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Cost Drivers in the European Airline Industry

An empirical analysis on factors influencing cost per flight

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Acknowledgements

> “The quickest way to become a millionaire in the airline industry is to start out as a billionaire” – Sir Richard Branson (Virgin Group founder)

This journey began with a topic we were passionate about and found exciting– the airline industry. Sir Richard Branson’s quote passionately illustrates the challenge we wanted to investigate.

First, we thank our supervisor, Kenneth Fjell, for showing excitement in our thesis. Through emails and meetings, your engagement and interest in our topic motivate us and make us believe in ourselves. You also put in more effort than we could ever hope for in advance by being thorough when guiding our written work. Thank you, Kenneth!

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Abstract

The airline industry is fiercely competitive, with companies striving to earn good profits. One crucial factor in achieving this is reducing costs, which can be achieved through structured performance management that identifies all cost drivers. Zuidbergs' 2014 article on airline cost economies explored the impact of cost drivers on various airlines globally. This thesis continues his research, focusing on the European market. Financial and operational data from quarterly reports between 2015-2019 and traffic data from the same period constitute the regression analysis's foundation. The findings largely support Zuidberg's, with some exceptions. One significant result is that fleet commonality length significantly reduce the cost per flight, which agrees with Zuidberg. The cost per flight is positively correlated with the average stage length, but the increase in cost is proportionally lower than the increase in stage length, which is contradictory to what Zuidberg found in his study. We also found that a higher load factor results in lower costs per flight, which Zuideberg did not find any evidence of. These three results suggest that (1) it's preferable to have a homogeneous fleet, (2) economies of stage length exist, and (3) that high load factor possibly is a reflection of optimized use of the fleet to meet demand. Future research can include revenue, and/or incorporate non-cost-related characteristics. Furthermore, to enhance the analysis, future research should aim to distinguish airlines quantitatively rather than relying solely on qualitative assessments which has been the method for this thesis.

Keywords – Cost drivers, Airline industry, Empirical, cot per flight, Eiken & Harr

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Term List and Dictionary

Load factor

Load factor is a statical reported percenntage which equals the percentage of seats occupied based on the available seats for the period.

Stage length

Stage length is the distance a route. Most airlines report the average stage length of their operations, which is the average distance of all flights flown in the given period.

LCC

Low-cost carriers are a business segment famously known for having lower prices than traditional airlines. A strict focus on costs and profitability achieves this.

FSNC

Full-service-network carriers. Airlines focus on network profitability which means that not all routes must be profitable as they might serve other routes with passengers. Typical airlines with "classes" used for customers with higher/lower willingness to pay.

ATC

Air traffic control which is a collective term for organizations and companies that monitor and control the airspace.

HUB

An airport hub is a major airport that serves as a transfer point for many flights from various locations, connecting passengers to their final destinations. Hubs are managerial and communicated decisions, not a result of their operation.

RPK

Revenue passenger kilometers is the number of kilometers traveled by paying passengers during a given period.

ASK

Average seat kilometers are reported by airlines as a measurement to quantify the passenger-carrying capacity. It represents the total number of seats available for passengers multiplied by the total distance flown by the airline in kilometers.

Output per point served

Output per point served equals the number of flights from airport i to airport j. Density only increases if i and j are constant.

1 Introduction

1.1 Background for the thesis

The aviation industry has gained notoriety for its narrow profit margins and high frequency of bankruptcies. In 2020, 64 airlines ceased operations due to rampant debt level (Buckley, 2023). This was, of course, a year out of the ordinary, but it shows the sector's narrow margins and low liquidity. Despite the inherent risks, some arilines have managed to operate for over a century, surviving market recessions and an endless list of emerging competitors. The COVID-19 pandemic brought significant attention to the expenses of these airlines as income disappeared.

The pandemic significantly impacted the airline industry in Europe, causing all flights to be grounded. This sudden halt in operations resulted in a loss of income for airlines while costs continued to accumulate. Unfortunately, some airlines were forced to permanently ground their planes due to financial difficulties. However, some airlines managed to take control of the situation and were able to convert originally fixed costs into avoidable costs by terminating contracts with employees and leasing companies. Not all airlines were able to take advantage of their operational structure, as some had invested heavily in planes. Moreover, some airlines were reluctant to cut too much, hoping for a quick return to normal operations.

Literature published during the last century, discussing the aviation industry, has highlighted most aspects of the industry. However, our literature review reveals that there has been a burst of research articles in the previous two decades compared to earlier years. This indicates that there still is much to be discussed. This thesis is inspired by Jost Zuidberg's (2014) article "Identifying airline cost economies: An econometric analysis of the factors affecting aircraft operating costs". Zuidberg's study focused on airlines worldwide with annual data. This thesis is different in that it concentrates on the largest airlines in Europe, using quarterly data to identify cost drivers and their effects. In contrast to many other researchers, the strength of his method is that while most research focuses on only a few factors and their impact on total cost, Zuidberg includes a comprehensive selection of variables and their effect on the cost per aircraft movement (flight). This selection includes airline-output variables, airline-fleet variables, and airline-market variables.

Airline managers must clearly understand how operational changes can impact the overall cost and the cost per aircraft flight. Without this clarity, operational changes can result in costly consequences and possibly even bankruptcy. A prime illustration of this is the case of Norwegian, which attempted to implement a low-cost model in the long-haul market, ultimately leading to the airline's near bankruptcy (Trumpy and Gran, 2022).

This research collects quantitative, secondary data from nine major European airlines' quarterly reports between 2015-2019. Initially, we were looking at the years 2015-2020, but because of the unusual characteristics of 2020 due to the covid-19 pandemic, we decided to leave out observations from 2020 as they would interfere with the linear regression model. The data collected consists of financial and operational information from published quarterly reports, and operational traffic figures from the last month of every quarter, published online by Eurocontrol[1] . The data is then combined and analyzed by using a regression analysis. Results from the regression display the potential of significant cost savings based on aircraft fleet and operational characteristics. Fleet commonality and stage length are the most prominent and clear results. The effect of fleet commonality indicates that a highly homogenous fleet will save costs, while the effect of average stage length suggests that economies of stage length might exist. This is a cost concept where the percentage growth in costs is less than in the distance.

1.2 Problem statement

This thesis aims to examine the airline cost variables that significantly impact the performance of European airlines. This research also discusses variables that are not significant, which yield valuable results as we're comparing our results with previous research. The findings from this research can offer insights to airline managers, policymakers, and researchers to understand better the most influential cost drivers

[1]Eurcontrol is an international organization that are working for a safe, efficient, and more cost-effective aviation in Europe. One of their responsibilities is monitoring the airspace and keep track of aircraft movements (ICAO, 2023).

and their effects on cost per flight. Although revenue is a crucial factor in profitability analysis, this thesis solely focuses on costs and the managerial decisions that affect them. This is similar to prior research done by Windle (1991), Banker and Johnston (1993), and Zuidberg (2014).

While the researchers mentioned above investigated worldwide and American airlines, this thesis focuses solely on European airlines. Three of the world's ten largest airlines (measured in revenue) are European, indicating that the market has the potential for high profits. However, the market consists of countless differences across the continent, making no airlines identical as they all target different strategies to increase their market share. Moreover, these strategies introduce operational costs which might be unintended and negative for the airline or stakeholders.

We want to look at a specific research question for this assignment to reduce the scope of possible strategies. As Saunders et al. (2019) stated, the research question is the central aspect of any research, influencing every part of the thesis. Therefore, the objective of this thesis is to answer the following research question:

What are the major cost drivers among some of the largest European airlines that significantly affect their performance?

The background section of the thesis introduces information about the market and operational costs. Then, the literature review builds upon this and explains what cost drivers are. After this, the research question will be broken down into hypotheses, which the regression analysis aims to test.

1.3 Thesis structure

The thesis is structured into seven chapters, each with a specific purpose. Chapter 2 introduces background information about the European airline industry. This includes the industry's evolution, current situation, important operational stakeholders, market characteristics, accounting regulation, and operational costs. Chapter 3 establishes the theoretical foundation with the literature review leading to the hypotheses. The literature review considers early general academic literature and research articles on cost economies. This is important because it influences research published on this side of the millennium.

Moreover, the literature review continues with different business models and cost drivers. Based on all this information, twelve hypotheses are introduced, which ends the chapter. Chapter 4 outlines the methodology, detailing the chosen approach, selection criteria, data collection, and analysis. It also discusses the thesis' limitations regarding reliability and validity. Chapter 5 presents the analysis findings, including our regression model and the results. Chapter 6 discusses the findings and the interpretation of the regression results. It is particularly interesting comparing our results with results from the literature review, even though previous literature displays ambiguous results on some topics. Finally, Chapter 7 provides a summary and conclusion regarding the research question. The thesis ends with some notes that propose what future research can investigate.

2 Background

Chapter 2 gives all the essential information for a theoretical understanding and the discussion chapter. The first part of the chapter provides general information on the industry, how it has evolved, critical stakeholders, and market fluctuations. The second part moves into the financial aspect of the industry with external and internal accounting. Firstly, information about accounting regulations is introduced, which are the external source of reported cost. Secondly, we present internal accounting; the method airlines use to track the costs generated by their operations.

2.1 Information about the industry

2.1.1 Evolution of the Industry

Air transport has been a part of the European infrastructure for over a century. The means of transport by air was first accomplished by the Wright brothers in 1903 when they performed the first flight ever in a power-driven aircraft. KLM (Dutch airline) was founded in 1919 and made their first flight to London from Schiphol in 1920 (KLM, 2023). Since then, many more commercial airlines have emerged and de-emerged as there have been many changes to the industry.

KLM was established as Koninklijke Luchtvaart Maatschappij voor Nederland en Koloniën (Royal Dutch Airlines for the Netherlands and Colonies). Governmental stakes were and still are highly relevant, as many airlines today have national governments owning shares and seats in the boardroom. The European market was strictly regulated until 1987 when the first of three packages was introduced. From then, restrictions on market entry, capacity, frequency, and pricing were slowly removed. In 1992, the third package was introduced, and the competition policy shifted. The shift was towards using regular competition laws to address anti-competitive behavior and market power abuse (ICAO, 2003).

After the last package was introduced, the number of airlines decreased as they merged into new groups with subsidiaries. There are several reasons why a merger is desired, state Romero and Salgado (2005). The primary goals are consolidating domestic markets and expanding operations into new external markets. Furthermore, utilizing the infrastructure of existing carriers is a method to enter new markets (Romero and Salgado, 2005).

Since 1980 (Figure 2.1), domestic and international air travel has increased almost five times to an all-time high in 2019, with 5 billion yearly travelers worldwide. The graph shows that the market nearly doubled between 2008 and 2020. A possible reason for this is technological advancements and high competition, leading to lower costs and ticket prices. Another result is a very competitive market where the profit margins did not reflect the passenger increase. This is supported by statistics where the profit margin on average was between 7 and 9 percent between 2015 and 2020 (IATA, 2022). This does not mean it was not exceptionally profitable. It just indicates that few (to none) airlines could generate super profit[2].

The travel industry has experienced minor declines during events such as the Gulf War, the Asian Financial Crisis, 9/11, SARS, and the Financial Crisis. However, the Covid-19 pandemic had a significant impact and caused the industry to come to a halt. This still affects the industry today, as statistics from the Norwegian governmental organization SSB indicate that the industry still has some ground to recover before it is back to pre-covid numbers (SSB, 2023).

[2]Super profit refers to the excess profit earned by a company or individual above and beyond the normal or expected level of profit (Bjornenak, 2020).

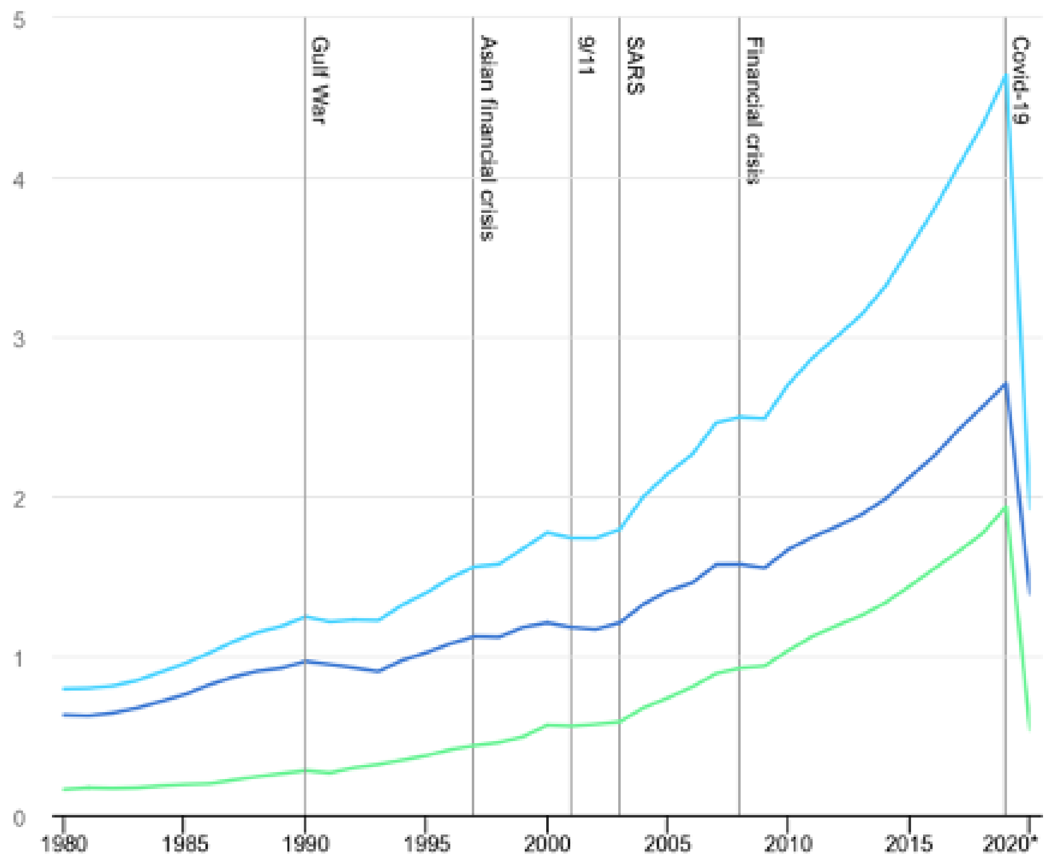

Figure 2.1: World air passenger traffic evolution, 1980-2020 (Source: (ICAO, 2020))

The size of the market has led to the airline industry being a frequent topic in the environmental debate. Around 4 percent of Europe's Co2 gas emissions originate from aviation (EuropeanCommission, 2023). Many environmental activists would argue for a substantial reduction in air travel. Financially invested stakeholders are looking into making the industry greener with, for instance, planes driven by battery cells instead of combustion engines. Implications for today's airlines are climate taxes that affect the total cost level. Since 2012, aviation has been included in the EU emissions trading system. Companies must monitor, report, and verify their emissions. Verification includes confirming that their total emission is beneath their allowed tradeable allowances. Environmental taxes affect today's companies and will affect them even more in the future as the EU plan is reducing the amount of permitted emission (EuropeanCommission, 2023).

2.1.2 Stakeholders in European commercial air transport

Aviation in Europe comprises various airlines that operate regionally, domestically, internationally, and intercontinental. The airlines rely on stakeholders who benefit from their services, including government and non-government organizations. Some stakeholders are mandatory partners, while others are optional. This section will provide a brief overview of stakeholders crucial to the airlines' functioning.

Governmental cooperation agreements

Every country in Europe has exclusive sovereignty over its airspace. However, through additional cooperation agreements, control is influenced. ICAO, International Civil Aviation Organization, is a vital stakeholder influencing aviation worldwide. ICAO decides the overarching rules governing civil aviation. They do not run the agencies controlling European airspace, but their guidelines influence how it is controlled and monetized. The European Union Aviation Safety Agency (EASA) is an agency of the European Union. They monitor and control the airspace, using the SES-framework(Single European Sky) introduced in 2004. Airlines pay an en-route fee which is charged directly to the airlines based on every single flight (TheNorwegianGovernment, 2023).

Public agencies

Organizations and ownership agreements with fewer governmental connections also affect the European airline industry. For instance, another organization that works closely with EASA is Eurcontrol. EU, through EASA, has delegated parts of the European airspace to Eurcontrol. This delegation keeps them responsible for maintaining the airspace safe and efficient (European Commission, 2023).

Most airports and local air-traffic-controls (ATC) in Europe are state-owned. At the airport, airlines pay a range of fees. ATC fees, parking fees, and other handling charges are some, to mention a few. Slot times have the last couple of years, become quite valuable. Slot times allow airlines to take off and land at an airport at a specific time. These slots have become increasingly costly as the most popular airports' infrastructure is stretched (Bel and Fageda, 2013). Some slots are so favorable that airlines trade them as valuable assets.

Private companies

Outsourcing is a familiar term in a business context and has become more used by airlines in recent years. However, it is primarily ground handling and sales/marketing that are outsourced, based on the airlines this thesis has investigated. However, the collected dataset also shows a distinct coherence. Traditional airlines often incorporate these services into their company, while low-cost carriers (LCC[3]) use external companies. The benefit of having it incorporated is a reliable service where customers value and trust the process. However, employing them directly in the corporation means stricter rules if letting employees off, making it difficult for airlines to cut salaries when the market reclines. Outsourcing complementary services such as ground handling also serves the benefit of easier keeping track of the operating profit per flight, as these companies charge per flight and work as variable costs. The input(s) that results in the invoiced cost, can be passengers or/and the number of flights.

2.1.3 Industry fluctuations

The airline industry consists of different market segments based on whether the purpose of travel is for business or pleasure. Business travel is a more uncomplicated and straightforward segment, while pleasure travel is more diverse with different individual needs. To address this, traditional airlines have implemented business models and classes. Additionally, these segments also experience seasonal fluctuations.

Figure 2.2 shows how the revenues in the airline industry fluctuate throughout the year. The model is based on the collected dataset for this thesis, where every year is the average of our airline's revenues. However, we argue that it represents all European airlines as it clearly figures the change from Q1 to Q4. Q1 is January to March, Q2 is April to June, Q3 is July to September, and Q4 is October to December. The figure shows that the third quarter has a much higher revenue stream than the first and last quarter. The third quarter is highly affected by being the summer when all European countries have their summer vacations. Regardless of the year, the graph displays the same trend. This highlights that the predictability in a normal year is quite apparent.

The market consists of a higher share of business travelers in the low season, the quarters outside the summer months. Research shows that they account for 12 percent of the

[3]Low-cost carriers are a business segment famously known for having lower prices than traditional airlines. A strict focus on costs and profitability achieves this.

passengers, while their revenue equals 75 percent on some flights (Brock, 2022). Since the market segments fluctuate with the seasons, airlines have solved this by having different business models. More about this topic in the literature review.

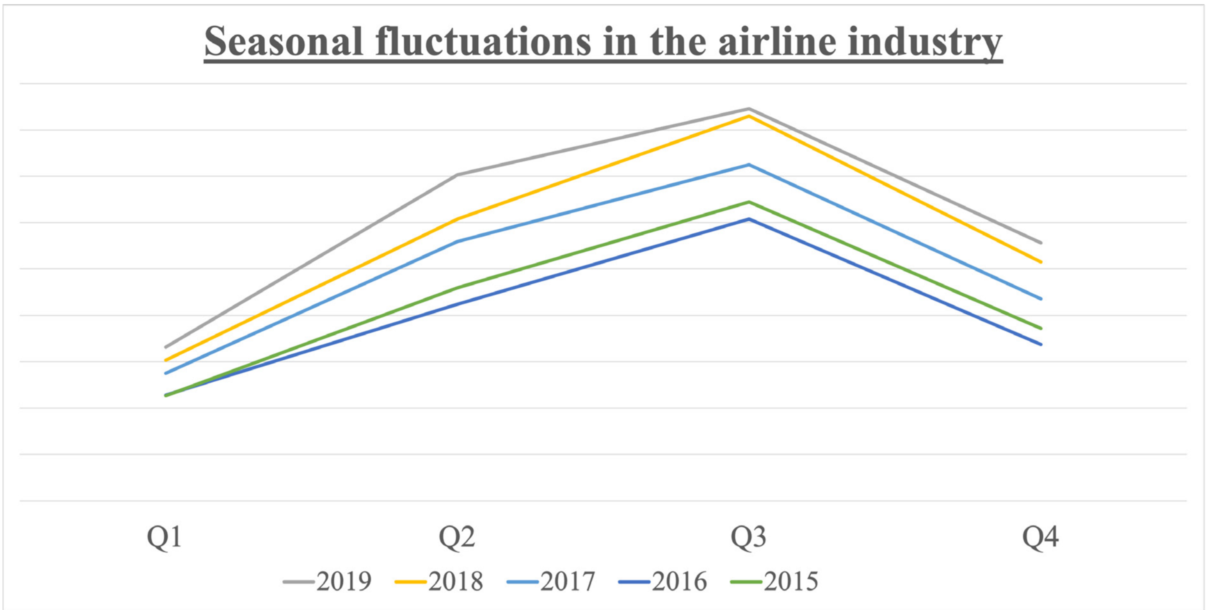

Figure 2.2: Seasonal fluctuations in the airline industry using revenues from the nine largest European airlines

2.2 Operational cost of commercial airlines

Every industry operates in its unique way, which results in varying operation costs. This section focuses on the operational costs of the airline industry. Firstly, we present some financial accounting rules, which are external accounting guidelines for airlines' reports. Secondly, we outline operation cost allocations to provide an overview of the types of costs airlines incur and track via internal accounting.

2.2.1 External Accounting

External accounting can be defined as: "Accounting that gives information you are required to give out to third parties (for example the fiscal office, the company register or credit institutions) based on legislations. (Nacken Hillebrand Partner, 2023)" The accounting regulation (legislation) the nine airlines in the thesis follow is the International Financial Reporting Standards (IFRS). This influences how the costs are reported and what to interpret from them.

Chapter 4 reviews a wide range of literature, where some have researched the American market. Just to give some context and separate legislations: American airlines use the Generally Accepted Accounting Principles (GAAP), and this thesis airlines follow the IFRS standard. Accountants consider methodology as the difference between IFRS and GAAP. IFRS is based on principles, and GAAP is more rule-based. Airlines using IFRS instead of GAAP are left with more room for interpretations instead of following strict rules. Proponents of IFRS argue that it causes a correct company picture. The standards aim to maintain stability and transparency in the financial world (Ross, 2022).

With the introduction of IFRS 16 in 2019 came changes in how companies reported leasing costs in the income statement. This is interesting for industries with significant expenditures on leasing costs. The aviation industry is well known for many airlines leasing their planes instead of owning them. From 2019, most leasing costs[4] are applied to depreciation and amortization in the income statement. The sum in the income statement is the depreciation of the present value of leasing liabilities. This is because IFRS is what accountants call balance oriented, meaning the balance sheet is the most crucial part of the financial report. Therefore, the income statement results from changes in the balance sheet. Leasing cost in the income statement is the change in leasing liabilities represented by depreciation (PwC, 2016). This differs from the years before 2019 when the leasing cost was a direct expenditure for airplane renting. After 2019, there will be an increase in the overall costs of all airlines in the dataset. This is because if the leasing contract is longer than one year, the depreciation of the present value of the leasing liability exceeds the financial cost generated annually from the leasing contracts.

2.2.2 Internal Accounting

External accounting provides information that is accessible to the public. However, it only provides a basic overview of the airline's revenues and expenses. Internal accounting offers more detailed and accurate information but is not accessible to the public. Internal accounting can be defined as: "cost accounting that gives the information required by the management and other decision makers within the company. Internal accounting does not know any regulations and can be configured in a way to fully solve the needs within the company (Nacken Hillebrand Partner, 2023)." The final part of the definition highlights

[4]Some exceptions that do not relate to the airlines included in this thesis

the importance of incorporating internal accounting into the thesis. By understanding the cost drivers of airlines, managers can gain valuable insights, and internal accounting provides a structured approach to achieving this. This section elaborates on the costs generated by the industry rather than providing a comprehensive setup, as each airline has its unique structure and needs. Understanding operating costs is important for the discussion and is ultimately our interpretation of what the basic external reports say about the airlines' expenses, structured internally by them.

The primary cost groups are the direct ones. Direct cost can be defined as all costs directly traced to produce a specific good or service (Bloomsbury Dictionary, 2023). These costs can be both variable and fixed. However, they are often variable as they fluctuate with production level.

Direct variable costs The most common group of costs are the costs that can be directly traced to the flights and that fluctuate with the production level. The most obvious are fuel, pilot and cabin crew salaries and services offered onboard (catering). In addition, airlines must either organize or outsource other services that are demanded. Services on an hourly basis are maintenance, baggage and goods handling, ground-crew personnel, and air-traffic control. Some directly traced costs vary with the routes, such as airport fees and the cost of air navigation. European airspace is divided into zones that are charged on a different basis. Individual flights are charged based on the zone fee and work as variable costs. The principle can be compared with motorways, where it is more expensive to operate in areas with high traffic (Eurocontrol, 2023).

Direct fixed cost The fixed costs directly traced to the plane are insurance, leasing, and depreciation. Depreciation is the cost of owning an airplane or the loss of value. Dry leasing is a service offered by various companies that rent planes on contracts. Expenditure on insurance occurs in conjunction with leasing or investing in planes. The reason for the three being direct costs instead of indirect is that they are vital for the operations and are inevitable for airlines operation. An important notice is that they are fixed because they do not vary with the number of flights. Leasing of planes is on contracts, making it impossible or hard to adjust for operation on a day-to-day, week-to-week, and even month-to-month basis. Research by Threthway (2004) indicates that leasing costs can be adjusted on a yearly basis. These results support the fact that leasing and depreciation are fixed.

Indirect costs (Overheads) Indirect costs, or overheads, are associated with employees that work with complementary work that is not directly tied to the product, in this case, the flights. However, they are still crucial for the airlines. These employees might be in marketing, sales, or other administrative work. There is also an indirect cost related to non-flight-related equipment or buildings.

This section is essential for the discussion and background information for the following chapter - the literature review. Before the method chapter, twelve hypotheses are introduced for the analysis originating from this part and the literature review.

3 Literature Review

This section of the thesis reviews relevant published literature in relation to the research question. The purpose of this is twofold: firstly, to establish hypotheses, and secondly, to provide a literature foundation for Chapter 5's discussion. The first section explores the emergence of aviation literature and its topics. This is followed by an overview of cost economies literature in section 3.2, highlighting this field's most frequently discussed topics. Section 3.3 focuses on the business model, providing background for the discussion, while section 3.4 reviews the most crucial literature for this thesis, cost drivers, which form the basis for most of the hypotheses outlined in section 3.5.

3.1 Literature development

Early work

Jome (1928) appears to be one of the earliest academic literature articles published about commercial air transportation. At that time, the aviation industry was in its early days, which meant the discussion focused on the service's future and viability. Jome discusses how aviation can go from being a costly supplementary transportation to a substitute with lower cost (Jome, 1928). The industry has since transformed from a complementary to a substitute to the main option for transportation from point A to point B. Between Jome and the outbreak of the war, most of the published research is focused within the same field of study. However, the sector positively evolved throughout the war. Crane (1944) concludes that air transportation is competitive in character and that the end of the war will result in increased volume and then be economically justified. A common perception of wars is that they push evolution by years. This might be true as the second world war resulted in the first jet-engine plane (StanfordUniversity, 2004). Post-war industry growth developed according to Crane's prediction. One reason was the impact of the evolution on planes' effectiveness and the average cost per flight.

The 50s rapid increase in volume caused several articles and research papers on labor conditions and strikes (see e.g., Kahn (1953), Murphy (1958)), which continued into the 60s with Kahn (1963), and Blum (1962). This early work still influences today's employment as labor rights perpetuate old discussions and settlings.

Throughout the 60s, a large share of the academic journal discussed the industry's business model. Between 1958 and 1963, the U.S. air travel industry witnessed an average growth rate of 8 percent, even though there were two small recessions in that period (Deaton, 1966). Stable growth meant new airlines and a market with international transatlantic flights. This influenced the literature, where market dynamics became a recurring subject. Deaton (1966), Steiner (1967), and Faville (1967) discusses factors that might constrain the market if not solved. Steiner, for instance, concludes that establishing substantial growth comes down to constraints such as airport infrastructure, support services, and aircraft that can handle future passenger demands. Faville supported Deaton's arguments and concluded that keeping full planes in the air as much as possible is viable for further expansion.

All these early academic articles serve as a foundation for new, published research. The same exciting subjects recur, even though there have been notable changes to the market.

3.2 Business models

In the fluctuation part, we mentioned that serving different business segments was one reason for having different business models. This part reviews these models and features. Airlines' business model reflects their core values and affects revenues and costs. The type of business model is a choice when starting a new airline, but there has also been an evolution in the business models. Until the 70s, traditional airlines, mostly government-owned, controlled the market. However, Pacific South West, and later Southwest, pioneered the low-cost carrier (LCC) model in 1973. In 1995 this concept was introduced to the European market with Ryanair (Dobruszkes, 2006).

Tretheway (2004) argues that low-cost carriers have gradually undermined network carriers' ability to practice price discrimination. Price discrimination has for decades been used by network carriers to recover their total cost. Tighter margins will, over time, reduce the airline's market share. Tretheway presumes that there are two business models. However, Lohmann (2013) concludes that significant variations exist between so-called full-service-network carriers (FNSC[5]) and low-cost carriers. His research indicates that there are

[5] Full-service-network carriers. Airlines focus on network profitability which means that not all routes must be profitable as they might serve other routes with passengers. Typical airlines with "classes" used for customers with higher/lower willingness to pay.

hybrids in-between the two categories. Lohmann conducted his research in the American market, but his conclusion is supported by Daft and Albers (2015), who analyzed the European market. Their paper shows that airlines converges against a middle between FNSCs and LCCs, with more similarities across the airlines. An article by de Wit and Zuidberg (2012) concludes that LCCs will ultimately be limited by route density in the European market. This will force them to (partly) adopt strategies from the FNSCs to continue to grow. This is in accordance with the empirical results of Daft and Alberts.

The convergence of the two business models might also go in another direction than the middle (Figure 3.1). Bacwhich and Wittman (2017) show that a new extreme variant of LCCs has emerged in recent years, called ultra-low-cost carriers (ULCC). A characteristic of these airlines is that they generate a significant portion of their operating revenue through ancillary services. In addition, they also have significantly lower costs than other LCCs. They, however, also have a three times higher risk than LCCs of abandoning the market within two years of entry (Bachwich and Wittman, 2017).

Figure 3.1: Illustration of Business Model Convergence

Airlines use networks and create hubs[6] to enable a higher load factor (more about this in 3.3) on long-haul flights. This is one of the benefits of traditional full-service carriers, in contrast to low-cost carriers. There has been a discussion in the last 20 years if the low-cost model can be transferred onto the long-haul market. Many low-cost carriers have tried to adapt their model to this segment with different luck. Albers and Daft (2012) claim that there is no clear distinction between short- and long-haul business models. However, the two can be divided into flights under/over 3000 km, where flights longer than this threshold are not flown by standard narrow-body aircraft. Francis et al. (2007), Morell (2008), and Daft and Albers (2012)) all discuss how LCCs can transfer the low-cost business model into long-haul operations. They all conclude that it is possible, but this is dependent on a range of different factors. Factors introduced include increasing the revenue stream and cutting operation costs.

[6]An airport hub is a major airport that serves as a transfer point for many flights from various locations, connecting passengers to their final destinations. Hubs are managerial, communicated decisions, and not a result of their operation.

Business models are an essential part of all industries. Examining published research indicates that this subject is highly relevant and a reason for the difference in airline costs. However, we will not introduce a business model variable in the analysis as it is hard to measure in a numeric value, but instead use this section in the discussion.

3.3 Literature Development of Cost Economies in the Airline Industry

This thesis' subject scope is the cost economies in the airline industry. One of the first articles published that discusses the topic is Judd (1949). The American airline industry was different then than today, and the topics Judd discusses are preliminary for later work. Nevertheless, his published article discusses many cost accounting concepts, some highly relevant today

Firstly, literature that has been conducted on the topic of cost economies has included variables measuring the operations of the airlines (output). These variables have been revenue passenger kilometers (RPK)[7], available seat kilometers (ASK)[8], actual flights flown and carried passengers. All papers have found that an increase in one of the mentioned variables correlates positively with an airline's total cost(Caves et al., 1984), (Gillen and Morrison, 2005), (Banker and Johnston, 1993), (Hansen et al., 2001), (Zuidberg, 2014).

One of the great topics within cost economies has been the possible existence of economies of scale. Caves et al. (1984) defines the resurrection of scale economies as: "a decline in unit costs as a result of an airline that adds flights to an airport that it had not been serving, and the additional flights cause no change in load factor[9], stage length[10], or output per point served[11]". Some researchers argue that it does not exist, while others claim the opposite. Caves et al. (1984), Gillen and Morrison (2005), and Zuidberg (2014), all

[7] Revenue passenger kilometers is the number of kilometers traveled by paying passengers during a given period.

[8] Available seat kilometers are the total number of kilometers each seat has traveled during a given period.

[9] Load factor is a statistical reported percentage which equals the percentage of seats that was occupied based on the available seats for the period.

[10] Stage length is the distance of a route. Airlines often reports the average stage length of their operations which is the average distance of all flights flown in the given period.

[11] Output per point served equals the number of flights that fly from airport i to airport j. Density only increase if i and j is constant.

concluded that economies of scale did not exist or were negligible. Johnston and Ozment (2013) conducted a similar empirical analysis with a larger data sample than ever before and found evidence of the opposite.

Many scholars agree that airlines exhibit economies of density. The difference between scale and density is in terms of routes. Economies of density are a type of economies of scale that occurs when an airline adds flight(s) to an existing route, causing a denser supply of departures on a specific route (Caves et al., 1984). An example of this is five daily departures from Oslo to London and the density increases by adding a sixth flight. The conclusion of Caves et al. is supported by Bailey and Friedlaender (1982), Romero and Salgado (2005), and Zuidberg (2014).

Romero and Salgado also introduced something called economies of networking and concluded that it was beneficial. However, Caves et al. (1984), Windle (1991), and Hansen et al. (2001) contradicts some of the network benefits. Their research concludes that diverse networks are more costly due to the number of points an airline serves. The argument is the same for research that concludes that no economies of scale exist, and that economies of density exist. This equals two interpretations:

1. Fewer points decrease possible routes and the effects of economies of scale.
2. Increasing routes decreases the density and cause an increase in cost per flight.

Minervini and Gitto (2007) also concluded in their research that a more complex network, causes a lower operating profit. The same two scholars also included load factor in their research (although they found no significant effect).

Zuidberg (2014) states that the research on load factor is relatively straightforward. Most research has found a negative relationship between load factor and total airline cost. Caves et al. (1984), Baltagi et al. (1995), Windle (1991), and Hansen et al. (2001), concludes that a higher load factor causes lower operational cost per flight, which is clear evidence of substantial economies of load factor (Zuidberg, 2014). More recent research has also concluded that the load factor affects the ticket price negatively (Szaba et al., 2018). This implies that the load factor positively impacts the operating margin, which Bitzan and Chi (2006) support. The interpretation is that the revenue increase more than the costs because passenger-based variables increase revenue more than costs.

3.4 Cost Drivers

Banker and Johnston's (1993) proposed in their article (An Empirical Study of Cost Drivers in the U.S. Airline Industry) two types of cost drivers, operational- and volume-based cost drivers. These two are used to structure different cost concepts. This is in this thesis further developed when structuring the literature review, which serves as the most relevant research for this thesis.

Firstly, some theoretical foundation on cost drivers. Cost drivers are a concept related to cost management and activity-based costing (ABC) introduced in the mid-1980s. The ABC method assigns the resource expenses to an activity where cost drivers refer to actions that trigger these expenses. There are primarily two principles used, transactional- and time-driven ABC. Transactional ABC counts the number of times an activity is executed, while time-driven ABC is how long something takes (Kaplan and Anderson, 2003). For this thesis, cost drivers are essential as they are a tool for dividing and understanding the cost per flight. Both types of drivers relate to the volume of input, which is the first to be introduced in the following section.

3.4.1 Volume-based Drivers (Input Variables)

There are primarily three different inputs required to run an airline: aircraft, fuel, and personnel. The total cost of an airline's aircraft is displayed in their annual reports presented by the depreciation. We are in this thesis most interested in the fleet characteristics, while an airline might use flights, hours, or passengers as the drivers. The financial data collected in this thesis show that labor and fuel comprise 41 percent of the total expenditure on average. However, initial data including 2020, strongly affects these negatively. This is because the fixed cost equals a larger share for these years as the variables are reduced by the fall in the total number of operations. The airlines Zuidberg (2014) studied had an average of approximately 50 percent of the total cost. Ryerson and Hansen (2013). Figure 3.2 shows how jet fuel prices globally follow the crude oil price. This is essential information as this highlights that the cost of fuel is out of reach for managers. Therefore, using other inputs efficiently is important to keep the profit margins stable.

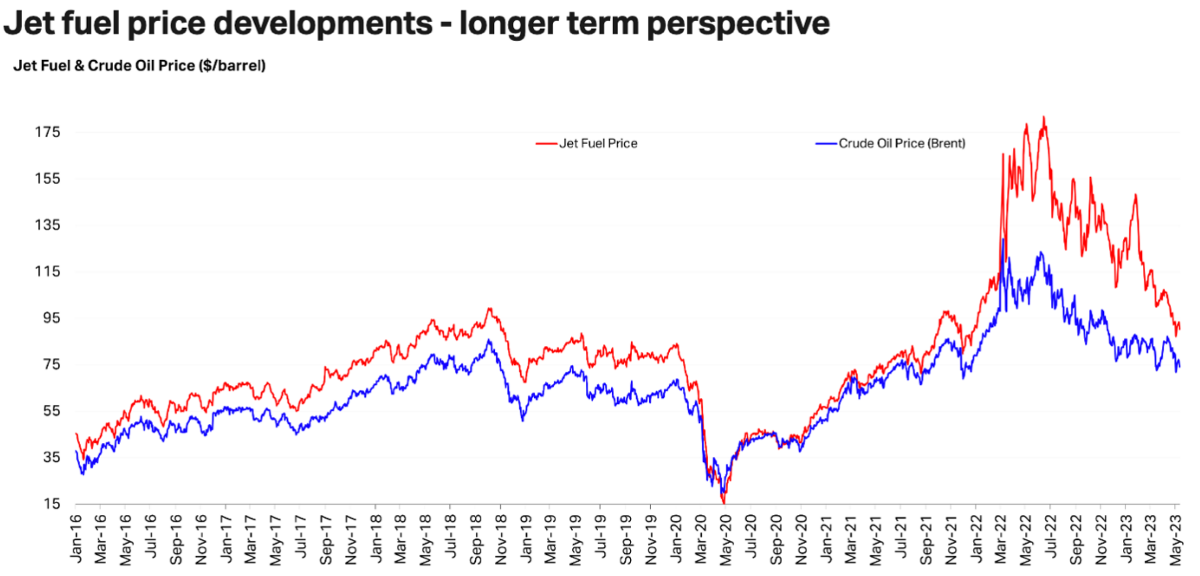

Figure 3.2: Jet fuel price developments between June 2016 to May 2023. Displaying the jet fuel and crude oil price relation (S&P Global, 2023)

3.4.2 Operation-based Drivers

Banker and Johnston (1993) introduced operation-based drivers in their article, defined as: «The drivers represent choices of alternative technologies, as embodied in choices of aircraft models, flight frequency or density, and traffic flow control (Banker and Johnston, 1993, p.582)." These choices are structured into aircraft fleet characteristics and operational choices[12]

Aircraft Fleet Characteristics An aircraft is an essential characteristic of the airline's input variables – no aircraft, no service. Airlines optimize their aircraft fleet to maximize their profits. The two largest manufacturers are the American company Boeing and the European company Airbus. Some smaller manufacturers are Bombardier and Embraer (Beers, 2012). Airlines choose between investing or leasing, and both have their benefits. Investing in aircraft has been preferred as it is cheaper than leasing but causes capital lock-up. On the other hand, selling airplanes might take time, making it harder to adjust aircraft after demand. In addition, fleet characteristics do constrain the operation type (short- or long-haul). Some planes do not have long-haul ranges, while others are too expensive to run on short-haul flights. Notably, this input variable has three characteristics

[12]Operational characteristics are a type of operation-drivers and includes operational choices the management in airlines do or are affected by. E.g., an airport departure is a choice and load factor are the markets respond to the departure. Both are cost drivers as it affects an airlines cost.

that affect total costs differently – age, size, and fleet commonality.

Ryerson and Hansen (2013) concluded that increased aircraft age leads to higher cost per flight. Banker and Johnston (1993) conducted extensive research on aircraft types, comparing older aircraft with new, more fuel-efficient ones. They concluded that there is no indication of the significance of age benefits. However, Zuidberg (2014) concludes that a 10 percent increase in average fleet age reduces operating costs by 0.3 percent. Banker and Johnston conducted their research nearly 20 years before Zuidberg. However, there have been technological improvements in aerodynamics and engines since then. The general assumption is that aircraft today should give considerable fuel and cost savings because of these technological improvements. Another hypothesis is that older aircraft tend to need more maintenance. However, the proposed explanation is that ownership costs exceed the fuel savings (Zuidberg, 2014). An interesting result by Hazel et al. (2012), even concluded that planes older than fifteen years have lower maintenance costs than planes ten to fifteen.

Banker and Johnston also found evidence of the cost-efficiency of larger aircraft. This is supported by several scholars (Wei and Hansen (2003), Bitzan and Chi (2006)), which implies that there are economies of aircraft size.

Another fleet characteristic involves commonality. The notion is that a more uniform fleet is more cost-efficient because it is less complex. One reason is that pilots and mechanics can be used on a larger share of the fleet without extra training. All aircraft models require specific education, which is costly (simulators, hours). Brüggen and Klose (2010), Zuidberg (2014), and Zou et al. (2015) find that a more standardized fleet leads to lower unit costs. The research by Zou et al. also indicates that fleet commonality negatively impacts revenue. Having a standardized fleet restricts the airline's opportunity to serve other markets. This issue will not be included in this thesis as we strictly consider costs.

Lastly, turboprop costs less than using airplanes of the same size with jet engines (Bitzan and Chi, 2006). A weakness of this conclusion is that only some aircraft are the same size as turboprop planes and that few jet propulsion planes operate on the same routes. However, we argue that there are some comparable cases. For example, turboprop planes are used parallel with jet engine planes on the short-distance network in Norway. Jets use a considerably shorter time on the same distance[13]. The faster aircraft uses more fuel to achieve this, which costs more since fuel is a significant input variable.

Operational Choices

Average stage length[14] is often recognized as the most important cost driver. An increase in stage length increases costs such as fuel, salary, and maintenance. However, earlier literature indicate that the average stage length has a negative effect on total costs (Caves et al., 1984), (Banker and Johnston, 1993). Keeping all other variables constant is an analytic method to evaluate the isolated effect of only one variable when the volume changes. This is clear evidence of economies of stage length. Zuidberg (2014) had contradicting results: increasing average stage length increases the operating cost per flight more than proportionally. This is supported by Baltagi et al. (1995), Bitzan and Chi (2006), and Tsoukalas et al. (2008).

Networks in Europe emerged throughout the 90s. European deregulation made the market completely open for cabotage[15] in April 1997. After this, carriers responded in three ways: mergers and acquisitions, setting up low-cost carriers, and entering alliances. These three alternatives created network opportunities. Several network connections are available, but economies of networks emerge when airlines set up hub-and-spoke networks. This enables connection flights and allows the airlines to concentrate their operation by “channeling large passenger flow through their hub airports” (Zuidberg, 2014). Hubbing is a familiar term within the airline industry. In short, hubs serve as central airports to enable transfer for a better stream of passenger flow. One of the benefits of using hubs is that the route density increases, which is concluded as a significant cost-saving element (Banker and Johnston (1993), Baltagi et al. (1995)).

3.5 Hypothesis

On the background of the literature review, the following list of hypotheses is presented. This is inspired by Zuidberg’s (2014) list of hypotheses to see if the isolated European market gives the same results as his research for his range of worldwide airlines. However,

[13]Comparison is from the route Bergen – Bodø with Widerøe, where their jet engine plane uses 1hr and 35 min and turboprop 1hr and 55 min.

[14]Average stage length is the average distance of all flights flown in the given period.

[15]Transport between places in a state other than where the carrier is domiciled.

the angle of a hypothesis might be different as they are based on the conclusions of the majority of the literature review. Furthermore, they are structured into operational,- aircraft fleet,- and seasonal characteristics, which will be recognized in the discussion structure.

Operational Characteristics

1. The number of flights causes less cost per flight because of economies of density.
2. The more points an airline serves, the higher the cost per flight.
3. Average stage length correlates positively with cost per flight.
4. A higher load factor will decrease the cost per flight.
5. Reducing the time an aircraft spends on the ground causes less cost per flight because of economies of aircraft utilization.
6. Route dominance causes airlines to be less cost-effective than those serving more competitive routes.
7. Airport dominance causes airlines to care less about cutting costs and are less cost-effective than competitive routes.

Aircraft Fleet Characteristics

8. The aircraft size correlates positively with operating cost per flight but less than the percentage increase because of economies of aircraft size.
9. Higher fleet commonality causes lower operating costs per flight.
10. Operators with turboprop aircraft have a lower operating cost per flight.
11. Airlines operating an older fleet will have lower costs than those operating a newer fuel-efficient fleet.

Seasonal effect

12. Costs are lower per flight in some quarters because of the fluctuations in traffic.

4 Methodology

This part of the thesis elaborates on the many possible methodological choices and approach regarding the research design. The key to these selections will be to ensure consistency throughout the research design (Saunders et al., 2019). Our methodology is based on the "Research Onion" by Saunders et al.(2019). Saunders, Lewis, and Thornhill describe research as an "onion," where each layer represents choices a researcher considers throughout the process. These choices are illustrated in Figure 4.1. We have a positivist and deductive theory approach to answer our research question, with an explanatory, quantitative research strategy.

In Chapter 4, the first section (4.1) briefly overviews the theoretical approach, while the second section (4.2) covers the methods, strategies, and time horizon. Unless otherwise noted, Saunders et al. (2019) is the primary theoretical source for these sections. The following two sections (4.3 and 4.4) focus on data selection and analysis. Lastly, section 4.5 evaluates the reliability and validity of the thesis.

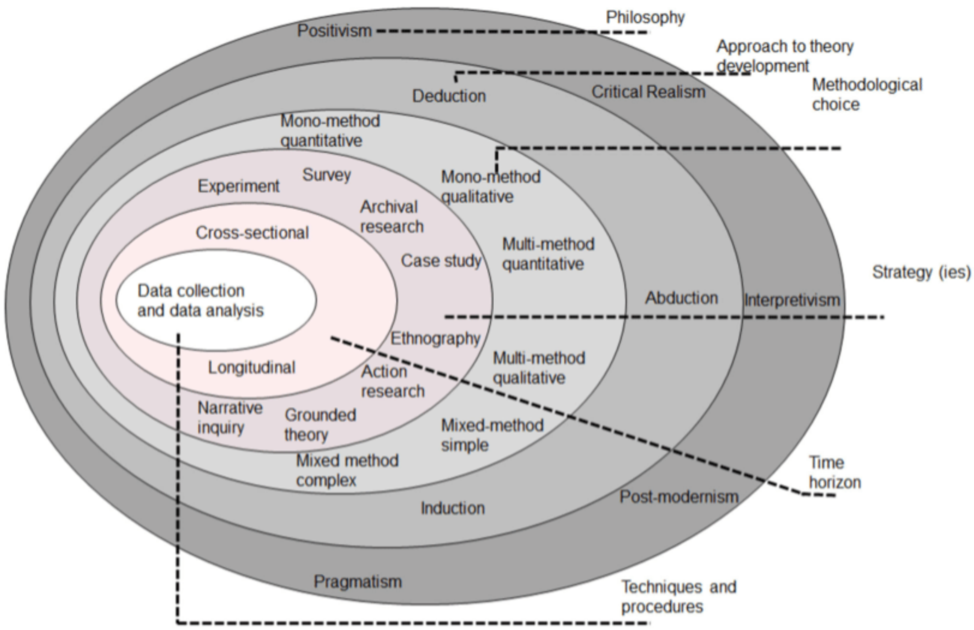

Figure 4.1: Research Onion by Saunders et al. (2019)

4.1 Approach to Theory

Researchers can have various research philosophies without realizing it when reviewing the literature. These philosophies differ in how they view the world, specifically in three means: ontology, epistemology, and axiology.

Ontology is how researchers view the nature of reality and how they see the world of business and management. Epistemology involves knowledge, how researchers accept, validate, and legitimate knowledge, and how it is accepted. Where ontology is more abstract, epistemology is more relevant when choosing research methods, as observed facts are considered trustworthy. For this research, numerical data is assumed true, but another study might adopt the visions/stories from company spokespersons and consider them reliable. Lastly, axiology refers to the role of values and ethics. It can be challenging to prevent personal values from influencing research, and this argument has some validity. However, the research topic reflects your beliefs as it is a personal choice with pre-assumptions. In particular, our values regarding the subject must be handled with awareness to trust the research results. We will revisit this topic in 4.6.

From the three philosophic assumptions, there are five major philosophies: positivism, critical realism, postmodernism, interpretivism, and pragmatism. They all share some similarities, which makes room for more than one answer. Philosophical assumptions matter because researchers see the world differently, resulting in them carrying the research out differently. The nature of this thesis is more "posited" -i.e., "given," which matches with positivism. Researchers with a positivist philosophy are concerned with discovering observable and measurable facts and regularities. Only observable facts lead to an analysis with credible and meaningful data. Critical realism argues that what you see is an illusion, and what is real is the underlying representation of the real world. Postmodernism differs from this and emphasizes the role of language and relations. Interpretivism differs as they criticize positivists for their attempts to discover definite, universal laws that apply to everybody. For an interpretivist, definite universal laws mean we lose insight into humanity. Lastly, pragmatism research starts with a problem that must be solved through their future proposed solution. This highlights some differences but is still quite abstract, so let's argue for our philosophical assumption by an example. A good example of this thesis is how theory is critically reviewed. A wide range of research papers displays the empirical foundation of what different researchers conclude about subtopics within the research question topic. This theory development leads to gathering facts (rather than impressions) that justify the hypothesis.

Choosing a positivist philosophy excludes some methodological choices, for instance, how we review the existing literature. There are three main approaches to implementing and developing theory: deductive, inductive, and abductive. *Deductive* reasoning is a logical process that starts with a general principle or theory and applies it to a specific topic to conclude. *Inductive* reasoning is a logical process that begins with detailed observations and uses this to form a general principle or theory. Lastly, *abductive* reasoning is a logical process that starts an unorganized set of observations and uses them to create a plausible explanation. For this thesis, a deductive approach is the most fitting one. The process of this thesis started with some factors influencing airline costs more than others. By reviewing the literature, some more specific hypotheses were introduced. Later in the thesis, these are tested, resulting in rejection or acceptance. This contradicts inductive and abductive. Inductive because we already had a general principle before we started. The approach also differs from abductive because the process is more linear. Abductive moves back and forth, effectively combining both deductive and inductive. Literature was reviewed before the principles were set and did not change after "new" information emerged.

This part of the thesis introduces the philosophical approach that has been elaborated thus far. The following section will develop upon the methodological decisions and tactics that significantly influence the remainder of the thesis. These decisions originate from the philosophical approach and will advance from it accordingly.

4.2 Research design

Section 4.2 emphasizes the importance of the research design in providing a framework for answering the research question. This involves selecting the appropriate method, strategy, and time period. Once these elements are established, the next step is to determine the most suitable method for data collection.

4.2.1 Qualitative versus Quantitative Methods

The main difference between the methodologies involves the data – numeric (numbers) and non-numeric (words, images, audio recordings, etc.). Numeric data is often referred to as "quantitative," while non-numeric data is often called "qualitative." While it is important to distinguish between the two, this is often problematic in a business context. Businesses and researchers will likely combine quantitative and qualitative elements in their work. Because of this, a mixed method exists where researchers combine the two.

For this research, we use a quantitative method approach. We will collect numerical financial data from structured and publicly available sources. Our research question aims to discover the most significant cost drivers, so we will also collect other observed characteristics in numerical form. These characteristics include average flight distance, flight type, route, and company. All data can be analyzed quantitatively. We use the same method for the two sources involving secondary data. Secondary data is "data collected by someone other than the user. (. . .) that have already been collected for some other purpose (Sindin, 2017)." The sources are all reliable secondary data as it is collected directly from the airlines, accompanied by data from the trustworthy organization Eurocontrol.

4.2.2 Strategies

Before we go into the specific strategy of this research, a recognition of the research purpose is elaborated. The purpose of the research design is either exploratory, descriptive, explanatory, or evaluative. Research purpose might also change over time as new information emerges. The purpose is connected with the research question as this reveals the true meaning of the research. Because this research aims to investigate relationships between variables, may the research be termed an explanatory study. The research tries to explain (explanatory) the causal relationship between variables by performing a statistical test. This is the background for different strategy choices.

Research strategy: *"A plan of how a researcher will answer their research question. It is the methodological link between your philosophy and subsequent choice of methods to collect and analyze data"* (Denzin and Lincoln, 2018).

The specific strategy on how we plan to answer the research question depends again on many choices. However, only a few strategies are relevant because of the positivist and deductive approach and the quantitative methodological choice. Because of the options, an experiment strategy is the most fitting one. An experiment might sound confusing as it has its roots in natural science. The purpose of an experiment is to study the probability of a change in an independent variable causing a change in another dependent variable. The essence of probability testing is through hypotheses, like in this thesis. There are two opposing hypotheses: null and alternative hypotheses. An example is:

$$H_0\text{: The number of flights does not positively affect costs per flight.} \quad (4.1)$$

This is the null hypothesis, whereas the alternative hypothesis would be:

$$H_A\text{: The number of flights affects costs per aircraft flight.} \quad (4.2)$$

An experiment can be conducted in many ways. Still, the experimentation in this thesis is an econometric one where the hypotheses in one of the experiments are tested with a fixed effects regression. In sections 4.3 and 4.4, an explanation of the experiment is given for collecting and analyzing data.

4.2.3 Time period

When determining the purpose of research, it is important to consider the time frame of the thesis. There are two types: cross-sectional and longitudinal studies. A cross-sectional study studies phenomena at a particular time, while a longitudinal study changes and develops over time. This study uses airline data collected over several years, which means it is longitudinal. Selected years of data are 2015 to 2019, with four quarters each year.

Our reasoning for using longitudinal instead of cross-sectional can be summarized with two arguments:

1. More observations: Data from the same company over a longer time horizon gives more observations for quantitative analysis. Data collection will be gathered from five years and four quarters each year. This equals twenty observations from every

airline and strengthens each observation.

2. Market change: Figure 4.2 illustrates the change in European commercial air transport. This indicates that there have been large market changes since Zuidberg published his research in 2014. A cross-sectional study will give insight into a given year. However, with all the changes relating to macroeconomics, in the last eight years, it is more interesting to see how this has influenced costs. A cross-sectional data collection will not see these and the seasonal effects, which gets transparent with the quarterly data.

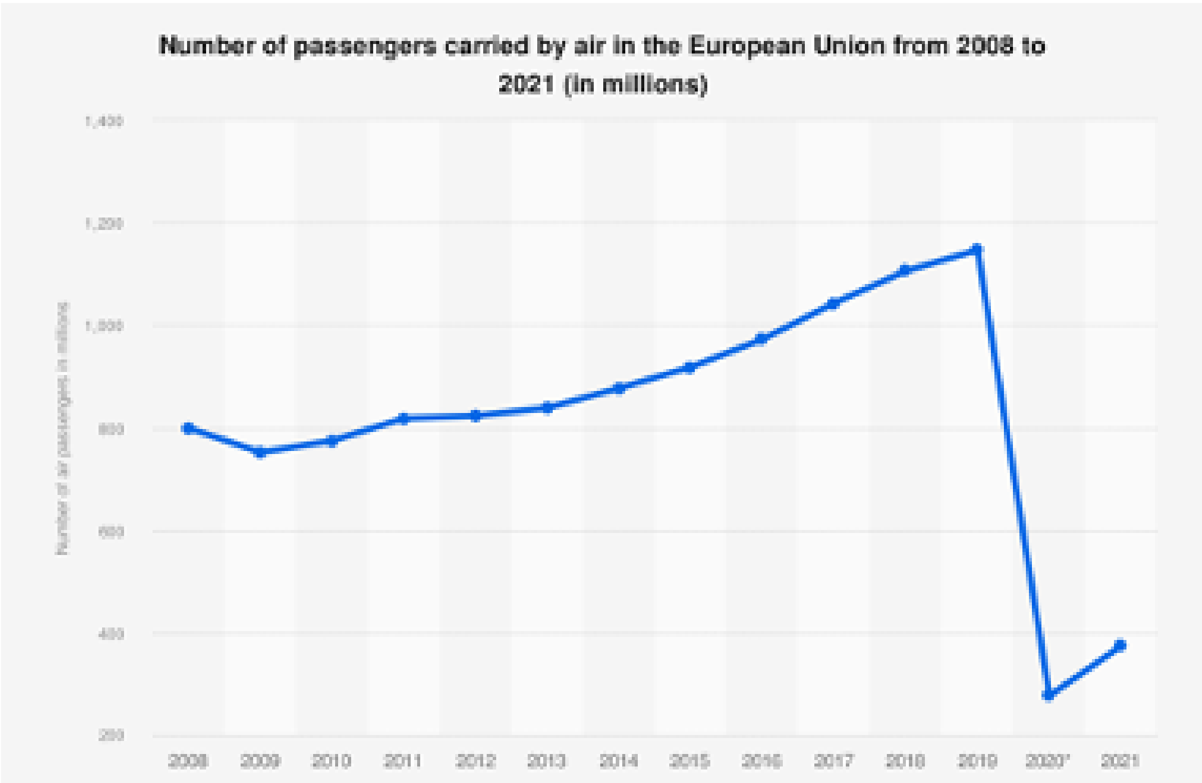

Figure 4.2: Number of airline passengers in Europe between 2008 and 2021 (Source: https://www.statista.com/statistics/1118397/air-passenger-transport-european-union/)

4.3 Data collection

In the following section, we will present our data collection method, how the dataset is constructed, and provide descriptive statistics.

4.3.1 Airlines

Our primary data sources are each carrier's public interim (quarterly) reports. Our focus has been on information about the operational costs and the aircraft fleet. The list of airlines includes:

Airline	Buiness Model/Type
Aegaen	FSNC
Air France-KLM	FSNC – Consolidated
Finnair	FSNC
IAG	FSNC – Consolidated
Air France-KLM	FSNC– Consolidated
Lufthansa Group	FSNC– Consolidated
Norwegian	LCC
Ryanair	ULCC
SAS	FSNC
Wizz air	ULCC

Table 4.1: Qualitative assessment of airline type/model

The sampling is based on several factors but is primarily a strategic choice. Our strategy is purposive sampling, defined as: "With purposive sampling, researchers use their judgment to select cases that will best enable them to answer the research question and meet the objectives (Saunders et al., 2019)". There are sub-types within this type, but we will use heterogenous sampling for this thesis. Heterogenous, purposive sampling uses judgment to choose participants with sufficiently diverse characteristics to provide maximum variation in the data of European airlines. The traffic data provided by Eurocontrol only covers traffic figures inside their jurisdiction, and because of this, we are limited to only looking at European airlines.

The first strategic choice to create maximum variation when sampling regards the business model features; ultra-low-cost, low-cost, and traditional full-service-network carriers (figure 4.3). Selecting airlines for these group are based on a qualitative judgment[16] with two specific considerations: (1) share of ancillary revenue in the income statement, and (2) joint public assessment of the airline. Ryanair and Wizz Air have a high share of ancillary service revenues. This implies that they can be placed more to the figure's left. However,

[16]A qualitative assessment is appropriate when there isn't enough time, money, or data to perform a quantitative assessment. A qualitative assessment is based on the experience, judgment, and wisdom of the members of the assessment team (Gregg, 2006).

this does not mean that they are not low-cost carriers, but their operation can justify them being a ULCC for the sake of this thesis. Historically, Norwegian has been perceived as a low-cost carrier and only offers a few network possibilities. FSNCs are put into two groups, consolidated airlines and not. SAS and Aegean are members of Star Alliance[17], while Finnair is a member of OneWorld[18]. The alliances offer the carriers network possibilities which make them a full-service-network carriers. The three remaining airlines are all consolidated companies – Lufthansa Group, Air France-KLM, and IAG (International Airlines Group). Romero Salgado (2005) concluded that airlines wanted to merge to consolidate domestic markets and expand operations into new external markets.

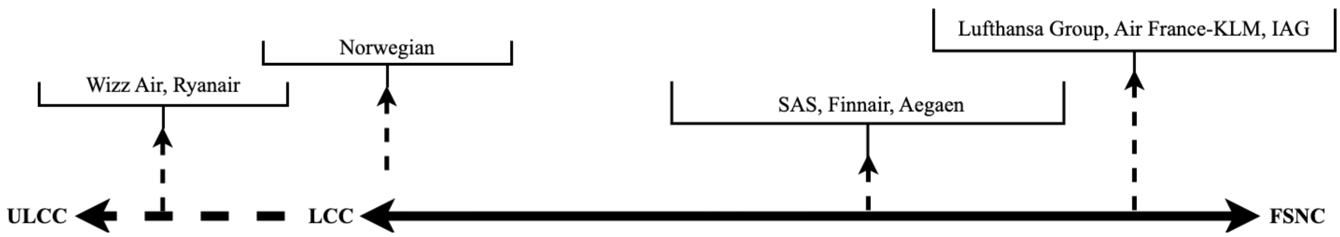

Figure 4.3: Strategic selection of European airlines

Thirdly, all are based in Europe and are the most prominent operators. This gives reliable observations as they have high costs and revenue streams. However, due to our traffic data being limited to European air traffic, limitations are set to conducting this research based on airlines from this area. Initially, we had a selection of the largest airlines in Europe. However, as financial reports are an essential source of our data, we encountered a problem when looking at airlines that are part of larger groups. We were unable to extract financial data for specific airlines from the groups' financial reports and opted to look at a group as one airline (i in the regression).

Income statement

The publication of quarterly reports is not a requirement, but most airlines provide it regardless. There are few regulations compared with annual reports, but every company uses a similar setup, whether yearly or quarterly. To secure measurement accuracy, every quarter in each year has been retrieved using the report for the year after. E.g. Q1 2019 has been retrieved from Q1 2020. The reasoning is that airlines might use different

[17]Star Alliance was founded in 1997 as the first global aviation alliance. Today the alliance consists of 26 airlines that offer "smooth connections across a world-leading global network." (Star Alliance, 2023)
[18]One World is an alliance with thirteen global airlines.

principles which effectively affect periodization. Collecting one-year-old data considers these effects and reflects more reasonable costs. Further one is the airline's total operating cost retrieved. We have also extracted personnel costs as this is used in the model, as **cost per employee**.

$$\text{Cost per employee} = \frac{\text{Personnel Cost}}{\text{Number of Employees}} \tag{4.3}$$

The following section presents the variables used in our regression analysis. Like Zuidberg (2014), this thesis uses a fixed effect model. The model will be explained further in section 4.4.

Fleet information

Each quarter includes all carrier's aircraft characteristics in total numbers and the specific aircraft models. Most quarterly reports provide the average **fleet age**. If the quarterly reports do not contain information about the fleet age, estimations are made based on information found in the annual reports and other sources. (*Specifics of the estimations will be presented in Appendix D*)

The **average seat capacity** of each carrier is gathered from the reports. If the reports does not provide average seat capacity, the airlines webpage has been used to gather information about the seat capacity of their selection of aircraft. The average seat capacity is calculated as a weighted average.

One aircraft characteristic we are looking at is whether a turboprop or jet propulsion engine powers the aircraft. Zuidberg (2014) looks at the average effect of operating a turboprop aircraft with the help of a dummy variable. We have instead opted to look at the relationship between the share of the fleet being powered by **turboprop** and the cost per flight. The reason is that there is considerable variance between our included airlines, and we believe it is unreasonable to look at an average effect when Aegean averages 22 percent share of the fleet while SAS, for instance, averages six percent across the years. The regressor will be the share of the airline's fleet powered by a turboprop in percentage.

To look at the effect of having a homogenous fleet, we include a variable for **fleet commonality**. Fleet commonality is calculated the same way as in Zuidberg's (2014) study:

$$\text{Fleet Commonality} = \frac{\left(\frac{\text{Number of Most Common Aircraft Type in Fleet}}{\text{Number of Aircraft in Fleet}} + \frac{1}{\text{Number of Aircraft Types in Fleet}}\right)}{2} \tag{4.4}$$

Aircraft utilization is another metric used by Zuidberg (2014). It is calculated by deviating the total number of flown kilometers in each quarter on the number of aircraft at the end of the quarter.

$$\text{Aircraft Utilization} = \frac{(\text{Number of Flights} \times \text{Avg Sector Length})}{\text{Number of Aircraft in Fleet}} \tag{4.5}$$

Operational statistics

Each airline in the dataset provides operational information for a given quarter. All airlines include load factor and ASK (Available Seat Kilometers), and some include more as the number of flights, number of passengers, aircraft in use, employees, etc. The allocation base for all costs is the number of flights. However, because not all airlines report this, operational data from another database generates this.

4.3.2 Operational data

We have been provided traffic data containing air traffic to and from all European airports for 2015-2019 by Eurocontrol and contains traffic figures for the last month in each quarter. The dataset has mainly been used to estimate traffic figures for carriers that do not provide them in their interim reports.

Calculations

Route dominance is one of the explanatory variables for the difference in operating cost per flight. With the dataset provided by Eurocontrol, we have calculated route dominance for the airlines for each quarter:

$$\text{Route Dominance Airline X} = \frac{\text{Number of Aircraft Movements by Airline X on All Routes}}{\text{Number of Aircraft Movements of All Airlines on All Routes Airline X Operates}} \quad (4.6)$$

The next variable we have derived from the traffic data is the **airport dominance** of each airline. It is defined as the average airport dominance of all the airports an airline has operations and is calculated as:

$$\text{Airport Dominance} = \frac{\text{Number of Aircraft Movements by Airline X from All Airports Airline X Operates}}{\text{Number of Aircraft Movements by All Airlines from All Airports Airline X Operates}} \quad (4.7)$$

The number of **points served** by each airline is found by summarizing the total number of airports served by each airline.

The dependent variable we are looking at is the cost per flight, and we look at the number of flights as an explanatory variable. Therefore, the total number of flights is essential information for this study. Unfortunately, just a few of the airlines in question report their number of flights in their interim and annual reports. However, most airlines report available seat kilometers (ASK), and with average aircraft capacity and stage length, we can estimate the number of flights for each airline. Specifics are presented in the appendix.

The dependent variable, **cost per flight,** is calculated by dividing the total cost by the number of flights for a given quarter.

4.3.3 Market data

Some information has been retrieved outside the financial reports and the dataset provided by Eurocontrol. First is the **oil price**, where the average price for the given quarter has been retrieved in US dollars (Appendix B). U.S. Energy Information Administration (EIA) provides a historical average of "Europe Brent Spot Price" that keeps track of each month in the given years (U.S. Energy Information Administration, 2023). Every company operates in the same area and is therefore affected by the price in the same way. The price is reported in US dollars.

The currency is different for some airlines in the dataset. For example, although all operate in the eurozone, not all airlines report in euros. Norwegian and SAS announce their numbers in NOK and SEK. Every quarter is adjusted into euros (Appendix B) to account for this. The method for this has been the historical currency change rate, provided online by the European Central Bank)ecb2023exchange). The exchange rate used, is the exchange rate on the last day of the given quarter.

With the following information, descriptive statistics of each carrier are presented in the following table. The table clearly indicates differences in the data set, which will be important evidence when we discuss business models in section 6.6.

	AEE	**AFK**	**DLH**	**FIN**	**IAG**	**NAX**	**SAS**	**RYR**	**WZZ**
Cost per flight	9.39	34.19	31.01	21.47	27.76	15.71	10.93	8.70	9.93
Average stage length	869	1 868	1 393	1 608	2 035	1 636	1 014	1 271	1 587
F**Flights**	28 303	187 386	275 281	29 521	188 757	54 610	77 548	172 236	41 934
Points served	115.58	282.58	279.42	104.58	252.00	103.79	130.47	201.58	129.68
Load factor	0.80	0.86	0.81	0.81	0.82	0.86	0.75	0.96	0.91
Average seat capacity	158.37	199.18	172.20	145.80	191.47	206.45	159.45	188.90	190.42
Aircraft utilization	411 025	672 491	580 074	615 581	734 980	665 751	508 037	569 908	756 334
Fleet commonality	0.40	0.13	0.17	0.16	0.24	0.61	0.29	0.92	1.00
Turboprop %	0.22	0.03	0.04	0.16	0.00	0.00	0.06	0.00	0.00
Fleet age	9.09	12.65	11.70	9.38	11.09	3.46	10.75	6.59	4.37
Cost per employee	12.18	22.64	16.11	18.61	19.39	18.49	14.12	15.23	13.05
Route dominance	0.62	0.71	0.71	0.80	0.58	0.54	0.71	0.80	0.85
Airport dominance	0.16	0.16	0.14	0.15	0.15	0.08	0.12	0.24	0.13

**AEE = Aegaen, AFK = Air Frace-KLM, DLH = Lufthansa, FIN = Finnair,NAX = Norwegian, RYR = Ryanair, WZZ = Wizz air*

Table 4.2: Descriptive statistics of the airlines

4.3.4 Logarithmic transformation

Some of the variables, including the dependent variable, are skewed, and to deal with this, we have used a logarithmic transformation to make them more normally distributed (Benoit, 2011). As we are looking at airlines of different sizes, it is a big variance in some of the variables for the different airlines. Because of this, it is more sensible to look at a percentage change rather than a change in absolute numbers. For example, Air France-KLM has an average of 274 points served, while Norwegian averages 93.

4.3.5 Descriptive statistics and Correlation matrix

All of the mentioned data features of data collection can be summarized in the following tables.

Variable	**N**	**Mean**	**Std. Dev.**	**Min**	**Pctl. 25**	**Pctl. 75**	**Max**
Cost per flight (€*)	168	18.95	9.77	6.671	9.676	28.79	37.82
Average stage length (km **)	168	1527	402	725	1314	1864	2322
Flights	168	118324	87177	18654	38898	186170	326258
Points served	168	178.4	74.53	80	114.8	255.8	323
Load factor (***)	168	0.843	0.067	0.682	0.803	0.886	0.97
Average seat capacity	168	179.3	20.52	130	159.3	195.8	218.8
Aircraft utilization	168	619987	124512	240364	556235	692916	857283
Fleet commonality ***	168	0.426	0.311	0.111	0.183	0.698	1
Turboprop ***	168	0.057	0.075	0	0	0.078	0.242
Fleet age	168	8.854	3.139	2.85	6.487	11.3	14.5
Oil price ($ per barrel)	168	53.60	8.611	33.18	48.16	59.08	69.76
Cost per employee (€*)	168	16.70	4.202	7.13	13.67	19.36	29.09
Route dominance (***)	168	0.701	0.102	0.514	0.593	0.794	0.878
Airport dominance (***)	168	0.145	0.049	0.058	0.117	0.161	0.316

In 1000' euro **In 1000' kilometer * In percent*

Table 4.3: Descriptive statistics of aircraft and route characteristics + oil price

The correlation matrix show the correlation between all of the variables. Table 4.4 on the next page show that, while some variables do not correlate, do others showcase a higher correlation sum. However, our of regression model is meant to take this into account.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Ln(Cost per flight)	1													
(2) Ln(Average Stage length)	0.70	1												
(3) Ln(Flights)	0.45	0.41	1											
(4) Ln(Points served)	0.49	0.43	0.92	1										
(5) Ln(Load factor)	-0.17	0.31	0.18	0.20	1									
(6) Average Seat capacity	0.23	0.55	0.44	0.36	0.55	1								
(7) Ln(Aircraft Utilization)	0.38	0.79	0.33	0.33	0.45	0.46	1							
(8) Ln(Fleet commonality)	-0.74	-0.28	-0.29	-0.38	0.52	0.33	-0.04	1						
(9) Turboprop	-0.21	-0.56	-0.61	-0.45	-0.44	-0.78	-0.58	-0.28	1					
(10) Ln(Fleet age)	0.37	0.00	0.42	0.54	-0.43	-0.42	-0.17	-0.80	0.30	1				
(11) Ln(Oil USD per barrel)	0.04	0.07	0.06	0.08	0.14	0.12	0.10	0.01	-0.05	0.03	1			
(12) Ln(Cost per employee)	0.71	0.61	0.32	0.31	0.08	0.30	0.44	-0.43	-0.23	0.13	0.11	1		
(13) Ln(Route dominance)	-0.26	-0.02	-0.06	0.01	0.25	-0.28	0.04	0.09	0.01	0.07	0.01	-0.14	1	
(14) Ln(Airport dominance)	-0.14	-0.08	0.23	0.29	0.14	-0.18	-0.33	-0.02	0.11	0.37	-0.13	-0.05	0.54	1

Table 4.4: Correlation matrix of aircraft and route characteristics + oil price

4.4 Data analysis

In the following section we will discuss the choice of regression model and an in-depth explanation.

4.5 Choice of regression model

We are working with panel data[19], where the data consists of quarterly observations of nine different airlines spanning from 2015-2019. Our model looks at what factors lead to increased or decreased cost per flight. As we are working with panel data, we believe the fixed effects model to be our best option.

[19]Panel data refers to a longitudinal study in which data is collected on the same subjects or entities over multiple periods, allowing for analysis of changes over time.

The causal model we are trying to estimate is:

$$\begin{aligned}\ln(\text{Cost per flight})_{it} &= \beta_0 + \beta_1 ln(\textit{Average stage length})_{it} \\ &+\beta_2 ln(Flights)_{it} + \beta_3 ln(\textit{Points served})_{it} + \beta_4 ln(\textit{Load factor})_{it} \\ &+\beta_5 \textit{Average seat capacity}_{it} + \beta_6 ln(\textit{Aircraft utilization})_{it} + \beta_7 ln(\textit{Fleet commonality})_{it} \\ &+\beta_8 Turboprop_{it} + \beta_9 ln(\textit{Cost per employee})_{it} + \beta_{10} ln(\textit{Fleet age})_{it} \\ &+\beta_{11}\textit{Oil price}_{it} + \beta_{12} ln(\textit{Route dominance})_{it} \\ &+\beta_{13} ln(\textit{Airport dominance})_{it} + \beta_{14}Q2 + \beta_{15}Q3 + \beta_{16}Q4+ \\ &\beta_{17}2016 + \beta_{18}2017 + \beta_{19}2018 + \beta_{20}2019 + u_i\end{aligned} \tag{4.8}$$

The error term r_{it} can be divided into $\alpha_i + u_{it}$, where α_i is the time invariant effect of individual i (airline i). In our case, we cannot tell for certain what these effects are, but since we are expecting them, we do need to control for these effects.

The observations come from a selection of different airlines across time, and it is expected to be a serial correlation between observations coming from the same individual, in this case the airlines. The random effects model, which is used by Zuidberg (2014) alongside the fixed effects model, is one way to deal with this. However, as the random effects model requires zero covariance between the time-invariant effects of each individual and the regressors to provide a consistent estimate, we will not use this model. In the event of covariance between the time-invariant individual effects and the regressors, the fixed effects model is sufficient to always provide consistent estimations. The main objective of this research is to look at the impact of cost drivers among the selection of airlines and not necessarily make predictions for other airlines. Based on this, we believe that the fixed effects model is the best option for this study.

4.5.1 The fixed effects model

By using the fixed effects model, the study gets a different intercept/constant for each airline. It is to some extent the same as adding a dummy variable for each airline, but to avoid having too many dummy variables, we opted for the fixed effect model. The general model is:

$$Y_{it} = \delta_i + \beta_1 X_{it} + ... + \beta_n X_{it} + u_{it} \tag{4.9}$$

Where δ_i is the constant for airline i, and is equal to $\beta_0 + \alpha_i$. The fixed effect of airline i can be written as:

$$\bar{Y}_i = \beta_1 \bar{X}_i + ... + \beta_n \bar{X}_i + u_i \tag{4.10}$$

As α_i is constant across time, $\alpha_i = \bar{\alpha}_i$[20], and subtracting the fixed effect of airline i from the model will give us:

$$\sum_{n=1}^{\infty} 2^{-n} = 1$$

$$Y_{it} - \bar{Y}_{it} = \beta_1(X_{it} - \bar{X}_i) + ... + \beta_n(X_{it} - \bar{X}_i) + (\alpha_i - \alpha_i) + (u_{it} - \bar{u}_i) \tag{4.12}$$

Which is:

$$Y_{it} - \bar{Y}_{it} = \beta_1(X_{it} - \bar{X}_i) + ... + \beta_n(X_{it} - \bar{X}_i) + (u_{it} - \bar{u}_i) \tag{4.13}$$

We have now removed the α_i (time invariant individual effect) from the model. The regression model we are using is:

20

$$\bar{\alpha}_i = \sum_{n=1}^{N} \alpha_i \cdot \frac{1}{N} \tag{4.11}$$

$$
\begin{aligned}
\ln(\text{Cost per operation}) &= \delta_i + \beta_1 ln(\textit{Average stage length}) \\
+\beta_2 ln(Flights) + \beta_3 ln(\textit{Points served}) + \beta_4 ln(\textit{Load factor}) \\
+\beta_5 \textit{Average seat capacity} + \beta_6 ln(\textit{Aircraft utilization}) + \beta_7 ln(\textit{Fleet commonality}) \\
+\beta_8 Turboprop + \beta_9 ln(\textit{Cost per employee}) + \beta_{10} ln(\textit{Fleet age}) \\
+\beta_{11} \textit{Oil price} + \beta_{12} ln(\textit{Route dominance}) \\
+\beta_{13} ln(\textit{Airport dominance})_{it} + \beta_{14} Q2 + \beta_{15} Q3 + \beta_{16} Q4 + \\
\beta_{17} 2016 + \beta_{18} 2017 + \beta_{19} 2018 + \beta_{20} 2019 + u_{it}
\end{aligned}
\tag{4.14}
$$

A dummy variable for each quarter and each year except 2015 is included in the model to deal with time specific effects that may affect the dependent variable. This is to prevent time specific effects that affect the cost per flight to be picket up by the other regressors.

4.6 Quality of research

Any researcher must ensure that the research can be trusted. A way of doing this is reducing the possibility of getting the conclusion(s) wrong. The quality of the research design relates to the reliability and validity, illustrated by Table 4.5. This demonstrates two dimensions of these terms, internal and external. In 465.1 and 4.6.2, this is elaborated in the context of this research.

	Internal	**External**
Reliability	Ensuring constituency throughout a research project.	If the data collection techniques and analytic procedures would give the same findings if we did the same again or if some other researcher replicated the process.
Validity	To what degree accurately measures the study what it intends to measure without any external causes outside the model?	Can our findings be generalized to other relevant contexts?

Table 4.5: The difference between external and internal reliability/validity (Saunders et al., 2019, p.213-216)

4.6.1 Reliability

Internal

Internal reliability involves all costs measuring the same concept, which is cost drivers. Variables chosen are believed to ensure good internal reliability as they all represent factors that affect costs. These variables are first introduced in the theory chapter, where they are all presented and accounted for. In this chapter, the method for testing them was introduced, and in the next one, this is performed before they are all evaluated in the discussion.

External

To ensure that others can replicate the process, an external evaluation of the sources is one of the first places to start. Numbers retrieved from the annual reports are trustworthy, as all the airlines included in this research are public companies that all publish their annual report following the IFRS code of conduct. The quarterly reports used for financial and fleet information are unaudited; thus, the numbers are not guaranteed to be correct. Quarterly reports, however, are meant to inform investors, and we believe that the airlines in question are to be trusted in their reporting. We also mentioned earlier that the numbers had been collected with one year delay, giving the most reliable data.

The dataset provided by Eurocontrol only contains traffic figures for the last month in each quarter. That means that calculations based on this dataset could be more precise. However, they are deemed as good enough for research purposes by Eurocontrol. Furthermore, the dataset only contains flights to or from airports inside Eurocontrol jurisdiction (and its partners). As we are only looking at European airlines, most of the flights are covered in this dataset, but flights and airports outside this area are not accounted for.

In most cases, the number of flights is calculated with the help of other information. That means that the numbers used for the dependent variable in this research do not precisely match the actual cost per flight for each airline. Nevertheless, it is a relatively accurate estimation based on reliable data. Because of this, we believe the regression results and possible replication can be trusted. The specific effect of each regressor might not be 100 percent correct for the sample, but it will overall give a good indication of the impact of each regressor.

The second part of external reliability is if the analytic procedures can be replicated. Because of the general analytical method, results should be trustworthy and possible to replicate.

4.6.2 Validity

Internal

Taking internal validity into account can be pretty challenging. The research question aims to investigate cost drivers and has chosen the usual types of cost variables. However, other cost drivers outside the model substantially affect costs. These might be weather-related, aircraft malfunctions, financial markets, etc. On the other hand, these are outside the airline's control, making them irrelevant for analysis as we strictly look at factors that can be influenced.

External

External validity means the results can be used for another relevant context outside this research. Firstly, the results are highly relevant for similar European airlines. The selected airlines are strategically chosen based on the characteristics mentioned in 4.3.1. However, the quota represents a wide range of airlines within FSNC to (U)LCCs, and the results apply to all airlines within this range. Secondly, management in global airlines within the same business model range can also assess the effects of the results of their airline as the independent variables are common among all operators. Thirdly, because this thesis focuses strictly on costs, revenues are not a part of the study. However, this does not mean that it is irrelevant for revenue departments or research on the environmental effects of the industry. Both can use the procedure and results to richen their understanding; managers to see how they can increase profits and environmental research on where taxation causes fewer external effects.

5 Analysis

5.1 The econometric results

Table 5.1 and 5.2 shows the results of the econometric analysis of cost influencing factors in the European airline industry. In the following section, we present the variables that significantly affect the cost per flight. This chapter strictly describes the results, while the next chapter, Chapter 6, discusses the results in depth.

Table 5.2 shows the fixed effects[21] of each airline.

Airline	**Fixed effect**
Aegean	4.5016
Air France-KLM	3.6499
Lufthansa Group	3.8529
Finnair	4.0586
IAG	3.9700
Norwegian	4.1112
Ryanair	3.9789
SAS	3.9358
Wizz Air	3.9160

Table 5.1: Fixed effect of each airline

The fixed effects model presents us with proof that airline-output effects exist. Keeping all other variables constant, the number of flights correlates positively with the cost per flight. Our results show that a 10 percent increase in average stage length will increase the cost per flight by 6.39 percent. Naturally, a longer flight will be costlier to operate. Still, the proportional increase in cost being lower than the proportional increase in flight distance suggests that economies of stage length might be prevalent. This is in line with the findings of Caves et al. (1984) and Banker and Johnston (1994). The number of flights is negatively correlated with the cost per flight, and an increase of 10 percent in the number of flights will cause a decrease in cost per flight of 1.67 percent. This is an indication of economies of scale/density being at play and matches with prior literature on cost economies in the aviation industry (Zuidberg (2014), Bailey and Friedlaender (1982), Caves et al. (1984) Gillen and Morrison(2005)). The effect of the number of points served

[21]This effect is the constant (intercept) for each given airline.

positively correlates with the dependent variable and shows that an increase of 10 percent will increase the cost per flight by 2.82 percent. This is evidence of increased cost due to the increased complexity of operations, which Zuidberg (2014) also found evidence of in his study. The effect of the load factor on cost per flight is negative and shows that an unit increase in the logarithmically transformed percentage of load factor causes the cost per flight to decrease by 51.5 percent. This is different from prior literature.

The model also shows that airline-fleet characteristics significantly affect the cost per flight. Aircraft utilization negatively affects the cost per flight, and a 10 percent increase will reduce the cost per flight by 4.27 percent. This follows the findings of Gillen and Morrison (2005) and later Zuidberg (2014). The fleet commonality is also negatively correlated with the cost per flight. One unit increase in the logarithmically transformed fleet commonality decreases the cost per flight by 57.7 percent. The effect of operating turboprop aircraft is also negatively correlated with the cost per flight. A one percent point increase in share of fleet being powered by turboprop will reduce cost per flight by 32.48 percent. This goes with Bitzan and Chi's (2006) findings. Finally, the effect of cost per employee is significantly positively correlated with the cost per flight. An increase in the cost per employee of 10 percent will increase the cost per flight by 4.66 percent. This is one of the main factor inputs, thus an increase in this variable causing an increase in the output is not too surprising and is in line with previous literature (Zuidberg, 2014).

The R-squared of our model is 0.855, which is high. This means that the explanatory power of the model is good. However, it is important to consider the fact that there are many explanatory variables. For example, adding an additional regressor will either strengthen the R-squared or not affect it all. It will never result in a lower R-squared. Additionally, the selection of airlines is relatively homogeneous, which might contribute to a high R-squared.

Lastly, the effects of fleet age, oil price, route and airport dominance, and time-related dummies do not show any sign of significance. Because of this, we cannot reject the null hypothesis of no effect on cost per flight.

	Dependent variable:	
	ln(Cost per flight)	
	Estimate	Std. error
ln(Average stage length)	0.509***	0.185
ln(Flights)	−0.308***	0.086
ln(Points served)	0.686***	0.153
ln(Load factor)	−0.515*	0.297
Average seat capacity	-0.006**	0.003
ln(Aircraft utilization)	−0.387**	0.151
ln(Fleet commonality)	−0.577***	0.081
Turboprop %	−3.248***	0.668
ln(Fleet age)	−0.130	0.152
Oil price in USD per barrel	0.001	0.002
ln(Cost per employee)	0.411***	0.060
ln(Route dominance)	−0.227	0.260
ln(Airport dominance)	0.083	0.106
Q2	−0.056	0.037
Q3	0.013	0.044
Q4	0.034	0.033
‘2016‘	0.0004	0.038
‘2017‘	0.024	0.038
‘2018‘	0.043	0.054
‘2019‘	0.022	0.054
Observations	168	
R^2	0.855	
Adjusted R^2	0.826	
F Statistic (df = 20; 139)	40.903***	
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 5.2: Econometric results: Regression model of airline specific variables

6 Discussion

This chapter goes into a thorough analysis and explanation of the regression results. To fully comprehend these results, it is essential to have a strong understanding of the background information and literature review. Our examination will begin with the results concerning operational characteristics, followed by aircraft fleet characteristics in section 6.2 We will then provide a concise comment on the quarterly independent variables before exploring the implications of the results in section 6.3, which leads us over to 6.4 that comments on the results ofthe input variables. Before the summary, a discussion on how the results affect the cost structure of the traditional business models is implemented. This chapter will conclude with a summary of Chapter 6.

6.1 Implication on Operational Characteristics

Average stage length

The results show that the average stage length increases the cost per flight. This is not unexpected as a long flight will increase inputs such as fuel and employee costs, and it would not make sense if a longer flight would be cheaper to operate than a short flight. What is interesting is the proportional relationship between the increase in flight distance and the increase in cost per flight. One could expect a 120 000-mile flight to be 20 percent costlier to operate than a 100 000-mile flight, and the rise in cost is proportional to the increase in flight distance. The results from the regression analysis show that a 10 percent increase in average stage length will increase the cost per flight by approximately 6 percent. This is evidence of economies of stage length being present. Aircraft are designed to be as efficient as possible during their cruising speed, which is the velocity an aircraft is running at during most of a flight. Take-off, landing, and any part of the flight not run at cruising speed will therefore be less fuel efficient. Thus, it is more economically beneficial that the aircraft operate at cruising speed for as much of the flight distance as possible. By following the logic that the time of the take-off and landing procedures is not affected by the flight distance, it makes sense that an increase in time spent at cruising speed is beneficial in allowing for more optimal use of the aircraft.

Another part of this discussion is the fact that longer flight distances tend to require more fuel. As an example we can use one specific type of aircraft used for two different flight distances carrying the same weight. Naturally, the aircraft operating the shorter flight would require less fuel than the one operating the longer flight. Because of this, the aircraft operating the longer flight would need more fuel, mainly to be able to fly the longer distance, but also to carry the added weight of the extra fuel.

There might be another reason for the disproportional growth in cost per flight. All flights initiate costs that relate to a basis of costs. For example, a web solution for buying tickets, departure costs as check-in service and baggage handling, and arrival services as ground handling. These costs apply for all flights, regardless of distance and might be a reason for economies of stage length.

Lastly, another reason, concluded by Banker and Johnston (1993), is that long-haul flights are often operated by newer and more fuel-efficient aircraft. Fuel is an expensive input which makes their argument reasonable. However, their study is at the time of writing almost 30 years old, so this conclusion might not hold up today.

Flights

Regarding the number of flights, the results show that an increase in the number of flights will reduce the cost per flight. This indicates that economies of scale, specifically economies of density, are at play. The notion here is that increasing the number of flights inside an existing network will allow for a more efficient operation, as a larger scale operation tends to allow for better utilization of certain factors. In this case, more flights allow for a wider distribution of administrative costs that are rarely affected by the number of flights.

Points served

On the other side of this discussion, are the number of points the airline serves. The results show that an increase in the number of destinations causes an increase in cost per flight, holding everything else fixed. One could argue that the number of destinations is a metric of an airline's size in the same as the number of flights. However, it is also a way of defining the complexity of the operation. These findings align with prior studies (Zuidberg, 2014), and the principle of increased cost due to a more diversified product line is a standard economic concept. Therefore, airlines could save costs by concentrating their operation on fewer destinations.

Load factor

One of the more interesting discoveries is the effect that the load factor has on the cost per flight. The results show a negative relationship between the load factor and the cost per flight. We hypothesized that the load factor would decrease the cost per flight based on prior literature that has discovered that a higher load factor leads to lower total operating costs (Caves et al.(1984), Hansen et al. (2001)). The more recent study, Zuidberg (2014), found no significant relationship between the load factor and the cost per operation, which is more relevant to our research. When looking at a flight isolated, it does not make sense to expect the cost of operating this specific flight to fall if the number of passengers increases. If anything, it should go up with the added weight of additional passengers. Our interpretation is a little different, as the research look at the effect load factor has, on average, on a number of flights. It is not necessarily the fact that the load factor is high that causes lower costs. It is instead the causal effect of the high load factor that is the reason for lower costs. We cannot pinpoint the exact reason but will go through some points we believe to be reasonable assumptions.

Of our selection of airlines, Ryanair and Wizz Air have the highest average load factor. Both airlines are so-called ultra-low-cost airlines with lower ticket prices than traditional airlines. As they have lower ticket prices, it is reasonable to believe they rely on a higher load factor to cover their costs than other airlines. This might reflect their strategy as a higher load factor is something they put focus on.

Another reason could be that the consistently high load factor results from better meeting the demand of passengers, which could result from better market analyses and planning in accordance with said analyses. These are again metrics outside of the model, but we believe they affect the cost per flight and that load factor reflects this.

Aircraft utilization

We are looking at aircraft utilization to see if there is any significant effect of having the fleet in operation instead of grounded. Unsurprisingly the two are negatively correlated; higher aircraft utilization causes lower cost per flight. A better air-to-ground ratio, timewise, allows for better distribution of expenses that are not directly tied to the operation. Zuidberg (2014) had similar results, which support the findings. The variable is a metric for how much output each airline gets from the capital costs tied to their aircraft fleet.

Route dominance

The results do not indicate any significant effect of route dominance on the cost per flight. A high route dominance was expected to correlate with higher costs, as airlines with little to no competition (monopoly) would be less cost-effective as they would be able to set higher prices with no threat of competitors undercutting the prices. However, all the observations in the sample have a high average route dominance. The reason is that routes are based on airports rather than cities. For example, the route Heathrow (London) to Charles de Gaulle (Paris) is counted as a different route than the route Gatwick (London) to Charles de Gaulle (Paris). Although they are technically different routes, it is reasonable to assume that most passengers, without connecting flights, do not view them too differently as they connect the same two cities. This goes for all larger cities with multiple airports, which constitute numerous different airport combinations, and thus many different routes. Although an airline has a high route dominance, it might still face competition from other airlines operating similar routes. We did not find any significant effect of route dominance on the operational costs.

Airport dominance

There is no significant effect of airport dominance on the cost per flight either. With the same argument as for route dominance, the results were expected to show that a higher average airport dominance, results in a higher cost per flight. In hindsight, we realized that looking at average airport dominance as an explanatory variable for cost per flight probably was not that good of a measure of dominance. It is, however, interesting in other ways. By operating flights to and from airports with high competition, an airline is bound to have low airport dominance, as no airline today is big enough to have a high airport dominance in a substantial number of their served airports. But if the airline serves airports with lower competition, a high average airport dominance is more likely. In our case, average airport dominance shows to what extent an airline's operation is being run on airports with high or low competition, and we would be able to see if it is less costly to fly to and from less popular airports. As we did not find any significant effect of this explanatory variable, we cannot say whether it does matter in the end.

6.2 Implication on Aircraft Fleet Characteristics

Average seat capacity

The regression did find a significant effect of average seat capacity on the cost per flight. The average seat capacity has been a metric for measuring aircraft size and has previously been used by Zuidberg (2014), and our results indicate that an increase in aircraft size reduces the cost per flight. It is an argument to be made whether this is a good measurement of aircraft size, considering that low-cost carriers tend to have more seats at the expense of passenger comfort compared to traditional airlines in similarly sized aircraft. Regardless, it is the metric of this research and should give a fair understanding of the differences in airlines' fleets. The correlation (see table 4.4) between the average seat capacity and the average stage length is high. This makes sense considering larger aircraft are usually used for long-haul flights and vice versa.

Fleet commonality

The fleet commonality shows a highly significant effect on the cost per flight. By operating a more uniform fleet, the competency required by pilots and technical staff will be less complex/diverse, and the cost tied to staff education will likely be lower. However, earlier literature (Zuidberg, 2014) found no evidence of fleet commonality on cost per flight.

Turboprop

The only fundamental aircraft-specific trait we looked at is whether turboprop or jet propulsion engines power them. Earlier literature has found that aircraft powered by turboprop engines are cheaper to operate than jet-propulsion engine-powered aircraft of the same size (Bitzan and Chi, 2006). The results show that having a larger share of the fleet powered by turboprop engines will lower the cost per flight. One essential thing to keep in mind, is that aircraft powered by turboprop engines are, for the most part, used for shorter distances.

Fleet age

Results do not indicate any effect of the fleet age on the cost per flight. Until this point, the literature has produced results showing that an older fleet can increase the operating cost (Ryerson and Hansen, 2013) and reduce the cost (Zuidberg, 2014). Hazel et al. (2012) concluded that aircraft older than 15 years were cheaper to operate than aircraft between

10 and 15 years old. No significant effect was found by Banker and Johnston (1993), which supports the notion that the higher ownership costs of newer aircraft outweigh the higher maintenance costs of older aircraft (Ryerson and Hansen, 2013). Therefore, our results are in line with some of the earlier literature.

6.3 Implication on Seasonal Effects

In section 2.1.3, the topic of seasonal fluctuation carved out a hypothesis that some months gave significantly lower operating costs per flight than others. However, the results indicate no sign of these. While Q2 shows slightly less than Q1 and Q4 and Q3 a little more, the results are insignificant, and no conclusion is made. The results are surprising as we hypothesized that less demand and, thus, revenue causes airlines to be more cautious of their costs during low season.

6.4 Results of input variables

Oil price

As expected, the results did not show any effect of changes in oil price on the cost per flight. Although Zuidberg (2014) found evidence of higher oil prices resulting in higher operational costs, this research hypothesized that the oil price would not effect cost per flight, as most airlines do fuel hedging. Although jet fuel is one of the main input factors and strictly follows the oil price (Figure 3.2), it is common for airlines to hedge themselves against fluctuations in the oil market. According to their financial reports, most airlines buy their fuel at pre-agreed prices to avoid being affected by sudden changes in the market.

Cost per employee

Unsurprisingly, the regression indicated a positive relationship between the cost per employee and the cost per flight. This is because the employees are necessary for the operation to run, and with a larger scale of operation comes more employees. It then indicates that a higher cost per employee results in a higher operational cost. This matches up with Zuidberg's (2014) result as well.

Because cost per employee has a significant effect on operating costs, airlines should try to cut the costs.

Because of the positive relationship between cost per employee and the cost per flight, airlines could make savings by reducing the personnel cost. However, this might be challenging, as cost per employee is strongly linked with the cost of salary. Figure 6.1 show the differences in median salary across countries in the EU, and there are clear differences. Based on this information, a possible way to decrease the cost per employee would be to employ staff from countries with lower median gross earnings or employ the labor force in foreign subsidiaries with fewer labor benefits. However, the last proposal was one of the reasons for the strike in Norwegian in 2015. The airline wanted to employee the pilots in a subsidiary, but the pilots refused which caused a strike Trumpy and Gran (2022).

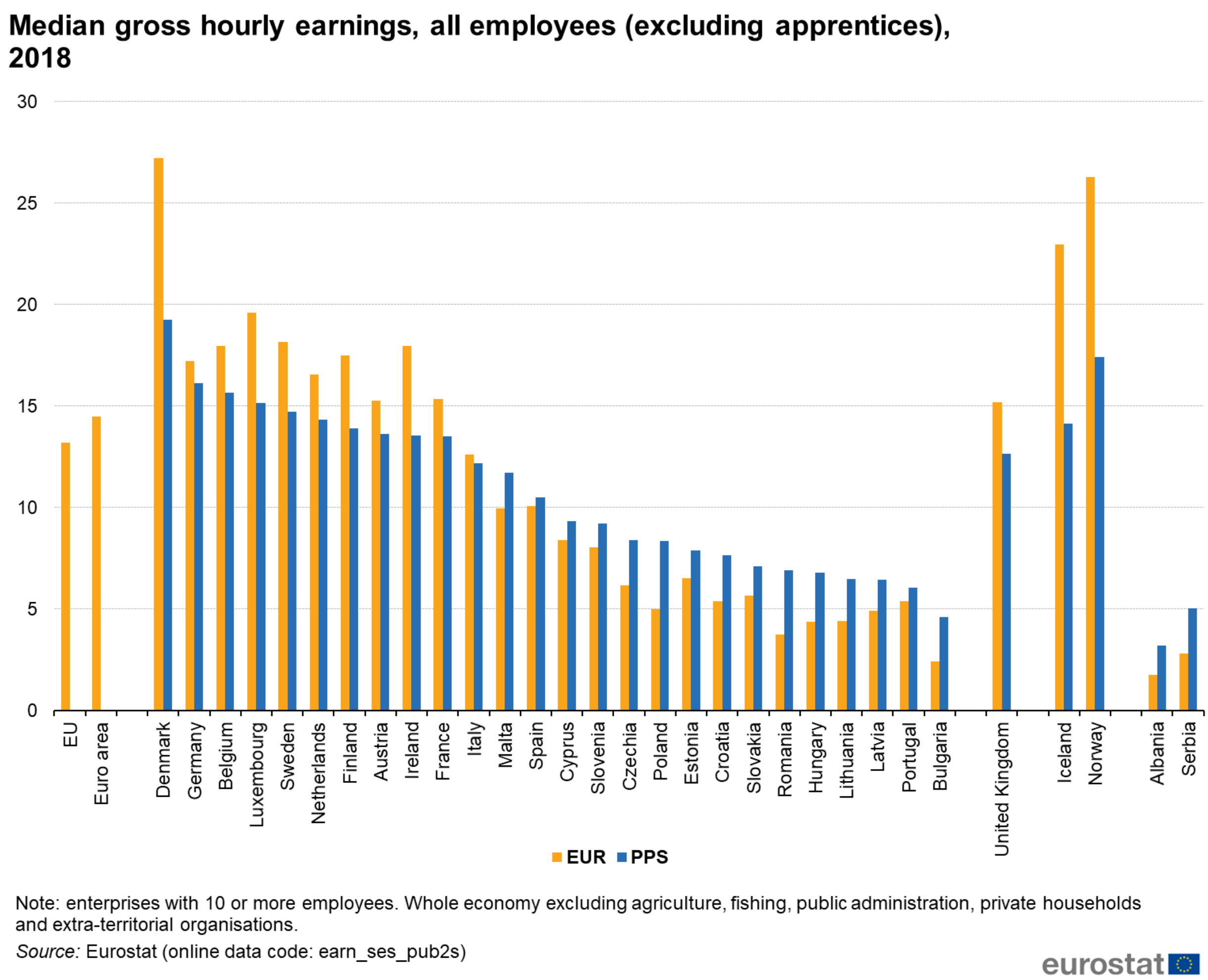

Figure 6.1: Median gross earnings in Europe for 2018

6.5 Complication of results on traditional Business models

Section 3.2 presented some conventional features of business models. However, the presented results contradict some of the literature reviewed, which has implications for interpreting those features.

Low-cost carriers

The first business model features to be discussed is low-cost carriers. The literature review revealed that although LCCs have undermined network carriers' ability to price discriminate, the two business models have converged. In 2012, de Wit and Zuidberg (2012) concluded that LCCs would be limited in Europe by route density, forcing them to adopt strategies from FNSCs to continue growing. The mentioned factors that reduce cost per flight serve as evidence that highlights the distinction in cost structure between low-cost carriers and network carriers. Characteristics of low-cost airlines are high aircraft utilization, fleet commonality, load factor, and that they don't have costly, complex networks. Our results show that all these independent variables significantly affect cost per flight.

An interesting result is that Zuidberg (2014) did not find evidence of fleet commonality having an effect on operational costs. A high fleet commonality is often in an attribute of low-cost carriers. Our dataset shows that Norwegian, Ryanair, and Wizz Air have a high fleet commonality, which is a result that stands out in this thesis.

In addition, cost per employee indicates efficient use of the employees. Low-cost carriers are well known for using this input efficiently. For instance, LCCs rarely offer complementary services onboard, and if they do, the service must be profitable. The effect of cost per employee on cost per flight is significant, which supports the structural differences between the two business models.

Full-service-network carriers

Secondly are the results reducing the cost for traditional full-service-network carriers. In the literature review, we discussed that the benefit of these models is that they create hubs. Economies of density emerge from hub networks as airlines centralize their operation from a few airports. This constitutes evidence supporting the difference in cost structure between the two types of traditional business models in the airline industry.

In addition, full-service-network carriers operate, on average, a more extensive fleet in terms of seat capacity. As a result, these planes are used on routes with a higher average distance or long-haul flights.

Long- vs. short-haul According to Francis et al. (2007), Morell (2008), and Daft and Albers (2012), low-cost carriers can expand into the long-haul market if their revenue is high enough and their costs are low enough. From the regression, the variables in relation to long-haul flights are the most interesting ones. These are average stage length, average seat capacity, and aircraft utilization. Average stage length and aircraft utilization are highly correlated, which is natural as both indicate time in the air. The longer the stage, the better utilization of the plane.

6.6 Section Summary

The findings suggest several implications for the operational characteristics and aircraft fleet characteristics of airlines. Regarding operational characteristics, the study found that higher average stage lengths increases the cost per flight, but proportionally less than the increase in stage length, indicating economies of stage length. This is because longer flights require more inputs such as fuel and personnel costs, but allows for a better utilization of the aircraft which is efficient for the total operation. Increasing the number of flights reduces the cost per flight, indicating economies of scale. However, increasing the number of destinations increases the cost per flight, suggesting that airlines could save costs by focusing on fewer destinations. The right ratio of number of flights to number of points served, causes economies of density. The load factor, which measures the percentage of seats filled on a flight, was found to have a negative relationship with the cost per flight, indicating that higher load factors result in lower costs. This effect are believed to come from a strategic factor that relates to the load factor. Higher aircraft utilization was also associated with lower costs per flight.

Regarding aircraft fleet characteristics, the study found that larger average seat capacity reduces the cost per flight, implying that larger aircraft are more cost-effective. Operating a more uniform fleet, measured by fleet commonality, was found to lower the cost per flight, as it is believed to reduces costs related to training of staff. In addition, having a larger share of the fleet powered by turboprop engines was associated with lower costs per flight. The age of the fleet did not show a significant effect on the cost per flight.

The study did not find any significant seasonal effects on the cost per flight, suggesting that operating costs remain relatively stable throughout the year. Changes in oil prices did not have a significant effect on the cost per flight, as most airlines hedge against price fluctuations in the oil market. The cost per employee was positively related to the cost per flight, indicating that reducing personnel costs could lead to savings for airlines.

Overall, the findings provide insights into the operational and fleet characteristics that influence airline costs and suggest areas where airlines can optimize their operations to reduce costs and improve efficiency.

7 Conclusion and Further Research

7.1 Main findings

The purpose of this thesis was to examine cost drivers in the European commercial airline industry and evaluate a range of variables to see if some influenced cost per operation more than others. Financial and operating data from nine airlines in Europe from 2015 to 2019 has been collected and analyzed. The core of the thesis has been the research questions which has been:

What are the major cost drivers among nine of the largest European airlines that significantly affect their performance?

This thesis has been sort of a continuation of Zuidberg (2014) in the way that our analysis is based on his research with some alterations. One of the reasons for adapting his research strategy is the strength of the analysis. Zuidberg's paper is unique in that it incorporates a diverse range of airline-output variables, airline-fleet variables, and airline-market variables, unlike most existing literature. This reduces the possibility of false or misleading relationships. This strength is further incorporated in this thesis to conduct similar research.

Throughout the theory chapter, an elaboration of general insight of the industry, costs, and a literature review, laid the foundation for twelve hypotheses. This considered (1) number of flights, (2) number of destinations served, (3) average stage length, (4) load factor, (5) aircraft utilization, (6) route dominance, (7) aircrafts size, (8) fleet commonality, (9) turboprop aircraft in fleet, (10) average fleet age, (11) airport dominance, and (12) lower cost in some seasons.

With a fixed-effects regression analysis, our results showed a significant effect of explanatory variables of both operations and fleet-characteristics related. We found significant positive effects of average stage length, number of points served and cost per employee on the cost per flight. Whilst the effects of number of flights, load factor, average seat capacity, aircraft utilization, fleet commonality and use of turboprop aircraft were significantly negative.

This indicates economies of fleet commonality and aircraft utilization. While the notion in the industry has been that changing fleet is a time-consuming process, research by Trethway (2004) shows that this can be done in less time than initially thought. Managers should therefore consider this to save costs.

Other results show that economies of density, stage length and load factor exist. Whilst inputs like cost per employee positively correlate with the operational costs. Low-cost airlines have traditionally had a high fleet commonality, load factor, and aircraft utilization. Additionally, they don't have large networks, which full-service-network carriers have. On the other side, a denser supply of flights, is a cost saving element typical for traditional FSNCs.

7.2 Limitations

All master theses with constrains on resources has its limitations. For this thesis, the most constraining resource has been time. The implications are a less comprehensive empirical data collection than originally wanted. We believe that more time would have given us the possibility of testing for additional characteristics, and possibly look at more specific aircraft features.

Loss of empirical observations weakens the internal validity to the study. However, the research strategy is an explanatory study, and the limitation of the study is set by us, and not the lack of data. The outline and rules of the research are already set in the preliminary, and lack of data does not affect the study when what we want to explain is decided. Banker and Johnston (1994) performed a more extensive research on aircraft characteristics which this thesis could not replicate. We acknowledge that there exists cost drivers outside of the model that contribute to costs per flight.

Some of the variables we look at are highly correlated. This causes problems with identifying what effect each driver really has on the cost per flight. In a real world scenario it is often hard to distinguish the isolated effect of a factor, as they often build on each other, which is the case in our study. Although this is a weakness of our study, we do believe that our discussion an reasoning gives a valuable insight to how these variables affect each other.

Furthermore, due to the large data size of the nine airlines, we have examined all airlines from an external standpoint. This approach causes limitations regarding the level of validity, as our analysis is based on publicly accessible information. Had our focus been solely on one company, it may have been possible to acquire confidential information exclusively from a single airline. In that case, it would have been necessary to classify the entire thesis as confidential. The implication of such confidential information could have enhanced the validity of our data material. However, because airlines use different business models, we believe that using an external perspective with more airlines is a better strategy for answering the research question.

7.3 Further research

The recent years has the prices of airlines tickets increased, compared with years before the pandemic. Future research can add a factor that measure revenue, either with total revenue or revenue per passenger. Other suggestion is adding other characteristics that are non-related to costs. For instance, company Credit rating[22] can be implemented to help understand the airlines better. An assumption has been that the financial situation to the airlines is solid enough for further operation for an indefinite time. Risk rating handles this assumption realistically. Finally, while the discussion included business models, the regression did not as it is hard to measure airline strategies in a numeric value. Future research that enables to distinguish them in with quantitative assessment, shall include this in the analysis.

[22]Credit Ratings are opinions about credit risk. They offer a perspective on an entity's ability and willingness to fulfill its financial obligations in a timely manner, as well as the creditworthiness of a specific debt instrument, like a corporate or municipal bond, and the likelihood of potential default(S&P Global, 2023)

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Appendix

Appendix A - Income Statement: Collected airlines - Years with Quarters

		SAS	NAX	FIN	RYR	WZZ	DLH	AEE	AFK	IAG
2020	**Q4**	X	X	X	X	X	X	X	X	X
	Q3	X	X	X	X	X	X	X	X	X
	Q2	X	X	X	X	X	X	X	X	X
	Q1	X	X	X	X	X	X	X	X	X
2019	**Q4**	X	X	X	X	X	X	X	X	X
	Q3	X	X	X	X	X	X	X	X	X
	Q2	X	X	X	X	X	X	X	X	X
	Q1	X	X	X	X	X	X	X	X	X
2018	**Q4**	*X*	*X*	*X*	X	X	X	X	X	X
	Q3	*X*	*X*	*X*	X	X	X	X	X	X
	Q2	*X*	*X*	*X*	X	X	X	X	X	X
	Q1	*X*	*X*	*X*	X	X	X	X	X	X
2017	**Q4**	*X*	*X*	*X*	X	X	X	X	X	X
	Q3	*X*	*X*	*X*	X	X	X	X	X	X
	Q2	X	X	X	X	X	X	X	X	X
	Q1	X	X	X	X	X	X	X	X	X
2016	**Q4**	*X*	*X*	*X*	X	X	X	X	X	X
	Q3	*X*	*X*	*X*	X	X	X	X	X	X
	Q2	*X*	*X*	*X*	X	X	X	X	X	X
	Q1	*X*	*X*	*X*	X	X	X	X	X	X
2015	**Q4**	*X*	*X*	*X*	X	X	X	X	X	X
	Q3	*X*	*X*	*X*	X	X	X	X	X	X
	Q2	*X*	*X*	*X*	X	X	X	X	X	X
	Q1	*X*	*X*	*X*			X	X	X	X

**NAX = Norwegian, FIN = Finnair, RYR = Ryanair, WZZ = Wizz air, DLH = Lufthansa, AEE = Aegaen, AFK = Air Frace-KLM,*

Appendix B - Collected oil price and currency conversion rate for each quarter

		Brent Crude Oil*	Currency (1 EUR =)**	
		In U.S dollar	***NOK***	***SEK***
2020	**Q4**	42.45	10.47	10.03
	Q3	40.89	11.10	10.57
	Q2	27.80	10.91	10.49
	Q1	45.75	11.51	11.06
2019	**Q4**	56.95	9.86	10.45
	Q3	56.37	9.90	10.70
	Q2	59.78	9,69	10.55
	Q1	54.82	9.65	10.41
2018	**Q4**	59.07	9.94	10.25
	Q3	69.75	9.45	10.32
	Q2	68.03	9.51	10.45
	Q1	62.88	9.66	10.29
2017	**Q4**	55.36	9.81	9.84
	Q3	48.16	9.40	9.63
	Q2	48.24	9.57	9.64
	Q1	51.76	9.17	9.53
2016	**Q4**	49.13	9.07	9.55
	Q3	44.85	8.99	9.62
	Q2	45.40	9.30	9.42
	Q1	33.18	9.41	9.23
2015	**Q4**	41.95	9.60	9.19
	Q3	46.41	9.52	9.40
	Q2	57.84	8.79	9.22
	Q1	48.54	8.70	9.29

**The price for each quartar is an average based on the end price of each day in the given quarter. Data is collected from the U.S Energy and Informaiton Administration (EIA)*
***The currency for each quarter is the exchange rate on the last day of the quarter. Data is collected from the European Central Bank*

Appendix C: Calculation of total costs

Norwegian

For the years 2020-2018 equals total operating costs: "Total operating expenses excl lease, depr. and amort." + "Aircraft lease, depreciation and amortization". For 2018-2015 equals total operaing costs: "Total operating expenses excl lease, depr. and amort." + "Leasing" + "Depreciation and amortization".

SAS

For SAS, their reports are shifted with a month each quarter. Q1 goes from February-April, Q2 from May-August on so on. For 2018-2015 equals total operaing costs: "Revenue" - "Operating income (EBIT)".

Finnair

For the years 2020-2015 equals total operating costs: "Revenue" - "Comparable EBITDA" + "Depreciation and impairment" However, for Q2 does the company only supply a Half-year Report. The numbers for Q2 are founded by subtracting the half year numbers by the Q1 numbers. The same is for Q4 where the company only gives out the "Annual Report 20xx". The same method is used but here we have subtracted Q1-Q3 from the Total Operating Costs.

Ryanair

Rynair have Q1, H1, Q3 and Full-year reports available. The last collected quarter is "Q3 FY 22" which equals Q4 2021. This means that every quarter is 3-months late. For Half and Full-year, we use the same subtracting method described for Finnair. For the years 2020-2015 equals total operating costs: "Total operating expenses".

Wizz Air

Wizz air supply reports with the same shift in months as Ryanair and supply the same type of reports: Q1, H1, Q3 and FY. The same method is used as for Ryanair. For the years 2020-2015 equals total operating costs: "Total operating expenses".

Lufthansa Group

Lufthansa Groups provides an income statement for Q1-Q3. For Q4 we use the "Annual report 20xx" and use the same method described previously. For the years 2020-2015 equals total operating costs: "Total Revenue" - "Profit / loss from operating activities".

Aegaen

Aegaen published "First Quarter", "First Half", "Nine month", and "Full Year". For the three first do all supply quarterly reports. For last quarter, we use same subtracting method as earlier mentioned. For the years 2020-2015 equals total operating costs: "Total Revenue" - "EBITDAR" + "Aircraft Leases" + "Depreciation" For 2020 is "Leases" included in the "EBITDAR" and therefor not added.

Air France-KLM

Air France-KLM provided "First Quarter", "Second Quarter", "Third Quarter" and "Full-Year". For last quarter, we use same subtracting method as earlier mentioned. For the years 2020-2015 equals total operating costs: "Revenues" - "EBITDA" + "Amortization, depreciation and provisions".

IAG

Internatioanl Airline Group (IAG) provides "Three months", "Six months", "Nine months", and "Full Year". However, all reports includes the three months (quarter) leadning up to the end of the period. For the years 2020-2015 equals total operating costs: "Total expenditure on operations".

Appendix D - Fleet Information

Norwegian

Norwegian only provides complete fleet information in their annual reports. The quarterly reports does contain information about acquisition and sales of aircraft. By thorough reading of the quarterly reports, we have estimated the fleet composition for each quarter, with the yearly fleet updates as the base. The fleet age is only found in the annual reports. The fleet age is calculated as:

$$age\,Q1 = age\,Q4_{previous\,year} + 0.25 \quad (.1)$$

$$age\,Q2 = age\,Q4_{previous\,year} + 0.5 \quad (.2)$$

$$age\,Q3 = age\,Q4 - 0.25 \quad (.3)$$

As the fleet of Norwegian has been somewhat stable and without major changes during the time period of our study, we believe that these estimations are reasonable.

SAS

SAS presents their fleet in all quarterly reports. The fleet is devided into narrow body, wide body and smaller aircraft. Because of this there is not specified a specific number for each aircraft model. For calculations of fleet commonality, the most used aircraft model has been retrieved from the dataset provided by Eurocontrol. The fleet's average age is presented in all quarterly reports.

Finnair

Finnair presents all fleet information necessary to this master thesis in all quarterly reports.

Ryanair

Ryanair presents all fleet information necessary to this master thesis in all quarterly reports. The fleet age is provided in the half year report and the annual report. The fleet age is calculated as:

$$age\,QT = \frac{(age\,Q_{T-1} + 0.25) + (age\,Q_{T+1} - 0.25)}{2} \quad (.4)$$

As the fleet of Ryanair has been stable and without major changes during the time period of our study, we believe that these estimations are reasonable.

Wizz Air

Wizz Air presents all fleet information necessary to this master thesis in all quarterly reports.

Lufthansa Group

The Lufthansa Group only presents their complete fleet information in their half year report (end of Q2) and in their annual report. The numbers of each aircraft in Q1 has been the average of the number of each aircraft between Q4 the previous year and Q2. The numbers of each aircraft in Q3 has been the average of the number of each aircraft between Q2 and Q4. The fleet age is provided in the half year report and the annual report. The fleet age is calculated as:

$$age\,QT = \frac{(age\,Q_{T-1} + 0.25) + (age\,Q_{T+1} - 0.25)}{2} \qquad (.5)$$

As the fleet of The Lufthansa Group has been stable and without major changes during the time period of our study, we believe that these estimations are reasonable.

Aegean

Aegean presents the numbers of all of their aircraft in their quarterly reports. Fleet age is not presented in any official media, thus unofficial sources has been used. With the dataset provided by Eurocontrol we have been able to look up the aircraft registration of each aircraft in operation during a given quarter. With Airfleets.net, we have been able to look up most of the aircraft and gather information about their age. With this information we have calculated the average fleet age for each quarter.

Air France-KLM Air Frnace-KLM has presented the numbers of all their aircraft in their quarterly reports. Fleet age is not presented. The current fleet age is gathered from the airline's web page. KLM publishes their own reports, which includes the fleet age of the KLM fleet. As the Air France and KLM are similar airlines and are part of the same group, we believe the KLM fleet age-development to be a sufficient estimate for the whole group. With the current fleet age of Air France-KLM and the changes in fleet age of KLM, we have calculated the fleet age of Air France-KLM from 2015-2019. The reason we opted to do it this way has to do with time limitations. The method used for gathering the fleet age of Aegean was time consuming, and the Air France-KLM fleet is nearly ten times the size of the Aegean fleet. We simply did not have the capacity to such an in-depth examination of the fleet age.

IAG IAG only presents their complete fleet information in their half year report (end of Q2) and in their annual report. The numbers of each aircraft in Q1 has been the average of the number of each aircraft between Q4 the previous year and Q2. The numbers of each aircraft in Q3 has been the average of the number of each aircraft between Q2 and Q4. The fleet age is provided in the half year report and the annual report. The fleet age is calculated as:

$$age\,QT = \frac{(age\,Q_{T-1} + 0.25) + (age\,Q_{T+1} - 0.25)}{2} \tag{.6}$$

As the fleet of IAG has been stable and without major changes during the time period of our study, we believe that these estimations are reasonable.

Appendix E - Calculations of the number of flights for Ryanair

Ryanair is the only airline included in this study that does not report their ASK. Because of this we have calculated the number of flights differently compared to the other airlines. In their annual report, Ryanair report the total number of sectors flown during the year. With the dataset provided by Eurocontrol, we have looked at what share of total flights during a year each quarter makes up. This percentage number has been multiplied with the number found in the annual report to estimate the number of flights in each quarter:

$$Total\,number\,of\,flights\,from\,annual\,report \cdot \frac{N\,of\,flights\,during\,QT}{N\,of\,flights\,during\,the\,year} \tag{.7}$$

Appendix F - List of airlines included

	Included airlines
Aegean	-Aegean -Olympic Air
Air France-KLM Group	-Air France -Hop -KLM -Martinair -Transavia
Finnair	-Finnair -Norra
IAG	-Aer Lingus -British Airways -Iberia -Level -Vueling
Lufthansa Group	-Brussel Airlines -Eurowings -Lufthansa -Swiss Airlines -Austrian Airlines
Norwegian	-Norwegian
Ryanair	-Buzz -Lauda -Malta Air -Ryanair
SAS	-SAS
Wizz Air	-Wizz Air