Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Statistics

Bachelor Thesis

Low-Cost Carriers and the European Airline Industry

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

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Economics and Management

Thesis title

Low-Cost Carriers and the European Airline Industry

Objectives of thesis

The main objective is to identify and assess the key characteristics and business models of low-cost carriers and traditional carriers in the European airline industry.
The specific objectives are:
i) To examine the economic performance of low-cost carriers and traditional carriers in terms of key financial indicators, such as revenue, profit, and return on investment.

ii) To compare and contrast the business models and economic performance of low-cost carriers and traditional carriers, highlighting the differences and similarities between the two.

iii) To explore the factors that influence the success or failure of low-cost carriers and traditional carriers in the European airline industry.

Methodology

The study will use a combination of quantitative and qualitative research methods. The quantitative analysis will involve statistical analysis of secondary data to identify trends and patterns in the airline industry's economic performance for low-cost carriers and traditional carriers. The qualitative analysis will involve a review of the literature and interviews with industry experts to provide insights into the underlying factors shaping the industry's economic performance.

The proposed extent of the thesis

30 – 40 pages

Keywords

Europe, airline, economy, business model, performance, profit, statistical analysis.

Recommended information sources

COOK, G. – BILLIG, B. Airline Operations and Management 2nd Edition. Routledge, 2023. ISBN 978-1032268729

CREATON, S. Ryanair: The Full Story of the Controversial Low-Cost Airline. Aurum Press, 2007. ISBN 9781845132934

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KOČENDA, Evžen; ČERNÝ, Alexandr; KODERA, Jan; VOŠVRDA, Miloslav; HAVLÍČEK, Jan. *Elements of time series econometrics : an applied approach.* [Prague, Czech Republic]: Karolinum, 2014. ISBN 9788024623535.

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Declaration

I declare that I have worked on my bachelor thesis titled "Low-Cost Carriers and the European Airline Industry" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 14.03.2024 ____________________________

Acknowledgement

I would like to thank my supervisor, Ing. Tomáš Hlavsa, Ph.D. for his invaluable guidance and support throughout the research and writing process of this thesis. His expertise, insightful feedback, and immense patience were instrumental in shaping this project into its final form.

Low-Cost Carriers and the European Airline Industry

Abstract

This thesis delves into the impact of low-cost carriers (LCCs) on the European airline industry, employing a quantitative comparison with traditional carriers. Utilizing regression models and time series analyses, the study examines key operational strategies like average flight distance, fleet composition, and ancillary fee structures. It then delves into financial performance, identifying key variables influencing passenger numbers and profit margins, such as ticket pricing strategies, operational efficiency, and fuel costs.

Additionally, the study explores broader implications for passengers, including changes in travel patterns and accessibility, as well as environmental concerns surrounding LCC operations. The analysis reveals significant differences between LCCs and traditional airlines in terms of their approaches to these aspects, offering valuable insights into the competitive dynamics of the industry.

Keywords: Europe, airline, economy, business model, performance, profit margin, passengers, statistical analysis, time series.

Nízkonákladoví dopravci a evropský letecký průmysl

Abstrakt

Tato práce se zabývá dopadem nízkonákladových dopravců (LCC) na evropský letecký průmysl a využívá kvantitativní srovnání s tradičními dopravci. S využitím regresních modelů a analýz časových řad studie zkoumá klíčové provozní strategie, jako je průměrná letová vzdálenost, složení flotily a struktura vedlejších poplatků. Dále se zabývá finanční výkonností a identifikuje klíčové proměnné ovlivňující počet cestujících a ziskové marže, jako jsou strategie tvorby cen letenek, provozní efektivita a náklady na palivo.

Studie dále zkoumá širší důsledky pro cestující, včetně změn v cestovních zvyklostech a dostupnosti, jakož i environmentálních problémů souvisejících s provozem LCC. Analýza odhaluje významné rozdíly mezi LCC a tradičními leteckými společnostmi, pokud jde o jejich přístup k těmto aspektům, a nabízí cenné poznatky o konkurenční dynamice odvětví.

Klíčová slova: Evropa, letecká společnost, ekonomika, obchodní model, výkonnost, ziskové rozpětí, cestující, statistická analýza, časové řady.

Table of content

1. Introduction

The European airline industry has become a battleground for contrasting philosophies: the established giants - traditional carriers, and the agile disruptors - low-cost carriers (LCCs). This thesis embarks on a quantitative exploration of this dynamic landscape, focusing on a comprehensive comparison between the two.

LCCs, with their innovative business models and aggressive pricing strategies, have carved out a significant market share. This study delves into their core strategies and operational differences compared to their traditional counterparts. Network development, pricing structures, and service offerings will be analysed using empirical data to understand their competitive advantages and challenges.

But understanding the financial implications of this disruption is crucial. This thesis goes beyond qualitative comparisons and builds regression models and time series analyses. The relationship between number of passengers, profit margins, and key operational variables for both LCCs and traditional carriers will be examined. This quantitative approach provides concrete insights into the financial impact of LCCs and sheds light on the competitive dynamics within the industry.

However, the comparison doesn't end at financial metrics. This thesis analyses the impact of LCCs on passenger demographics, travel patterns, and the overall accessibility of air travel. Additionally, the environmental concerns surrounding LCC operations and their contribution to the industry's sustainability efforts are examined.

By combining a comparative approach with quantitative analysis, this study aims to provide a comprehensive understanding of the LCC phenomenon in the European airline industry. It offers valuable insights for industry professionals, policymakers, and anyone interested in the future of aviation.

2. Objectives and Methodology

2.1 Objectives

The main objective is to identify and assess the key characteristics and business models of low-cost carriers and traditional carriers in the European airline industry. The specific objectives are:

i) To examine the economic performance of low-cost carriers and traditional carriers in terms of key financial indicators, such as revenue, profit, and financial efficiency.

ii) To compare and contrast the business models and economic performance of low-cost carriers and traditional carriers, highlighting the differences and similarities between the two.

iii) To explore the factors that influence the success or failure of low-cost carriers and traditional carriers in the European airline industry.

2.2 Methodology

This study will employ a mixed-methods approach combining quantitative and qualitative research techniques. The quantitative component will involve analysing secondary data through time series and regression models to uncover trends and patterns in the economic performance of the airline industry, specifically comparing Ryanair to British Airways. The qualitative aspect will focus on reviewing existing literature to explore the underlying factors influencing the industry's economic performance.

3. Literature Review

3.1 Evolution of Low-Cost Carriers (LCCs) in Europe

Modern European aviation is not complete without low-cost airlines (LCCs). The largest airlines on the continent are operated by some of these businesses. However, compared to a traditional full-service airline, this kind of operator is a little more recent on the market.

Opening up competition in Europe has been a constant trend since the Single European Act of 1986. Beginning in 1987, three liberalization initiatives were put into place. Thus, by the middle of the 1990s, all trade barriers that prevented European airlines from operating within the EU had been lifted. As a result, there is now a single aviation market among the member nations, as well as Norway, Iceland, Switzerland, and some other relevant neighbors. (Britannica, 1987)

In 1996, the European Union reported that 20 new airlines have been created since the signing of The Single European Act in 1986 (Bijan Vasigh, 2013).

The process of liberalization had a number of significant effects. In the European Community, two carriers served 30% of the routes in 1996, and three or more carriers covered 6% of the routes. In 1993, the latter number was merely 2%. In addition, 520 routes were flown, up from 490 three years earlier. This was accompanied by the emergence of 80 new operators and the phase-out of 60 others, underscoring the intensifying competition on the continent. Notably, when more airlines entered the market, prices declined on the routes they served, bringing cheaper costs with them. (Singh, Simple Flying, 2021)

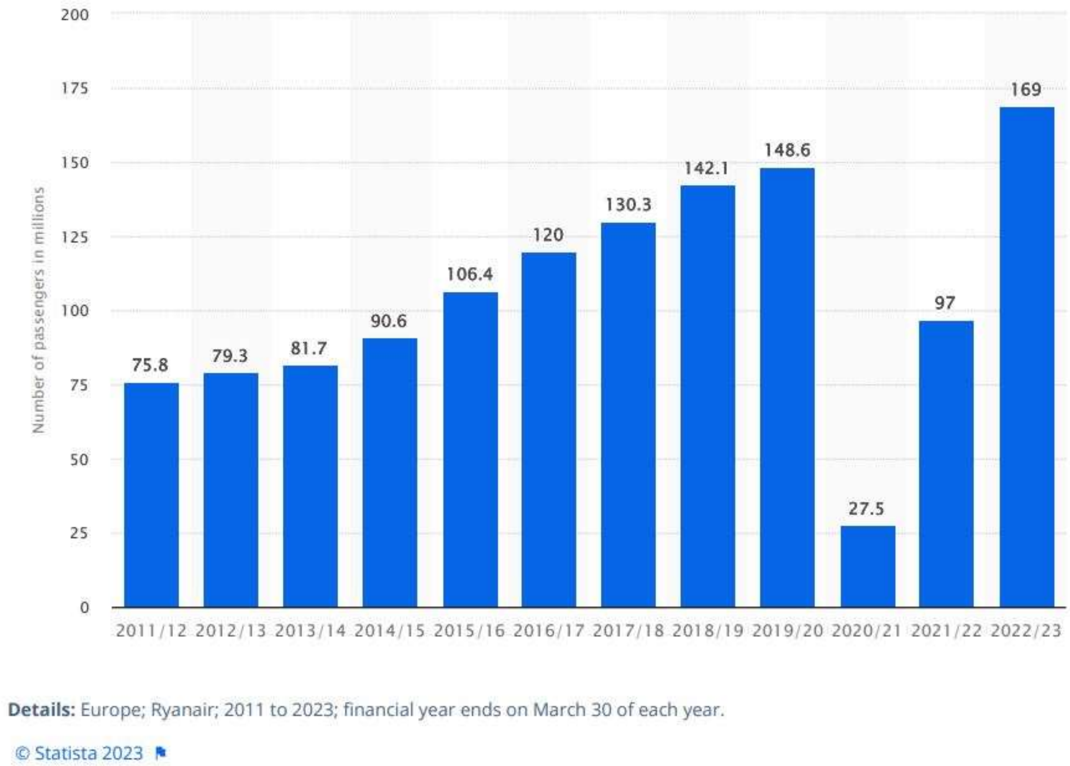
EasyJet made its debut at this time as one of the most renowned LCCs. In March 1995, the British carrier was established. The mix of acquisitions and base openings, which were encouraged by passenger demand for low rates, helped it flourish successfully. (Singh, Simple Flying, 2023)

According to the number of passengers serviced, low-cost airlines now make up half of the top 20 airlines in Europe. Ryanair carried approximately 150 million passengers in 2019 (Ryanair, 2019). Furthermore, the growth of LLCs continued far into the 1990s.

Obrázek 1 Current Ryanair logo (Logos World, 2023)

To understand how the rise of low-cost airlines has impacted the aviation landscape, it's essential to investigate the financial health of key players in this sector. Ryanair, a standout among low-cost carriers, provides a compelling case study, as it carried a staggering 150 million passengers in 2019, underscoring its immense influence in the European market.

The increase in passengers is evidence of the popularity of low-cost airlines, but it also begs interesting concerns about the business models and financial standing of firms like Ryanair. Let's examine how financially this successful carrier has performed despite this increase in passenger numbers.



Obrázek 2 Ryanair passengers carried (Statista, 2023)

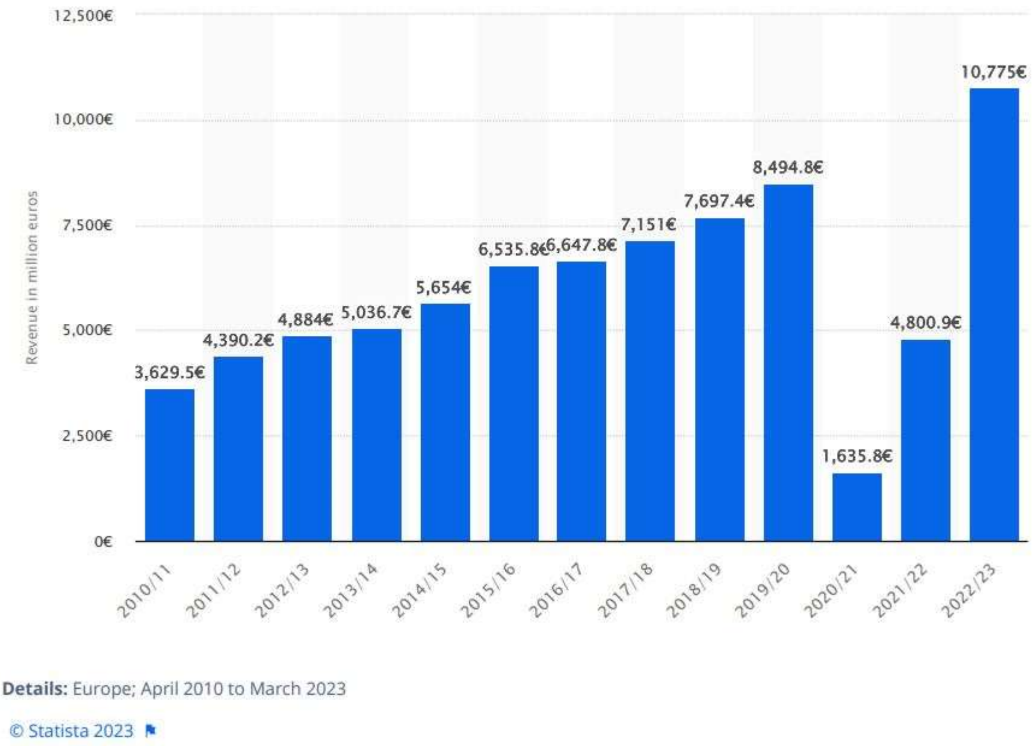
The amazing milestone of 150 million passengers carried by Ryanair in 2019 demonstrates the airline's enormous reach and popularity. This number of passengers points to the airline's success in attracting customers with its aggressive pricing, broad network of routes, and commitment to provide inexpensive air travel alternatives.

This remarkable number ranks Ryanair among the busiest airlines in Europe. The success of the airline is not just due to its low fares, but also to its unwavering dedication to operational efficiency, which enables it to provide cost-effective services while catering to a sizable and varied client base.

Ryanair's capacity to continually carry millions of passengers a year illustrates its adaptability and significance within the European aviation market as the aviation sector continues to develop and consumer tastes shift.

This growth is more than simply a numerical accomplishment; it is also concrete proof of the enormous influence Ryanair has had on the way people travel throughout the continent. The airline's affordable fares and wide-ranging route network have not only increased accessibility to air travel but also transformed how tourists see Europe.

This influential presence in the European aviation landscape significantly contributes to Ryanair's annual revenue figures. The revenue is a direct result of the millions of passengers it transports and the services it provides to a diverse and growing customer base. As we look into Ryanair's annual revenue, we gain further insights into the financial health and success of this influential low-cost carrier.



Obrázek 3 Ryanair revenue (Statista, 2023)

In recent years, Ryanair's yearly income has increased significantly, regularly topping billions of euros. This incredible financial success is a result of the company's constant dedication to cost effectiveness, which allows it to provide passengers reasonably priced travel alternatives while still operating profitably.

The airline's extensive route network and persistent commitment to operational excellence are strongly related to its capacity to produce sizable income. Through the use of this tactic, Ryanair has been able to draw in a wide range of steadily expanding customers, making it one of the most well-known and often used airlines in all of Europe.

The global travel restrictions and decreased passenger demand resulted in a significant drop in Ryanair's revenue in 2020. The airline's capacity was drastically reduced as a result of the pandemic forcing it to ground a sizable section of its fleet. The yearly income numbers, which in previous years had constantly topped billions of euros, suffered a significant decline. However, in 2021 the airline started to recover and in 2022 it managed to set a new revenue record. (Statista, 2023)

“Ryanair Holdings net profit margin as of June 30, 2023 is 14.96%. “, according to macrotrends website (Macrotrends, 2023),

Companies like Wizz Air were established in the new century and are now expanding not just in Europe but also globally. Originally founded in Hungary in 2003, Wizz Air initially focused on serving European destinations. However, over the past two decades, it has rapidly evolved into a global airline giant beyond European borders, serving destinations in Asia, Northern Africa and the Middle East. (WizzAir, 2023)

An investigation of the effects of the growth of LCCs was performed by the International Civil Aviation Organization (ICAO). The status quo of the European aviation sector was undoubtedly influenced by the rise of low-cost carriers.

"*In contrast to the rapid growth in the number of flights and seats supplied by the low cost carriers, the output of full service providers has either stagnated or contracted. The main carriers therefore find themselves in somewhat less dominant market positions in their home market. Customers have not lost out in terms of the routes served or the flights offered, but the incumbents have marginally reduced in importance in these markets. However, relatively few of the short haul markets served from London by the major carriers have experienced a reduction in capacity, which is most likely due to the need for these carriers to feed passengers into their long-haul network. This would seem to suggest that in the principal short haul markets, low cost developments have not forced network carriers to retrench. It is in the smaller markets that incumbents are more likely to reduce capacity in the face of increased competition*." (ICAO, 2003)

As we entered the new millennium, LCCs kept on rising. As they mastered their strategy, their market share kept increasing.

"The low-cost carriers rapidly made substantial inroads in the intra-EU market after the liberalisation, partly by generating new demand on unique routes partly by cannibalising demand of full-service carriers in direct competition on the same routes and partly also indirectly on parallel or semi parallel routes. The low-cost market share in Europe grew in the period 2001-2013 from 3% to 27%," (Burghouwt, Mendes de Leon, & de Wit, 2015)

"The difference in airfares between full-service carriers and low-cost carriers reflected in the structurally lower unit costs strongly contributed to this growth in market share by generating new low fare demand." (Burghouwt, Mendes de Leon, & de Wit, 2015)

Some older airlines eventually had to change to the new environment. For instance, in 2004 the company Monarch Airlines changed its business model in favor of a low-cost strategy. The company thereafter stopped operating in 2017. (Martin, 2017)

In all, low-cost airlines gave the general public and business a number of fresh options. Flying across Europe has became more affordable than traveling the same distance by train. Concerns have been raised regarding the capacity to maintain this strategy in the face of changes like Brexit. However, LCCs are optimistic that they can keep their models going for the time being.

3.1.1 Innovation in Operations and Services by LCCs in Europe

1) Streamlined Operations:

Low-Cost Carriers in Europe have revolutionized the airline industry with their commitment to streamlined operations. Efficiency is at the heart of their success, enabling them to offer competitive fares while maintaining profitability. Several key aspects illustrate the innovative strategies employed by LCCs in this regard.

One of the main features of LCCs is their relentless pursuit of minimizing turnaround times at airports. Unlike traditional carriers that often have longer layovers, LCCs optimize every minute on the ground. This optimization translates into shorter aircraft ground time, allowing for more frequent flights and a higher aircraft utilization rate. (Hayward, 2020)

Ryanair takes this measure to the extreme, with a typical turnaround being 30 minutes. The airline frequently uses the front and back steps of the aircraft to expedite the exit of passengers. Ryanair can practically cut the time it takes to exit the plane in half by using the back door in addition to the front one, which is how other airlines only let people out. Ryanair also has a very tight luggage restrictions. Only passengers with Priority Boarding are permitted to bring a bag that will be stored in an overhead bin. The number of Priority Boarding spaces is restricted, nevertheless. Therefore, the airline shouldn't be in a situation where there are more luggage than there are seats available. (Boon, 2019)

For passengers, this means more options and flexibility when choosing flight times. Technology plays an important role in this streamlining process. LCCs have embraced digital solutions to expedite operations. Mobile apps for check-in, electronic boarding passes, and automated baggage handling systems reduce the need for physical infrastructure and personnel, further cutting costs and enhancing the passenger experience. Passengers can navigate airports swiftly, and airline staff can focus on critical tasks, reducing congestion and delays (Bijan Vasigh, 2013).

Moreover, LCCs have adopted a point-to-point routing strategy as opposed to the traditional hub-and-spoke model utilized by legacy carriers. This innovative approach minimizes operational complexities and costs associated with connecting flights. Passengers can fly directly to their desired destinations without the inconvenience of layovers, reflecting the LCC commitment to providing efficient travel options. (Ryanair, 2023)

2) Fleet selection

In the fiercely competitive landscape of European aviation, Low-Cost Carriers have displayed a knack for innovation, particularly in their choices regarding fleet selection. One notable innovation is their careful selection of aircraft types. LCCs operating in Europe have been early adopters of more fuel-efficient aircraft models, such as the Boeing 737 in the case of Ryanair (Ryanair Corporate, 2023) and Airbus A320 families in the case of EasyJet (EasyJet, 2023). These modern, technologically advanced aircraft not only offer significant fuel savings but also reduce maintenance costs due to their reliability and efficiency. By investing in newer aircraft, LCCs not only minimize their carbon footprint but also bolster their economic sustainability.

Fleet standardization is yet another innovation. LCCs often maintain a homogenous fleet, operating multiple aircraft of the same type. This approach simplifies maintenance operations, reduces training costs for flight and maintenance crews, and streamlines spare parts management. It enables quicker turnarounds and minimizes the risk of operational disruptions due to aircraft incompatibility.

Furthermore, LCCs in Europe have explored partnerships with aircraft manufacturers and leasing companies to secure advantageous deals. These partnerships not only facilitate fleet expansion but also provide access to the latest aviation technologies and improvements, ensuring that LCCs remain at the forefront of operational efficiency. In May 2023, $40bn deal for 300 new 737MAX aircraft was signed between Ryanair and Boeing.

"*Ryanair has agreed a $40bn (£31bn) deal with Boeing that will see it purchase up to 300 new aircraft over the next decade. Half of the 737-MAX-10 order has been described as firm, with the remaining being options. The airline claims this is the largest order ever placed by an Irish company for US manufactured goods. Phased deliveries will start in 2027 and run until 2033.*" (BBC News, 2023)

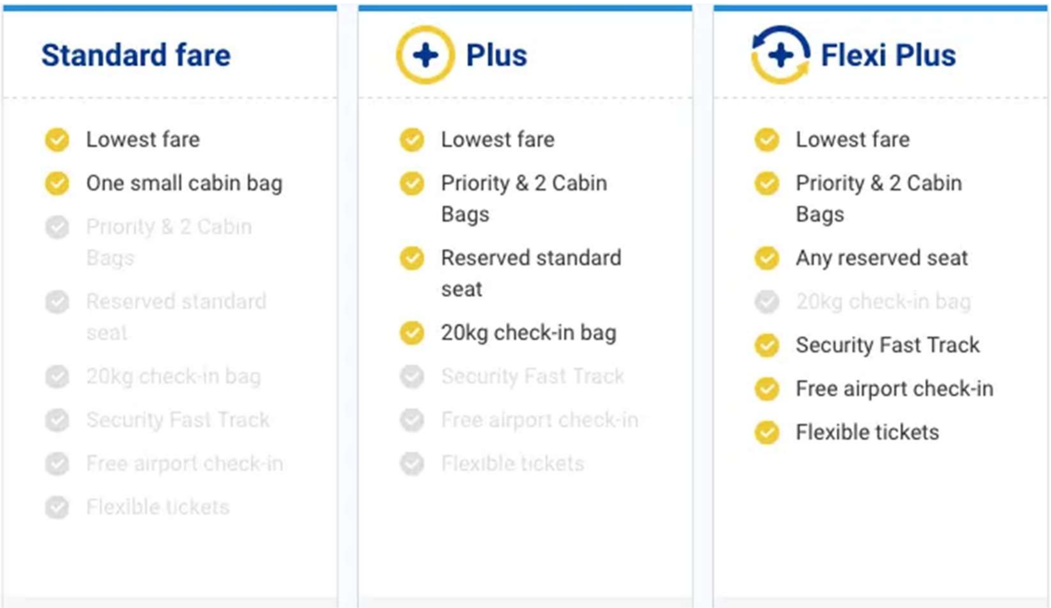
Obrázek 4 Ryanair orders 300 new 737MAX aircraft (Ryanair Corporate, 2023)

3) Ancillary services and Revenue generation

One of the primary ways LCCs increase revenue is by offering a menu of optional ancillary services. These services include everything from in-flight meals and beverages to priority boarding, seat selection, and extra legroom seating. By allowing passengers to customize their travel experience and pay only for the services they desire, LCCs can keep base fares low, appealing to price-conscious travelers while still capitalizing on additional spending from passengers who choose these extras. (Ryanair, 2023)

Furthermore, LCCs have embraced the concept of customer segmentation. They categorize passengers into various groups based on factors like loyalty status, booking class, and travel history. This segmentation enables them to tailor their ancillary offerings to different customer segments effectively. For example, loyal frequent flyers might receive exclusive discounts or benefits, while price-sensitive travelers can choose from more basic services.

Promoting supplementary services requires effective marketing and communication strategies. LCCs use their websites, mobile apps, and email marketing to notify customers about the services they may use, as well as about exclusive offers and discounts. Additionally, they make it simple for passengers to include these services in their reservations at the time of booking or at a later time through self-service portals.

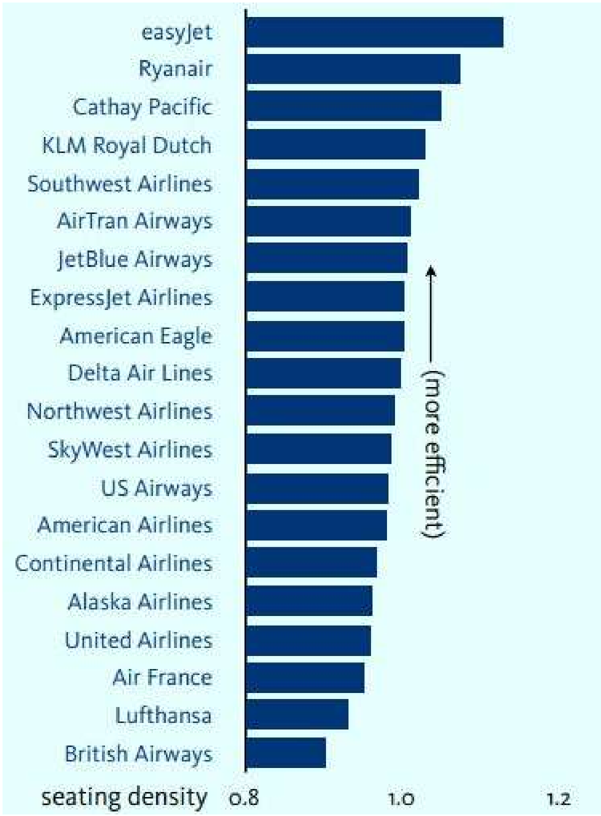


Obrázek 5 Ryanair fares (Travel Dealz, 2019)

4) Cabin configuration and seating

One of the key innovations is the introduction of slimline seats. LCCs have adopted these thinner, lightweight seats to maximize the number of seats in the cabin without sacrificing passenger comfort. Slimline seats offer adequate comfort for short to medium-haul flights, allowing LCCs to increase their seating density and, subsequently, revenue per flight.

According to “Air Travel Carbon and Energy Efficiency“ (Hough, 2011) , Ryanair and Easyjet were top 2 airlines in the world in the Seating density efficiency :



Obrázek 6 Seating density (Hough, 2011)

Additionally, LCCs often use a single-class cabin configuration, eliminating the traditional separation of classes like business and economy. This approach simplifies cabin layout, reduces operational complexity, and ensures that every passenger enjoys a similar level of service. It aligns with the ethos of affordability and accessibility that LCCs emphasize (Safiuddin, 2019).

Some LCCs also offer unique seating arrangements to cater to various passenger preferences. For example, they might offer the option to purchase extra legroom seats, which are usually located at the front of the cabin or exit rows. Passengers willing to pay a premium for additional space can choose these seats, providing a source of additional revenue for the airline. (Seat Guru, 2023)

Moreover, innovative cabin designs are used to enhance passenger comfort and satisfaction. Mood lighting is a popular feature, providing a more pleasant ambiance during the flight. While not directly related to seating, it contributes to an overall improved in-flight experience.

LCCs also prioritize efficient use of cabin space for storage and passenger convenience. Overhead bins are designed to maximize storage capacity, ensuring that passengers have ample room for their carry-on items. This helps expedite boarding and disembarking processes. (Ryanair, 2023)

3.1.2 Challenges and Opportunities for Low-Cost Carriers

Low-Cost Carriers (LCCs) operating in Europe have navigated a dynamic landscape characterized by both challenges and opportunities. Understanding these factors is essential in assessing their prospects in the region's competitive airline industry.

Challenges:

1) Regulatory and Operational Hurdles:

LCCs often encounter regulatory challenges in Europe, including slot constraints at busy airports, airspace congestion, and strict safety and security regulations. Overcoming these hurdles requires careful planning and negotiation with aviation authorities.

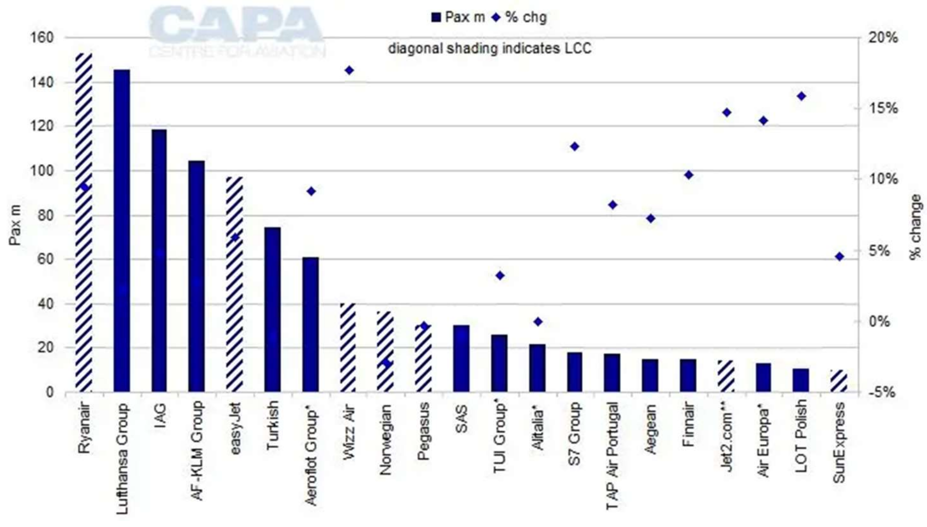
On July 15–16, Ryanair pilots in Belgium went on strike in support of improved pay and working conditions. 20,000 people were impacted by the strike, and 120 flights were reportedly cancelled as a result. (Reuters, 2023)

Air traffic control strikes have occurred often in France in response to President Emmanuel Macron's proposal to raise the retirement age, which has caused delays and fewer travel options around the nation and increased airspace congestion in Europe. More than 900 flights were canceled by Ryanair in June as a result of French ATC strikes, and the airline is pushing the European Commission to protect overflights from strike interruption. (Reuters, 2023)

2) Intense Competition:

The European aviation market is fiercely competitive. LCCs face rivalry not only from other LCCs but also from legacy carriers and hybrid carriers offering a range of fare options. Sustaining profitability in such a competitive environment is a significant challenge. (Hayward, 2020)

According to an analysis done by CAPA in 2020, the top 20 airlines in Europe by passengers carried were following :



Obrázek 7 Top 20 airlines by passengers carried (CAPA, 2020)

"Ryanair Group jumped over Lufthansa Group as Europe's leading airline group by passengers in 2019, followed by IAG, AF-KLM, easyJet, Turkish Airlines and Aeroflot. Fastest growing in the top 20 was Wizz Air, ranked at number 8. SunExpress and LOT Polish entered the 2019 ranking in equal 20th place.
Ryanair remains by far Europe's biggest individual airline brand." (CAPA, 2020)

3) Economic Sensitivity:

LCCs' business models are highly sensitive to economic fluctuations. Economic downturns can lead to reduced passenger demand, impacting ticket sales and profitability. Economic stability and adaptability are crucial for their success (Khan, 2020).

The 2020 global pandemic had a significant impact on air travel in the whole world. In Europe, there were 6.1 million fewer flights in 2020 than there were in 2019, a decline of 55.2%.

"The collapse in traffic in 2020 had a significant impact on revenues and on the ability of both the EU and US systems to finance their operations. In Europe, it is estimated that revenues in 2020 decreased by some 58% to around €3.7bn (compared to some €8.5bn in 2019). To mitigate the impact of the dramatic traffic reduction on their activity, but also to address potential cash shortages, a number of European Air Navigation Service Providers introduced measures, including the implementation of cost-containment initiatives, taking up loans to alleviate liquidity risks as well as, in some cases, receiving support from national governments." (European Comission, 2021)

4) Operational Efficiency:

Maintaining high levels of operational efficiency is a constant challenge. Delays, disruptions, or maintenance issues can have a significant impact on LCCs' ability to offer frequent, on-time flights. (Hayward, 2020)

a) Air Traffic Congestion:

European skies are among the busiest in the world, with numerous flights crisscrossing the continent daily. According to Eurocontrol, during the 23-29 week of August 2023, there were 32 540 flights on average daily in the European skies (Eurocontrol, 2023). Air traffic congestion can lead to delays and increased fuel consumption, which directly impact the operational efficiency of low-cost airlines. Managing and optimizing flight routes to navigate crowded airspace is a constant challenge (Bijan Vasigh, 2013).

b) Slot Constraints:

Major airports in the EU often have limited available slots for takeoffs and landings, especially during peak hours. Securing these slots at prime airports is crucial for LCCs, but competition for them is fierce. The inability to secure favorable slots can disrupt schedules and hinder operational efficiency.

"The value of each slot pair varies considerably by time of day. Around 10 years ago, an early morning slot pair (i.e., an arriving red-eye JFK-LHR flight, departing back to JFK a

few hours later) was reported to be worth around £15 million. By midday, the value of slots would fall to around £10 million, and then drop again to £5 million in the evening. However, in a competitive European market, and with Heathrow more capacity-constrained than it's ever been, the price airlines will pay for slots is skyrocketing.“ (Macheras, 2019)

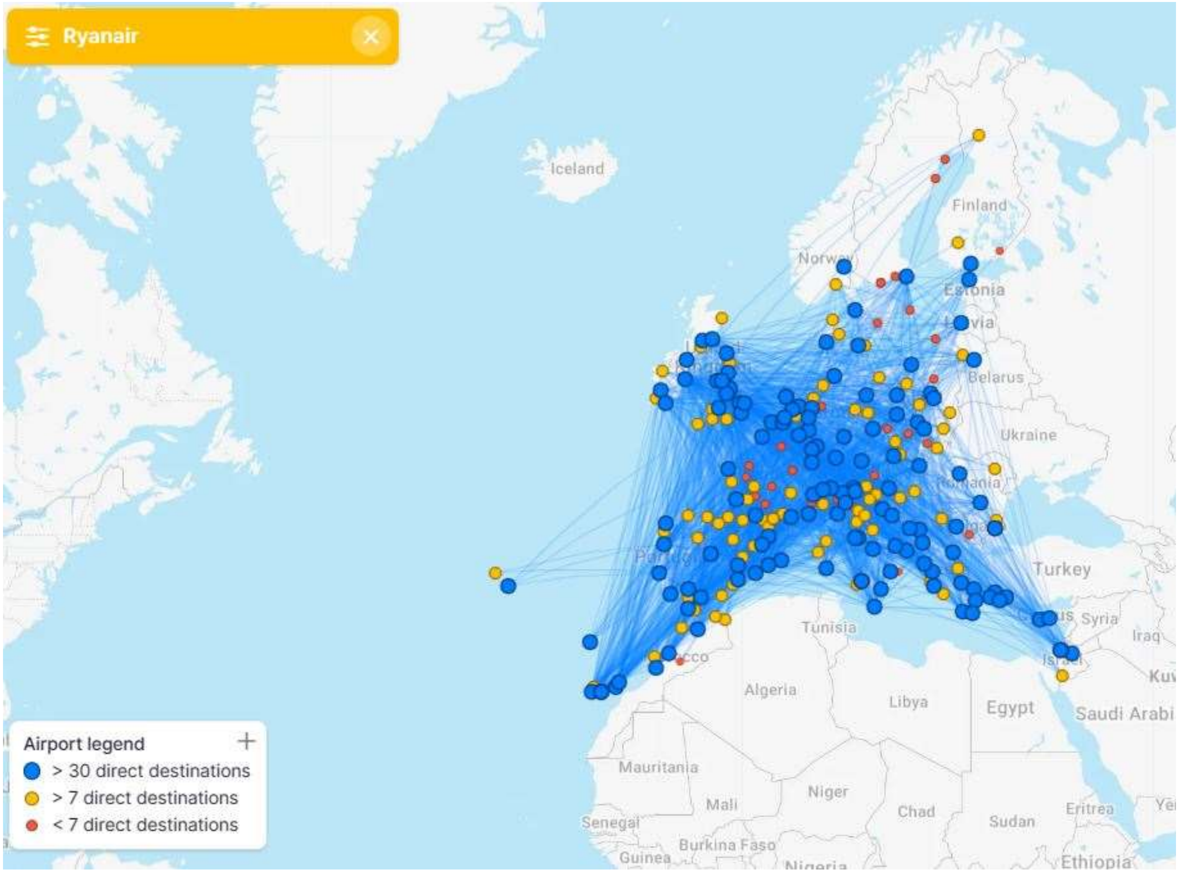
c) Airports Fees and Charges:

European airports frequently impose various fees and charges, including landing fees, passenger fees, and airport facility charges (Lordan, 2014). For LCCs operating on tight budgets, these additional costs can erode their cost advantage. Negotiating favorable terms with airports can be a complex and ongoing challenge. Almost all LLCs in Europe choose to not use the main airports in countries but rather secondary ones. Instead of using the Heathrow airport in London, where the fees are too high for LLCs, these airlines may use London Gatwick, London City or London Stansted (Ryanair, 2023).

Opportunities :

1) Market Expansion:

LCCs have opportunities for market expansion in Europe. They can target underserved regions, secondary airports, and niche markets that may not be adequately addressed by legacy carriers. By offering direct, low-cost connections, LCCs can stimulate passenger demand.



Obrázek 8 Ryanair route network (Flight Connections, 2023)

2) Technological Advancements:

Continued advancements in technology offer opportunities for LCCs to enhance operational efficiency, passenger experience, and distribution (Tungate, 2017). This includes the use of data analytics for route optimization and personalized marketing, as well as implementing eco-friendly technologies to reduce environmental impact.

3) Sustainability Initiatives:

LCCs can seize the opportunity to lead in sustainability efforts. By investing in fuel-efficient aircraft, carbon offset programs, and eco-friendly practices, they can align with growing passenger concerns about environmental responsibility. (EasyJet, 2023)

4) Partnerships and Alliances:

Collaborative ventures, including partnerships with other airlines or joining alliances, can provide LCCs access to a broader network and shared resources. This can enhance their competitiveness and broaden their reach. (FlightsFrom, 2019)

5) Cost Management:

LCCs have the advantage of a cost-conscious approach. By continuously optimizing operations and exploring innovative ways to reduce expenses, they can maintain their cost advantage over legacy carriers.

3.2 The State of Traditional Carriers in Europe

Legacy carriers in Europe represent a group of well-established airlines with deep-rooted histories and a strong presence across the continent. These airlines, often characterized by their premium services and extensive global networks, have played a pivotal role in shaping the European aviation industry. Airlines such as British Airways, Lufthansa, Air France-KLM, and others have become household names, known for their reliability and commitment to delivering a comprehensive travel experience.

British Airways, a national carrier of the UK, has come to represent the best of British aviation. It was established in 1974 and is the direct descendant of two pioneering airlines, BOAC and BEA, that date back to the very beginnings of modern aviation (Singh, Simple Flying, 2023). British Airways has remained committed to its legacy of top-notch service, offering travelers a truly British experience.

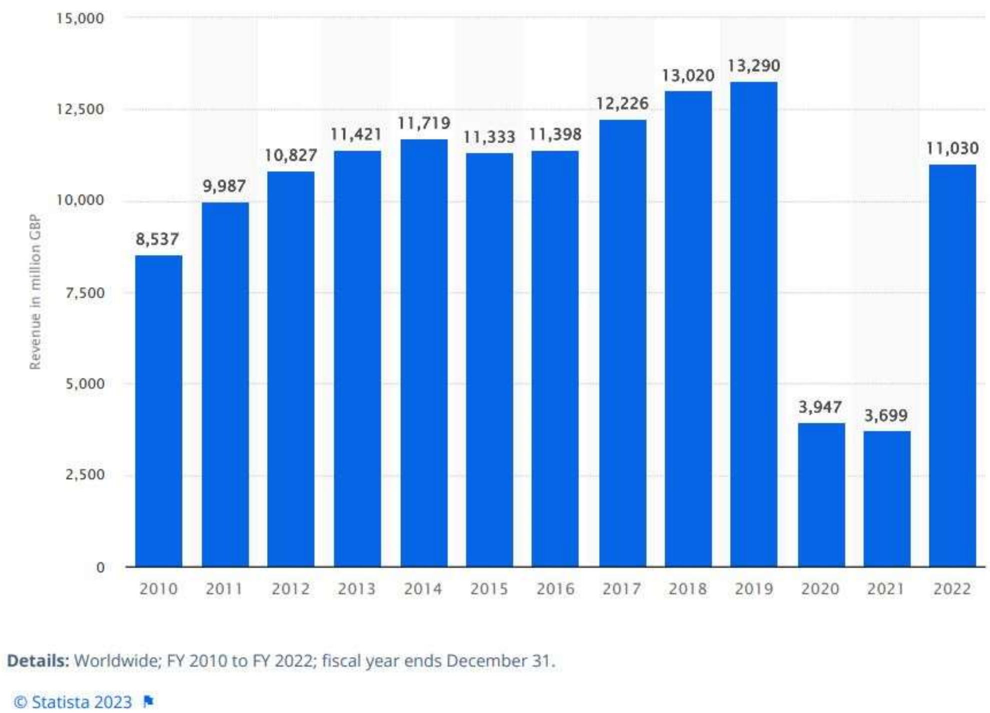
As of October 2023, British Airways operates the A320 family, A320neo family, A350-1000, A380 aircraft produced by Airbus. Boeing has a significant presence in their fleet aswell, consisting of the 777 and 787 widebodies (British Airways, 2023). Interestingly enough, most wide-body planes in their fleet, are powered by the British-made Rolls-Royce Trent engines.

British Airways will get up to 42 Boeing 777X aircraft from International Airlines Group (parent company of BA) as a replacement for its fleet of 747-400 aircraft. The commitment comprises 18 firm orders and 24 options for the new 777-9 type, which has not yet taken flight, and is worth up to $18.6 billion at list prices (AeroExpo, 2023).

British Airways guarantees a smooth travel experience for customers across its vast network with a diversified fleet that includes the above mentioned planes. However, the airline's financial stability is just as important to retaining its status as a leader in world aviation as its hangars and runways. Let's examine British Airways' financial picture and see how their fleet management is closely related to their financial health.

a) BA worldwide revenue in the 2010 – 2022 fiscal years.

British Airways global revenue has shown both resiliency and adaptability from 2010 to 2022. The airline's revenue for the fiscal year 2010 was around 8.5 billion pounds. The trajectory of its income was later determined by elements including economic downturns, changes in the price of gasoline, and the entry of new rivals.



Obrázek 9 BA revenue (Statista, 2023)

The years that followed saw a mix of challenges and opportunities for British Airways. For instance, in 2014, revenue saw a notable uptick, reaching 11.7 billion pounds due to various strategies aimed at enhancing customer experience and operational efficiency.

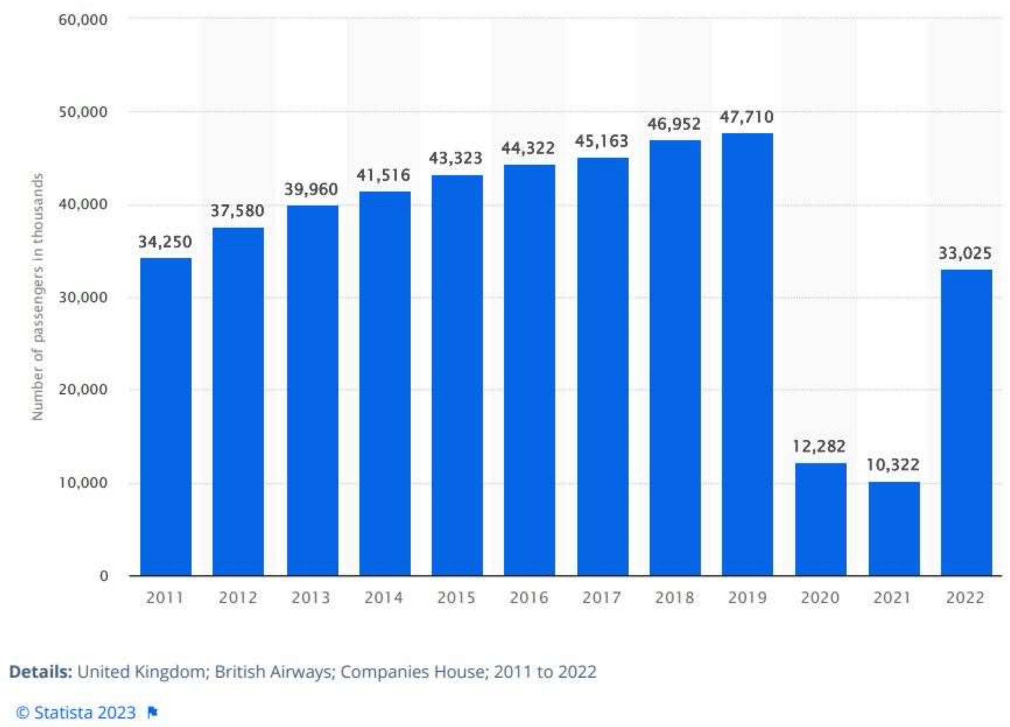
However, the aviation sector is known for being vulnerable to outside forces, and this became clear in the years that followed. In 2020 and 2021, situations like the COVID-19 pandemic, price swings in petroleum, and the global economic crisis created significant disruptions. Similar to other airlines throughout the world, British Airways saw revenue decreases at this time, falling to around 3.9 billion in 2020 and slightly decreasing more to 3.6 billion in 2021. (IAG, 2022)

However, British Airways showed dedication when travel restrictions were relaxed and customer demand began to improve. The airline had adopted strategic steps by 2022 to adjust to the new normal, producing revenue of around 11 billion pounds.

These revenue numbers show the airline's capacity to manage difficult situations, make investments in innovation and customer-centered solutions, and stay a major force in the global aviation sector. Moving forward, British Airways balances economic stability with its dedication to offering customers top-notch travel experiences by continuing to adapt and innovate.

b) Number of passengers carried by British Airways

British Airways continuously carried a sizable number of passengers each year from 2011 to 2019. Millions of passengers were transported by the airline at this time over its vast worldwide network. It even broke passenger records in several years, demonstrating its appeal to a variety of visitors, from tourists and business people to those going to see friends and family.



Obrázek 10 BA number of passengers carried (Statista, 2023)

British Airways, like many other airlines, faced difficulties during the COVID-19 pandemic, which had a negative influence on international travel. The airline's passenger numbers substantially decreased in 2020 and 2021 as a result of widespread travel restrictions, lockdowns, and passenger fear. (IAG, 2022)

Nevertheless, British Airways, with its powerful brand and broad range of services, has shown the potential to adapt as the globe gradually recovered from the pandemic and travel restrictions started to loosen. As a result of a high demand and the airline's efforts to offer safe and enjoyable travel, the number of customers using the airline has began to recover, with 33 million passengers serviced in 2022.

Lufthansa, Germany’s biggest airline, was founded in 1955, has continuously evolved to represent the pinnacle of German engineering and efficiency. The distinctive livery of Lufthansa has become synonymous with reliability and quality, making it a symbol of German excellence in the aviation world.

The impact of Lufthansa goes well beyond the boundaries of Germany. It represents German engineering and efficiency on a worldwide scale, demonstrating the nation's commitment to innovation and the highest standards. This global presence highlights Germany's position as a world leader in a number of industries and strengthens its favorable reputation.

As of October 2023, Lufthansa operates the following wide-body aircraft:

Airbus : A330, A340, A350, A380.
Boeing: 747-4, 747-8.

As for short-haul aircraft, the list is following:

Airbus: A320 family, A320neo family
Embraer : E190, E195
Bombardier: CRJ900 (Lufthansa, 2023).

Interestingly enough, Lufthansa doesn’t operate any short-haul Boeing aircraft, like the 737 or the 737MAX.

The success of Lufthansa is a reflection of German craftsmanship's values and fundamental values as well as of its ability to adapt and grow in a fast-paced sector. With a history that dates back to the middle of the 20th century and a constant commitment to perfection, Lufthansa has unquestionably earned its reputation as a benchmark of German aviation excellence.

One of the defining features of legacy carriers is their ability to connect Europe with the rest of the world. They typically offer a wide range of international destinations, seamlessly bridging continents and providing travelers with extensive route options. This interconnectedness is further enhanced through their participation in global airline alliances like Star Alliance, oneworld, and SkyTeam, which enable code-sharing agreements and shared resources. (FlightsFrom, 2019)

These legacy carriers have also had a big impact on Europe's economy. They serve as major entry points to European cities, bringing in tourists and business travelers. They have extensive networks that help with trade and cultural exchanges (Hanif D. Sherali, 2005). They create jobs and drive advancements in aviation technology.

As of October 2023, British Airways (part of the Oneworld alliance) has service to all 5 inhabited continents, specifically 196 international and 13 domestic locations throughout 76 countries (Flight Connections, 2023).

Lufthansa (part of the Star Alliance) also serves all 5 inhabited continents, 17 domestic and 203 international locations in 73 countries (Flight Connections, 2023).

These well-known airlines are renowned for the excellent level of service they offer. They make the travel enjoyable and memorable, instead of just getting passengers from one location to another. These airlines are trustworthy and are essential to European aviation. The stories they tell are more than simply historical, they are a vital part of the European aviation, which has successfully and efficiently bridged continents.

Historical Significance:

Traditional carriers in Europe have a deep-rooted historical significance in the aviation industry. Airlines like British Airways, Lufthansa, Air France-KLM, and others have been pivotal in establishing air travel as a fundamental mode of transportation across the continent. These airlines are the founders of commercial aviation and have profoundly influenced how people interact and travel throughout the globe. They were historically significant in the following ways:

a) The beginning of commercial aviation:

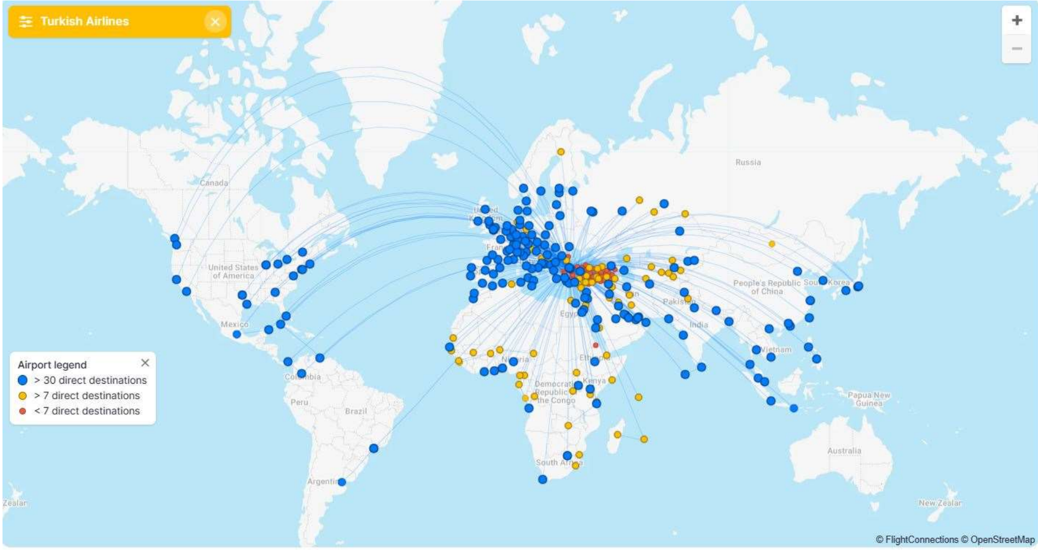
The development of commercial aviation as we know it today was driven by traditional airlines. Many of them were created at the beginning of the 20th century and were crucial in bringing in the age of widespread air travel. Among the oldest in the world are airlines like KLM and Avianca, both founded in 1919 (Doornbos, 2023).

Obrázek 11 Current Avianca logo (Wikipedia, 2023)

b) Global connectivity:

These airlines are in charge of creating and growing the vast air route networks that circle the world. They have established connections between individuals and locations on several continents, greatly advancing global commerce, travel, and cultural exchange. Their travel paths frequently reflect the historical alliances and relationships between countries.

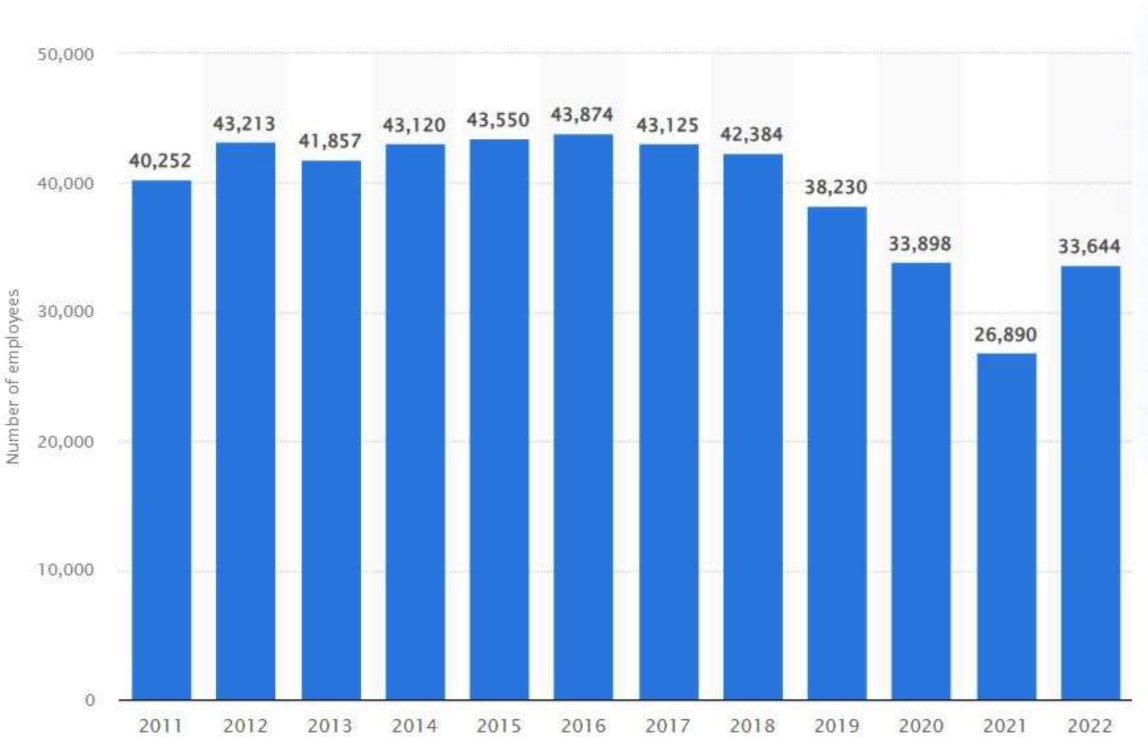
Turkish Airlines (TK), Turkey's national airline, operates flights to 340 destinations as of 2022, with 287 international and 53 domestic routes spread across 123 countries. It is the only airline that flies to more than 100 countries worldwide. (Velani, 2023).



Obrázek 12 TK destinations (Flight Connections, 2023)

c) Economic Impact:

Traditional airlines have a significant influence on both national and international economy. In their own countries, they have contributed to economic growth, revenue, and employment. These legacy airlines have helped the aviation sector grow and have sparked economic growth across many areas. Below is a chart describing the number of people employed by British Airways:



Obrázek 13 BA number of employees (Statista, 2023)

BA has a sizable workforce that works in a variety of capacities, including management, maintenance, ground crew, pilots, cabin crew and many other departments.

d) Cultural Icons:

Through their logos, liveries, and onboard amenities, certain traditional airlines have elevated themselves to the status of cultural and national symbols. For example, the choice of colors, patterns, and symbols in the branding may draw from the national flag, important historical events, or cultural icons. These visual representations become instantly recognizable symbols of a nation, both domestically and internationally.

Obrázek 14 Evolution of BA logo (Logos World, 2023)

Following a number of modifications, the brand name now incorporates the curved Speedmarque line and the colors of the UK national flag.

e) Preservation of History:

In order to preserve both their own history and the history of aviation as a whole, several traditional airlines have built aviation museums, archives, and collections. These establishments educate the public about the development of aviation while also acting as popular tourist destinations. One of these is the " The British Airways Heritage Collection", which, according to (British Airways, 2023) *" was formed to preserve the records and artefacts of British Airways' predecessor companies BOAC, BEA, BSAA and the pre-war Imperial Airways Limited as well as British Airways Ltd."*

Global Networks and Alliances:

Traditional carriers have maintained robust global networks, often bolstered by their participation in global airline alliances like Star Alliance, oneworld, and SkyTeam. These alliances enable traditional carriers to provide passengers with a wide range of route options, code-sharing agreements, and seamless connections. This interconnectedness is a key strength, as it appeals to travelers with diverse itineraries, solidifying the position of traditional carriers in the international aviation arena. (FlightsFrom, 2019)

Obrázek 15 Major airline alliances and their members (FlightsFrom, 2019)

Full-Service Offerings:

Traditional carriers are renowned for their commitment to providing passengers with a full-service travel experience. This includes in-flight meals, entertainment systems, spacious seating arrangements, and various amenities that enhance the comfort and convenience of air travel. This approach caters to travelers who prioritize a comprehensive, premium experience during their journeys, distinguishing traditional carriers from budget-focused competitors. (British Airways, 2023)

Corporate and Premium Markets:

Traditional carriers have cultivated a loyal customer base within the corporate and premium travel segments. These carriers offer tailored services, flexible booking options, and access to exclusive airport lounges, catering to the needs of business travelers and those willing to pay a premium for personalized services and added conveniences. This focus on premium markets contributes significantly to their revenue streams. (British Airways, 2023)

Brand Loyalty and Recognition:

Legacy carriers often enjoy strong brand recognition and a loyal customer following. These airlines have built their reputations over decades, earning the trust of frequent flyers and corporate clients. The consistent reliability, service quality, and comprehensive offerings provided by traditional carriers contribute to their brand loyalty and recognition, making them a preferred choice for many travelers. (IAG, 2022)

Sustainability Initiatives:

In response to growing environmental concerns, traditional carriers have increasingly prioritized sustainability initiatives. This includes investments in modern, fuel-efficient aircraft, carbon offset programs to mitigate their environmental impact, and efforts to reduce carbon emissions. By adopting environmentally responsible practices, traditional carriers aim to align with evolving passenger preferences and contribute to a more sustainable aviation industry. (IAG, 2022)

Challenges and Adaptation:

Traditional carriers also face challenges, including cost-efficiency concerns, price competition from LCCs, and regulatory constraints. To remain competitive and relevant in the evolving aviation landscape, these carriers must continually adapt to changing market dynamics, embrace technological advancements, and cater to shifting passenger preferences. Successfully navigating these challenges while preserving their core strengths is essential for their continued success in Europe's aviation industry. (ICAO, 2003)

Competition from Low-Cost Carriers:

One of the most prominent challenges facing traditional carriers in Europe is the rise of Low-Cost Carriers. As mentioned before, these budget-focused airlines have redefined the industry by offering simplified services and competitive pricing. This has resulted in intense price competition on short-haul routes, pressuring traditional carriers to reconsider their pricing strategies and cost structures. LCCs have disrupted the market dynamics, compelling legacy carriers to adapt to this changing competitive landscape. (WizzAir, 2023)

3.3 Case Study: Ryanair and British Airways

Aircraft Type	Number of Aircraft	Range (miles)	Maximum Seating Capacity
Boeing 737-800	485	3 000	189
Boeing 737 MAX 200	38	3 845	197
Boeing 737-700	12	2 340	149
Boeing 737-300	8	1 850	148
Total	543		

Tabulka 1 Ryanair fleet (Ryanair Corporate, 2023)

Boeing 737-800:

With 485 of the airline's 543 aircraft, the Boeing 737-800 is the most common aircraft in Ryanair's fleet. With a range of 3,000 miles, the 737-800 is a twin-engine, single-aisle airliner that can accommodate up to 189 people.

Boeing 737 MAX 200:

Ryanair began operating the Boeing 737 MAX 200, a more recent model of the 737 family, in 2021 (Ryanair Corporate, 2023). A high-capacity airplane, the MAX 200 can accommodate up to 197 people. Additionally, with a maximum range of 3,845 miles, it has a greater range than the 737-800.

Ryanair is able to provide such low tickets in part because of its fleet, which consists entirely of Boeing 737s. The 737 is a dependable and fuel-efficient aircraft, and Ryanair has one of the newest fleets globally (Ryanair Corporate, 2023). This contributes to the airline's low operational expenses, which enable it to provide savings to its passengers.

An important indicator of the effectiveness and profitability of the airline is Ryanair's load factor. The number of people carried divided by the number of seats available provides the result. An airline that has a high load factor is one that is filling its aircraft and making more money every flight. Ryanair's profitability can be attributed in large part to its constantly high load factor. Ryanair had the greatest load factor in Europe in 2022, at 94%. (Ryanair, 2023)

Year	Load Factor (%)
2015	88,00%
2016	90,00%
2017	92,10%
2018	93,70%
2019	97,30%
2020	71,10%
2021	81,90%
2022	94,00%

Tabulka 2 Ryanair load factor (Ryanair, 2023)

Ryanair's home country is Ireland. The airline was founded in Dublin, Ireland, in 1984, and its headquarters are still located in Swords, Dublin (Tungate, 2017). There is little question that Ryanair's presence in Ireland helped in the economic growth of the nation. The tourism industry has benefited from more people being able to travel to and from Ireland because to the airline's affordable rates.

Ireland's economy has grown remarkably in the last several years. Ireland's GDP rose at the quickest pace in the European Union in 2022, rising by 13.4%. It is anticipated that the Irish economy would keep expanding in the upcoming years. GDP growth in 2023 and 2024 is expected by the government to be 3.5% and 4.5%, respectively. Continued robust domestic demand, as well as higher exports and foreign direct investment, will all contribute to this expansion (International Monetary Fund, 2023).

Year	GDP Growth Rate (%)
2015	7,80%
2016	4,70%
2017	7,10%
2018	9,60%
2019	5,00%
2020	-1,30%
2021	13,40%
2022	15,10%
2023 (Forecast)	3,50%
2024 (Forecast)	4,50%

Tabulka 3 Ireland's GDP growth (International Monetary Fund, 2023)

British Airways:

British Airways is the largest airline in the United Kingdom and one of the largest in the world. It is a member of the Oneworld alliance and operates a network of routes to Europe, North America, Africa, Asia, and Oceania.

As of 2023, BA's average flight distance is 2750 kilometres, with 1500 flights per day (British Airways, 2023). BA serves 75 countries. Its network has over 600 routes and connects 300 airports (British Airways, 2023).

British Airways operates a mixed fleet of Airbus and Boeing aircraft, including single-aisle aircraft, twin-aisle aircraft, and wide-body aircraft. The airline also operates a small fleet of Embraer ERJ-190 aircraft for its regional subsidiary, BA CityFlyer.

Aircraft Type	Number in Fleet
Airbus A319-100	14
Airbus A320-200	44
Airbus A321-200	29
Airbus A320neo	68
Airbus A321neo	10
Airbus A330-200	36
Airbus A350-1000	12
Airbus A380-800	12
Boeing 777-200ER	42
Boeing 777-300ER	52
Boeing 787-8	18
Boeing 787-9	33
Embraer ERJ-190	20

Tabulka 4 BA Fleet (British Airways, 2023)

With one of the most mixed fleets in the world today, British Airways has a long history of flying a variety of aircraft. British Airways is dedicated to running a sustainable and ecologically friendly fleet, which is why the airline is always adding new, more fuel-efficient aircraft.

Year	Load Factor
2015	79,90%
2016	80,30%
2017	81,10%
2018	82,10%
2019	82,90%
2020	53,90%
2021	68,30%
2022	75,20%

Tabulka 5 BA Load Factor (Statista Research Department, 2023)

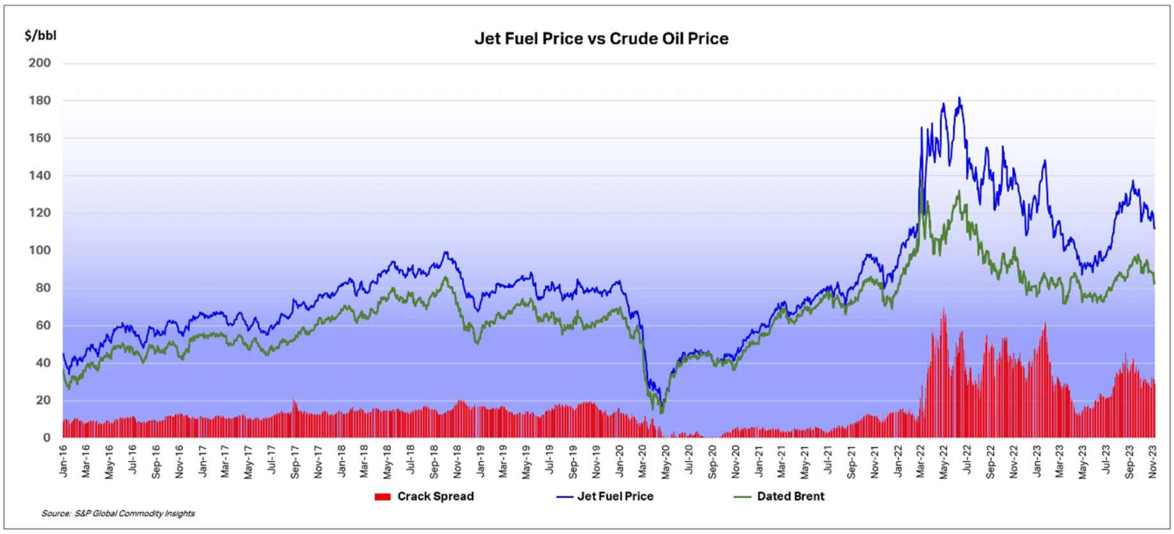
The load factor for British Airways has been steadily increasing since 2015, with the exception of 2020 due to the COVID-19 pandemic. Strong demand, airline's focus on expanding its network to new destinations, airline's investment in new and more fuel-efficient aircraft led to the fast revival of the load factor (IAG, 2022).

Year	GDP Growth Rate (%)
2015	2,2%
2016	2%
2017	1,8%
2018	1,4%
2019	1,3%
2020	-11,2%
2021	7,5%
2022	7,3%

Tabulka 6 UK's GDP development (Office for National Statistics, 2023)

From 2015 to 2019, the economy of the United Kingdom grew steadily, with GDP rising by 1.8% year on average. However, the COVID-19 pandemic caused a severe recession in 2020, with GDP decreasing by 11.2%. The economy rebounded strongly in 2021, with GDP growing by 7.5%, and continued to grow in 2022, with GDP increasing by 7.3% (Office for National Statistics, 2023).

Although the UK economy grew steadily between 2015 and 2019 and saw a notable upturn in 2021 and 2022, the aviation sector faced a major obstacle at this time: the unpredictability of jet fuel costs. Jet fuel prices are a major cost for airlines, and they can fluctuate significantly due to a number of factors, including global supply and demand, geopolitical events, and the price of crude oil (IATA, 2023).



Tabulka 7 Jet Fuel Price vs Crude Oil Price (IATA, 2023)

Jet fuel costs were comparatively steady between 2015 and 2019, averaging about $70 per barrel. However, the COVID-19 pandemic-related decline in air travel demand in 2020 resulted in a dramatic drop in jet fuel prices. Jet fuel reached a record low of $13 per barrel in April 2020.

Jet fuel costs substantially increased in 2021 as air travel demand started to revive. The cost of jet fuel increased to more than $100 per barrel by the end of 2021. Numerous reasons contributed to this, including as rising energy prices, problems in the supply chain, and increased demand from airlines (IATA, 2023).

The cost of jet fuel increased further in 2022, averaging around $140 per barrel. Since 2008, this was the highest average price. Significant pressure was placed on airline profitability by the high cost, which led several carriers to increase ticket prices (Eurocontrol, 2023).

Having thoroughly examined the independent variables that influence airline performance, we now turn our attention to the dependent variables that reflect the airline's financial success. These dependent variables - **number of passengers carried** and **profit margin** provide valuable insights into the overall profitability and financial health of an airline.

Number of passengers correlation table:

Independent Variable	Effect on Number of Passengers
Average flight distance	Positive
Number of routes	Positive
Fuel prices	Negative
Fleet composition	Positive
Economic growth in the home country of the airline	Positive
Load factor	Neutral

Tabulka 8 Correlation between number of passengers and independet variables (Own creation)

Explanation	Source
Shorter flights take less time and can be turned around more quickly, which means that airlines can fly more passengers per day.	"Airline Route Networks" by Oriol Lordan, February 2014
A large network of routes gives airlines access to a large number of potential passengers.	"Airline Route Networks" by Oriol Lordan, February 2014
Higher fuel prices can lead to airlines reducing the number of flights they offer, which can lead to a decrease in the number of passengers carried.	"The Impact of Oil Prices on the Air Transportation Industry" by John Hansman, Dominic McConnachie and Christoph Wollersheim, March 2014
A modern fleet of fuel-efficient aircraft can help airlines to save money on fuel costs. This can allow airlines to offer lower fares, which can attract more passengers.	"Airline fleet assignment concepts, models, and algorithms" by Hanif D. Sherali, Ebru K. Bish, Xiaomei Zhu, January 2005
Economic growth in the home country of an airline can lead to increased demand for air travel. This is because people have more money to spend on travel when the economy is doing well.	"Factors Affecting Tourism Industry and Its Impacts on Global Economy of the World" by Naushad Khan, March 2020
A higher load factor means that an airline is making more money from each flight. However, a higher load factor can also lead to congestion and delays, which can make air travel less appealing to passengers.	"Passenger Load Factor and Financial Health -A Study of Select Airline Companies" by Dr.Syed Khaja Safiuddin, November 2019

Tabulka 9 Correlation between number of passengers and independet variables (Own creation)

Profit Margin correlation table:

Independent Variable	Effect on Profit Margin
Average flight distance	Positive
Number of routes	Neutral
Fuel prices	Negative
Fleet composition	Positive
Economic growth in the home country of the airline	Positive
Load factor	Positive

Tabulka 10 Correlation between profit margin and independet variables (Own creation)

Explanation	Source
Shorter flights require less fuel and can be turned around more quickly, which means that airlines can fly more passengers per day. This can lead to higher profits.	"Airline Route Networks" by Oriol Lordan, February 2014
A large network of routes can give airlines access to new markets and customers, which can lead to increased revenue. However, a large network of routes can also come with higher costs, such as airport fees and marketing expenses.	"Airline Route Networks" by Oriol Lordan, February 2014
Fuel is one of the largest expenses for airlines, so changes in fuel prices can have a significant impact on their profits. Higher fuel prices can lead to lower profits.	"The Impact of Oil Prices on the Air Transportation Industry" by John Hansman, Dominic McConnachie and Christoph Wollersheim, March 2014
A modern fleet of fuel-efficient aircraft can help airlines to save money on fuel costs, which can lead to higher profits.	"Airline fleet assignment concepts, models, and algorithms" by Hanif D. Sherali, Ebru K. Bish, Xiaomei Zhu, January 2005
Economic growth in the home country of an airline can lead to increased demand for air travel, which can lead to higher profits.	"Factors Affecting Tourism Industry and Its Impacts on Global Economy of the World" by Naushad Khan, March 2020
A higher load factor means that an airline is making more money from each flight, which can lead to higher profits.	"Passenger Load Factor and Financial Health -A Study of Select Airline Companies" by Dr.Syed Khaja Safiuddin, November 2019

Tabulka 11 Correlation between profit margin and independet variables (Own creation)

4. Practical Part

The practical part will include 2 parts:

1) Time series analysis of both airlines (Ryanair and British airways) and some of the above-mentioned variables – number of passengers, profit margin, average flight distance, number of routes, fleet composition and global fuel prices.

2) Regression analysis of dependent variables (number of passengers and profit margin) for both airlines.

4.1 Analysis of Ryanair

In order to better understand the situation of Ryanair, it is necessary to look at different indicators and variables throughout some time. The 2015 – 2022 period has been chosen, as it is useful to better understand what is happening with the airline right now, and see how the pandemic affected the airlines' operations, and which steps had to be taken in order to stay afloat.

4.1.1 Time series analysis

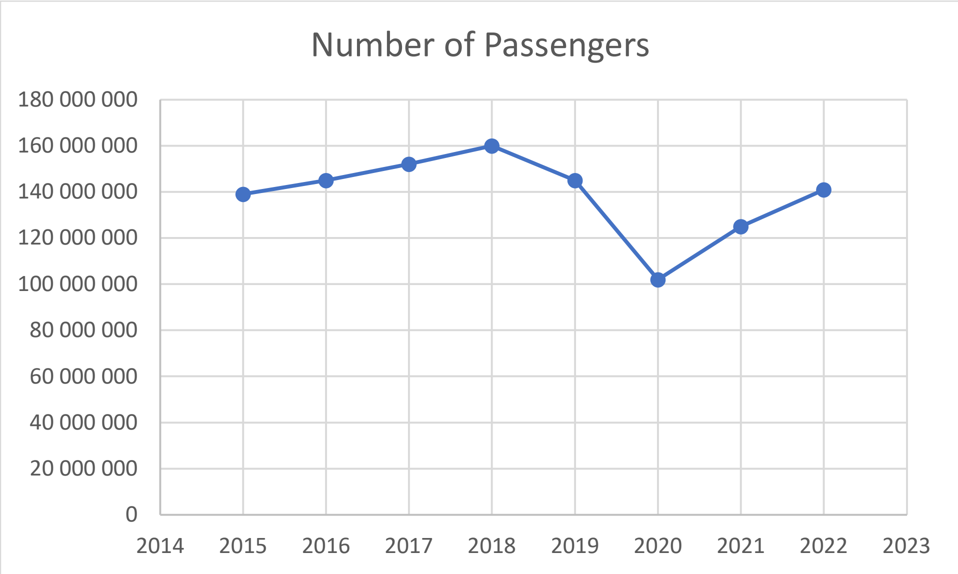
First time series analysis is going to be focused on Ryanair's **number of passengers**, years 2015 – 2022.

Tabulka 12 Ryanair number of passsengers (Statista, 2023)

Year	Number of Passengers
2015	139 000 000
2016	145 000 000
2017	152 000 000
2018	160 000 000
2019	145 000 000
2020	102 000 000
2021	125 000 000
2022	141 000 000

For this analysis, MS Excel software will be used.

Tabulka 13 Number of passengers graph



There is a steady increase in years 2015 – 2018, rising from 139 million to 160 million. A slight decrease is then followed in 2019, with another big decrease in 2020, dropping to 102 million, due to the Covid-19 pandemic. However, as mentioned earlier, Ryanair managed to quickly gain traction again and recover, with 2022 figure being same as the 2015 one at 140 million.
It is also important to look at the descriptive statistics of a chosen variable, the number of passsengers in this case.

Tabulka 14 Numb.of.pass. descriptive stat.

Number of Passengers	
Mean	138625000
Standard Error	6338480,834
Median	143000000
Mode	145000000
Standard Deviation	17927931,12
Sample Variance	3,21411E+14
Kurtosis	1,996240549
Skewness	-1,288108267
Range	58000000
Minimum	102000000
Maximum	160000000
Sum	1109000000
Count	8

Mean, which is the average number, is equal to 138 625 000. Median, which is the middle value is 143 000 000, and mode, the value which is the most frequent in the dataset is equal to 145 000 000. Standard deviation is the measure of how far on average our is the data from the mean value, in this case it's 17 927 931. Minimum, 102 000 000, occured in the year 2020, with the maximum, 160 000 000, in the year 2018.

Kurtosis is a measure of how often extreme values (outliers) occur. Values less than 3, in this case 1,9, indicate that these distributions have lighter tails than normal, meaning there are fewer extreme values, and are called "Platykurtic".

Skewness measures the symmetry of the distribution -

0: Symmetrical distribution (like a normal bell curve).
Positive value: Distribution skewed to the right, meaning there are more values on the left side (tail is longer).
Negative value: Distribution skewed to the left, meaning there are more values on the right side (tail is longer).

Absolute values:

Less than 0.5: Approximately symmetrical.
Between 0.5 and 1: Moderately skewed.
Greater than 1: Highly skewed.

Since skewness is equal to -1,288, the conclusion is that there are more values to the right and they are highly skewed.

Tabulka 15 Ryanair numb.of pass. chain index table

Number of Passengers	Chain index	Change in %
2015 - 139 000 000		
2016 - 145 000 000	1,043	4,32%
2017 - 152 000 000	1,048	4,83%
2018 - 160 000 000	1,053	5,26%
2019 - 145 000 000	0,906	-9,38%
2020 - 102 000 000	0,703	-29,66%
2021 - 125 000 000	1,225	22,55%
2022 - 141 000 000	1,128	12,80%

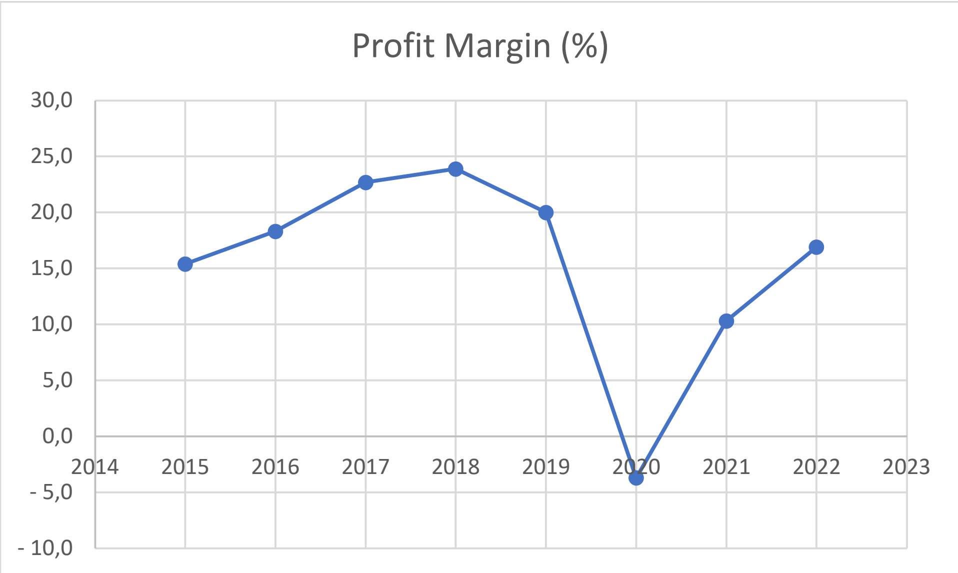
The table above shows the chain indices for number of passengers from 2015 to 2022. From 2015 to 2018 there is a steady increase, as all the indices are greater than 1, with an average growth of 5%. Starting from 2018 to 2020 a big decrease is present as the indices are less than 1, with the highest drop being equal to -29,66% in 2020. After the pandemic, the recovery began, and the indices are yet again greater than 1.

Second variable to be examined is Ryanair’s **profit margin**:

Tabulka 16 Ryanair's profit margin (Macrotrends, 2023)

Year	Profit Margin (%)
2015	15,4
2016	18,3
2017	22,7
2018	23,9
2019	20,0
2020	-3,7
2021	10,3
2022	16,9

Tabulka 17 Profit margin graph



Tabulka 18 Profit margin descriptive stat.

Profit Margin (%)	
Mean	15,475
Standard Error	3,128597929
Median	17,6
Mode	#N/A
Standard Deviation	8,849011244
Sample Variance	78,305
Kurtosis	3,160617866
Skewness	-1,675613674
Range	27,6
Minimum	-3,7
Maximum	23,9
Sum	123,8
Count	8

Steady rise every year in the 2015 – 2018 period, followed by decline in 2018 – 2020. During pandemic recovery, since 2021, the profit margin is back on positive track and increasing.

The mean value is equal to 15,475, while the median is 17,6. Mode is not present as there are no repeating values. Standard deviation is 8,85, with the minimum equal to -3,7 in 2020 and maximum 23,9 in 2018. Kurtosis is equal to 3,16 which means that the distribution has heavier tails than normal, indicating more extreme values, and is called "leptokurtic". Skewness is equal to -1,675, which means that that there are more values to the right and they are highly skewed.

Tabulka 19 Ryanair profit margin chain index table

Profit Margin	Chain index	Change in %
2015 - 15,4		
2016 - 18,3	1,188	18,83%
2017 - 22,7	1,240	24,04%
2018 - 23,9	1,053	5,29%
2019 - 20,0	0,837	-16,32%
2020 - -3,7	0,185	-118,50%
2021 - 10,3	2,784	378,38%
2022 - 16,9	1,641	64,08%

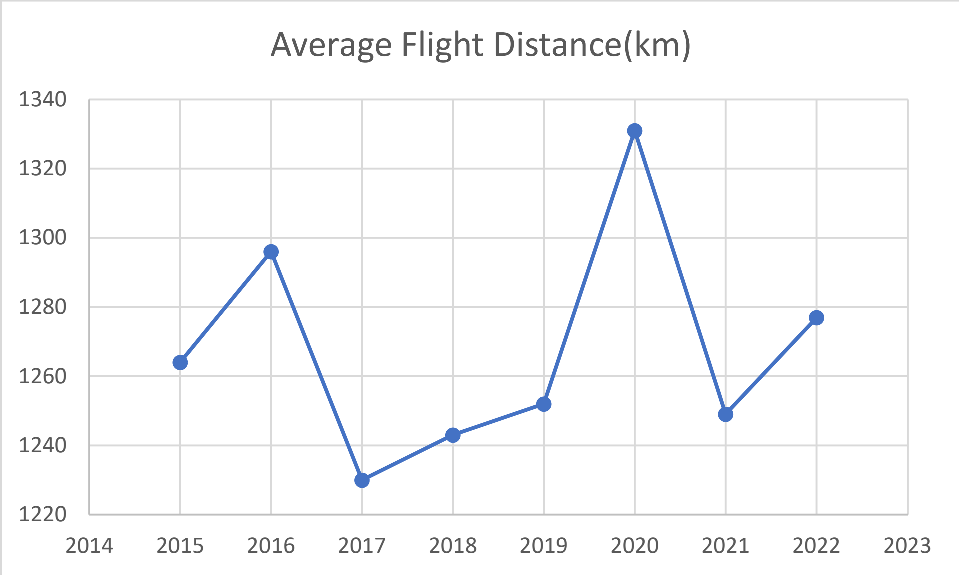
Similar to number of passengers the chain indices for the years 2015 – 2018 are all greater than 1, which suggest growth every year. 2020 index is only 0,185 which shows to a big drop in profit margin, and the change is -118,50 %. 2021 was a good recovery year though, as the index is equal to 2,784 and 378,38% positive change.

Third variable to be analysed is the **average flight distance**.

Tabulka 20 Ryanair's average flight distance (Ryanair, 2023)

Year	Average Flight Distance(km)
2015	1264
2016	1296
2017	1230
2018	1243
2019	1252
2020	1331
2021	1249
2022	1277

Tabulka 21 Average flight distance graph



Tabulka 22 Av.flight.dist. descriptive stat.

Average Flight Distance(km)	
Mean	1267,75
Standard Error	11,60010776
Median	1258
Mode	#N/A
Standard Deviation	32,81005943
Sample Variance	1076,5
Kurtosis	0,792358326
Skewness	1,061659863
Range	101
Minimum	1230
Maximum	1331
Sum	10142
Count	8

As shown on the graph, there is a big fluctuation in the average flight distance. First there is an increase from 1264 to 1296, and then decrease to 1230 and then an increase again to 1243, and so on. The mean value is equal to 1267,75, median is 1258 and mode doesn't exist, as there are no repeating values. Standard deviation is 32,8, which shows us that some data lies far from the average. Minimum is 1230 which is the year 2017 and the maximum happened in 2020, with the value being equal to 1331.

Kurtosis value is equal to 0,792, which indicates that it is platykurtic. Skewness is equal to 1,06, which shows that it is moderately skewed to the right as there are more values on the left side.

Tabulka 23 Ryanair average fl. dist. chain index table

Average Flight Distance	Chain index	Change in %
2015 - 1264		
2016 - 1296	1,025	2,53%
2017 - 1230	0,949	-5,09%
2018 - 1243	1,011	1,06%
2019 - 1252	1,007	0,72%
2020 - 1331	1,063	6,31%
2021 - 1249	0,938	-6,16%
2022 - 1277	1,022	2,24%

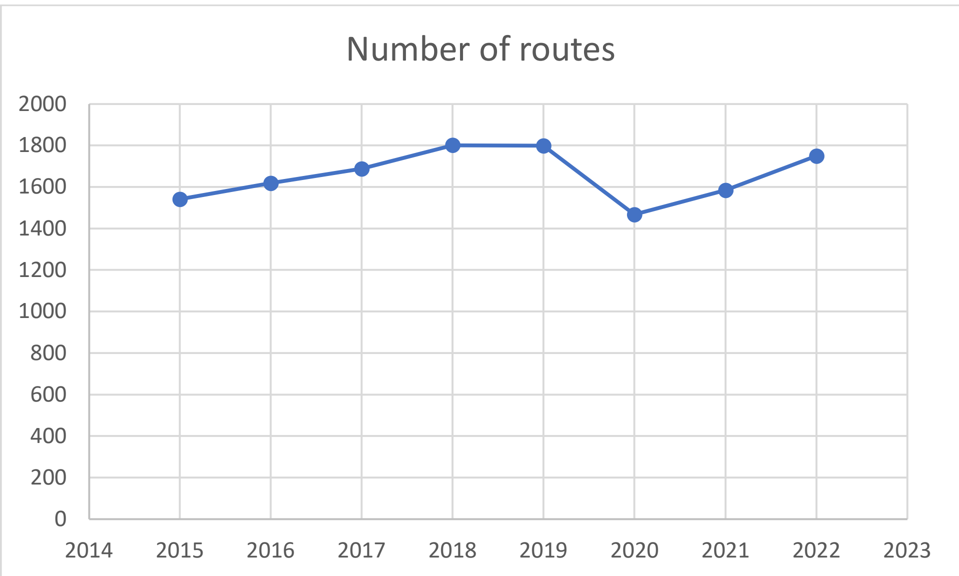
The average flight distance varies a lot, as the indices change from higher than 1, to less than 1 often. Highest increase, 6,31% was in the year 2020, highest decrease in the year 2021 - -6,16%.

Next variable to be analysed is **number of routes**.

Tabulka 24 Ryanair's number of routes (Ryanair, 2023)

Year	Number of routes
2015	1542
2016	1618
2017	1687
2018	1801
2019	1798
2020	1468
2021	1585
2022	1750

Tabulka 25 Number of routes graph



Tabulka 26 Numb.of.routes descriptive stat.

Number of routes	
Mean	1656,125
Standard Error	43,46814823
Median	1652,5
Mode	#N/A
Standard Deviation	122,9464895
Sample Variance	15115,83929
Kurtosis	-1,337528434
Skewness	-0,185141527
Range	333
Minimum	1468
Maximum	1801
Sum	13249
Count	8

A steady climb is present initially in the years 2015 – 2019. In 2020 a major decrease is present, dropping from 1798 routes to 1468. However, another climb start right after, rising to 1750 routes in 2022. The mean value is equal to 1656,125, and the middle value, median, is 1652,5. Once again, mode value does not exist, and the standard deviation for this data set is 122,95. Minimum is equal to 1468 which occured in 2020, and the maximum is 1801 which happened to be in 2018.

The kurtosis value is equal to -1,337, so it is safe to say that there are fewer outliers. The skewness value is close to zero, so it can be assumed that the distribution is symmetrical.

Tabulka 27 Ryanair number of routes chain index table

Number of routes	Chain index	Change in %
2015 - 1542		
2016 - 1618	1,049	4,93%
2017 - 1687	1,043	4,26%
2018 - 1801	1,068	6,76%
2019 - 1798	0,998	-0,17%
2020 - 1468	0,816	-18,35%
2021 - 1585	1,080	7,97%
2022 - 1750	1,104	10,41%

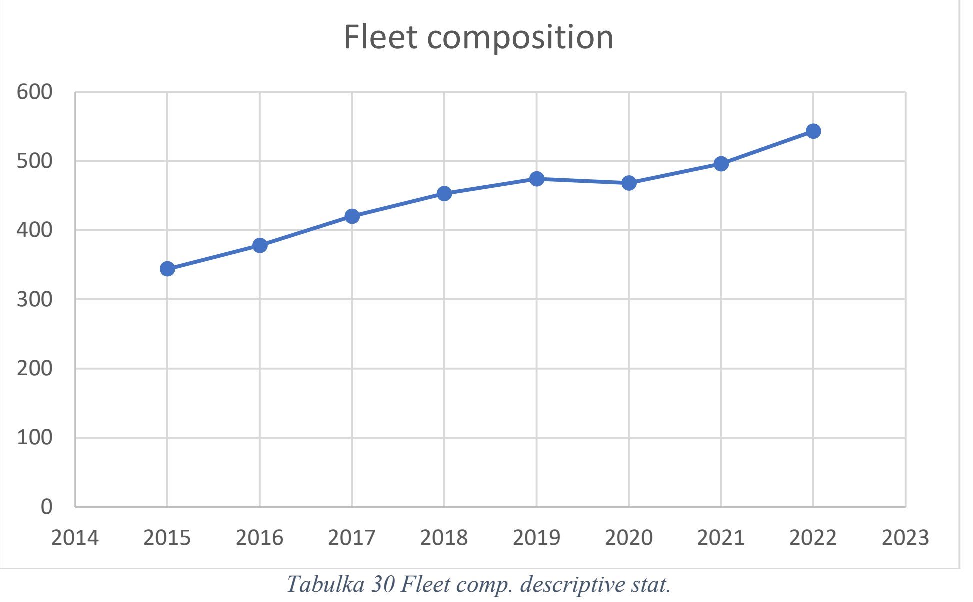
All indices are very close to 1, except years 2020 and 2022. From 2016 till 2018 there is a slow but steady increase, with an average 5% change. Big decrease occured in 2020, with index being equal to 0,816 and a 18,35% negative change.

Next variable is the number of planes, otherwise known as **fleet composition**.

Tabulka 28 Ryanair's fleet composition (Ryanair Corporate, 2023)

Year	Fleet composition
2015	344
2016	378
2017	420
2018	453
2019	474
2020	468
2021	496
2022	543

Tabulka 29 Fleet composition graph



Tabulka 30 Fleet comp. descriptive stat.

Fleet composition	
Mean	447
Standard Error	22,7258506
Median	460,5
Mode	#N/A
Standard Deviation	64,27841228
Sample Variance	4131,714286
Kurtosis	-0,337369365
Skewness	-0,293606408
Range	199
Minimum	344
Maximum	543
Sum	3576
Count	8

There is a steady increase in all but the 2019 – 2020 years, starting with 344 planes in 2015 and ending with 543 in 2022. The mean value is equal to 447, and the median is 460,5. Since there are no repeating values, the mode value does not exist. Standard deviation is equal to 64,28 with the minimum being 344 and maximum 543.

-0,337 is the value of kurtosis, which means that it is platykurtic. The skewness value is equal to -0,293, which indicates that the distribution is skewed to the left and is approximately symmetrical.

Tabulka 31 Ryanair fleet composition chain index table

Fleet composition	Chain index	Change in %
2015 - 344		
2016 - 378	1,099	9,88%
2017 - 420	1,111	11,11%
2018 - 453	1,079	7,86%
2019 - 474	1,046	4,64%
2020 - 468	0,987	-1,27%
2021 - 496	1,060	5,98%
2022 - 543	1,095	9,48%

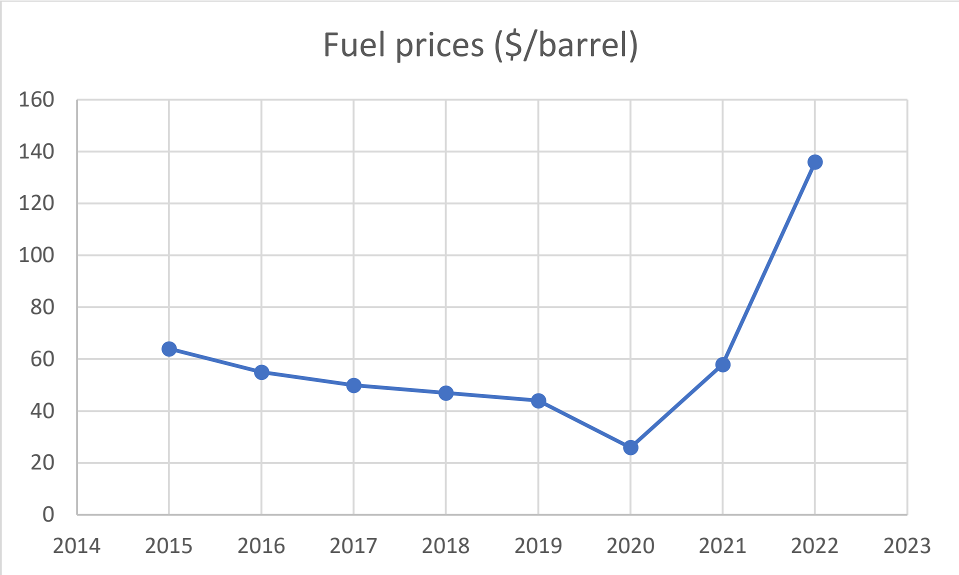
All but one indices are greater than 1, which means a steady increase year over year in the number of planes. Highest index is present in the year 2017 – 1,111. Percentage year for the same year was equal to 11,11%. In 2020 Ryanair utilized less planes, hence why the corresponding index is less than 1 – 0,987 and the precentage change is negative 1,27%.

Fuel prices variable is to be examined next.

Tabulka 32 Global fuel prices (IATA, 2023)

Year	Fuel prices ($/barrel)
2015	64
2016	55
2017	50
2018	47
2019	44
2020	26
2021	58
2022	136

Tabulka 33 Fuel prices graph



Tabulka 34 Fuel prices descriptive stat.

Fuel prices ($/barrel)	
Mean	60
Standard Error	11,57429418
Median	52,5
Mode	#N/A
Standard Deviation	32,7370476
Sample Variance	1071,714286
Kurtosis	5,48910553
Skewness	2,129862393
Range	110
Minimum	26
Maximum	136
Sum	480
Count	8

In the 2015 – 2020 range there is a steady decrease in fuel prices with the minimum being $26 per barrel in 2020. In 2021, when the aviation sector began to recover from the pandemic, fuel prices skyrocketed to a new heights, reaching $58 the same year, and continuing to increase, reaching $136 in 2022.

Mean value is equal to 60, median is 52,5, and the mode value once again does not exist for this dataset. Standard deviation is 32,7 on average, with the minimum being 26 and maximim 136. There are a lot of outliers as the kurtosis value is equal to 5,4. Since skewness is equal to 2,12, it is highly skewed to the right.

Tabulka 35 Fuel prices chain index table

Fuel prices	Chain index	Change in %
2015 - 64		
2016 - 55	0,859	14,06%
2017 - 50	0,909	-9,09%
2018 - 47	0,940	-6,00%
2019 - 44	0,936	-6,38%
2020 - 26	0,591	-40,91%
2021 - 58	2,231	123,08%
2022 - 136	2,345	134,48%

Fuel prices were decreasing constantly in the 2015 – 2020 period, as the indeces in the table above show. Highest drop occured in the year 2020, when the price lowered by 40,91%. After-covid recovery greatly influenced the fuel prices, as in the year 2021, the chain index is equal to 2,231, which is a 123% increase compared to the year before. The trend got even stronger in 2022, with the chain index equal to 2,345, which is a 134,48% increase over 2021.

4.1.2 Regression analysis of number of passengers

Next step of the analysis is building the regression model. This type of analysis is used to determine relationships between variables.

In this case, 2 regression analyses will be conducted – one where the dependent variable is the number of passengers, and the second one being profit margin. Both regressions will have the same four independent variables – average flight distance, number of routes, fleet composition and jet fuel prices.

Regression model typically looks like this:

$$\mathbf{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon.}$$

Where Y is the dependent variable which is being explained by the other variables in the equation, β_0 is the intercept; X_1, X_2, X_n are the independent variables; β_1, β_2, β_n are their corresponding coefficients and ε is the error.

Before building the model, it is necessary to conduct a multicollinearity check, which can tell us if there are some variables that are too similar to each other. Overall, addressing multicollinearity is crucial for ensuring the validity, reliability, and interpretability of the regression analysis. It safeguards the model from misleading interpretations and unstable predictions, ultimately building a foundation for trustworthy conclusions.

SAS Software will be used for all steps.

Parameter Estimates							
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	Intercept	1	149575983	125987413	1.19	0.3206	0
Average_Flight_Distance	Average_Flight_Distance	1	-111297	80568	-1.38	0.2611	1.78529
Number_of_routes	Number_of_routes	1	118974	23383	5.09	0.0147	2.11154
Fleet_composition	Fleet_composition	1	-163736	36630	-4.47	0.0209	1.41632
Fuel_prices	Fuel_prices	1	105003	67980	1.54	0.2201	1.26536

Figure 1 Multicollinearity check for first regression

The column which is important is the "Variance Inflation". It starts at 1 and has no upper limit. If the value is equal to exactly one, it means that there is no correlation between the independent variable and the other ones. If the variation inflation value is between 1 and 5, it suggests that there may be some slight correlation, however so small, that it will not hinder the regression model. If the value is above 5, there is strong correlation which needs attention.

In the table above, all values are less than 5, which is a good sign, and it can be proceeded to building the regression model.

Next step is Testing for Autocorrelation using The Durbin-Watson test.

The Durbin-Watson test is a statistical test used to detect the presence of autocorrelation in the residuals of a linear regression model. Autocorrelation occurs when the error terms (residuals) in the regression model are not independent but are instead correlated with each other over time.

H_0: There is no correlation among the residuals.
H_1: The residuals are autocorrelated.

Durbin-Watson Statistics			
Order	DW	Pr < DW	Pr > DW
1	2.3001	0.2229	0.7771
2	2.0662	0.6595	0.3405
3	2.3796	0.9840	0.0160
4	0.4053	0.0200	0.9800

Figure 2 First regression test for Autocorrelation

The test statistic always ranges from 0 to 4 where:
DW = 2 indicates no autocorrelation.
DW < 2 indicates positive serial correlation.
DW > 2 indicates negative serial correlation.

If DW is between 1.5 and 2.5 then autocorrelation is likely not a cause for concern. Since the output test statistic in the 1st order is equal to 2,3, it is necessary to accept H_0. There is no correlation among the residuals.

Next step of the regression is hypothesis testing in ANOVA.

ANOVA (Analysis of Variance) is used to determine if the model as whole, is significant. Hypothesis testing is necessary for this step.

H_0: there is no relationship between the number of passengers and all independent variables.
H_1: at least one of the independent variables has a relationship with the number of passengers.
Significance level = 5% (0.05)

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2.167679E15	5.419198E14	19.78	0.0171
Error	3	8.219586E13	2.739862E13		
Corrected Total	7	2.249875E15			

Figure 3 First regression ANOVA

Pr> F is the most important column. It shows the p value of the whole model.

Since the significance level was set at 0.05, and the result p value is 0.01, the conclusion is that the whole regression model is statistically significant as it contains at least one independendent variable with a relationship to number of passengers.

Now it is neccessary to look at all the independent variables p values separately.
Hypotheses:

H_0: There is no significant relationship between the number of passengers and the independent variable (each variable separately)
H_1: Significant relationship exists.
Significance level = 0.05

Root MSE	5234369	R-Square	0.9635
Dependent Mean	138625000	Adj R-Sq	0.9148
Coeff Var	3.77592		

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	149575983	125987413	1.19	0.3206
Average_Flight_Distance	Average_Flight_Distance	1	-111297	80568	-1.38	0.2611
Number_of_routes	Number_of_routes	1	118974	23383	5.09	0.0147
Fleet_composition	Fleet_composition	1	-163736	36630	-4.47	0.0209
Fuel_prices	Fuel_prices	1	105003	67980	1.54	0.2201

Figure 4 First regression output table

In the upper table there is a value called "R-Square", which is equal to 0.9635. This means that the model just constructed explains 96,35% of the variability of the dependent variables. However, in the lower table, p values of some variables are higher than the set significance level of 0.05, so the H_0 is proven correct, some variables are insignificant in this model. It is necessary to delete those variables from the model, including the intercept.

After running the regression again, only with variables with p values less than 0.05, this is the final output table:

Root MSE	6184919	R-Square	0.9985
Dependent Mean	138625000	Adj R-Sq	0.9980
Coeff Var	4.46162		

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Number_of_routes	Number_of_routes	1	128681	10436	12.33	<.0001
Fleet_composition	Fleet_composition	1	-166317	38414	-4.33	0.0049

Figure 5 First regression final output table

Now the R-Square value increased to 99,85% and all of the independent variables p values are less than 0.05. Alternate hypotheses is now accepted, all variables in the model are statistically significant.

Coefficient for number of routes is positive and is equal to 128681, coefficient for fleet composition is negative and is equal to -166317.

Next step is the homoscedasticity check. This process assumes that the variance of the errors (difference between predicted and actual values) is constant across all values of the independent variables. This step also requires hypotheses testing.

H_0: Variance of errors is constant.
H_1: Variance of errors is not constant.
Significance level = 0.05

Test of First and Second Moment Specification		
DF	Chi-Square	Pr > ChiSq
3	3.34	0.3424

Figure 6 First regression homoscedasticity check

Yet again we are interested in the final p value. In this case it is equal to 0,3424, which is greater that the set level of 0.05. This means that the H_0 must be accepted, so the variance of errors is constant.

Final step of the regression is the check for normal distribution of residuals. This also requires hypotheses testing.

H_0: Residuals are normally distributed
H_1: Residuals are not normally distributed.
Significance level = 0.05

Fitted Normal Distribution for r_ (Residual)

Goodness-of-Fit Tests for Normal Distribution				
Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.23968248	Pr > D	>0.150
Cramer-von Mises	W-Sq	0.06297167	Pr > W-Sq	>0.250
Anderson-Darling	A-Sq	0.40229129	Pr > A-Sq	>0.250

Figure 7 First regression normal distrib. of errors check

The row of interest is the Kolmogorov – Smirnov test. P value is greater than 0.15, which is greater than 0.05, so H_0 must be accepted. This means that residuals are normally distributed.

After completing all the necessary steps and checks for the regression analysis, the final model looks following:

$$\mathbf{Y = 128681 * X_1 - 166317 * X_2 + \varepsilon.}$$

Where Y is the number of passengers, 128681 is the coefficient for number of routes, X_1 is the number of routes, -166317 is the coefficient for fleet composition, X_2 is the fleet composition and ε is the error.

4.1.3 Regression analysis of profit margin

As in every regression analysis, the first step is multicollinearity check. Independent variables are same as in the regression above, only the dependent variable is different – now profit margin is being analysed.

Parameter Estimates							
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	Intercept	1	56.84570	52.27477	1.09	0.3564	0
Average_Flight_Distance	Average_Flight_Distance	1	-0.07936	0.03343	-2.37	0.0981	1.78529
Number_of_routes	Number_of_routes	1	0.05358	0.00970	5.52	0.0117	2.11154
Fleet_composition	Fleet_composition	1	-0.07365	0.01520	-4.85	0.0168	1.41632
Fuel_prices	Fuel_prices	1	0.05717	0.02821	2.03	0.1358	1.26536

Figure 8 Multicollinearity check for second regression

Variance Inflation does not exceed 5 in any of the rows, which means there is no multicollinearity problem in this dataset.

Next step is the Autocorrelation testing, which checks for correlation between residuals.

H_0: There is no correlation among the residuals.
H_1: The residuals are autocorrelated.

Durbin-Watson Statistics			
Order	DW	Pr < DW	Pr > DW
1	1.9618	0.0947	0.9053
2	2.0268	0.6357	0.3643
3	1.6563	0.7327	0.2673
4	0.6296	0.1207	0.8793

Figure 9 Second regression test for Autocorrelation

Since the test statistic in the output table is equal to 1.9618, which lies in the 1.5 – 2,5 range, H_0 is accepted, and therefore there is no correlation among the residuals.

Next step is the analysis of variance.

H_0: there is no relationship between the profit margin and all independent variables.
H_1: at least one of the independent variables has a relationship with the profit margin.
Significance level = 5% (0.05)

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	533.98424	133.49606	28.30	0.0102
Error	3	14.15076	4.71692		
Corrected Total	7	548.13500			

Root MSE	2.17185	R-Square	0.9742
Dependent Mean	15.47500	Adj R-Sq	0.9398
Coeff Var	14.03455		

Figure 10 Second regression ANOVA

P value is equal to 0.0102, which is less than 0.05, so H_1 must be accepted. Therefore, the model contains at least one independent variable which has a strong relationship with the profit margin.

R-Square is equal to 0.9742, which suggests that currently, the model describes 97,42% of the variation of the data.

Now it is neccessary to look at all the independent variables p values separately.

Hypotheses:

H_0: There is no significant relationship between the profit margin and the independent variable (each variable separately).
H_1: Significant relationship exists.
Significance level = 0.05

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	56.84570	52.27477	1.09	0.3564
Average_Flight_Distance	Average_Flight_Distance	1	-0.07936	0.03343	-2.37	0.0981
Number_of_routes	Number_of_routes	1	0.05358	0.00970	5.52	0.0117
Fleet_composition	Fleet_composition	1	-0.07365	0.01520	-4.85	0.0168
Fuel_prices	Fuel_prices	1	0.05717	0.02821	2.03	0.1358

Figure 11 Second regression output table

As the table above clearly shows, fuel prices' p value is 0.13, which exceeds the set threshold of 0.05. Intercept also exceeds that value. In order for the regression to be correct, it is necessary to delete these variables.

Root MSE	2.72827	R-Square	0.9849
Dependent Mean	15.47500	Adj R-Sq	0.9758
Coeff Var	17.63020		

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Average_Flight_Distance	Average_Flight_Distance	1	-0.04731	0.00907	-5.22	0.0034
Number_of_routes	Number_of_routes	1	0.06374	0.00742	8.59	0.0004
Fleet_composition	Fleet_composition	1	-0.06737	0.01742	-3.87	0.0118

Figure 12 Second regression final output table

R-Square value has risen to 98,49%. All independent variables p values are well below 0.05, so H_1 must be accepted. All variables are statistically significant.

Coefficient for average flight distance is -0.04731, number of routes coefficient is 0.06374 and fleet composition's coefficient is -0.06737.

Homoscedasticity check is next.

H_0: Variance of errors is constant.
H_1: Variance of errors is not constant.
Significance level = 0.05

Model: MODEL1
Dependent Variable: Profit_Margin Profit_Margin

Test of First and Second Moment Specification		
DF	Chi-Square	Pr > ChiSq
6	6.26	0.3945

Figure 13 Second regression homoscedasticity check

Since p value is equal to 0.39, which is greater than significance level of 0.05, H_0 is accepted and therefore variance of errors is constant.

Next and final step of the regression is the check for normal distribution of residuals. This also requires hypotheses testing.

H_0: Residuals are normally distributed
H_1: Residuals are not normally distributed.
Significance level = 0.05

Fitted Normal Distribution for r_ (Residual)

Goodness-of-Fit Tests for Normal Distribution				
Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.26315383	Pr > D	0.099
Cramer-von Mises	W-Sq	0.08320419	Pr > W-Sq	0.165
Anderson-Darling	A-Sq	0.50223766	Pr > A-Sq	0.146

Figure 14 Second regression normal distrib. of errors check

The row of interest is the Kolmogorov – Smirnov test. P value is equal to 0.09, which is greater than 0.05, so H_0 must be accepted. This means that residuals are normally distributed.

After completing all the necessary steps and checks for the regression analysis, the final model looks following:

$Y = -0.04731 * X_1 + 0.06374 * X_2 - 0.06737 * X_3 + \varepsilon$.

Where y is the profit margin, -0.04731 is the coefficient for average flight distance, X_1 is the average flight distance, 0.06374 is the coefficient for number of routes, X_2 is the number of routes, -0.06737 is the coefficient for fleet composition, X_3 is the fleet composition and ε is the error.

4.2 Analysis of British Airways

In order to compare British Airways to Ryanair, it is necessary to complete the same analysis of variables.

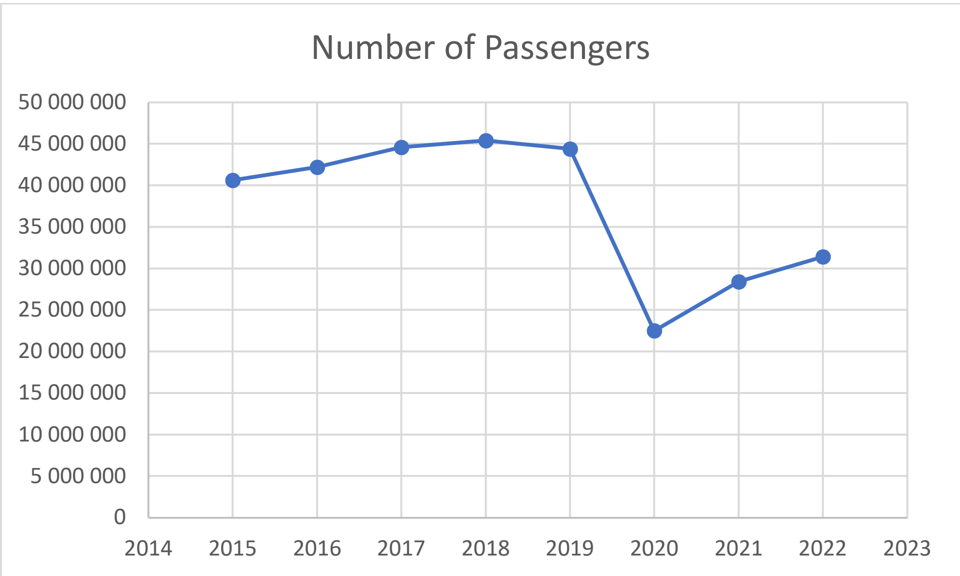
4.2.1 Time series analysis

First variable to be examined is the **number of passengers**.

Tabulka 36 BA's number of passengers (Statista, 2023)

Year	Number of Passengers
2015	40 600 000
2016	42 200 000
2017	44 600 000
2018	45 400 000
2019	44 400 000
2020	22 500 000
2021	28 400 000
2022	31 400 000

Tabulka 37 Number of passengers graph



Tabulka 38 Numb.of.pass. descriptive stat.

Number of Passengers	
Mean	37437500
Standard Error	3096999,556
Median	41400000
Mode	#N/A
Standard Deviation	8759637,55
Sample Variance	7,67313E+13
Kurtosis	-0,974968908
Skewness	-0,833663141
Range	22900000
Minimum	22500000
Maximum	45400000
Sum	299500000
Count	8

Steady increase can be seen throughout 2015 – 2018 period, with a slight decrease in 2019 and a major decrease in 2020. 2021 was the year when number of passengers started climbing again, however even with more increase the 2022 level is well below the pre-pandemic levels.

Mean, the average value, is equal to 37 437 500, while median is 41 400 000. Mode doesn't exist as no values repeat in this dataset. Standard deviation is 8 758 638. Minimum is in the year 2020 – 22 500 000 passengers, with the maximum recorded in the year 2018 – 45 400 000 passengers.

Kurtosis is equal to -0,97, which indicates that it is platykurtic. -0.833 is the value of skewness, which means that it is moderately skewed to the left.

Tabulka 39 BA's numb. of pass. chain index table

Year	Number of Passengers	Chain index	Change in %
2015	40 600 000	-	-
2016	42 200 000	1,039	3,94%
2017	44 600 000	1,057	5,69%
2018	45 400 000	1,018	1,79%
2019	44 400 000	0,978	-2,20%
2020	22 500 000	0,507	-49,32%
2021	28 400 000	1,262	26,22%
2022	31 400 000	1,106	10,56%

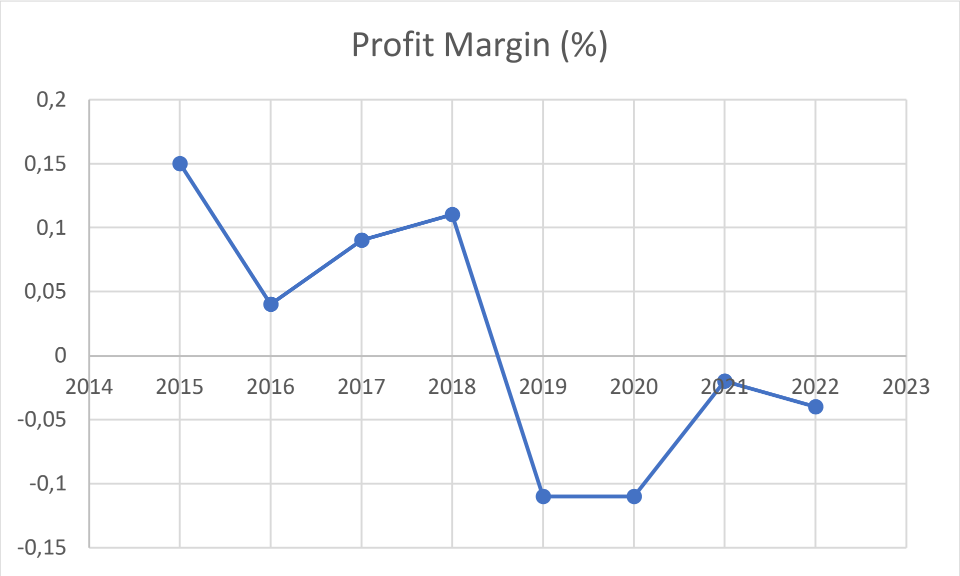
The chain index values are generally above 1, indicating an increase in the number of passengers compared to the previous year, except for:
2019: a slight decrease of 2,20%, 2020: a significant decrease of 49.32%, due to the COVID-19 pandemic.

Next variable to be analysed is the **profit margin**.

Tabulka 40 BA's profit margin (British Airways, 2023)

Year	Profit Margin (%)
2015	0,15
2016	0,04
2017	0,09
2018	0,11
2019	-0,11
2020	-0,11
2021	-0,02
2022	-0,04

Tabulka 41 Profit margin graph



Tabulka 42 Profit margin descriptive stat.

Profit Margin (%)	
Mean	0,01375
Standard Error	0,035098713
Median	0,01
Mode	-0,11
Standard Deviation	0,099274151
Sample Variance	0,009855357
Kurtosis	-1,569808533
Skewness	-0,019766596
Range	0,26
Minimum	-0,11
Maximum	0,15
Sum	0,11
Count	8

It’s clear that BA’s profit margin has been unsteady throughout the 2015 – 2022 period. Starting with 0,15 in 2015, dropping to 0,04 in 2016 and so on. It needs to be pointed out that even before the pandemic, the profit margin went negative, which may suggest some financial problems even before the border closures and restrictions that came with Covid-19.

Mean is 0,01 (1%), median is also 0,01. Mode is present and is equal to -0,11. Standard deviation is 0,09. Minimum is in the years 2019 and 2020 and is equal to -0,11, maximum is equal to 0,15 recorded in the year 2015. Kurtosis is platykurtic since its equal to -1,56. The distribution is symmetrical as the skewness value is very close to 0.

Tabulka 43 BA's profit margin chain index table

Year	Profit Margin	Chain index	Change in %
2015	0,15	-	-
2016	0,04	0,267	-73,33%
2017	0,09	2,250	125,00%
2018	0,11	1,222	22,22%
2019	-0,11	1,000	-200,00%
2020	-0,11	1,000	0,00%
2021	-0,02	0,182	-81,82%
2022	-0,04	2,000	100,00%

The chain indices fluctuate significantly: 2016 has an index of 0,267 which is a 73,33% decrease in profit margin. In 2017 the index was equal to 2,250 which is equal to 125% gain. 2019 had a 200% decrease in profit margin and stayed the same throughout 2020. 2021’s index is 0,182, however in this case it represents the profit margin 5 times larger than the year prior, but still in the negative.

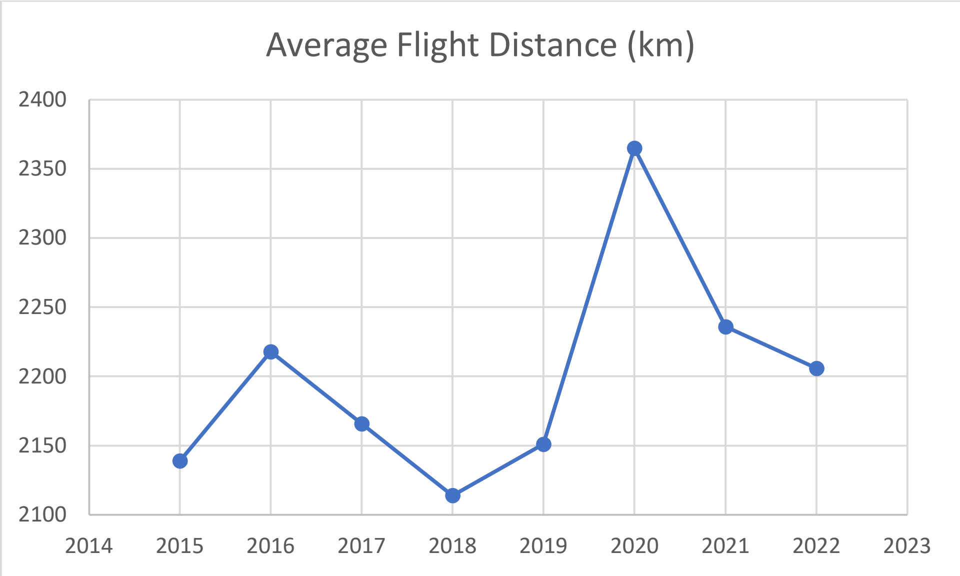
The YoY change for 2022, calculated as 100%, indicates that the profit margin in 2022 is twice the value in 2021 in absolute terms. However, it's crucial to recognize that both values are negative, meaning the company experienced a larger loss in 2022 compared to the previous year.

Average flight distance is the next variable to be looked at.

Tabulka 44 BA's average flight distance (British Airways, 2023)

Year	Average Flight Distance (km)
2015	2139
2016	2218
2017	2166
2018	2114
2019	2151
2020	2365
2021	2236
2022	2206

Tabulka 45 Average flight distance graph



Tabulka 46 Av. flight distance descriptive stat.

Average Flight Distance (km)	
Mean	2199,375
Standard Error	27,88748919
Median	2186
Mode	#N/A
Standard Deviation	78,87773088
Sample Variance	6221,696429
Kurtosis	2,429747507
Skewness	1,399791958
Range	251
Minimum	2114
Maximum	2365
Sum	17595
Count	8

The average flight distance varies greatly, as shown on the graph above. Biggest increase is in the years 2019 – 2020, where the distance increased from 2151 kilometres to 2365 kilometres. It is unknow if the Covid-19 pandemic had any influence on that, but it is important to point out that Ryanair had the biggest increase in the same years also.

Mean value is 2199, median is equal to 2186. Once again mode is not present. Standard deviation is 78,87 kilometres. Minimum occurred in the year 2018 and is equal to 2114. Maximum occurred during the 2020 year and is equal to 2365 kilometres.

Kurtosis is yet again platykurtic as it is equal to 2,43. The skewness value of 1,399 indicates that the distribution is highly skewed to the right.

Tabulka 47 BA's average fl. dist. chain index table

Year	Average Flight Distance	Chain index	Change in %
2015	2139	-	-
2016	2218	1,037	3,69%
2017	2166	0,977	-2,34%
2018	2114	0,976	-2,40%
2019	2151	1,018	1,75%
2020	2365	1,099	9,95%
2021	2236	0,945	-5,45%
2022	2206	0,987	-1,34%

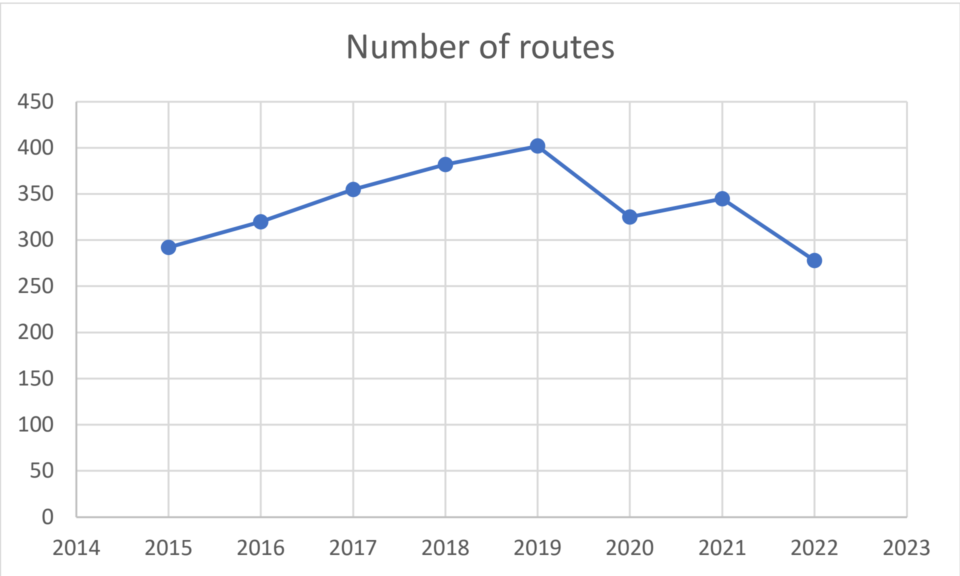
All the indices vary around 1 which shows less fluctuation. Biggest increase occurred in 2020, where the index is equal to 1,099 compared to 1,018 the year before. This is equal to 9,95% increase. Biggest drop happened the year after, where the index fell to 0,945, which is a 5,45% drop in average flight distance.

The next variable to be analysed is the **number of routes**.

Tabulka 48 BA's number of routes (British Airways, 2023)

Year	Number of routes
2015	292
2016	320
2017	355
2018	382
2019	402
2020	325
2021	345
2022	278

Tabulka 49 Number of routes graph



Tabulka 50 Number of routes descriptive stat.

Number of routes	
Mean	337,375
Standard Error	14,985633
Median	335
Mode	#N/A
Standard Deviation	42,38577086
Sample Variance	1796,553571
Kurtosis	-0,832613704
Skewness	0,137077664
Range	124
Minimum	278
Maximum	402
Sum	2699
Count	8

2015 – 2019 had a steady increase, ranging from 292 up to 402. This was followed by a decrease, increase and another decrease, ending with 278 routes in 2022.

Mean value is 337, median is equal to 335. Mode doesn't exist and the standard deviation is equal to 42, 39. Minimum was recorded in the year 2022 and is equal to 278, with the maximum in the year 2019 and being 402 routes.

In this case the kurtosis is platykurtic as its value is equal to -0,83. The skewness is equal to 0,13, which shows that the distribution is approximately symmetrical.

Tabulka 51 BA's numb. of routes chain index table

Year	Number of routes	Chain index	Change in %
2015	292	-	-
2016	320	1,096	9,59%
2017	355	1,109	10,94%
2018	382	1,076	7,61%
2019	402	1,052	5,24%
2020	325	0,808	-19,15%
2021	345	1,062	6,15%
2022	278	0,806	-19,42%

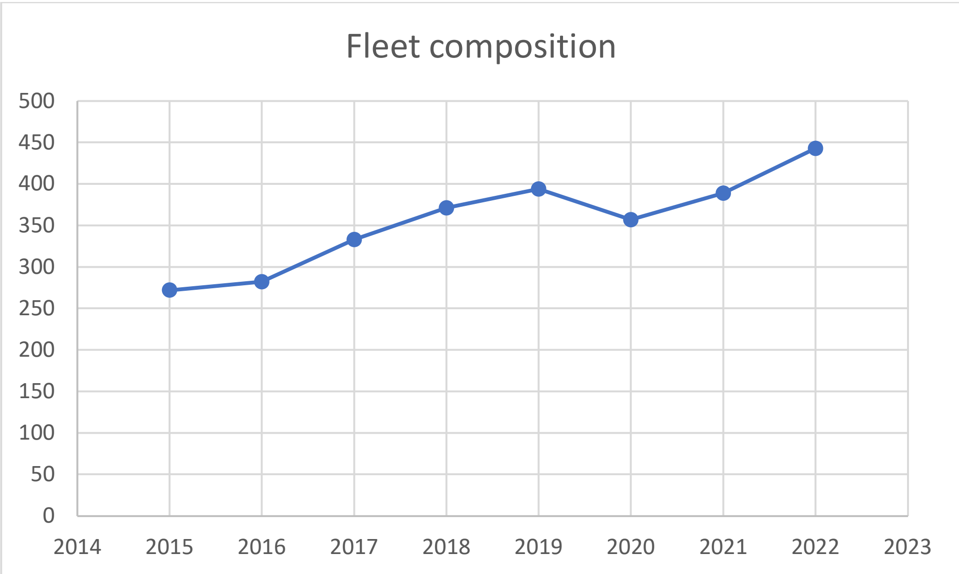
All indices, except for the years 2020 and 2020 are above 1, which suggests growth in the number of routes. In 2020, the number of routes dropped from 402 to 325, hence the 0,808 index, which is a 19,15% decrease. Similarly, 2020's index is 0,806 which is a 19,42% decrease.

Last variable to be examined is the **fleet composition** of British Airways.

Tabulka 52 BA's fleet composition (British Airways, 2023)

Year	Fleet composition
2015	272
2016	282
2017	333
2018	371
2019	394
2020	357
2021	389
2022	443

Tabulka 53 Fleet composition graph



Tabulka 54 Fleet comp. descriptive stat.

Fleet composition	
Mean	355,125
Standard Error	20,434073
Median	364
Mode	#N/A
Standard Deviation	57,79628634
Sample Variance	3340,410714
Kurtosis	-0,60223462
Skewness	-0,193394808
Range	171
Minimum	272
Maximum	443
Sum	2841
Count	8

Similar to number of routes, the fleet composition increases from 2015 till 2019, and then decreases in 2020. However, as the airline kept welcoming new planes into its fleet, in 2021 the variable started to increase yet again to a new height of 443 in 2022.

Mean is equal to 355, median to 364. Mode is not present yet again and the standard deviation is 57,80. Minimum number of planes was in the year 2015, with the value being 272. Maximum, 443 planes, is in the year 2022. Kurtosis is yet again platykurtic and the distribution is approximately symmetrical, due to skewness value being close to 0.

Tabulka 55 BA's fleet comp. chain index table

Year	Fleet composition	Chain index	Change in %
2015	272	-	-
2016	282	1,037	3,68%
2017	333	1,181	18,09%
2018	371	1,114	11,41%
2019	394	1,062	6,20%
2020	357	0,906	-9,39%
2021	389	1,090	8,96%
2022	443	1,139	13,88%

2020 is the only year in which the index is less than 1, 0,906 to be precise. This occurred because the number of planes decreased from 394 year before to 357. Other than that, a clear pattern is present, where the fleet is steadily increasing.

Since global jet fuel prices are the same for both airlines, it is not necessary to examine this variable again.

4.2.2 Regression analysis of number of passengers

Similar to the regression analysis of Ryanair, the first variable to be examined is the number of passengers. Independent variables are also the same – average flight distance, number of routes, fleet composition and fuel prices.

First step is the multicollinearity check using the SAS Software. The output table looks following:

Parameter Estimates							
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	Intercept	1	39594867	99722023	0.40	0.7179	0
Average_Flight_Distance	Average_Flight_Distance	1	-22240	35068	-0.63	0.5710	6.01175
Number_of_routes	Number_of_routes	1	248752	103224	2.41	0.0950	15.04125
Fleet_composition	Fleet_composition	1	-151791	57136	-2.66	0.0766	8.56836
Fuel_prices	Fuel_prices	1	278962	144007	1.94	0.1481	17.46315

Figure 15 Multicollinearity check for third regression

Variance Inflation column is the area of interest. In previous regressions the values for the independent varibles all were below 5, however, here the fuel prices variance inflation is equal to 17, and number of routes variance inflation is equal to 15. This shows us that there is a multicollinearity problem, which needs to be solved. In order for the regression to be accurate, the fuel prices variable will not be included, as its variance inflation is the highest. After deleting the variable from the model, the new multicollinearity check output table looks following:

Parameter Estimates							
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	Intercept	1	218865753	48268801	4.53	0.0105	0
Average_Flight_Distance	Average_Flight_Distance	1	-83403	19826	-4.21	0.0136	1.13825
Number_of_routes	Number_of_routes	1	56650	37231	1.52	0.2028	1.15907
Fleet_composition	Fleet_composition	1	-48171	26091	-1.85	0.1386	1.05842

Figure 16 Third regression multicollinearity check final table

Now, after deleting the problematic variable, all Variance Inflation values are around 1.1, which suggests that there is no more multicollinearity problem in this model.

Next step is the Autocorrelation testing, which checks for correlation between residuals.

H_0: There is no correlation among the residuals.
H_1: The residuals are autocorrelated.

Durbin-Watson Statistics			
Order	DW	Pr < DW	Pr > DW
1	2.2700	0.1940	0.8060
2	1.6034	0.4441	0.5559
3	0.5904	0.1352	0.8648
4	1.5998	0.8115	0.1885

Figure 17 Third regression test for Autocorrelation

Since the test statistic in the output table is equal to 2,27, which lies in the 1.5 – 2,5 range, H_0 is accepted, and therefore there is no correlation among the residuals.

Next step of the regression is hypothesis testing in ANOVA.

ANOVA (Analysis of Variance) is used to determine if the model as whole, is significant. Hypothesis testing is necessary for this step.

H_0: there is no relationship between the number of passengers and all independent variables.
H_1: at least one of the independent variables has a relationship with the number of passengers.
Significance level = 5% (0.05)

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	4.769617E14	1.589872E14	10.57	0.0226
Error	4	6.015708E13	1.503927E13		
Corrected Total	7	5.371188E14			

Root MSE	3878050	R-Square	0.8880
Dependent Mean	37437500	Adj R-Sq	0.8040
Coeff Var	10.35873		

Figure 18 Third regression ANOVA

Since we set significance level at 0.05, and the result p value is 0.02, the conclusion is that the whole regression model is statistically significant as it contains at least one independent variable with a relationship with the dependent one. R-Square value is equal to 88.8%.

Now it is neccessary to look at all the independent variables p values separately.

Hypotheses:

H_0: There is no significant relationship between the number of passengers and the independent variable (each variable separately).
H_1: Significant relationship exists.
Significance level = 0.05

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	218865753	48268801	4.53	0.0105
Average_Flight_Distance	Average_Flight_Distance	1	-83403	19826	-4.21	0.0136
Number_of_routes	Number_of_routes	1	56650	37231	1.52	0.2028
Fleet_composition	Fleet_composition	1	-48171	26091	-1.85	0.1386

Figure 19 Third regression output table

As the table above shows, some variables' p values are greater than 0.05, so H_0 must be accepted for them. Therefore, these variables must be excluded from the model as they are not statistically significant. These variables are – number of routes and fleet composition.

Root MSE	4681926	R-Square	0.7551
Dependent Mean	37437500	Adj R-Sq	0.7143
Coeff Var	12.50598		

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	249685094	49370173	5.06	0.0023
Average_Flight_Distance	Average_Flight_Distance	1	-96504	22435	-4.30	0.0051

Figure 20 Third regression final output table

Now, all variables' p values are lesser than 0.05, so we accept H_1 – all variables are statistically significant. In this case its the intercept and the average flight distance.

R-Square value decreased to 0.7551, which shows thats 75.51% of data is described by this model. Intercept is equal to 249685094, and the coefficient for the average flight distance is -96504.

Next step is the Homoscedasticity check.

H_0: Variance of errors is constant.
H_1: Variance of errors is not constant.
Significance level = 0.05

Model: MODEL1
Dependent Variable: Number_of_Passengers Number_of_Passengers

Test of First and Second Moment Specification		
DF	Chi-Square	Pr > ChiSq
2	5.21	0.0739

Figure 21 Third regression homoscedasticity check

The output p value is 0.07, which is greater than 0.05, so H_0 must be accepted – variance of errors is constant.

Next and final step of the regression is the check for normal distribution of residuals. This also requires hypotheses testing.

H_0: Residuals are normally distributed
H_1: Residuals are not normally distributed.
Significance level = 0.05

Fitted Normal Distribution for r_ (Residual)

Goodness-of-Fit Tests for Normal Distribution				
Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.14350027	Pr > D	>0.150
Cramer-von Mises	W-Sq	0.02309867	Pr > W-Sq	>0.250
Anderson-Darling	A-Sq	0.18876742	Pr > A-Sq	>0.250

Figure 22 Third regression normal distrib. of errors check

The row of interest is the Kolmogorov – Smirnov test. P value is greater than 0.15, which is greater than 0.05, so H_0 must be accepted. This means that residuals are normally distributed.

After completing all the necessary steps and checks for the regression analysis, the final model looks following:

$Y = 249685094 - 96504 * X_1 + \varepsilon$.

Where Y is the number of passengers, 249685094 is the intercept, X_1 is the average flight distance, -96504 is the coefficient for the average flight distance and ε is the error term.

4.2.3 Regression analysis of profit margin

Last regression to be made is about the profit margin of British Airways. Independent variables are also the same – average flight distance, number of routes, fleet composition and fuel prices.

First step is the multicollinearity check using the SAS Software. The output table looks following:

Parameter Estimates							
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	Intercept	1	4.03358	2.25605	1.79	0.1718	0
Average_Flight_Distance	Average_Flight_Distance	1	-0.00140	0.00079335	-1.77	0.1749	6.01175
Number_of_routes	Number_of_routes	1	-0.00242	0.00234	-1.04	0.3754	15.04125
Fleet_composition	Fleet_composition	1	0.00011503	0.00129	0.09	0.9347	8.56836
Fuel_prices	Fuel_prices	1	-0.00257	0.00326	-0.79	0.4873	17.46315

Figure 23 Multicollinearity check for fourth regression

The column of interest is the Variance Inflation. Values above 5 suggest a strong collinearity between some variables, and it is necessary to delete some. Fuel prices variable will not be included in the regression, as its Variance Inflation value is the highest.

After deleting fuel prices, and doing the multicollinearity check again, this is the output table:

Parameter Estimates							
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	Intercept	1	2.37983	0.79998	2.97	0.0409	0
Average_Flight_Distance	Average_Flight_Distance	1	-0.00083990	0.00032858	-2.56	0.0629	1.13825
Number_of_routes	Number_of_routes	1	-0.00065272	0.00061704	-1.06	0.3498	1.15907
Fleet_composition	Fleet_composition	1	-0.00084085	0.00043242	-1.94	0.1237	1.05842

Figure 24 Fourth regression multicollinearity check final table

All remaining variables’ Variance Inflation values are near 1, which suggests that the multicollinearity problem has been solved and it is safe to proceed to the next step which is building the regression model itself.

Next step is the Autocorrelation testing, which checks for correlation between residuals.

H_0: There is no correlation among the residuals.
H_1: The residuals are autocorrelated.

Durbin-Watson Statistics			
Order	DW	Pr < DW	Pr > DW
1	2.1835	0.3697	0.6303
2	2.9020	0.9469	0.0531
3	1.1022	0.4015	0.5985
4	0.8360	0.3449	0.6551

Figure 25 Fourth regression test for Autocorrelation

Since the test statistic in the output table is equal to 2.1835, which lies in the 1.5 – 2,5 range, H_0 is accepted, and therefore there is no correlation among the residuals.

Next step of the regression is hypothesis testing in ANOVA.

ANOVA (Analysis of Variance) is used to determine if the model as whole, is significant. Hypothesis testing is necessary for this step.

H_0: there is no relationship between the profit margin and all independent variables.
H_1: at least one of the independent variables has a relationship with the profit margin.
Significance level = 10% (0.1)

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.05246	0.01749	4.23	0.0986
Error	4	0.01652	0.00413		
Corrected Total	7	0.06899			

Root MSE	0.06427	R-Square	0.7605
Dependent Mean	0.01375	Adj R-Sq	0.5808
Coeff Var	467.43851		

Figure 26 Fourth regression ANOVA

The Pr>F value is equal to 0.0986 which is less than the set alpha of 0.1, which proves that the whole regression model is statistically significant as it contains at least one independent variable with a relationship with the dependent one. R-Square value is equal to 76.05%.

Now it is neccessary to look at all the independent variables p values separately.

Hypotheses:

H_0: There is no significant relationship between the profit margin and the independent variable (each variable separately)
H_1: Significant relationship exists.
Significance level = 0.1

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	2.37983	0.79998	2.97	0.0409
Average_Flight_Distance	Average_Flight_Distance	1	-0.00083990	0.00032858	-2.56	0.0629
Number_of_routes	Number_of_routes	1	-0.00065272	0.00061704	-1.06	0.3498
Fleet_composition	Fleet_composition	1	-0.00084085	0.00043242	-1.94	0.1237

Figure 27 Fourth regression output table

Number of routes and fleet composition variables‘ p values are greater than 0.1, which suggest they are insignificant. However, before deleting both, first will be deleted the one with the higher p value, that being the number of routes variable, as doing so may decrease the other variables‘ p value below the 0.1 threshold.

Root MSE	0.06503	R-Square	0.6935
Dependent Mean	0.01375	Adj R-Sq	0.5709
Coeff Var	472.96821		

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	1.93824	0.69050	2.81	0.0377
Average_Flight_Distance	Average_Flight_Distance	1	-0.00072357	0.00031330	-2.31	0.0689
Fleet_composition	Fleet_composition	1	-0.00093792	0.00042757	-2.19	0.0797

Figure 28 Fourth regression final output table

As shown on the figure above, fleet compostion’s p value decreased below the 0.1 threshold and is equal to 0.07. Other remaining variables’ p values are also below 0.1, and therefore H_1 must be accepted.

R-Square value decreased slightly do 69.35%, intercept is equal to 1.93824, coefficient of average flight distance is equal to -0.00072357 and fleet composition’s coefficient is equal to -0.00093792.

Next step is the Homoscedasticity check.

H_0: Variance of errors is constant.
H_1: Variance of errors is not constant.
Significance level = 0.1

Model: MODEL1
Dependent Variable: Profit_Margin Profit_Margin

Test of First and Second Moment Specification		
DF	Chi-Square	Pr > ChiSq
5	2.02	0.8470

Figure 29 Fourth regression homoscedasticity check

The output p value is 0.847, which is greater than 0.1, so H_0 must be accepted – variance of errors is constant.

Next and final step of the regression is the check for normal distribution of residuals. This also requires hypotheses testing.

H_0: Residuals are normally distributed
H_1: Residuals are not normally distributed.
Significance level = 0.1

Fitted Normal Distribution for r_ (Residual)

Goodness-of-Fit Tests for Normal Distribution				
Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.23440307	Pr > D	>0.150
Cramer-von Mises	W-Sq	0.11775703	Pr > W-Sq	0.052
Anderson-Darling	A-Sq	0.71224982	Pr > A-Sq	0.039

Figure 30 Fourth regression normal distrib. of errors check

The row of interest is the Kolmogorov – Smirnov test. P value is greater than 0.15, which is greater than 0.1, so H_0 must be accepted. This means that residuals are normally distributed.

After completing all the necessary steps and checks for the regression analysis, the final model looks following:

$$\mathbf{Y = 1.93824 - 0.00072357 * X_1 - 0.00093792 * X_2 + \varepsilon.}$$

Where Y is the profit margin, 1.93824 is the intercept, X_1 and X_2 are average flight distance and fleet compostition respectively, and -0.00072357 and -0.00093792 are their respective coefficients and ε is the error term.

5. Results and Discussion

This chapter presents the results of the quantitative investigation into the impact of low-cost carriers (LCCs) on the European airline industry.

Time series analyses:

This approach explored trends and patterns in key variables over time, allowing for comparison between Ryanair and British Airways across the 2015 – 2022 period.

Regression models:

Two regression models were built for each airline. One dependent variable, same for both airlines, was the number of passengers. Average flight distance, number of routes, fleet composition and jet fuel prices acted as the independent variables.

The other two regressions had profit margin as the dependent variable, with the independent variables being the same.

5.1 Analysis of Ryanair results

As discussed previously, the time series analyses provided valuable insights into the trends and patterns of key variables over time. Building upon those findings, this section dives deeper into the relationships between these variables by examining the results of the regression models. These models offer a more detailed understanding of the factors influencing Ryanair's number of passengers and profit margin using the independent variables.

First regression had **number of passengers** as the dependent variable and average flight distance, number of routes, fleet composition and jet fuel prices as the independent ones.

First step when building the regression model was the Multicollinearity check, which refers to a situation where two or more independent variables in a regression model are highly correlated with each other. This creates challenges in interpreting the individual effects of each variable on the dependent variable, as their influence can be misleading. Using SAS Software, and looking at the VIF value of each variable, it was concluded that there is no multicollinearity problem, and it was proceeded to the next step, which was test for Autocorrelation.

Autocorrelation occurs when the error terms (residuals) in the regression model are not independent but are instead correlated with each other over time.

H_0: There is no correlation among the residuals.
H_1: The residuals are autocorrelated.

If DW is between 1.5 and 2.5 then autocorrelation is likely not a cause for concern. Since the output test statistic in the 1st order was equal to 2.3, it was necessary to accept H_0. There is no correlation among the residuals.

Next step of the regression was ANOVA.

For this step, hypotheses testing was implemented, which looked following:

H_0: there is no relationship between the number of passengers and all independent variables.
H_1: at least one of the independent variables has a relationship with the number of passengers.
Significance level = 5% (0.05)

Since the output p value was less than the set significance level of 0.05, it was concluded that the whole model is statistically significant.

Next step was the hypothesis testing for each of the independent variables, which looked following:

H_0: There is no significant relationship between the number of passenger and the independent variable (each variable separately).
H_1: Significant relationship exists.
Significance level = 0.05

Intercept, average flight distance and fuel prices' p values were less than the set significance level of 0.05, so they had to be deleted from the model. Number of routes' final p value was less than 0.0001, and fleet compositions was equal to 0.0049. 0.9985 was the value of R-Squared, which showed that 99.85% of the variability of number of passengers was explained by number of routes and fleet composition.

Coefficients for number of routes and fleet composition were 128681 and -166317 respectively.

Next step was the Homoscedasticity check, which tests if the variance of errors is constant.

The hypothesis looked following:

H_0: Variance of errors is constant.
H_1: Variance of errors is not constant.
Significance level = 0.05

Since the output p value was equal to 0.34, which is greater than 0.05, H_0 was accepted. Next and final step was the normal distribution of residuals check using the Kolmogorov-Smirnov Goodness-of-Fit test.

H_0: Residuals are normally distributed.
H_1: Residuals are not normally distributed.
Significance level = 0.05

The p value for this test was greater than 0.05, so it was concluded that residuals are in fact normally distributed.

After completing all the necessary steps and checks for the regression analysis, the final model looked following:

$$Y = 128681 * X_1 - 166317 * X_2 + \varepsilon.$$

Where Y is the number of passengers, 128681 is the coefficient for number of routes, X_1 is the number of routes, -166317 is the coefficient for fleet composition, X_2 is the fleet composition and ε is the error.

Number of Routes (X_1): Represented by a coefficient of 128681, a positive relationship exists. This suggests that an increase in the number of routes offered by Ryanair leads to an increase in the number of passengers. In other words, the more routes Ryanair's network can offer, the more passengers it can carry.

Number of Planes (X_2): Represented by a coefficient of -166317, a negative relationship exists. This indicates that having a larger fleet size (more planes) is associated with a decrease in the total number of passengers. It is impossible to say confidently what causes that, but here are some possible interpretations:

1) Potential overcapacity: This could suggest that the airline might have more planes than necessary to serve the existing routes efficiently. This could lead to empty seats and lower number of passengers carried.

2) Inefficient deployment: The negative association might arise from inefficient allocation of planes across routes. Some routes might have more planes than needed, while others might be under-served.

The model does not include an intercept term. While a statistically insignificant p-value (> 0.05) often accompanies the intercept in regression models, it was opted to remove it in this specific case. This decision was based on the following considerations:

1) Theoretical Context: In this model, where Y represents Ryanair's number of passengers and X_1 and X_2 represent the number of routes and airplanes, respectively, the intercept would signify the predicted number of passengers when both routes and airplanes are zero. This scenario is conceptually unrealistic and doesn't align with the practical context of the airline industry.

2) Model Fit: Removing the intercept resulted in a slightly improved model fit as measured by R-squared. This suggests that the model performs marginally better without the intercept in capturing the relationship between the number of routes, airplanes, and passenger numbers.

Next variable in the Ryanair part of regression analysis was the **profit margin**, which followed the exact same steps.

The multicollinearity check was conducted first. As no variable had VIF value above 5, it was determined that there was no multicollinearity problem in the dataset.

Next step was the Autocorrelation test.

H_0: There is no correlation among the residuals.
H_1: The residuals are autocorrelated.

Since the test statistic in the output table was equal to 1.9618, which lies in the 1.5 – 2,5 range, H_0 was accepted, and therefore there is no correlation among the residuals.

Next step was the ANOVA. The hypothesis looked following:

H_0: there is no relationship between the profit margin and all independent variables.
H_1: at least one of the independent variables has a relationship with profit margin.
Significance level = 5% (0.05)

Since the output p value was equal to 0.01, which is less than the set significance level of 0.05, it was concluded that the whole model is statistically significant.

Next step was the hypothesis testing for each of the independent variables, which looked following:
H_0: There is no significant relationship between the profit margin and the independent variable (each variable separately).
H_1: Significant relationship exists.
Significance level = 0.05

Intercept and fuel prices had p value exceeding the set threshold of 0.05, so these variables were deleted from the model. Average flight distance, number of routes and fleet composition were proven to be significant and -0.04731, 0.06374 and -0.06737 were there corresponding coefficients.

Homoscedasticity check was up next, where the variance of errors was tested.

H_0: Variance of errors is constant.
H_1: Variance of errors is not constant.
Significance level = 0.05

The output p value was equal to 0.39, so the H_0 was accepted. Next and final step was the normal distribution of residuals check using the Kolmogorov-Smirnov Goodness-of-Fit test.

H_0: Residuals are normally distributed.
H_1: Residuals are not normally distributed.
Significance level = 0.05

The p value for this test was greater than 0.05, so it was concluded that residuals are in fact normally distributed.

After completing all the necessary steps and checks for the regression analysis, the final model looked following:

$$\mathbf{Y = -0.04731 * X_1 + 0.06374 * X_2 - 0.06737 * X_3 + \varepsilon.}$$

Where Y is the profit margin, X_1 is the average flight distance, X_2 is the number of routes, X_3 is the fleet composition, -0.04731, 0.06374 and -0.06737 are there corresponding coefficients and ε is the error.

Average Flight Distance (X_1): Represented by a coefficient of -0.04731, a negative relationship exists. Routes with longer flight distance tend to have lower profit margins due to factors like higher fuel and maintenance costs.

Number of Routes (X_2): Represented by a coefficient of 0.06374, a positive relationship exists. The more routes Ryanair can offer, the higher profit margins due to potential economies of scale and network effects.

Fleet Composition (X_3): Represented by a coefficient of -0.06737, a negative relationship exists. This suggests that having a larger fleet size (more planes) is associated with a decrease in profit margin.

The intercept term was intentionally omitted from the model due to its p value exceeding 0.05 threshold and because of lack of theoretical meaning in this context. Profit margin cannot exist when average flight distance, number of routes, and fleet composition are all zero.

5.2 Analysis of British Airways results

Similar to the regression analysis of Ryanair, the first variable to be examined was the number of passengers. Independent variables were also the same – average flight distance, number of routes, fleet composition and fuel prices. All procedures were done in SAS Software.

First step was the multicollinearity check.

The variance inflation of number of routes was equal to 15, while the VIF for fuel prices was equal to 17. This showed that there is multicollinearity problem in this dataset, which needed to be fixed. In order to for the regression to be accurate, it was decided to delete the fuel prices variable and not include it in the next steps.

After deleting the problematic variable, all variables' VIF values set to around 1.1, which suggested that the problem has been solved.

Next up was the Autocorrelation testing, which checked for correlation between residuals. The Durbin-Watson test was used for this procedure.

H_0: There is no correlation among the residuals.
H_1: The residuals are autocorrelated.

Since the test statistic in the output table was equal to 2,27, which lied in the 1.5 – 2,5 range, H_0 was accepted, and therefore there was no correlation among the residuals.

Next step was the Analysis of Variance, which is used to determine if the model as whole, is significant. Hypothesis testing was necessary for this step.

H_0: there is no relationship between the number of passengers and all independent variables.
H_1: at least one of the independent variables has a relationship with the number of passengers.
Significance level = 5% (0.05)

The result p value in the output table was equal to 0.02, which proved that H_1 must be accepted. The conclusion was that the whole regression model was statistically significant as it contained at least one independent variable with a relationship with the dependent one.

Next step was to look at all the independent variables p values separately.
Hypotheses:

H_0: There is no significant relationship between the number of passengers and the independent variable (each variable separately).
H_1: Significant relationship exists.
Significance level = 0.05

In the first output table 2 variables – number of routes and fleet composition, had p values exceeding the 0.05 threshold, so they had to be excluded from the model.

Second output table had intercept with p value equal to 0.0023 and average flight distance variable p value equal to 0.0051. Therefore, H_1 was accepted. R-Square value was equal to 0.7551.

Next step was the Homoscedasticity check.

H_0: Variance of errors is constant.
H_1: Variance of errors is not constant.
Significance level = 0.05

The output p value was 0.07, which was greater than 0.05, so H_0 was accepted – variance of errors is constant.

Next and final step of the regression was the check for normal distribution of residuals. This also required hypotheses testing.

H_0: Residuals are normally distributed
H_1: Residuals are not normally distributed.
Significance level = 0.05

The row of interest was the Kolmogorov – Smirnov test. P value was greater than 0.15, which is greater than 0.05, so H_0 was accepted. This meant that residuals are normally distributed.

After completing all the necessary steps and checks for the regression analysis, the final model looks following:

$$\mathbf{Y = 249685094 - 96504 * X_1 + \varepsilon.}$$

Where Y is the number of passengers, 249685094 is the intercept, X_1 is the average flight distance, -96504 is the coefficient for the average flight distance and ε is the error term.

Average Flight Distance (X_1): Represented by a coefficient of -96504, a negative relationship exists. This suggests that BA's flights with longer average flight distances tend to have fewer passengers. There are several possible explanations for this:

1) Capacity limitations: Larger aircraft used for long-haul flights might have higher passenger capacity, but the model doesn't account for this. If the number of flights remains constant, longer distances might simply translate to fewer flights overall, leading to a lower total number of passengers.

2) Market factors: Long-haul flights often cater to specific market segments (e.g., business travellers) compared to short-haul flights with potentially broader appeal. This could lead to a smaller pool of potential passengers for long-distance routes.

In the equation, the intercept (249685094) represents the predicted number of passengers when the average flight distance (X_1) is zero. However, interpreting the intercept in this context is tricky, as an average flight distance of zero is not a realistic scenario for any airline. Therefore, the intercept doesn't represent a meaningful number of passengers in the real world.

The final regression covered the British Airways' profit margin as the dependent variables, with the independent variables being the same.

First step was the multicollinearity check, where similar to the regression above, number of routes and fuel prices both had high VIF values, exceeding the 5 units threshold. Fuel prices was chosen to be deleted as its VIF was higher.

The exclusion of this variables led to all other variables VIF values come down to around 1.1. This suggested that the multicollinearity problem had been solved.

Next was the Autocorrelation test, which checked for correlation between residuals.

H_0: There is no correlation among the residuals.
H_1: The residuals are autocorrelated.

Since the test statistic in the output table was equal to 2.1835, which lied in the 1.5 – 2,5 range, H_0 was accepted, and therefore there was no correlation among the residuals.

Analysis of Variance followed, where the model as a whole was tested for significancy using hypothesis testing.

H_0: there is no relationship between the profit margin and all independent variables.
H_1: at least one of the independent variables has a relationship with the profit margin.
Significance level = 10% (0.1)

H_1 was accepted since the output p value was equal to 0.0986, which is less than the set alpha of 0.1. This proved that the whole regression model was statistically significant as it contained at least one independent variable with a relationship with the dependent one. R-Square value was equal to 76.05%.

Then it was necessary to examine all the independent variables separately using hypothesis testing.

H_0: There is no significant relationship between the profit margin and the independent variable (each variable separately)
H_1: Significant relationship exists.
Significance level = 0.1

Number of routes p value was greater than 0.1, so H_0 was accepted for this variable. This led to this variable being deleted from the model.

After testing the remaining variables again, all p values were less than 0.1, and H_1 was accepted for all of them. R-Square value decreased slightly do 69.35%, intercept was equal to 1.93824, coefficient of average flight distance was equal to -0.00072357 and fleet composition's coefficient was equal to -0.00093792.
Next step was the Homoscedasticity check.

H_0: Variance of errors is constant.
H_1: Variance of errors is not constant.
Significance level = 0.1

The output p value was 0.847, which is greater than 0.1, so H_0 must have been accepted – variance of errors is constant.

Next and final step of the regression was the check for normal distribution of residuals. This also required hypotheses testing.

H_0: Residuals are normally distributed
H_1: Residuals are not normally distributed.
Significance level = 0.1

Output p value was greater than 0.15, which is greater than 0.1, so H_0 was accepted. This meant that residuals are normally distributed.

After completing all the necessary steps and checks for the regression analysis, the final model looks following:

$$\mathbf{Y = 1.93824 - 0.00072357 * X_1 - 0.00093792 * X_2 + \varepsilon.}$$

Where Y is the profit margin, 1.93824 is the intercept, X_1 and X_2 are average flight distance and fleet compostition respectively, and -0.00072357 and -0.00093792 are their respective coefficients and ε is the error term.

Average Flight Distance (X_1): Represented by a coefficient of -0.00072357, a negative relationship exists. This suggests that having a larger average flight distance is associated with a decrease in profit margin. It may be explained by:

1) Increased maintenance costs for larger aircraft typically used for long-haul flights.

2) More intense competition on longer routes, putting pressure on profit margins.

Number of Planes (X_2): Represented by a coefficient of -0.00093792, a negative relationship exists. This suggests that having a larger fleet size (more planes) is associated with a decrease in profit margin. Here are some interpretations:

1) Potential overcapacity: This could suggest that the airline might have more planes than necessary to serve its existing routes efficiently.

2) Empty seats and lower revenue per flight due to underutilization of planes.

3) Higher fixed costs associated with maintaining a larger fleet, even if they are not fully utilized.

4) Inefficient deployment: The negative association might arise from inefficient allocation of planes across routes. Some routes might have more planes than needed, while others might be under-served.

5) Missed opportunities on under-served routes with potentially higher profitability.

In the equation, the intercept (1.93824) represents the predicted profit margin when both the average flight distance (X_1) and the number of planes (X_2) are zero. However, having an average flight distance and number of planes of zero is not a realistic scenario for any airline. Therefore, the intercept doesn't represent a meaningful profit margin in the real world.

6. Conclusion

This quantitative analysis explored the dynamic landscape of the European airline industry, where established giants (British Airways) and agile disruptors (Ryanair) competed with contrasting business models. Real-world data analysis aimed to provide a comprehensive understanding of factors influencing the performance of both types of carriers.

Ryanair and Number of Passengers:

An investigation of Ryanair, a prominent LCC, revealed a positive relationship between the number of routes and passenger numbers. This suggests LCCs benefit from extensive networks that cater to a wider range of destinations, potentially attracting more passengers. However, further research into factors beyond network size, such as pricing strategies and brand image, could provide a more holistic view of passenger preferences.

Ryanair and Profit Margin:

The analysis of Ryanair's profit margin highlighted the potential challenges associated with longer routes. The negative coefficient for average flight distance suggests LCCs might experience lower profit margins on routes with higher fuel costs or lower passenger demand for longer journeys. Optimizing network design and aircraft selection for specific routes could be crucial for LCCs to maintain profitability on longer distances.

British Airways and Number of Passengers:

The analysis of British Airways (BA), a traditional carrier, revealed a statistically significant negative relationship between average flight distance and passenger numbers. This finding aligned with expectations, as longer flights offered by traditional carriers typically catered to a smaller market segment compared to shorter, more affordable routes offered by LCCs. Understanding passenger preferences for different flight distances could help BA optimize their route network and pricing strategies.

British Airways and Profit Margin:

The analysis of BA's profit margin identified two key factors influencing profitability. The negative coefficient for average flight distance suggests a potential decrease in profit margin with longer routes, similar to the findings for Ryanair. Additionally, the negative coefficient for fleet composition (number of planes) suggests a potential link between having a larger fleet and lower profit margin due to higher fixed costs. Optimizing fleet size, route allocation, and aircraft types for specific routes could be crucial for BA to improve profitability.

Overall Significance:

This research contributes to a deeper understanding of the complex dynamics within the European airline industry. Analysing both LCCs and traditional carriers using a quantitative approach shed light on the factors influencing passenger numbers and profit margins.

The statistical models employed included intercept terms, which represent hypothetical scenarios where all other variables have no impact. While these intercepts can be mathematically interesting, it's important to recognize that they often translate to unrealistic situations in the real world (e.g., BA having a positive profit margin even with zero average flight distance). The focus should be on the coefficients, which reveal the direction and strength of the relationships between the variables of interest.

These insights can be valuable for airline executives, policymakers, and industry stakeholders as they navigate the evolving competitive landscape.

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8. List of pictures, tables, graphs and abbreviations

8.1 List of pictures

8.2 List of tables

8.3 List of graphs

8.4 List of abbreviations

LCC – Low-Cost Carrier
BA – British Airways
TK – Turkish Airlines
UK – United Kingdom

Appendix