Taxing the skies

A study on the Swedish air passenger tax and its impact on the number of passengers

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Abstract:

The purpose of the thesis is to analyze the impact of the Swedish air passenger tax on the number of air passengers in Sweden. The tax was implemented in April 2018 with the aim to reduce air travel demand and decrease the aviation industry's greenhouse gas emissions. Since aviation emissions contribute significantly to climate change and are not adequately priced or accounted for, the tax serves as a corrective measure for these negative externalities. Using the difference-in-differences method and utilizing Denmark as a control group, this study evaluates the effect of the tax on the number of passengers in Sweden. The analysis covers the time period between 2016-2020 and shows a likely effect of the tax, leading to a reduction in the number of passengers traveling to and from Sweden.

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Table of Contents

1. Introduction

International aviation is the fastest-growing part of transportation, but also the most complex to govern because it falls outside the jurisdiction of a single country (International Transport Forum, 2021). Between the years 2009 and 2017, the aviation industry experienced great expansion, playing a critical role in economic progress in Europe. This growth resulted in improved connectivity and mobility for European citizens. However, in order to adjust with the economic expansion, the aviation sector had to undergo significant transformations, especially by increasing the frequency of direct flights connecting major cities worldwide. This adaptation has led to a rise in carbon dioxide emissions (Eurocontrol, 2020). Sweden has experienced a yearly increase of 3.6% in the number of flights by population (Larsson et al., 2018). The climate impact of the Swedish population's flying is approximately equal to that of car traffic, and the average annual aviation emissions per Swedish resident are about 1.1 tons of CO_2 equivalents, which is approximately five times higher than the global average (The Swedish Environmental Protection Agency, 2018).

In April 2018, the Swedish government introduced ticket tax as a policy instrument with the purpose to limit carbon-heavy consumption caused by air travel (Swedish Energy Agency, 2017). The aviation tax hence aims to make the aviation industry bear its climate costs while encouraging consumers to choose greener alternatives. This aligns with the government's goal of sustainable transportation provision and socio-economic efficiency (SOU, 2016).

Policy instruments, such as taxes, aim to achieve a desired outcome efficiently by ensuring that the resources allocated to achieve a certain goal result in an optimal balance where the incremental costs and incremental benefits are in equilibrium (Kolstad, 2011). In the transport industry, ticket taxes are commonly used since charging VAT on international flights or taxing kerosene would require renegotiations of international agreements (Sonnenschein & Smedby, 2019).

The purpose of this study is to examine how the implementation of the ticket tax has affected the number of Swedish travelers choosing to fly to domestic and international destinations. The topic of aviation tax is interesting and relevant as the increasing volume of air travel contributes significantly to negative climate impact, and different nations implement different guidelines to address this externality. Hence, our research question is: *How has the implementation of the Swedish aviation tax influenced the number of Swedish air passengers?*

The research question is answered by using a difference-in-differences method applied to time series data. The treated unit is Sweden, and the control unit is Denmark, a neighboring country that has not implemented an aviation tax. Data is collected for the two units, and three different regression analyses will be made to determine the influence of the Swedish aviation tax on passenger numbers in Sweden. The hypothesis of the study is as follows: *The Swedish aviation tax has a noticeable effect on the number of passengers in Sweden*.

2. Background

Sweden has a rich history of active involvement in environmental matters at the national level and acquires several environmental institutions. Sweden has also made substantial contributions to the international environmental field over the years (Christensen et al, 2013). The investigation into taxing air travel was initiated in 2015. The purpose was to achieve Sweden's and EU's climate goals. The investigation aimed to explore possible approaches for taxing air travel. Introducing a tax was a way of reducing the number of flights and thereby decreasing the environmental impact on climate change. The largest reduction in air travel was expected to occur in domestic flights, according to the investigation. Since the aviation tax is a specific tax that is being applied to each trip, the government views it as a way of encouraging consumers to take bigger responsibility for the negative environmental effects associated with air travel, by choosing greener alternatives (SOU 2016:83).

On the 1st of April 2018, the Swedish government established a tax on air travel. The aim was to encourage more sustainable forms of transportation and to reduce greenhouse gas emissions, since an aviation tax is efficient in reducing negative externalities that arise from the consumption of air travel (Perloff, 2014). The flight tax introduced for a domestic flight within Sweden was 60 SEK, and a flight to a destination outside of Europe incurred a tax of 400 SEK (Sonnenschein & Smedby, 2019). Air taxes similar to the ticket tax implemented in Sweden can also be found in other countries, like Germany. A study conducted by Falk and Hagsten (2019) has demonstrated the impact of such taxes on air travel, leading to a reduction in the number of flights within the country. In addition to influencing travel behavior, these taxes offer several positive effects as funds collected from aviation taxes can be allocated towards various public purposes. Governments can utilize these funds to support infrastructure development, invest in renewable energy projects, or address other societal needs. This way, the revenue generated from the taxes can contribute to broader sustainability initiatives and promote environmentally friendly practices (Transport & Environment, n.d). Implementing and managing a ticket tax imposes a relatively minimal administrative burden on both public administrations and airlines. As a result, the implementation of a ticket tax can be considered a relatively straightforward policy measure (Ricardo, 2021).

While implementing an aviation tax can contribute to positive environmental outcomes, it also introduces potential disturbances to market equilibrium (Kolstad, 2011). A tax affects costs, reduces profitability, and can cause a shift in consumer behavior, potentially disrupting the demand for air travel as well and creating an imbalance between supply and demand in the aviation market. It is important to note that the effectiveness of an aviation tax also relies on finding the optimal level, and setting the tax at an incorrect level can lead to unintended consequences (Ricardo, 2021). If the tax is too low, it may not effectively discourage air travel or provide sufficient incentive for the development of greener technologies. Conversely, if the tax is set too high, it could disproportionately burden the aviation industry, hindering its ability to invest in sustainable practices. It is also worth noting that market conditions play a significant role (Transport & Environment, n.d). However, this study will not focus on the optimal level of tax, but rather analyze whether there has been a change in demand as a result of a tax implementation.

Denmark has decided not to implement a special flight tax, unlike Norway and Sweden that have introduced such taxes. The Danish government believes that imposing an aviation tax would negatively impact the conditions and competitiveness of Danish aviation, leading to reduced connectivity. Instead, the government plans to adjust the regulatory model to allocate a larger portion of Copenhagen Airport's commercial revenue to cover air traffic costs (Ministry of transport, 2017). This adjustment aims to enhance national and international connectivity. Danish parties agreed to abolish passenger fees in 2007. The objective of this measure was to strengthen the framework for Danish airports, including regional airports, and potentially facilitate the establishment of more low-cost routes, thereby expanding the number of available departures and destinations (Ministry of Finance, 2006).

3. Theoretical framework

3.1 Externalities

An externality occurs when production or consumption affects a third party, without this being reflected in the market price. The externality is negative if the third party is negatively affected. When the externality is not included in the market price, the market will produce too many of the goods due to the price being too low. To be able to secure the total social cost, the cost of the negative externality needs to be added to the company's private marginal cost. If this is not done, there will be a market failure (Perloff, 2014). Negative externalities can be a source of economic inefficiencies as they are not adequately incorporated in market prices. Unnecessary social costs arise as a result of companies not considering the damage associated with negative externalities, such as the flight industry's failure to incorporate the costs associated with environmental damage. In the case of aviation, to correct an inefficient outcome and reduce externalities, firms must reduce their number of flights which can be achieved through a ticket tax (Pindyck, 2017). To ensure that externality costs are borne by passengers, aviation taxes are imposed on a society.

In theory, the air travel market without regulations can be equated to a perfectly competitive market, where equilibrium occurs when supply equals demand. This is illustrated in Figure 1 at point A. If negative externalities exist, they lead to market distortions. Since the negative externalities are not reflected in the ticket price, individuals and companies tend to overconsume the service. This means that the consumption of air travel is not at a socially optimal level (Perloff, 2014). The overconsumption is illustrated in the figure, at point B. We can observe that the optimal consumption at point B is lower than at point A. The marginal private cost curve, denoted as "MC_P" in the figure, represents the costs of additional flights. The marginal social cost curve, denoted as "MC_S", represents cost to society with each additional flight. "MC_G" represents the marginal cost of emissions. An equilibrium is reached when the demand curve equals private marginal costs, and this is where the number of flights reach an optimal level. The equilibrium levels are denoted by Q* and P*. However, the social cost of flying at the optimal level exceeds the benefits, which is illustrated by the triangle area between the marginal social cost curve and the marginal private cost curve. The triangle also embodies the welfare loss. To eliminate the welfare loss, an aviation tax is implemented which increases the private cost to a point where marginal social cost equals demand. By setting the tax equal to the harm, the socially optimal point is reached (Kolstad, 2011).

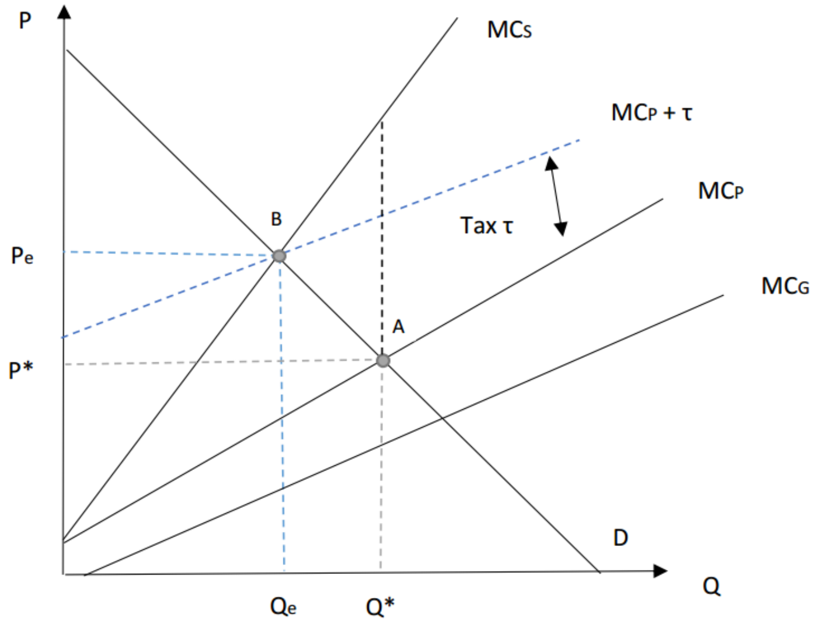


Figure 1. Negative externality and unit tax. Source: Perloff (2014).

The socially optimal production and consumption is calculated as follows (Perloff, 2014):

$MC_S = D$ when $MC_S = MC_P + MC_G$

The introduction of the air passenger tax in Sweden aims to internalize social costs by implementing a tax. The purpose is to address negative externalities that are not fully resolved by other policies. By raising the cost of air travel for passengers, the demand is expected to be reduced. The effect is however dependent on the elasticity of the supply- and demand curves. If the supply curve is elastic, airlines can pass a significant amount of the tax burden to the passengers which in turn decreases demand. If the supply curve is relatively inelastic, the tax will not be transferred to the passengers. This will result in the demand being unchanged. In that case, the tax will fail to achieve its purpose and effectively reduce the emissions caused by aviation (Keen & Strand, 2007).

3.2 Pigouvian fee

The idea of the Pigouvian tax, first introduced by Arthur C. Pigou in 1920, is a tax that can help create an efficient allocation and address a situation of market failure. When the marginal social cost is higher than the company's marginal cost, a tax should be introduced. This type of tax is today called a Pigouvian tax and is used for negative externalities (Kolstad, 2011). To be effective, the tax should equal the marginal cost of emissions at the socially optimal quantity $\boldsymbol{\tau}(Q) = MC_G$ where $\boldsymbol{\tau}(Q)$ denotes the unit tax. The private marginal cost after the introduction of the tax is illustrated in Figure 1, resulting in the firm's private marginal cost being equivalent to the social marginal cost. By setting the tax equal to the damage, the socially optimal point is reached (Perloff, 2014).

A Pigouvian tax is a mechanism for imposing charges, which can include taxes on emissions. The tax is a type of environmental levy that aims to transfer the societal cost of externalities to the consumer. The principle is that the tax is set to correspond to the optimal marginal cost, where the difference between the private cost for the user and the societal cost of the activity is imposed on the user as a tax (Kolstad, 2011). Although the Pigouvian tax is an efficient tool for imposing charges, the theory requires knowledge of marginal damage and elasticities to be able to compute the size of the tax. Accurate information about the marginal damage is crucial for setting the tax at an appropriate level that internalizes the external costs without creating excessive burden or distortion in the market. Regarding elasticities, policymakers need to understand the price elasticity of demand for the activity being taxed. This information helps determine how much the tax will affect the quantity demanded (Buchanan, 1969).

A significant amount of CO2 emissions, which stem from aviation, remains untaxed and unregulated, leading to negative externalities that adversely impact the climate (European Commission, 2021). As discussed earlier, implementing a tax can effectively mitigate the negative environmental effects of air travel. However, the Pigouvian tax does not vary based on the quantity of emissions generated by flights, thereby lacking the incentive for airlines to reduce their marginal emissions. Therefore, the primary objective is to reduce emissions by reducing demand (Wolde & Mulat, 2021).

4. Literature review

Borbely (2019) studies the effects of the German aviation tax on the number of passengers within German airports and nations located close to Germany. The researcher uses the synthetic control method. Contrary to difference-in-differences estimations, synthetic control estimates do not depend on the assumption of parallel trends between the treated and the control groups. The study finds that there is a decrease in the number of passengers for a majority of the German airports and passenger numbers decreased by barely two percent. Borbely (2019) also highlights another important finding: there is a substitution effect where the number of passengers within small airports is decreasing more than for bigger airports. The study concludes that a tax leads to a substitution effect rather than a remarkable effect on passenger numbers.

Falk & Hagsten (2019) also analyze the effects of taxes on the number of passengers in Germany and Austria. Unlike Borbely (2019), the researchers use a difference-in-difference method and find that the taxes implemented have negative effects in the short run. The year that the taxes were introduced, the passengers decreased by nine percent. In the year after, the number decreased by five percent. Another finding is that the regular airports are not as affected by the tax as the airports where low-cost airlines depart from.

Keen & Strand (2007) discuss two different variants of taxes. Firstly, tax on aviation fuel and secondly, tax on the final price of the airline ticket. The conclusion of the study is that there are valid reasons to introduce indirect taxes on air travel. The first variant, tax on fuel, will compensate for the negative externalities that are associated with air travel. A tax on tickets will generate more revenue for the government. The researchers explain that air travel taxes need to be coordinated to achieve significant results. The study proposes that an effective air travel tax therefore should be a combination of both a uniform tax on ticket prices and fuel tax.

Mayor and Toll (2010) evaluate what affects climate policies implemented by different European states have had on emissions from aviation. The researchers use a model of both international and domestic tourist numbers. The findings from the analysis are that the policies studied do not fully accomplish their purpose and in turn do not result in any significant reduction of emissions. They also find that the flight taxes implemented by the UK and Netherlands generate substitution effects. In the UK, the tax resulted in a decrease in the number of tourists travelling to the country and in turn, the tourists travelled to other destinations. The same effect could be seen in the case of the Netherlands. The tax resulted in an increase in prices for long-distance travel, while prices for short-distance travel decreased. As a consequence, there was a reduction in the number of long-distance journeys. The overall effect resulted in a substitution effect, where long-distance travel was substituted with short-distance travel. The researchers also discuss impacts of different taxes on travel to and from the United Kingdom. They find that boarding taxes are efficient in raising government revenue, but not effective in reducing carbon emissions. Contrary to the researcher's expectations, emissions are also expected to increase as a result of higher tax rates due to destination choice being determined by relative prices, and a tax raises the cost of flights to the nearby foreign countries more than those to the distant foreign countries. Mayor and Toll (2010) also find that an increase in aviation tax will result in a decrease of flights domestically, however flights globally increase by a larger percent, resulting in emission reduction not being accomplished.

Seetaram et al. (2014) study the Air Passenger Duty (APD) in the United Kingdom. APD is a levy imposed by the UK government on air travel departing from domestic airports. The purpose of the levy is to reduce the attractiveness of aviation through pricing. The study aims to assess the APD's impact on travel demand for ten different destinations. The researchers analyze the influence of the APD on the elasticity of air travel demand. The study reveals varying income elasticities, ranging from 0.36 to 4.11. This indicates that air travel was largely influenced by income levels. At the same time, price elasticities range from -0.05 to -2.02, which indicates that an increase in prices for foreign destinations has led to a decrease in demand for air travel. The analysis indicates that the APD had a decreasing effect on travel demand for five out of the ten destinations that were studied.

Ekeström and Lokrantz (2019) evaluate the aviation market during the six months with the aviation tax in Sweden compared to the previous years. The researchers find that international traffic to destinations outside Europe continues to follow the same trend as before the implementation of the tax. For travel within Europe, there is a trend break where the growth is not as robust as before. The researchers observed a decrease in domestic travel, which indicates that travelers are more price-sensitive when flying to a nearer destination. Ekeström and Lokrantz (2019) also find that the Swedish market experienced a decline before the introduction of the tax. They mean that this can be caused by natural fluctuations in the aviation market.

In summary, previous research has found that taxes on air travel have led to a decrease in the number of passengers. There are also substitution effects observed, where larger airports experience a smaller decrease in passengers compared to smaller airports. The introduction of aviation taxes has also resulted in a change in destination preferences, where travelers now choose alternative locations and exhibit higher price sensitivity, especially towards shorter trips.

5. Method

5.1 The difference-in-difference method

To estimate the effects of the policy, we chose the Difference-in-Differences, DiD, approach for our research paper. This method is a statistical technique used to estimate the causal effect of a policy intervention by comparing changes in outcomes over time between a treatment group and a control group. The causal relationship of interest is whether the aviation tax has led to fewer individuals choosing to fly. Formally, the DiD estimate of policy impact is calculated as the difference between the changes in the outcome variable over time in the treatment group and the control group, as follows (Lechner, 2011):

$$DiD = (Y^{treated,\ after} - Y^{treated,\ before}) - (Y^{control,\ after} - Y^{control,\ before}).$$

A further function fulfilled by the Difference-in-Differences estimator is that it considers whether there are remaining differences between the treatment and control groups, both before and after the treatment, since they are not randomized. The estimator is calculated by estimating the average change in the treatment group minus the average change in the control group (Stock & Watson, 2015):

$$DiD = (Y^{treatment,\ after} - Y^{treatment,\ before}) - Y^{control,\ after} - Y^{control,\ before}) = \Delta Y^{treatment} - \Delta Y^{control}$$

$\Delta Y^{treatment}$ represents the average change in the outcome variable, Y, within the treatment group. $\Delta Y^{control}$ represents the average change in Y within the control group (Stock & Watson, 2015). In that way, the DiD variable serves as an estimator that represents the causal effect of the aviation tax.

By studying the change in outcome, the Difference-in-Differences estimator removes the initial values of the treatment group and the control group, which can have an impact on results and may differ at the beginning since the groups are not entirely similar (Stock & Watson, 2015). The difference-in-differences method is a popular approach for evaluating the causal effects of a treatment on an outcome variable, however the method is subject to several potential sources of bias and limitations and relies on several key assumptions. The first assumption is the "parallel trends" assumption. Shown in figure 2, this assumption posits that the outcome variable of interest in the treated group would have followed a similar time trend as the outcome variable in the control group if the treated group had not received the treatment. This assumption is supported by analyzing data from pre-treatment periods and demonstrating a consistent pattern between the treated and control groups (Vandenberghe, 2019).

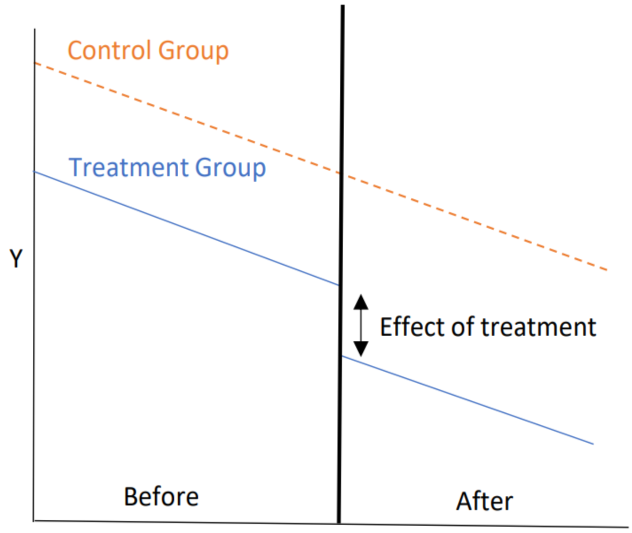


Figure 2. Control group and treatment group before and after treatment. Source: Vandenberghe (2019).

An approach to provide support for the parallel trends assumption is to conduct a placebo regression. In these regressions, the difference-in-differences method is applied exclusively to observations from the pre-treatment period. By excluding observations from the post-treatment period, the estimation of any significant treatment effect should be eliminated. If a sufficient number of observations is available, running a placebo regression by considering only pre-treatment data can be beneficial (Fredriksson & de Oliveira, 2021). Therefore, a placebo regression will be included in the analysis.

Another critical assumption is the absence of spillover effects. Spillover effects can lead to biased treatment effect estimates. Therefore, the treatment effect should be confined to the treated group and not affect the control group, and vice versa (Wardani et al, 2022). The concern is that the composition of the treatment and control groups may change if travelers opt to fly from neighboring countries to avoid the aviation tax in Sweden. This could introduce bias into the results as these travelers would not be included in the domestic flight data. Additionally, the control variables used in the analysis should be exogenous, meaning they are not influenced by the treatment. If the treatment is endogenous, meaning correlated with other factors that affect the outcome variable, then the DiD estimates will be biased. Although there are a number of potential biases and limitations with the DiD approach, it is crucial to remember that these criticisms do not necessarily imply that the method is wrong or ineffective. Rather, they highlight the importance of carefully assessing the assumptions and limitations of the DiD method in each particular application (Fredriksson & de Oliveira, 2021).

The ideal method for identifying the causal relationship of a policy intervention such as flight tax, would be to conduct a randomized controlled experiment in the country of interest, by randomly assigning a flight tax to some individuals, and not to others, at a given time in Sweden. As randomness determines which individuals have to pay the flight tax or not, the proportion of air passengers will not be related to other factors that may affect the outcome. Randomness thus has the same effect as holding everything else constant (Angrist & Pischke, 2015). However, it is problematic to conduct a randomized experiment in practice. There are, among other things, ethical, political, and democratic arguments against this type of study. To circumvent this problem and still create a situation that resembles a randomized experiment, quasi-experiments are used, a so-called natural experiment. This type of investigation is possible to carry out when, for example, a policy change naturally causes one group to receive treatment and another group not to receive treatment (Stock & Watson, 2015).

5.2 Specifications

We estimate two models: one without any control variables and one with several control variables.

(1) $Log\ Passengers_{it} = \beta_{0i} + \beta_1 Log\ Passengers_{it-1} + \beta_2 Time_t + \beta_3 Treatment_i + Season_t + \varepsilon_{it}$

$$(2)\ Log\ Passengers_{it} = \beta_0 + \beta_1 LogPassengers_{it-1} + \beta_2 LogDGDP_t + \beta_3 LogDCPI_t + \beta_4 Log\ DOilprice_t + \beta_5 Time_t + \beta_6 Treatment_i + Season_t + \varepsilon_{it}$$

In the regression, the outcome variable is Passengers. The intercept term is represented by β0. The variable $Passengers_{it-1}$ represents the total number of individuals traveling by air within the countries studied during a month, one month prior to the observation of the dependent variable. This variable is included due to empirical evidence that passenger numbers in different time periods tend to exhibit similarities to their corresponding periods in previous years. Thus, a lagged value of the variable is used.

This study uses a fixed effect modeling approach, which means that our model accounts for factors that remain constant over time and may affect the outcome that is being studied. Using fixed effects helps isolate the causal effect of the variable of interest which also is controlling for unobserved heterogeneity. The utilization of fixed effects in our panel data analysis is anticipated to enhance the reliability and validity of our findings (Hill et al., 2020).

GDP represents the rate of change in the natural logarithm of the real gross domestic product between successive time periods. When the natural logarithm of GDP is taken, it allows for a transformation that can stabilize the variance and provide a linearization effect on the data. By taking the first difference, the percentage change in GDP from one period to the next is captured. GDP has been chosen as a control variable because it captures demand for travel. The GDP is collected on a quarterly basis and is interpolated.

The first difference of CPI represents the percentage change in the natural logarithm of the Consumer Price Index between successive time periods. The variable measures demand and costs in general. A positive first difference indicates an increase in CPI, implying inflation. On the other hand, a negative first difference suggests a decrease in CPI, which indicates deflation. When considering changes in the CPI, we can assess the broader inflationary environment. Therefore, this variable will be included in the regression. The CPI is collected on a monthly basis.

Oil price represents the rate of change in the natural logarithm of the oil price between time periods. Since there are fluctuations in the data, the first difference is taken in order to remove trends and make the data stationary. Oil price is included in the analysis because it has a direct influence on the operational costs and prices of airlines. Including an oil price variable helps to capture the potential cost burden faced by airlines because of fluctuations in oil prices. This could in turn influence ticket prices.

Time is a variable that represents the temporal dimension in the dataset. The variable captures the sequential ordering of observations and allows for the analysis of data over time. Since the data consists of monthly data and 50 months each are observed, the time variable takes values from 1-50 for Sweden, and 1-50 for Denmark.

Treatment is a dummy variable that determines whether an observation belongs within the time period before or after the implementation of the Swedish air passenger tax. The dummy variable is 0 for Denmark. Since the Swedish aviation tax was introduced in April 2018, the dummy variable is assigned a value of zero for Sweden if an observation belongs to a time period before April 2018. For periods after April 2018, the dummy variable is assigned a value of one for Sweden. Since we are using fixed effects, the coefficient of the treatment variable represents the difference-in-difference approach.

Season is a dummy variable that measures seasonal patterns and fluctuations in time series data. Since monthly data is analyzed, 11 seasonal dummies are created to represent the 11 months (one month is excluded). Each seasonal dummy variable takes a value of 1 if the observation corresponds to the respective season and 0 otherwise. The seasonal dummies are included in the regression model for it to be possible to estimate and control for the average effect of each season of the dependent variable. This allows us to isolate the impact of the seasons separately from other factors. Since we are analyzing air passengers, these vary during time periods of the year. For example, more people are travelling during the summer compared to other seasons.

6. Data

To evaluate the impact of the tax, we will be using data on arrivals and departures from Sweden, the treatment group, and Denmark, the control group. The number of passengers is collected from all existing airports in the country and is provided by Eurostat. Along with national statistical authorities, Eurostat develops standardized classifications for European statistics using information gathered by national statistical agencies in accordance with harmonized criteria (Eurostat, n.d.). The data from Eurostat includes the number of passengers boarding, the total number of flights, and the number of available seats. The information gathered is time series data for two different countries, that when combined becomes panel data, a sort of dataset that includes observations on numerous variables for the same group of units, such as people, nations, or businesses over time. In this case, the data includes observations for EU member states across time. Each nation can be thought of as a cross-sectional entity, and every period of time can be thought of as a panel or long-term dimension. The data can be used for research in the field of air transportation as it facilitates the analysis of trends and patterns over time and across multiple nations (Stock & Watson, 2008).

Apart from data on the number of passengers flying to and from Sweden's airports, we have also collected data on GDP that will be included in the analysis. The data is collected from Eurostat on a quarterly basis. Oil prices are collected from the International Energy Agency, IEA, for both countries. The data is measured on a monthly basis. Lastly, we will use data on monthly CPI which is collected from Statistics Sweden. Monthly CPI for Denmark is collected from Statistics Denmark.

The time period analyzed is from January 2016 until March 2020. This is because we want to exclude any effects that could have been caused by Covid-19. Both nations have the same number of observations which makes this dataset balanced panel data. The number of observations per nation is 50 and thus there are 100 observations in total. Because both nations consist of the same number of observations, the data is balanced panel data.

Table 1. Descriptive statistics for Sweden before tax

Variable	Obs	Mean	Std. Dev.	Min	Max
Passengers	28	3711922	444494	2863738	4292423
GDP	28	118365.10	3654.37	111312	122485
CPI	28	320.21	3.89	313	327
Oil price	28	1.62	0.11	1.45	1.83

Table 2. Descriptive statistics for Denmark before tax

Variable	Obs	Mean	Std. Dev.	Min	Max
Passengers	28	2712856	437307	2064353	3531785
GDP	28	72562.96	1747.67	69514	75013
CPI	28	100.90	0.88	99	102
Oil price	28	1.66	0.11	1.49	1.88

Table 3. Descriptive statistics for Sweden after tax

Variable	Obs	Mean	Std. Dev.	Min	Max
Passengers	22	3734366	511461.20	2888456	4341019
GDP	22	118357.60	2221.65	111861	120960
CPI	22	332.72	2.83	328	338
Oil price	22	1.69	0.07	1.60	1.81

Table 4. Descriptive statistics for Denmark after tax

Variable	Obs	Mean	Std. Dev.	Min	Max
Passengers	22	2912129	508546.60	2233010	3686607
GDP	22	77072.27	1101.09	75013	79035
CPI	22	102.86	0.47	102	104
Oil price	22	1.82	0.07	1.7	1.95

Table 1 and 2 represent the descriptive statistics for the countries Sweden and Denmark before the tax was implemented in Sweden. Table 3 and 4 represent the descriptive statistics for the two countries after the implementation of the tax. Comparing the two, it is noticeable that the variable "Passengers" displays both higher minimum and maximum values after the tax was implemented. This applies for both Sweden and Denmark. Additionally, the mean is also showing an increase. Similar trends can be observed for the rest of the variables, except for the GDP and oil price in the case of Sweden, where the max values decreased after the tax was implemented.

6.1 Trends between treatment- and control group

The figures presented below show the natural logarithmic form of the total number of individuals traveling by air for Sweden and Denmark. By observing the pre-treatment period, it is noticeable that Sweden and Denmark follow a similar trend. Analysis of the first figure shows an upward trend in air travel for Sweden until 2018. After that, the passenger numbers slightly decreased. In contrast, the number of passengers for Denmark are constantly increasing. Consequently, the disparity between the nations' air travel figures exhibits a diminishing trend, which is shown in figure 4. The figure demonstrates that the disparity between the number of passengers in the two countries initially grew until 2018, followed by a continuous decline. This indicates a decrease in passenger numbers for Sweden, an increase in passenger number for Denmark, or a combination of both. By observing figure number 3, we can conclude that the observed trend indeed is a combination of these factors. The time period is of particular interest, since the decrease of the Swedish number of passengers in year 2018 aligns with the tax that was introduced the same year in April.

Figure 3. Passenger numbers (logarithm) in Sweden and Denmark during the sampling period

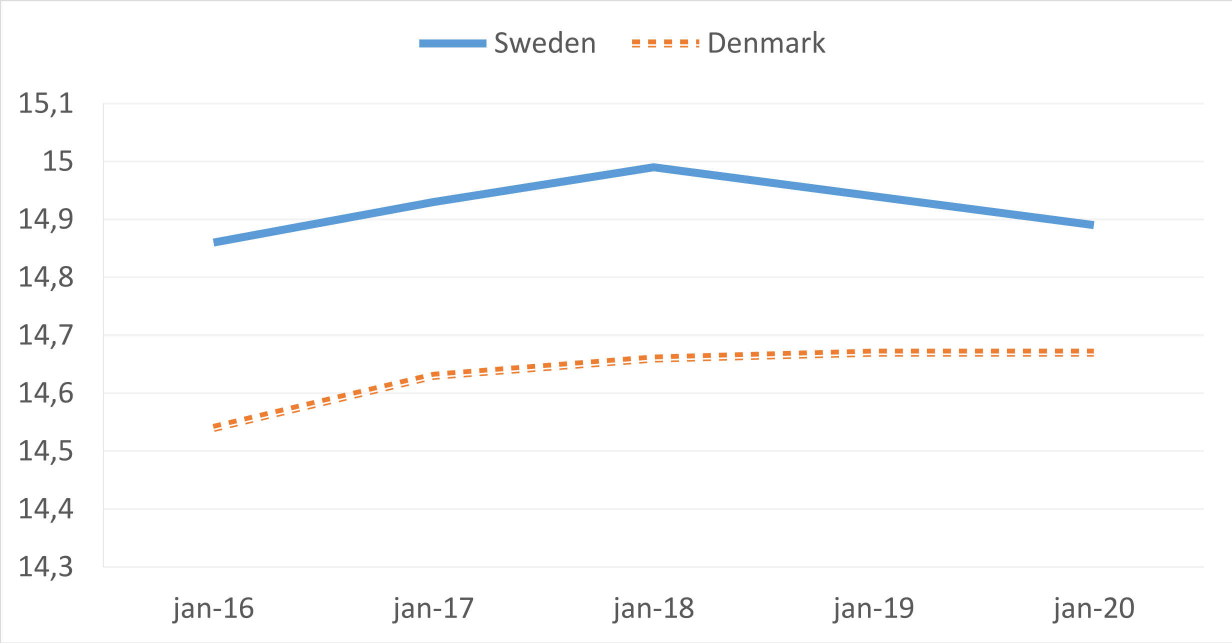
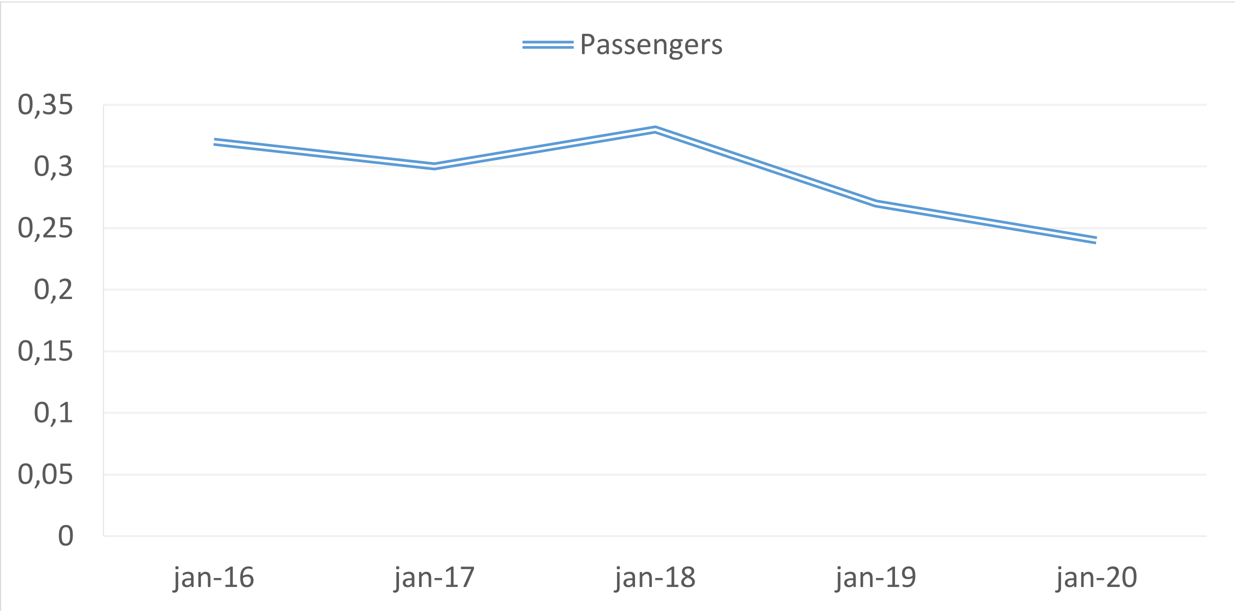


Figure 4. Difference in Passenger numbers (logarithm) between Sweden and Denmark



Figures 6 and 7 illustrate the fluctuations in GDP data and oil price data before taking the first difference; thus, the first difference is used to make the data stationary.

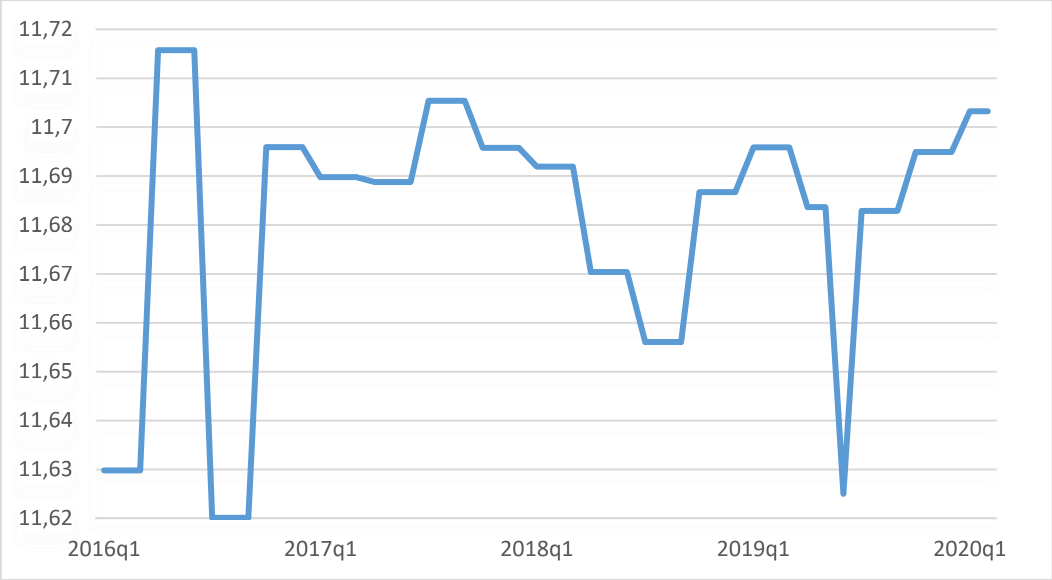


Figure 5. Fluctuations in GDP data for Sweden before taking the first difference (logarithm). Source: Eurostat

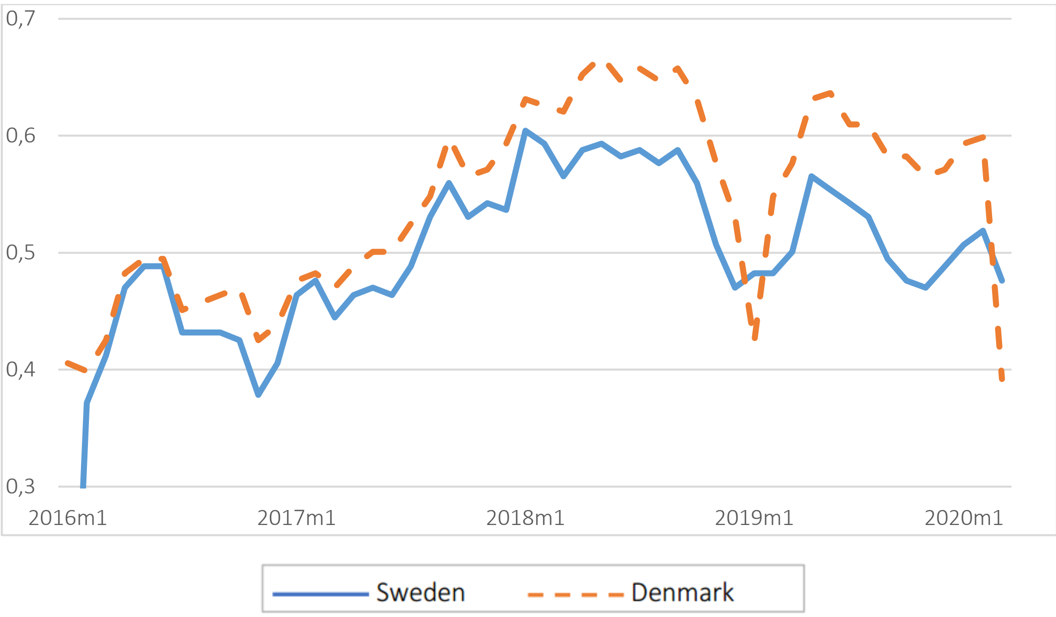


Figure 6. Fluctuations in oil price data before taking the first difference (logarithm). Source: IEA

7. Results

7.1 Placebo regression

Table 5 presents the results from running a placebo regression on time periods before the implementation of the Swedish aviation tax. The regression includes monthly observations from January 2016 until March 2018 and consists of 55 observations. Since the treatment variable is 0 for all observations in the pre-treatment period, a treatment is created for one specific month of each year studied. There are three treatments per regression, with a one-year gap. The coefficients of the treatment variable range from negative ten percent to negative 17 percent. The p-value indicates that the coefficients are far from statistically significant. These findings support the parallel trends assumption and confirms the presence of a shared trend between Sweden and Denmark in the pre-treatment period.

Table 5. Observations in the pre-treatment period.

VARIABLES	***Log Passengers$_{it}$***	***Log Passengers$_{it}$***	***Log Passengers$_{it}$***
Log Passengers (it-1)	*0.364** (0.115)*	*0.365** (0.113)*	*0.366** (0.116)*
Time	*0.024*** (0.003)*	*0.022*** (0.003)*	*0.023*** (0.003)*
Treatment	*-0.179 (0.076)*	*-0.109 (0.087)*	*-0.139 (0.067)*
Constant	*20.060*** (1.703)*	*20.116*** (1.678)*	*20.101*** (1.721)*
Observations	*55*	*55*	*55*
R-squared	*0.499*	*0.514*	*0.499*

Note: Standard error within parentheses. Eleven seasonal dummies are included in the regression.

***p<0.01, **p<0.05, *p<0.1

7.2 Regression without control variables

Based on the information provided, Table 6 presents the results of the first specification, which is a simple model without any control variables. The coefficient of the treatment variable is negative, indicating a decrease of approximately 0.9 percent. However, it is mentioned that this coefficient is not statistically significant, meaning that the observed decrease could be due to random chance rather than a true effect of the tax.

Table 6. Regression without the use of control variables

VARIABLES	***Log Passengers$_{it}$***	
Log Passengers (it-1)	*0.365****	*(0.101)*
Time	*0.011**	*(0.009)*
Treatment	*-0.009*	*(0.045)*
Constant	*13.086****	*(1.367)*
Observations	*99*	
R-squared	*0.677*	

Note: Standard error within parentheses. Eleven seasonal dummies are included in the regression.
***p<0.01, **p<0.05, *p<0.1

The R^2 value of 0.677 indicates that about 68 percent of the variance in passenger numbers is explained by the variables included in this simple model. This suggests that there are other factors or variables not considered in the model that may have a significant influence on passenger numbers. Given the limitations of the simple model and the lack of statistical significance for the treatment variable, it is not possible to draw conclusions about the effect of the tax on passenger numbers based solely on this analysis. The model is deemed insufficient for explaining and understanding the variations in passenger numbers, as about 32 percent of the total variance remains unexplained. Further analysis with more comprehensive models and additional control variables is necessary to obtain a clearer understanding of the relationship between the tax and passenger numbers.

7.3 Regression with control variables

Table 7 presents the results obtained from running the second specification, which incorporates various control variables. The inclusion of these control variables is expected to explain the variance of passenger numbers to a much greater extent, given that the control variables are the correct ones determining passenger numbers.

Table 7. Regression with the use of control variables

VARIABLES	***Log Passengers$_{it}$***
Log Passengers (it-1)	*0.429** (0.091)*
Log DGDP	*0.057*** (0.087)*
Log DCPI	*-0.032* (0.035)*
Log DOilprice	*-0.195* (0.079)*
Time	*0.002* (0.012)*
Treatment	*-0.041** (0.014)*
Constant	*8.620*** (1.022)*
Observations	*99*
R-squared	*0.973*

Note: Standard error within parentheses. Eleven seasonal dummies are included in the regression.

***p<0.01, **p<0.05, *p<0.1

Upon analyzing the treatment variable in this specification, we observe that the coefficient is negative. This estimate suggests that there has been a reduction of approximately four percent in passenger numbers. Importantly, the coefficient is statistically significant at the five percent level. This is reinforcing the notion that, according to this specification, the treatment variable and consequently the tax has had a negative impact on passenger numbers. In this case, if the coefficient is statistically significant at the five percent level, it means that the p-value associated with the coefficient is less than 0.05. This indicates that the probability of observing a coefficient as extreme as the one estimated, assuming the null hypothesis is true, is less than five percent. Therefore, we have evidence to reject the null hypothesis and conclude that the coefficient is statistically different from zero.

We can examine the R^2 value, which measures the proportion of the total variance in passenger numbers explained by this specification. A high R-squared value typically refers to a situation where a large proportion of the variability in the dependent variable is explained by the independent variables in a regression model (Behrman et al, 1983). The R-squared value of 0.973 indicates that this specification accounts for approximately 97 percent of the total variance. In other words, our R-squared provides an indication the model fitting the data and a large proportion of the variability can be attributed to the predictors. However, even if the R-squared is high, it does not address potential biases or violations of the underlying assumptions. Therefore, it is benefical to carefully evaluate these assumptions.

Based on the analysis conducted, it is estimated that the lagged variable of passenger numbers from one year earlier has the largest impact among all the coefficients and stands out significantly. Furthermore, the coefficient of Log dGDP is positive and statistically significant at the one percent level. This implies that as GDP increases by one percent, passenger numbers are estimated to increase by approximatley 0.057 percent, since both variables are logged. The coefficent of Log DCPI is negative and statistically significant at the ten percent level. If the first difference of the Consumer Price Index increases, then this can signify higher inflation and have a negative impact on the number of passengers. The coefficient of Log DOilprice is negative and statistically significant at the ten percent level, meaning that an increase in the price of oil decreases the number of passengers. This finding suggests that the price of oil plays a significant role in influencing passenger demand for air travel.

A noticable change between table 6 and 7 is that the treatment variable becomes significant. By studying this, we observe that oil price and GDP play a crucial role. When excluding both of these control variables, the treatment variable becomes insignificant. When including both of these control variables, the treatment variable becomes significant. We do not observe the same effect when excluding CPI as a control variable.

8. Discussion

According to economic theory (Keen & Strand, 2007), the implementation of a tax results in reduced consumption of the taxed product, and this outcome aligns with the findings of the study. The impact of the tax on passenger demand is influenced by the elasticity of the supply and demand curves, as highlighted by Keen and Strand (2007). However, since the study did not include data on elasticity, it is not possible to determine the precise extent to which the tax affected passenger demand. Therefore, statements regarding the tax's impact on passenger demand cannot be made based on the available data in this study. Perloff (2014) highlights another perspective. He argues that because the negative externalities associated with air travel are not accounted for in ticket prices, both individuals and companies tend to overconsume this service. This study and results alone may not adequately address the question of whether air travel consumption is at an optimal level from a societal standpoint. To assess the social and environmental impacts of the taxed activity, data on externalities and associated costs are required. For example, in the case of a carbon tax, data on greenhouse gas emissions or pollution levels can be necessary to evaluate the tax's effectiveness in reducing negative externalities. Due to time constraints and limited data availability, we were unable to incorporate this data into our study.

The implementation of the tax has influenced consumer behavior and resulted in a decrease in the number of flight passengers, aligning with Kolstad's (2011) principles on externalities. By imposing the tax, the aim was to internalize external costs and discourage excessive consumption, which our findings support. This suggests that the tax has effectively reduced consumption levels, bringing it closer to a socially optimal level.

Consistent with previous research, Falk and Hagsten (2019) found a nine percent decrease in passenger numbers initially, followed by a five percent decrease the following year. Our study corroborates these findings, showing an overall effect of a seven percent reduction in passenger numbers. These results align with Keen & Strand's (2007) conclusions, which emphasized the valid reasons for implementing an air travel tax. Similarly, Mayor and Toll (2010) discovered a negative relationship between the number of passengers and aviation tax, observing a substitution effect where long-distance travel was replaced by short-distance travel. While our study did not include data to study these types of substitution effects, it still supports the understanding that a tax on air travel leads to a decrease in the number of people choosing to travel by flight.

The treatment variable, representing the Swedish air passenger tax, has a negative effect on passenger numbers according to this model. Without including control variables, the coefficient is not statistically significant, limiting the ability to draw conclusions about the tax's impact. However, when the control variables are included, the variable is statistically significant, which indicates that the aviation tax has a negative impact on the number of passengers, whereas the number decreases by about four percent.

To achieve further reductions in air traffic, it may be necessary to significantly increase the tax or implement other policies addressing air travel and emissions. The analysis would also benefit from including additional variables and employing more comprehensive models to gain a better understanding of air travel dynamics, such as including elasticities on price. As mentioned by Keen & Strand (2007), the effect of the tax however is dependent partly on the elasticity of the demand. Hence to conclude whether the tax will be transferred to the passengers and achieve its purpose by being set at an optimal level, would require data on demand elasticity which is not part of this study due to time constraint and limited availability. In this study, it could only be concluded that the tax indeed does have an impact on demand, however it could not be concluded whether the tax was set at an optimal level. The results within the study depend on price elasticity, however it would be beneficial to include exactly how high these price elasticities are. If the price elasticities were high, this would further support the argument that flight tax reduces demand. Demand elasticity refers to the responsiveness of the quantity demanded to change in price. In the context of aviation taxes, understanding the demand elasticity of air travel is crucial for assessing the impact of the tax on passenger behavior. Higher demand elasticity implies that passengers are more sensitive to price changes, and thus the tax may have a larger effect on reducing air travel demand. Using econometric techniques to estimate the price elasticity of demand for air travel would benefit the study though providing insights into the sensitivity of passengers to changes in prices due to the tax (Seetaram et al, 2014).

The parallel trends assumption states there is no treatment effect in the treatment group before the treatment has been administered. But there are cases where the parallel trends assumption is violated. Violations of the parallel trends assumption can occur when there are behavioral changes in the treatment group before the actual treatment is administered. These changes in behavior or anticipation of the treatment can lead to deviations from parallel trends between the treatment and control groups. If individuals in the treatment group are aware of an upcoming treatment or intervention, they might modify their behavior in anticipation of its effects (Holger & Schuman, 2020). Including oil prices as an independent variable in the regression can potentially help address the violation of parallel trends caused by external shocks or events. Oil prices are often considered a relevant factor affecting the aviation industry, as they influence fuel costs, which can impact airlines' operations, ticket prices, and overall performance. By including oil prices as an independent variable in the regression model, we are accounting for the potential influence of this external factor on the outcome variable of interest. This can help control the effects of oil price fluctuations that may affect both the treatment and control group (Yun & Yoon, 2019). Also, by observing figure 3 and 4 and running a Placebo regression, we can conclude that Sweden and Denmark indeed share a common trend before treatment. This results in the parallel trend assumption being supported. Upon analyzing the results and especially the treatment coefficient, we can conclude that Sweden and Denmark shared a common trend before treatment.

Another limitation within the study is that the concept of flight shame was not included in the analysis. Flight shame refers to a growing social phenomenon where individuals feel guilty or concerned about the environmental impact of air travel. This sentiment can influence consumer behavior and potentially affect demand for air travel. If flight shame becomes more prevalent, it can interact with the aviation tax, leading to greater responsiveness in demand and potentially amplifying the impact of the tax on air travel (Chiambarreto et al, 2021). When utilizing the DiD method, it is beneficial to consider how flight shame may influence the treatment group, those subjected to the tax, differently compared to the control group, those not subjected to the tax. If flight shame is more pronounced in the treatment group, it can contribute to a steeper decline in air travel demand in response to the tax. Gathering data on airfare prices and the quantity of air travel (e.g., passenger miles, number of flights) for both the treatment and control groups before and after the tax implementation is a way to address these factors in a DiD analysis of aviation tax impact (Seetaram et al, 2014). The concept of flight shame could also impact the parallel trends assumption. If flight shame is more dominant in one country compared to the other, trends could differ between the two countries since a rise in the importance of flight shame could potentially lead to a decrease in demand for air travel. Although our study did not consider the effects of the growing importance of flight shame, our results did not differ significantly from previous research conducted outside of the scope of aviation tax. This suggests that aviation tax may not have had a significant impact on our results.

It is crucial to identify an appropriate control group when using a difference-in-differences method. Spillover effects occurring between the control group and the treatment group can lead to the parallel trends assumptions being violated. Consequently, using two neighboring countries in the analysis could have resulted in the results being biased. A decrease in the number of passengers in Sweden and an increase in the number of passengers in Denmark, could be explained by Swedish passengers flying from a Danish airport instead to avoid the aviation tax. To enhance the robustness of the estimations, one approach would have been to include more control groups and run the regressions again.

9. Conclusions

In conclusion, our study has analyzed the impact of the Swedish aviation tax, introduced in 2018, on the number of passengers flying to and from Sweden. The study has demonstrated a noticeable reduction in passenger numbers, where this reduction amounted to a significant extent of about four percent. Based on previous research, studies on air passenger taxes have observed similar effects, where decreasing passenger volumes have been noted. By running a placebo regression and analyzing figure 3 and figure 4, the parallel trends assumption could be supported. The figures showed a reduction in passenger numbers for Sweden after January 2018. These figures, along with the results obtained from running multiple regressions, support the findings of previous research.

There could be potential spill-over effects in the study. The findings presented in this study could arise when passengers choose to travel from neighboring countries that have not implemented such taxes. For instance, a person living in a Swedish town nearby Denmark may opt to fly from Denmark, a country that have not imposed aviation tax, instead of flying from Sweden. This could be an explanation for the findings in the study. In that case, the Swedish aviation tax has not fulfilled its purpose. Since this study did not control for spillover effects, further research could control for any potential spillover effects between the countries that are being analyzed. The analysis could benefit further by analyzing both price- and demand elasticities and the growing impact of flight shame. In this way, the results would be more robust when investigating short-run impacts of the aviation tax.

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Appendix

Seasonal dummies for regression with and without control variables.

VARIABLES	***(1) Log Passengers$_{it}$***	***(2) Log Passengers$_{it}$***
Sesd2	*0.020*** (0.051)*	*0.022*** (0.059)*
Sesd3	*0.217*** (0.055)*	*0.210*** (0.058)*
Sesd4	*0.244*** (0.056)*	*0.257*** (0.058)*
Sesd5	*0.391*** (0.058)*	*0.395*** (0.059)*
Sesd6	*0.476*** (0.060)*	*0.476*** (0.063)*
Sesd7	*0.531*** (0.060)*	*0.531*** (0.063)*
Sesd8	*0.505*** (0.062)*	*0.051*** (0.064)*
Sesd9	*0.463*** (0.060)*	*0.471*** (0.060)*
Sesd10	*0.404*** (0.057)*	*0.384*** (0.064)*
Sesd11	*0.286** (0.056)*	*0.267** (0.062)*
Sesd12	*0.206** (0.055)*	*0.207** (0.060)*
Observations	*55*	*99*
R-squared	*0.677*	*0.973*

Note: Standard error within parentheses.

***p<0.01, **p<0.05, *p<0.1