull factor (Atzema et al, 2009). The different spatial qualities of periphery regions make the accessibility of these regions poorer than regions with more favorable economic circumstances. Airports can help periphery regions as infrastructure needed for the link with other regions can be realized with a modest amount of capital in comparison with other modes of transport (Belobaba, 2016). Accessibility is the extent to which land use and transport systems enable individuals to reach activities or destinations via any combination of transport modes (Matisziw, Lee and Grubesic, 2012). We assume reasons for the economic conditions as given. Yet, they can explain why a periphery region lacks accessibility and why LCCs would abandon certain routes resulting in a loss of accessibility. Periphery regions not only suffer from less favorable economic conditions, but also have less favorable demographic statistics. The relation between demographics and lack of accessibility is rather straightforward. The smaller the market, the less feasible the conditions are to operate links between the region and other regions. These two aspects, the demographics and the economic conditions also describe the more favorable conditions of more prosperous regions. The largest NLCs that still operate today, that remained after the consolidation in the industry, operate from large economic hubs mostly in the economic heartland of Europe (namely London Heathrow, Schiphol Amsterdam, Frankfurt and Paris Charles de Gaulle). LCCs are a relatively new phenomenon that took advantage of market dynamics in periphery regions (Dziedzic and Warnock-Smith, 2016). These market dynamics most notably include the deregulation of the industry. This made it possible to operate virtually any desired route between two points. Freedom of flights underpinned the development of the growth of LCCs. As they started to grow, more capital became available which accelerated their growth process. In turn, they started to challenge the NLCs at their hubs as they were now financially capable of operating from these hubs. This is the phenomenon we see today. Covid-19 will probably cause another shake-out in the industry, accelerating the consolidation of the entire industry with possible profound effects on the accessibility of periphery regions that contribute to a much lesser extent to a healthy business. Viruses but also natural disaster like volcano disruptions cause major havoc which affects the fragile infrastructure and affects the accessibility of regions.

The recent moves by LCCs to change strategy and operate from larger airports can have profound impacts on the accessibility and connectivity of periphery regions. Implications are not yet known. Especially in less favorable economic conditions, routes to periphery regions that serve as a vital link between these regions and regions with better economic circumstances might be abandoned first. As these links are mostly the only infrastructure in place, the region might end up with no link at all. This further deteriorates the economic conditions and furthermore could have a long-lasting effect on the demographics of the respective region. It is essential to know the background of this shift in strategy. Which regions are affected by this shift and what does this imply for the connectivity and accessibility of the respective region? Relevance is furthermore enhanced by recent Covid-19 events as regions with airport infrastructure as their most important mode of transport become virtually non-accessible. Other circumstances such as Brexit in the case of the UK also prove to be challenging. This leads to the following research question.

1.2 Research Question

The aim of this study is to find empirical evidence that LCCs are indeed shifting capacity in favor of larger airports. A classification of airports is used to empirically test any changes in airline business models of LCCs.

What is the impact on regional and secondary airports in the United Kingdom and the periphery regions they serve in terms of their connectivity and accessibility in the period 2010-2019 as LCCs change their business models from regional airports to large hubs?

1.3 Sub questions

1. How did the connectivity in terms of network operated from airports in the United Kingdom change in the period 2010-2019 with the growth of airlines with a low-cost business model?

2. In what way did the expansion of low-cost carriers impact the air accessibility of the airports and the regions served in the United Kingdom in the period 2010-2019?

1.4 Geographical demarcation

The United Kingdom offers a unique region for this thesis. The UK, executed by the Civil Aviation Authority, collects standardized data that is relevant for the topic. The UK can be considered a mature air services market (Dziedzic and Warnock-Smith, 2016). This offers unique opportunities for businesses operating in the airline industry. LCCs like homegrown EasyJet and Irish carrier Ryanair have been dominant at the UK market for some time now. The UK transport market furthermore offers unique opportunities due to the lack of proper railway infrastructure, offering chances for airlines and LCCs in particular. Furthermore, all types of airport can be found in the United Kingdom. Regional airports, major international hubs and secondary airports.

1.5 Methodology

To address the sub questions and the research question, an analysis will be made of the connectivity of British airports in the period 2010-2019. Only airports where LCCs operate or have operated will be taken into account. Connectivity will be measured through the assessment of route maps and passenger data from the Civil Aviation Authority. Which routes are operated and abandoned? Accessibility will be analyzed through the application of the catchment area of the airport. The analysis will help answer the question when and if LCCs interchange regional and secondary airports for larger hubs and affect connectivity of these airports.

Chapter 2

Theory and application

The angle in this study is the changing business model of low-cost carriers and the impact this has on accessibility of regions in the United Kingdom. This changing focus influences the networks served in the regions and the quality of accessibility of these regions. It furthermore leads to the evolution of airport business models. In this chapter, the current stance on airports and airlines is discussed. The growth of the airline industry in the UK as well as the specific growth and changing focus of low-cost carriers is discussed. Furthermore, the link between LCCs and airports will be analyzed with current knowledge on this topic.

2.1 Airports

Airports are one of the two constituents that form the worldwide aviation infrastructure and are the physical component of it (Belobaba, 2016). Critical elements of airport infrastructure are discussed in this part. The effects of deregulation, the effects of congestion, accessibility of the region that airports serve and a typology of types of airports.

2.1.1 Deregulation and airports

In the last two decades, the airline industry has been facing deregulation. Airlines today have more freedom to operate routes and fly between different city pairs than ever before. Two decades ago, when the airline industry was dominated by NLCs, airlines were protected by national legislation and often bounded to their hub. Major development that revolutionized the industry were the 1978 deregulation of the domestic market of the United States and notably the deregulation of the European market (Hazeldine, 2011; Belobaba, 2016). The United Kingdom in cooperation with the republic of Ireland deregulated air traffic between the two countries in 1987. This resulted in a reduction of air fares with 50%. Passenger numbers grew with 100% after the deregulation. The success of particularly the Anglo-Irish reforms are explained by the availability of low cost labour (arbitrage opportunities) and the Irish diaspora in the UK, the exit of British Airways on routes between Ireland and the UK, weak competition and the absence of airlines with a charter model (Barrett, 1997). The European market deregulation followed the expansion of the European Union, resulting in higher passenger numbers to and from the UK. Nowadays, policy makers are working on the unification of the air space, which will provide airline companies with opportunities to organize their operations more efficiently. The regulation of both the US and European market and bilateral agreements like the Anglo-Irish agreement meant an opening of a market that was before protected for new entrants. The deregulation provided an opportunity for growth of the airline industry and provided firms with arbitrage opportunities, that made it possible to seek for the most attractive options at other regulated markets for labor agreements, taxation and capital leases lowering costs of particularly LCCs.

2.1.2 Congestion

Europe's largest airports experience congestion. Legal restrictions on the maximum capacity of the airport means that not all demand can be realized, affecting potential services to periphery regions. Several constraints can be identified, notably the number of runways. A runway can handle aircraft up to a technical maximum, but also to a desirable maximum when taking into consideration the safety of the flights as well as stakeholders of the airport such as residents in the surroundings. Demand management is one way of dealing with congestion (Belobaba, 2016). A set of administrative and economic policies restrain access to the airport. Through demand management, the airport can spread out inbound and outbound traffic and ease congestion at the busiest times. Airports constrain traffic by the allocation of slots to airlines. A slot is a right to land and take-off at a pre-designated time. Slots allow airports to regulated traffic and organize traffic at the airport by planning which airline fly which flights with designated aircraft. This also allows airport to control passengers flows. Not every aircraft can be handled at every gate. A problem congested airports face when congestion is already a challenge is when airlines allocate larger types of aircraft to the airport. The physical infrastructure has to have the right equipment like gates, but also the right hard infrastructure such as runways to accommodate aircraft types. The above-named constituents form the input for calculations of total capacity and the slot allocation process. Slots are often a valuable asset of airline companies, as they can be sold to other airlines but also result in landing rights and the most valuable times of the day (Belobaba, 2016). Especially at congested airports, slots can be very valuable.

Congestion impacts the business models of LCCs as they focus more on primary airports where congestion is the most prone (Klophaus, Conrady & Fichert, 2012). LCCs and FSNCs (full-service network carriers) are the opponents, fighting for the same assets. LCCs with their lower cost base will destabilize the position of FSNCs at first as they start serving the same city pairs at lower costs. The hybridization of the business model of FSNCs is a result and the industry moves to a new equilibrium with a more efficient outcome (Franke, 2004). The secondary or periphery airport can reap the benefits if it has a favorable position in comparison with the congested airport, like London Luton and London Heathrow. If the airport however is competing, it will lose the battle with the primary airport. Congestion in this way determines the relative position of the LCCs. The more congested the airport is in the first place, the less likely it will be that the LCC will gain ground as slots will be scarce.

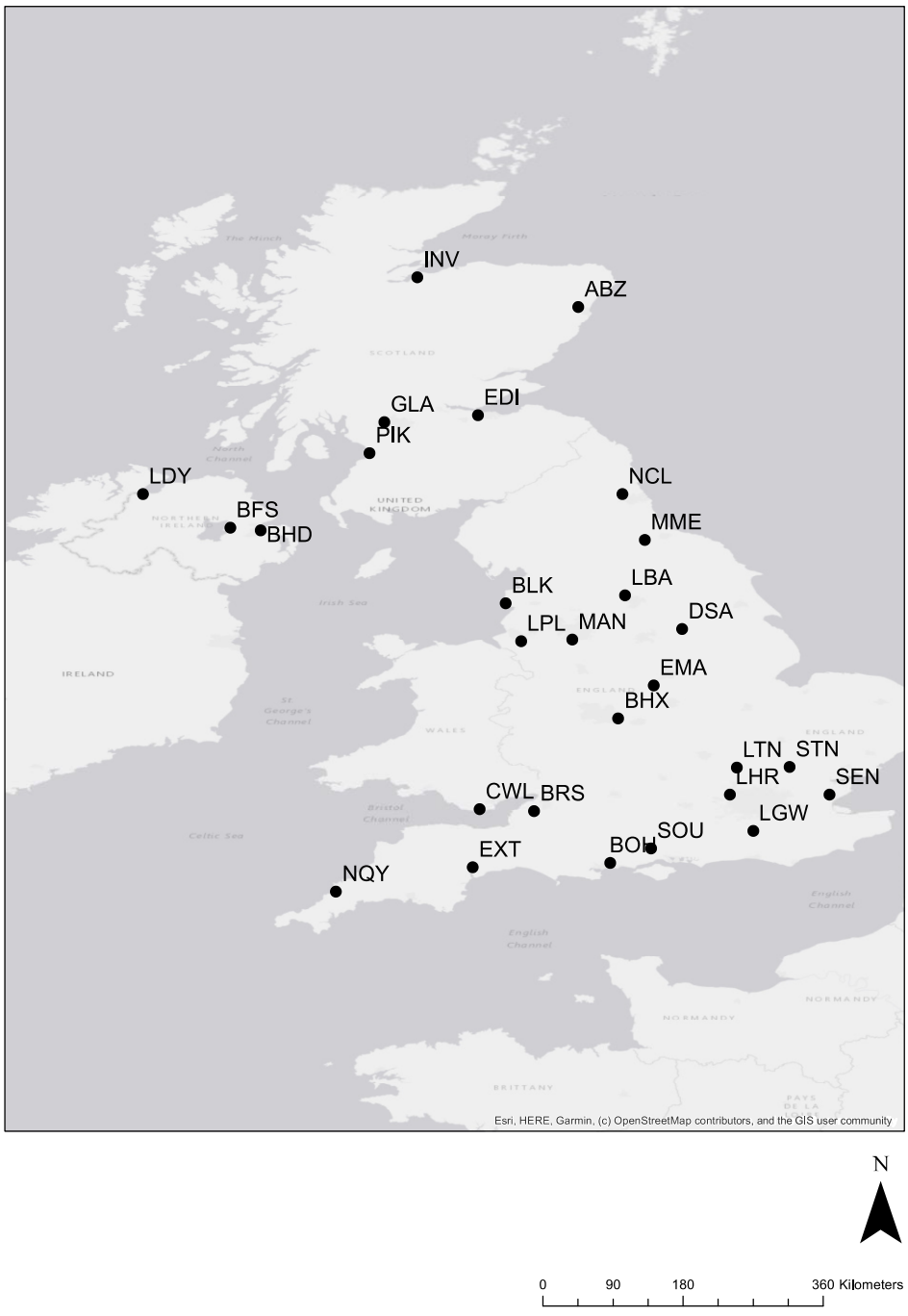


Figure 2.1: Map of UK airport with LCC operations.

2.1.3 Accessibility and regional air connectedness

Accessibility is a broad concept which literally means the possibility to get into or reach an entity (Longman, 2007). Accessibility describes how easy it is to reach the rest of the network starting at a certain node (Redondi, Malighetti and Paleari, 2011; Zuidberg and Veldhuis, 2012). A broad definition of accessibility is potential of opportunities of interactions (Bruinsma and Rietveld, 1998). The catchment area is a matter of perspective. The perspective from the airport and the perspective from the airline. From the perspective of the customers however, the catchment area is of less relevance. Customers will look at price of ground transport, travel time to the airport, destinations offered at the airport and the price of the tickets (Belobaba, 2016). From the perspective of competitiveness of the airport, the distance to the economic centers is relevant and the time to get there. Which customers is the airport able to attract based on these attributes? Location in mind, people, goods and information from a certain location can access the region served by the airport. Time, cost and effort moderate the size of the catchment area. The liberalization of the Anglo-Irish air services market gave way to entrants like Ryanair and reduced average air fares, increased passenger numbers and gave way to new possibilities for regional and secondary airports (Barrett, 1997). This liberalization improved the accessibility of British airports as LCCs used particularly airports in the periphery as cost, demand and efficiency determine the choice of airport of the LCC (Dziedzic and Warnock-Smith, 2016). The airports in the periphery had been underutilized and were seeking revenue opportunities through the use of subsidies for new routes. LCCs were attracted by these opportunities as they were just established and couldn't afford to operate out of the bigger airports like Heathrow. Ryanair first operated routes out of Luton to serve London as slots at Heathrow were impossible to get hold of. However, the city center of London is hard to reach from Luton and Ryanair decided to move to Stansted (Barrett, 1997). The attractiveness of an airport for passengers is partly determined by the possibilities of how simple it is to access the cities and settlements in the region (Lian and Rønnevik, 2011). From a broad social and economic perspective, the airport gives an airline and its customers access to a certain geographical area. This results in economic possibilities as well as social opportunities like visiting relatives or going on holiday. In any perspective, the concept of accessibility is closely linked to the catchment area of the airport (Dobruszkes, Lennert, & Van Hamme, 2011). The catchment area is not static, and the strategy of the airport can be adjusted to attract more airlines, for example by attracting more LCCs (Lieshout et al, 2016). It has to be stressed however that this is closely linked to the geographical location of the airport and the possibilities that arise from it which will differ per airport. It is not hard to imagine that a secondary airport close to a large metropolitan area has better options in terms of creating revenues in comparison with an airport serving a scarcely populated area in the periphery. Now that the underlying concepts and their relevance are discussed, a typology is developed to be able to categorize airports.

2.1.4 Airport typology

Airports can be categorized regionally and by total passenger numbers. Airports serve a particular market, which is the catchment area discussed in subparagraph 2.1.3. This market

serves as the source of passengers and cargo, the two main categories that are to be transported. More mature market in countries with a high GDP often have more than one gateway via air to spread air traffic as does the United Kingdom. One primary gateway can be identified and the other can be classified as secondary airports. However, classification of the airport is primarily based on passenger numbers and the classification can be seen in figure [2.2] (Dobruszkes, Givoni and Vowles, 2017). Cities with multiple airports are designated with letter A. Category B handles 1-2 million passengers, category C 0,5-1 million, D 0,25-0,5 million and a category E airport less than 0,25 million passengers per year. The number of passengers is important, has airports come with high costs. Self-sufficiency can be reached if an airport handles more than 3 million passengers a year (Belobaba, 2016).

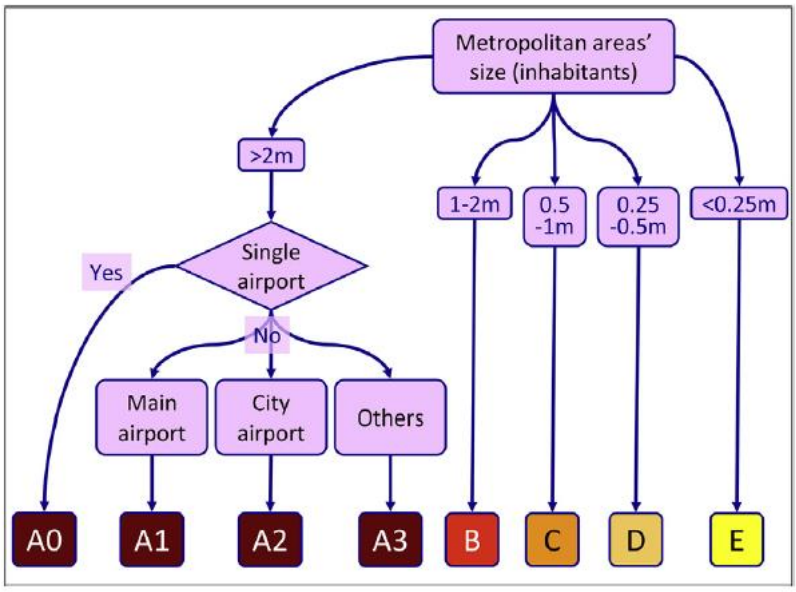


Figure 2.2: classification typology of airports (Dobruszkes, Givoni and Vowles, 2017).

Airport in regions with with multiple airports compete in a common catchment area. In the UK, London is not only served by Heathrow, but also by Gatwick, Luton, Stansted, Southend and London City airport. The Greater Manchester area with the cities of Manchester, Liverpool and Leeds are served by Liverpool Airport, Manchester Airport and Leeds Bradford Airport. These airports will compete for passengers, freight and airlines that can serve the airport. Competition between the airports drives innovation of the business models of these airports (Bracaglia, D'Alfonso and Nastasi, 2014). Airports compete when they serve the same catchment area (Lieshout, 2012), or when they have a favorable geographical position on the route from A to B, of relevance to FSNCs (Belobaba, 2016). Geography is therefore a very important moderator. Airports can influence the decision-making process of passengers and face competition in a number of ways. Air fares like discussed earlier in subparagraph 2.1.3 are an important determinant. Services provided at the airport also influence the decision-making process of customers (Bracaglia, D'Alfonso and Nastasi, 2014). These services are often strategically offered at time of ticket purchase and can be anything from parking at a discount, free public transport to the airport and lounge access. Services generate up to half of total revenues of airports and competition for airlines and their customers is fierce (Graham, 2009).

Airports need to strategically act on marketing and route development to differentiate from the competition. Especially as technology makes it easy for customers and airlines to compare when buying a ticket or select a new airport (Bergantino, Intini and Volta, 2020).

2.2 Airlines

The next step is an analysis of strategies airlines use now that the physical infrastructure is covered. In the following paragraph, categories of airline business models will be introduced and explained. Also, deregulation plays a vital role as it does in relationship to the airports. Aspects of the low-cost business model are explored as well as understanding the relationship between airports and airlines.

2.2.1 Airline business models

Airline companies can broadly be classified into three categories. Full-service network carriers (FSNCs), low-cost carriers (LCCs) and hybrid carriers. Important to note is the NLCs will have adopted a full-service strategy or a hybrid strategy. Hybridization of business models has been an important evolutionary process in terms of airline business models in the last decade and is a strategic move to keep up with competition (Lohmann and Koo, 2013). Hybridization is common among most airlines to some extent as it generates extra opportunities for revenue creation (Dziedzic and Warnock-Smith, 2016; Klophaus, Conrady and Fichert, 2012). It is important to note that within the categories, differences are still very recognizable as the industry itself has a very dynamic nature (Mason and Morrison, 2009). The airlines and airports serve as critical components of the socio-economic structure (Bergantino, Intini and Volta, 2020. Especially in periphery regions with a lack of access to any type of transport like the north of Scotland, airport provide a vital socio-economic link with the rest of the country (Lieshout et al, 2016). This national and economic interest leads to state-funds in a regulated market. State funds that act as accelerators of network development and developing financial viability. This is also particularly relevant in times of crises. Airlines and airports receive state funds to survive as they are seen as critical and will only operate efficiently when serving more than 3 million passengers a year, their minimum efficient scale (Ramos-Pérez, 2016; Belobaba, 2016). Many airlines merged or participate in an airline alliance, making them financially healthier and better equipped to face competition.

2.2.1 Deregulation and airlines

Deregulation gave way to new entrants, entrants that adopted innovative business models. The rise of airline companies with a focus on low costs started two decades ago (Lin, Mak and Won, 2013; Franke, 2004). The drive for low costs and offering low prices to customers is not new and not industry specific. Standardization, the benefits of economies of scale and no thrills are part of the strategy of this business model (Belobaba, 2016). To develop a proper understanding of the business model of LCCs, just like with FSNCs one has to look at the product architecture (Mason and Morrison, 2009). Fundamental elements are the service

quality of the product relative to the consumer preferences and the design of the organization, the structure, the production and distribution choices. Mason and Morrison (2009) analyzed the business models of LCCs in Europe and made an index. This index shows the scores for six LCCs, namely Easyjet, Ryanair, Air Berlin (defunct), Norwegian, Flybe (defunct) and SkyEurope. A thorough understanding of the strategy can explain performance and operations of the airlines active on the UK market. It seems that specifically Ryanair, which scores best in terms of profitability, and operates mostly from secondary airports. Ryanair mostly operates monopoly routes and faces little competition. This positively influences profitability. A more extensive network in general tends to be a good indicator of better overall financial performance. Competition between airlines in the United Kingdom grew rapidly between 2002 and 2012 (Lieshout et al, 2016).

Deregulation opened up the market at any airport, even the large, classification A airports. This means that any airline from the European Union is now able to fly from any airport within Europe. This depends on the availability of slots at the preferred airport like discussed before. As air traffic and population in the vicinity of larger, classification A airports is denser, more revenue opportunities exist for airlines but which are harder to get hold off (Belobaba, 2016). Low-cost carriers however first made use of opportunities to fly from secondary and regional airports. Operating costs are generally lower, and slots are easier to get hold off. The business model of low-cost airlines is focused on minimizing operating costs, being able to lower the airline fare and offering no-thrills onboard (Mason and Morrison, 2009). Periphery regions have reaped the benefits from the growth of LCCs as they provided new destinations and therefore improved the connectivity of the periphery regions. As these airlines are now shifting to larger, classification A airports, loss of connectivity may be a risk for regional and secondary airports (Lian and Rønnevik, 2011). LCCs seek opportunities at larger airports as there is a larger customer base and therefore larger windows of opportunities, focusing on the more profitable business passenger (Dziedzic and Warnock-Smith, 2016).

2.3 Relationship between airports and airlines

Airports and airlines have a symbiotic relationship. They benefit from each other and need each other. Without airports, no airlines. Without airlines, no need for an airport. This might be true at a conceptual level. Airlines however choose which airports they serve and particularly LCCs have a strong bargaining position. Only very big hubs that suffer congestion challenges have a relatively strong bargaining position in respect to the airlines and compromise less in comparison with regional airports (Lin, Mak and Won, 2013). The exception is the airport that is dependent on one carrier. The big advantage for regional airports when served by a FSNC is the ability to offer not only the direct destination, like London Heathrow from Aberdeen, but also destinations beyond the destination served. In this way, the regional airport can offer a virtual network beyond the scope of their market. This results in better connectivity and accessibility for the region served (Belobaba, 2016).

The relationship between regional airports and LCCs is not always resulting in mutual benefits. Regional airports often have problems being profitable despite the growth of passenger

numbers with the arrival of LCCs at the airport (Červinka and Matušková, 2018). Regional airports studied in Southeast Asia often had a weak bargaining position. Power imbalance and extreme dependency upon LCCs makes regional airports financially vulnerable (Lin, Mak and Won, 2013). Studies in Germany and Austria show similar financial distress at regional airports (Červinka and Matušková, 2018). Analysis of Lin, Mak and Won (2013) suggest that the relative importance of a destination for the LCC can be analyzed through the deployment of assets. The higher the frequency, the more important the destination is for the LCC. This also strengthens the relative position of the airport to the LCC. The more important the destination for the LCC, the better the relationship with the airport will be.

2.4 Conceptual model

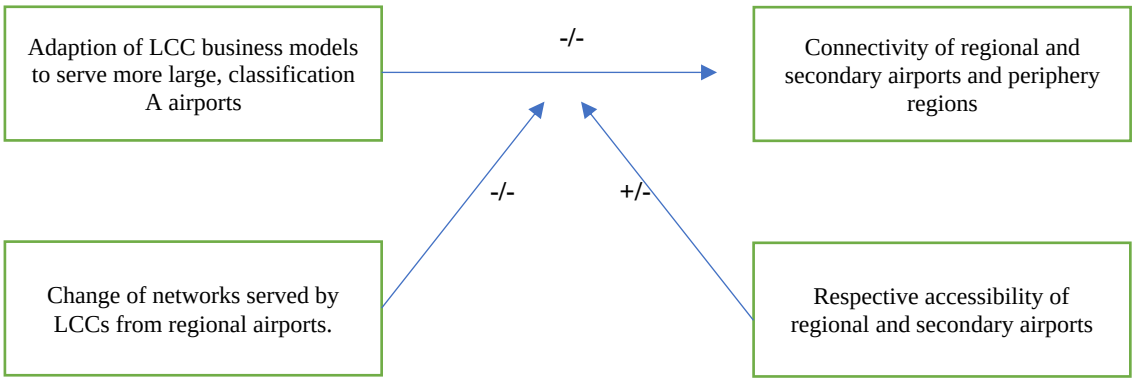


Figure 2.3: conceptual model

The relationship between adapting and evolving business models and passenger numbers at regional and secondary airports is considered to be negative. The more the business models of LCCs develop towards larger, classification A airports, the more pressure this will put on the passenger numbers of the regional and secondary airports. Therefore, the propose relationship is negative.

2.5 Resume

In chapter 2, the theoretical framework discussed. Airports and the catchment areas they serve have reaped the benefits from the deregulation of the air services market in the UK that started in 1980s. Regions saw an increase in regional air connectedness as LCCs started air services and provided customers with lower air fares and more travel options. Airline companies reaped the benefit from increased competition between airports and strengthened their bargaining position. Now that business models are evolving, regional and secondary airports see a shift away of air services towards larger hubs affecting the regions served by these airports and the business model of the airports themselves. The next chapter discusses the ways in which the research question and the sub questions are addressed in this thesis.

Chapter 3

Methodology

3.1 Introduction

The changing behaviour of LCCs has been introduced and discussed theoretically in chapters 1 and 2. The next step in this thesis is to test situation through four steps. (1) First, the actual behaviour of LCCs is analyzed in terms of routes served and passenger numbers. This is done for the UK market for air services in the period 2010-2019 at 28 UK airports that have or have had LCC operations. (2) The second step is to introduce the concept of accessibility. Regional air connectedness over time is analyzed through the total contribution of the airport to accessibility of the respective region and the contribution of LCC operations to the accessibility of the regions. A comparison will be made between the total contribution of the airport in terms of accessibility of the region. (3) Thirdly, differences between regions will be assessed based on the outcomes of the contribution of LCCs to the accessibility of the airports and the regions served over time. (4) The fourth step is to test for the relationship between LCC and regional air connectedness and therefore correlation and causality will be tested. The first step (4.1) is to test the correlation between regional air connectedness and connectivity that is provided by LCCs at regional and secondary airports. If the criteria for causality are meet, the next step (4.2) is to test causality between regional air connectedness and connectivity provided by LCCs and is tested with the use of OLS regression analysis on a regional level.

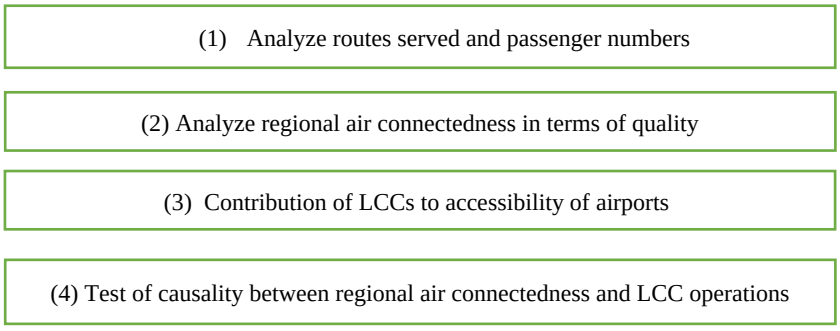


Figure 3.1: schematic overview of research steps

Methods that are used for exploratory analysis of data focus on a descriptive summary and the graphical display of the data (Flowerdew and Martin, 2005). The analysis of LCC behaviour at UK airports is executed to explore trends in their behaviour. Current theory suggests a shift from operating at secondary airports towards the larger airports. To confirm this trend, their operations and their passenger numbers from 28 UK airports (see figure [3.2]) over a ten-year period will be analyzed. Exploratory analysis is ideal as this form can identify trends and also detects outliers which might be interesting in the case of airport business models (Flowerdew and Martin, 2005). All the input data for the analysis will be ratio variables. The starting point

of exploratory research is to examine the distribution of the values. A combination of SPSS and Excel will therefore be used to build the database and analyze the data. Hopefully, on the basis of the theoretical framework and the data, answer can be given about the behaviour of LCCs.

3.2 Geographical demarcation

The United Kingdom is an appropriate case as the air services market is one of the biggest in Europe and the UK market for LCC services is one of the biggest in Europe. LCCs have had a strong presence in the United Kingdom for a long time. The liberalized economy of the UK makes it relatively easy to do business. The UK has 60 airports in every specified category, according to the typology presented in the theoretical framework. London Heathrow serves as the primary gateway to the country. It is the most important airport and serves as the hub for British Airways. Several secondary airports serve the metropolitan area of London, Gatwick, Stansted, Luton, City and Southend (Gallop, 2019). Most airport are primarily served by LCCs. The United Kingdom collects specific data on the number of movements and passengers to specific destinations. The Civil Aviation Authority collects data for 60 airports in the UK which tracks back to the 1990s, enough to cover the data needs of this research. A big advantage of the data set is that gathering of data is standardized for whole scope of this thesis, which will improve the quality and validity of the analysis. The data shows the traffic flows per airport on route basis. This means that for every airport, every route is specified. This is done on a monthly basis. This makes the United Kingdom a relevant area within the scope of the analysis. The is also data available that gives insights in non-aeronautical revenues of the airports.

The United Kingdom with its challenging geography, particularly in the north in Scotland, has a number of airports that serve local communities. These local airports connect regions that have low connectivity. The airports in general don't host any large carrier as market demand is low. The airports have a societal function and are not commercial. As the airports generally have a societal function, don't accommodate any large LCC and have a small number of passengers they are being excluded from the analysis of this thesis. London City airport is excluded for different reasons. The airport has a very challenging geography and strict limitations when it comes to landing rights. Capacity is very limited. LCCs don't operate out of this airport. Due to this limitation, London City is also excluded. 28 airports in the United Kingdom are within the scope of this thesis and are therefore selected. The airports are listed below with the LCC operating out of the respective airport, currently operating or have had operations in the period 2010-2019.

3.3 Selection of airlines

To identify LCCs, the list developed by de Wit and Zuidberg (2016) is used. Ryanair, Wizz Air and EasyJet are the three primary LCCs of Europe based on market volume. Vueling, Eurowings and Transavia are the parts of legacy carriers IAG, Lufthansa and Air-France-

KLM. As they are part of a legacy carrier group, but function like an LCC, it makes sense to include them. Smaller carriers are Lauda (part of Ryanair) and Blue Air from Romania.

Regional carriers like Flybe and Eastern Airways have characteristics of LCCs but don't completely follow the classic LCC model. Flybe however is included as their business model had more LCC characteristics than FSNC characteristics. Furthermore, the operations of Flybe were hard to distinguish from other LCCs at the selected airports. As discussed in chapter 2, categorizing airlines is not as straightforward as it seems.

Name of airport (IATA code)	Ryanair	Wizz Air	EasyJet	Vueling	Blue Air	Eurowings
Aberdeen (ABZ)	X	X	X			
Belfast City (BHD)				X		
Belfast International (BFS)	X	X	X			
Birmingham (BHX)	X	X	X	X	X	X
Blackpool (BLK)	X					
Bournemouth (BOH)			X			
Bristol (BRS)	X	X	X			
Cardiff (CWL)	X			X		
City of Derry (LDY)	X					
Doncaster Sheffield (DSA)		X				
East Midlands International (EMA)	X					
Edinburgh (EDI)	X	X	X	X		X
Exeter (EXT)	X		X			
Gatwick (LGW)	X	X	X	X		X
Glasgow (GLA)	X	X	X			
Heathrow (LHR)				X		X
Inverness (INV)			X			
Leeds Bradford (LBA)	X		X			
Liverpool John Lennon (LPL)	X	X				

Name of airport (IATA code)	Ryanair	Wizz Air	EasyJet	Vueling	Blue Air	Eurowings
Manchester (MAN)	X	X	X	X		
Newcastle (NCL)	X		X			
Newquay (NQY)	X					X
Prestwick (PIK)	X					
Southampton (SOU)			X			
Southend (SEN)	X	X	X			
Stansted (STN)	X		X			X
Teesside International (MME)	X					

Figure 3.1: UK airports, their LCC operators and destinations offered (Civil Aviation Authority, 2020).

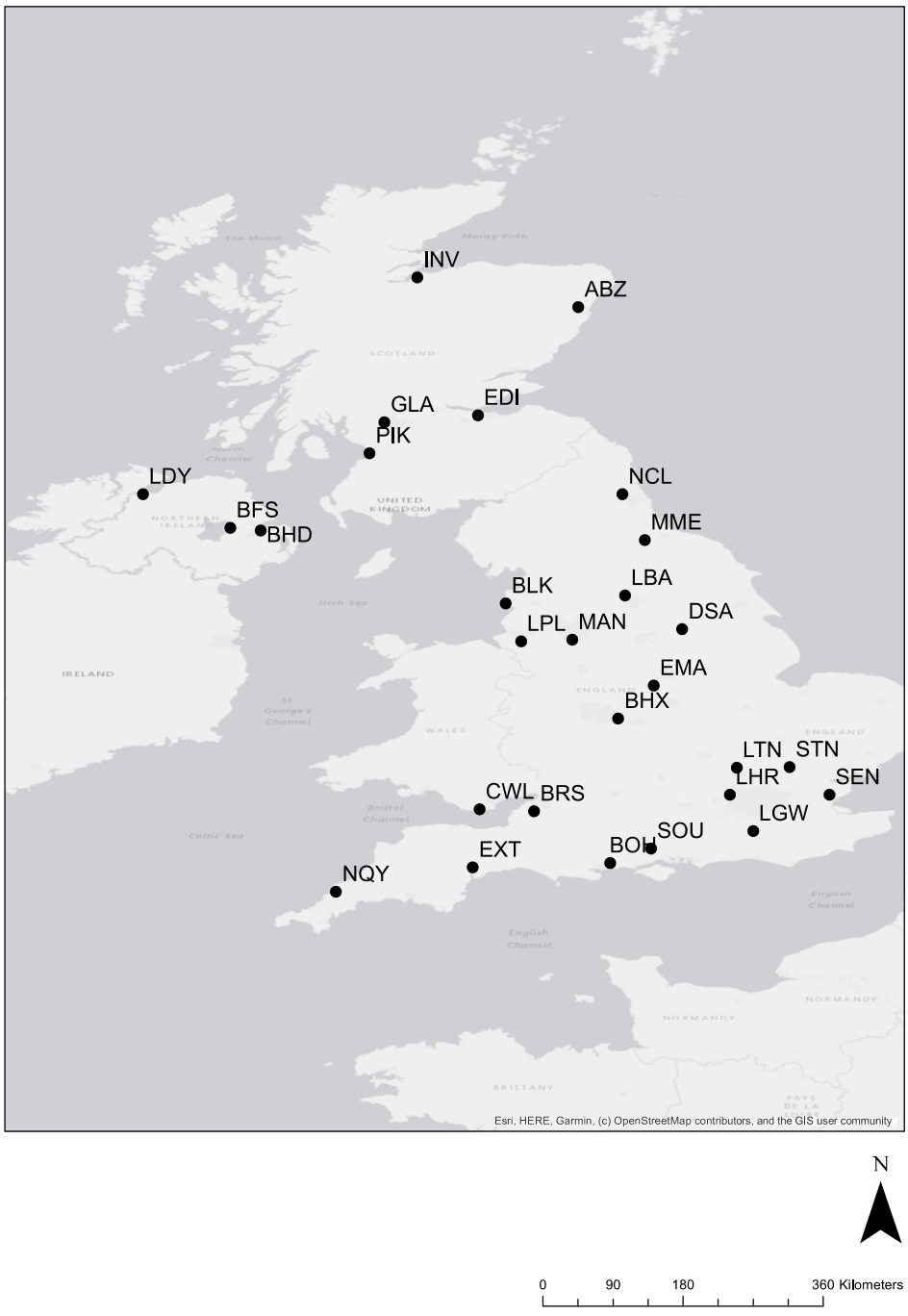


Figure 3.2: Map of UK airport with LCC operations.

3.4.1 Data and material to assess connectivity

The civil aviation authority (CAA) collects data on passenger traffic flows in the United Kingdom. To determine the connectivity of airports data is drawn from the databases of the CAA. Specifically, the data on passenger numbers from each of the airports to every destination served from the airport. An individual assessment of each specified airport will be made which will result in an aggregated overview of changes per airport. The CAA provides monthly data as well as data on a yearly basis. The data of the yearly passenger numbers will be used for this thesis. The period of ten years gives insight into the connectivity changes at the specified airports. Table 12.1, the figures on international air passenger traffic analysis and table 2.2 domestic air passenger traffic analysis will be used as input for the period 2010-2019. A spreadsheet per airport with passenger flows per route for the period 2010-2019 will be the result. A limitation of this approach is the possibility of multiple carriers on one route. As there is no specification of the numbers of individual carriers and information of types deployed only result in information about capacity and not about actual passenger numbers, it makes it hard to distinguish between type of carrier. In practice, in makes it hard to gather the right data at the level of the carrier. Information is not publicly available and only obtainable at high costs. Therefore, it is necessary to make assumptions about the carriers. Annual reports, news articles and the standardized fleet of LCCs would make it possible to make an estimate of which airports are used by LCCs in particular. Primary airports that have a diversified mix such as Heathrow, Birmingham, Gatwick and Manchester and attract FSNC customers or serve as their hub will be excluded for international flights as it is not possible to distinguish at the level of the carrier. As access to these airports is already restricted in terms of available slots, capacity growth is constrained and can't be used by LCCs. LCCs do however operate from these airports as slots become available. As every destination adds to the quality score of the connectivity, the passenger numbers reflect the development of the connectivity of the airport.

3.4.2 Accessibility of UK airports methodology

Accessibility has its roots in graph theory (Malighetti, Paleari and Redondi, 2008). Graph theory is applicable for studies of networks of any kind and is often used in studies of airline networks. All airline networks can be described by an array of nodes connected by links. The nodes are the airports and the links the routes flown by airlines. One particular feature is the speed in which an entity, a passenger, cargo and the aircraft assets in the case of the airline industry, can be moved from one node to another. As explained, LCCs that perform best have high aircraft utilization. The choices of passengers are harder to predict as the shortest path is not always the most cost-efficient for the passenger. The passenger might choose a longer path to save costs. LCCs only offer direct flights which result in a high score on direct accessibility (Zuidberg and Veldhuis, 2012). The most relevant way of measuring accessibility within the scope of this thesis are the passenger numbers. The period, 2010-2019, can reveal changes in strategic behaviour. Growth in frequency can reveal if destinations became more important or the other way around. It will also reveal if routes are abandoned. In this way, the analysis of accessibility at British airports can give an insight in the accessibility offered. Charter flights

are not incorporated in this thesis, as this data is not available on the level of the carrier and will not result in a constant offering of this destination. Other types of flights such as private jet services are also excluded as they are not provided on a constant basis either.

A first evaluation of the importance of destinations is made by Zuidberg & Veldhuis (2012). They proposed a "scorecard" for destinations. A direct route would result in a score of 1. An indirect route, offered by a FSNC to hub, e.g. Aberdeen – Stavanger offered by KLM via Amsterdam would already score lower than 1, as the route is not direct. It is not within the scope of this thesis to evaluate all indirect options of the UK airports, as LCCs only offer direct routes and have only begun experimenting with offering connections. Not every destination will contribute in the same way to the economy of the region. A flight from Aberdeen to Faro (Portugal), a holiday destination, will not be as beneficial to the economy as a flight from Aberdeen to Stavanger, a destination with similar economic characteristics (oil industry) in comparison with Aberdeen. A standardized evaluation method is developed to be able to the relative importance of the destination to the region of the airport. This is evaluated one-way round, from the perspective of the UK airport. The flight from Aberdeen to Faro would inevitably be beneficial for the tourism industry in Portugal. To input variables for the analysis are the population of the destination, in the functional urban area as collected by Eurostat. A scale of 1-5 is proposed, 1 = 0-100.000; 2 = 100.000-200.000; 3 = 200.000-500.000; 4 = 501.000-750.000; 5 = 750.001-1.000.000; 6 = >1.000.001. The bigger the population, the higher the demand for the service will be. The second variable is the number of companies active in destination city. Eurostat provides standardized data of regional gross domestic product for most regions in Europe. A scale of 1-6 is proposed, 1 = €0-5.000; 2 = €5.000-€10.000; 3 = €10.000-15.000; 4 = €15.000-€20.000; 5 = €20.000-25.000; 6 = > €25.000. The higher the income per person per year, the more likely it is the region can benefit from the service. The third variable is the amount of passenger travelling on the route on average in the period 2011-2019. A scale of 1-6 is proposed. 1 = 0-5.000; 2 = 5.000-10.000; 3 = 10.000-25.000; 4 = 25.000-50.000; 5 = 50.000-100.000; 6 = >100.000 passengers per annum. On average, the seat capacity of a typical 737 (Ryanair, 189 seats) or A320 (Wizz Air and EasyJet, 186 seats) is 187. Routes served on a weekly basis, year-round will result in a capacity of 9724 seats. Seasonal routes will do half of that, 4862 seats per year. If the carrier starts operating more flights per week, the capacity will increase just like the amount of passenger transported. A daily flight will result in a capacity of 68255 seats per year. As the number of weekly services increases, the quality of the service does as well. Therefore, a higher number for a higher number of passengers. The lowest possible score is 3 and the highest possible score is 18.

Consider the route from Manchester Airport to Paris Charles De Gaulle. The Paris metropolitan area in 2016 according to Eurostat had 12,824,378 inhabitants. This will result in a score of 6, as 12,824,378 is more than 1,000,001 inhabitants. Secondly, the regional gross domestic product is considered. The Paris metropolitan area in 2019 had a regional gross domestic product per citizen of €54.200, - (Eurostat, 2020). This is more than €25.000 per annum, which results in a score of 6. In 2019, 286.380 travelled from Manchester to Paris, the most important economic center in France. As 286.380 is more than a daily service, it gets a 6 as a score. The total score for the air service between Manchester and Paris Charles De Gaulle is 18. This

doesnot come as a surprise as the Metropolitan area of Paris in Europe has only equal, Greater London.

Combined, every route is scored and the total score of all destinations will give an indication of the quality of the network of each of the UK airports. To evaluate changes it the period, the calculation is performed at the beginning in 2011 and in 2019. As the networks of LCCs expand, the score will get higher. Particularly if LCCs open service to regions with economic importance, this will add to the infrastructure function of the airport. Due to limitations in the data, not all international routes are included as they are both served by LCCs and FSNCs. The connectivity of the networks is established to assess the relative quality of the networks overtime at the selected airports. This to make a comparison overtime as well as between the airports.

3.5.1 Data and material to assess accessibility and catchment area of UK airports

The next section will discuss data collection, the processing and methods used to specifically answer the question on accessibility. Regional air connectedness will be analyzed to answer the question if LCC behaviour changed the accessibility of the region.

The first step is the catchment area of each of the 28 specified airports. As discussed, defining the catchment area is a complex matter. The first step is to calculate the weight of the 28 airports in their respective NUTS-2 region. Zuidberg and Veldhuis (2012) identified that the maximum travel time the airport serves is 120 minutes. LCCs and the air fares they offer widens the catchment area. As this depends on the air fare, but also on geography of the region and other travel options, the measurement will be too complex to perform as this is rather idiosyncratic. The travel time of 120 minutes will serve as a proxy as the 120 minutes is widely researched and used. Zuidberg and Veldhuis (2012) use the most important economic center of the region as central node for the calculation of the contribution of an airport to the regional connectedness. The city center of each of the NUTS-2 regions in the United Kingdom will serve as the central node from which the calculation is executed. As the position of the airport as well as the position of the city center is static, the calculation of the weight of the airport is valid for the entire period unless the economic center of gravity in the NUTS-2 region would change. Zuidberg and Veldhuis (2012) argue that the contribution is linear. Zero (0) minutes of travel time results in a score of 1 and all travel times of more than 120 minutes result in a score of zero (0). For all 28 airports the weight will be calculated as follows: w_{ir} = weight of airport i for region r; and T_{ir} = travel time by car in minutes to airport i with respect to region r

$$w_{ir} = 0 \text{ if } T_{ir} > 120 \quad (3.1)$$

$$\text{If } T_{ir} < 120: w_{ir} = 1 - (T_{ir} /120) \quad (3.2)$$

Also, for question 2, data of the CAA will be used as input for the analysis. Total passenger numbers as well as the passengers transported by LCCs will be used, namely table 12.1, the figures on international air passenger traffic analysis and table 2.2 domestic air passenger

traffic analysis from the CAA. The weight of the airport calculated for sub question 1 is used and the population of the regions in year *t* provided by the Office for National Statistics. This results in the following formula:

$$CON_{rt} = \frac{\sum_{i \in N} pax_{it} w_{ir}}{pop_{rt}} \quad (3.3)$$

With the calculation of the travel time without congestion with the help of Google, the weight of the airport will be calculated and the contribution of the airport to the regional air connectedness.

3.6.3 Correlation between passenger numbers, population size and gross domestic product per capita

Regression analysis is used to test the relationship between population size, gross domestic product per capita and passenger numbers. The empirical results serve as evidence that LCCs will more likely serve primary airports. LCC business models tend to shift towards metropolitan areas with higher population numbers and better economic performance. A higher number of LCCs carriers operating out of the airport will result in higher connectivity. This relationship based on the theory is assumed to be linear. The bigger the population, the bigger the market for air services will be. LCCs like argued offer low cost air fares, making the relative wealth of the population less influential. Fact remains that with higher purchasing power, people tend to have more spare time and consume more air services. As most of the 28 airports in the sample have high numbers of LCCs operating out of them and mostly a lack of FSNCs and LCCs offer direct connections with a high score on connectivity, LCCs behaviour and changes will have an immediate effect on the regional air connectedness of the region in question. The variables are described in figure [3.4]. Outlying cases have been found in the analysis, which has to do with the geography of the country. London is relatively large in comparison with other cities both in terms of population and gross domestic product per capita. With the use of log transformation, this has been issued. Data might be incomplete for airports with multiple operators or operators in the distant past. However, these destinations provided the airport connectivity and will therefore be included. OLS or ordinary least square analysis is a form of regression most common and used for observational studies like performed in this thesis (Flowerdew and Martin, 2005). This results in the following formula:

$$PAX_{rt} = \beta_0 + \beta_1 POP_{rt} + \beta_1 GDP_{rt} + \varepsilon$$

Variable	Description
Main	
CON_{rt}	Level of regional air connectedness offered by LCCs in region *r* in year *t*.
PAX_{rt}	Passenger numbers and connectivity score in region *r* in year *t*.
POP_{rt}	Population in region *r* in year *t*.
GDP_{rt}	Regional Gross Domestic product pps in region *r* in year *t*.

Figure 3.4: Description of variables used in the OLS model.

3.6.4 Hypotheses for OLS model

For the models above, the following hypothesis is designed.

H0: There is no linear relationship between the passenger numbers at the airport, the GDP per capita of the region served by the airport at NUTS-2 level and the population of the region served by the airport at NUTS-2 level.

H1: There is linear relationship between the passenger numbers at the airport, the GDP per capita of the region served by the airport at NUTS-2 level and the population of the region served by the airport at NUTS-2 level.

3.7 Resume

To answer the research question, three elements are addressed in the data analysis. A review of the network at 28 airports in the United Kingdom that have LCC operations in the period 2010-2019. An assessment of the impact in the same period for changes in the quality of the network offered at the 28 airports. The relationship between the passenger numbers, the GDP per capita and the population of the area will be statistically tested.

Chapter 4

Data analysis and results

4.1 Network development at British airports

The first part addresses the networks that are operated from the airports in the sample. Insights into the networks overtime make clear where capacity grew and at what airports it declined. The insights provide the first empirical evidence for the shifts of capacity of LCCs in the UK. In table 4.1 below, the total number of destinations per airport is shown ranked from the highest number of destinations served to the lowest. Included on the right side is the size of the functional urban area that is served by the airport. In all cases except London the name of the airport corresponds to the name of the urban area. The rank number on the right side of table 4.1 is the rank of the urban area and its population size in the United Kingdom. It seems that the size of the population corresponds with the number of destinations served from the airport. The colours stand for growth or decline. Green means a growth in terms of destinations served and red means decline in the period 2011-2019. The blue lining indicates the airport is serving London.

Based on the data, three categories of airports can be described from the destination analysis. Winners, middle-of-the-roads and the disadvantaged. Most notably, all airports in the metropolitan area of London gained double-digit figures of destinations. Luton, popular with Easyjet and Wizz air, doubled its network in the last ten years. Other gainers are mostly in larger metropolitan areas like Manchester, Birmingham, Edinburgh and Glasgow. All important economic centers in the United Kingdom. The second category, the middle-of-the-road airports, hardly changed in the last decade. Airport that face fierce competition in the north of England like Leeds Bradford and Liverpool and airports that serve remote areas like Inverness in the north of Scotland and Newquay in Cornwall in the southwest of England. The disadvantaged lost destinations and the quality of the network diminished. Blackpool, close to Liverpool, shut down entirely. Prestwick, popular as alternative to Glasgow but only served by Ryanair, also lost a considerable part of its network. Belfast City is heavily constrained and Belfast International serving the same catchment area reaped the benefits. Based on the number of destinations served, large metropolitan areas are gaining in terms of destinations served and small towns see a decline.

The air services market of the UK in terms of destinations at the largest airports grew steadily since 2011. The airport that had a smaller network showed a stable network or even decline in the number of destinations. The airports that already had higher numbers of destinations served and thus with the better connectivity figures grew. This might be explained by the uniform fleet of LCCs (Belobaba, 2016) that make it harder to provide business opportunities at airports that serve a smaller functional urban area. It may be observed that airports that have an unfavorable position within the UK have a bigger network as these airports benefit from their relatively

isolated location and customers have fewer options. This creates more favorable conditions for the airport business itself and for the region being served. Brexit as well as Covid-19 means uncertainty for the networks offered by any carrier.

Categorization	Pax numbers (x1000)	2011	2012	2013	2014	2015	2016	2017	2018	2019
A0	BIRMINGHAM	83	89	86	88	104	121	140	131	125
A1	HEATHROW (LONDON)	185	188	173	180	186	195	208	218	228
A1	MANCHESTER	145	149	154	149	175	192	199	212	220
A3	GATWICK (LONDON)	187	187	178	185	197	208	220	232	237
A3	LEEDS BRADFORD	65	70	62	58	62	66	68	67	72
A3	LIVERPOOL	70	65	56	48	60	66	69	72	70
A3	LUTON (LONDON)	88	92	86	73	111	123	136	146	150
A3	SOUTHEND (LONDON)	3	13	15	22	22	23	37	41	51
A3	STANSTED (LONDON)	157	152	147	156	171	183	210	204	204
B	DONCASTER SHEFFIELD	13	11	9	10	12	22	27	26	26
B	NEWCASTLE	54	54	49	52	58	74	79	83	81
B1	GLASGOW	59	60	65	70	93	99	106	109	92
B3	PRESTWICK	25	28	27	24	16	18	18	16	18
C	BELFAST	29	32	23	27	23	23	24	22	18
C	BELFAST INTERNATIONAL	36	34	32	33	42	44	42	57	60
C	BOURNEMOUTH	15	20	18	18	20	16	12	12	15
C	BRISTOL	82	83	78	76	93	102	112	115	118
C	CARDIFF	21	15	14	16	24	25	27	27	26
C	EAST MIDLANDS	66	69	58	59	60	65	74	70	76
C	EDINBURGH	105	106	103	100	106	118	138	150	154
C	NEWQUAY	14	10	11	10	11	18	19	21	21
C	SOUTHAMPTON	43	43	32	28	36	38	41	38	34
C	TEESSIDE	5	3	3	3	3	3	5	3	3
D	ABERDEEN	31	31	29	31	34	37	39	41	35
D	BLACKPOOL	10	10	12	12	1	2	1	0	0
D	EXETER	27	26	18	17	21	21	22	21	23
E	CITY OF DERRY	9	8	6	7	5	4	3	4	6
E	INVERNESS	13	13	13	13	15	15	13	12	13

Table 4.1: total number of destinations offered at UK airport in the period 2011-2019.

The total number of destinations offered from each of the airports shows variety. This number has been composed of the international destinations offered at each of the airports and the domestic destinations. Further details on the differences between the domestic networks and the international airports are discussed at paragraph 4.3. It is tempting to generalize the relationship between the size of the population and the number of destinations served. The size of the population determines the market size of the catchment. This does not explain some other observations in the data. Relatively small airports may serve a large number of destinations such as Edinburgh. This may due to the fact that Edinburgh is a popular tourist destination for tourists from outside the UK. Competition among airports in the UK is common, particularly in areas with a high population density which concerns most parts of England. Every city has its own airport, despite the relative short travel distance between most places. Good examples are the airports of Leeds Bradford and Liverpool, serving a relatively small number of destinations as Manchester is close. The travel time in most cases is within the benchmark of two hours. Airport that compete for new air services and serve rural airports face different challenges. These areas have a low population density, which results in a small market size. A more challenging geography with remote islands makes air transport the most cost effective as well as fastest mode. Airport that have a favorable geographical position and have a sufficient market size often serve as link between remote areas and the world. The networks of the airports grew in quality which is discussed next.

4.2 Passenger numbers

The growth in terms of passengers using the airport cannot be fully explained by the growth in number of destinations served. Airlines might increase flights on a certain route that already is served by another airline or might choose to increase flights to a particular destination. This means that growth in passengers' numbers is not necessarily an increase in quality of productivity. What the data reveals is that, like the number of destinations served, most growth is realized in the key metropolitan areas of the UK. The table is organized from highest to lowest annual passenger numbers. Green means that the airport has seen growth in the 2011-2019 period. Red means decline. The green prevails in the table. A clear link with the size of the metropolitan area can be observed with the largest metropolitan areas showing the highest figures in terms of passenger numbers in table 4.3 and the change in passenger numbers in table 4.2.

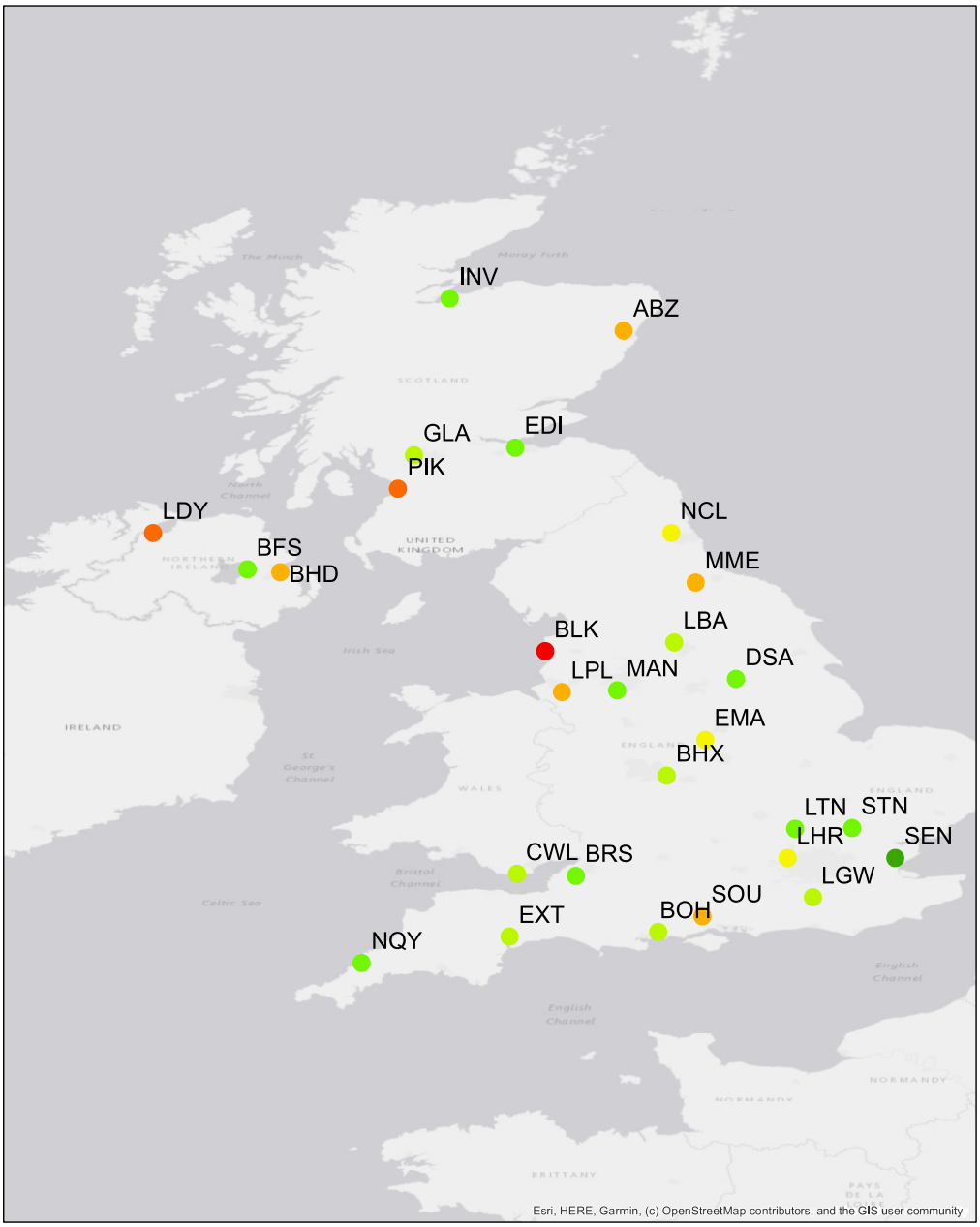


Figure 4.1: change in passenger (Pax) numbers, 2011-2019, all airports.

Categorization	Pax numbers (x1000)	PAX 2011	PAX 2019	Change
A3	SOUTHEND (LONDON)	42	2036	98%
C	NEWQUAY	210	461	54%
A3	LUTON (LONDON)	9510	18214	48%
B	DONCASTER SHEFFIELD	822	1408	42%
E	INVERNESS	579	938	38%
C	EDINBURGH	9384	14734	36%
A1	MANCHESTER	18807	29367	36%
A3	STANSTED (LONDON)	18047	28124	36%
C	BRISTOL	5768	8960	36%
C	BELFAST INTERNATIONAL	4102	6278	35%
A0	BIRMINGHAM	8608	12646	32%
D	EXETER	709	1022	31%
A3	GATWICK (LONDON)	33644	46575	28%
C	CARDIFF	1208	1655	27%
A3	LEEDS BRADFORD	2937	3992	26%
C	BOURNEMOUTH	613	803	24%
B1	GLASGOW	6858	8843	22%
B	NEWCASTLE	4336	5199	17%
A1	HEATHROW (LONDON)	69391	80887	14%
C	EAST MIDLANDS	4208	4674	10%
C	BELFAST	2397	2455	2%
C	SOUTHAMPTON	1762	1781	1%
A3	LIVERPOOL	5247	5044	-4%
D	ABERDEEN	3083	2913	-6%
C	TEESSIDE	190	148	-28%
E	CITY OF DERRY	406	204	-99%
B3	PRESTWICK	1296	639	-103%
D	BLACKPOOL	236	15	-1473%

Table 4.2: Change in number of passengers (PAX) at UK airports in the period 2011-2019.

		Pax numbers (x1000)								
Categorization	Name airport	2011	2012	2013	2014	2015	2016	2017	2018	2019
A1	HEATHROW (LONDON)	69391	69983	72332	73371	74954	75672	77988	80100	80887
A3	GATWICK (LONDON)	33644	34219	35429	38094	40260	43143	45554	46081	46575
A1	MANCHESTER	18807	19654	20680	21950	23095	25599	27774	28256	29367
A3	STANSTED (LONDON)	18047	17465	17849	19958	22513	24318	25903	27995	28124
A3	LUTON (LONDON)	9510	9614	9693	10482	12263	14642	15989	16767	18214
C	EDINBURGH	9384	9194	9775	10159	11113	12348	13410	14292	14734
A0	BIRMINGHAM	8608	8916	9114	9698	10180	11639	12982	12455	12646
C	BRISTOL	5768	5916	6125	6333	6781	7604	8234	8697	8960
B1	GLASGOW	6858	7150	7358	7709	8710	9343	9895	9653	8843
C	BELFAST INTERNATIONAL	4102	4312	4022	4032	4390	5147	5873	6269	6278
B	NEWCASTLE	4336	4355	4415	4513	4560	4805	5298	5332	5199
A3	LIVERPOOL	5247	4459	4186	3984	4296	4777	4897	5042	5044
C	EAST MIDLANDS	4208	4068	4328	4507	4446	4651	4878	4874	4674
A3	LEEDS BRADFORD	2937	2969	3314	3263	3445	3611	4075	4038	3992
D	ABERDEEN	3083	3329	3440	3723	3469	2955	3090	3056	2913
C	BELFAST	2397	2246	2542	2555	2693	2665	2560	2510	2455
A3	SOUTHEND (LONDON)	42	617	970	1102	901	874	1092	1480	2036
C	SOUTHAMPTON	1762	1693	1722	1830	1776	1947	2070	1991	1781
C	CARDIFF	1208	1013	1057	1020	1158	1344	1464	1579	1655
B	DONCASTER SHEFFIELD	822	693	690	724	857	1256	1336	1222	1408
D	EXETER	709	695	738	767	821	850	908	931	1022
E	INVERNESS	579	602	607	611	668	782	874	893	938
C	BOURNEMOUTH	613	690	659	660	705	666	694	675	803
B3	PRESTWICK	1296	1067	1145	912	610	672	696	681	639
C	NEWQUAY	210	166	175	219	250	370	460	457	461
E	CITY OF DERRY	406	398	385	350	284	291	194	186	204
C	TEESSIDE	190	165	159	142	140	131	128	140	148
D	BLACKPOOL	236	235	263	224	33	36	23	19	15

Table 4.3: total number of passengers (PAX) at UK airports in the period 2011-2019.

Overall, in the bottom of the table, the number of passengers grew steadily every consecutive year since 2011. The largest growth can be observed in the largest metropolitan areas of the United Kingdom. This is coherent with the observations in paragraph 4.1 in regard to the number of destinations. A number of exceptions can be observed in the table. Three airports

saw a sharp decline. City of Derry, Prestwick and Blackpool are all (partly) abandoned by Ryanair as the airline moved operations elsewhere.

Classification	Airport	Size functional urban area	Region NUTS 1	Functional Urban Area / *County*
A0	BIRMINGHAM (BHX)	3097965	West Midlands	Birmingham
A1	HEATHROW (LHR)	12434823	Greater London	London
A1	MANCHESTER (MAN)	3348274	North West	Manchester
A3	GATWICK (LGW)	12434823	Greater London	London
A3	LEEDS BRADFORD (LBA)	2619128	Yorkshire and the Humber	Leeds/Bradford
A3	LIVERPOOL (LPL)	1533860	North West	Liverpool
A3	LUTON (LTN)	12434823	Greater London	London
A3	SOUTHEND (SEN)	12434823	Greater London	London
A3	STANSTED (STN)	12434823	Greater London	London
B	DONCASTER SHEFFIELD (DSA)	1189393	Yorkshire and the Humber	Sheffield
B	NEWCASTLE (NCL)	1175274	North East England	Newcastle upon Tyne
B1	GLASGOW (GLA)	1830710	Scotland	Glasgow
B3	PRESTWICK (PIK)	1830710	Scotland	Glasgow
C	BELFAST (BHD)	787135	Northern Ireland	Belfast
C	BELFAST INTERNATIONAL (BFS)	787135	Northern Ireland	Belfast
C	BOURNEMOUTH (BOH)	532293	South West England	Bournemouth
C	BRISTOL (BRS)	955541	South West England	Bristol
C	CARDIFF (CWL)	915466	Wales	Cardiff
C	EAST MIDLANDS (EMA)	896515	East Midlands	Leicester
C	EDINBURGH (EDI)	893610	Scotland	Edinburgh
C	NEWQUAY (NQY)	569578	South West England	*County of Cornwall*
C	SOUTHAMPTON (SOU)	687971	South East England	Southampton
C	TEESSIDE (MME)	530094	North East England	*County of Durham*
D	ABERDEEN (ABZ_	489815	Scotland	Aberdeen
D	BLACKPOOL (BLK)	329729	North West	Blackpool
D	EXETER (EXT)	486263	South West England	Exeter
E	CITY OF DERRY (LDY)	150680	Northern Ireland	Derry
E	INVERNESS (INV)	235830	Scotland	*Inverness / County of Highland*

Table 4.4: categorization of UK airports.

In table 4.4 the categorization of UK airports is shown based on the typology developed by Dobruszkes, Givoni and Vowles (2017). The functional urban area is derived from Eurostat (2018). As expected, the UK hosts a relative high number of airports that can be classified in the A category, in metropolitan areas with more than 2 million inhabitants. Greater London is by far the largest metropolitan area in the UK and hosts a large number of A category airports. Heathrow is the biggest airport of London and hosts British Airways. However, it doesn't offer the greatest connectivity as Gatwick offers more destinations as seen in table 4.1. As not all destinations have been considered due to the fact that Heathrow is served primarily by FSNCs, this might not be solely cover the connectivity comparison. In terms of passenger numbers, it is the largest and can be classified as the main airport serving Greater London and is therefore classified as A0. All the other airports in London are A3, except for London City which can be classified as A2. Outside of London, the West Midlands metropolitan area with Birmingham as biggest city only hosts one airport, Birmingham Airport. Birmingham Airport is therefore classified as A0. However, airport like Bristol Airport, Manchester Airport and Cardiff Airport are rather close and within the two-hour travel range. Passenger might choose to depart from any of the other airport within this range. This is also true for most airport in Northern England and in South West England. Manchester Airport is the main airport with almost 30 million passengers in 2019. It is the main airport in Northern England with 220 destinations. Only eight destinations short of Heathrow. Airport in the periphery regions of the UK like City of Derry (Londonderry) in Northern Ireland and Inverness in Scotland have the lowest classification (E) which is reflected in the relative low number of passengers and lack of connectivity. Notable is also Teesside International Airport (MME). MME is situated in North East England and can be classified as type C. However, the airport only has 3 destinations and a relative low number

of passengers. The proximity of other airports with higher connectivity means the statistics do not fully comply with the classification proposed by Dobruszkes, Givoni and Vowles (2017). For the analysis, this means that the actual empirical evidence does not fully correspond with the theoretical expectation. The capacity of airlines at these airports may be lower or higher than can be expected as a result of other airports in the area, demographic factors and economic factors like high tourism appeal in for example Edinburgh in category C. In the light of the analysis, this is not a problem as most categories have multiple airports in them. Furthermore, in the original typology only A had extra categories. Glasgow however has two airports, Glasgow Airport and Prestwick Airport. Glasgow can be seen as the main airport as it has higher passenger numbers and higher connectivity in terms of network. Glasgow Airport therefore gets the classification of B1, in line with the categories under A and Prestwick Airports classifies as B3. The classification is in this way the same as the categorization of type A airports with the further distinction of type B airports. The size of the metropolitan area is the only difference. The categorization is shown in table 4.5.

	Pax numbers (x1000)									
Category	2011	2012	2013	2014	2015	2016	2017	2018	2019	Growth
A	166233	167896	173567	181902	191907	204275	216254	222214	226885	36%
B	13312	13265	13608	13858	14737	16076	17225	16888	16089	21%
C	29842	29463	30564	31457	33452	36873	39771	41484	41949	41%
D	4028	4259	4441	4714	4323	3841	4021	4006	3950	-2%
E	985	1000	992	961	952	1073	1068	1079	1142	16%

Table 4.5: Growth of passenger numbers (Pax) per category in the period 2011-2019.

A shift between the categories as seen in the data is proof of the changing focus of LCCs. Interestingly, like seen in table 4.5, the largest relative growth in the last decade is at category C airports. The largest quantitative growth is at category A airports. The largest growth of capacity is, as expected, at category A airports. Although the relative growth is lower in comparison with category C airports, the absolute growth in passenger numbers is the largest at category A airports. The airline industry as an entity shows grows at all categories except for a minor decrease at category D airports. This can be explained by a growth of the economy and a growth of the population. The absolute growth at category A airports also illustrates the deployment of assets at these airports and the shift of LCCs to category A airports. This despite that the fact that overall there is growth and capacity is deployed at the most profitable routes.

4.3 Quality of the network

Every airport is scored based on the economic indicator, the demographic indicator and the route development indicator to assess the quality of the network offered. The shift in focus of LCCs will theoretically improve the quality of the networks at category A and B airports and show no improvements at category C, D and E airports. The data is described for the domestic airports served and for the international airports. The development of the domestic network at UK airport in the last decade showed an overall decline of quality. The majority of airports lost domestic destinations and the overall quality score declined as well. Was the average score of

quality of the domestic network in 2011 135, the score declined to an average of 115 in 2019. When looking at the scores of demography, a clear trend is visible. The population grows in large metropolitan areas and stabilizes or declines in the more rural parts of the United Kingdom. As the period is 2011-2019, the economy tends to show signs of recovery as the 2011 is 3 years after the economic crisis of 2008. The economic indicator shows no immediate explanation for the decline. Another clear pattern is the size of the domestic networks in the vicinity of rural areas. The airports in Scotland have the largest domestic networks, as the serve as the vital link between the numerous islands at the coast of Scotland and the rest of the world. Airports in England mostly lack a domestic network as other modes of transport are more easily accessible or the distance is simply too short. The North of England are treated as distinct metropolitan areas, still the distance in almost any case is less than two hours. Most cities in England have their own airport, which show a small domestic network and large international network.

Categorization	Name Airport (IATA) DOMESTIC	2011	2012	2013	2014	2015	2016	2017	2018	2019
A0	BIRMINGHAM (BHX)	131	139	131	142	132	131	107	122	121
A1	HEATHROW (LHR)	101	114	106	106	106	118	118	118	----------
A1	MANCHESTER (MAN)	218	206	205	190	203	200	243	240	248
A3	GATWICK (LGW)	185	162	160	146	144	130	120	133	115
A3	LEEDS BRADFORD (LBA)	146	127	85	75	78	83	86	72	62
A3	LIVERPOOL (LPL)	69	47	56	56	79	80	66	66	56
A3	LUTON (LTN)	99	88	85	68	68	79	89	89	90
A3	SOUTHEND (SEN)	7	21	45	31	9	9	36	41	69
A3	STANSTED (STN)	112	84	72	83	109	104	85	83	73
B	DONCASTER SHEFFIELD (DSA)	18	8	7	15	7	20	28	19	29
B	NEWCASTLE (NCL)	173	166	164	164	179	157	124	123	129
B1	GLASGOW (GLA)	344	343	356	356	345	332	359	361	346
B3	PRESTWICK (PIK)	28	11	11	11	0	0	0	0	0
C	BELFAST (BHD)	331	284	244	241	254	240	241	250	221
C	BELFAST INTERNATIONAL (BFS)	201	236	219	190	160	160	178	178	187
C	BOURNEMOUTH (BOH)	0	7	0	0	39	13	13	0	7
C	BRISTOL (BRS)	168	136	109	100	110	120	110	110	120
C	CARDIFF (CWL)	76	74	75	74	74	82	84	70	68
C	EAST MIDLANDS (EMA)	84	72	72	72	72	72	75	61	69
C	EDINBURGH (EDI)	340	333	306	297	309	311	308	309	326
C	NEWQUAY (NQY)	129	94	118	111	112	153	157	153	151
C	SOUTHAMPTON (SOU)	170	156	141	132	136	134	134	133	132
C	TEESSIDE (MME)	30	18	18	18	18	17	17	17	17
D	ABERDEEN (ABZ_	267	280	287	290	298	292	277	274	243
D	BLACKPOOL (BLK)	27	27	19	10	10	10	8	0	0
D	EXETER (EXT)	115	128	94	109	111	128	129	129	129
E	CITY OF DERRY (LDY)	78	67	64	76	47	47	46	58	86
E	INVERNESS (INV)	141	138	138	154	153	149	124	124	135
		135	127	121	118	120	120	120	119	120

Table 4.6: Scores of quality of domestic networks at UK airports.

The quality of the international network of the airports in the sample shows clear signs of growth. The average quality of the network was 449 in 2011, in 2019 the score was 627. Based on the indicators, this means that accessibility of regions in the UK in general improved on average. Growth tends to concentrate in the larger metropolitan areas, but most likely in London. The growth can be explained by the opening of new services to metropolitan areas all over Europe, but most notably by new services to Eastern Europe. The majority of UK airports welcomed new services to Eastern Europe, particularly served by Ryanair and Wizz Air. The combination of free movement of people within the European Union and the positive growth figures after 2011 in the United Kingdom attracted economic migrants from Eastern Europe to the UK. The airports in the metropolitan area of London showed a steady growth in the quality of network offered to Eastern Europe, serving not only capital cities, but also other urban areas. Poland and Romania are the two most important markets in Eastern Europe, with the highest

number of destinations, passenger numbers and the highest quality of the network. The link between fast(er) growth and size of the metropolitan areas is evident. The larger the size of the metropolitan area, the larger the growth of the quality of the network seems to be. As most airports in England compete with each other, their domestic networks tend to be rather shallow and their international networks focused on Southern and Eastern Europe. The increase in quality is the highest in large metropolitan areas.

Categorization	Name Airport (IATA) INTERNATIONAL	2011	2012	2013	2014	2015	2016	2017	2018	2019
A3	STANSTED (LONDON)	2151	2140	2190	2283	2281	2395	2552	2632	2682
A3	LUTON (LONDON)	1132	1203	1201	1306	1440	1579	1729	1892	1975
A3	LIVERPOOL	919	852	770	743	737	809	869	911	884
A3	LEEDS BRADFORD	663	724	791	782	675	721	779	799	824
A3	SOUTHEND (LONDON)	25	143	192	280	270	261	370	443	528
B	NEWCASTLE	471	494	502	502	497	685	761	754	714
B	DONCASTER SHEFFIELD	129	133	119	129	156	271	317	296	289
B1	GLASGOW	280	328	391	508	661	743	849	823	671
B3	PRESTWICK	334	371	384	329	215	228	241	220	226
C	EDINBURGH	1084	1094	1106	1035	1024	1170	1421	1531	1556
C	BRISTOL	559	615	698	663	778	824	892	926	954
C	EAST MIDLANDS	775	817	788	755	701	743	832	822	837
C	BELFAST	287	259	281	295	370	398	439	559	583
C	SOUTHAMPTON	376	387	347	296	328	352	355	343	317
C	CARDIFF	120	85	134	173	216	222	253	267	246
C	BOURNEMOUTH	176	238	235	259	198	174	163	173	191
C	NEWQUAY	37	0	13	13	26	55	75	103	87
C	TEESSIDE	18	18	17	18	18	18	17	18	18
D	EXETER	177	176	182	171	142	148	148	150	175
D	BLACKPOOL	89	89	125	126	0	0	0	0	0
E	INVERNESS	27	29	29	39	41	41	42	40	31
E	CITY OF DERRY	47	33	22	22	19	9	0	0	0
		449	465	478	488	491	538	596	623	627

Table 4.7: Scores of quality of international networks at UK airports.

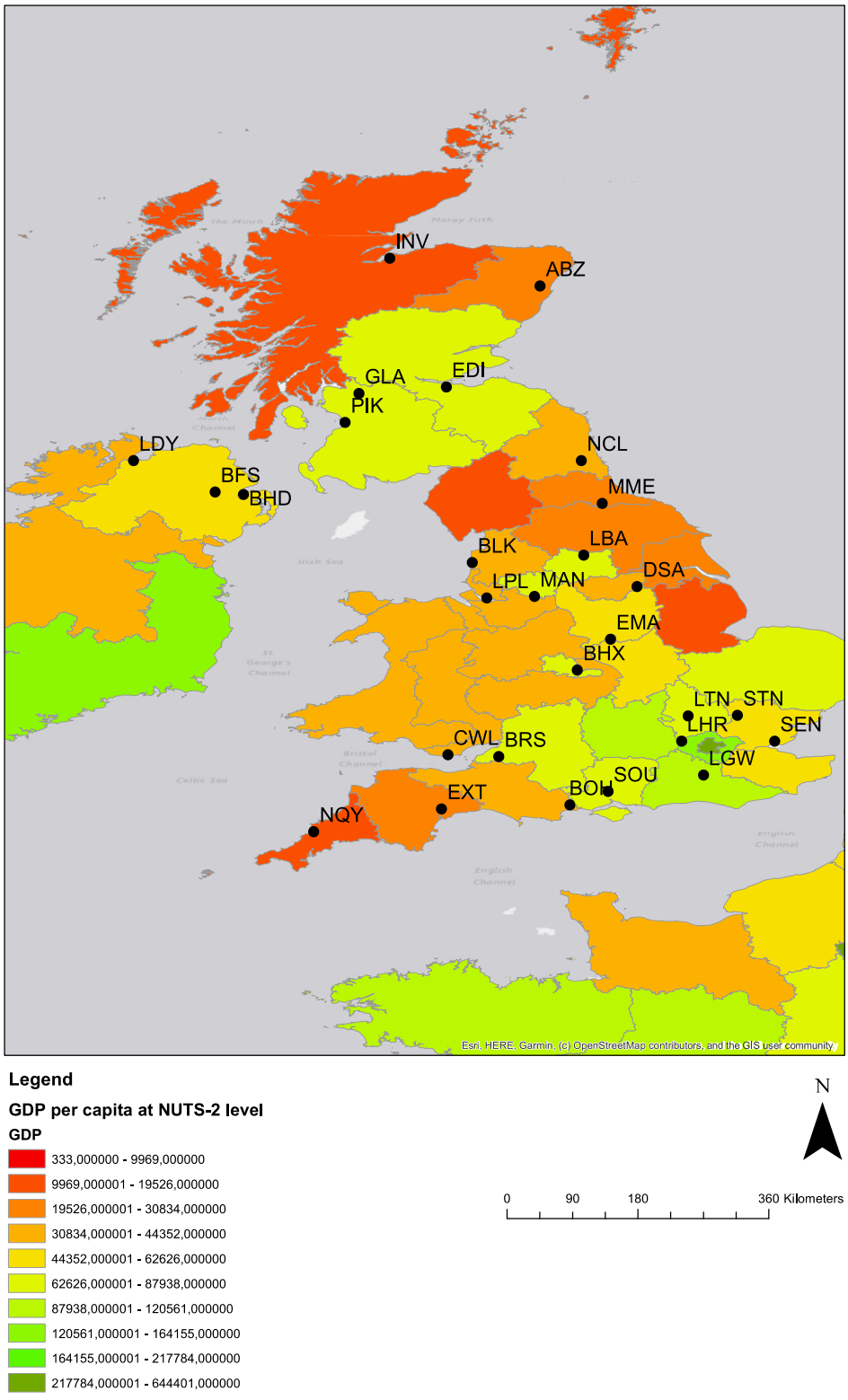


Figure 4.2: GDP per capita at NUTS-2 level in 2019.

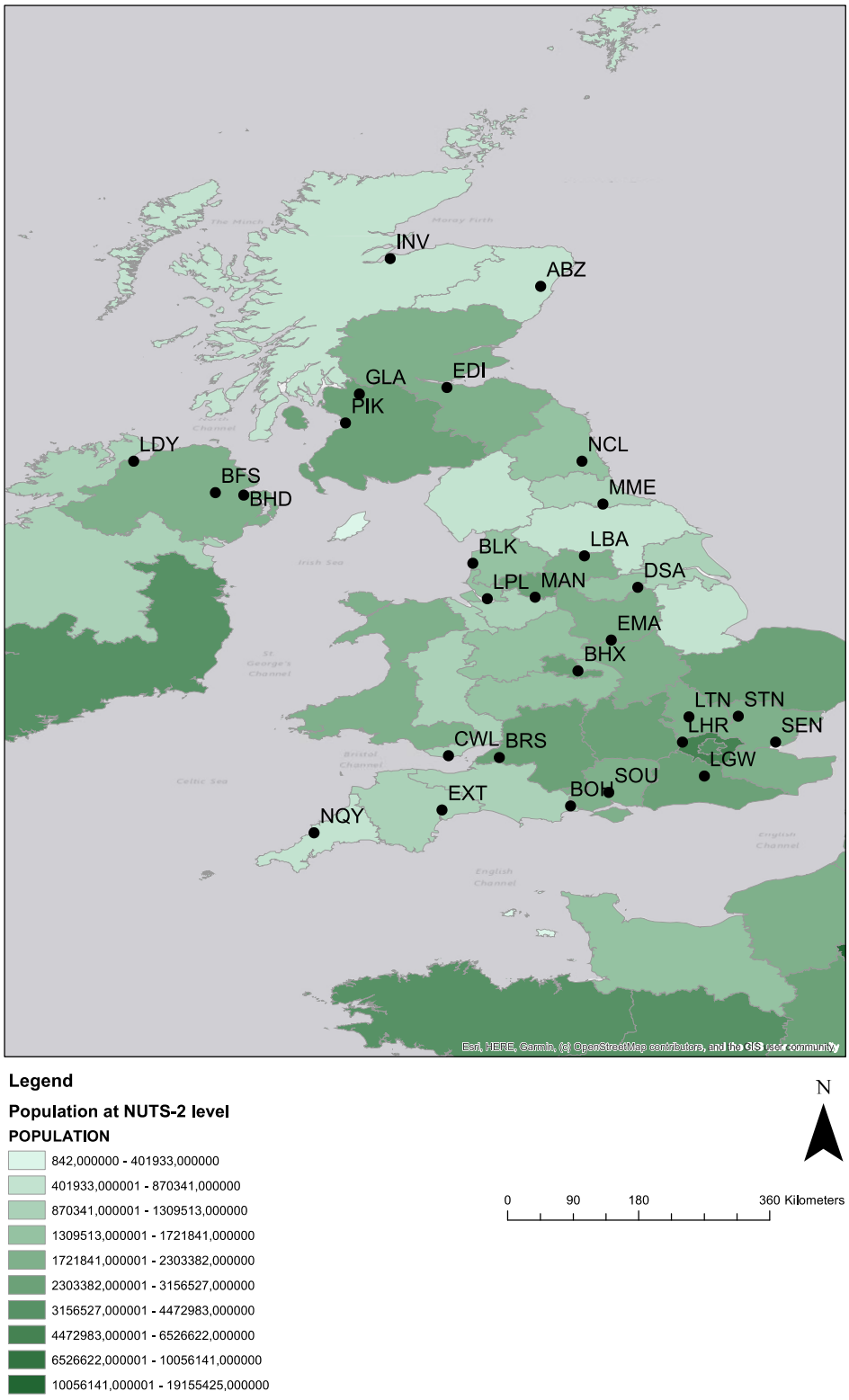


Figure 4.3: Population at NUTS-2 level in 2019.

4.4 Regional Air Connectedness

All airports in the sample have travel times below the 120 minutes barrier. The customer in the UK in most regions has a choice when it comes to airports to depart from. Airports are competing with one another, which is good for the customer (lower prices) and airlines (better bargaining position). Will airlines concentrate their operations? Only a few regions have less than 2 options, most notably the rural regions of the UK. The Highlands of Scotland only have one airport, Inverness. Areas like South West England have a relatively big airport like Bristol and a number of smaller airports like Bournemouth, Southampton, Cardiff (Wales) and Exeter. All of these cities can reach Bristol within the two hours' time frame. From Cardiff to Bristol is even less than an hour.

		2018	2011				
Classification	Airport	Size functional urban area	Size functional urban area	Travel time	Wir: 1 - (Tir /120) (3.2)	Contribution (CONrt) 2018	Contribution (CONrt) 2011
A0	BIRMINGHAM (BHX)	3097965	2860749	19	0,84	0,8	0,9
A1	HEATHROW (LHR)	12434823	12100598	38	0,68	0,1	0,1
A1	MANCHESTER (MAN)	3348274	2773420	20	0,83	1,6	1,2
A3	GATWICK (LGW)	12434823	12100598	69	0,43	0,4	0,3
A3	LEEDS BRADFORD (LBA)	2619128	1160771	19	0,84	0,0	0,2
A3	LIVERPOOL (LPL)	1533860	1506935	22	0,82	0,4	0,3
A3	LUTON (LTN)	12434823	12100598	55	0,54	0,4	0,3
A3	SOUTHEND (SEN)	12434823	12100598	67	0,44	0,1	0,0
A3	STANSTED (STN)	12434823	12100598	53	0,56	0,0	0,0
B	DONCASTER SHEFFIELD (DSA)	1189393	909001	32	0,73	0,8	0,7
B	NEWCASTLE (NCL)	1175274	1145347	13	0,89	3,7	3,3
B1	GLASGOW (GLA)	1830710	1787515	22	0,82	6,4	4,3
B3	PRESTWICK (PIK)	1830710	1787515	40	0,67	0,3	0,3
C	BELFAST (BHD)	787135		10	0,92	53,7	
C	BELFAST INTERNATIONAL (BFS)	787135		25	0,79	9,7	
C	BOURNEMOUTH (BOH)	532293	511027	12	0,90	135,4	122,2
C	BRISTOL (BRS)	955541	893567	17	0,86	0,8	0,6
C	CARDIFF (CWL)	915466	885642	24	0,80	3,5	2,7
C	EAST MIDLANDS (EMA)	896515	836484	25	0,79	4,5	5,0
C	EDINBURGH (EDI)	893610	834648	21	0,83	15,5	9,4
C	NEWQUAY (NQY)	569578	533760	12	0,90	44,6	31,7
C	SOUTHAMPTON (SOU)	687971	362081	11	0,91	7,0	10,9
C	TEESSIDE (MME)	530094	512994	19	0,84	0,7	0,3
D	ABERDEEN (ABZ_	489815	475766	15	0,88	1,2	2,4
D	BLACKPOOL (BLK)	329729	325571	11	0,91	5,5	4,9
D	EXETER (EXT)	486263	327980	14	0,88	2,7	0,1
E	CITY OF DERRY (LDY)	150680	148191	13	0,89	165,7	108,6
E	INVERNESS (INV)	235830	232730	16	0,87	0,5	0,7
		3144539	3127488	25,5	0,79	16,6	12,0

Table 4.8: Regional Air Connectedness and travel times of UK airports.

The size of the functional urban area in table 4.6 is the population as defined by Eurostat in 2018. The travel time is in minutes and corresponds to the time from the airport to the city center by car without congestion. The weight of the airport corresponds to the travel time, with the incorporation of the maximum travel time of 120 minutes. Particularly the airports in Greater London score low. All airports are far from the city center of London in comparison with other airports in the UK. Gatwick even is 69 minutes from the city center, without congestion resulting in the lowest score in the sample, 0.43. The best score is for Belfast City Airport, only 10 minutes from the city center of Belfast. Then the contribution of the airports to connectedness. Blackpool obviously does not contribute at all, as the airport shut down before 2018. Low scores at airport that are in business can be seen at the airports in Greater London. As the population of Greater London is rather big and travel times are long as most airports are distant from the city center, their contribution is rather low in comparison with other airports in the sample. Still, the airports do score as their passenger numbers are much higher due to market demand. Other airports also score relatively low in comparison with their geographical location and the size of the population. Teesside faces competition from airports in the region like Newcastle and Leeds Bradford. Only three destinations were offered resulting in the modest score of 0.2. Leeds Bradford itself scores a low 1.3, despite its sizeable

population. The airport of Manchester is within reach and serves most of North England. It scores 7.0. Most notable exception is Edinburgh Airport, which scores 13.2. The relatively small population in the urban area combined with the number of passengers at the airport and the favorable geographical location can explain this high number. Furthermore, Edinburgh is a popular tourist destination and offers a high number of connections to remote areas of Scotland. Bristol Airport has a favorable geographical position in South West England. The average score is 3.0 in 2018. The average weight is 0.79 in 2018.

Over time, connectedness of UK airports increases. Whereas on average, UK airports had a score of 2.5 in 2011, the score increased to 3.0 in 2018. Airports that gain ground mostly saw an improvement of their network, mostly due to expansion of LCCs. This is also true for airports that lost ground like City of Derry and Prestwick. Both airports saw Ryanair downsize its operations. Airport in large metropolitan areas like Manchester, Birmingham and Edinburgh as well as all Greater London airports saw figures improve, due to expansion of LCCs. This follows population growth in the Britain's metropolitan areas. Overall, LCCs expanded at category A airports and downsized or remained a stable operation at airports classified as B-E. This is in line with earlier research on the behaviour of LCCs. As the census of 2011 did not include data on the urban area of Belfast, figures were not included. LCCs did expand at Belfast International in the period in terms of passenger numbers and network offered.

4.5 Statistical relationship between economy, population and passenger numbers

This paragraph evaluates the results of the linear regression that has been executed to test the relationship between the passenger numbers, the population of the NUTS-2 region the airport serves and the GDP per capita of the NUTS-2 region. The total of passenger numbers of all the airports in the sample of the year 2019 have been included. To improve the linear relationship between the variables, two of the variables have been subjected to log transformation. The two variables are passenger numbers per annum and the population of the NUTS-2 region. This resulted in better fit and improved the linear relationship. The GDP per capita at NUTS-2 level has not been subjected to log transformation as this did not improve linearity in the analysis. The assumptions of the linear regression model improved after log transformation. The scatterplot (see Appendix I) meets assumptions and therefore the linear regression can be executed. The outliers in the graph can be explained by the demography of the United Kingdom. The metropolitan area of London relatively large in terms of population numbers (12.434.823) and a considerable proportion of the people of the United Kingdom (66.796.800) live in the capital. Graphically represented, this implies that airports serving the London metropolitan area will become an outlier. The log transformation made it less prone in the graphs.

Model summary

R	R square
0,769[a]	0,591

a. Predictors: (Constant), Population size, GDP per capita (log)

b. Dependent variable: passenger numbers

Coefficients

	Unstandardized Coefficients	Unstandardized Coefficients	Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	1,323	1,367		0,968	0,342
GDP per capita (Log)	0,751	0,245	0,502	3,060	0,005
Population size	9,792E-6	0,000	0,348	2,122	0,044

Table 4.9: Model summary and coefficients.

In a multivariable linear regression, the R Square is important as it adjust for the number of variables in the model, in this case one dependent (passenger numbers) and two independent (population size and GDP per capita) variables. 0.591 (table 4.8) implies a moderate influence of the two variables on the size of passenger numbers. Both independent variables (V3LOG being population numbers per NUTS-2 region and V4 the GDP per capita per NUTS-2 region) shows significance stronger than 0.05. This implies that both the population and GDP per capita are predictors of passenger numbers at British airports. It confirms the importance of market size and the economic indicators for the demand of travel. LCCs will opt to serve larger markets as it will be easier to generate economies of scale at larger markets. We can accept hypothesis H1 for both the relationship between the passenger numbers and the population of the area and between the passenger numbers and the GDP per capita of the area. We can reject the null hypothesis for both independent variables.

Chapter 5

Conclusion and discussion

LCCs provide a fundamental adaption of the market for air services. Their innovative business model primarily differs from FSNCs in terms of uniformity of fleet, lack of legacy structure in terms of human capital and a lack of base that provides the flexibility to offer those routes that are most profitable for the firm. The business model of LCCs is focuses at expansion at those markets that combine the necessary scale in terms of population size, the necessary wealth in terms of GDP per capita and the necessary windows of opportunity in the form of airports with a lacking customer base that gives the LCCs a beneficial bargaining position. The unique combination of a business model that is focused on low costs created by economies of scale makes it possible to offer a low price. As all thrills are scrapped from the air ticket, customers pay only for the services they want. This model makes the market size bigger as flying becomes available to more customers. The shift of growth towards larger metropolitan areas has implications for regions that saw the LCCs come and go. Their connectivity decreases and in some cases collapses. Market forces determine where LCCs operate and the harsh economic reality is that this means growth at places that are already well connected and decline at places that already had a hard time keeping up.

The core regions of the United Kingdom see the benefits from the growth of LCCs at their airports. The larger metropolitan areas attract LCCs with their large population, particularly London, and their relative wealth in terms of GDP per capita. As FSNCs only serve these places scarcely with the notable exception of London Heathrow as the hub of British Airways, LCCs gracefully entered the markets providing the necessary air services to a wide array of European destinations. Most notably to holiday destinations in Southern Europe and as a bridge between Eastern Europe and the UK, the latter being a popular destination for labour migrants. The costs of the air fare no longer being relevant as prices become lower and lower. The more efficient the LCCs become, which is caused by generating economies of scale due to centralization at selected airports, the better it is for their networks offered at these selected airports. In this way, airports other than London Heathrow gained in importance due to the networks offered by LCCs and LCCs provided a kind of hub at the airports. Theoretically, this is not a hub in the classical sense as passengers do not use these airports and these airlines to transfer between flights.

The LCCs in the study have operations in other European countries. It is not hard to imagine that the models that these companies operate does not differ on other markets. The aspects of the LCC business model will not completely change. They are irrespective of the market. Airports that serve as hub for a FSNC are harder to get access to as they might have the same challenges as London Heathrow. However, to be completely certain about these challenges, individual airports should be analyzed. Larger European markets like France, Germany and Italy provide unique market opportunities for LCCs as they have one centralized hub for the

respective FSNC. Secondary destinations with sufficient demand provide opportunities for LCCs. Market demand not seen by FSNC or simply operated more efficiently by LCCs.

LCCs in the United Kingdom grew their operations specifically at the airports serving the larger markets. Connectivity and accessibility of larger metropolitan areas grew while the periphery regions dependent on air services saw growth at a slower pace as market demand was not sufficient enough to justify larger LCC operations. The concentration of air services of LCCs at larger markets is sound from a business perspective. Centripetal forces might be at play, where commercial air services simply follow market demand. The quality of the network improved at the places that already were frontrunners in terms of network quality.

The competitive landscape of the UK market for air services while writing this thesis changed dramatically. The dangerous entrant, Covid-19, shocked the entire economy and let the contemporary economic structure collapse. Shockwaves that moved through the airline industry quickly. Airlines had to shut down their entire operations for months. It is not yet clear what the implications of the lockdown will be. Airlines have to cut capacity, prepare for lay-offs and cope with the new reality. The competitive landscape in the UK changed before the current crisis when the United Kingdom voted to leave the European Union (EU). In the last decade, the United Kingdom attracted a large workforce from Eastern Europe. The economic implications are yet to be revealed at the end of this year when the UK will ultimately leave the EU indefinitely. Third major crisis is the collapse of Flybe, one of the largest regional carriers in Europe. Flybe was included in this thesis as the business model is mostly low cost. The primary difference of Flybe in comparison with EasyJet, Ryanair and Wizz Air is the fleet. The deployment of smaller aircraft made it economically viable to fly from smaller airports for a long time. This was very beneficial and even necessary for the remote regions of the UK, where deployment without subsidies is not economically viable for the LCCs. LCCs are clearly bounded by their economic reality as the analysis shows. LCCs focus on the larger markets in the UK. The airports of Greater London, the North of England and larger metropolitan areas in the rest of the UK, namely Bristol, Belfast and the urban areas of Scotland. They provide the biggest customers base and generate the largest revenues. The diminishment of Flybe meant airports like Southampton (95%) and Belfast City (80%) lost a large proportion of their flights. As the analysis clearly shows, passenger numbers would not be sufficient for another LCC to step in. The connectivity landscape of the UK dramatically changed in the last ten years with the focus on large urban areas and concentration (resulting in the necessary economies of scale) at airports in the proximity of these urban areas. Current Government vowed to commit to regional connectivity, but in practice no support means no connectivity as Flybe was loss-making for most of its existence.

As data was not as straightforward as it seems, the quality of the thesis would have been better if the CAA would have provided the data. Data on the level of the carrier. This would have improved the validity as it would have been 100% sure which carriers is responsible for which part of non-monopoly routes. It would also have been sensible to know the exact type of aircraft used for the operations and the exact number of passengers per month. Not every route is operated on an annual basis and most routes are operated seasonally. A route served on an

annual basis provides better quality for the network in comparison with a seasonal service. More detailed data would have given insight in these aspects. The validity of the data is nevertheless trustworthy as they come straight from the CAA and the respective websites of the airports.

The results show a clear process that LCCs been through in the last decade. LCC started expanding their fleets, expanding their networks from the majority of airports in the UK and this started to improve the quality of the airports. The airports that gained the most are located near the areas with the largest market potential. The regions with a larger population saw higher gains in terms of destinations offered, the number of passengers departing from the airports and the highest quality score. It would be interesting to see what the Covid-19 pandemic will do in terms of networks offered at UK airports and what the effects will be on the business models of the airports.

The quality score of the networks at British airports generally shows growth. The quality of the network has been growing more significantly in the large, metropolitan areas of the UK. The quality shows a relative decline at airports that serve periphery regions or show stagnation. This is in line with the prediction that growth tends to concentrate at airports that serve major metropolitan areas. It is also in line with the prediction that LCCs that open bases at these airports serve as the engine for growth. It shows the quality score of the domestic airports and the international airports served within Europe. Limitation in this respect is the absence of airports outside of the Europe. This component is therefore not included in the quality scores presented in this thesis. It means that airports that have FSNCs serving intercontinental destinations have a lower score in this study than in the real situation. Even without the scores of these routes, the scores are already substantially higher at these airports than airports without these services.

The statistical analysis shows a clear relationship between the size of the population and the number of passengers. The population size of the area served is a clear indicator of the relative size of the airport. The larger the population size of the region the airport serves, the more passengers the airport can expect. This is in line with the theory on airports and in line with the database data. The population size can be seen as one important explanatory variable for the size of the airport, but there are some notable limitations. The first one is the geographical entity used to test the relationship between population size and number of passengers. NUTS-2 level has been used which is a statistical level used by Eurostat and the national office of statistics of the UK. It is a relevant level as economic, social and demographic indicators are collected at this level. This makes it easier and more reliable to compare regions. However, the NUTS-2 level does not always correspond with the catchment area of the airport. It could imply that some airports have a market size than anticipated and some have a lower market size. As the catchment are theoretically depends on the travel time between the customer and the airport and not necessarily distance, the size may also depend on other antecedents such as congestion, available modes of transport and costs of travel. The personal decision-making process depends on the personal context of customers making it borders of the catchment area more fluid than stable. A larger population is not a guarantee for a large number of passengers, as airport

serving less prosperous region with lower power purchasing parity will imply a lower number of people that can potentially afford a ticket or fly less frequent. Obviously, the entrance of LCCs in this respect will results in lower prices and improved accessibility of air travel as a mode of transport.

Prosperity of the region is therefore an important determinant besides population size. The gross domestic product per capita of the region is also measured at NUTS-2 level, but this is in comparison with the size of the population less problematic. The differences within the catchment area when mapped show that there are differences between the core and the areas surrounding the core, which shows centripetal effects. But GDP per capita is still high meaning that it still has an influence on passenger numbers. The linear relationship might also imply that the higher your income, the higher consumption of air travel can be. This is in line with theory on for example labor economics. When people have higher wages, leisure time becomes more affordable and with declining prices for air tickets, making it more attractive to use air travel as a mode of transport and also more frequent than people for which leisure time is a more expensive commodity. This is of course not tested as such but could be empirically tested. The data shows that the GDP per capita is a significant determinant of passenger numbers, but less significant in comparison with population size. This might have to do with the decrease of prices for air tickets, making this component less relevant in the decision-making process of customers. A limitation might be the variable itself. The gross domestic product per capita simply is the total figure of production in the NUTS-2 level for a specific period divided by the population size. The use of power purchasing parity might say more about the relative influence of income on frequency of air travel and therefore passenger numbers. The relative costs of leisure time might be an important determinant of frequency of air travel as prices of air travel decline. Interesting would be to analyze the potential effects of internalizing the costs of externalities such as emissions on the frequency of air travel and the passenger numbers.

References

Aci-europe.org. (2019). *Fast Facts | ACI EUROPE*. [online] Available at: https://www.aci-europe.org/policy/fast-facts.html [Accessed 7 Jan. 2019].

Atallah, S., Hotle, S. L., & Mumbower, S. (2018). *The evolution of low-cost Carrier operational strategies pre- and post-recession* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.jairtraman.2018.08.011

Barbot, C. (2006). *Low-cost airlines, secondary airports, and state aid: An economic assessment of the Ryanair–Charleroi Airport agreement*

Barrett, S. D. (1997). The implications of the ireland-uk airline deregulation for an EU internal market. *Journal of Air Transport Management, 3*(2), 67–73. https://doi.org/10.1016/S0969-6997(97)00003-3

Belobaba, P., Odoni, A. and Barnhart, C. (2016). *The Global Airline Industry, Second Edition*. John Wiley & Sons.

Bergantino, A., Intini, M., & Volta, N. (2020). Competition among airports at worldwide level: A spatial analysis. *Transportation Research Procedia, 45*, 621-626. doi:10.1016/j.trpro.2020.03.049

Bernier, X. (2010). Regional airports and the accessibility of mountain areas: networks, importance and contribution to development. *International Journal of Sustainable Development and Planning, 5*(2), 130-140.

Bracaglia, V., D′Alfonso, T., & Nastasi, A. (2014). Competition between multiproduct airports. *Economics of Transportation, 3*(4), 270-281. doi:10.1016/j.ecotra.2015.02.004

Braw, E. (2019). BA and Norwegian Air Shuttle cut costs, but at what price for flight attendants?. Retrieved from https://www.theguardian.com/sustainable-business/ba-norwegian-air-shuttle-cut-costs-flight-attendants

Bruinsma, F., & Rietveld, P. (1998). The accessibility of european cities: theoretical framework and comparison of approaches. *Environment & Planning A, 30*(3), 499–499.

Červinka, M., & Matušková, S. (2018). Are low cost carriers a problem for the management of regional airports? *Transportation Research Procedia, 35*, 54-63. doi:10.1016/j.trpro.2018.12.012

Corporate.ryanair.com. (2019). *History of Ryanair | Ryanair's Corporate Website*. [online] Available at: https://corporate.ryanair.com/about-us/history-of-ryanair/.

Dziedzic, M., & Warnock-Smith, D. (2016). The role of secondary airports for today's low-cost carrier business models: the european case. *Research in Transportation Business & Management, 21*, 19–32. https://doi.org/10.1016/j.rtbm.2016.07.002

Dobruszkes, F. (2013). *The geography of European low-cost airline networks: a contemporary analysis* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.jtrangeo.2012.10.012

Dobruszkes, F., Givoni, M., & Vowles, T. (2017). *Hello major airports, goodbye regional airports? Recent changes in European and US low-cost airline airport choice* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.jairtraman.2016.11.005

Dobruszkes, F., & Graham, A. (2016). *Air transport liberalisation and airline network dynamics: Investigating the complex relationships* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.jtrangeo.2015.08.004 "

Dobruszkes, F., Lennert, M., & Van Hamme, G. (2011). An analysis of the determinants of air traffic volume for european metropolitan areas. *Journal of Transport Geography, 19*(4), 755-762. doi:10.1016/j.jtrangeo.2010.09.003

Doganis, R. (2009). *Flying off course IV: airline economics and marketing*. Routledge.

Flowerdew, R., & Martin, D. (2005). *Methods in human geography : a guide for students doing a research project*(2nd ed.). Prentice Hall.

Forbes. (2019). *How will Boeing gain market share?- Forbes* [online] Available at: https://www.forbes.com/sites/greatspeculations/2019/02/21/how-will-boeing-gain-market-share/#5fb2a4591e9b

Francis, G., Fidato, A., & Humphreys, I. (2003). Airport–airline interaction: the impact of low-cost carriers on two European airports. *Journal of Air Transport Management*, *9*(4), 267-273.

Franke, M. (2004). Competition between network carriers and low-cost carriers—retreat battle or breakthrough to a new level of efficiency?. *Journal of Air Transport Management, 10*(1), 15-21.

Friedman, M. (1962). *Capitalism & Freedom*. Chicago: The University of Chicago Press.

Fuellhart, K., & O'Connor, K. (2019). A supply-side categorization of airports across global multiple-airport cities and regions. *Geojournal : Spatially Integrated Social Sciences and Humanities,84*(1), 15-30. doi:10.1007/s10708-018-9847-6

Gallop, A. (2019). *Heathrow airport : Yesterday, today and tomorrow*. Havertown: Pen & Sword Books Limited. (2019). Retrieved April 17, 2020, from INSERT-MISSING-DATABASE-NAME.

Gillen, D., & Lall, A. (2004). Competitive advantage of low-cost carriers: Some implications for airports. *Journal of Air Transport Management, 10*(1), 41-50. doi:10.1016/j.jairtraman.2003.10.009

Gordon, R. (1990). *The measurement of durable goods prices* (National bureau of economic research monograph). Chicago: University of Chicago Press. (1990). Retrieved April 15, 2020, from INSERT-MISSING-DATABASE-NAME.

Gössling, S., Fichert, F., & Forsyth, P. (2017). Subsidies in Aviation. *Sustainability*, *9*(8), 1295.

Graham, A. (2009). How important are commercial revenues to today's airports? *Journal of Air Transport Management, 15*(3), 106-111. doi:10.1016/j.jairtraman.2008.11.004

Hazledine, T. (2011). Legacy carriers fight back: Pricing and product differentiation in modern airline marketing. *Journal of Air Transport Management, 17*(2), 129-134. doi:10.1016/j.jairtraman.2010.10.008

Hummels, D. (2007). Transportation costs and international trade in the second era of globalization. *The Journal of Economic Perspectives, 21*(3), 131-154.

Hüschelrath, K., & Müller, K. (2012). Low Cost Carriers and the Evolution of the Domestic U.S. Airline Industry. *Competition and Regulation in Network Industries, 13*(2), 133-159.

Iata.org. (2019). *Fact Sheets*. [online] Available at: https://www.iata.org/pressroom/facts_figures/fact_sheets/Pages/index.aspx

Karna, A., & Sharma, S. (2008). Deregulation and Competition: Lessons from the Airline Industry. *Vikalpa: The Journal for Decision Makers, 33*(1), 148-150.

Kenneth, B. (2012). Low-cost airlines a failed business model? *Transportation Journal, 51*(2), 197-219.

Klophaus, R., Conrady, R., & Fichert, F. (2012). Low cost carriers going hybrid: evidence from europe. *Journal of Air Transport Management*, *23*, 54–58. https://doi.org/10.1016/j.jairtraman.2012.01.015

Knowles, R., 2006. Transport shaping space. Differential collapse in time–space. Journal of Transport Geography 14 (6), 407–425.

Kobie, N. (2019). *The wild logistics of Heathrow Airport will instantly devour its much-needed third runway*. [online] Wired.co.uk. Available at: https://www.wired.co.uk/article/heathrow-third-runway-plans-expansion [Accessed 7 Jan. 2019].

Lian, J. I., & Rønnevik, J. (2011). *Airport competition – Regional airports losing ground to main airports* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.jtrangeo.2009.12.004

Lieshout, R. (2012). Measuring the size of an airport's catchment area. *Journal of Transport Geography, 25*, 27-34.

Lieshout, R., Malighetti, P., Redondi, R., & Burghouwt, G. (2016). The competitive landscape of air transport in europe. *Journal of Transport Geography*, *50*, 68–82. https://doi.org/10.1016/j.jtrangeo.2015.06.001

Lin, E., Mak, B., & Wong, K. (2013). The business relationships between lccs and airports in southeast asia: Influences of power imbalance and mutual dependence. *Transportation Research Part A, 50,* 33-46. doi:10.1016/j.tra.2013.01.036

Lohmann, G., & Koo, T. (2013). The airline business model spectrum. *Journal of Air Transport Management, 31*, 7-9. doi:10.1016/j.jairtraman.2012.10.005

Longman /New York, N.Y. (2007). *Longman advanced american dictionary* ([New], 2nd ed.). Harlow: Pearson/Longman.

Luchtvaartnieuws. (2019). *Ryanair vanaf Schiphol ook naar Malaga*. [online] Available at: https://www.luchtvaartnieuws.nl/nieuws/categorie/ryanair-vanaf-schiphol-ook-naar-malaga

Malighetti, P., Paleari, S., & Redondi, R. (2008). Connectivity of the european airport network: "self-help hubbing" and business implications. *Journal of Air Transport Management, 14*(2), 53-65. doi:10.1016/j.jairtraman.2007.10.003

Marcucci, E., & Gatta, V. (2011). Regional airport choice: Consumer behaviour and policy implications. *Journal of Transport Geography, 19*(1), 70-84. doi:10.1016/j.jtrangeo.2009.10.001

Mason, K., & Morrison, W. (2009). Towards a means of consistently comparing airline business models with an application to the 'low cost' airline sector. *Research in Transportation Economics, 24*(1), 75-84. doi:10.1016/j.retrec.2009.01.006

Matisziw, T. C., Lee, C., & Grubesic, T. H. (2012). *An analysis of essential air service structure and performance* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.jairtraman.2011.05.002

McGee, J., Thomas, H., & Wilson, D. (2010). *Strategy: Analysis and practice* (2nd ed.). London: McGraw-Hill.

Miller, B. I., Dewey, J. F., Denslow, D., & Miller, E. B. (2016). *A welfare analysis of subsidies for airports* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.jairtraman.2015.10.006

Niewiadomski, P. (2017). *Global production networks in the passenger aviation industry* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.geoforum.2017.09.013

Núñez-Sánchez, R. (2015). Regional public support to airlines and airports: An unsolved puzzle. *Transportation Research Part E, 76*, 93-107. doi:10.1016/j.tre.2015.02.005

O'Kelly, M. E., & Bryan, D. L. (1998). *Hub location with flow economies of scale* doi:https://doi-org.proxy-ub.rug.nl/10.1016/S0191-2615(98)00021-6

Pan, J. Y., & Truong, D. (2018). *Passengers' intentions to use low-cost carriers: An extended theory of planned behavior model* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.jairtraman.2018.01.006

Perboli, G., Ghirardi, M., Gobbato, L., & Perfetti, F. (2015). Flights and their economic impact on the airport catchment area: An application to the italian tourist market. *Journal of Optimization Theory and Applications, 164*(3), 1109-1133. doi:10.1007/s10957-014-0613-8

Ramos-Pérez, D. (2016). State aid to airlines in Spain: An assessment of regional and local government support from 1996 to 2014. *Transport Policy, 49*, 137-147. doi:10.1016/j.tranpol.2016.05.004

Redondi, R., Malighetti, P., & Paleari, S. (2011). New routes and airport connectivity. *Networks and Spatial Economics : A Journal of Infrastructure Modeling and Computation,11*(4), 713-725. doi:10.1007/s11067-010-9131-x

SAS Irish subsidiary to begin flights in November. (2019). Retrieved from https://www.irishtimes.com/business/transport-and-tourism/sas-irish-subsidiary-to-begin-flights-in-november-1.2992398

Sellner, R., & Nagl, P. (2010). Air accessibility and growth - the economic effects of a capacity expansion at vienna international airport. *Journal of Air Transport Management, 16*(6), 325–329. doi: 10.1016/j.jairtraman.2010.04.003

Suau-Sanchez, P., & Voltes-Dorta, A. (2019). Drivers of airport scheduled traffic in European winter tourism areas: Infrastructure, accessibility, competition and catchment area. *Journal of Air Transport Management, 81* doi:10.1016/j.jairtraman.2019.101723

The Economist. (2019). *Ups and downs*. [online] Available at: https://www.economist.com/britain/2016/01/28/ups-and-downs

Up in the Sky. (2019). *Ryanair start Amsterdam-Dublin in oktober - Up in the Sky*. [online] Available at: https://www.upinthesky.nl/2015/09/03/ryanair-start-amsterdam-dublin-in-oktober/

Valido, J., Pilar Socorro, M., Hernández, A., & Betancor, O. (2014). *Air transport subsidies for resident passengers when carriers have market power* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.tre.2014.08.001

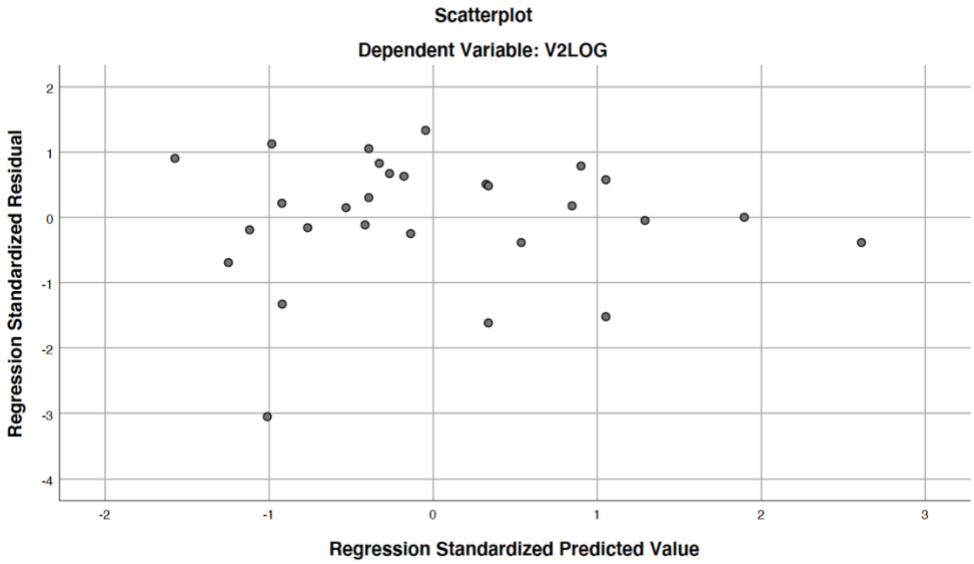
Wee, B., Annema, J., & Banister, D. (Eds.). (2013). *The transport system and transport policy: An introduction*. Cheltenham, UK: Edward Elgar.

de Wit, J. G., & Zuidberg, J. (2016). *Route churn: an analysis of low-cost carrier route continuity in Europe* doi:https://doi-org.proxy-ub.rug.nl/10.1016/j.jtrangeo.2015.04.003

Zuidberg, J. & Veldhuis, J. (2012). The role of regional airports in a future transportation system. Amsterdam: SEO Economisch Onderzoek.

Appendix

Appendix I: Scatterplot



Appendix II: Graph representing V2LOG (passenger numbers) and V3LOG (population numbers)