

AVIATION UNDER THE EU EMISSIONS TRADING SYSTEM

IMPLICATIONS ON FINANCIAL PERFORMANCE OF AIRLINES

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Abstract

Since 2005, the European Emissions Trading System (EU ETS) has been the EU's main instrument to reduce CO₂ emissions. As one of the fastest growing emitters, the aviation industry was included in the system in 2012. Previous research shows that the EU ETS has successfully reduced CO₂ emissions in the aviation industry, while local studies indicate that the effect on financial performance has been minimal. In this thesis, we provide the first large-scale, ex-post analysis of the EU ETS' effect on the financial performance of the aviation industry. We conduct a difference-in-differences analysis and find that the policy had little to no financial effect on airlines, although we observe a weak statistically significant effect on SG&A costs, possibly caused by the administrative burden of the EU ETS. Our results show that the reduction in CO₂ emissions caused by the EU ETS has been achieved without hurting the profitability of airlines, suggesting that more stringent regulations could be a viable option to further reduce CO₂ emissions.

Keywords:

European Emissions Trading Scheme, Aviation, Economic impact, Climate policy

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Table of contents

List of figures	III
List of tables	IV
1. Introduction	1
2. Theoretical background and literature review	4
2.1 Characteristics of the European airline industry	4
2.2 Origin and function of the European Emissions Trading System	6
2.3 Aviation under the European Emissions Trading System	9
2.4 Allowance allocation and cost to airlines	11
2.5 Review of literature on the economic impact of the EU ETS	13
2.6 Review of literature on the impact of the EU ETS on the aviation industry ...	16
3. Empirical analysis	19
3.1 Data collection	19
3.2 Methodology	22
3.3 Results and discussion	24
3.4 Robustness and sensitivity tests	26
3.5 Qualitative analysis using annual reports	29
4. Critical appraisal.....	32
5. Conclusion.....	33
References	35
Appendix	43

List of figures

Figure 1: CO2 emissions from international aviation between 1990 and 2020	2
Figure 2: Leading airlines in Europe based on passenger numbers 2021	5
Figure 3: Number of passengers carried by air in the EU from 2008 to 2020	6
Figure 4: Historical pricing of EUAs in EUR per tonne of CO2 equivalent.....	9
Figure 5: Design of the EU Emissions Trading Scheme for aviation	11
Figure 6: Dataset visualized - Countries which are represented in the final dataset.....	22

List of tables

Table 1: Descriptive statistics..... 21

Table 2: Difference-in-differences analysis results 24

Table 3: Difference-in-differences analysis with clustered standard errors results..... 26

Table 4: Sensitivity analysis results..... 28

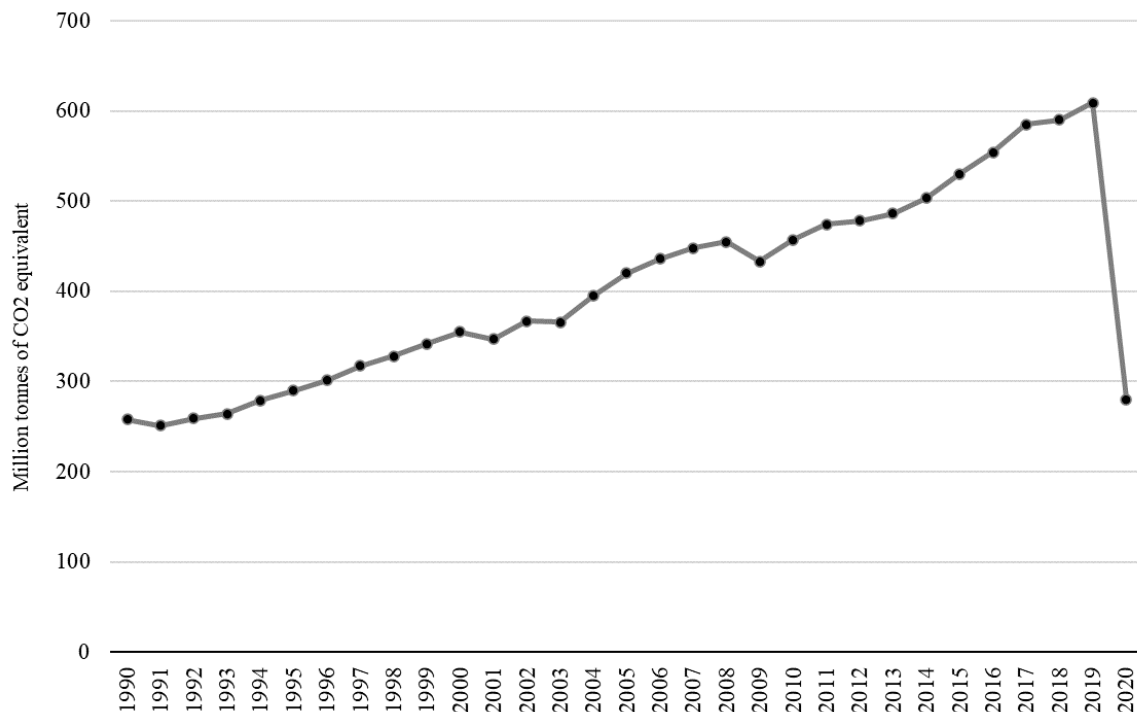
1. Introduction

Climate change is increasingly being embraced in society and is more and more discussed in media and politics. Currently, global warming is estimated at 1.01°C compared to pre-industrial times. The year 2020 is tied with 2016 to be the second warmest in the history of 140 years of temperature recording. 19 of the 20 warmest years ever have occurred since 2000 (NASA, 2022). Global warming and greenhouse gas emissions have become one of the most important political questions for the past several years, and regulators are constantly trying to make environmental improvements without excessively hampering the economy. The European Union Emissions Trading System (EU ETS) is the European Union's main instrument to combat climate change by reducing carbon dioxide (CO₂) emissions. Introduced in 2005, the EU ETS is the first multinational greenhouse gas cap-and-trade system and until now remains the world's biggest. It covers firms and installations within the energy producing sector, CO₂ intensive industries, and aviation. The aviation industry was added to the system in 2012. The regulator sets a total cap on emissions for all participating companies and distributes a corresponding amount of European Union Allowances (EUAs) to companies. One EUA gives the holder the right to emit one tonne of CO₂ or the global warming potential equivalent of another greenhouse gas. Companies must submit an allowance for each tonne of emitted CO₂ at the end of each year. If they need more EUAs to meet their emissions, they can purchase additional permits on the open market from companies which have a surplus of EUAs. This incentivizes companies to reduce their emissions and develop sustainable solutions as it introduces an opportunity cost to carbon emissions. EU Allowance Certificates are allocated for free or by auction (European Commission, 2015).

A conventional economic view would suggest that the ETS negatively affects firms' economic performance. However, research on the EU ETS has found that it has been successful in reducing carbon emissions while having no (Dechezleprêtre, et al., 2018) or even a positive effect on financial performance (Marin, et al., 2018). Furthermore, research shows that the EU ETS does not affect all industries the same way (Chan, et al., 2013).

Aviation contributes to about 2.5% of global CO₂ emissions (Ritchie, 2020), but also adds to global warming through several other factors, such as the formation of high-altitude clouds. Despite its relatively small contribution to total CO₂ emissions, aviation is argued to be the most unsustainable mode of transport. Air travel is also one of the highest growing emitters and its contribution to total emissions increases every year. The high amount of CO₂ emissions per flight and person makes air travel the biggest part of many peoples personal CO₂ footprint (Ritchie, 2020). Thus, although the airline industry doesn't emit much compared to other industries, it is still very important to control its growing emissions with regulations that are efficient for both the environment and the economy. Especially in the airline industry, this aim poses a great challenge since the market can be characterized as very competitive with high pressure on cost and there is already a big body of existing regulations. Hence, academic research on the EU ETS plays an essential role and can build a bridge between economic and ecological interests while helping to find the optimal solution for society.

Figure 1: CO₂ emissions from international aviation between 1990 and 2020



Source: Climate Action Tracker (2021), own figure

The aviation industry was introduced to the EU ETS in 2012 as to incentivize the development toward less emissions. Initially, all flights to and from the Euro Economic Area (EEA) were included, but in 2013 this was revised to only include flights within the EEA (European Commission, 2015). EUAs are allocated either for free or via auctions. Between 2013 and 2016, freely allocated allowances covered between 50% and 60% of airlines' total emissions. The remaining allowances had to be purchased via auction from the regulator or on the market for carbon with prices ranging between EUR 2.68 and EUR 8.65 per EUA. The EU ETS can impose costs to an airline in several ways: Costs can occur from buying allowances via auctions or on the market, increased administrative work, investments into climate efficiency and potential fines due to non-compliance.

While some ex-ante analyses suggest that the aviation industry would be a net buyer of EUAs, and thereby not reduce their own emissions significantly (Vespermann & Wald, 2011) (Scheelhaase, et al., 2012), others suggest that the EU ETS could lead to substantial reductions in carbon emissions (Anger, 2010). Anger concludes that the EU ETS could reduce air travel emissions by 7.4% until 2020 without hurting industry growth rates or having a notable impact on real GDP in the EU. Common for most existing research evaluating the EU-ETS ex-ante, is the expected small effect on financial performance, even though most researchers substantially overestimated the price of EUAs. Only a few ex-post analyses have been made on the effect of the EU ETS on the aviation industry. Their main finding is that carbon emissions were indeed reduced due to the EU ETS (Fageda & Teixeira, 2022). Research on a local level finds that the EU ETS had little to no effect on financial performance of airlines in Italy (Meleo, et al., 2016), Austria, and Germany (Oesingmann, 2022).

In this thesis, we provide the first large-scale, ex-post investigation of the EU ETS' effect on the financial performance of the European airline industry. We conduct a difference-in-differences analysis comparing European airlines with international airlines before and after the year 2013, which is the first year that airlines had to surrender allowances. We find that the inclusion in the EU ETS had little to no effect on financial performance in the airline industry. After a robustness test introducing clustered standard errors at a region level, the only effect of the EU ETS that showed a (weak) statistical

significance was a positive effect on selling, general and administrative cost (SG&A). One explanation for this effect could be the increased administrative burden of managing emission rights, which multiple airlines have expressed concerns about. We find no significant impact of the EU ETS on airlines' stock prices, revenues, costs, or profits. This confirms the modest effect of the EU ETS on financial performance found in previous literature. We show that the current form of the regulation does not significantly hurt airlines, which underlines that the EU ETS could be more stringent to reduce carbon emissions even more.

In the following theoretical part, we provide important background information about the EU ETS and the aviation industry. This supports the subsequent analysis using empirical methods on historical data and qualitative evaluation of annual reports. We then conclude with a summary of results, implications for policy making and a critical appraisal of our work.

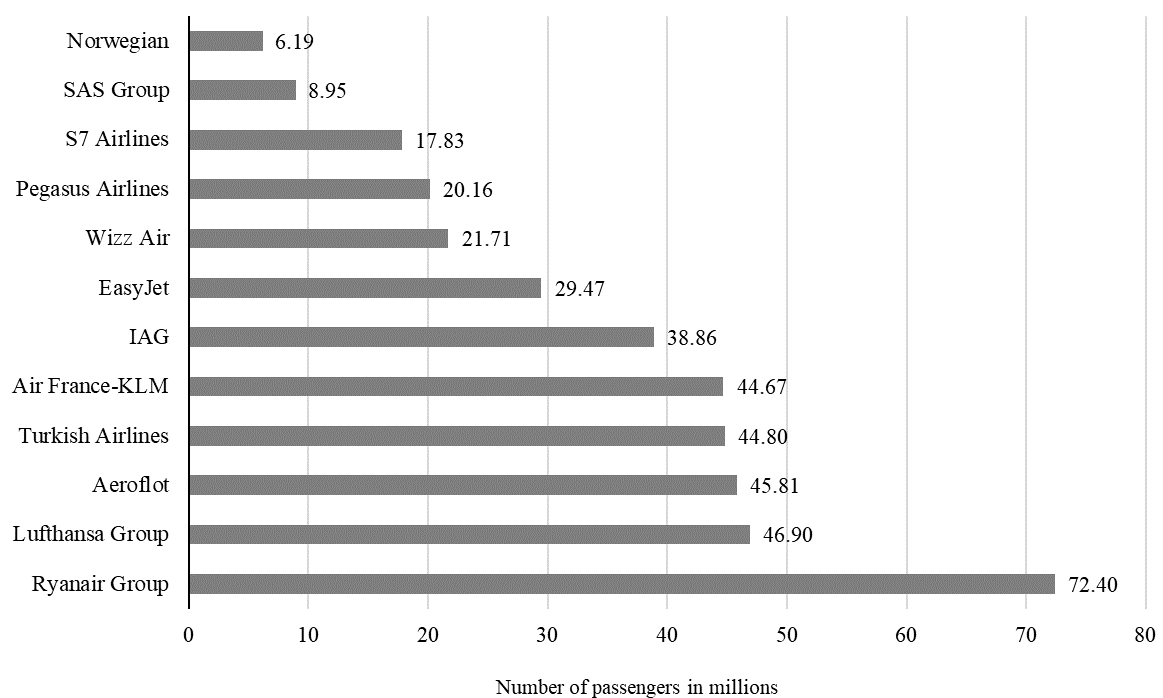
2. Theoretical background and literature review

2.1 Characteristics of the European airline industry

The European air transport market as it is today has emerged after significant deregulation and liberalization of the industry in the late 1990s. Before, aviation had been under strict national regulations and was dominated by monopolistic national carriers and publicly owned airports (European Parliament, 2022). The liberalization stipulated a strong growth of the sector during the last 20 years and triggered the emergence of many new market participants making the industry increasingly fragmented. The number of air passengers has grown at a CAGR of 4% since the year 2000 (Airports Council International, 2018). The annual turnover of the air transport industry in the European Union has also been steadily increasing until it reached a peak of EUR 128.5 billion in 2019 (Eurostat, 2022), just before COVID-19 shut down most of global air travel. Having turned over USD 248 billion in 2019, the U.S. airline industry is considerably larger (Bureau of Transportation Statistics, 2021). The European Airline industry contributes about 16% to the global revenue of commercial airlines (IATA, 2021).

Whilst the deregulation increased market fragmentation, consolidation has characterized the EU airline industry's development during the recent years. The biggest carriers are continuing to grow through M&A which has resulted in a combined market share of more than 50% for the top five airlines (Scope Ratings, 2019). Among those are big groups such as Lufthansa, who combine many individual airlines under their corporate umbrella.

Figure 2: Leading airlines in Europe based on passenger numbers 2021

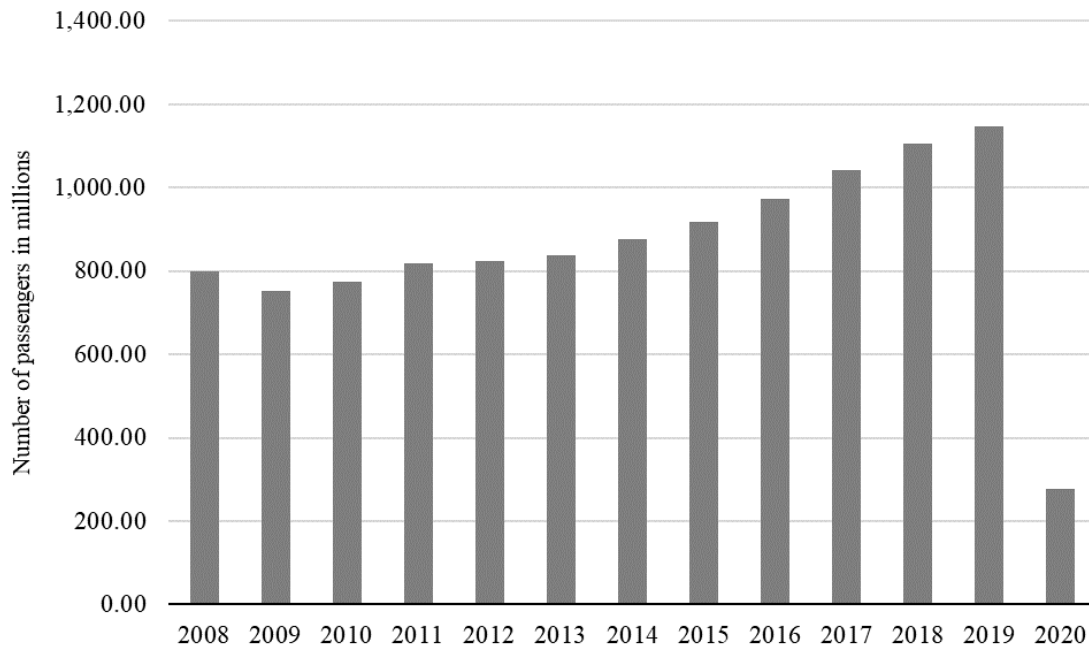


Source: Statista (2022), own figure

Despite high growth, the air transport industry is cyclical and subject to a high degree of profit uncertainty, many regulations, and increasing cost pressure. Profitability depends largely on an airline's capability to manage costs, fares, and load factors to adjust to demand cyclicity (Commission of the European Communities, 1999). Volatile jet fuel prices and an increase in regulations put further pressure on profits. Especially small airlines are having problems to pass on rising costs. Combined with the increasing competitive pressure by low-cost airlines, this has led to the collapse of some smaller EU airlines in recent years (Scope Ratings, 2019). Examples include Air Berlin, Aigle Azur, Alitalia, Adria Airways, and Thomas Cook. Low-cost carriers such as Ryanair, Wizzair or easyJet, on the other hand, have done particularly well in recent years' market

environment. Besides growing cost pressure, key industry risks include competition from alternative modes of transport and societal/political pressure regarding aviation's impact on climate change.

Figure 3: *Number of passengers carried by air in the EU from 2008 to 2020*



Source: Eurostat (2021), own figure

2.2 Origin and function of the European Emissions Trading System

The EU ETS is the European Union's key tool for reducing greenhouse gas emissions and thereby combating climate change. Within this theoretical part of our paper, we provide a basic understanding of the system's origin and functioning.

Legally binding greenhouse gas limitation and reduction commitments for industrialized countries have first been introduced by the 1997 Kyoto Protocol. The Kyoto Protocol is considered as a milestone in international climate policy and has been ratified by 191 countries, including all EU Member States. The protocol defines three main mechanisms to tackle climate change: Joint Implementation (JI), Clean Development Mechanism (CDM), and International Emission Trading (IET) (UNFCCC, 1997). The European Union has realized the Kyoto Protocol measures by introducing the EU ETS in 2005. The EU ETS is based on the Kyoto Protocol's guidelines and applies its approach at a company level (Wagner, 2007).

Carbon pricing affects firms by increasing marginal costs and thus motivates to lower emissions through both a reduction in total output of goods or services and a reduction in emissions per output unit (Fageda & Teixido, 2022). The EU ETS operates under the institutional framework of a “cap and trade system”. The scheme’s basic principles are explained by the European commission in their EU ETS Handbook (European Commission, 2015). The total EU emissions cap is set by the EU regulator each year based on environmental targets and decreases annually. The corresponding number of EU Allowance Certificates (EUAs) are allocated to companies by auction or through free allocation at the beginning of every year. Participating companies are only allowed to emit as much greenhouse gases as the EUAs they hold. One EUA corresponds to greenhouse gas emissions equivalent to the global warming potential of 1 tonne of CO₂ (tCO₂e). That is, at the end of each year, participating companies must submit one EUA for every tonne of emitted CO₂. They can, however, freely trade EUAs on the market. If the emissions of a participating company exceed their permits, they must buy more permits on the open market to avoid fines. Likewise, a climate-friendly production can result in an EUA surplus, which the company can sell for a profit. A cap-and-trade system is regarded as the most efficient way of greenhouse gas reduction in economic theory (Harrington & Morgenstern, 2007). Companies are free to decide how and where to save carbon emissions. Because surplus allowances can be sold for a profit and excess emissions can be covered by acquiring more allowances, companies are incentivized to save emissions in the most cost-efficient way for the economy. The cap allows the regulator to set a specific emissions reduction target, which can be achieved with a high degree of certainty. Additionally, the regulator can generate revenues through the sale of permits.

The EU ETS came into force in 2005 and since then evolved through four trading periods (European Commission, 2015). The first trading period, which started in 2005 can be characterized as a test phase. The allocated allowances exceeded actual carbon emissions, which lead to a low market demand for EUAs and a price drop to nearly zero. Almost all allowances were given away for free. Some countries began auctioning EUAs with the start of the second phase in 2008. In the same year Iceland, Liechtenstein, and Norway joined the system. The second phase also marks the inclusion of aviation into

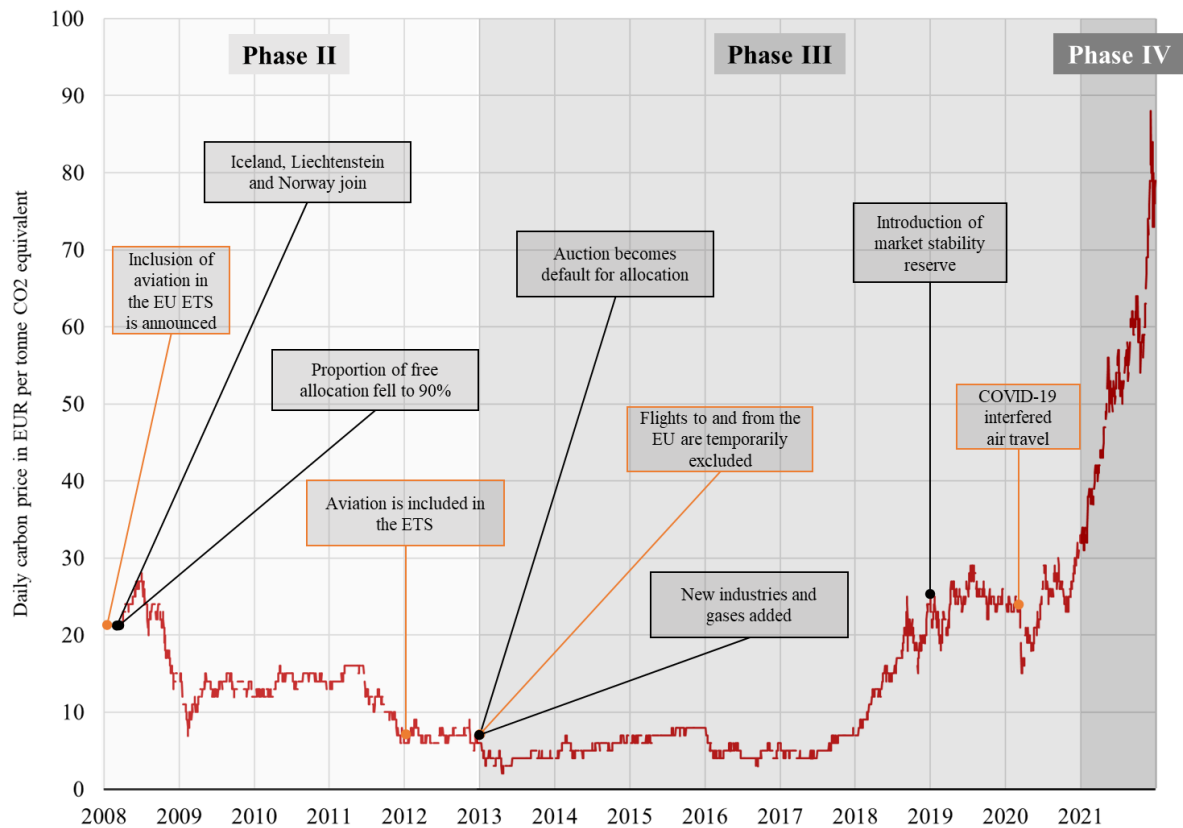
the EU ETS in 2012. The systems' scope was further extended to include more industries and gases. The price of EUAs however was still relatively low because the financial crisis led industries to emit less than expected, resulting in an oversupply of allowances (Schumacher, et al., 2012). The third phase started in 2013 and incorporated the biggest reform of the system so far. Auctioning of EUAs was set as the default allocation method and even more industries and gases were included. A single EU-wide emissions cap replaced the national caps that were in place before. A Market Stability Reserve (MSR) was introduced in 2019 to address the surplus of allowances that had built up in the market. The MSR is used to adjust EUA supply and demand and thereby ensures a more stable and higher price. Currently, the ETS is in its fourth trading period, which started in 2021 and will end in 2030. The current trading period also included several legislative changes, as well as a more ambitious target of at least 55% net reduction of emissions by 2030 (European Commission, 2021).

As the EU ETS is an environmental law, decisions are made at the European level and through its main institutions: the European Parliament, the European Commission, and the European Council. Geographically, the EU ETS applies to all 27 EU member states plus Iceland, Liechtenstein, and Norway. The Swiss ETS system is linked to the EU ETS. The United Kingdom was part of the EU ETS until January 2021, when it replaced the scheme with its own ETS due to its withdrawal from the European Union (UK Government, 2022). In terms of sectoral scope, the EU ETS covers emissions from the power sector, industrial processes, and aviation. Industrial processes under the ETS include energy-intensive industry sectors including oil refineries, steel works, production of iron, aluminum, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids, and bulk organic chemicals. Currently the EU ETS covers emissions from more than 10.000 installations within those sectors (European Commission, 2015).

As of 2021, the EU ETS covered approximately 36% of the European Union's total greenhouse gas emissions according to the International Carbon Action Partnership (ICAP, 2022). The EU ETS produced total revenues of EUR 94 billion until 2021 and around 43% of emissions have been cut by installations under the ETS since the system was introduced in 2005. The EU ETS was the first major emissions trading system and

remains the biggest carbon market and the blueprint for all following emissions trading systems around the world according to the European Commission (European Commission, 2022).

Figure 4: Historical pricing of EUAs in EUR per tonne of CO₂ equivalent



Source: Data from International Carbon Action Partnership (2022), own figure

2.3 Aviation under the European Emissions Trading System

The aviation industry is one of the major drivers of global warming. Contributing a share of 24.6% to total EU greenhouse gas emissions, the transportation sector is the third largest emitter and is only topped by energy industries (28%) and fuel combustion by energy users (25.5%) (Eurostat, 2018). Aviation is responsible for approximately 16% of the transport sector's emissions, but also contributes to global warming through several other ways. Furthermore, aviation has been a very fast-growing emitter due to ever increasing passenger numbers (Ritchie, 2020). Beside CO₂, airplanes emit water vapor, nitrogen oxides, sulphate aerosols, and compounds from incomplete combustion and particulates (soot). Their emissions result in a long term decrease of ozone and exhaust

gases can form high altitude cirrostratus clouds and contrails (linear clouds) that reflect heat back to the surface of the earth (Grewe, et al., 2021). The overall effect of aviation to global warming has been quantified by Lee et al. (2021). They estimate that aviation contributes 3.5% of total global warming, of which only one third is attributed to CO₂ emissions. Yet, the Paris Agreement on climate policy and the EU Emissions Trading System do not take non-CO₂ effects into account. A contribution of 3.5% might not seem particularly high, but air travel still is the biggest part in many peoples personal CO₂ footprint. This is especially true for people living in wealthy western countries (Ritchie, 2020). This further underlines the importance of regulatory steps to decarbonize air travel.

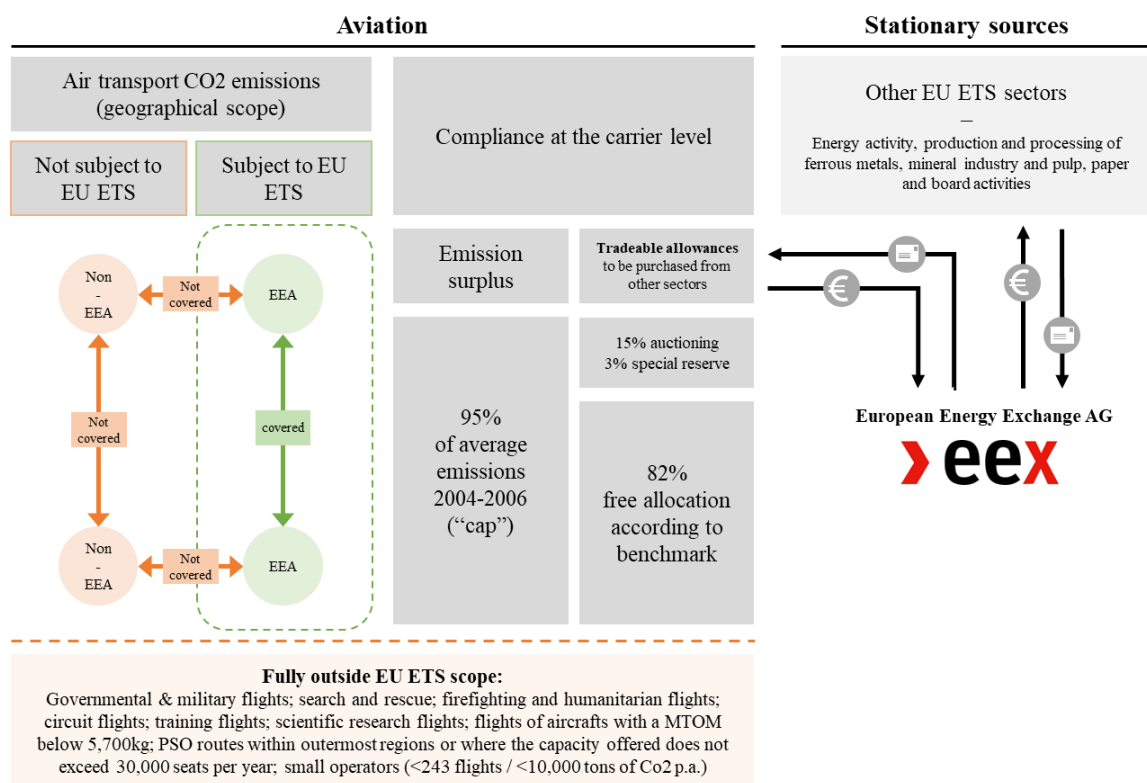
In 2008 the European Parliament and the council of the EU agreed on a directive to include the aviation sector in the EU ETS (European Parliament and Council, 2008). The directive came into force in 2012. From then on, EU and non-EU airlines had to submit EUAs equivalent to their CO₂ emissions of flights from, to and within the countries participating in the EU ETS. The aviation part of the Swiss ETS is linked to the EU ETS and shares the same principles. Exemptions from the ETS are granted for very light aircrafts, military, police, rescue, and customs flights, as well as state, government, training, and testing flights.

In March 2013 however the EU decided to suspend enforcement of the regulation of flights to or from non-EEA countries, meaning that aircraft operators only have to submit allowances for flights that start and land in EU ETS countries (European Parliament and Council, 2013). The purpose of this decision was to allow the International Civil Aviation Organization (ICAO) to agree on a global regulation to reduce emissions from international air travel. In 2016, ICAO agreed on a Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA came into force in 2021 but will stay non-mandatory for airlines until 2027 (ICAO, 2022). CORSIA is considered less stringent than the EU ETS. Flights to or from non-EU ETS members however contribute most of European aviation's CO₂ emissions.

According to the European Commission's EU ETS Handbook (2015), the emissions cap for aviation has been calculated to be at 95% of historical average yearly emissions of the EU aviation sector from 2004-2006, which results in 221,420,279 tCO₂e annually.

This means that from 2012 onwards, airlines would have to reduce their emissions by 5% or purchase additional allowances, if they could not meet the emissions cap. The cap for phase three was later adjusted to reflect the smaller scope of only intra EU ETS flights but stayed at 95% of historical allowances throughout the third phase until 2020. From 2021, the aviation emissions cap is reduced by 2.2% annually, which is the same reduction factor that applies to stationary installations.

Figure 5: Design of the EU Emissions Trading Scheme for aviation



Source: Maertens, et al. (2019), own figure

2.4 Allowance allocation and cost to airlines

Until the end of trading phase III in 2020, 82% of allocated allowances were distributed to aircraft operators for free, 15% were auctioned, and 3% were held in a special reserve for distribution to new entrants or particularly fast-growing airlines (European Commission, 2022). The free allocation of EUAs between 2012 and 2020 was based on tonne-kilometres flown, a commonly used aviation efficiency metric. An aircraft operator received 0.6422 allowances per 1,000 tonne-kilometres flown. There are special aviation allowances, which are distributed to aircraft operators and can only be used by them.

These EUAs cannot be used by stationary installations, but airlines can also surrender normal allowances. Otherwise, key compliance rules for stationary installations and aircraft operators are mostly the same. Compliance of aircraft operators has been at 99.5% according to the European Commission (2022).

Aircraft operators face several different costs related to the European Emissions Trading System. First, they must buy 15% of their allowances through auctions from the regulator. Second, the emissions cap forces airlines to either reduce emissions compared to 2004-2006 or buy additional allowances on the market to cover excess emissions. Reducing emissions is also likely to cause costs, because investments in more efficient technology must be made. Additionally, airlines might face costs through penalties if they fail to comply to the EU ETS rules. Companies that fail to submit the necessary quantity of EUAs are obliged to pay €100 per tonne of CO₂ in penalties.

Airlines can pass these extra costs on to consumers through higher fares similar to fuel surcharges or absorb them in their profits. The degree to which airlines can pass on the extra cost depends primarily on their consumers' elasticity of demand. Studies conducted before the EU ETS was introduced predicted the cost pass-through to be high and range between 75% and 100% (DG Environment, 2005), (International Air Transport Association, 2007) & (Defra, 2007). According to research by Nava, et al. (2018), Airline company's profits are influenced by the EU ETS through two main factors: The share of freely distributed allowances and the airline's abatement effort cost. The share of allowances distributed free of charge positively influences profits, because more free allowances simply mean that an airline must purchase less EUAs to cover its excess emissions. Abatement effort costs negatively influence profits, if airlines are not efficient because they made a low level of investments aimed at reducing emissions. In terms of profit, there is a trade-off between the share of freely distributed allowances and the efficiency cost of individual airlines. A comparison of the freely allocated allowances and actual emissions incurred by airlines shows that airlines had to purchase a significant amount of EUAs through auctions or on the free market. Fageda and Teixido (2022) illustrate that only between 60% and 51% of total airline emissions from 2013 to 2016 have been covered by freely distributed allowances. This percentage was decreasing,

because the amount of freely distributed allowances stayed constant, while airlines increased their flights and therefore emissions. The additional cost this imposed on airlines during the first five years of the EU ETS is estimated to be approximately EUR 650 million (Fageda & Teixeira, 2022).

2.5 Review of literature on the economic impact of the EU ETS

The economic effect of the EU ETS was a major concern throughout the debate regarding the system's introduction and design. A conventional economic view would suggest that the ETS would negatively affect firm's economic performance. Regulated firms must utilize additional capacities as they must implement emissions reduction measures or buy allowances to cover their emissions. This could lead to a non-optimal use of resources that might otherwise be used more efficiently and thus negatively affect firms. Firms under the ETS would also face a competitive disadvantage compared to non-regulated firms outside the European Union. Nevertheless, empirical studies using historical data show that this theory generally does not hold for the EU ETS in practice (Dechezleprêtre, et al. (2018), Marin, et al. (2018), and Chan, et al. (2013)). The economic impact on companies was very limited for the most part. Theoretical support for these observations can be found in the Porter hypothesis (Porter, 1991), which suggests that environmental regulation can increase firm's commercial competitiveness by inducing efficiency and innovation. A wide range of studies exists on the emissions trading system's economic implications, both conducted ex-post and ex-ante. Most of the studies however only look at a specific country. Only few academic articles exist, that are evaluating the subject across Europe and across industries.

Dechezleprêtre, et al. (2018) conducted a general analysis of the EU ETS's impact on economic performance and carbon emissions. They use firm level data on revenues, assets, profits, and employment for 2,000 firms in all countries covered by the EU ETS to analyze economic performance. The influence on emissions is analyzed through data from national pollution registers in France, Netherlands, Norway, the UK and the European Pollutant Release and Transfer Register. The researchers use a matching methodology and difference-in-differences approach to analyze the impact of the EU ETS. Companies that are subject to the EU ETS are matched to similar ones which are

not included and both are then compared to each other. No negative correlation between the EU ETS and economic performance is found. In the contrary, the EU ETS led to a statistically significant increase in revenues and in fixed assets. Furthermore, a statistically significant reduction in emissions in the treatment group has been observed in the range of 10% to 14% during the sample period of 2005 to 2012. The reduction can be mainly attributed to the second trading phase after 2008 and to larger installations. The low economic impact can be explained by two main factors: The high degree of freely allocated allowances and the relatively low price of CO₂ during the sample period. The price of CO₂ under the EU ETS dropped to zero at the end of the first trading period, then started around EUR 20 in 2008, but dropped below EUR 10 in 2009 and stayed there for the most part until it rose again above EUR 20 in 2019 (see figure 4). Most of the ex-ante impact studies on the EU ETS expected higher prices of EUR 20 to EUR 40. Almost all EUAs have been allocated for free until the beginning of the third EU ETS trading period in 2013, when free allocation dropped to around two thirds of allocated allowances (European Court of Auditors, 2020).

Another study on the impact of the EU ETS on economic indicators has been conducted by Marin, et al. (2018). They observe a larger selection of output variables and evaluate employment, average wages, turnover, value added, markup, investment, labor productivity, total factor productivity, and ROI. The researchers use a sample of more than 3,000 companies within the manufacturing industry across 19 EU countries during the first and second EU ETS trading phase (2005-2012). A difference-in-differences approach is used to analyze the data. Similar non-European manufacturing companies serve as a control group. Contrary to expectations, the authors find that the ETS positively affected turnover, employment, and investment. A full and partly even more than 100% pass through of the ETS cost is identified as the main reason for this finding. The study does not find a significant effect on labor productivity and average wages and a slightly negative effect on profitability and total factor profitability.

Research also suggests that not all industries are affected by the EU ETS in the same way. A comparison of how the EU ETS has affected competitiveness across different industries has been conducted by Chan, et al. (2013). The authors analyze a

sample of 5,873 firms across 10 EU countries within the power industry, cement production and the iron and steel industry during 2001-2009. Effects on competitiveness are measured in material costs, employment, and revenue by using a difference-in-differences methodology. The researchers find that the ETS had no significant effect on firms in the cement, iron, and steel sectors. For the power sector, a positive effect on material cost and revenues was observed. Concordant with the previously discussed academic works, the researchers attribute these effects to a high degree of cost pass-through to costumers. It must be noted that the study's sample period ranged from 2001 to 2009 and therefore only covered the first (2005-2008) and beginning of the second EU ETS trading period (2009-2012). This time period was characterized by several factors which significantly weakened the ETS cost impact on companies: A very low CO₂ price, free allocation of almost all allowances, and a general oversupply of allowances.

The existing research is quite homogenous in that most studies find no significant negative effect of the EU ETS on firms. However, it must be noted that outcomes differ across industries and that the ETS considerably changed and developed along the different trading phases. Especially the change from free allocation of almost all EUAs in the first period to an increasing number of auctioned allowances from phase three onwards and the sharp increase in CO₂ price after 2018. As most ex-post studies focus on the first and second trading period, it would be interesting to evaluate more recent data to find out whether the systems changes had an effect on its economic impact. We add to the existing literature on the EU ETS by providing an analysis on yet another sector, the aviation industry, and by making a distinction on the assessment of public and private firms across all of Europe's air travel companies.

2.6 Review of literature on the impact of the EU ETS on the aviation industry

The existing academic literature on the impact of the EU ETS on the aviation industry can be divided into two categories: Ex-ante and ex-post analysis. Most academic research on aviation under the EU ETS has been published at the time when aviation was introduced to the ETS and tried to answer the question what impact the inclusion will have in the future, both economically and ecologically.

Vespermann & Wald (2011) used a simulation model to estimate the economic impact and the ecological effects of the EU ETS on the aviation industry before the sector was included in 2012. The authors predict the yearly financial cost of the EU ETS on the aviation industry to be about EUR 3 billion, which would correspond to 1.25% of total industry costs. They argue that this is a rather small burden for the industry and would likely not result in any competition distortions. The actual cost, however, would be to a large degree dependent on allowance prices and air travel demand. The study used an expected value of EUR 25 per EUA, which is significantly higher than what the actual emissions prices in the simulation period turned out to be (see figure 4 for a graph of the EU ETS CO₂ price). In terms of ecological effects, the authors estimate that airlines would be a strong net buyer of emission certificates and thus induce a reduction effect in other industries but would not significantly reduce emissions themselves.

Another simulation model of aviation under the EU ETS was published by Scheelhaase, et al. (2012). The researchers also expect the aviation industry to be a net buyer of allowances and estimate the sector to spend between EUR 20.5 billion to EUR 41 billion on EUAs in the period between 2012 and 2020. This corresponds to an average yearly expense of EUR 2.3 billion to EUR 4.6 billion and is thus similar to what Vespermann & Wald (2011) found. Using a carbon price of EUR 20 to EUR 40, Scheelhaase, et al. (Scheelhaase, et al., 2012) also overestimated costs compared to actual CO₂ prices. The authors also simulated the exemption of international flights from the EU ETS and found that it would have the potential to cause significant competitive distortions in the airline sector and might lead to route reconfigurations. In previous research, Scheelhaase, et al. (2010) derived similar results regarding the cost that airlines would face under the ETS. They also concluded that the potential for endogenous carbon

emissions reduction in the industry would be low due to technological limitations and that the sector would hence need to purchase allowances for up to one third of its emissions. This research also identifies that European network carrier airlines are subject to a competitive disadvantage compared to non-EU airlines because the ratio of freely allocated EUAs is lower for European airlines.

Annela Anger (2010) examines aviation under the EU ETS from a macroeconomic perspective. She finds that CO₂ reduction by the air travel industry might be as high as 7.4% in 2020 compared to a no-action scenario. Economic growth rates of the industry however would not be impacted by the ETS according to Anger. Accordingly, the economic effect for the European Union in terms of real GDP would be very low and even a scenario with a CO₂ price of up to EUR 40 would not induce any significant changes in the air transport sector.

An analysis of the effect the EU ETS would have on air traffic routes was conducted by Albers, et al. (2009). The authors simulated cost and demand implication for a route-based analysis of airlines. They conclude that the ETS increases the costs per route by EUR 9 to EUR 27 for European airlines. According to the author's assessment, this is not high enough to trigger major route reconfigurations.

Research on the European Emissions Trading System's actual effect on the aviation sector based on historical data is relatively rare. Fegada and Teixido (2022) conducted the first ex-post research on the effects of carbon trading in the European Union in terms of greenhouse gas emissions reduction and air traffic supply based on historical data from 2010 to 2016. The analysis is based on data on the airline route level that covers all flights within Europe during the sample period. The researchers used a difference-in-differences methodology with intra-European flights being the treatment group and flights with origin or destination outside the EU being the control group. The authors find that the EU ETS caused a reduction in emissions of 4.7% in total. They also note that the reduction was the strongest for short-haul flights (10.7%) and low-cost airlines (11%). Fegada and Teixido (2022) attribute the emission reductions mainly to a lower growth of the number of flights on ETS-covered routes and even the closure of some routes. This effect was

especially notable for routes with a high competition from other modes of transport and shows the effectiveness of the EU ETS.

Research focused on the cost induced by the ETS on airlines has been conducted by Meleo, et al. (2016), who calculated the direct EU ETS cost on Italian airlines between 2012 and 2014. The researchers developed an economic model-based approach. Their formula to estimate direct ETS cost includes costs of EUAs purchased by auction and on the market, as well as civil penalties. Total direct costs are reduced by revenues from the sale of surplus allowances. The authors concluded that the cost of the ETS and the impact on both airlines and consumers have been relatively low during the study period. These low costs were mainly driven by an overallocation of free allowances in 2012, the first year of aviation in the EU ETS, which led to a big surplus of EUAs for airlines. In 2012, Italian airlines generated profits of EUR 6.5 million by selling their EUA surplus on the carbon market. The allocation of EUAs was adapted in the following years, which led to EUA deficits that forced airlines to buy allowances on the secondary market. According to the authors, a higher carbon price could induce more abatement efforts by airlines but might cause financial strain, especially for some of Italy's airlines which are already experiencing economic problems.

Another ex-post study was undertaken by Katrin Oesingman (2022). She analyzed the impact of the EU ETS on air passenger numbers and compared it to the effect of German and Austrian airplane ticket taxes. She estimated the empirical effect on aviation demand on a country-pair level by using a gravity model. Oesingmann's regression does not find that the EU ETS has any significant demand reducing effect on passenger flows for her sample period between 2002 to 2018. The compared ticket tax, on the other hand, did effect demand on a significant and robust level, which can be explained by the fact that the price of the tax was much higher compared to EU ETS cost in the sample period. However, Oesingmann (2022) notes that a ticket tax, although it reduces air travel demand, is not the optimal policy, because it does not relate to the amount of greenhouse gas emissions by airlines. Emissions trading on the other hand does so and incentivizes efficient emissions reductions.

The body of existing academic literature on aviation under the EU ETS is not very extensive. Most studies have been conducted ex-ante and used simulations and expected values for allowance prices and allocations. Most of such studies expected the effect of the EU ETS on economic performance to be low or moderate. Yet, most ex-ante simulation-based studies arguably overestimated the EU ETS effect because they expected a significantly higher carbon price and did not consider the oversupply of EUAs during the first and beginning of the second trading phase. In conclusion, the subject offers significant room for further research. A better understanding of the actual economic effect on the aviation industry is needed with respect to firm-level microeconomic indicators based on historical and recent data. In order to facilitate a continued improvement of the EU ETS for the aviation sector, insights on its influence on stock prices, costs, revenues and profitability, as well as the effect on demand, supply, ticket pricing and air travel routes would be helpful. Our analysis seeks to tighten that research gap by being the first to examine the EU ETS' effect on stock prices, revenues, costs, and profitability for all public and private airline companies under the EU ETS, using a difference-in-differences approach with historical financial data.

3. Empirical analysis

3.1 Data collection

To analyze the financial effect of inclusion in the EU ETS we used S&P Global's Capital IQ database to obtain quarterly (yearly) financial data on public (private) airlines from 2010 to 2015. We used S&P Global's Capital IQ screening feature to filter the database for airline companies, including several screening criteria to narrow down the search. Companies would need to be classified within the airline industry, be founded before 2010, and have revenue data available for the years 2010 to 2015. The screening resulted in a list of 201 European and 158 non-European companies. We then looked at each company individually to ensure that it fits our criteria and that it actually is an airline. Some companies are not correctly classified in S&P and were therefore removed from our sample. If companies are subsidiaries and belong to a group, we included only the parent company in our final dataset.

The final selection includes 147 airlines which are divided into a treatment group of 14 public airlines and 55 private airlines, and a control group of 53 public airlines and 25 private airlines. The treatment group consists of airlines that are based in countries that are included in the EU ETS (countries within the EEA). The remaining airlines make up the control group. Note that all flights between or within EEA countries are subject to the EU ETS, regardless of whether the airline operating the aircraft is based in the EEA or not. Thus, there might be airlines in the control group that are exposed to the EU ETS. However, we recognize that most intra-EEA flights are conducted by airlines that are based in the EU, hence we use country of incorporation as a proxy for exposure to the EU ETS.

We chose 2010-2015 as our sample period. If we were to use older data, we would risk having our results tainted by the Great Recession that occurred between 2007 and 2009. Additionally, if we were to extend the data beyond 2015 the risk increases that the economic effects of the inclusion in the EU ETS, which previous literature suggest should be minor, is washed out by other macroeconomic events. Furthermore, an analysis of the effects of the steep incline in emission right prices in 2021 would be interesting to better understand the economic effects of the EU ETS. However, due to the Covid-19 pandemic's detrimental effect on the aviation industry and the fact that very little time has passed since the start of the price incline, such an analysis would be hard to accurately conduct at this time. Hence, we deem 2010-2015 to be a suitable time frame. To test for robustness of our results however we also experimented with other time frames (see section 3.4).

Due to limited data availability and the fact that most private airlines only report annual data, the total number of observations when analyzing the whole dataset (private and public airlines) ranges between 683 and 786 depending on which variable is being analyzed. To estimate the EU ETS' economic effect on airlines we observed firm-year (firm-quarter for public airlines) level data on revenues; cost of goods sold (COGS); earnings before interest and taxes (EBIT) margin; sales, general and administrative expenses (SG&A), and stock price. COGS and SG&A are both included since it is not obvious how the airlines would report costs related to the EU ETS. In our analysis, COGS

and SG&A were scaled by revenues as to create a ratio. That is, the COGS ratio variable is defined as COGS divided by revenues, and the SG&A ratio variable is defined as SG&A divided by revenues. Similarly, EBIT margin is defined as EBIT divided by revenues. We created an index for the stock price data by setting the beginning of 2010 to 100 and thereby allow fair comparisons. All monetary variables are stated in millions of euros.

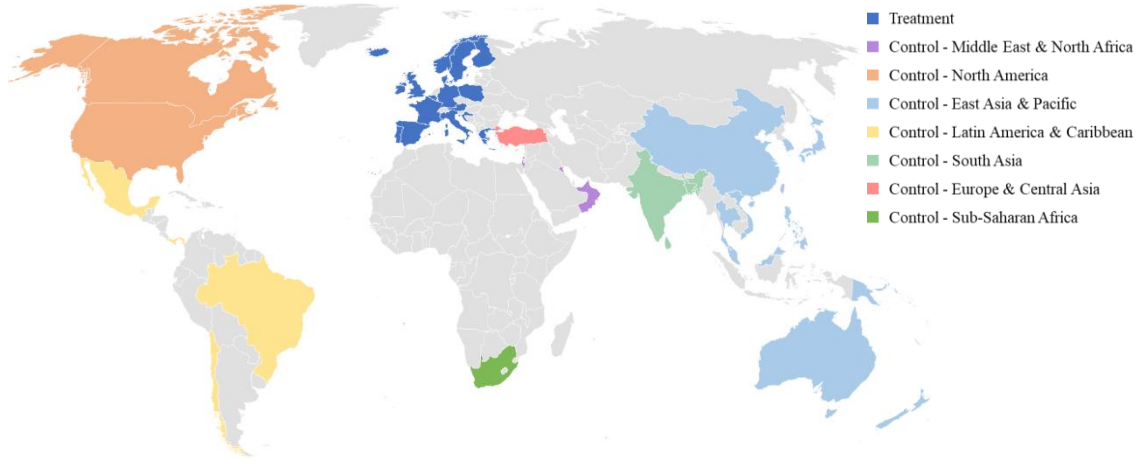
Table 1: Descriptive statistics

	Treatment group			Control group			Diff. in means
	Obs.	Mean	Std.	Obs.	Mean	Std.	
Revenues	69	1697	5183	71	4031	6014	2334
COGS ratio	59	0.5431	0.4133	70	0.7922	0.1586	0.2492
SG&A ratio	55	0.2347	0.2730	67	0.0819	0.0801	-0.1529
EBIT margin	69	-0.0040	0.2081	70	0.0429	0.0997	0.0469
Market cap.	16	1596	2362	47	2249	2543	653
Total assets	69	1633	5241	71	5302	7481	3670
Leverage	69	7.13	20.92	71	4.07	10.80	-3.06

2012 data

Through S&P Global's Capital IQ database we could also observe data on total assets and total liabilities, which were used to construct control variables. Total assets were included as a proxy for airline size and total liabilities were divided by total assets to create a leverage ratio. Further control variables include competition, air traffic, and local stock market data. The competition variable was constructed within the dataset by counting the number of airlines that were incorporated in each country at a given year, creating a proxy for competition on a country-year level. For air traffic, we used annual air passenger data from the International Civil Aviation Organization (ICAO), Civil Aviation Statistics of the World and ICAO staff estimates which have been compiled by The World Bank. The data was divided into seven geographical regions (see figure 6), thus allowing us to use it as a proxy for air traffic at the region-year level. Finally, we used 44 local stock indexes as a proxy for local market conditions at the country-year level. Local stock market data was retrieved from the Organization for Economic Cooperation and Development's (OECD) database and investing.com. The data was then indexed by setting the beginning of 2010 to 100 to allow for fair comparisons.

Figure 6: Dataset visualized - Countries which are represented in the final dataset



Source: Own figure, the colors indicate which region the country lies within as defined by The World Bank (The World Bank, 2020).

3.2 Methodology

To determine the economic effect of the EU ETS on the aviation industry, we estimate five difference-in-differences (DID) models. This is done by comparing the treatment group with the control group before and after the inclusion of aviation in the EU ETS to determine the effect of said inclusion. We estimate the following models for airline i in year t (or quarter q for analyses only including public companies).

$$\begin{aligned}
 (1) \text{ Stock price}_{iq} &= \alpha + \beta ETS_{iq} + \lambda X_{iq} + \varepsilon_{iq} \\
 (2) \text{ Revenues}_{i(t/q)} &= \alpha + \beta ETS_{i(t/q)} + \lambda Z_{i(t/q)} + \varepsilon_{i(t/q)} \\
 (3) \text{ COGS ratio}_{i(t/q)} &= \alpha + \beta ETS_{i(t/q)} + \lambda X_{i(t/q)} + \varepsilon_{i(t/q)} \\
 (4) \text{ EBIT margin}_{i(t/q)} &= \alpha + \beta ETS_{i(t/q)} + \lambda X_{i(t/q)} + \varepsilon_{i(t/q)} \\
 (5) \text{ SG\&A ratio}_{i(t/q)} &= \alpha + \beta ETS_{i(t/q)} + \lambda X_{i(t/q)} + \varepsilon_{i(t/q)}
 \end{aligned}$$

Economic impact is measured by estimating the effect of the EU ETS on stock price, revenues, COGS ratio, EBIT margin, and SG&A ratio. The ETS variable is a binary variable which takes the value of 1 for airlines in the treatment group once the event threshold has passed. Although aviation was included in the emissions trading scheme in 2012, we use 2013 as the threshold in our model since that was when airlines had to surrender their emission rights for the first time. At the date of inclusion in early 2012,

no actual requirements or mandatory costs were imposed that would directly affect the airlines, whereas actual costs would have been imposed by the time of surrendering EUAs in the beginning of 2013. Furthermore, as of the initial inclusion in 2012, all flights to and from the EEA were included in the EU ETS. In 2013, however, this was revised to only include flights within the EEA, hence drawing a clearer line between our treatment and control group. As such, we deem 2013 to be a more significant event and more suitable threshold for our analysis.

β is the effect of inclusion in the EU ETS on the dependent variable, which is what we're interested in estimating. X includes a set of control variables. The control variables include firm fixed effects, year fixed effects, country-year level local stock index and number of competitors, region-year level air traffic index and firm-year level total assets, leverage, and revenues. Z is identical to X except for the control variable for revenues which is excluded in Z as it is the dependent variable in that model. λ represents the betas for the control variables. α is the intercept and ε is the error term. All models were estimated using the full data set, as well as subsets of the dataset with public and private airlines separated.

3.3 Results and discussion

The main results of the difference-in-differences analysis are displayed in Table 2. The estimates for the ETS variable can be interpreted as the change in the dependent variable caused by the inclusion in the EU ETS. Although not shown in the table, all regressions include control variables as described in section 3.2.

Table 2: *Difference-in-differences analysis results*

DID MODEL	(1)	(2)	(3)	(4)	(5)
DEPENDENT VARIABLE	Stock Price	Revenues	COGS ratio	EBIT Margin	SG&A ratio
PANEL 1: Full sample					
ETS		-235.12* (127.05)	0.18 (0.25)	-0.14 (0.32)	0.04 (0.04)
Observations		786	723	780	683
R ²		0.9869	0.2288	0.1926	0.5614
R ² adj.		0.9839	0.0433	0.0048	0.4551
PANEL 2: Public Airlines					
ETS	-6.94 (15.45)	-80.78* (42.82)	0.03 (0.03)	0 (0.01)	-0.01 (0.05)
Observations	952	1178	1160	1178	986
R ²	0.6814	0.9814	0.5145	0.5012	0.1471
R ² adj.	0.6565	0.9799	0.4746	0.4609	0.0665
PANEL 3: Private Airlines					
ETS		-18.11 (57.04)	0.57 (0.49)	-0.49 (0.6)	0.11 (0.08)
Observations		440	377	434	358
R ²		0.9863	0.2428	0.2343	0.5212
R ² adj.		0.983	0.0446	0.0473	0.396

The table shows the regression of stock price (1), revenues (2), COGS ratio (3), EBIT margin (4) and SG&A ratio (5) on the ETS binary variable. Values in parentheses indicate the standard error of the estimate. The models were estimated for the full sample (panel 1), public airlines (panel 2), and private airlines (panel 3). Panel 2 uses quarterly data and Panel 1 and 3 use yearly data. ***p < 0.01, **p < 0.05, *p < 0.1.

The results show that the EU ETS had a negative impact on revenues and a positive impact on the COGS ratio, although these effects are only statistically significant at a 10% level, if at all significant. The lower revenue levels could be caused by airlines passing on the additional costs associated with the EU ETS to their customers to the extent that people choose other means of transport, thereby lowering the revenues for the airlines. The increased COGS could be explained by airlines treating the direct costs of the emission rights as COGS in their financial statements. Another explanation could be

that airlines that are included in the EU ETS are encouraged to reduce their emissions, for example by using fuel that is less harmful to the environment, thereby increasing their costs.

Although not statistically significant, the analysis also indicates that the ETS led to an increased SG&A ratio of 4% for the full sample, and 11% for private airlines. The increase might be a result of airlines reporting the direct costs of the EU ETS, that is acquiring EUAs and/or paying fines for exceeding the emission limits, as SG&A. However, if that was the case, we would expect to see a similar effect on public airlines, which is not observable. There is, of course, a possibility that private and public companies treat the expense differently in their financial statements. Perhaps a more plausible explanation for the effect is that it can be an administrative burden and cost for companies to manage emission rights, stay up to date on regulations, and report properly. Public firms are generally larger in size, have extensive administrative units and are used to report information to the public and government agencies. Therefore, the added administrative requirements for the EU ETS could be negligible. Some private firms, however, are smaller in size and are not as used to manage this kind of administrative tasks and the associated reporting. Therefore, the inclusion in the EU ETS might have led to a significant increase in administrative work and thus lead to higher SG&A costs. Furthermore, the EU ETS' potential effects on revenues, COGS and SG&A were not enough to cause any statistically significant effect the airlines' EBIT margins.

Finally, the results show no statistically significant effect of the inclusion in the EU ETS on stock prices. This suggests that investors believe that the ETS will not have a major effect on the airlines' financials and/or risk profile. Alternatively, the investors' expectations of the effects have already been accounted for in the stock price since the announcement to include airlines in the EU ETS which was made in 2008. Given that the actual effect did not differ enough from the initial expectation, stock prices would remain unchanged.

3.4 Robustness and sensitivity tests

Whereas the treatment group is geographically concentrated as all airlines are incorporated in the EEA, the control group consists of a geographically diverse group of airlines from countries all over the world. One could argue that it is likely that firms from the same part of the world would behave similarly to each other in certain regards. Adding a variable for region fixed effects would not make a difference as that is already covered by the firm fixed effects, however, there is still a risk that the broad diversity in the control group could cause heteroskedasticity. To mitigate this, we conduct a robustness test with clustered standard errors on the region level. We split the control group into seven regions as defined by The World Bank (The World Bank, 2020) and cluster the standard errors to create a more homoscedastic regression. Then, we conduct the same five regressions again and examine the results.

Table 3: *Difference-in-differences analysis with clustered standard errors results*

DID MODEL	(1)	(2)	(3)	(4)	(5)
DEPENDENT VARIABLE	Stock Price	Revenues	COGS ratio	EBIT Margin	SG&A ratio
PANEL 1: Full sample					
ETS		-235.12 (146.75)	0.18 (0.13)	-0.14 (0.15)	0.04* (0.02)
Observations		786	723	780	683
R ²		0.9869	0.2288	0.1926	0.5614
R ² adj.		0.9839	0.0433	0.0048	0.4551
PANEL 2: Public Airlines					
ETS	-6.94 (14.1475)	-80.78 (88.77)	0.03 (0.03)	0 (0.01)	-0.01 (0.01)
Observations	952	1178	1160	1178	986
R ²	0.6814	0.9814	0.5145	0.5012	0.1471
R ² adj.	0.6565	0.9799	0.4746	0.4609	0.0665
PANEL 3: Private Airlines					
ETS		-18.11 (56.06)	0.57 (0.36)	-0.49 (0.44)	0.11* (0.05)
Observations		440	377	434	358
R ²		0.9863	0.2428	0.2343	0.5212
R ² adj.		0.983	0.0446	0.0473	0.396

The same five analyses were conducted, this time with clustered standard errors. The table shows the regression of stock price (1), revenues (2), COGS ratio (3), EBIT margin (4), and SG&A ratio (5) on the ETS binary variable. Values in parentheses indicate the standard error of the estimate. The models were estimated for the full sample (panel 1), public airlines (panel 2), and private airlines (panel 3). Panel 2 uses quarterly data and Panel 1 and 3 use yearly data. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

As shown in table 3, the effect of the EU ETS on revenues is no longer statistically significant at a 10% level, suggesting that this effect does not exist. However, the effect on SG&A is now statistically significant at the 10% level. Although this is a weak statistical significance, our confidence in the existence of the effect is backed by the fact that multiple airlines have expressed concerns about the administrative burden of the EU ETS (see section 3.5).

Focusing solely on model (5) with SG&A ratio as the dependent variable we conduct a sensitivity analysis changing the timespan in which we observe the data. In addition to the original model, we use three variations of the model with different sample periods that start in either 2009 or 2010 and end in either 2015 or 2016. The main conclusion to be drawn from table 4 is that the model is sensitive to the sample period used. The significance level varies from 5% to not being significant at all, which is not reassuring regarding the robustness of the model. The effect of the EU ETS on private airlines is not statistically significant using any sample period other than the original period from 2010 to 2015. Earlier in this thesis, we ruled out any other sample period as to avoid the effects of the great recession and not to have a too long duration which increases the exposure to macroeconomic events that may wash out the effect of the EU ETS. Nonetheless, our model has shown to be highly sensitive to the sample period, lowering our confidence in the existence of the effect. Expanding on the potential explanation that the EU ETS leads to higher SG&A cost in private firms due to the large administrative burden, it is possible that this effect wears off over time as companies become accustomed to it, hence the lower significance levels when the sample period is extended to 2016. Because of this we remain cautiously optimistic regarding the existence of the effect on private airlines.

Table 4: Sensitivity analysis results

DID MODEL	(5)	(5)	(5)	(5)
DEPENDENT VARIABLE	SG&A ratio	SG&A ratio	SG&A ratio	SG&A ratio
PANEL 1: Full sample				
ETS	0.04* (0.02)	0.05** (0.02)	-1.13 (16.26)	3.03 (8.93)
Observations	683	798	785	900
R ²	0.5614	0.5807	0.1603	0.1578
R ² adj.	0.4551	0.4952	-0.0159	0.0051
PANEL 2: Public Airlines				
ETS	-0.01 (0.01)	-0.02 (0.02)	-0.02 (0.01)	-0.02 (0.02)
Observations	986	1185	1120	1319
R ²	0.1471	0.1544	0.1711	0.1777
R ² adj.	0.0665	0.084	0.0978	0.1123
PANEL 3: Private Airlines				
ETS	0.11* (0.05)	0.12 (0.06)	-6.43 (69.26)	5.62 (41.01)
Observations	358	413	415	470
R ²	0.5212	0.5359	0.1941	0.184
R ² adj.	0.396	0.4326	0.01	0.0213
First data year	2010	2010	2009	2009
Last data year	2015	2016	2015	2016
Clustered standard errors	YES	YES	YES	YES

The first column is the original model. Column 2-4 show variations of the original model using different time periods for the data observations. Values in parentheses indicate the standard error of the estimate. The models were estimated for the full sample (panel 1), public airlines (panel 2), and private airlines (panel 3). Panel 2 uses quarterly data and Panel 1 and 3 use yearly data. Note that a few outliers caused some betas to be extremely high. Excluding these outliers did not change the significance level of the results. ***p < 0.01, **p < 0.05, *p < 0.1.

3.5 Qualitative analysis using annual reports

Supplementary to the quantitative analysis using regressions on historical financial data, we provide another perspective on the research question by qualitatively analyzing the annual reports of European airlines. That is to say, we collected the annual reports of the European public airlines in our dataset and searched them for content about the European Emissions Trading Scheme.

We looked at reports for the years of 2010 to 2015 and thus covered the time before, after, and during the introduction of aviation to emissions trading. Our dataset contains 15 European public airlines. For two airlines there are no annual reports available for the sample period (Enter Air Sp. z o.o. & Wizz Air Holdings Plc). 67 of the 78 reviewed annual reports mentioned the EU ETS at least once. On average, an EU airline mentioned the ETS about five times in its annual report. Aegean Airlines and Norwegian Air Shuttle did not mention the regulation at all. The airline that talked most about the EU ETS was Deutsche Lufthansa. It mentioned the regulation an average of more than ten times per annual report.

A simple counting of how many times the EU ETS was mentioned in each annual report already indicates that airlines were most concerned about the regulation during the time of its introduction. Mentions of the EU ETS in annual reports increased by more than 60% in 2012, stayed high in 2013 (-6%), and decreased again significantly in 2014 (-29%). Those observations are relatable, since 2012 marked the year of the aviation industry's introduction to emissions trading and 2013 was the year when airlines had to surrender their allowances for the first time. The beginning of emissions trading was characterized by a high degree of uncertainty for European airlines. They did not yet know how the allowance allocation would work in the future, how carbon prices would develop, and if their internal working, control, and monitoring process would function as intended. The subsequent decline of mentions in annual reports corresponds to the relatively low-cost impact that airlines actually measured in the first two years of the systems operation.

Moving on to a more qualitative analysis of what airlines said about the EU ETS gives insights about their opinion regarding policy design as well as associated costs and

risks. In general, it can be said that almost all airlines acknowledged the importance of fighting against climate change and saving CO₂ emissions (Lufthansa, 2010).

The Lufthansa Group has set itself ambitious targets for climate and environmental responsibility. In 2008, it set up a strategic environmental programme, which provides for reductions in specific emissions, research into and promotion of alternative fuels and other topics. The programme is intended to help the Lufthansa Group make further progress towards protecting the climate and environment by 2020. Its key areas of actions are to reduce fuel consumption and emissions, active noise abatement, energy and resource management and investment in research. (Lufthansa, 2014)

Most annual reports dedicated a subsection to the company's environmental policies (see IAG (2015) among others). Many airlines, including IAG (2012) and Finnair (2011), also specifically stated that regulations are needed to decarbonize the sector and that emissions trading is the best and most efficient way to do that.

IAG is fully supportive of carbon trading being the most effective way to reduce aviation emissions. The long-term solution must be a global approach led by ICAO, with whom the industry must work closely. (IAG, 2013)

However, almost all airlines from our sample stated that they advocate a global emissions trading solution for the aviation industry instead of the EU ETS. easyJet was the only airline expressing support for aviation's entry in the EU ETS (easyJet, 2011) and described it as the best way for aviation to tackle climate change. The opponents of the EU ETS among European airlines declared that they fear a structural cost disadvantage compared to airlines not flying through European airspace. They argued that the regulation would negatively impact the European airline industry and cause distortions to international competitiveness. Instead of the EU ETS, many airlines argued in favor of a global aviation emissions trading system developed by the International Civil Aviation Organization (ICAO). Lufthansa (2010), Air Berlin (2013), Finnair (2011), IAG (2012) and SAS (2011) are among airlines proposing such a regulation.

Together with the entire air transport industry, Lufthansa continues to call for a global approach – and has already achieved some initial success. The International Civil Aviation Organization (ICAO) in collaboration with industry representatives was the first UN organization to adopt worldwide aspirational targets for reducing CO₂. (Lufthansa, 2010)

SAS supports the concept of a global solution for airline emissions rather than regional or local programs. (SAS, 2011)

Lobbying by airlines has been partly successful, as the EU in 2013 suspended flights that start or land outside the EEA from emissions trading to allow ICAO to develop a global system instead. The EU ETS however will stay in place, even after the ICAO ETS starts. Further criticism on the EU ETS has been targeted at the system's operating and reporting structure. For example, Lufthansa (2010) complained about a complex reporting structure in which 17 of the airline's subsidiaries that are affected by emissions trading have to report to seven different national authorities.

Whilst many airlines complained about the EU ETS on the one hand, they also described the actual economic consequence to be relatively low. Finnair for example faced direct EU ETS cost of EUR 1.5 million in 2012 and EUR 2.6 million in 2014 according to their annual reports (Finnair, 2012) & (2014). In 2014, these costs corresponded to only 0.14% of their total cost of goods sold. In comparison to fuel cost volatility, the financial consequences of the EU ETS were trivial according to Icelandair (2013).

However, while the consequences of the ETS compliance is economically trivial in comparison with the magnitude of fuel cost volatility, the emission allowances will not be imbedded into the fuel hedge strategies yet, but instead procured on a rolling 3-6 month basis in relation to fuel consumption. (Icelandair, 2013)

Having said that, the airline also said in its 2012 annual report that the additional EU ETS cost were passed to ticket prices and caused a drop in passengers (Icelandair, 2012). Some airlines explained that they seek to hedge their exposure to EU ETS cost through forward hedging instruments in addition to the freely allocated number of emission allowances (Air Berlin, 2013), (Icelandair, 2013) & (Ryanair, 2011).

4. Critical appraisal

We chose to conduct a difference-in-differences (DiD) analysis to estimate the economic effects of the EU ETS on the airline industry. The DiD method involves a comparison of a treatment group and a control group before and after a certain event to determine the effects of the event on the treatment group. For an effective analysis, the event (treatment) should be substantial and there should be clear definitions of the before and after periods, as well as clear definitions for the treatment and control group. In our analysis, the event and the definitions are not as clear as desired.

First, the significance of the event itself is questionable. When the airline industry was introduced in the EU ETS, most EUAs were allocated for free and those that had to be purchased were trading at historically low prices. Therefore, our analysis lacks a large shock that would trigger a change in the treatment group. Perhaps a more substantial shock would have been the sharp increase in EUA prices in 2021. Second, although we know the dates when the airline industry was first included in the EU ETS (2012) and when the airlines first had to surrender their EUAs (2013), it is not clear exactly when airlines would start incurring additional costs. Because of this, it is not possible to perfectly capture the period after the event. We use 2013 as a proxy for the timing of the event as that was when airlines first had the obligation to present EUAs corresponding to their emissions. Third, we were unable to perfectly separate airlines that were affected by the EU ETS and those that were not. If an airline was incorporated in an affected country (within the EEA) it would be included in our treatment group. However, country of incorporation is not a perfect proxy, because there are airlines that are incorporated outside of the EEA and operate routes within the EEA. Hence, we have failed to perfectly separate the treatment group and the control group. Last, the airline industry has got a few characteristics that make it less than ideal to analyze. The industry is concentrated with only a few large players dominating each market, creating an oligopolistic structure (Nava, et al., 2018) that limits competition through high barriers to entry. The low number of airlines leads to a low number of observations in our analysis, which might have a negative effect on the accuracy of the regression model. In conclusion, the overall econometric approach of our analysis is relatively weak.

5. Conclusion

The EU ETS had a positive environmental effect on the participating countries through lower carbon emissions. Moreover, the major concerns about its effect on financial performance proved to be fruitless as the actual effects ended up being minor. As the inclusion of the airline industry to the EU ETS was approaching in 2012, the economic effects were expected to remain modest, which has been confirmed by a few small-scale, local studies. In this thesis, we provide the first large-scale, ex-post investigation of the EU ETS' effect on the financial performance of the European airline industry.

We find that the EU ETS led to higher SG&A expenses among private airlines (weak statistical significance). This could be due to the increased administrative burden of managing emission rights, which multiple airlines have expressed concerns about. Further research is needed to fully understand the cause of this effect and if it can be mitigated. We find no significant impact of the EU ETS on airlines' stock price, revenues, costs, or profit, confirming that the effect on financial performance is limited.

From a policy perspective, our findings add important information to the discussion about the possibility of making the EU ETS more stringent. The scheme was introduced to reduce carbon emissions, which it has accomplished both in the airline industry and Europe as a whole. Our findings show that this has been achieved without hurting the profitability and competitiveness of airlines, suggesting that more stringent regulations could be a viable option to further mitigate greenhouse gas emissions. Further research is needed to understand how to adjust the EU ETS to improve its effectiveness against emissions without introducing negative effects on financial performance.

The scope of our analysis was limited to the inclusion in the EU ETS and did not consider the price of EUAs. The price was relatively stable and very low at around EUR 5 to EUR 15 per tonne of CO₂ equivalent during our sample period. However, in later years, especially with the start of phase IV in 2021, prices have increased substantially and peaked at around EUR 97 in early 2022. Since high EUA prices is a rather new phenomenon, further research is needed to understand the ecological and economical effects of the carbon price. However, the increase in prices coincided with the Covid-19

pandemic, making it difficult to do such an analysis at the moment. This is especially true for the airline industry which was significantly hurt by the pandemic.

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Appendix

Appendix 1: Qualitative Analysis using Annual Reports

The annual reports have been searched for the terms: “EU ETS”, “emissions trading” & “emission trading”. The results have been added up to the number of how many times the European Emissions Trading System was mentioned in the annual reports.

year	times mentioned in annual reports	% increase
2010	47	-
2011	56	19%
2012	90	61%
2013	85	-6%
2014	60	-29%
2015	53	-12%

