The seemingly extraordinary growth of Amsterdam Schiphol placed into perspective

A study on the growth of the Dutch hub airport in relation to the growth of competing European airports

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Abstract

This thesis addresses the growth of the Dutch hub airport Amsterdam Schiphol (AMS), by placing its growth figures into perspective of the European hub airport market. Firstly, the competitive features of the airport industry are studied by analysing the development it has gone through since the first airplane took off about 115 years ago. The same is hereafter done for the development of AMS in particular. After examining the factors influencing the growth of airports, this thesis concludes by running a regression analysis including the growth figures of ten European hubs and its growth variables, in order to determine how the growth of AMS relates to competing hubs. Based on the results, no evidence was found for the statement that the growth of AMS is extraordinary in relation to other European hub airports, let alone statements that this growth is *surprisingly* high. Overall, the growth of AMS suits a fast-growing industry in which it has been growing generally ever since its establishment, like its competing European hub airports. To maintain its leading hub function and to keep up with the expected growth of the overall market in the coming years, solutions should be found for the capacity- and legislation constraints the airport is currently facing.

Preface

This thesis concludes my bachelor programme in Economics and Business Economics, followed at the Erasmus School of Economics. It was meant to gain knowledge in the context of Amsterdam Schiphol's growth, a topic relevant both in terms of time and in terms of economic interest for The Netherlands.

Special thanks to my supervisor Peran van Reeven for helping me throughout the writing process.

Gijs van Koeveringe

Rotterdam, July 2017

Table of contents

List of abbreviations

ACI - Airport Council International

AdP - Aéroports de Paris

AMS - Amsterdam Schiphol

BRU - Brussels Airport (Zaventem)

CDG - Paris-Charles de Gaulle Airport

CPH - Copenhagen Airport

FAA - Federal Aviation Administration

FRA - Frankfurt Airport

HEL - Helsinki Airport

HSR - High-speed rail

IAG - International Consolidated Airlines Group S.A.

IATA - International Air Transport Association

ICAO - International Civil Aviation Organization

IST - Istanbul Atatürk Airport

KLM - KLM Royal Dutch Airlines (*De Koninklijke Nederlandse Luchtvaartmaatschappij*)

LHR - London Heathrow

MAD - Madrid Barajas Airport

MUC - Munich Airport

SVO - Sheremetyevo International Airport (Moscow)

ZRH - Zürich Airport

1. Introduction

The fast-growing Amsterdam Schiphol Airport contributes an estimated nine billion euros to the Dutch economy each year (Decisio, 2015). However, doubts are being raised about its continuous growth. The *Dutch Research Council for Safety* has already accordingly expressed its concerns regarding safety issues and legislation when Schiphol continues to grow (Schreuder, 2017). Amongst others, Duursma (2016) reports about the continuous growth of the Amsterdam Schiphol Airport and raises the question whether, and especially how, the Dutch hub airport can grow even further than it already does. Passengers have to deal with the consequences, facing long-lasting queues during busier travel days, leading to delays and even missed flights (Leijten, 2017). Amsterdam Schiphol is facing an important policy issue; if everything stays at it is, the airport's growth will be limited until at least the beginning of 2021 (Stil, 2017). The borders of growth have almost been reached, whereas competing airports are expected to keep growing instead. Pieters (2017) adds that the growth of the Amsterdam airport has been higher than expected and Duursma (2017) additionally reports of a 'surprising fast growth'. However, such statements raise the question whether the growth of Schiphol really has been that unexpectedly high, especially when compared to the growth of other important European airports. Therefore, the research question of this thesis is the following:

How does the growth of Amsterdam Schiphol over the years relate to the growth of other competing European airports?

To be able to answer the research question a literature review will be done first. Chapter 2 addresses the airport industry in general, to determine what the overall airport market looks like and how it has developed over the years. Furthermore, the different airport types are defined in this chapter as well, in order to see which type Schiphol Airport belongs to and which types can be considered as comparable later on. It does not make any sense to end up comparing the growth of, for example, a hub airport with a regional airport, possibly leading to the wrong inferences.

The second part of the literature review, chapter 3, focusses on Amsterdam Schiphol itself. How has the airport developed over the years and which relevant markets does it belong to? The answer to this question is of relevance to the data research. It only makes sense to collect data on the airports that operate and compete in the same markets as Schiphol.

Hereafter, the factors that influence the growth of airports in terms of passengers are discussed. This implies examining the factors influencing both the demand- and supply-side of

the airport industry. Those factors return in the data section where they make up the independent variables in the regression.

In order to be able to answer the research question chapter 5 consists of the data and methodology. With the help of the section about the different types of airports, data of ten European hub airports that compete in the same market as Amsterdam Schiphol are collected. The data especially consists of annual passenger numbers over the period 2000-2014 for each of the included airports in the dataset. These data are available on the websites of the different airports. Having collected the data, a panel regression analysis is conducted with annual passenger number being the dependent variable and the growth factors gathered in the last part of the literature study being the independent variables. The obtained results are used to conclude how the growth of Amsterdam Schiphol relates to the other European airports.

The thesis is concluded by the conclusion and discussion, in which both the central research question is answered and its implications are discussed, both in perspective of the European airport market and Amsterdam Schiphol's development over the years, which are addressed in chapter 2 and 3.

All in all, this thesis covers six chapters. After the introduction this thesis continues with chapter 2: *The airport industry*. The next chapter, chapter 3, is called *The competitive field of Amsterdam Schiphol Airport*, followed by chapter 4: *Factors influencing the growth of airports*. Chapter 5 and 6 are respectively named *Data and methodology* and *Results.* The thesis is concluded by chapter 7: *Conclusion and discussion.*

2. The airport industry

Airports have an essential function in the aviation industry, providing the necessary infrastructure to both passengers as well as cargo, and offering the possibility for airlines to depart and land. They offer a broad range of different facilities, ranging from air traffic control and security to commercial facilities, such as stores and hotels. Not only do they play an essential role in the aviation industry itself, they also contribute to the economies of the regions they cover, providing employment, wealth and stimulation of the tourism sector. In a study conducted by InterVISTAS (2015), prepared for the ACI, it was found that the European airport industry contributes 675 billion euros to the GDP of Europe (4.1 percent of its total), employing over 12 million people. How has the airport industry evolved over the years, becoming as important as it is nowadays?

2.1 Development of the industry

The industry has undergone massive changes since the first actual airplane departed for take-off, back in 1905. Until as long as the last decade of the 20th century, the airport industry was marked by government ownership. From Paris to Madrid, and from Bangkok to Johannesburg; almost every major city was served by an airport owned by the public sector. Usually the ownership was in hands of the national government, but there were also airports that were owned by the local government, as was the case with many regional airports in the UK. There were also quite some airports partly owned by both the national government and the local government. The latter applied to Amsterdam Schiphol Airport. The standard used to be public ownership, limiting the interference of the private sector.

When the aviation industry started to grow rapidly during the 70's and 80's of the 20th century, the first signs of commercialization appeared. A more business-driven approach was adopted in the management of airports, as the first steps towards airline deregulation were taken. The commercialization process was characterized by some coherent developments. Firstly, there was the introduction of independent airport authorities, taking over the airport operation from the national governments. In other cases, companies of which the state was just a minor shareholder, were established to carry responsibility for the airport operations. This led to more commercial freedom for the airports and even enabled the opportunity for private sector inference. Major airports got under long-term control by private authorities, in order to improve efficiency and integration with the local economy. Secondly, there was the shift in importance

from aeronautical revenues (landing and passengers fees) to non-aeronautical revenues (retail and other commercial activities). Airports became more than just the provider of landing and departing facilities for airlines and passengers, especially in Europe. As airports had to change their management approach due to the increasing competition in the airline industry, they were forced to adopt a more customer-focused business approach.

From the commercialization of the airport industry it was just a small step to privatization in the 1990s. According to Graham (2014) privatization of airports involves the transfer of management rights (and sometimes even ownership rights) from public hands to private ones. The biggest advantage of privatization was believed to be an increase in both efficiency as well as in competition. It was seen as the final step in the transformation of airports from public enterprises to commercial ones. According to a global study of the airport industry, conducted by the ICAO in 2008, nearly one out of four airports was partially or fully owned by private parties, which should be interpreted in the context that not long ago every airport was strictly in public hands (ICAO, 2008). The remaining airports are still under, although commercially managed, some extent of public control, including Amsterdam Schiphol.

As a result of privatization, internationalization of the airport industry could take place. In the late 1990's airport companies were actively seeking to expand their business, through investing in foreign airports. This resulted in the establishment of multi-airport companies. Schiphol Group is, for example, apart from owning and operating other Dutch airports also involved in foreign airports as Brisbane Airport and Aéroports de Paris (Airport Suppliers, 2016). Like in other business sectors, international mergers and acquisitions were believed to grow shareholder value and diversify risk, by not being dependent on individual economies anymore. The increasing number of mergers and acquisitions is known as the consolidation of the airport industry, more or less copied from the airline industry. Nevertheless, the incentive behind consolidation is different for the airport industry than for the airline industry. Whereas airlines can profit from obvious synergies of scope by expanding their operation market, airports do not seem to profit from these synergies of scope. The incentive for companies to invest in other airports and thus forming multi-airport companies lays more in increased profits through sharing knowledge, expertise and financial means (Graham, 2013). Another incentive for the consolidation in the airport industry is the potential creation of economies of scale. Cost advantages might be achieved through bulk buying, joint purchases, centralizing the operation departments and combined marketing. In terms of competition, multi-airport companies can have another advantage. If a company owns airports relatively close to each other it could lead

to reduced competition in that area. This implies potential mergers and acquisitions must be closely watched by the competition authorities.

Consolidation does not only consist of mergers and acquisitions, but also of the establishment of airport alliances, another force behind the internationalization of the airport industry. The development in the airline industry, consisting of increased competition and the establishment of global airline alliances, meant that the airport industry was facing more competition itself. Increased cooperation among airports through airport alliances was believed to be a suitable response. For instance, Schiphol Group and Freeport joined forces in an alliance called Pantares, in 2000 (Gillen *et al*., 2012). In 2008, Schiphol Group entered into another alliance, this time with Aéroports de Paris (AdP). Contrary to mergers and acquisitions, airports stay independent in the case of alliances. The cooperation is reflected in the coordination of strategies.

Another, more recent, development is the so-called sister agreements between airports, involving memoranda of understanding, meaning airports agree to share certain information or agree to work together on the development of new routes. Whether this development is sustainable is not clear yet (Graham, 2013).

Generally, the European aviation market grew by 80 percent between 1990 and 2014, in terms of number of flights. It is expected to grow even further between 2014 and 2035, by 45 percent (European Commission, 2016). Commercialisation, privatisation, internationalisation and consolidation have brought the industry to where it stands nowadays. What types of airports can be defined in this industry?

2.2 Different airport types

First of all, there is not a general categorization of airports. Different types can, for instance, range from rural airstrips, private airstrips, military airports, small community airports and regional community airports to regional airports, major city airports and hub airports (Fay *et al*., 2010). This is just an example of how types of airports can be classified. Among different countries and authorities different kinds of classifications are used.

In the United States, for example, the Federal Aviation Administration (FAA) bases its categories on the percentage of annual passenger numbers. This results in six different airport types; large, medium and small hubs, non-hub primary airports, non-primary commercial service airports and reliever airports. Hub airports are defined as airports being part of the hub-and-spoke system, in which the hub airports serve as the central airport surrounded in a system

by smaller airports. For the sake of efficiency, passengers travelling from the one relatively small airport to the other are directed via the hub. That is why hub airports are generally the bigger airports, serving many passengers travelling to and from the different smaller airports in the system. According to the FAA, hubs serve between 0.05 and 1 percent of the total annual passengers. The smaller hub airports are divided into non-hub primary (more than 10 000 passengers, but not enough to qualify for a hub), non-primary commercial service airports (between 2500 and 10 000 annual passengers) and reliever airports (also called spillover airports). The latter category of airports is meant to relieve capacity from primary airports that are located near them. This is the case for the Dutch Lelystad Airport, which functions as a reliever airport to Amsterdam Schiphol.

In Europe, different classifications are used. The European Union categorizes airports into different types based on the number of annual passengers. Four different types are distinguished: large community airports, national airports, large regional airports and small regional airports. These serve respectively more than 10 million, between 5 and 10 million, between 1 and 5 million and less than 1 million passengers a year. Although this categorization is different from the one used by the FAA, they are not as different as it seems. Both are based on the number of annual passengers, which means a large community airport can be compared to a hub, a national airport to a non-hub primary airport, a large regional airport to a non-primary commercial service airport and a small regional airport can be compared to a reliever airport.

Overlooking the classifications used in scientific literature, also four types of airports can be distinguished. These types consist of primary, secondary, tertiary and quartiary airports (Sterzenbach, Conrady & Fichert, 2009). Primary airports are airports serving a hub function and therefore handling a relatively large number of transfer passengers. Examples are London Heathrow, Frankfurt Airport and Amsterdam Schiphol. Secondary airports are not hubs, but they are connected to them and still serve a relatively large number of passengers. Examples of secondary airports are found in Milan and Glasgow. Tertiary airports are all the airports that do not belong to the first two categories, but that still have international services and services to hub airports. Examples are the German airports in Hannover and Bremen. The final category, quartiary airports, consists of the smaller regional or military airports, often used by low-cost carriers.

It can be concluded that many different classifications for airport types are used across the world. Overall, the biggest airports are classified as hubs or primary airports with a hub function, serving a relatively large number of transfer passengers. Among these hubs is Amsterdam Schiphol. It served 64 million passengers in 2016, of which nearly 40 percent consists

of transfer passengers, making it a hub airport according to the different conditions mentioned above. According to Rodríquez-Deniz *et al.* (2013) a hub is characterized by two dimensions: traffic generation and connectivity. The connectivity dimension means the hub airport connects two minor airports by serving a significant number of transfer passengers. The generation dimension refers to the large local market a hub relies on. A hub airport consolidates originating and transfer passenger flows and accommodates hub-and-spoke operations. For a great part they rely on the operations of the network carriers which are active in the hub-and-spoke network. The latter is further discussed in 2.4 of this thesis.

2.3 Europe's major hub airports

As defined in the introduction, this research is limited to European airports of the same type as Amsterdam Schiphol. In the previous paragraph it was discussed that Schiphol can be classified as a hub airport. The other hub airports completing the sample selection will be based both on the hubs in the competitive field of Amsterdam Schiphol and former studies involving the main European airports. Several studies have been conducted in which the, according to the particular researcher, main European hub airports were involved. Lenoir (2016) conducted a study in the name of The European Parliament in which the main European hub airports were investigated. According to her the ten main hub airports inside the European Union are Amsterdam Schiphol, Barcelona Airport, Frankfurt Airport, London-Gatwick, London-Heathrow, Madrid Barajas, Munich Airport, Paris-de-Gaulle, Paris-Orly and Rome Airport. In a study by Van Herck *et al.* (2004) the nine main European airports were identified as Amsterdam, Athens (Hellinikon), Brussels (Zaventem), London Heathrow, Madrid Barajas, Milan (Malpensa), Munich (MUC), Stockholm (Arlanda International) and Zurich (Unique). Barrett (2004) determined twelve main European hub airports, among which are the airports of London Heathrow, Glasgow, Manchester, Brussels, Stockholm, Oslo, Venice, Milan, Frankfurt, Hamburg, Rome and Paris (CDG). Research done by Dennis (2005) also involved the main European hubs. According to this study these are London Heathrow, London Gatwick, Paris CDG, Amsterdam, Frankfurt, Munich, Zurich, Milan Malpensa, Rome Fiumicino, Madrid, Brussels, Copenhagen and Vienna.

Which of those airports are included in the competitive field of Amsterdam Schiphol is examined in the next chapter.

2.4 Airport competition

To further examine the airport industry, the competition in the industry is addressed. Airports compete at different levels, as there exists competition between airports, competition within airport groups and competition inside airports. For the sake of the research topic, only the competition between airports will be considered.

Until not long ago airports were believed to be monopolies, having significant market power. However, due to the increased commercialization and privatization of the airport industry, discussed in chapter 2, the competitiveness of airports has increased enormously. They do not only compete for passengers, but also for freight and airlines. The competitiveness in the industry can be examined based on Michael E. Porter's five forces: the bargaining power of buyers, the threat of substitute products or services, the bargaining power of suppliers, the threat of new entrants and the competitive rivalry (Porter, 2008).

The competitive rivalry in the industry is often the biggest indicator of the extent of competitiveness. Obviously, the rivalry between existing airports depends on the location. If an airport is located on a remote piece of land or even an island, it will not have to fear much rivalry from other airports. The competition is potentially much fiercer in cases where airports' catchment areas overlap. This typically is the case for many European airports. Such type of competition may be overcome by common ownership (Graham, 2013). The latter occurs not only in Paris, where Aéroports de Paris owns three local airports, but also in the Netherlands; Schiphol Group is, apart from Amsterdam Schiphol, owner of Rotterdam The Hague Airport and Lelystad Airport and has a controlling interest in Eindhoven Airport (Schiphol Group, 2017). This so-called common ownership potentially removes the incentive for fierce competition.

The competitive strength of a hub airport depends for a great part on the operations and strength of the airlines operating from the airport. Hub airport growth is heavily associated with the operations of so-called hub carriers. During the economic crisis of 2008 for example, many airlines rescheduled their operations, leading to more focus on operations at hub airports, rather than operations at point-to-point airports. Especially the constitution of larger airline alliances operating from hub airports has increased the competitive strength of those hub airports (Belobaba, 2015). An example of this is the alliance between Northwest and KLM towards the end of the 20th century, leading to significant growth of Amsterdam Schiphol due to the resulting increase in flights between Amsterdam Schiphol and hub airports in the United States. Cur-

rently there are three main airline alliances active in the European hub market; Oneworld (operating from London Heathrow and Madrid), SkyTeam (operating from Paris CDG and Amsterdam Schiphol) and Star Alliance (operating from Frankfurt and Munich). Those alliances contain the biggest airlines in Europe, as displayed in table 2.1 below.

	Airline (group)	Passengers 01-2017[1]	Alliance	Main hub(s)
1	Ryanair*	8.77	-	-
2	Lufthansa Group	7.87	Star Alliance	FRA
3	International Airlines Group	6.69	Oneworld	LHR, MAD
4	Air France-KLM	6.85	SkyTeam	CDG, AMS
5	easyJet*	4.75	-	-

*Table 2.1: the largest airlines in Europe and their matching passenger numbers over January 2017, including the airline alliance they belong to and the main hubs they operate from. * = a point-to-point carrier rather than a hub carrier. International Airlines Group includes Iberia and British Airlines.*

A recent phenomenon in the airport industry is the emergence of low-cost airports, forming a new discipline of competition for hub airports. With the increase in market share of low-cost airlines flying from low-cost airports, came a decrease in market share for the main airports. This occurred in Milan for example, where the competition of low-cost airport Bergamo led to a reduction of nearly twenty percent in the total market share of major airports Milan Linate and Malpensa (Graham, 2013). These low-cost airports rely upon operational efficiency and a minimal amount of additional services (de Neufville, 2007). They are smaller than the main airports, often have fewer delays, more flexible pricing and the aircrafts are closer to the terminals; reasons for people to choose a low-cost airport over a hub. However, whereas hub airports are often closer located to their *host cities*, these low-cost airports are often situated further from these cities.

[1] In millions, retrieved from: http://www.worldatlas.com/articles/which-are-the-largest-airlines-in-europe.html (June 6, 2017)

Then there is the bargaining power of the suppliers. Concerning the suppliers, the airport *product* should be considered as consisting of the commercial facilities, ground handling, security and air traffic control (Graham, 2004). The bargaining power of the suppliers very much depends on the extent to which they are restricted by regulatory policies, as these policies can prescribe a required type of security, and whether the airport provides the service by its own. Sometimes the suppliers even charge the airline directly for their services. So generally one can say that the power of suppliers very much depends on the individual situation, but that this power can be highly limited.

Concerning the bargaining power of buyers, Graham (2014) states that the extent of competition is the lowest for hub airports that provide both long- as well as short-range flights, which to a considerable extent applies to Amsterdam Schiphol. Such a combination is attractive for the established airlines that offer regular flights both for shorter and longer routes and makes it difficult for smaller surrounding airports to offer significant competition. Airports are anyway very much dependent on the strategies of the airlines. It is therefore that the consolidation of the airline industry through forming alliances and joint ventures has its impact on the airport industry, discussed earlier on. Airlines concentrate more at certain hub airports, so that it gets harder for other airports to attract these airlines in order to compete with the hubs. Airport concentration is found to be the most important source of market power for airlines (Bilotkach & Lakew, 2014). Their power increases once they unite through alliances, which on the one hand can stimulate the airport's growth, but on the other hand, offers leverage for the airline alliance. However, it should be noted that the extent of the leverage depends on whether the carriers can easily switch to another competing airport.

Considering the buyer power in terms of passengers, one can say this seems to be ambiguous. Usually the passenger traveling inside Europe knows its specific origin and destination beforehand. However, this can be different for intercontinental traffic. For example, for a person travelling from Asia for a visit to Europe it might not matter if he arrives in Paris, Amsterdam or London at first. Hubs in these cities compete for these kind of intercontinental passengers.

Concerning the threat of new entrants, this threat is often negligible. The airport industry is known for its high entry barriers due to, firstly, the significant sunk costs that entrants face. These sunk costs are formed by the required investments in runways, towers and ground facilities (Bailey & Panzar, 1981). Another significant cost the entrant has to make consists of the lasting regulative process it has to undergo prior to its entry. High entry barriers are also caused by the economies of scale that are found to be significant in the industry (Martín & Voltes-

Dorta, 2008). These economies of scale seem to be limited though. According to Jeong (2005) there are increasing returns to scale up to 2.5 million annual passengers. This means that new entrants, having a lower output than incumbents, will have a hard time to compete, because they will face higher average costs than the incumbent airports that do benefit from the economies of scale. On top of that, it is often hard to find an appropriate location for a new airport, not only in terms of space but also in terms of connectivity with other types of transport.

Finally, the threat of substitute products or services should be assessed. This threat is not significant for the airport industry. Substitute services for aviation consist of other types of transport. Nowadays, if there is a threat, it comes from high-speed rail (HSR), which are a fast and convenient manner of covering larger distances. However, their scope is limited and it is hard to cover intercontinental distances with this mode of transport. Considering the threat for AMS in particular, it might come from High-Speed Line South, connecting Amsterdam, Brussels and Paris. However, the net effect of its introduction still has to be examined further to draw any conclusions (Bilotkach & Mueller, 2012). Substitutes are further assessed in chapter 4.1 of this thesis.

All in all, whereas the threat of entry and the threat of substitutes is generally low, the competitive rivalry in the industry and the power of the buyers can make the airport industry quite competitive. How does this apply to the specific case of Amsterdam Schiphol?

3. The competitive field of Amsterdam Schiphol Airport

In 1916 Amsterdam Schiphol Airport was established. From an average of ten passengers a day in the 1920s, the airport has evolved to a hub airport serving almost 64 million passengers in 2016, operating a 420 million euros profit (Schiphol Group, 2016).

3.1 The early days

It was only until the beginning of the 1930's that Schiphol began to be part of the leading air transport network in Europe. Following the airports in London, Paris and Vienna, Schiphol quickly secured a place amongst the busiest European airports. And it did not quite sit back, as the Dutch airport surpassed Vienna in terms of annual international flights already by the end of the 1930s. Meanwhile it served an average number of hundred passengers a day, which was a significant increase compared to the 10 passengers a decade before, but not yet a trigger for large private investments in the airport industry. Governmental subsidies provided by the municipality of Amsterdam paved the way to a modernized Schiphol Airport. The progress was however suspended by the emerging World War II.

Overseeing the consequences of the war, it could be concluded that Schiphol could just about start all over again. Most of the airport's infrastructure had been destroyed. The recovery of the airport was nevertheless prodigious. By the end of 1945 airplanes could land on and depart from Schiphol again. It was in the same year that the Dutch government followed the advice from a special commission, stressing that Schiphol should become the main (international) airport in The Netherlands. Meanwhile, the airport industry was developing itself quickly, thanks to the increase in demand for air transport and the technological progress. The growth resulted in an adopted plan for expansion of Schiphol Airport: *Plan voor Uitbreiding van de Luchthaven Schiphol*. Schiphol would grow to such an extent, such that it was not only valuable to Amsterdam anymore, but to the Dutch nation as a whole.

By the end of the 1960's it was not only about providing the right infrastructure anymore; passengers started to expect more from airports. This meant the start for the employment of commercial activities as catering, hotel bookings and car rentals, as discussed in the previous chapter. What caught the eye the most was the emergence of tax-free shopping. Airports slowly began to look like what they are nowadays. Meanwhile, Schiphol Airport became one of the fastest growing airports in Western Europe, with an eleven percent increase in traffic from 1966 to 1968, supplying almost 77 000 flights in 1967. For the policy makers it was yet unknown

how the growth of the airport would develop in the coming years. It had not been foreseen that the airport would grow as fast as it did in the previous years. What was clear, was that Schiphol hugely needed expansion of its capacity in order to cover the fast-growing demand once again. In the end, predictions were that air traffic from and to Schiphol would continue to grow by ten percent each year till the middle of the 1970s, after which the growth would slightly decrease to seven percent each year. Plans had to be made in order to overcome capacity shortage. To cover the expected growth of the airport, an investment of 370 million Dutch guilders was required.

As from 1969, Schiphol managed to be a profitable business. Plans for expansion were continued, but were held back when Schiphol had to deal with strongly increasing oil prices, due to the oil crisis in 1973. This crisis had its effect on the total market, leading to a recession in the aviation industry. Doubts were raised on whether to continue the execution of the expansion plans for Schiphol, as the airport's profits vanished. To cover the imminent losses, the dock charges that had to be paid by the airlines were increased. When these charges reached a level comparable to that of competing airports, Schiphol was forced to seek other sources of income. As a result, attention was shifted to marketing means. Schiphol positioned itself as a worthy intercontinental transfer-alternative to the airports in London, marking the first steps in the process of becoming a hub airport. Those tactics paid off: it was in 1978 that Schiphol served more foreign than domestic passengers for the first time, respectively 55 and 45 percent. This motivated the policy makers to further enhance the foreign marketing, attracting more foreign transfer passengers. It marked the start of an ongoing development: revenues from transfer passengers increased over the years, demonstrating Schiphol's growing status as a hub airport. Tax-free sales increased at the same time, enabling a discontinuation of the increasing dock charges for the airlines, so that a policy focused on revenues mainly from dock charges was replaced by a broader, more commercially focused policy.

In 1980, however, a decrease in passenger numbers had to be dealt with, causing scepticism about the growth of the airport. Especially the European charter flights, which made up a relatively large part of the total flights from and to Schiphol, were confronted with a large fall (20 percent) in passenger numbers. However, a report on the economic value of Schiphol Airport (*De Economische Betekenis van Schiphol*) once again stressed the importance of the airport for not only Amsterdam, but also for the country: Schiphol managed a share of one percent in the total national income. This convinced stakeholders to trust the potential of the airport, backed by the conclusion of the report that companies should be given room to establish their offices in the Schiphol-area, to further amplify the airport's economic position. This led to the

fact that the temporary relapse in passenger numbers was barely observable in the financial reports. Confidence in the airport was quickly rebuilt by recovering passenger numbers throughout the 1980s and a new investment plan was set up: a total of 1.4 billion Dutch guilders was going to be invested throughout the period until 1995. Responding to the liberalization process of the European aviation industry, the main concern of the airport was not merely flying anymore, but was far more commercially orientated.

Throughout the 20th century questions kept being raised about how to manage the growth of Schiphol. It was not always clear whether a densely populated country like The Netherlands could host such a fast-growing airport. There have always been discussions on either moving Schiphol to another location, or building a completely new airport. Recurring factors in those discussions are the social costs, consisting of the noise disturbance caused by planes and the harm done to the environment. These factors have always had to be taken into account when plans regarding expansion of the airport were to be made. In the last decade of the 20th century the government policy was focused on the support of the *mainport function* of Schiphol. A *mainport* is a concept invented by the Dutch government to describe that Schiphol is much more than just an airport supplying a worldwide aviation network. It operates as a junction of reinforcing companies and activities. The *mainport* Schiphol connects The Netherlands with important economic, political and cultural centres in Europe and the rest of the world, making it a driving force for the Dutch economy and its employment opportunities and functioning as primary hub airport for network carrier KLM (Rijksoverheid, 2013).

In line with its development to becoming a so-called *mainport,* Schiphol realized a spectacular growth in the last decade of the 20th century; from 16.3 million passengers in 1990 to 36.4 million in 1999 (CBS, 2016). Entering the 21st century, Schiphol continued to grow even further. Only during the economic crisis, between 2007 and 2009, a significant loss in passenger numbers occurred (CBS, 2016). In 2000, the airport served slightly more than 39 million passengers, whereas in 2016 this number was increased with almost two third, to 63.6 million (Leijten, 2017). Recent studies reflect the economic contribution of Amsterdam Schiphol to the Dutch economy, contributing approximately nine billion euros to its gross domestic product and 114 000 jobs either directly or indirectly related to the hub airport (Decisio, 2015). Schiphol's centurial anniversary in 2016 was therefore celebrated with the fact that, even after 100 years of existence, the airport is ever fast-growing, expressing its status of a leading hub airport. Pieters (2017) and Duursma (2017) even claim the growth to be 'surprisingly' and 'unexpectedly' high. The airport managed a new record with the handling of an estimated 230 000 passengers in just one day, at July 31st 2017 (Financieel Dagblad, 2017).

However, this continuous growth has downsides as well. Long-lasting queues during periods of high demand have been a problem over the recent years, leading to hundreds of passengers missing their flights. According to René de Groot, Chief Operating Officer at KLM, those missed flights are due to ineffective policy of the airport, having neglected to invest in the right infrastructure to manage the growth of passengers (Volkskrant, 2017). It is claimed that KLM has incurred losses of millions of euros due to those missed flights. The airport now tries to overcome the long waits by introducing a new departure hall which, however, only offers temporary release (Duursma, 2017). According to a report issued by the ACI it is essential for Amsterdam Schiphol to keep investing in a sustainable long-term growth to maintain its important function as hub airport (ACI, 2016).

The long queues are due to current capacity limits, but there is another factor that seems to restrain the future airport's growth: legislation. The airport agreed upon a 500 000 annual limit of take-offs and departures, for environmental reasons and maximization of noise disturbance for the neighbourhood (Stil, 2016). Due to the continuous growth, this limit has almost been reached and further growth potentials are constrained until at least 2020. Furthermore, the *Dutch Research Council for Safety* issued a report in which it expressed its concerns for safety issues when the growth of the airport continues. According to the institution the borders for a safe handling of all the flight traffic are about to be crossed if the current growth rates are maintained in the coming years (Schreuder, 2017). The factors (possibly) influencing Schiphol's growth are further examined in chapter 4.

3.2 Schiphol's relevant markets

In order to be able to determine economic factors that influence Schiphol's market power (and thus the factors that influence its growth) and subsequently comparing the growth of Schiphol with the growth of other airports active in the same markets, the relevant markets Schiphol competes are defined first. The relevant markets will be defined according to the conditions used by Polk and Bilotkach (2013) in their study on the market power of hub airports. In order to derive the relevant markets for Schiphol it is important to address the presence of Schiphol in both an upstream and a downstream market. As for the upstream market, Schiphol has the role of a supplier to the airlines. It offers them services with respect to infrastructure. Besides that, it often serves the end-user directly as well, by offering parking facilities, such as Schiphol does with Smart Parking. In terms of the downstream market, airports are confronted with derived demand, meaning demand for airport capacity comes from the airlines, but this demand

is created directly by the end-user (the passenger). Taking this into account, the first thing to consider when defining a relevant market is that it consists of both a demand- and supply-side definition. This implies both the substitute products for consumers, as well as the substitute sources of supply should be taken into account (King, 2001). Supply-side substitution however does barely play a role in the airport industry, as can be derived from chapter 2. Supply-side substitution only plays a role when the threat of a new entrant is feasible at the moment the incumbent firm raises its price. Concerning the airport industry, a potential entrant should be able to enter the market quickly after an incumbent raised its price. Taking into account that entry barriers in the airport industry are high, as the large investment costs an airport has to deal with when it enters the market, this is highly unlikely to happen. Therefore, just demand-side substitution will be taken into account in the process.

According to King (2011) defining a relevant market consists of four elements: a product, functional, geographic and temporal element. Considering the product element, this consists of the ability of firms to respond to price changes or differences, or in economic terms: the cross-price elasticity. This reflects the responsiveness of demand for the one good, after a change in the price of the other, related good. When the cross-price elasticity is high, the particular goods can be regarded to be present in the same market. As for the temporal market, the focus lays rather on the long term. Instead of looking at the responsiveness of products to price changes of other products in the short term, this element is about the long term. The geographic element is about the geographic area in which the end-user considers products to be interchangeable. Another word for the geographic market of an airport is the airport's catchment area. The geographic market is assessed by the European Commission in a two-step approach. At first, a starting point for the catchment area is defined by *circling* an area surrounding the airport. According to Bilotkach and Mueller (2012) this is done as follows: the catchment area for O&D-passengers consists of locations from which Amsterdam Schiphol can be reached in about two hours, whereas the catchment area for transfer passengers, in case of a large hub, is larger. The European Commission defines the catchment area for European hubs to consist of all the other European hubs that can be reached within two hours by plane. The second step includes a competitive assessment of the airports involved in the catchment area. This two-step approach is used in the remaining of this chapter.

In case the catchment areas of two (or more) different airports overlap, the airports concerned could be substitutable to some extent. In such case, when at the same time the concerned airports offer comparable services to passengers, a significant price increase by X will lead to an increase in demand for airport Y. The bigger this correlation, the higher the substitutability.

According to Bilotkach and Mueller (2012) this depends on the extent to which the services offered by the airlines to the end-customers are comparable. Theoretically, a catchment area consisting of mainly transfer passengers and a catchment area consisting of mainly origin-and-destination (O&D) passengers overlapping, does not always have to mean the two airports concerned are substitutable. A so-called ‘natural experiment' in 2008 with the increase in ticket prices for O&D-passengers at Schiphol has after all demonstrated that the market for transfer passengers on the one hand and the market for O&D-passengers on the other hand are two separate ones (Gordijn & Kolkman, 2011). This division is also in line with the pricing being used by Amsterdam Schiphol, as it charges airlines that use Schiphol as a transfer airport differently than the airlines using Schiphol as a point-to-point airport. Another reason for the difference between the two is the difference in price elasticity of demand. Passengers using Schiphol for their hub-function and thus being classified as transfer passengers, are more likely to switch to another airport than O&D-passengers which are far less likely to regard other airports as alternatives for Schiphol. This is reflected in the fact that the catchment area for transfer passengers is larger than the catchment are for O&D-passengers. This makes Schiphol able to charge higher fees for O&D-passengers than for transfer passengers. Considering the above, this research will stick to the division between the market for transfer passengers and the market for O&D-passengers. As the main point of interest of this research concerns hub airports, and thus transfer passengers, only the market for transfer passengers is taken into account in the process.

The functional market relates to the competition coming from other products serving the same function as the product that is being studied. In case of Amsterdam Schiphol, the relevant functional market consists of the market for transport. For the sake of the research question, that only considers comparisons between Schiphol and other airports, only the product and geographical market will be taken into account. This is also done by Müller *et al.* (2010), in their enquiry into the economic market power of Amsterdam Airport Schiphol, commissioned by the Netherlands Competition Authority.

3.3 Schiphol’s catchment area for transfer passengers

Concerning the transfer passengers, Schiphol acts in its capacity of a hub airport in the hub-and-spoke model. Being a hub airport, transfer passengers make up a significant part of the total number of passengers at Schiphol; an estimated 40 to 45 percent of the passengers use the

airport as transfer airport. Schiphol is a popular airport used for transfer purposes, relying heavily on the transfer operations offered by hub carrier KLM. As the study on the competitive market of Schiphol for transfer passengers by Burghouwt *et al.* (2008) shows, the main hub markets for Schiphol are those between North-America and Europe, Asia/Pacific and Europe and the hub market within Europe. According to information from both Schiphol and KLM the main competition from other European hubs comes from Frankfurt (FRA), Paris Charles de Gaulle (CDG) and London Heathrow (LHR). Other European hubs Schiphol faces competition from are Munich Airport (MUC) and Copenhagen Airport (CPH), both in the intra-European market, Helsinki Airport (HEL, in the market covering routes between Europe and Asia) and Madrid Barajas Airport (MAD, between Europa and Latin-America).

Seredynski (2016) also conducted a study involving the competition for transfer passengers. From this study, it can be concluded that Schiphol faces competition to at least some extent from not only FRA, CDG, CPH, LHR, HEL, and MUC, but also from the airport of Zürich (ZRH), of which the latter one has also already been mentioned in the paragraph about the main European hubs (chapter 2).

4. Factors influencing the growth of airports

This chapter examines the factors which are believed to influence the growth of airports, in terms of passenger numbers.

4.1 Substitution and price elasticity

Consumer demand is heavily related to price elasticity. The price elasticity on its turn depends on the number of substitutes of the good a consumer can choose from. In particular, when the number of substitutes is relatively low or non-existent, the price elasticity of demand for the good will be low (or even inelastic); a change in the price will not lead to a relatively big change in demand. Whereas equivalently, when there are relatively many substitutes available, the price elasticity of demand will be high; a change in the price of the good will lead to a relatively big change in demand of the particular good. Brons *et al.* (2002) determine different modes of substitutes in the airport industry.

First of all, there is intra-modal substitution, meaning the consumer may be willing to choose from multiple airlines and thus from different airports. As long as those airlines operate at the same airport, this will not affect the passenger numbers of the airport. In the case where the choice set of airlines consist of airlines operating from different airports however, the situation could change. In such case, choosing from different airlines will implicate choosing from different airports. Besides, the extent of substitutability is also determined by the extent to which the different goods, the airlines (or airports), are homogeneous to each other. On the one hand, the more the offered quality differs between alternatives, the less substitutability there will be. On the other hand, in a situation where the goods tend to be homogeneous, a situation of perfect competition will arise, leading to high elasticity of demand.

Secondly, substitutability may come from other modes of transport. How relevant substitutability from other transport modes is, depends mostly on geographic factors. In mountainous areas for example, the availability of other transport modes will be low. All in all, this threat tends to be low, as was discussed in chapter 2.4.

Thirdly, substitutability in terms of destinations can occur. Brons *et al.* (2012) explain this based on the utility functions of rational consumers. The user will make its decision based on its belief of which destination will yield the highest overall utility. The specific characteristics, one of them being the price, of the possible destinations in the choice set contribute to the overall utility. An increase in price for one of the destinations means this particular destination

yield less utility. Based on whether the individual characteristics of this destination can be substituted by another destination, the user may choose another destination that yields a higher utility according to its own belief. According to Heyns *et al.* (2011) the other features of an airport that contribute to the overall utility are the following: on-time arrival/departure, frequency of service, seat availability, departure time, time to/from the airport, ease of access, ease of check-in, airport safety, parking security, cost of parking and the cost of transport to the airport.

4.2 Economic drivers of demand

Several studies have found that there is a relationship between demand for air transport and income. In case of price increases, one would initially expect that due to decreasing marginal utility the loss in utility would be lower for the ones with a higher disposable income. Therefore, the price elasticity would be lower for this group of consumers. However, studies such as the one by Mutti and Murai (1977) have demonstrated that consumers with higher disposables incomes are associated with a higher demand for air transport. So notwithstanding decreasing marginal utility, the utility losses for consumers with higher incomes will be larger than for the ones with lower incomes in case of a price increase. Especially the demand for long-distance flights increases when the disposable income of a consumer increases. On the contrary, demand is found to be low (or even non-existent) at low levels of disposable income. Equivalently, a study conducted by BCG (2005) demonstrated that there is a strong positive relationship between the growth of GDP and the growth of demand for air travel. The study found a common demand growth rate of between 1.5 and 2 times the GDP growth. Rising GDP, which improves the overall living standards, as a driver of demand is one of the economic factors related to the so-called underlying demand growth: growth occurring at the current real-price levels. Amongst those other economic factors are rising populations, increases in trade and changes in taste. The latter one is a result of changes in consumer choices, discussed in the previous paragraph. Increasing populations is a demographic factor that is believed to be related to air travel growth. Especially for demographic groups of which the working population rises a strong relationship with growth in demand for air travel is observed, as the working population tends to travel more on average (IATA, 2015).

There is another factor which has to be accounted for: the induced demand growth, which reflects the difference between the observed demand growth and the underlying demand growth. The induced demand growth represents the demand for seats in cases of excess capacity

on flights. Airlines generally prefer to fill their planes against the cost of lower prices, rather than to keep empty seats. The study of BCG found that prices would have to decrease by 1.4 per cent to fill every one percent of excess seats, based on data collected throughout the 1990s on routes between Europe and Asia, North America and Europe and Asia and North America. Mason (2005) found in his study on air travel demand that prices are a significant driving factor of demand growth, having observed the growing emergence of low-cost airlines leading to a higher demand for leisure air travel. Graham (2006) even suggests that it is not income changes that are the major driving factor behind demand growth for air travel, but that this is rather price changes that cause shifts in demand. The academic literature has not quite reached consensus on this (Wang & Song, 2010). Njegovan (2006) concluded in his studies that demand for air travel is relatively inelastic solely with respect to air travel prices.

4.3 Other factors that influence the growth

According to the so-called PESTEL-framework, which assesses the relevant political, economic, social, technological, environmental and legal factors that influence air travel, other factors that influence the growth of the industry can be defined (Cederholm, 2014). The economic and social factors have already been discussed above, but are just one of the other relevant factors.

4.3.1 Political factors

Issues like war, terrorist attacks and outbreaks of deadly diseases are political factors that potentially have their effects on the air travel industry. Well-known examples include oil crises, discussed in chapter 3. A more recent and illustrating example are the terrorist attacks of September 11, 2001. Figures from the IATA (2015) show that the attacks affected the whole of the global aviation industry and led to an overall industry loss of thirteen billion dollars in 2001. The industry did not manage to overcome these effects until five years after, in 2006, when the global industry finally reported profits after having had to deal with four years of reported losses.

4.3.2 Legal factors

A significant factor in the growth of air travel demand has been the deregulation of the industry, discussed in chapter 2. Studies have shown that in the period that the process of deregulation was in process at the fullest, towards the end of the 1970s, air fares started to fall (Goetz & Vowles 2009). Studies based on US air fares even showed that prices have dropped by 50 percent in 30 years since 1978, when the US Deregulation Act came into force (Thompson 2013).

4.3.3 The role of technology

The role of technology has its effect mainly on the supply factors in the aviation industry. New technology, when adopted by the airlines, can reduce fuel costs significantly. Currently progress is being made on the development of a new system engine that could reduce fuel use by sixteen percent, meaning an average saving of about 1.7 million dollars per plane on an annual base (Grose, 2013).

4.3.4 Environmental factors

Environmental awareness is growing across the aviation industry nowadays. Environmental factors can include gaps on the emission of CO2, which stimulated airlines to seek for alternative fuels. According to Cederholm (2014) these alternative fuels can reduce the emission of CO2 by 80 percent. This will influence the cost structure for the supply side on the longer term.

4.4 Concluding remarks on growth factors

The factors discussed in the first part of this chapter are captured by relatively easily retrievable economic data. The effect of increasing populations on passenger numbers can be measured based on population figures of each of the countries hosting the relevant airports, over the years 2000-2014. The effect of GDP on passenger numbers can be measured based on annual GDP figures, and subsequently the annual GDP/capita figures. Other factors discussed in this chapter are less easily captured by systematic data. As much as possible, those effects will be included in the fixed effects. Concerning the substitutability alternatives discussed in 4.1, those are not explicitly included in the regression. As this particular research only considers European hubs, those alternatives are assumed not to differ too much among the included airports in the dataset. More on this is discussed in the next chapter, *Data and methodology*.

5. Data and methodology

5.1 Hypothesis

The growth of Amsterdam Schiphol will be quantitatively addressed by running a panel regression analysis. In chapter 4 it has been discussed that Amsterdam Schiphol has generally been growing ever since its establishment, such that capacity constraints, next to legislation and safety demands, now seem to limit further growth potentials. Accordingly, it is claimed that the growth has been 'unexpectedly' and 'surprisingly' high. Such statements raise the question whether the growth of Schiphol really has been that unexpectedly high, especially when compared to the growth of other European hub airports. Therefore, the hypothesis that will be tested is the following:

Hypothesis: Amsterdam Schiphol grows faster than other European hub airports[2]

5.2 Data

The research consists of panel data (or longitudinal data), as the dataset contains multiple observations of multiple airports, observed over different years (over the period 2000-2014). In particular the data consists of a balanced panel, since each variable is observed for the same amount of time. Panel data controls for factors that differ across the different entities, but do not differ over time, for factors that cause omitted variable bias if they are not included in the model and for factors which are unobserved or unmeasured (Stock & Watson, 2015).

To perform the panel data regression, data on the relevant airports and growth factors is collected based on the previous theoretical chapters. In chapter 2.2 it has been discussed that Amsterdam Schiphol can be classified as a hub airport. In 2.3 it has been discussed which hub airports have been taken into account in other studies involving European hub airports. Hereafter, in chapter 3.2.1, the relevant competitive hub airports for Schiphol have been discussed. Based on these chapters the following airports make up the dataset of this thesis:

- Amsterdam Schiphol (AMS)
- Brussels Zaventem (BRU)

[2] growth is defined in terms of change in annual passenger numbers

- Copenhagen (CPH)
- Frankfurt (FRA)
- Helsinki (HEL)
- London Heathrow (LHR)
- Madrid Barajas (MAD)
- Munich (MUC)
- Paris Charles de Gaulle (CDG)
- Zürich (ZRH)

The matching passenger numbers, displayed in table 5.1 below, have been retrieved from the particular airport websites and annual reports.

Airport	2000	2014	Average
AMS	39.270.610	54.940.534	45.559.271
BRU	21.637.003	21.933.190	17.924.413
CPH	18.400.000	25.627.093	20.816.434
FRA	49.360.620	59.570.000	52.932.370
HEL	10.010.148	15.948.760	12.420.984
LHR	64.618.254	73.405.330	67.153.792
MAD	32.893.190	41.833.374	42.738.210
MUC	23.125.872	39.700.515	31.380.790
CDG	48.246.137	63.813.756	56.003.375
ZRH	22.675.366	25.477.622	21.344.173

Table 5.1: the included airports and their matching passenger numbers over the period 2000-2014

Table 5.1 shows the passenger numbers of the different airports in the years 2000 and 2014, as well as the average passenger number throughout the period 2000-2014. What immediately stands out is that almost every airport faced a significant growth over the 15-year period, except for the airports of Zürich and especially Brussels. Also, despite the fact that all the included

airports are considered to be hub airports, there still exist significant differences among some of them in terms of passenger numbers. For example, LHR managed 4.6 times the passenger number of CPH in 2014.

Each factor believed to influence the passenger numbers at airports is taken into account, according to chapter 4.4 of this thesis. This means the population and the GDP/capita figures for every country hosting the relevant airports have been collected over the period 2000-2014. These figures have been retrieved from *The World Bank*. The data consist of the GDP/capita instead of the absolute GDP, as the GDP is correlated to the population numbers. To manage the same currency for every airport and its hosting country, the GDP/capita is calculated in terms of current US dollars.

	Passenger number	Population	GDP/capita
Mean	45.559.271	16.425.615	$43980.61
Minimum	39.270.610	15.925.513	$25921.13
Maximum	54.940.534	16.865.008	$56928.82
Observations	15	15	15

Table 5.2: summary statistics concerning the included variables for AMS

	Passenger number	Population	GDP/capita
Mean	36.827.381	37.889.605	$41593.72
Minimum	9.609.887	5.176.209	$14676.71
Maximum	73.405.330	82.534.176	$88002.61
Observations	150	150	150

Table 5.3: summary statistics concerning the included variables for all the airports in the dataset

Table 5.2 shows the summary statistics for the variables belonging to AMS, whereas table 5.3 shows the summary statistics for all the included airports in the dataset. From comparing both tables, one can conclude that AMS has an above average passenger number, combined with a relatively low population number and an average GDP/capita; all in relation to the other airports in the dataset.

5.3 Methodology

Firstly, preliminary conclusions are made based on descriptive statistics. To give a general impression on the annual growth of the passenger numbers at AMS in relation to the other hub airports in the dataset, the growth numbers of AMS and the average growth numbers of all the airports in the dataset are plotted in a line graph, having annual growth percentages on the vertical axis and time in years on the horizontal axis. Those plotted lines are then compared and subsequently it can be concluded whether the two growth rates seem to differ from each other at first sight. This gives some context on the growth of the hub airports, prior to conducting the regression analysis.

To test the hypothesis, a regression analysis is conducted using the 'ordinary least squares'-method (OLS-method). This means the regression obtains the least squares estimators of the unknown parameters in the analysis, ending up with the estimated coefficients for the relevant variables, minimizing the differences between the estimated and observed data. It is the most suitable method as it, under certain assumptions, leads to unbiased results for linear regressions.

As already briefly discussed in chapter 4.4, fixed effects have to be accounted for. To account for differences in political, legal, technological and environmental factors across the different countries in the dataset, cross-section fixed effects are included in the analysis. This is done by assigning a dummy variable to every hub airport. The retrieved coefficients belonging to those dummy variables are different intercepts for every airport. This controls for unobservable time-invariant variables, preventing non-random characteristics of the airports ending up in the error term, causing omitted variable bias. In addition, time fixed effects are accounted for as well. The latter controls for aggregate time trends, another source of omitted variable bias. The time fixed effects are also included by introducing dummy variable estimators. It means for every year, ranging from 2000 up to and including 2014, a dummy is included (Stock & Watson, 2015).

For interpretational reasons, the dependent variable (passenger numbers) and the independent variables population and GDP/capita are transformed into logarithmic variables.[3] This potentially adds more sense to the comparisons that are made in the conclusions of this research. In such way a so-called log-log model is created.

[3] As the dataset does not contain any zeros or negative numbers, no problem arises when taking the logarithmic values (before possibly taking the first difference)

Besides the threat of omitted variable bias, there is the threat of non-stationarity. In order not to end up with spurious results that indicate a relationship between variables that in practice does not exist, we need to make sure the analysis is conducted using stationary data. To test whether the dataset contains non-stationary data a Levin-Lin-Chu Test (LLC), a panel unit-root test, is conducted for each of the variables. The null-hypothesis of this test is that each of the data series contains a unit-root (meaning the data is non-stationary), whereas the alternative hypothesis is that each of the series is stationary (Hall & Mairesse, 2002). If the null-hypothesis cannot be rejected, a solution can be found in first-differencing the non-stationary variables. LLC works particularly well when the number of observations ranges between 10 and 250, and when the number of observed time periods ranges between 5 and 250 (Nell & Zimmermann, 2011). Since the regression analysis in this particular research contains 140 observations and 15 observed time periods, LLC is suitable to test for stationarity in this case.

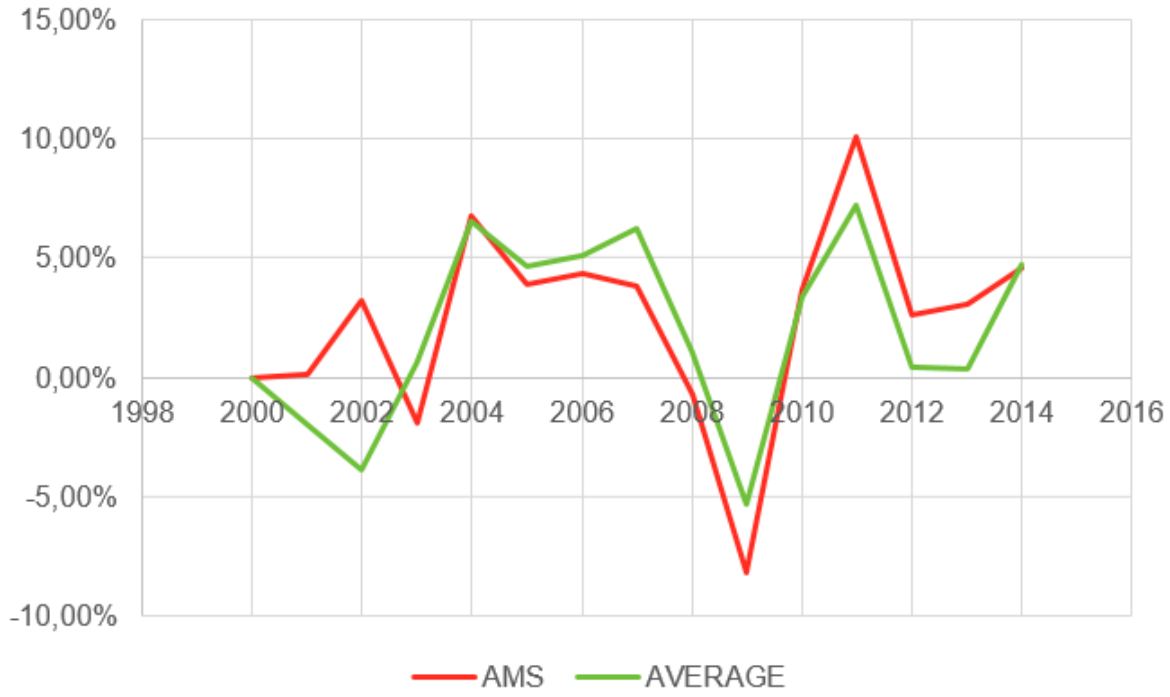
In the end, two different models are estimated. In particular, the first model contains the logarithmic value of annual passenger number as the dependent variable (*lnypax*), the logarithmic value of both population (*lnpopulation*) as well as GDP/capita (*lngdpcapita*) as the independent variables and the dummies to cover the fixed effects.[4] Besides, a significance level of 5% is being used, implying that there is a risk of 5% that the null-hypothesis is rejected, while it should not have been rejected.

The second model addresses the main point of interest, the growth of AMS in relation to the other European hub airports. The difference with the first model is that this second model accounts for the specific growth of Amsterdam Schiphol by adding an extra variable: *growthAMS*. This variable adopts value 1 for the year 2000 and AMS, value 2 for the year 2001 and AMS, value 3 for the year 2002 and AMS, sequentially leading up to a value of 15 for the year 2014 and AMS. For all the remaining hub airports this variable adopts value 0. If the retrieved coefficient belonging to this variable ends up to be significant and positive, one can conclude that the growth of AMS indeed seems to be significantly higher than the growth of the other hub airports. Accordingly, if this variable ends up to be significant and negative, the growth of AMS seems to be significantly lower than the growth of the other hub airports. If the variable is not significant, one cannot conclude that the growth of AMS differs from the growth of the other hub airports.

[4] Note that the first-differences of the independent variables are used if the LLC-test indicates the presence of a unit-root

6. Results

Firstly, the annual growth numbers of the different hub airports (in percentages) were calculated based on the annual passenger numbers. These figures were then plotted in a line graph, as shown in graph 6.1.



Graph 6.1: the annual growth of AMS in relation to the average annual growth of all the airports in the dataset

Based on graph 6.1, one can hardly conclude that the annual growth figures of AMS differ from the average growth figures, especially from 2003 onwards. Apart from that the growth numbers of AMS seem to follow the same pattern as the average growth numbers, they also stay at a comparable level throughout the observed time period. Based on this graph it cannot be concluded that AMS grows faster than other European hubs. To find quantitative proof for this (preliminary) conclusion, the panel regression was conducted. Furthermore, the graph shows that, apart from the years 2000-2001 and the period of the most recent economic crisis (2008-2010), significant positive growth numbers are showed throughout whole of the observed period.

Hereafter, the LLC-test was conducted to test for non-stationarity. This resulted in the output as shown in table 6.1 below.

Variable	Levin, Lin & Chu
lnpopulation	0.582
lnpopulation(D1)	0.027*
lngdpcapita	0.000*

*Table 6.1: corresponding p-values of the LLC-tests for the different variables. The null-hypothesis assumes the presence of a unit-root (non-stationarity). * = p<0.05 (significant)*

Table 6.1 shows that the unit-root test for the logarithmic value of population (*lnpopulation*) ended up with an insignificant result (0.58>0.05), so that the null-hypothesis assuming non-stationarity could not be rejected. Therefore, a variable representing the first-difference of the logarithmic value of population was computed: *lnpopulation(D1)*. Subsequently, the LLC-test was once again conducted on this new variable, leading to a significant result (0.03<0.05). One can therefore safely use the first difference of *lnpopulation*, as the null-hypothesis assuming non-stationarity can be rejected for this specific variable. Finally, the output of the LLC-test on the logarithmic value of the variable GDP/capita (*lngdpcapita*) led to a significant result (0.00<0.05), leading to the rejection of the null-hypothesis. *lngdpcapita* can therefore be used in the regression analysis without having to worry about non-stationarity.

6.1 Main findings

After the unit-root tests were conducted and *lnpopulation* was transformed into the first difference, the logarithmic passenger number was regressed on the first difference of the logarithmic population as well as on the logarithmic GDP/capita variable (and on the extra variable *growthAMS* for model 2), at the same time accounting for cross-section- as well as time fixed effects. This resulted in the panel regression-output for both models, displayed in table 6.2.

	Model 1	Model 2
C	11.270*	11.266*
	(1.114)	(1.118)
lnpopulation(D1)	1.235	1.217

	Model 1	Model 2
	(1.518)	(1.523)
lngdpcapita	0.566*	0.567*
	(0.105)	(0.106)
growthAMS	-	-0.002
	-	(0.004)
R-squared	0.990	0.990
Observations	140	140

*Table 6.2: estimated coefficients and matching standard errors for panel regression models 1 and 2, having the logarithmic value of Annual Passenger Number (lnypax) as dependent variable. Both time- and cross-section fixed effects are included in model 1 as well as in model 2. * = p<0.05 (significant)*

Table 6.2 shows the estimated coefficients for the different variables in both models, including the matching standard errors, displayed between brackets. To address the specific growth of AMS in relation to the growth of the other hub airports, a special variable (*growthAMS*) was computed and added in model 2, as explained in the last paragraph of chapter 5.3 of this thesis. The resulting p-value belonging to the corresponding coefficient is higher than 0.05 (0.628), providing no proof for the statement that AMS has been growing significantly faster than other European hub airports. This is supported by the fact that the coefficients belonging to the other variables barely change after adding this specific variable, when comparing the coefficients in model 1 and model 2. The same goes for the cross-section fixed effects, which stay nearly the same after adding the extra variable (displayed in table 6.3 below). This corresponds with what was observed earlier on, based on the visual line graph. The corresponding regression output matches the finding that no significant difference in growth rates between AMS and the other hub airports could be observed. The hypothesis, stating that AMS grows faster than the other European hub airports, is therefore rejected.

Concerning the estimated cross-section fixed effects, varying results across the different airports were observed. What stands out, is that for FRA, LHR, MAD, CDG and to a less extent AMS, strong positive fixed effects were observed. For BRU, CPH and especially HEL, however, strong negative fixed effects were observed. A possible explanation for those differences

might be found in the major hub airlines (alliances) operating from the hub airports with a strong positive fixed effect. In chapter 2.4 it was discussed that large airline (alliances) operating at hub airports provide a strong competitive advantage for those airports. Concerning the European aviation market, this applies to three airline alliances: Oneworld, SkyTeam and Star Alliance. If one has a close look at the airlines operating at the hub airports in this dataset, possible proof can be found for those findings. Lists of the biggest airlines[5] in Europe include successively Lufthansa (part of Star Alliance and considering FRA as its primary hub airport), International Airlines Group (part of Oneworld, considering MAD and LHR as primary hub airport), and Air France-KLM (part of SkyTeam and operating from the main hubs CDG and AMS). Lack of major airlines considering BRU, CPH and HEL as their primary hub are possibly responsible for a smaller hub function and therefore a lower (and even negative) fixed effect in this analysis.

Airport	Model 1	Model 2
AMS	0.308	0.324
BRU	-0.582	-0.584
CPH	-0.561	-0.563
FRA	0.551	0.549
HEL	-0.960	-0.962
LHR	0.752	0.750
MAD	0.522	0.521
MUC	0.028	0.026
CDG	0.621	0.619
ZRH	-0.678	-0.680

Table 6.4: the cross-section fixed effects for every hub airport included in the dataset

[5] See table 2.1

6.2 Other findings

From the output in table 6.2 it can furthermore be concluded that changes in population do not significantly influence the annual passenger number of hub airports in both the models, due to an insignificant effect of *lnpopulation(D1)*. A possible explanation for this is found in chapter 4.2 of this thesis, where it is explained that the working population tends to travel significantly more than other demographic groups. Changes in population do not typically have to indicate changes in working population. Fluctuations in population are generally caused by the number of births and the number of deaths in the observed period of time. The group representing the number of deaths is particularly composed of the oldest group of people in a population. Because this group typically flies less often than the working population, of which the latter is composed of a relatively younger group of people, their deaths are not expected to have much effect on the passenger numbers at hub airports. The same goes for the number of births, as babies are also expected to fly less often than the working population. Another trigger for changes in population are economic and political immigrants, neither a demographic group expected to influence the aviation passenger numbers significantly.

As for the variable *lngdpcapita*, the results show a significant estimated effect in both models, meaning changes in GDP/capita significantly influence the annual passenger numbers at hub airports. This supports the findings discussed in chapter 4.2 of this thesis, which showed that increases in income levels were highly related to rises in annual passenger numbers. Economic standards are reflected in GDP/capita levels, and the higher the economic standards, the more demand there will be for business-related air traffic, as well as for leisure-related air traffic. The relatively strong positive and significant effect (0.57 in both model 1 and 2) reflects this relationship.

As for the estimated time-fixed effects, the conclusion could be drawn that the period of the latest economic crisis, starting in 2008, had an overall negative effect on the annual passenger numbers. This was observed earlier on when analysing the line graph. The time-fixed effects are displayed in table 6.3 below.

Year	Model 1	Model 2
2001	0.151	0.149
2002	0.061	0.060

Year	Model 1	Model 2
2003	-0.041	-0.041
2004	-0.052	-0.053
2005	-0.030	-0.030
2006	-0.012	-0.012
2007	-0.028	-0.028
2008	-0.063	-0.063
2009	-0.061	-0.061
2010	-0.024	-0.024
2011	-0.000	0.000
2012	0.035	0.036
2013	0.017	0.018
2014	0.048	0.050

Table 6.3: the time-fixed effects over the period 2001-2014[6]

[6] To control for non-stationarity in the population-variable (*lnpopulation),* a new variable with the first difference of *lnpopulation* had to computed, meaning the year 2000 is not accounted for

7. Conclusion and discussion

Doubts are being raised about the continuous growth of Amsterdam Schiphol (AMS), a recurring discussed item across Dutch media, with the airport facing capacity constraints and potential safety issues. The growth is claimed to be *unexpectedly* and *surprisingly* high. The aim of this thesis was to put the growth of the Dutch airport in perspective of the European airport industry and the growth of other European hub airports. This aim was captured by the central research question:

How does the growth of Amsterdam Schiphol over the years relate to the growth of competing European airports?

7.1 Conclusion

Analysing the development the airport industry has gone through, one can conclude it is a fast- and ever-developing industry. It was still until the 1990's that public ownership and a low extent of commercial discipline was the standard. Towards the end of the 20th century this standard started to break down when big steps were made towards privatization of the industry, resulting in a significant number of airports being in mainly private hands nowadays. From a highly regulated industry it has evolved to a commercialized and internationalized industry, contributing an estimated 675 billion euros to the European GDP each year. Overall, the airport industry grew by 80 percent between 1990 and 2014, and is expected to grow even further in the coming years: by 45 percent until 2035.

Along with the rapid development of the general industry, AMS evolved from an airport handling 10 passengers a day during the 1920's to a leading hub airport, handling nearly 64 million passengers in 2016. Increased focus on the international playing field led to more attention for traffic generation and connectivity, marking the current status of AMS as a hub airport, handling a significant number of transfer passengers. The airport's growth was generally only held back by external factors, like oil crises and general economic crises. Over the years, the airport has always managed to recover quickly from drops in passenger numbers, before facing significant growth again. Nevertheless, its growth figures came with continuous doubts about how to manage necessary expansion of the airport capacity, in order to serve the increasing demand. It has recently been claimed that Schiphol's policy makers have neglected to invest in the right infrastructure to compensate for the growth, leading to the unusual long

queues at the airport during the latest periods of higher demand. Expansion of the capacity is eventually needed, as prediction figures show the nearly 64 million passengers in 2016 are not an all-time high and the passenger numbers are expected to grow even further in the coming years.

The competitive market for AMS can be divided in the market for transfer passengers and the market for O&D-passengers. A hub typically features the market for transfer passengers. In this market AMS faces competition from FRA, CDG, CPH, LHR, HEL, MUC and ZRH. To relate the growth of AMS to the growth of these European hub airports, a panel regression was conducted over the period 2000-2014. The results did not show any evidence for statements that the growth of AMS was significantly higher than other European hub airports. Instead, the growth showed a comparable pattern to the average growth of the European hubs. Furthermore, the estimated cross-section fixed effects showed that the presence of the biggest European airlines Lufthansa Group, British Airways, Iberia and Air France-KLM, that respectively consider FRA, LHR, MAD, CDG and AMS as their primary hubs, positively affects the competitive position of those hubs.

7.2 Discussion

Due to the current capacity issues and recent articles by Dutch journalists who claimed the growth of AMS to be *surprisingly* high, it was expected that the growth of the airport had been significantly higher than the growth of other hub airports. The obtained results from the regression analysis meet the expectations to the extent that Amsterdam Schiphol has indeed been growing over the latest years. However, the growth has not proven to be extraordinary in relation to the growth of other European hub airports. Instead, the growth seems to suit a fast- and continuously developing industry. Nevertheless, despite the continuous growth of the airport, Schiphol's policy does not seem to be adapted enough to adequately cover the growing demand. It was rather negligent not to anticipate potential capacity issues, knowing that not only Schiphol itself had generally been growing over whole of the period 2000-2014, but also that competing hub airports showed comparable growth figures. One only has to consider the returning long-lasting queues at the airport to come to such a conclusion. The advice for policy makers would therefore be to finally come up with a long-term sustainable solution and either increase Schiphol's capacity (which would probably involve changes in legislation on, for example, noise disturbance) or accelerate increasing capacity at reliever airport Lelystad Airport. Considering the economic interests the airport contributes to the Dutch economy, it is needed

to maintain Schiphol's status as a leading hub airport, instead of watching its competitors surpass them. After all, the (European) aviation market is expected to grow even further in the coming years and will not wait for AMS to adapt.

Furthermore, it was discussed that the competitive strength of a hub airport for a great part depends on the strength of the main hub carrier, often belonging to a leading airline alliance, operating from the airport. The latter matches the results, as the cross-section fixed effects belonging to the airports with a strong hub carrier turned out to be higher than those belonging to the airports lacking such a strong hub carrier. Possible implication of these findings is that AMS should maintain, and maybe even strengthen, its relation with hub carrier KLM. However, further in-depth analysis of effects of the latter are left out of the scope of this research.

A side note that can be made to the research is that it is assumed that all the relevant factors influencing the passenger numbers at airports are believed to be captured by either the included variables (GDP/capita and population) or the fixed effects, due to the impossibility to gather data on all the relevant variables. Neither are the years 2015 and 2016 taken into account, due to unavailability of data for all the included airports over these particular years.

Further research possibilities lay in increasing the observed time frame and extending the research to the global aviation market. In addition, it would be interesting to investigate whether comparable capacity constraints are faced by other airports and how they deal with them.

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