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The relationship between fuel hedging and operating expenses

Evidence from European and US airline industry

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ABSTRACT:

Aviation industry faces many significant risks; fuel is typically the largest operating cost for airlines. Previous literature presents many valid reasons for airlines to hedge their future fuel needs. Fuel prices are volatile and therefore can cause financial distress to airlines. Fuel hedging is a commonly used risk management tool in the aviation industry. This study examines whether fuel hedging lowers operating expenses. The analysis is based on a panel dataset of 20 airlines in Europe and US and covers the years 2016-2024. The study applies Ordinary Least Squares (OLS) regression models with airline and year fixed effects. Operating costs are measured relative to capacity, and the models control key factors such as fuel prices, load factor, airline size and revenue structure. The results do not provide robust evidence that fuel hedging reduces operating expenses. While some statistically significant relationships appear, they are not consistent across model specifications, and weaken when controlling structural differences, or excluding the COVID period. In addition, hedging shows no significant effect on fuel costs or profitability. In conclusion, findings indicate that fuel hedging acts as a risk management tool to reduce uncertainty of fuel costs.

KEYWORDS: fuel hedging, airline industry, operating expenses, risk management,

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1 Introduction

The aviation industry plays a crucial role in the world economy. According to IATA (2024c) the industry added 4,1 trillion USD to the world's GDP and provided 87 million jobs to people around the world. Aviation enables businesses to transport freight across the world and stimulates tourism. The industry presents fierce competition among companies. Airlines vary from each other from many different aspects. Business models present different approaches in aviation. Some airlines target customers with low ticket prices and others with more conventional routes and some focus on the higher quality experience during flights.

Due to the highly competitive nature of the aviation industry and relatively heavy cost structure, companies aim to be as profitable as possible and acquire investors. Profitability is simply defined as that the expenses are lower than the revenues. The challenge in the aviation industry is that the expenses are usually remarkably high. IATA (2024b) states in their report that jet fuel is typically the largest operational cost of an airline, during the fiscal year of 2024 it was around 30% of total operating costs. The importance of knowing the most significant expense in the operational costs is crucial because then the companies can take measures to use different tactics in trying to either reduce costs or manage them. Therefore, this thesis seeks to assess whether fuel hedging lowers operating costs.

Hedging is a commonly used practice over several industries to manage different risks that can occur to a company, and it can be applied in several ways. Airlines have multiple risks to hedge in their business model, for instance there are various market-, operating-, legal and political- and financial risks to name a few. This thesis focuses primarily on financial risks.

Airlines face various financial risks in their business environment. Most common are exchange rate risks, interest rate risks and fuel risks. Airlines typically operate across countries and continents, which means that their transactions occur in various currencies, however the most important notion is that jet fuel is typically settled in USD IATA (2025), therefore airlines outside US who operate in different currencies must consider foreign exchange rate fluctuations.

The interest rate risks can occur when airlines make investments, for instance renewing their fleet. Airplanes are expensive investments and buying them without financing them would cause liquidity problems for airlines' financial positions. Renewing of fleet does not always consider buying new aircrafts, common principle in the industry is to lease planes, either from manufacturers or from other airlines. Leasing of planes also is included in the interest rate risk, because the lease contracts often have interest rate as one component of the lease price.

Fuel risk occurs when oil prices fluctuate and furthermore affects the jet fuel prices. Aircraft fuel is a product which is refined from crude oil. U.S. Energy Information Administration (2024) states that refineries can use less dense crude oils to produce high value products such as gasoline, diesel and jet fuel with simple distillation.

Fuel hedging is a well-studied topic in finance literature. Previous studies have had multiple approaches to study the effects of fuel hedging. Research shows findings in firm value, risk exposure, stock returns and operational costs, to name a few. Studies present alternating results from fuel hedging relationship between different dependent variables.

Motivation for this research is to study complex but fascinating industry. In addition, fuel hedging is a well-studied subject but there are still gaps in literature, hence the approach of fuel hedging's impact on operating costs. This thesis builds on the framework of Lim and Hong (2014) and aims to provide new findings from a more recent data set and expanding sample region from US-only to both US and European airlines.

Recent news of the circumstances in the Strait of Hormuz has caused fears of running out of jet fuel and significant oil price hikes. Moreover, Russia's attack on Ukraine in February 2022 also affected oil prices significantly. Due to these types of market shocks fuel hedging is a relevant topic to study.

The structure of this thesis is as follows. First literature review presents previous research and their findings, then methodology of this thesis is explained, which is followed by empirical analysis which presents the results. After empirical results thesis provides discussion of results and how they align with previous research. In addition, discussion gives suggestions for further research. Lastly thesis gives conclusion and reference list.

This thesis uses the help of artificial intelligence. The model used is OpenAI's ChatGPT plus version, this thesis uses models from GPT-4o to GPT-5.4. Change of model is due to the use of the latest available model from Chat GPT and therefore it cannot be specified into one model. Author of this thesis recognizes University of Vaasa's guidelines. Help of AI has been used to form structure for the thesis, retrieve relevant articles, proofreading, and help with conducting the research and methodology.

2 Literature review

This section of the thesis focuses on the previous literature and the findings. First hedging as a concept is covered shortly with theoretical frame of why non-financial companies are hedging. Then literature explains why hedging is relevant in the airline industry. In addition, different hedging strategies are covered shortly and in addition why some airlines decide not to hedge. Lastly this literature review is concluded with a summary of findings.

2.1 What is hedging?

Hedging in finance is defined as risk management which aims to lower the exposure to market risks that can weaken company's: cash flow, result, or value. In practice hedging can be achieved with derivatives, such as forward and future contracts, options, and swaps. Moreover, companies can also hedge operatively by adjusting their operational processes, for example timing related to making investment or production decisions. Therefore, it is important to consider hedging as a broader concept rather than only derivative contracts. Stulz (2004) explains that derivatives are instruments, which value is derived from the underlying value of another asset. The initial use of derivatives is to transfer the risks to other parties who have better capacity to carry them. Aretz, Bartram and Dufey (2007) use analogy that economically sensible non-financial firms hedge their exposure to financial risks by selling them into broader markets.

Aretz, Bartram and Dufey (2007) bring up in their research that the neo-classical finance theory argues that corporate hedging cannot increase firm value because in efficient markets investors can diversify their portfolios to hedge the risks that one specific firm faces in their operating environment. Theory also suggests that investors cannot avoid systematic risk which supports the claim that corporate hedging is not relevant because investors would get higher returns for investing into riskier businesses. However, it is important to distinguish the different risks that nonfinancial firms are up against, especially between business risk and financial risk. Aretz, Bartram and Dufey (2007) state that business risk is often impossible or not relevant to hedge because the non-financial firms have competitive edge of managing the risks whereas they do not have competitive advantage in financial risks. Business risks that Aretz, Bartram and Dufey (2007) list are the core operational risks that firms manage, such as product quality, input costs, technological factors and customer demand changes. In the airline industry companies can, for example, use marketing to enhance attracting more customers and train their staff to keep the quality of service high.

The financial risks are unexpected changes in exchange rates, interest rates and commodity prices. Airlines operate in a global environment which means that transactions are performed in different currencies. Moreover, jet fuel is sold in USD which means that airlines operating outside the US are more likely to use different currencies in their operations and therefore they must manage currency risk alongside oil price fluctuations. Research from Smith and Stulz (1985) develop a positive theory of hedging behavior of value-maximizing corporations. Their theory states that companies use hedging as part of overall financing policy. Value-maximizing companies will hedge for three reasons: taxation, cost of financial distress and managerial risk aversion. In other words, companies are hedging more when it enhances the financing position for the companies. When the companies are stabilizing their cash flows or reducing bankruptcy risk, financiers are more willing to give better terms to companies who need financing for new investments.

Tufano P. (1996) studies the managerial risk aversion aspect of hedging especially from agency theory perspective. His research studies gold mining industry where there are different approaches to hedging. Tufano (1996) finds that managers with more option-based incentives are less willing to hedge and managers who hold more shares of the managing company are more risk averse. The findings explain that the managers holding options can benefit from share price volatility more and the shareholders are more likely to benefit from stable profits. Literature gives a perspective that in aviation management incentives should be thought out carefully so that managers would not cause agency theory problems to the stakeholders since it is a very volatile industry. However, Tufano

(1996) states in his conclusion that even though there is evidence that in his study management's hedging decision-making correlates with incentive drivers, it does not give the whole picture of the overall behavior of all managers with hedging decisions, and the phenomenon should be studied more.

2.2 Why is hedging relevant for aviation industry?

This section covers several factors that can affect the decision making of hedging the fuel price. Literature also covers how hedging can affect the company's valuation and stock returns.

2.2.1 Fuel expenses cover a significant share of total expenses

Fuel hedging relevance in the aviation industry is primarily due to fuel being an economically significant factor in the operations. Morrell and Swan (2006) state that airlines' fuel costs in their sample covered on average circa 15% of the operating expenses, when crude oil price was around 25 dollars per barrel. Recent literature is stating that the share of fuel cost to operating expenses is higher. Treanor et al. (2014b) reports that during Q3 of 2008 fuel costs covered 35% of total expenses. Moreover, Berghöfer and Lucey (2014) cite in their research based on IATA's figures that fuel expense share rose from 13% in 2001 to 22% in 2005 and later to 33% in 2012. In parallel, Merkert and Swidan (2019) highlight that oil price fluctuations have changed fuel costs as one of the industry's most critical cost factors.

Fuel expenses in aviation are problematic in perception, since it is an expense which airlines cannot control in their processes as they would with personnel, marketing and administrative expenses. Airlines can manage their fuel costs in the long run by improving fuel efficiency through operational hedging, such as investing in a new fuel-efficient fleet or managing the operational aspects of flight routes (Merkert and Swidan, 2019). However, in the short run the fuel price is dependent on the global energy markets.

Therefore, increase in fuel prices can cause shocks in the cost structure which can weaken the result or cash flows even if the operational performance stays the same. Due to these factors, fuel hedging is a reasonable action for airlines to consider.

2.2.2 Fuel price volatility

By itself high coverage of total costs from fuel does not explain the significance of hedging, it is important to take account the volatility of fuel prices as well. Rao (1999) highlights that the profits of airlines have been volatile and one of the explanatory factors is the fuel price volatility. His study finds that continuous hedging policy can lower airlines' unexpected volatilities in results. Morrell and Swan (2006) also note that airlines are not hedging to improve long-term profit, they hedge primarily to stabilize the results, which could lead to better stock performance. Treanor et al. (2014a) support this finding by stating that in their research jet fuel prices are four times more volatile when compared to most used foreign exchange rates. Foreign exchange rates are relevant to have in comparison with the jet fuel prices because most of the corporate financing hedging research is based on currency and interest rates, which can have to a lesser extent of economic significance when compared to the fuel price risks.

The significance of volatility is supported by oil and capital market literature. Kang, Perez de Garcia and Ratti (2021) state that increase of oil prices, uncertainty of economical politics and jet fuel price volatility are all negatively affecting US airline stock returns. Horobet et al. (2022) find that oil price risk has a significant negative impact on global aviation stock prices both in short-term and long term. These findings suggest that fuel risk is not only a matter of cost accounting, but also a determinant for airline valuation in the capital markets.

2.2.3 Exposure to fuel price risk is not constant

In the fuel hedging literature important addition is that there is evidence that the exposure to fuel price for airlines is not constant, it varies over time. Treanor et al. (2014b) present that the exposure to fuel prices for US airlines is remarkably higher when fuel prices are high or they are increasing. According to them exposure during high prices is four times when compared to during lower price level time spans.

This finding is significant for two reasons. Firstly, it points out that hedging's economic significance is increasing right when the cost of the risk is at its highest. Secondly, it helps to understand why previous literature has different outcomes from benefits of hedging. If research manages to study a time period when fuel prices are low and exposure is marginal, hedging can seem irrelevant for companies. However, if research is conducted from higher price and exposure period, meaningfulness of hedging increases.

In other words, fuel hedging relevance in aviation is not constant but situational. This makes the topic empirically challenging, but research wise very intriguing.

2.2.4 Cost transfer to pricing

One of the aviation industry's special characteristics is that cost shocks are hard to transfer to the customer prices. This is due to multiple reasons. One reason is that competition is intense in the field of aviation, which is why a single airline cannot freely raise prices without risking their demand for their flights. Another reason is that flights are typically sold beforehand, usually weeks or months before departure. This binds part of the future revenues before the actual acquiring price of fuel is clear. Morrell and Swan (2006), Almansur et al. (2019) and Lim and Hong (2014) emphasize that these factors make fuel cost increases difficult to transfer into the customer prices.

This view is also supported by research from Gayle and Lin (2020), they state that cost transfer to flight tickets is not simply positive. According to their research pass-through relationship between price of crude oil and airline ticket prices can be either positive or negative, depending on market structure, flight duration and airlines hedging strategy. Therefore, increase in fuel costs does not automatically raise ticket prices and the decrease in fuel prices does not lower the ticket prices. Hence hedging the fuel price can affect indirectly the competitive setting and the market behavior of products.

2.2.5 Cost of financial distress and underinvesting

Corporate finance theory states that one of the key reasons to hedge is to avoid financial distress and underinvesting (Smith & Stulz, 1985; Froot et al.,1993; Stulz 1996). Carter et al. (2006a) apply this theory to their research with the airline industry. They state that the airline industry represents well the theoretical frame from Froot, Scharfstein and Stein (1993), where hedging is valuable because it protects companies investing capabilities in situations where financing is expensive and cash flow from operations is weak. For instance, in the airline industry these types of investments are most commonly renewal of the fleet, companies can also have other strategic improvements to fulfil, in the current operating environment these can be digitalization of services and operations. Carter et al. (2006a) mention that airlines that face financial distress during the times they have invested might have to sell their aircrafts below the market value to survive, these are referred as “fire sales”.

Therefore, Carter et al. (2006a) present that fuel hedging can be seen as an insurance which protects the airlines from situations where high price of fuel is weakening the operational cash flow at the same time when operations or investments should be maintained. Carter et al. (2006b) states that this explains why hedging in airline industry can be meaningful, even though efficient market theory states that hedging should not create value. Carter et al. (2006b) also emphasizes that in the real world most of the assumptions of perfect capital markets are violated, if not all. Hence, the access to financing, timing of investments and survival of airlines are sensitive to cost shocks.

2.3 Airline hedging strategies

This section covers different strategies that airlines use to hedge. Literature presents that airlines try to avoid the same risk, but they have different approaches to execute that.

2.3.1 Financial hedging with derivatives

Most common fuel hedging strategy that literature presents is financial hedging with derivatives. Airlines can use several derivative instruments, for instance futures, forwards, swaps, options, collars or combinations of these instruments to secure the future acquiring price of fuel. They can either secure the full requirement or part of it. Morrell and Swan (2006) describe that the most common hedging policy in practice is partial hedging. Most airlines cover only part of their future requirements of fuel, typically between one third or two thirds of their need, and the hedging horizon is typically between six to twelve months. Samunderu (2023) finds in his study that airlines often hedge their fuel needs for the following 6 months, and the hedge ratio is covering from 30 to 60 percent the future fuel requirements.

Case study from Gerner and Ronn (2013) presents a layered hedging model from an international airline. They describe on a detailed level how the hedging policy from one unnamed airline works. The airline begins hedging with small partial hedges covering up to a two-year horizon, and they gradually increase their hedging coverage until the actual need for fuel usage. Hedging model which Gerner and Ronn (2013) present is logical because the fuel requirement is not usually certain with longer horizons, airlines can alter route planning which either increase or decrease the fuel requirement, if airlines cover all their current fuel requirements too soon, they might be over-hedged at the time of fuel purchase.

In addition, market timing risk decreases when hedging is diversified for several time periods instead of one market timing. Gerner and Ronn (2013) emphasize that optimal hedge is dependent on company’s credit rating, transactional costs, correlations between fuel quantities the company needs and the prices they pay, and also company’s internal risk profile. Therefore, there is not one universal hedging strategy for all airlines in the industry.

2.3.2 Cross-hedging and basis risk

Airlines sometimes face practical difficulties with fuel hedging because there are not always enough liquid and purposeful derivatives for jet fuel in the markets. Therefore, companies often rely on cross hedging. Adams and Gerner (2012) and Turner and Lim (2015) study these kinds of proxy instruments, such as WTI, Brent, gasoil and heating oil. The results from these studies point out that the efficiency of hedging instruments depends both on the market and maturity. Adams and Gerner (2012) state that gasoil is efficient instrument for short horizons, meanwhile Turner and Lim (2015) finds heating oil to be the best proxy instrument.

Both studies conclude that none of the proxy instruments are perfect. This is due to basis risk, which means that hedging instruments’ price fluctuations do not follow perfectly the price of the actual commodity which needs to be hedged, which in this case is jet fuel. In aviation this is a key challenge because even small changes in spreads can weaken the hedging efficiency.

2.3.3 Alternative hedging: Operative hedging and vertical integration

Previous literature presents another approach to hedging where airlines do not only control fuel risk with derivatives. Operative hedging means implementing strategical choices in operating environments which aim to lower fuel price effects without financial instruments. Merkert and Swidan (2019) state that airlines can use two ways to deal with fuel prices without using derivatives. They can transfer the cost of fuel to the customers or increase the fuel efficiency of operations. As previously mentioned, the cost transfer to customers is not very sufficient. Increased fuel efficiency can be achieved by choosing fuel-efficient planes for the fleet or through optimizing flight routes.

Treanor et al. (2014b) present that airlines can choose airplanes which are newer and more fuel efficient, and also diversifications in fleets lower the fuel price risk. They argue that operational hedges could have more economic significance than financial hedges lowering the risk exposure.

Literature also presents that vertical integration can be considered as a hedging measure. Almansur et al. (2019) analyze Delta Air Lines decision to acquire Trainer refinery during the year of 2012. They state that markets valued this decision positively, Delta was exposed less to refining margin risk and their cashflow volatility and cost of financing decreased when compared to their competitors. This is a remarkable finding to aviation industry literature because it shows alternative approach to minimizing fuel price risk. However, acquiring a refinery is not cheap and therefore not applicable measure for many operators in the industry. Larger airlines could consider similar approaches but smaller airlines most likely will not.

2.4 Why some airlines do not hedge fuel?

Previous chapters have covered the literature of motivations for hedging and different strategies which airlines can apply in hedging. Although the motivation for hedging the fuel is remarkable in aviation, some airlines use a strategy to not hedge fuel prices. This chapter examines previous literature and their findings, why airlines might decide not to hedge fuel through financial instruments.

2.4.1 Credit rating limitations

One reason for airlines not to use hedging in their operations is explained by the costs of hedging. Gerner and Ronn (2013) emphasize the importance of credit rating. They state that companies who have higher credit rating have more options in the OTC markets, because their counterparts are more willing to trade with them. They also state that credit rating also affects the costs of hedging. Gerner and Ronn (2013) also found that most active fuel hedgers are larger airlines who possess least debt and have high credit ratings. Due to these circumstances airlines with lower credit ratings might consider not to hedge if they cannot find hedging instruments from the OTC markets from lack of available counterparts or higher trading costs.

2.4.2 Decrease in fuel prices and competitive disadvantage

Another explanation for airlines choosing not to hedge is related to competition in aviation, and airlines try to gain competitive advantage. Some airlines might consider elasticity as a competitive advantage; hedging can be competitive disadvantage when fuel prices are decreasing in the markets and remain low. Merkert and Swidan (2019) state that unhedged competitors can buy fuel at remarkably lower prices than their competitors who have hedged, during the time periods when fuel prices are decreasing. Morrell and Swan (2006) support this view as well. They state that hedging protects against sudden cost increases but prevents savings from decreasing prices.

2.4.3 Selective hedging and alternative hedging

Treanor et al. (2014a) raise an important view from selective hedging. They present that airlines are increasing hedging when exposure is high, but markets do not reward reactive additional hedging with value premium. This means that even if the company feels that they are making a rational choice by adding coverage, investors do not see this as a value-adding activity. Airlines employing stable hedging policies are valued more by investors.

Alternative hedging is in the grey area of fuel hedging literature. Most of the research on aviation fuel hedging considers hedging through financial instruments, and therefore using only operational hedging can be considered that airline is not purely hedging fuel prices. This thesis divides hedging activities through only using financial instruments.

2.5 Results from previous research

Literature review has now covered three main questions from previous research related to aviation and fuel hedging; What is hedging and why is it relevant to the airline industry? How do airlines hedge? Why do some airlines choose not to hedge? This thesis aims to find an answer to the following question: does fuel hedging lower operational costs? Previous literature has focused on more studying firm value related topics, which means that there is relevancy for research related to studying the effects on operational costs.

Most relevant research related to this thesis is conducted by Lim and Hong (2014), who analyze connections between fuel hedging and operative expenses from the US airline industry. They find that hedging airlines have around nine to twelve percent lower operating costs than their competitors. However, their study states that the effect is not statistically significant. Their results imply that there might be connections between hedging and cost efficiency but there is not enough evidence to prove that hedging lowers operating cost level systematically.

Other literature offers some explanations to the results from Lim and Hong (2014). Hedging is financial risk management tool, not a production-efficiency mechanism. Fuel hedging does not lower the physical fuel consumption, and it is not changing the operational technical efficiency. It affects predictability, variation and timing of costs. Therefore, the benefits of hedging can be shown as a more stable cost environment rather than having lower cost levels.

Research from Merkert and Swidan (2019) gives support to this by stating: “Our results further suggest that capacity optimization (load factor), a key element of operational hedging, leads to enhanced operational profitability (EBIT margins), whereas financial (i.e., jet fuel price) hedging primarily reduces EBIT margin volatility.” Similarly, Rao (1999) points out that continuous fuel hedging can lower the volatility of airlines’ results, and the key benefit is related to more stable control of revenue and cost control.

2.6 Conclusion from previous literature

Previous studies present that fuel hedging is a relevant topic for research in the aviation industry, because fuel is a significant part of operating expenses and presents fluctuations over time. In addition, fuel price fluctuations present many challenges for airlines to manage. For instance, weakening the cash flow, adding financial distress and complicating investment planning. Meanwhile, literature presents that there are multiple approaches to the effects of hedging: firm value, stock returns, exposure, volatility of profits, pricing and operative costs, which is why the results of literature alter.

For this thesis key finding is that previous literature does not present strong evidence that fuel hedging lowers airlines' operating expenses systematically. In contrast, literature supports that hedging stabilizes the costs to a level where it is more anticipated, which lowers the uncertainty in operating environment. Therefore, relationship between fuel hedging and operating expenses presents a gap in research. Literature offers strong theoretical background, but empirical evidence is still open to interpretation.

3 Methodology

This study builds on Lim and Hong (2014), who examine whether fuel hedging reduces airline operating costs but differs by using an updated panel dataset and fixed-effects OLS specifications rather than a cost frontier approach. This thesis examines the relationship between fuel hedging and operating expenses in the airline industry from Europe and US.

The research data is constructed from 11 European airlines and 9 US airlines, total of 20 airlines. Table 1 below shows the airlines that are in this study.

Airline	Region
Aegean	EU
Air France-KLM	EU
Alaska Air	US
Allegiant	US
American Airlines	US
Delta Air Lines	US
EasyJet	EU
Finnair	EU
Hawaiian	US
IAG	EU
JetBlue Airways	US
Lufthansa Group	EU
Norwegian	EU
Ryanair	EU
SAS	EU
Southwest Airlines	US
Spirit Airlines	US
Turkish Airlines	EU
United Airlines	US
Wizz Air	EU

Table 1. Airlines and their regions from dataset

Data is collected from fiscal years of 2016-2024, which constructs airline-year level panel dataset. The regression analysis was conducted in Python using the statsmodels library. Ordinary Least Squares (OLS) models were estimated with airline fixed effects and, where applicable, year fixed effects. Standard errors were clustered at the airline level. Observations with missing values were excluded using a complete-case approach.

The use of panel data enables the exploitation of both temporal and cross-sectional variation, thereby improving estimation precision and reducing bias.

The research question of this thesis is: Does fuel hedging lower the operating expenses?

3.1 Data and variables

The data for this thesis is collected from annual reports and 10-K reports of the airlines from fiscal years of 2016 to 2024. Airlines were chosen by the availability of annual reports and 10-K reports. In their study Lim and Hong (2014) present that in the US airline industry there were significant changes in the industry during the years of 2000-2012, bankruptcies and mergers and acquisitions formed the industry to be more concentrated. The sample size is limited due to the limitations of publicly available data. Dataset includes following metrics: operating expenses, fuel expenses, capacity metrics (Available seat kilometers/miles, ASK/ASM), load factor, revenue, market capitalization, and fuel hedging (binary and hedge percentage if it was stated).

Operating expenses are the costs that airline faces in their normal operating environment, these can be personnel expenses, maintenance of aircraft or passenger and handling costs. Fuel expenses are one of the operating expenses which reports the cost of acquiring fuel. Capacity metric ASK or ASM is calculated from number of available seats multiplied by distance flown. Airlines use this metric to evaluate the capacity of their operations. Load factor is derived from two metrics, Revenue Passenger Kilometers/Miles, (RPK/RPM) which is then divided by the ASK/ASM. RPK is calculated from number of revenue passengers multiplied by distance flown. Load factor is a great indicator of capacity utilization. (IATA, 2024a) Revenue is total amount of money coming from operating environment. Market capitalization is calculated from total shares outstanding during the last day of the fiscal year, which is multiplied by the closing price of the day's share price. Fuel hedging was derived from reports, the hedge ratios and binary values are lagged in the dataset because airlines announced their hedge positions covering the following year of the report's fiscal year.

Since the data includes European and US airlines, the data needs to be converted into comparable units. Variables that had monetary values were converted into USD according to the average yearly rate, except for the market capitalization, which used year end closing rate. ASK values were converted into ASM.

The main dependent variable in this thesis is operating cost per capacity unit in logarithmic form:

$$\ln(Operating\ Expenses/ASM) \tag{1}$$

In addition, in the robustness test Fuel expenses and EBIT margins are used. Merkert and Swidan (2019) studied the fuel hedging effects in EBIT margin volatility and operating costs which has also affected the construction of these models.

Key explanatory variable is hedging ratio and alternatively hedging dummy. Control factors used as well are fuel price, load factor, capacity (ln ASM), revenue per ASM and market capitalization.

3.2 Dataset preparations

Before regression analysis, data set was prepared in a way that observations which lacked variables from the model were removed from the analysis, this enables using complete case estimation. This was applied especially to the hedge ratio factor, which was not available for all airlines, which informed in their annual publications that they are hedging fuel. This measure dropped three airlines from regressions using the hedge ratio measurement.

This procedure ensured that the regression models were estimated only using complete observations and that the fixed effects were constructed only from the units included in the analysis. This avoids the creation of inappropriate dummy variables and improves the reliability of the estimates.

3.3 Regression models and estimation

This study estimates several linear panel regression models, which have a generic form of:

$$ln(Cost_{it}/ASM_{it}) = \beta_1 Hedge_{it} + \beta_2 X_{it} + \alpha_i + \lambda_t + \varepsilon_{it}, \qquad (2)$$

where
i refers to airline
t refers to year
$Hedge_{it}$ refers to hedging ratio
X_{it} is a vector of control of variables
α_i is airline specific fixed effect
λ_t is year specific fixed effect
ε_{it} is error term

The baseline model M1 measures the association between hedging and costs while controlling key cost drivers. The extended model M2 adds the revenue per ASM variable and serves as the main model of the study, as it accounts for differences in airlines' business models and sizes. The two-way fixed effects model M3 additionally controls year-specific shocks such as fuel price fluctuations and macroeconomic changes.

Model M2 is selected as the preferred specification because it controls key differences in airline business models through the inclusion of revenue per ASM, while still preserving variation related to fuel market conditions. While the dataset does not explicitly classify airline business models, revenue per ASM works as a proxy variable to capture the structural differences between airlines. Full-service airlines typically have higher unit costs than low-cost carriers due to the nature of more complex business models. Therefore, the revenue per ASM variable helps control the bias which is not taken into account in the M1 model.

Although Model M3 additionally includes year fixed effects, these effects absorb a substantial portion of the common variation in fuel prices and macroeconomic conditions, which are directly related to the economic rationale of fuel hedging. Therefore, M2 provides a more economically interpretable specification for evaluating whether fuel hedging affects operating expenses, while M3 is primarily used as a robustness check.

In addition, several robustness checks are estimated using one alternative dependent variable, fuel price measures and an interaction term between hedging and fuel prices, which is also used by Treanor et al. (2014a). Because the dependent variable is expressed in logarithmic form, the coefficients can be interpreted as approximate percentage changes. M4 uses ln(fuel cost/ASM) as dependent variable, M5 reviews the profitability with EBIT margin, M6 uses alternative fuel price variable (Brent oil), M7 measures differences between hedging companies and non-hedging companies with hedge dummy variables and M8 uses interaction variables, while also excluding the years 2020-2021 from sample to test COVID Robustness.

Models are estimated with the Ordinary Least Squares method (OLS). Previous literature has used more advanced estimating techniques with OLS, due to the limitations of technical capabilities this thesis uses more simplistic approach with fixed effects. The objective of the method is to minimize the sum of squared deviations between the observed and predicted values. Regressions include airline-specific fixed effects and model M3 also year specific fixed effects. Standard errors were clustered on airline level, which considers dependence on observations within the company. OLS estimation has a set of assumptions. First assumption is that explanatory and dependent variables have a linear relationship. Second assumption is that the error term is not systematically connected to explanatory variables. In addition, it is assumed that there is not a severe multicollinearity, which means that explanatory variables do not correlate with each other strongly because it would give unstable results. In this study the assumptions are addressed by using multiple control variables and fixed effects, which help to limit bias risk.

Model specifications are built in a way that control variables are added in stages, this enables reviewing the hedge variables changes between different models. Extended model (M2) is the preferred model for this thesis because it contains the most essential control variables and considers business model differences. Fixed effects remove company specific factors which do not change over time. Therefore, estimation is based on the internal changes of companies over time.

Fuel hedging is not a random variable, because it is a strategic choice by the companies, thus it can cause endogeneity. Due to this fact, results should be interpreted as statistical connections not as causality. Using multiple models is enhancing the trustworthiness of results. Robustness is tested by using alternative variables and model specifications.

Even though the M8 model removes the data from years 2020-2021 in the first regressions, models are tested with two datasets, one including all the values from years 2016-2024, and second where whole data from COVID years are removed (2020-2021). This adds robustness to the thesis.

4 Empirical analysis

This chapter analyses the results of this research. First the descriptive statistics are presented and analyzed, then correlation matrix and lastly the regression models. After presenting the results the findings are concluded.

4.1 Descriptive analysis

Below are the descriptive statistics of the datasets presented.

Variable	count	mean	std	min	25%	50%	75%	max
Log_Cost_Y	179,000	-1,707	1,482	-2,851	-2,236	-1,990	-1,794	4,796
Cost_per_ASM	179,000	5,044	21,691	0,058	0,107	0,137	0,166	121,078
Log_FuelCost_Y_alt	179,000	-3,155	1,521	-4,164	-3,682	-3,476	-3,250	3,790
FuelCost_per_ASM	179,000	1,476	6,542	0,016	0,025	0,031	0,039	44,237
Hedge_Ratio	150,000	0,374	0,325	0,000	0,000	0,425	0,658	1,090
Hedge_Dummy	179,000	0,704	0,458	0,000	0,000	1,000	1,000	1,000
Fuel_Price_Kerosine	180,000	2,009	0,676	1,099	1,558	1,879	2,338	3,374
Brent_Spot_USD_per_bbl	180,000	67,797	18,148	41,960	54,130	70,860	80,520	100,930
Load_Factor	179,000	0,801	0,096	0,428	0,767	0,831	0,850	0,960
Log_ASM	179,000	4,092	1,068	1,497	3,187	4,130	5,091	5,740
Log_Revenue_per_ASM	179,000	-1,693	1,502	-2,984	-2,138	-1,981	-1,830	4,894
EBIT_Margin	179,000	-0,020	0,295	-2,613	-0,034	0,063	0,119	0,272

Table 2. Descriptive statistics of full sample

Variable	count	mean	std	min	25%	50%	75%	max
Log_Cost_Y	139,000	-1,746	1,497	-2,851	-2,254	-2,059	-1,851	4,796
Cost_per_ASM	139,000	5,268	22,671	0,058	0,105	0,128	0,157	121,078
Log_FuelCost_Y_alt	139,000	-3,121	1,534	-4,112	-3,641	-3,438	-3,219	3,790
FuelCost_per_ASM	139,000	1,590	6,987	0,016	0,026	0,032	0,040	44,237
Hedge_Ratio	117,000	0,371	0,321	0,000	0,000	0,430	0,660	0,950
Hedge_Dummy	139,000	0,719	0,451	0,000	0,000	1,000	1,000	1,000
Fuel_Price_Kerosine	140,000	2,161	0,666	1,252	1,558	2,027	2,699	3,374
Brent_Spot_USD_per_bbl	140,000	71,050	17,778	43,640	54,130	71,340	82,490	100,930
Load_Factor	139,000	0,839	0,045	0,676	0,820	0,839	0,855	0,960
Log_ASM	139,000	4,234	1,017	2,320	3,335	4,180	5,181	5,740
Log_Revenue_per_ASM	139,000	-1,659	1,511	-2,984	-2,091	-1,946	-1,818	4,894
EBIT_Margin	139,000	0,074	0,085	-0,280	0,048	0,080	0,130	0,272

Table 3. Descriptive statistics of COVID adjusted sample

Table 2 presents the variables used in this study from years 2016-2024, including COVID period and their key descriptive figures. Table 3 has same figures without COVID years (2020-2021). Whole data includes 180 observations; however, 179 of these are usable because Alaska Airlines and Hawaiian Airlines merged during the fiscal year of 2024, Hawaiian is included in Alaska airlines annual report from 2024. To avoid overlapping data

Hawaiian does not present any data from 2024. Some variables present a lower number of observations. Especially hedge ratio variable only presents 150, which means that all airlines are not reporting hedging ratios on a yearly basis. It is important to notice because hedge ratio-based regression models are only applied to the observations where the information is available.

In Table 2 the main dependent variable which is logarithmic value of operating costs divided by ASM has a mean of -1,707 and standard deviation of 1,482. This shows that there are significant fluctuations in unit costs. Deviations can be due to differences in business models of the airlines, capacity usage and cost structures. Respectively operating expenses per ASM variables mean is 5,044 but the standard deviation is significantly high 21,691. Table 3 presents the logarithmic operating costs per ASM mean of -1,746 and Standard deviation of 1,497 which was surprising finding, since initial intuition is that when COVID period is removed, the deviations would be lower. However, pandemic had a significant impact on airline industry due to restrictions and low demand. which might reflect the operations recovering from the market shock during years of 2022-2024.

Fuel cost per ASM variables mean is 1,476 and standard deviation is 6,542 for the whole sample. This variable presents also large deviations, which also emphasizes the significance of fuel expenses in total operating expenses. Because fuel is one of the largest and most volatile cost items it is logical to analyze it with robustness tests. Adjusted values in Table 3 are slightly higher, this is logical since during the pandemic airlines did not have to buy fuel as much as they normally would, therefore the fuel costs are lower.

Table 2 presents that hedge ratio variable mean 0,374 and standard deviation 0,325, which means that the findings which present the hedge ratio, the hedging coverage is on average 37,4 percentage of estimated consumption. Table 3 shows slightly lower findings, but the values do not present much of a difference. The variables minimum value is 0 and its maximum 1,09. This is explaining that some airlines do not hedge at all their fuel costs and some hedge larger portions of their fuel requirements. The maximum value, which is 109%, is from Wizz Air and they presented in their annual report from 2020 that the hedge coverage for 2021 is over the fuel requirement due to the significant drop of operating capabilities during COVID. Adjusted numbers in Table 3 removes the Wizz Air outlier and presents a maximum value of 95%. Hedge dummy variable has mean of 0,704, which explains that circa 70% of samples airlines use hedging in some way, which confirms that fuel hedging is a common practice in aviation industry. However, since the data sample is a bit biased with coverage of 60% of European airlines and 40% US airlines these results should not be interpreted as the industry standard. Previous literature from Rao (1999) states that the US airlines are not as active with fuel hedging than European counterparts.

Kerosene price mean is 2,009 and Brent-oil spot price's 67,797 USD/barrel. Both fuel price variables present fluctuations during the sample period. This is important finding for the thesis, since fuel price volatility is of the primary motivation for hedging. If fuel prices remain stable for long periods of time, fuel hedging would not be relevant to exercise. Table 3 shows that during the pandemic fuel prices were lower since the adjusted averages are higher.

Load factor variable presents a mean of 0,801 which means that the airlines in this data sample had on average 80% utilization rate, however the range was broad with minimum value of 0,42 and maximum value of 0,960. This can also be explained with the market shock that the pandemic caused. Table 3 shows that adjusted data presents higher load factor of nearly 84% and standard deviation is almost half when compared to Table 2.

EBIT margin has a mean of -0,020 which means that on average the profitability of airlines was negative during the sample period. When pandemic years are removed the average margin is 0,074. This shows significancy of the market shock that occurred, which is also noted with the other variables.

Descriptive figures show that data includes sufficient number of deviations between airlines and over time. This finding supports the use of panel data and regression, because data enables reviewing the connections between hedging, costs and control variables.

4.2 Correlation analysis

Correlation matrix is attached to Appendix 1. offers a preliminary view of connections between variables before regression analysis. Correlation analysis itself does not provide sufficient information to draw conclusions, because it does not control other factors related to costs. Therefore, regression analysis is needed.

Fuel price variables have expectedly positive correlation of 0,021 with operating expenses. This is logical since fuel price increases raises fuel costs, which are essential part of operating expenses. Correlation between load factor and operating expenses provides insight which implies that higher usage rate can lower unit costs, load factor and operating expenses had correlation of -0,09.

Simple correlation between hedge ratio and operating expenses does not explain well the effect hedging has. It is possible that hedging companies differ systematically from companies who decide not to hedge or hedge less. For instance, explaining factors can be related to business models, difference or size of the airline. Correlation between hedge ratio and operating expenses is -0,297.

4.3 Regression results

Table 4 presents the panel data regression results from the data set which includes all the years from research period, and it includes eight models Table 5 is constructed in same manner but only difference is that years 2020 and 2021 are removed from the regression data. Models M1-M3 has a depend variable logarithmic operating expenses per ASM, model M4 changes dependent variable to logarithmic fuel cost per ASM, and model M5 reviews EBIT margin. In the Model M6 Kerosene price is changed to Brent oil price, model M7 changes the hedge ratio to hedge dummy variable, and model M8 includes interaction term where hedge ratio is multiplied by fuel price. All models use airline specific fixed effects, which control for time-invariant differences across airlines. Model M3 additionally adds year fixed effects. Standard errors are clustered at the airline level to account for within airline correlation across observations over time.

Variable	M1	M2	M3	M4	M5	M6	M7	M8
	Baseline cost	**Preferred cost**	**Two-way FE**	**Fuel cost DV**	**EBIT margin**	**Brent robustness**	**Hedge dummy**	**Interaction excl. COVID**
Sample	Full sample 2016-2024	Full sample 2016-2024	Full sample 2016-2024	Full sample 2016-20	Full sample 2016-2024	Full sample 2016-2024	Full sample 2016-2024	Excluding 2020-2021
Dependent variable	ln(OpEx/ASM)	ln(OpEx/ASM)	ln(OpEx/ASM)	ln(FuelExp/ASM)	EBIT margin	ln(OpEx/ASM)	ln(OpEx/ASM)	ln(OpEx/ASM)
Hedge ratio	0.308**	0.138	0.205***	0.057	-0.205*	0.121		0.250**
	(0.122)	(0.084)	(0.072)	(0.080)	(0.114)	(0.083)		(0.104)
Hedge dummy							0.153**	
							(0.076)	
Hedge ratio × kerosene price								-0.106***
								(0.028)
Kerosene price	0.121***	0.052***		0.217***	-0.053**		0.052***	0.094***
	(0.026)	(0.016)		(0.037)	(0.022)		(0.013)	(0.013)
Brent spot price						0.002***		
						(0.001)		
Load factor	-0.459*	-1.120***	-0.538	-0.426	1.092**	-1.101***	-1.121***	-1.242***
	(0.240)	(0.340)	(0.419)	(0.298)	(0.486)	(0.339)	(0.364)	(0.402)
ln(ASM)	-0.244***	-0.154*	-0.213***	0.009	0.271**	-0.151*	-0.192**	0.148***
	(0.094)	(0.080)	(0.060)	(0.063)	(0.132)	(0.079)	(0.086)	(0.029)
ln(Revenue/ASM)		0.662***	0.424**	0.870***	0.424**	0.674***	0.699***	0.763***
		(0.109)	(0.172)	(0.182)	(0.190)	(0.110)	(0.137)	(0.074)
ln(Market cap)	-0.061**							
	(0.030)							
Observations	149,000	150,000	150,000	150,000	150,000	150,000	179,000	117,000
Airlines	17,000	17,000	17,000	17,000	17,000	17,000	20,000	17,000
Adjusted R-squared	0.992	0.994	0.995	0.994	0.461	0.993	0.993	0.999
Airline fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	Yes	No	No	No	No	No

Notes: Standard errors clustered by airline are reported in parentheses.
Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.10.
M2 is the preferred cost specification because it controls for revenue intensity.
M8 excludes COVID-19 years 2020–2021 and tests the interaction between hedging and kerosene price.
Fixed-effect coefficients are not reported because they are included only as controls.

Table 4. Journal regression table from full sample, table created with help of AI, prompt "create a journal regression table from the results in excel format" (OpenAI, 2022)

4.3.1 Regression evaluation and comparison of the samples

In the baseline model (M1), the coefficient on the hedge ratio is positive and statistically significant (0,308; p=0,011). This suggests that higher hedging ratio is associated with higher operating expenses per ASM. Because dependent variable is in logarithmic form, effects are economically meaningful. However, the result is contrary to the study’s hypothesis, which posits that fuel hedging should reduce costs.

When ln(Revenue/ASM), which controls differences in business models, is added to the model (M2), the coefficient on the hedge ratio decreases to 0.138 and is no longer statistically significant (p = 0.101). This is a key finding, as it indicates that the positive association observed in the baseline model is largely driven by structural differences between airlines rather than by hedging activity.

In the two-way fixed effects model (M3), which controls both airline-specific and year-specific effects, the coefficient on the hedge ratio remains positive and statistically significant (0.205; p=0.004). However, the direction of the effect continues to contradict the hypothesis, and the model therefore does not support a cost-reducing impact of hedging.

In conclusion, while some model specifications present statistically significant relationship between hedging and costs, the direction of the effect is inconsistent with the hypothesis and the relationship across the specifications is not robust.

Variable	M1	M2	M3	M4	M5	M6	M7	M8
	Baseline cost	**Preferred cost**	**Two-way FE**	**Fuel cost DV**	**EBIT margin**	**Brent robustness**	**Hedge dummy**	**Interaction excl. COVID**
Sample	Adj. Sample excl. 20-21	Adj. Sample excl. 20-21	Adj. Sample excl. 20-21	Adj. Sample excl. 20-21	Adj. Sample excl. 20-21	Adj. Sample excl. 20-21	Adj. Sample excl. 20-21	Adj. Sample excl. 20-21
Dependent variable	ln(OpEx/ASM)	ln(OpEx/ASM)	ln(OpEx/ASM)	ln(FuelExp/ASM)	EBIT margin	ln(OpEx/ASM)	ln(OpEx/ASM)	ln(OpEx/ASM)
Hedge ratio	0.233*	0.028	0.064	-0.152	-0.008	0.031		0.250**
	(0.128)	(0.084)	(0.077)	(0.125)	(0.071)	(0.085)		(0.104)
Hedge dummy							-0.037	
							(0.045)	
Hedge ratio × kerosene price								-0.106***
								(0.028)
Kerosene price	0.156***	0.058***		0.217***	-0.059***		0.056***	0.094***
	(0.023)	(0.014)		(0.041)	(0.012)		(0.012)	(0.013)
Brent spot price						0.002***		
						(0.000)		
Load factor	0.164	-1.279***	-1.006***	-0.169	1.140***	-1.324***	-1.343***	-1.242***
	(0.558)	(0.413)	(0.362)	(0.566)	(0.351)	(0.395)	(0.331)	(0.402)
ln(ASM)	0.039	0.139***	0.097**	0.118**	-0.135***	0.128***	0.158***	0.148***
	(0.103)	(0.038)	(0.041)	(0.059)	(0.035)	(0.037)	(0.042)	(0.029)
ln(Revenue/ASM)		0.778***	0.608***	1.000***	0.208***	0.767***	0.803***	0.763***
		(0.069)	(0.082)	(0.217)	(0.064)	(0.064)	(0.069)	(0.074)
ln(Market cap)	-0.040***							
	(0.012)							
Observations	116	117	117	117	117	117	139	117
Airlines	17	17	17	17	17	17	20	17
Adjusted R-squared	0.997	0.999	0.999	0.996	0.670	0.999	0.999	0.999
Airline fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	Yes	No	No	No	No	No

Table 5. Journal regression table from COVID adjusted sample, table created with help of AI, prompt “create a journal regression table from the results in excel format” (OpenAI, 2022)

Because the sample period includes the pandemic years 2020 and 2021, the analysis was repeated by excluding mentioned years. Table 5 shows that the results change noticeably.

In the baseline model M1, the coefficient on hedge ratio decreases from 0,308 to 0,233 and is only marginally significant (p=0,069). In the main model M2, coefficient drops to a near zero value (0,028; p=0,739) and it is not statistically significant. Similarly, M3 model which uses two-way fixed effects loses its statistical significance with coefficient value (0,064; p=0,406)

A similar pattern occurs across the robustness of testing models. In M4 which controls the fuel cost, dependent variable ln(fuel cost/ASM), the hedge ratio is not statistically significant in either sample. Full sample gives coefficient value (0,057; p=0,476) and adjusted sample (-0,152; p=0,226), which is important to note since the effects of hedging would be expected to occur most directly in fuel costs. In the EBIT margin model M5 there is a marginal statistical significance with full sample (-0,205; p=0,072) but it disappears in the adjusted data (-0,008; p=0,913).

The Brent robustness model M6, the hedge ratio, does not give statistically significant results in either data sets, this implies that results are not sensitive to the choice of fuel proxy. In the hedge dummy model M7 the positive and statistically significant result occurs in the full sample (0,153; p=0,044) but loses significance in the adjusted sample (-0,037; p=0,408) suggesting that the difference is driven by the pandemic period between the hedging and non-hedging airlines.

Results present that the statistically significant findings in the full sample are not robust, due to the exceptional circumstances during pandemic. Steep decline in capacity and demand increased unit costs while hedged fuel volumes did not match with the actual consumptions. These factors skew the interpretation of hedge factor variable and explain part of the whole sample's results.

4.3.2 Control variables and cost factors

Results of control variables are mainly logical. Kerosene price coefficient is positive and statistically significant, which confirms the key role of fuel price as a cost factor. Increase in fuel price adds operating expenses per ASM.

Load factor has negative and statistically significant coefficient, which implies that higher usage rate of capacity lowers the unit costs. This supports importance of efficient capacity usage in the airline cost structure.

Ln(ASM) variable shows weak signals of economic scale, however the impact was lower than the load factor. Meanwhile, revenue per ASM is strongly positive and statistically significant. This means that airlines who have higher unit revenues also have higher unit costs, reflecting differences in business models.

4.3.3 Robustness

Robustness models support main model interpretations, Fuel expense model M4 hedge ratio is not statistically significant, although effects are expected to show exactly in this model. On the contrary, fuel market price explains costs well. This weakens the argument of cost reduction through hedging.

EBIT margin model M5 does not present evidence that hedging improves profit. Brent robustness model M6 proves that results are not reliable on the fuel variable. Hedge dummy model M7 presents statistically significant differences in the full sample when comparing hedging and non-hedging airlines, however this disappears when the regression sample is adjusted.

Interaction model M8 brings understanding the role of hedging. Interaction term (hedge ratio multiplied by jet fuel price) is negative and statistically significant, which implies that relationship between hedging and costs is reliable on fuel price. When fuel prices rise, hedge ratios positive relationship with costs decreases. This implies that hedging can be relatively useful during higher price environment. Effects economical significance is on average quite small which limits its meaningfulness on cost level.

4.3.4 Conclusions

The empirical analysis does not provide consistent or robust evidence that fuel hedging reduces airlines’ operating costs. Although the hedge ratio is statistically significant in some full-sample regressions, the effect does not stay once key control variables are included or when the COVID years are excluded from the sample.

Importantly, hedging does not explain fuel costs or profitability. This weakens the argument that fuel hedging functions as a mechanism for reducing average costs.

The results suggest that the observed connection between hedging and costs is more likely driven by structural differences between airlines and by exceptional time periods, rather than by hedging activity itself. Airlines that engage in hedging may differ systematically from others in terms of size, market position, or strategic orientation.

Overall, the findings support the view that fuel hedging primarily serves as a risk management tool. Its purpose is not to reduce average costs, but to decrease cost volatility and improve predictability. This interpretation is consistent with prior findings in the literature and provides a clear answer to the research question in this thesis.

5 Discussion

This chapter discusses the main findings of the study in relation to the research objectives and the existing literature. The discussion begins by interpreting the empirical results and evaluating their implications for the relationship between fuel hedging and airline operational performance. Next, the findings are compared with prior research to assess whether they are consistent with, or deviate from, existing evidence in the fuel hedging literature.

The chapter then considers the broader economic and industry-specific context, highlighting how external factors such as market volatility and structural characteristics of the airline industry may influence the observed outcomes. The chapter also addresses the key limitations of the study. Finally, the discussion concludes with the main implications of the findings and provides suggestions for future research.

5.1 Main findings

The objective of this study was to examine whether fuel hedging lowers airline operating expenses. The empirical results do not provide robust support for this hypothesis. In some full-sample models, hedging appears statistically significant, but the relationship is generally positive, indicating higher operating costs for more heavily hedged airlines.
However, this relationship is not robust. When controlling business model differences using revenue per ASM, the effect of hedging becomes statistically insignificant. Furthermore, when the COVID years (2020–2021) are excluded, hedging is no longer significant in any of the main model specifications. This suggests that earlier findings are partly driven by pandemic-related biases in airline cost structures.

Additional analysis shows that hedging does not significantly affect fuel costs or profitability. Fuel costs are primarily explained by market prices rather than hedging activity, and no consistent relationship is found between hedging and EBIT margins. Overall, the findings indicate that fuel hedging does not reduce operating expenses. Instead, it appears to function primarily as a risk management tool as previous literature argues, helping airlines manage fuel price volatility rather than lower costs.

5.2 Results and previous research

The findings differ from the study of Lim and Hong (2014), which provided the basis of this thesis. They found that hedging had a negative but insignificant effect on operating costs, which is the opposite of the base model regressions with the full sample, however as previously stated the results are not robust and therefore insignificant. Whereas Lim and Hong (2014) found weak directional evidence that hedging may lower operating costs, the conclusion of both their study and this thesis is that there is no statistically significant evidence that fuel hedging affects operating costs.

Control variables in this thesis supports the findings of Merkert and Swidan (2019).
They found that load factor is the key factor for operating costs and results with high correlations. This thesis finds load factor to have a negative coefficient, and it is statistically significant, which implies that higher usage rate of capacity lowers the unit costs, and furthermore could improve operating results.

In addition, in interaction model M8, the hedge ratio coefficient is positive, whereas the interaction coefficient is negative. Both coefficients are statistically significant. This suggests that the effect of hedging is not constant; rather, hedging may be beneficial when fuel prices are high, while its effect weakens when fuel prices are at a lower level. Treanor et al. (2014a) also use an interaction approach in their study and find that firms tend to hedge more when fuel prices are high or rising and when airlines are more exposed to fuel price risk. Their findings may help explain this result, as airlines appear to adjust their hedging behavior in response to the prevailing fuel price environment. This thesis uses U.S. Gulf Coast Kerosene-Type Jet Fuel Spot Price FOB (Dollars per Gallon) as the fuel variable in regressions. Line chart from figure 1 shows that during the sample period prices were relatively lower for 2016-2019 when compared to prices 10 years before. Therefore, based on the findings that Treanor et al. (2014a) presented, this can be considered one of the explanations why the model in this thesis shows hedging inefficiencies with operating costs.

Figure 1 also illustrates well how two market shocks affected the sample data in this thesis. Pandemic lowers the demand significantly, due to restrictions in travel, and when the demand started to recover towards the beginning of 2022 Russia began its invasion to Ukraine. Due to sanctions against Russia, oil prices rose significantly because Russia faced sanctions from western allied countries. Russia provided a lot of gas to Europe before and the sanctions caused energy crisis, which led to Europeans using alternative energy sources.

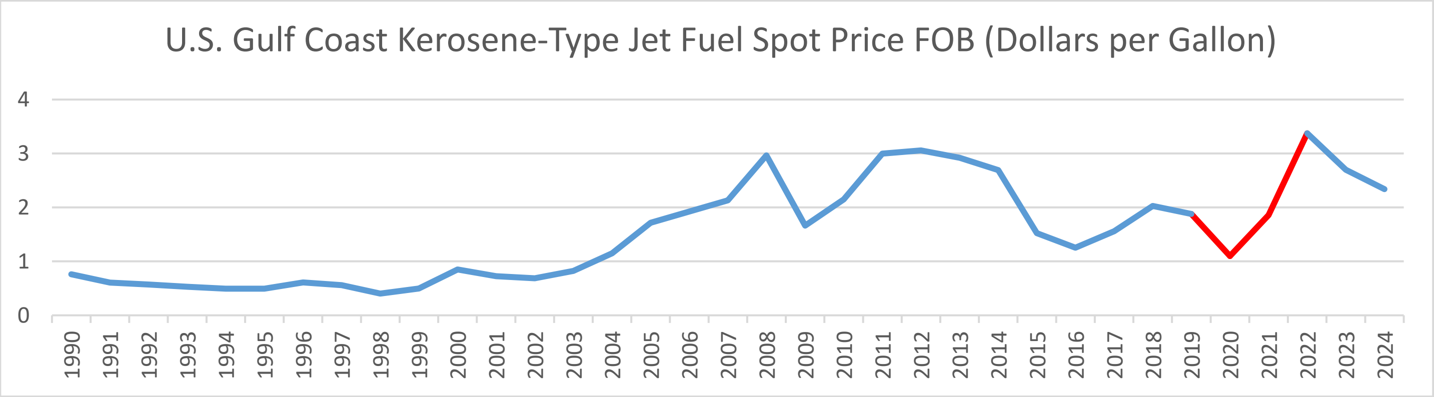

Figure 1. U.S. Gulf Coast Kerosene-Type Jet Fuel Spot Price FOB (Dollars per Gallon), (U.S. Energy Information Administration, n.d.)

Since the thesis examines airlines from two different regions it is relevant to point differences between them. Lim and Hong (2014) state that the US aviation industry became more concentrated during their sample period due to bankruptcies, mergers and acquisitions. This thesis confirms that to be true. Including US airlines in the sample was more difficult than anticipated. Available public data of US airlines is limited. This implies that there is less competition than in Europe where industry is more divided. One of the key reasons is that sample was drawn from both Europe and the US is that previous literature from Rao (1999) and data gathered from annual reports presents that US airlines do not hedge as eagerly as European counterparts. This could imply that US executives are more willing to take risk or they do not want to lose competitive advantage of buying fuel cheaper when prices are low (Merkert & Swidan, 2019; Morrell & Swan, 2006).

Another remarkable difference from the regions is mandatory regulation, especially towards emission reporting. European airlines face more direct and legal obligation and cost to carbon emissions than US airlines. European aviation is required to be part of EU Emissions Trading System (ETS) and airlines have been part of ETS since 2012. Airlines must monitor, report and verify their emissions that are operated in the European airspace. In addition, they must surrender allowances against the emissions they have produced. Airlines receive tradeable allowances covering a certain level of emissions from their flights on a yearly basis. (European Commission, n.d.)

The cost risk is increasing for European airlines because the free allocation of allowances is reduced. During the years 2012-2023, 82% of emission allowances were granted for free to the airlines. Around 15% of emissions allowances were auctioned and remaining part was allocated free to new operators. (Traficom, 2024) In 2024 free allowances were reduced by 25% and during the year 2025 reduction grew to 50%. Furthermore, the free allocation is transferred to full auctioning in 2026 in the airline industry. This means that the emissions will affect airline operating costs more in the near future and it is relevant topic to research in the future.

US airlines do not have a similar emissions trading system as Europeans have for regional flights. Therefore, they do not have national requirement to surrender emission allowances from regional flights to their government. However, US airlines are required to follow The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA is an international compensation system for carbon emissions. Airlines are obligated to acquire and cancel eligible emissions units from the global carbon market. (FAA, n.d.)

The practical cost structure difference is significant. European airlines must follow strict obligation for emissions. This requires more forecasting work of their emissions and acquiring the allowances and following the mandatory timelines. These create more operational costs on the personnel side, and the change from free allowance to fully auction-based system creates higher price risks to be considered as well.

European Union is also bringing new obligations to achieve its climate targets. From 2025 EU airports are required to provide fuel which contains at least 2% share of sustainable aviation fuel (SAF), and long-term goal is to reach 70% in 2050, the requirement is called the ReFuelEU aviation (European commission, n.d.). ReFuelEU does not affect this thesis, but it is a relevant topic for further research. Many airlines already have SAF usage, but when the regulations tighten it is interesting to see how it affects the cost structure.

Since this study focuses on fuel hedging and operational costs, why is emission trading relevant? It is relevant since the regulations in the sample regions are different. European airlines must focus on more risks in their operating environments due to stricter emissions policy and therefore the hedging of jet fuel can be considered more relevant to minimize financial risks in their operations. This would suggest that US airlines could take more financial risk with jet fuel price risk and benefit from it. However, this should not be taken as a causality why hedging is not as relevant for US airlines than for European airlines, the topic needs to be studied more in future research, which could answer the question.

5.3 Limitations of study

While the study aims to maintain a high standard of execution, a few limitations should be acknowledged.

First key limitation relates to the relatively small sample size, consisting of 20 airlines over the observation period. This primarily reflects the structure of the airline industry and data availability. As noted by Lim and Hong (2014), the U.S. airline industry has undergone significant consolidation, resulting in a market dominated by a few large carriers, alongside multiple bankruptcies during their study period (2000–2012). In contrast, the European airline market is more fragmented, offering a broader set of potential observations. However, data availability remains limited, as many European airlines are not publicly listed and therefore are not required to disclose detailed financial and operational data. Consequently, the small sample size reduces the statistical power of the analysis and may limit the detection of significant effects.

Second limitation is that the sample period introduces additional challenges. The study does not aim to specifically analyze the impact of COVID-19. However, the selected timeframe includes two major external shocks. The COVID-19 pandemic significantly disrupted the airline industry, and the subsequent recovery period was affected by the Russian invasion of Ukraine in 2022. This event led to the closure of Russian airspace for many European carriers and contributed to a sharp increase in oil prices due to international sanctions. The occurrence of these consecutive shocks complicates the interpretation of results and makes it more difficult to isolate the effects of fuel hedging.

Finally, data collection presents a limitation. The dataset was compiled manually from annual reports, which is both time-consuming and subject to potential human error. In addition, there is considerable variation in reporting practices across airlines. Key variables, such as hedge ratios, are disclosed inconsistently, and in some cases not at all, even when hedging activity is mentioned. This further reduces the number of usable observations in the regression analysis and may affect the robustness of the results.

6 Conclusion and recommendations

This research aims to study whether fuel hedging lowers the operating expenses in the airline industry. Research was conducted with panel dataset of airlines from US and Europe. Empirical analysis was conducted with OLS-panel regression models using airline and year specific fixed effects.

The results of this study do not provide sufficient evidence that fuel hedging lowers airlines' operating expenses systematically. While some regression models provide statistical significance between hedging and costs, results were not robust when models added more control variables or when COVID period was removed from dataset. In addition, fuel hedging did not explain the relationship between hedging and profitability systematically.

The key conclusion of this research is that fuel hedging's primary benefit does not seem to be lowering the costs, instead as previous literature suggest, it is more likely to be used to lower the uncertainty and price fluctuations. Hedging gives airlines the opportunity to stabilize the cash-flows, increase predictability and lower the risk of exposure to sudden price fluctuations, especially during the time periods of high prices.

In addition, this study shows that structural factors affect airlines' operating costs significantly, such as the load factor, business model and market circumstances. The most significant factor for cost efficiency was found to be the load factor. This implies that operative decisions and capacity optimization could have greater impact on cost efficiency rather than hedging fuel with financial instruments.

The results also have practical implications for the management of airlines. Fuel hedging should be considered more as a stabilizing tool for risk management rather than price lowering mechanism as previous studies have stated. Airlines have greater opportunities to forecast their expenses, which can help for instance in the budgeting process when the most significant cost is noted in the risk assessment and furthermore stabilizing the profitability.

The study presents opportunities for further research. Since load factor was the most significant factor explaining the operating costs in this thesis, it would be beneficial to scope further research into studying whether fuel hedging affects load factor and, through it, operating expenses. This could present beneficial findings regarding managerial implications. Limitations of this study also presented that it would be beneficial to include more regions to study fuel hedging with a greater sample size of airlines. Previous literature presents studies regarding other regions, however the scope is not focused on operating expenses, and therefore there is room for further research.

Moreover, differences in regulatory environments present opportunities for further research between regions. Europe's heavy regulation in emissions trading is a factor that can affect hedging behavior differences. Furthermore, addition of ReFuelEU regulation can affect cost structures and risk management of European airlines in the future. The increase of environmental considerations in the aviation industry also presents the increased use of sustainable aviation fuels. SAF adaptation and aircraft technology developments create further opportunities to study fuel hedging relevance in aviation.

Overall, this study contributes an addition to previous literature for fuel hedging and operative expenses with more recent data and two-region sample. It supports that fuel hedging is still commonly used risk management strategy for many companies in the aviation industry and it presents various opportunities to study the topic more.

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Appendices

Appendix 1. Correlation matrix

Variable	Log_Cost_Y	Hedge_Ratio	Hedge_Dummy	Fuel_Price_Kerosine	Brent_Spot_USD_per_bbl	Load_Factor	Log_ASM	Log_Revenue_per_ASM	EBIT_Margin
Log_Cost_Y	1,000	-0,297	-0,370	0,021	0,024	-0,090	-0,229	0,989	0,016
Hedge_Ratio	-0,297	1,000	0,810	-0,173	-0,165	0,118	-0,148	-0,293	-0,019
Hedge_Dummy	-0,370	0,810	1,000	-0,059	-0,074	0,083	-0,139	-0,366	-0,043
Fuel_Price_Kerosine	0,021	-0,173	-0,059	1,000	0,979	0,245	0,118	0,047	0,216
Brent_Spot_USD_per_bbl	0,024	-0,165	-0,074	0,979	1,000	0,195	0,108	0,046	0,197
Load_Factor	-0,090	0,118	0,083	0,245	0,195	1,000	0,266	0,007	0,582
Log_ASM	-0,229	-0,148	-0,139	0,118	0,108	0,266	1,000	-0,202	0,270
Log_Revenue_per_ASM	0,989	-0,293	-0,366	0,047	0,046	0,007	-0,202	1,000	0,151
EBIT_Margin	0,016	-0,019	-0,043	0,216	0,197	0,582	0,270	0,151	1,000