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Do the aviation taxes in Norway and Sweden decrease passenger numbers?

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Title: Do the aviation taxes in Norway and Sweden decrease passenger numbers?	
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Abstract: Norway implemented an aviation tax on departing air travel passengers in 2016. Sweden did the same in the year 2018. This thesis investigates effects of the aviation taxes on total passenger numbers, as well as the possibility that the effect is greater on low-cost flights in the low-cost segment. The analysis includes the years 2011-2019 and 129 airports. I perform dynamic difference-in-differences regression analyses and find that the aviation taxes in Norway and Sweden did not have a significant impact on overall passenger numbers. The effect was not significant for airports catering to the low-cost segment either. When performing the regressions exclusively for domestic air travel, the results were significant. For Sweden, this is the case when studying domestic air travel from airports that have a low-cost presence. The tax appears to have reduced domestic travel from these airports by over 10%. For Norway, the effect is present when studying air travel from all airports. The Norwegian aviation tax appears to reduce domestic air travel by 24%. However, as the overall passenger numbers are not decreased as a consequence of the aviation taxes, the taxes fail as an environmental tax. I recommend further research on the impact of aviation taxes with more detailed data on airfare and the destination of air travellers.	
Key words: Aviation tax, Pigouvian tax, Difference-in-differences, Panel data, Dynamic, Carbon tax, Passenger numbers, Tourism	
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1. Introduction

Avoiding a 2ºC increase in global temperature is one of the main goals in the fight against climate change. A key factor for success is cutting carbon dioxide emissions. (Bows-Larkin, Mander, Traut, Anderson, & Wood, 2010) Aviation contributes to a relatively large degree to these emissions, being responsible for about 12% of global transportation-related carbon dioxide emissions with only 3% of the global fossil fuel consumption. (Simone, Stettler, & Barrett, 2013).

Climate change awareness has been accompanied by increased environmental legislation (Kumar, Ugirashebuja, Carnwath, Tamminen, & Boyd, 2019). Among the most discussed pieces of legislation in Sweden was the aviation tax implemented in April 2018. The tax is applied to all airline passengers departing Swedish airports with some exceptions. Another Nordic country, Norway, implemented an aviation tax in June 2016. Both taxes are designed to make air transport bear a larger part of the costs caused by air transport emissions. (Andersson & Falck, 2017) In this thesis I study the impact of these two taxes on airline passenger volume using a difference-in-differences method with fixed effects. As a note, Norway adjusted their tax in April 2019 to closer match the aviation tax in Sweden. However, this tax will not be included in the analysis as it is too recent.

1.1 Research objective & hypotheses

The objective of this thesis is to study if the aviation taxes in Sweden and Norway have impacted passenger numbers. I am using a dynamic difference-in-differences method with fixed effects and airport-level data in line with what Falk and Hagsten (2019) established. My contribution is applying robust statistical methods in analysing the impact of these aviation taxes in the Nordic countries. I am not studying the elasticity of demand or supply. This thesis' methods differ slightly from Falk and Hagsten (2019): The analysis is completed with monthly seasonally adjusted data, instead of yearly data. I also utilize conventional fixed effects regressions, instead of Falk and Hagsten's choice of a fixed effects quasi maximum likelihood estimator (QML-FE).

The Nordic countries are more isolated than Central Europe so the potential for isolating the effect of the aviation tax could be greater, as travelling to a neighbouring country to fly from there is harder. This thesis can provide relevant insight to decision-makers in the Nordic countries on the impact of the aviation taxes. The statistical methods in use theoretically allow drawing causal links specifically for the Nordic countries. This is especially useful for Finnish decision-makers as a citizens' initiative calling for an aviation tax has reached the required number of signatures to reach the Finnish parliament (Jääskeläinen & Kilpinen, 2019). This thesis is therefore a small contribution to the economics papers helping fight climate change.

Based on previous research I have formed the following hypotheses:

1. *The aviation taxes in Sweden and Norway have reduced passenger numbers at a significant level only at airports dominated by low-cost airlines.*
2. *The aviation taxes in Sweden and Norway have not reduced passenger numbers at a significant level when accounting for all airports.*

These hypotheses would be partially in accordance with the findings of Falk and Hagsten (2019) studying Germany and Austria. However, my hypothesis predicts the taxes will not have a significant effect, with the exception of airports dominated by low-cost airlines. Fichert, Forsyth and Niemer (2014) claim that the low-cost segment of air travel is more sensitive to price increases due to a lower number of business travellers and a higher increase in percentage terms.

The third hypothesis is the null hypothesis:

3. *The aviation taxes in Sweden and Norway have not had a significant impact on passenger numbers regardless of airport characteristics.*

This would be in line with the findings of Seetaram, Song and Page in the United Kingdom. (Seetaram, Song, & Page, 2014)

1.2 Overview of passenger air transport in Norway and Sweden 2010-2019

Norway implemented a flat rate aviation tax on all departing passengers in June 2016. In 2018 Sweden implemented a similar tax. In an effort to make the tax reflect airline emissions, they designed the tax to have three rates roughly dependant on flight distance. One year later Norway copied the design of the Swedish aviation tax, although only utilising two different amounts. In tables 1.1 and 1.2 the timelines of the aviation taxes in Norway and Sweden are displayed.

Table 1.1 Norwegian aviation tax rates 2010-2019, departing passengers.

	All departures	Destination country in Europe	Destination country outside Europe
– 5/2016	-	-	-
6/2016 – 12/2016	80 NOK	-	-
2017	82 NOK	-	-
2018	83 NOK	-	-
1/2019 – 3/2019	84 NOK	-	-
4/2019 – 12/2019	-	75 NOK	200 NOK

Table 1.2 Swedish aviation tax rates 2010-2019, departing passengers.

	Annex 1: Destination country in Europe	Annex 2: Select destinations close to Europe	Other countries
– 3/2018	-	-	-
4/2018 – 12/2018	60 SEK	250 SEK	400 SEK
2019	61 SEK	255 SEK	416 SEK

1.3 Arguments behind aviation taxes

There are several arguments for implementing a specific tax on air travel, as air travel generally has an advantageous position from a tax standpoint. For example, air travel is generally exempt from VAT. In some countries such as Germany there is VAT on domestic air travel, however, this is not the case in all countries. Another benefit for the aviation sector is the fact that air fuel, kerosene, is exempt from tax globally. (Fichert et al., 2014) One could make the argument that air travel has unfair tax advantages.

2. Theoretical background

2.1 Negative externalities

An aviation tax is essentially a tax on a negative externality. A negative externality is a cost imposed on a third party not included in the original transaction. There are two types of negative externalities: Consumption externalities, such as the negative impact of passive smoking. Production externalities, such as the pollution of a chemical factory in a river. A negative externality can cause a loss in efficiency in the economy. If companies do not consider the negative externalities of their production, the economy will suffer.

An example of a negative production externality causing economic loss is the chemical factory mentioned earlier. In fig. 1 the production decision of the company can be seen. In this model we assume pollution is strictly tied to production levels. The company is maximising their profit by producing where the marginal cost MC equals the marginal revenue (price P in this case) the level q_1. However, as the company produces more it also pollutes more, the marginal external cost MEC. In this model MEC directly translates to environmental damage. From the viewpoint of society, the company is overproducing, and the optimal level is q^* where the marginal social cost MSC equals marginal revenue. The marginal social cost is the marginal cost and the marginal external cost added together. (Pindyck et al., 2009)

In fig. 2 the example of a polluting company is extended to the whole chemical industry. Where: MC = the supply curve of the chemical industry, MEC = aggregate marginal environmental cost, MSC = marginal social cost of all companies in the chemical industry. Here we can see that the price P_1 is not optimal due to not accounting for the marginal social cost. Fig. 2 displays in the area highlighted in yellow the cost of the negative externality. Moving from the production level that maximises profit, Q_1, to the one maximising marginal social cost reduces chemical company profits and consumers of chemicals have to pay higher prices. This is offset by the fact that the environment was harmed less leaving society better off by the amount in the highlighted triangle in Fig. 2. (Pindyck et al., 2009)

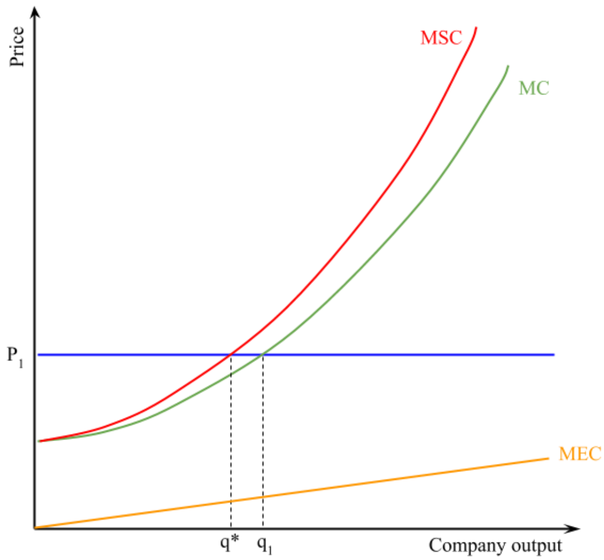

Figure 1 Simple model of a chemical company production decision. MSC = marginal social cost, MC = marginal cost, MEC = marginal external cost, P_1 = price of steel. (self-drawn graph, based on Pindyck et al., 2009)

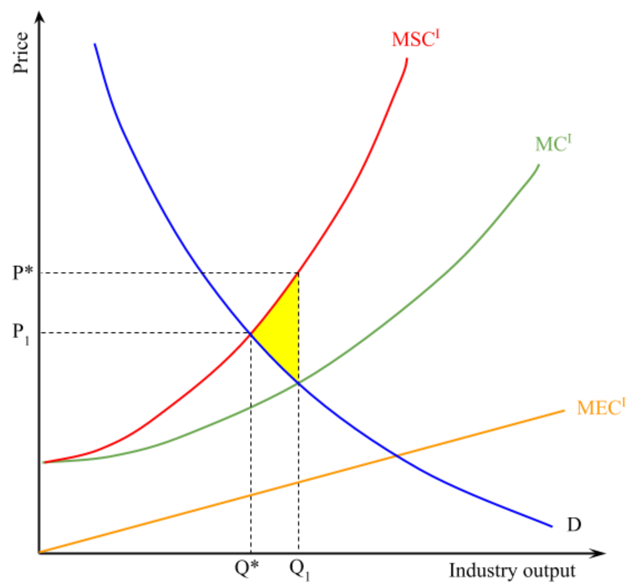

Figure 2 Simplified model for the chemical market assuming a negative externality (pollution) and assuming all companies behave as illustrated in Fig.1. (self-drawn graph, based on Pindyck et al., 2009)

Air traffic pollution is a textbook example of a negative externality. In countries with no aviation tax or cap and trade system, airlines bear hardly any of the cost for the pollution they cause. The fuel used by airplanes, kerosene, is globally exempt from tax. This is also the case with flights in the European Union. (Council Directive, 2003/96/EC) However, the European Economic Area does have a cap and trade system in place for aviation emissions.

2.1.1 Tax theory on negative externalities

There are several methods governments can utilise in fighting negative externalities. I will present the two most prominent alternatives, one type already in use in certain countries in Europe and one in the whole European Economic Area:

In his book The Economics of Welfare (1920) A. Pigou presents way to combat negative externalities. Now known as a Pigouvian tax, the tax targets negative externalities through taxing the market activity leading to the externalities. The goal of a tax is to adjust a sub-optimal market outcome. The size of the Pigouvian tax is adjusted to be equal to the social cost of the negative externalities. (Pigou, 1920) Aviation taxes, which are a type of carbon tax, are an example of Pigouvian taxes. The challenge in implementing a Pigouvian tax is calculating the social cost of the pollution.

Another method of controlling negative externalities, specifically pollution, is a so called "Cap and Trade" emissions trading system. There are several systems of this kind in place, but they all operate on the same basic principle; a cap is set on the maximum amount of emissions allowed during a time period. Subsequently rights to pollute are allocated or auctioned off to the market participants in the industries under the respective emissions trading schemes. (Council directive, 2003/87/EC)

The current system in place in the EU, Norway, Iceland, and Liechtenstein is known as the European Union Emission Trading Scheme, and since 2012 aviation emissions are also included. This means that the aviation sector in the countries of interest for this study is already part of a cap and trade system. The original plan was for the system to apply to all flights to and from the European Economic Area. However, the scheme only includes flights inside the EEA, because of resistance from the United States and China. (EU Regulation 2017/2392)

The general consensus among economists is that a carbon tax is the best alternative in the fight against climate change. United States economists believe in the tax so strongly that a joint statement of over 3500 economists, including 27 Nobel Laureate Economists, was published in the Wall Street Journal advocating for carbon taxes. (Climate Leadership Council, 2019)

2.1.2 Goals of a tax on a negative externality

Reducing the harmful effects of the negative externality is commonly the main goal of a negative externality. This is common for taxes such as the alcohol tax in many countries, meant to reduce consumption. A secondary goal of a Pigouvian tax is revenue for the state. Depending on the elasticity of the tax both goals of the tax can be achieved. If the product being taxed is inelastic, the harmful effects of the tax will not be reduced. This appears to be the case for the aviation taxes in Norway and Sweden. However, if the product being taxed is elastic, taxing it would reduce the harmful effects of the externality. One could say that the goal of a negative externality tax is to destroy its tax base.

2.2 Elasticity and Deadweight loss

2.2.1 Elasticity

Elasticity measures how a change in one variable proportionally changes another. For example, how a change in the price of air travel impacts passenger numbers. This will be discussed in the following chapter. In equation (1) the formula for the x-elasticity of y can be seen.

$$\varepsilon = \frac{\partial y/y}{\partial x/x} \tag{1}$$

Rewriting this into a formula for the price elasticity of a quantity demanded or supplied yields (2):

$$\varepsilon = \frac{\partial Q/Q}{\partial P/P} \tag{2}$$

An elasticity of $\varepsilon > 1$ means the price elasticity is elastic, $\varepsilon < 1$ means it is inelastic, whereas $\varepsilon = 1$ is neutral or unit elastic.

Brons, Pels, Nijkamp and Rietveld (2002) completed a meta-analysis of 37 studies on the price elasticity of air travel. They claim the price elasticity of air travel is directly related to the number of substitutes available, such as alternative modes of transport. Other factors such as geography, the country's wealth and population can affect the elasticity as well. Brons et al. also note that for leisure travel, different routes may be substitutes for each other, i.e. Mallorca and Cyprus for a Mediterranean vacation. The result of the meta-analysis was a mean price elasticity of -1.146 and the estimate had a standard deviation of 0.619 (Brons et al., 2002). This would indicate that an increase in price would result in a proportionally larger decrease in demand. Gallet and Doucouliagos (2014) completed a similar meta-analysis and estimated the price elasticity of air travel to be -1.186. However, they emphasised the unique circumstances of different air travel routes would cause this estimate to vary greatly.

In a more recent study, Sainz-González, Núnez-Sánchez and Coto-Millán (2011) studied the impact of airport fees on airfares for the leisure market in Spain. They found the price elasticity of demand to be between -1.4 and -0.98, which they claim is consistent with Gillen, Morrison & Stewart (2003) (as cited in Sainz-González et al., 2011).

In 1976, Jung and Fujii studied the price elasticity of demand of air travel in select cities in the United States, focusing on the difference of long-haul and short-haul routes. Their findings put the median elasticity of demand at -2.737, with a 95 percent confidence interval of -1.776 to -3.150. However, the study only looked at routes under 500 miles (804 km) so no conclusions can be drawn for longer routes. Fichert et al. (2014) claim the elasticity of air travel varies between 0.3, for long-haul business travel to 1.5 for short-haul private travel.

2.2.2 Tax incidence

Tax incidence indicates whether the consumer or producer bears the economic cost of a tax (not to be confused with statutory incidence, who legally pays the tax). The elasticity of demand and supply determine the tax incidence. In a situation with perfectly inelastic demand the consumer bears the entire cost of the tax. With perfectly elastic demand the producer bears the entire cost of the tax. Concerning supply, if it is perfectly inelastic, the producer bears the entire cost of the tax. If it is perfectly elastic, the consumer bears the entire cost of the tax. (Kotlikoff & Summers, 1987) (Fullerton & Metcalf, 2002)

Studying the tax incidence of passenger air transport, the burden of the tax or fees appears to be placed completely on the consumer; Sainz-González et al. (2011) studied the impact of airport fees on airfares and tax incidence for the leisure market in Spain. They found that airlines transfer all airport fees (taxes) onto the passengers.

Huang and Kanafani (2010) estimated airport tax incidence in the United States between 1993-1995. The results for nonstop flights were in line with Sainz-González et al. (2011), the entire tax burden is shifted onto the consumer. For nonstop flights, the price increase for the consumers was actually higher than the tax, a so called overshift. However, for connecting flights the airlines seemed to bear the full cost of the tax. This can be due to the design of the specific tax punishing connecting flights.

2.2.3 Deadweight loss

Deadweight loss comes from the loss of economic efficiency when there is not a free market equilibrium for a particular market. This is illustrated in figure 3. Should the government implement a tax on a free market the economic efficiency lost is the wedge-shaped area between Q_1 and Q_2 in fig. 3. This area is known as a tax wedge and describes the deadweight loss from a tax. Specifically, it is the difference between the equilibrium price and quantity and the price and quantity arising in a taxed market. Different taxes impact the size of deadweight loss in different ways. (Krugman, Wells, & Graddy, 2007)

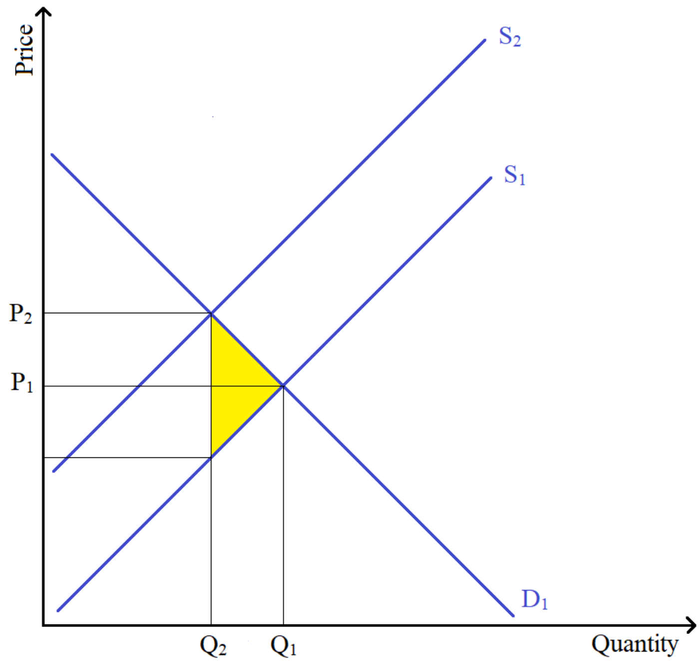

Figure 3 Deadweight loss of a market with a tax in place.

When implementing a tax or other control scheme, such as cap and trade, for addressing negative externalities, it is inevitable that there will be deadweight loss. However, the lost economic efficiency is not the only factor at play: Theoretically the tax could reduce the quantity of product traded, e.g. airline tickets, which in turn would result in less pollution. With pollution being a negative externality, this would fulfil the goal of a Pigouvian tax. However, if demand is inelastic the Pigouvian tax may not impact the amount of airline passengers. An example of this can be seen in figure 4. (Krugman et al., 2007)

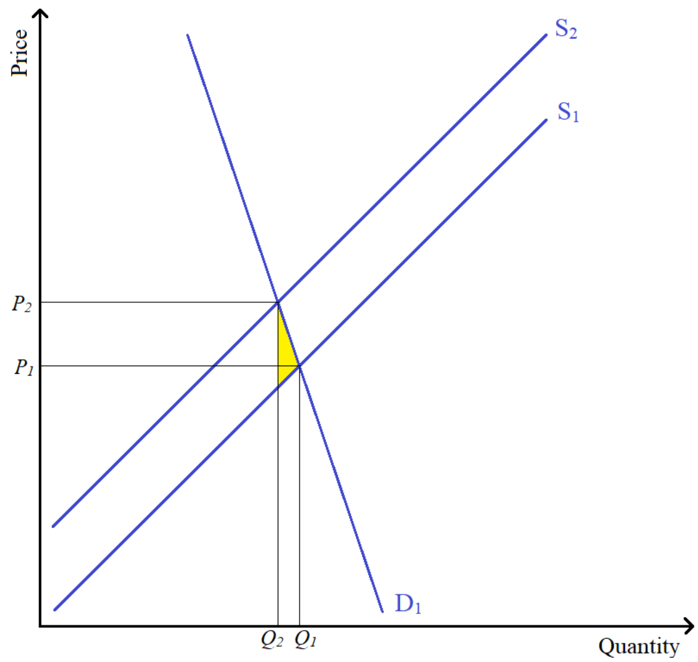

Figure 4 Deadweight loss on inelastic market with a tax in place.

2.3 Substitutes for air travel

When conducting an analysis on how a tax affects a mode of transport it is important to control for substitutes. For short to medium distances, the substitutes for air travel are trains, ferries, buses and cars. For countries with greater access to alternative modes of transport the effect of an aviation tax on passenger numbers can be greater, as there is more competition. However, for longer distances air travel is often the only realistic option.

Sainz-González et al. (2011) found that air travel on the Spanish mainland, in comparison to air travel to islands, was more competitive. They speculate this is because of a lack of substitutes to air travel for the island routes.

3. Previous research

3.1 Air traffic pollution and climate change

The pollution from air traffic contributes disproportionately to climate change, in relation to other sources of pollution. Combating climate change has, trough many international agreements, become part of the agenda of many governments around the world. For many countries, part of this agenda is reducing passenger air travel.

3.2 Research on the impact of aviation taxes on passenger numbers

There are previous papers on the effect of aviation taxes on air transport passenger numbers. The results from many of them have been conflicting. Areas that are relatively isolated geographically appear to have more inelastic demand of air transport. Mayor and Tol (2007) studied the impact of the aviation tax in the United Kingdom on passenger numbers and carbon dioxide emissions. They evaluated different policy proposals using different elasticity levels. Mayor and Tol estimated the aviation tax in the UK had not significantly impacted passenger numbers in the UK and claim it has not been an effective policy instrument in fighting climate change. They suggest a more aggressive tax if a significant effect on passenger numbers is desired. (Mayor & Tol, 2007) Seetram, Song and Page (2014) studied the UK aviation tax seven years later. They utilised an autoregressive distributed lag model to estimate the elasticities of income, price and the aviation tax. The study came to similar results as Mayor and Tol in 2007, estimating that tax had only a marginal impact. The econometric model used was a regression model studying tourist flows by air from the UK, using a log-linear to facilitate the interpretation of elasticities. The explanatory variables used were an aggregate income variable for the UK, a relative price variable adjusted for exchange rates, a variable for the tax, seasonal dummy variables, and dummy variables for extraordinary events such as the SARS outbreak. (Seetaram et al., 2014)

This thesis is based on the paper by Falk & Hagsten (2019) in the International Journal of Tourism Research: *Short run impact of the flight departure tax on air travel*. Falk &

Hagsten study the impact of an aviation tax in Germany and Austria on passenger numbers.

The method used is a dynamic panel difference-in-differences model and passenger data from 310 European airports. Since a difference-in-differences method assumes both the treatment group and the control group have a common trend before the treatment, the authors exclude airports close to the German and Austrian border from the control group. The main contribution of the paper is that it is the first quantitative analysis where airports are separated into two categories: regular airports and airports primarily trafficked by low cost airlines. Falk & Hagsten (2019) found that implementing a flight departure tax resulted in reduced passenger numbers, by 9% the year of implementation, and by 5% the year following. This change was primarily due to reduced traffic at airports where low-cost airlines were dominant. The main constraint of this paper is that the effects in the medium and long term cannot be predicted without detailed data on alternative transport modes (substitutes). They also suggest recreating this study with the aviation taxes implemented recently in Norway and Sweden due to their relative geographic isolation. (Falk & Hagsten, 2019)

3.3 Options for aviation tax design

Fichert et al. (2014) present the two main categories of tax commonly used should a country decide to implement an aviation tax. The first being VAT: Value added tax can easily be applied for domestic flights, however, it causes some problems with international flights. There is no clear system for which country has jurisdiction in certain situations. For example, how should the cost of a round-trip ticket be divided? The cost varies depending on several factors and cannot be easily divided in half. For this reason, VAT is generally not used for international flights.

The second tax category is a passenger volume tax. This type of tax is easier to enforce as it can simply be charged for every departing passenger in a country, avoiding jurisdictional complications. There are three main types of passenger volume tax designs:

1. A flat rate for all departing passengers, no matter the destination, like the aviation tax in Norway in 2016.

2. Different rates depending on distance or by destination country i.e. the Swedish aviation tax design.
3. Different rates depending on the type of ticket. For example, the aviation tax in France is higher for business class tickets than for economy tickets. (Fichert et al., 2014)

3.4 Possible limits on the effectiveness of an aviation tax

Fichert, Forsyth and Niemeier discussed the limits of the effectiveness of aviation taxes in their paper in 2014. One such example is elasticity: The elasticity of air travel can vary significantly depending on trip type. In previous literature the consensus appears to be that low-cost (leisure) air travel has a high price elasticity, while business travel is quite inelastic. A flat rate aviation tax is regressive, as the effect is greater proportionally for lower priced tickets. This leads to the effect being larger for low-cost air travel.

Fichert et al. (2014) bring an important point on the possible limitations of a tax on air travel: Capacity constraints can have a significant effect, many airports are operating at maximum capacity. Hypothetically the passenger capacity limit of the airport could be smaller than the monopoly quantity, if the airport had unlimited capacity. This would mean that the airport and airlines are collecting scarcity rents and a tax would only serve to convert some of these rents into tax revenue, with sales volume and prices remaining unchanged. (Fichert et al., 2014)

An aviation tax with several tiers based on distance has a possible loophole for long-haul passengers. A passenger could fly to a nearby airport outside the country and with a separate ticket complete the journey. However, Fichert et al. (2014) found no evidence of this while studying the German aviation tax. (Fichert et al., 2014)

Another possible limit on the effectiveness of an aviation tax is tax perception. There is evidence people do not make rational decisions when it comes to consuming, most famously by Tversky and Kahneman (1974) . This could impact the validity of the estimate.

4. Method and data

To analyse if the aviation taxes in Norway and Sweden decreased passenger numbers, I perform an econometric analysis. The analysis has three stages: Firstly, identifying a general effect of the aviation taxes. Secondly, identifying if airports dominated by low-cost airlines are particularly affected. The included variables are motivated by the theory and previous research presented in chapters two and three. To examine if domestic air travel is particularly affected by the tax, separate regressions for foreign and domestic air travel are also included. The data used for analysis is a panel data set compiled from, among other sources, national statistics agencies in Nordic countries and from the nationally owned airport companies in Nordic countries. In this chapter I present the econometric methods and the sources of the data.

4.1 Data

The data used for passenger numbers at airports in the Nordic countries is monthly data from the years 2010-2019. The time period was chosen for data availability reasons. It is a strongly balanced panel of all commercial airports in Norway, Sweden, Finland and Denmark, 129 airports in total. The passenger numbers for Finland are from Finavia, for Sweden from Transportstyrelsen, for Norway from Statistics Norway, and for Denmark from Danish Transport, Construction and Housing Authority. The passenger numbers I will analyse are departing commercial passengers, excluding transfer passengers and children under the age of two. The method used is a dynamic difference-in-differences analysis with monthly fixed effects and airport fixed effects.

4.1.1 Air transport passenger numbers

Norway: Statistics Norway is the national statistical institute of Norway. The data retrieved from this source are passenger numbers for international and domestic flights departing Norway for the years 2010-2019, on a monthly basis (Statistics Norway, 2020). Sweden: The Swedish transportation provided monthly data on departing passenger numbers from Swedish airports. (Transportstyrelsen, 2020) Finland: Finavia is a publicly owned limited company responsible for development and maintenance of Finland's airport network. The data retrieved from Finavia are monthly departing passenger numbers from Finnish airports from the years 2010-2019. (Finavia, 2020) Denmark: The Danish Authority on transport, construction and housing provided data on monthly departing passenger numbers from Danish airports, the years 2010-2019. (Trafik- Bygge- og Boligstyrelsen, 2020)

4.1.2 Price indices and GDP per capita

Eurostat: A Directorate-General of the European Commission, Eurostat is responsible for statistical information in the EU. From Eurostat the data retrieved are the price indices for the consumer prices of accommodation and flight tickets. (Eurostat, 2020a) (Eurostat, 2020b)

International Monetary Fund: The data on GDP per capita for the years 2010–2019 is retrieved from the IMF Database. Data for the year 2019 is an estimate, as definite numbers are not available at the time of writing. (International Monetary Fund, 2019)

4.2 Variables

The data set is comprised of variables on passenger numbers, economic factors, as well as specific adjustment variables. The main dependent variable is the natural logarithm of the total number of passengers departing an airport: *ln(p_total)*. However, I will also conduct the same regressions with domestic passengers only and international passengers only. The variables are described more in detail below:

4.2.1 Dependent variables

ln(p_total): The total number of passengers departing from an airport, *ln(p_total)* is the main dependent variable. The variable excludes infants under two years old, as well as passengers on layover. This is the data available from the selected countries and fits well as these exclusions apply to the taxes in place in Norway and Sweden as well.

Using the logarithm of a variable is advised if the variable has a right skew, that is if the mean is larger than the median. I use the logarithm to ease the interpretation as well and to conform to the norm for studying passenger numbers.

ln(p_domestic): Additional variable from the same data as *ln(p_total)*, containing only domestic departing passengers.

ln(p_international): Additional variable from the same data as *ln(p_total)*, containing only international departing passengers.

4.2.2 Independent variables

sweden: Dummy variable where 1 = airport located in Sweden and 0 = airport located outside Sweden.

aftertax2018: Dummy variable where 1 = after the month of implementation of the Swedish aviation tax in April 2019.

*sweden*aftertax2018*: Difference-in-differences variable signifying the treatment group: Swedish airports, after the tax was implemented.

*norway*aftertax2016*: Difference-in-differences variable signifying the treatment group: Norwegian airports, after the tax was implemented.

ln(gdp_cap): GDP per capita for the different countries in logarithmic form. This variable functions as a control for income elasticity. Using the logarithmic form of GDP is consistent with previous research into aviation taxes (Falk & Hagsten, 2019) (Seetaram et al., 2014).

hotelprice_index: An index for the price of accommodation such as hotels, hostels, and short-term rentals for the different Nordic countries (excluding Iceland). This variable is the control for possible price effects of accommodation on air transport. The control is in in line with the regressions of Falk & Hagsten (2019).

airfare_index: An index for airfare on the country level from Eurostat.

4.2.3 Variables accounting for extraordinary events

I have chosen not to include variables accounting for extraordinary events such as global epidemics. Thießen, Haucke and Wosnitza (2013) argue that any correction of passenger numbers accounting for extraordinary events is dubious. Special circumstances such as the SARS epidemic will occur again in the future. Additionally, during the period of study there have not been any extraordinary events that would impact aviation in a significant way. Another argument against correcting for extraordinary events is consumer behaviour: If there is a conflict or disease in another country, people are more likely to simply change their destination than to avoid flying altogether. (Thießen, Haucke, & Wosnitza, 2013) The time period I am using does not include a time when the COVID-19 pandemic was affecting air travel, as the last month I am including in my analysis is December 2019.

4.3 Descriptive statistics

The airports in the Nordic countries (excluding Iceland) vary in size quite radically. The sample includes everything from near-abandoned airports to the four main airports in the countries of interest.

Table 2 Descriptive statistics, whole sample, 129 airports.

	N	mean	median	std. dev	min	max
p_total	15 480	47 620	4 393	169 412	0	1.590e+06
gdp_cap	15 480	55 204	51 742	11 750	38 732	76 684
airfare_index	15 480	102.3	101.2	13.26	71.80	145
hotelprice_index	15 480	103.9	102	8.31	88.83	171
p_domestic	15 480	18 007	3 131	50 139	0	548 656
p_international	15 480	29 614	24	133 659	0	1.510e+06

Table 3 Descriptive statistics, Sweden, 41 airports.

	N	mean	median	std. dev	min	max
p_total	4 920	41 872	4 251	151 146	0	1.338e+06
gdp_cap	4 920	48 390	48 198	3 930.18	42 569	54 628
airfare_index	4 920	99.74	99.32	13.08	76.46	142.39
hotelprice_index	4 920	101.45	99.99	6.88	88.83	119.97
p_domestic	4 920	14 720	1 368	35 966	0	262 328
p_international	4 920	27 152	514	119 273	0	1.129e+06

Where: *p_total*: monthly passenger numbers by airport, *gdp_cap*: GDP per capita by country, *airfare_index*: index of airfare by country, *hotelprice_index*: index of hotel prices by country, *p_domestic*: monthly domestic passenger numbers by airport, *p_international*: monthly international passenger numbers by airport.

Table 4 Descriptive statistics, Norway, 52 airports.

	N	mean	median	std. dev	min	max
p_total	6 240	42 771	4 648	146 588	0	1.407e+06
gdp_cap	6 240	68 364	68 155	4 723	61 513	76 684
airfare_index	6 240	101.20	100.4	14.51	71.8	145
hotelprice_index	6 240	104.28	104	4.26	93.9	116.5
p_domestic	6 240	25 479	4 532	68 867	0	548 656
p_international	6 240	17 292	0	81 409	0	949 022

Table 5 Descriptive statistics, Finland, 25 airports.

	N	mean	median	std. dev	min	max
p_total	3 000	34 752	2 977	139 726	0	1.042e+06
gdp_cap	3 000	42 451.3	41 119	2 883.38	38 732	47 975
airfare_index	3 000	107.82	108.29	10.22	84.48	134.76
hotelprice_index	3 000	105.70	101.28	11.37	90.32	138.37
p_domestic	3 000	8 860	2 369	22 502	0	164 762
p_international	3 000	25 892	358	119 259	0	941 856

Table 6 Descriptive statistics, Denmark, 11 airports.

	N	mean	median	std. dev	min	max
p_total	1 320	121 212	9 176	315 518	0	1.589e+06
gdp_cap	1 320	47 370.2	46 999	3 800.64	41 947	53 882
airfare_index	1 320	103.96	101.75	9.52	83	135.6
hotelprice_index	1 320	107.24	102.25	14.59	90.2	171
p_domestic	1 320	15 721	7 177	24 349	0	116 082
p_international	1 320	105 492	771	293 898	0	1.510e+06

Where: *p_total*: monthly passenger numbers by airport, *gdp_cap*: GDP per capita by country, *airfare_index*: index of airfare by country, *hotelprice_index*: index of hotel prices by country, *p_domestic*: monthly domestic passenger numbers by airport, *p_international*: monthly international passenger numbers by airport.

4.4 Method

The established way in economics to study the behavioural effects of a tax is using a statistical regression model. The method I am using is a dynamic difference-in-differences regression model with monthly fixed effects and airport-specific fixed effects to study if the aviation taxes reduce passenger numbers in Norway and Sweden, despite the geographical isolation of the Nordic countries. The model is based on the methods established by Falk & Hagsten (2019) who studied the impact of the Austrian and German aviation taxes on passenger numbers. According to Falk & Hagsten (2019) and Fichert et al. (2014) the impact of aviation taxes is greater at airports dominated by low-cost airports, therefore I am doing an additional model as well, separated by airport characteristics. Fichert et al. (2014) as well as Jung and Fujii (1976) claim the distance traveled can impact the price elasticity of air travel. For this reason, I include additional regressions separating the passenger numbers by domestic and international travel. All the regressions are summarised in table 7 and they are all completed utilizing robust standard errors.

4.4.1 Dynamic difference-in-differences regression models with fixed effects

The OLS-regressions I am using are to estimate the effect of the independent variable, the aviation tax, on the dependent variable, air traffic passenger numbers. I chose a dynamnic difference-in-differences analysis to account for general trends in aviation passenger numbers in the Nordic countries. Falk and Hagsten (2019) utilised a dynamic difference-in-differences model as well, when studying the impact of aviation taxes in Germany and Austria.

A difference-in-differences regression model is a statistical model designed to emulate an experimental research design. With the model one can study the effects of a natural experiment using a “treatment group” and “control group”. The regression model calculates the difference of the treated group with a group that has not received the treatment, over time. In this thesis the countries with aviation taxes are the treatment groups (in separate models) and the untaxed countries are the control group. One of the most important factors in utilising a difference-in-differences regression model is to choose a valid control group.

A Difference-in-differences method is based on the assumption of a common trend. In figure 5 the common trend of the Nordic countries air transport passenger numbers can be seen in absolute terms. While the common trend assumption appears to break when it comes to Finland, this is primarily due to the lower number of passengers flying from Finland. In figure 6, I overlay the passenger trends in the countries visualising the common trend. Combined with the fact that Finland is similarly geographically isolated as the treatment groups, I believe it is a functioning control group for models on both the Norwegian and Swedish tax. This is due to the countries' geographical proximity, cultural similarity and demographic similarity. To account for Finland possibly not having the perfect common trend, I include regressions without Finland included in the control group in Appendix A. However, as Denmark is not as geographically isolated as the other countries of interest, I estimate regressions without Denmark included. All the alternative regressions can be found in Appendix A, tables 1-4.

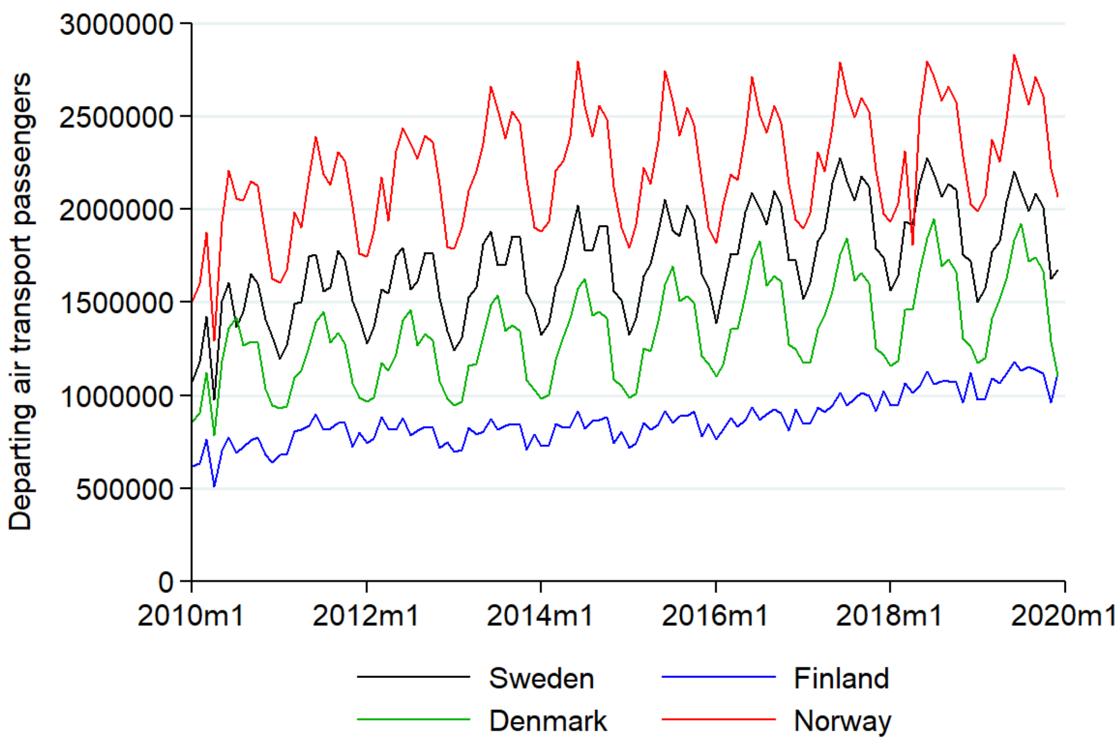

Figure 5 Monthly departing air transport passengers in the Nordic countries (excluding Iceland).

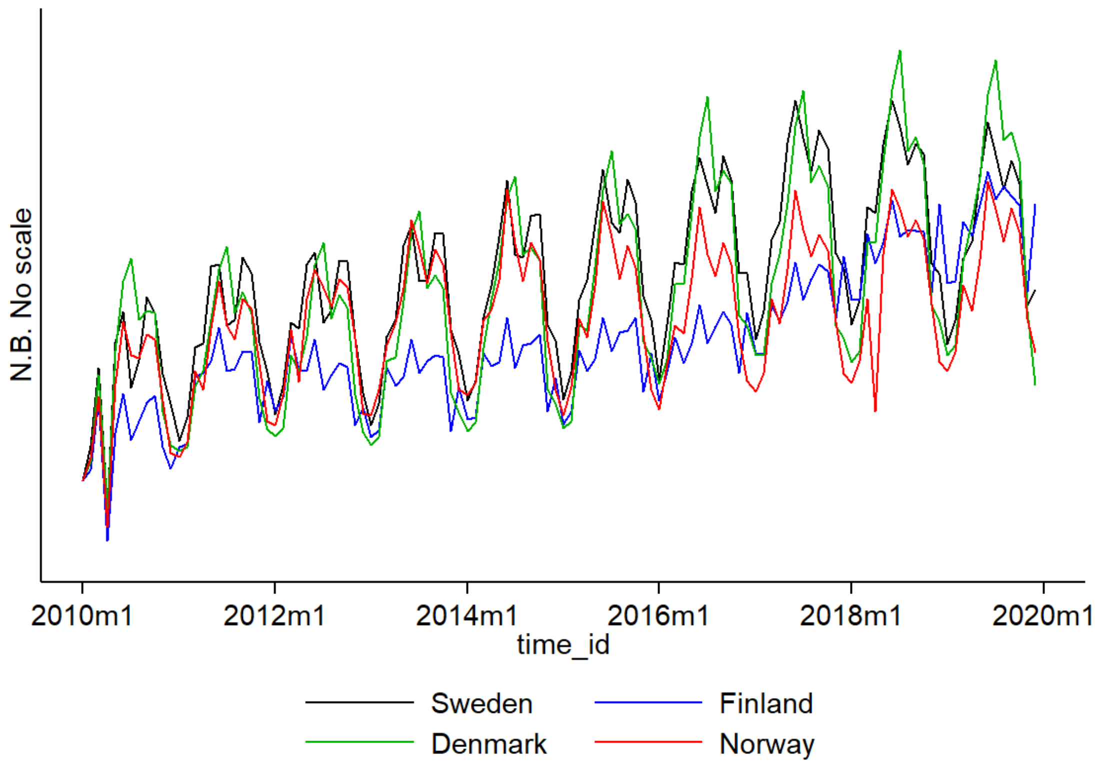

Figure 6 The common trend of monthly departing air transport passengers in the Nordic countries visualised. N.B. There is no scale on the Y-axis as this graph exists purely to visualise the common trend.

Utilising fixed effects in panel data is done to control for omitted variable bias. Since the data is airport-level data the specific characteristics of the airport could have an impact on the estimate. I am therefore utilising fixed effects to account for the heterogeneity of airport characteristics in the studied countries. I performed a Hausman specification test in Stata and verified that a fixed effects method is the correct choice for the data. The Hausman specification test can be used to decide if one should use fixed effects or random effects in a panel data regression (Hausman, 1978). The test compares estimable coefficients of regressors that vary over time and was performed with the *sigmamore* option as recommended by Cameron & Trivedi (2009). The *sigmamore* option for the Hausman specification test option specifies that the covariance matrices of both estimators, fixed and random effects, are based on the estimated disturbance variance of the efficient estimator. This is essentially done to prevent the chi squared test from taking on a negative value. (Cameron & Trivedi, 2009)

4.4.2 Empirical models

The general specification for analysis of the aviation tax in Sweden is as follows:

$$\ln(p\_total)_{it} = \beta_0 + \beta_1 \cdot sweden_i * aftertax2018_t + \beta_2 \cdot sweden_i + \beta_3 \cdot aftertax2018_t + \beta_4 \cdot \ln(p\_total)_{it-12} + \beta_5 \cdot \ln(GDPcap)_i + \beta_6 \cdot airfare\_index_i + \beta_7 \cdot hotel\_index_i + \alpha_i + \delta_t + \varepsilon_{it}$$

This concerns models (1), (2) and (3). Where the dependent variable is $ln(p\_total)_{it}$, departing passengers in logarithmic form, *i* is the individual airport, and *t* the month, $sweden_i$ is a dummy variable for if an airport is in Sweden or not, $aftertax2018_t$ is a dummy variable for time after the aviation tax was implemented in Sweden. Additionally, $sweden_i * aftertax2018_t$ is the treatment group variable after treatment, Swedish airports after the tax. There are also three other control variables: $ln(GDPcap)_i$, GDP per capita in logarithmic form, $airfare\_index_i$, an index for airfare, as well as $hotel\_index_i$, an index for accommodation prices in the different countries. The variable α_i represents the unobserved effect, unrelated to the time variable, of each airport. The variable δ_t represents the time effects that impact all airports, such as the business cycle. All models studying the Swedish aviation tax exclude Norway from the control group due to the Norwegian aviation tax. The control group for Sweden is therefore Finland and Denmark. The model for Sweden excludes two airports due to their close proximity to the Swedish-Danish border: Copenhagen airport and Malmö airport. I do this to account for the possible effect of people traveling over the border by land to fly from Denmark.

Model (A1) includes all airports in the sample. Model (A2) only includes airports dominated by low-cost airlines. Model (A3) includes all airports where low-cost airlines are present. The airports included in each regression can be seen in Appendix B.

For Norway, the general specification for analysis is:

$$\ln(p\_total)_{it} = \beta_0 + \beta_1 \cdot norway_i * aftertax2016_t + \beta_2 \cdot norway_i + \beta_3 \cdot aftertax2016_t + \beta_4 \cdot \ln(p\_total)_{it-12} + \beta_5 \cdot \ln(GDP\_cap)_i + \beta_6 \cdot airfare\_index_i + \beta_7 \cdot hotel\_index_i + \alpha_i + \delta_t + \varepsilon_{it}$$

The model is functionally identical to the model for Sweden. I study only the Norwegian aviation tax implemented in 2016, denoted $aftertax2016_t$. The tax raise in 2019 is too recent for analysis. Here $norway_i*aftertax2016_t$ is a dummy variable denoting an airport in Norway after the tax. This model does not exclude any airports due to close border proximity, as Norway is geographically very isolated.

Model (B1) includes all airports in Norway, Sweden, Finland and Denmark. Model (B2) only includes airports dominated by low-cost airlines. Model (B3) includes all airports where low-cost airlines are present. All the models for Norway are restricted to the time before the Swedish aviation tax came into effect in April 2018.

For all models I adjust the passenger amounts *ln(p_total)* seasonally to yield better results. I add dummy variables for each month as a seasonal adjustment, in line with most research on tourism and travel. Additionally, I add a lag term in line with previous research: The lag term $lnptotal_{it-12}$ is added to predict the passenger amounts in a particular month using the same month in the previous year, as consumers are slow to react to price changes in tourism industries and holidays are often planned a year in advance (Fichert et al., 2014). Due to the nature of the lag variable the year 2010 is excluded, leaving the years 2011-2019.

4.4.3 International and domestic air travel

Jung and Fujii found that air travel is more elastic for short-haul destinations. To account for this possibility, I perform the regressions separating air travel by domestic and international to isolate the possible effect of the taxes on short-haul travel. The regressions for domestic air travel are C1-C3 for Sweden and D1-D3 for Norway. For international air travel the regressions for Sweden are E1-E3 and for F1-F3 for Norway. A summary of all the regressions can be seen in table 7.

Table 7 Summary of regressions.

Regression code	**Treatment group**	**Airports included**	**Type of air transport passengers included**	**Control group**
Main regressions				
A1	SWE	all	all passengers	FIN+DEN
A2	SWE	low-cost dominated	all passengers	FIN+DEN
A3	SWE	low-cost present	all passengers	FIN+DEN
B1	NOR	all	all passengers	FIN+DEN+SWE
B2	NOR	low-cost dominated	all passengers	FIN+DEN+SWE
B3	NOR	low-cost present	all passengers	FIN+DEN+SWE
Domestic air travel passengers only				
C1	SWE	all	domestic only	FIN+DEN
C2	SWE	low-cost dominated	domestic only	FIN+DEN
C3	SWE	low-cost present	domestic only	FIN+DEN
D1	NOR	all	domestic only	FIN+DEN+SWE
D2	NOR	low-cost dominated	domestic only	FIN+DEN+SWE
D3	NOR	low-cost present	domestic only	FIN+DEN+SWE
International air travel passengers only				
E1	SWE	all	international only	FIN+DEN
E2	SWE	low-cost dominated	international only	FIN+DEN
E3	SWE	low-cost present	international only	FIN+DEN
F1	NOR	all	international only	FIN+DEN+SWE
F2	NOR	low-cost dominated	international only	FIN+DEN+SWE
F3	NOR	low-cost present	international only	FIN+DEN+SWE

5. Results

In this chapter I present the results of the econometric models presented in the previous chapter. The models follow the methods established by Falk and Hagsten (2019).

5.1 The Swedish aviation tax 2018

In table 8 the three dynamic difference-in-differences regressions studying the Swedish aviation tax can be seen (with Finland and Denmark functioning as the control group). Regression A1 includes all airports in the sample. Regression A2 includes only airports dominated by low-cost airlines. Regression A3 includes only airports where low-cost airlines are present. The airports included in each regression can be seen in Appendix B. In each model the effect of the variable for the tax, $sweden_i*aftertax2018_t$, on the dependent variable $ln(p\_total)_{it}$, can be seen.

I find no significant connection between the Swedish aviation tax implemented in 2018 and overall passenger numbers (A1). The same is true when only studying airports with a low-cost airline presence (A3) and when only accounting for airports dominated by low-cost airlines (A2). The 12-month lag is the most consistent variable estimating passenger numbers, significant in regressions (A1) and (A3), and with a weak correlation for equation (A2). This is to be expected due to the strong seasonality and the generally slow reactions of the air transport market.

The increase in the price of airfare, *airfare_index* appears to slightly increase the number of passengers departing from airports dominated by low-cost airlines. This indicates passengers are choosing cheaper air travel as prices increase, valuing the cheap prices over the comfort of more premium airlines.

Table 8 The effect of the aviation tax in Sweden on passenger numbers. Monthly and airport fixed effects for the time period 2011-2019.

	(A1) All airports	(A2) Low-cost dominated	(A3) Low-cost present
*sweden*after*	-0.022	0.116	-0.006
	(0.057)	(0.174)	(0.059)
aftertax2018	-0.036	-0.024	-0.006
	(0.077)	(0.180)	(0.056)
ln(p_total)$_{it-12}$	0.660***	0.527*	0.675***
	(0.054)	(0.209)	(0.129)
ln(gdp_cap)	-0.445	0.966	0.354
	(0.459)	(0.644)	(0.233)
airfare_index	-0.001	0.005**	0.003*
	(0.001)	(0.001)	(0.001)
hotelprice_index	0.004**	-0.016	-0.001
	(0.001)	(0.010)	(0.001)
Constant	7.399	-5.034	-0.549
	(4.740)	(8.142)	(3.205)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	7 219	490	1 030
R-squared	0.412	0.659	0.673
Number of airports	73	5	10

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*sweden*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2018*: after April 2018. *ln(p_total)*$_{it-12}$: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

5.2 The Norwegian aviation tax 2016

The aviation taxes implemented in Norway in 2016 did not have a statistically significant impact on passenger numbers, as presented in table 9. The coefficient for the tax, *norway*after* is negative but not significant with quite large standard errors. The results are in line with hypothesis 1, that the aviation taxes did not decrease passenger numbers, but due to large standard errors not definitively proven. Hypothesis 2, that the aviation taxes decreased passenger numbers at airports dominated by low-cost airlines, is not proven. The results for the aviation tax are equally weak in the case of airports dominated by low-cost airlines and airports with low-cost airlines present.

In line with the results for Sweden, the lag variables are statistically significant and positive, indicating a general increasing trend for all air travel passengers. The variable for the time period after the Norwegian aviation, *aftertax2016*, tax is significant only for the airports with a low-cost presence and for airports dominated by low-cost airlines.

Table 9 The effect of the aviation tax in Norway on passenger numbers. Monthly and airport fixed effects for the time period January 2011 – March 2018.

	(B1) All airports	(B2) Low-cost dominated	(B3) Low-cost present
*norway*after*	-0.039	-0.106	-0.045
	(0.032)	(0.115)	(0.069)
aftertax2016	0.091	0.213***	0.086**
	(0.058)	(0.052)	(0.034)
ln(p_total)$_{it-12}$	0.690***	0.513**	0.632***
	(0.045)	(0.196)	(0.133)
ln(gdp_cap)	-0.706	-0.762	-0.250
	(0.499)	(0.482)	(0.241)
airfare_index	-0.001*	0.001	0.001
	(0.001)	(0.001)	(0.001)
hotelprice_index	0.000	-0.015	-0.002
	(0.001)	(0.009)	(0.002)
Constant	10.38*	14.28*	6.793*
	(5.291)	(7.108)	(3.249)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	10 451	650	1 346
R-squared	0.429	0.615	0.651
Number of airports	127	8	16

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*norway*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2016*: after June 2016. *ln(p_total)*$_{it-12}$: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

5.3 Regressions on domestic air travel

5.3.1 Swedish aviation tax, domestic travel only

The regressions for domestic air travel only indicate that the Swedish aviation tax may have a significant effect on flights in the low-cost segment, as displayed in table 10. The tax appears to reduce domestic air travel by 12.6%[1] when studying airports that have a low-cost presence (C3). However, when looking at airports primarily operated by low-cost airlines this effect disappears (C2). The results when looking at domestic air travel only are similar to Falk and Hagsten (2019), with the tax having more of an effect on the low-cost segment.

The variable for the lag, $ln(p\_total)_{it-12}$ is significant in line with the other regressions (A1-B3) but only when accounting for all airport types. The lag indicates a generally increasing trend for air travel in Sweden, Denmark and Finland.

The variable for GDP per capita is negative and significant, which would indicate that if GDP per capita increases with 1%, domestic air travel decreases by 1.7%. A possible reason could be travellers choosing to travel internationally in times when the economy is stronger.

[1] Calculation based on coefficient for *sweden*after* = -0.135 as seen in table 10: $(e^{-0.135}-1)\cdot 100 = -12.63$

Table 10 The effect of the aviation tax in Sweden on domestic passenger numbers. Monthly and airport fixed effects for the time period 2011-2019.

	(C1) All airports	(C2) Low-cost dominated	(C3) Low-cost present
*sweden*after*	-0.213	-0.424	-0.135**
	(0.164)	(0.213)	(0.050)
aftertax2018	-0.016	0.359	0.060
	(0.123)	(0.338)	(0.061)
ln(p_total)$_{it-12}$	0.532***	0.331	0.355*
	(0.112)	(0.240)	(0.158)
ln(gdp_cap)	-1.732**	-0.328	-1.020*
	(0.669)	(1.150)	(0.480)
airfare_index	0.000	0.005	0.000
	(0.003)	(0.008)	(0.003)
hotelprice_index	0.006*	-0.009	0.000
	(0.003)	(0.021)	(0.005)
Constant	20.87***	4.736	14.35**
	(6.979)	(10.73)	(4.591)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	7 351	502	1 042
R-squared	0.168	0.038	0.042
Number of airports	74	5	10

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*norway*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2016*: after June 2016. *ln(p_total)*$_{it-12}$: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

5.3.1 Norwegian aviation tax, domestic travel only

I performed the same regressions, studying only domestic air travel, for Norway. In table 11 the effect of the Norwegian aviation tax on domestic air passengers can be seen. The aviation tax appears to have reduced domestic air travel in Norway by 24.1%[2]. This is consistent with Jung & Fujii (1976), short-haul routes being the most elastic. The results are unexpected because Norway is so geographically isolated. Norway is mountainous and traveling within the country by land is challenging. I did not expect the tax to reduce passenger numbers on domestic routes in Norway.

The variable for the lag, $ln(p\_total)_{it-12}$, is significant in line with the main regressions (A1-B3) but only when accounting for all airport types. The lag indicates a generally increasing trend for air travel in the Nordic countries (excluding Iceland).

Here, as in the regression for Sweden, the variable for GDP per capita is negative and significant, but only when accounting for all airports. The results mean that an increase of 1% in GDP per capita would decrease domestic air travel by 2.7%. As with Sweden I believe this is caused by air travellers substituting domestic air travel for international air travel when the economy is booming.

[2] Calculation based on coefficient for *norway*after* = -0.276 as seen in table 11: $(e^{-0.279}-1)\cdot 100 = -24.12$

Table 11 The effect of the aviation tax in Norway on domestic passenger numbers. Monthly and airport fixed effects for the time period 2011-2019.

	(D1) All airports	(D2) Low-cost dominated	(D3) Low-cost present
*norway*after*	-0.276**	-1.282	-0.966
	(0.135)	(0.956)	(0.829)
aftertax2016	0.215**	0.769	0.490
	(0.087)	(0.449)	(0.377)
ln(p_total)$_{it-12}$	0.595***	0.162	0.297
	(0.103)	(0.304)	(0.186)
ln(gdp_cap)	-2.737***	-13.14	-6.491
	(0.938)	(11.31)	(5.254)
airfare_index	-0.001	-0.008	-0.008
	(0.002)	(0.011)	(0.009)
hotelprice_index	-0.001	0.045	0.007
	(0.003)	(0.063)	(0.011)
Constant	32.63***	142.9	75.07
	(9.937)	(120.2)	(58.19)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	10 620	674	1 370
R-squared	0.142	0.136	0.088
Number of airports	128	8	16

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*norway*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2016*: after June 2016. *ln(p_total)*$_{it-12}$: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

5.4 Regressions on international travel

The regressions on international air travel yielded no significant results for the variables of interest. No previous studies have found international air travel to be particularly elastic compared to domestic air travel. The results can be seen in Appendix I, tables 5 and 6.

5.5 Discussion

The variables of interest did not yield significant results for the main regressions. This indicates that the price elasticity of air travel in Norway and Sweden is inelastic as a whole. The countries are quite geographically isolated which would explain the aviation taxes having no effect on overall passenger numbers.

When looking at exclusively domestic air travel, the effect of the variable for the tax becomes significant in some of the regressions. For Sweden, this is the case when studying domestic air travel from airports that have a low-cost presence (C3). The tax appears to have reduced domestic travel from these airports by over 10%. For Norway, the effect is present when studying air travel from all airports (D1). The Norwegian aviation tax appears to reduce domestic air travel by 24%. This is unexpected, as Norway is more geographically isolated than Sweden, Denmark and Finland.

To ensure the assumption of a common trend is valid I perform the regressions excluding certain countries from the control group. The results of the alternative regressions can be seen in Appendix I, tables 1-4. The alternative regressions provide differing results to the main regressions, implying some heterogeneity in the control group.

5.6 Critique & Limitations

Due to high standard errors I can not draw any conclusions about the overall effect or lack thereof of the aviation taxes in Norway and Sweden. One of the possible limitations of this thesis is omitted variable bias: A possible cause of omitted variable bias in the regressions studying Sweden is the concept gaining ground in recent years: “flygskam”, Swedish for flight shame. Flygskam can be defined as feeling guilty about the environmental harm of flying, it is a symbolic movement of Swedish people that are avoiding flying (Wolrath Söderberg & Wormbs, 2019). This movement could impact the results of the regression analysis. The effects of flygskam are hard to quantify and as such have not been accounted for. In Figure 7 the search interest for the term can be seen. It is measured on an index of 0 to 100 based on search interest. The greyed out part of the graph is outside the time period being analysed.

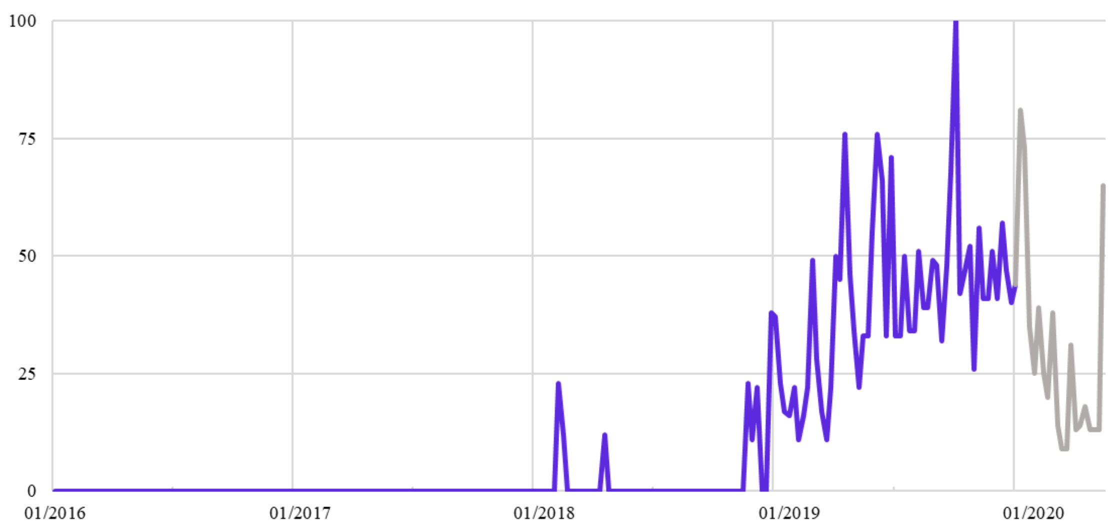

Figure 7 Search interest for the term "flygskam", index 0—100. (Google Inc., 2020)

Another possible limitation is the fact that the treatment group countries border the control group countries. In the regressions (A1), (A2) and (A3) Sweden is the treatment group and Denmark and Finland are the control group. Swedish air passengers travel frequently to the control group countries. If the aviation tax reduces passenger numbers in Sweden, the Swedish aviation tax could in theory reduce passenger numbers in the control group countries as well. This would violate the principle of independence for the control group. The same issue is present with the regressions for Norway, (B1), (B2), and (B3), as Norwegians fly to the control group countries as well. To combat this possible bias, I suggest future studies find a way to remove the effect of air travel between the treatment and control countries.

An additional border effect is the possibility that air passengers travel by land to other countries to fly. Due to the geographical isolation in the Nordic countries I believe this not to be a big problem with most airports. As previously stated, the only airports where this is a possible problem are Malmö and Copenhagen airports. I exclude them from the regressions on the Swedish aviation tax.

These border effects are not a problem for the regressions exclusively studying domestic traffic. Therefore, the results for the regressions C1-C3 and D1-D3 do not suffer from this problem.

The variable for airfare, *airfare_index*, could be problematic. It is connected to the variables for the taxes, *sweden*after* and *norway*after*. Due to the very small effect of the variable *airfare_index* I determine this problem does not affect the regression results in a significant way.

The lack of detailed price statistics on airfare is problematic as well. Business travel and leisure travel have different elasticities and react differently to taxes. More detailed statistics are desired when it comes to air journeys as well. Being able to control for different types of routes would make the results more robust.

6. Conclusions

This thesis aims to study whether the aviation taxes in Norway and Sweden decreased passenger numbers. In previous studies the results have varied. Falk and Hagsten (2019) found the aviation taxes in Germany and Austria decreased passenger numbers. Mayor and Tol (2007) found no impact when studying the impact of the aviaton tax on passenger numbers in the United Kingdom. Seetaram et al. (2014) found similar results studying the aviation tax in the United Kingdom in 2014.

In the results of the dynamic difference-in-differences regression models studying all air travel (A1-B3) I find no significant effect by the aviation taxes in Norway and Sweden on total passenger numbers, nor can I definitively confirm an effect does not exist. The high standard errors prevent any definite conclusions from being drawn. The main hypothesis, that the aviation taxes did not have an effect on passenger numbers, can therefore not be disproved based on the results. The results indicate that the taxes probably did not have a significant effect on passenger numbers. A possible reason for the non-significant results is the relatively low monetary amount of the tax. The geographic isolation of the countries could reduce the effect of the tax as well. The secondary hypothesis, "The aviation taxes had a significant effect on passenger numbers at airports dominated by low-cost airports.", can not be disproven either. The main regressions (A1-B3) are attempting to recreate the study by Falk and Hagsten (2019). In addition, I completed some modified regressions.

I study the effect of the aviation taxes in Norway and Sweden on domestic air travel passenger numbers. This is done to account for the possibility that air travel is more elastic for short-haul journeys. The results for Sweden indicate that the tax reduces domestic air travel by 12.6% for airports with a low-cost presence. For Norway, the results indicate that the Norwegian aviation tax reduces domestic air travel by 24.1%, for all airports in Norway. The results are in line with Jung and Fujii (1976). However, domestic air travel can also be influenced by the availability of substitutes, which this thesis does not control for. The results for aviation taxes could be an effective measure for reducing domestic air travel. The results are not conclusive, as the effect was significant only for two out of the six domestic air travel regressions.

Pigouvian taxes still remain relevant to this day as a possible measure in mitigating the damage of negative externalities. One of the goals of aviation taxes is to reduce passenger numbers, to reduce emissions. Should the reduction of passenger numbers not succeed, the tax is effective from a different perspective, as a revenue collection tool for the state. For air travel, the potential of the tax to reduce passenger numbers appears to be the most effective for domestic flights.

This thesis contributes to the existing research by applying robust statistical methods to study the effect of the aviation taxes in Sweden and Norway on passenger numbers. Further research is needed into the effect of aviation taxes on passenger numbers.

Summary in Swedish – Svensk sammanfattning

Inledning

Att undvika en global temperaturökning på 2 grader Celsius är ett av de huvudsakliga målen i kampen mot klimatförändringen. En viktig faktor i sammanhanget är minskandet av koldioxidutsläpp. (Bows-Larkin, Mander, Traut, Anderson, & Wood, 2010) Flygandet drabbar klimatet relativt hårt: trots att flyg konsumerar endast tre procent av världens fossila bränslen står de för tolv procent av koldioxidutsläppen. (Simone, Stettler, & Barrett, 2013).

Klimatförändringen har bidragit till ökad ekologisk lagstiftning. (Kumar, Ugirashebuja, Carnwath, Tamminen, & Boyd, 2019). Sveriges flygskatt som implementerades i april 2018 har varit bland de mest diskuterade lagarna de senaste åren. Skatten varierar mellan 60 och 400 SEK beroende på slutdestinationen. Ett annat land i Norden, Norge, implementerade en flygskatt på 80 NOK år 2016. Norge höjde sin flygskatt år 2019 för att i stora drag motsvara Sveriges. Flygtrafiken har globalt sett många skatteförmåner, bl.a. är flygbränsle skattefritt. (Fichert, Forsyth, & Niemeier, 2014) Flygskatternas syfte är att få flygbolagen att till större del bära flygutsläppens ekologiska kostnader. (Andersson & Falck, 2017)

Syfte och ämnesmotivering

I denna avhandling studerar jag om dessa skatter minskat antalet flygresenärer i respektive land. Jag utnyttjar en ekonometrisk difference-in-differences-metod med fixa effekter. Huvudsakligen studerar jag skatterna som implementerades 2016 i Norge och 2018 i Sverige. Skattehöjningen 2019 skedde alltför nyligen för att kunna ligga som grund för en ekonometrisk analys. Jag utnyttjar en difference-in-differences-metod i enlighet med Falk & Hagsten (2019). Jag utför även samma analys med endast inrikesflyg i syfte att isolera skatternas effekt på kortare flygrutter. Min kontribution är en analys av flygskatterna i Norden med hjälp av robusta statistiska metoder. Jag utnyttjar data på månads- och flygplatsnivå. Norden är mer isolerad än Centraleuropa så möjligheten att isolera effekten av flygskatterna är större.

Med utgångspunkt i tidigare forskning har jag följande hypoteser:

1. Flygskatterna i Norge och Sverige har minskat antalet flygresenärer på en statistiskt signifikant nivå endast vid flygplatser som är huvudsakligen för lågprisflyg.
2. Flygskatterna i Norge och Sverige har inte minskat antalet flygresenärer på en statistiskt signifikant nivå när alla flygplatser beaktas.

Hypotes nr. 1 är i enlighet med Falk & Hagsten (2019).

Min tredje hypotes är en nollhypotes:

3. Flygskatterna i Norge och Sverige har inte påverkat antalet flygresenärer på en statistiskt signifikant nivå.

Nollhypotesen är i enlighet med studien av Seetaram, Song och Page i Storbritannien. (Seetaram, Song, & Page, 2014)

Utsläppen från flygtrafiken är ett exempel på en negativ externalitet. Det finns ett antal olika sätt för länder att bekämpa negativa externaliteter. Pigou (1920) föreslog en skatt på negativa externaliteter och att den skatten ska motsvara välfärdsförlusten som den negativiteten gav upphov till. En skatt av denna typ kallas en Pigouviansk skatt. (Pigou, 1920)

Ett annat sätt att bekämpa negativa externaliteter är utsläppshandel enligt det så kallade ”Cap and trade”-systemet som används i hela Europeiska ekonomiska samarbetsområdet. Systemet som heter *European Union Emissions Trading System* (EU ETS) går ut på försäljning och köp av en begränsad mängd utsläppsrättigheter. En del länder har i bruk en Pigouviansk skatt på flygtrafik och är dessutom med i EU ETS.

När ett land vill beskatta en negativ externalitet bör den underliggande varans elasticitet beaktas. Efterfrågans elasticitet beskriver hur mycket en prisförändring påverkar efterfrågan på varan. När det kommer till flygtrafiken har olika konsumentgrupper väldigt olika elasticitet. T.ex. affärsresor är väldigt oelastiska.

Det finns ett antal tidigare studier om flygskatters effektivitet. Områden som är mer geografiskt isolerade verkar ha en oelastisk efterfrågan på flygtrafik. Mayor och Tol (2007) studerade effekten av en flygskatt i Storbritannien på passagerarantal och utsläpp.

De estimerade att flygskatten inte hade någon signifikant effekt och att skatten inte var ett effektivt instrument i att minska mängden utsläpp. De föreslog en mer aggressiv skatt om en utsläppsminskning önskades (Mayor & Tol, 2007) I en liknande studie år 2013 kom Seetaram, Song och Page fram till motsvarande resultat. (Seetaram et al., 2014)

En av de bästa studierna av flygskatter i Europa gjordes av Falk och Hagsten (2019). De studerade hur flygskatter påverkade antalet flygresenärer i Tyskland och Österrike med hjälp av en difference-in-differences-modell. Studien delade upp flygplatser enligt flygplatser som dominerades av lågprisflyg och övriga flygplatser. Studien fann en minskning i passagerarantal som en konsekvens av skatten: 9 procent året efter att skatten implementerades och 5 procent påföljande år. Minskningen gällde främst flygplatserna som dominerades av lågprisflyg. Falk och Hagsten rekommenderade en reproduktion av studien med flygskatterna i Norden som fokus. I min analys gör jag en liknande uppdelning. (Falk & Hagsten, 2019)

Metod och data

Data om passagerarantal är balanserad paneldata hämtade från Transportstyrelsen (Sverige), Finavia (Finland), Statistisk Sentralbyrå (Norge), och Transport- og Boligministeriet (Danmark). Studien omfattar åren 2010–2019 på månadsnivå och 129 flygplatser. Analysen gäller avgående passagerare, exklusive passagerare på mellanlandning.

Prisindex på hotell och flygbiljetter som jag utnyttjar är från Eurostat (Eurostat, 2020). Data om BNP per capita är hämtade från Internationella Valutafonden (International Monetary Fund, 2019).

Metoden är en dynamisk difference-in-differences-regression med månadsfixa effekter. Målsättningen är en analys av hur flygskatterna påverkar passagerarantalet i Norge och Sverige, uppdelat enligt flygplatsernas typ. Variablerna som inkluderas i analysen är motiverade av tidigare forskning.

Den beroende variabeln är logaritmerat passagerarantal på flygplatsnivå. Följande oberoende variabler inkluderas i modellerna:

*csweden*after2018*: Flygplatser i Sverige efter flygskatten implementerades år 2018.

*cnorway*after2016*: Flygplatser i Norge efter flygskatten implementerades år 2016.

airfare_index: Index för pris på flygbiljetter.

accommodation_index: Index för pris på hotell och motsvarande tjänster.

Effekten av flygskatten i Sverige 2018 studeras med tre olika modeller:

A1 Alla flygplatser i Danmark och Finland som kontrollgrupp.

A2 Inkluderar endast flygplatser som är huvudsakligen för lågprisflyg.

A3 Inkluderar endast flygplatser som är trafikerade av lågprisflyg, men som även kan ha mycket övrig trafik.

Modellen för Sverige är uppbyggd på följande sätt:

$$lnptotal_{it} = \beta_0 + \beta_1 \cdot sweden_i * aftertax2018_t + \beta_2 \cdot csweden_i + \beta_3 \cdot aftertax2018_t + \beta_4 \cdot lnptotal_{it-12} + \beta_5 \cdot lnGDPcap_i + \beta_6 \cdot airfareindex_i + \beta_7 \cdot hotelindex_i + \alpha_i + \delta_t + \varepsilon_{it}$$

Effekten av flygskatten i Norge 2016 studeras med tre olika modeller:

B1 Alla flygplatser i Sverige, Danmark och Finland som kontrollgrupp

B2 Inkluderar endast flygplatser som är huvudsakligen för lågprisflyg.

B3 Inkluderar endast flygplatser som är trafikerade av lågprisflyg, men som även kan ha mycket övrig trafik.

Modellen för Norge är uppbyggd på följande sätt:

$$lnptotal_{it} = \beta_0 + \beta_1 \cdot norway_i * aftertax2016_t + \beta_2 \cdot norway_i + \beta_3 \cdot aftertax2016_t + \beta_4 \cdot lnptotal_{it-12} + \beta_5 \cdot lnGDPcap_i + \beta_6 \cdot airfareindex_i + \beta_7 \cdot hotelindex_i + \alpha_i + \delta_t + \varepsilon_{it}$$

Dessa samma regressioner utförs även med endast inrikesflyg (modellerna C1–C3 och D1–D3) samt endast utrikesflyg (Appendix A, modellerna 5–6)

Analys och resultat

Svenska flygskatten 2018

Jag hittar ingen signifikant korrelation mellan den svenska flygskatten 2018 och totala passagerarantal (modell A1). Samma gäller modellerna A2 och A3. Dock finns det en signifikant effekt på inrikesflyg när man endast beaktar flygplatser som trafikeras delvis av lågprisflyg. Enligt min modell minskar skatten passagerarantal från flygplatser av denna typ med 12,6%.

Norska flygskatten 2016

Flygskatten som implementerades i Norge år 2016 hade inte någon statistiskt signifikant effekt på totala passagerarantal (B1). Även för flygplatser som huvudsakligen trafikeras av lågprisflyg (modell B2) var effekten noll. Samma gällde flygplatser som delvis trafikeras av lågprisflyg (modell B3). Även här är effekten av flygskatten statistiskt signifikant endast när det gäller inrikesflyg. Effekten är signifikant endast när alla flygplatser i Norge beaktas. Flygskatten minskar inrikesflyg i Norge med 24,1% enligt min modell.

Flygskatterna i Norge och Sverige verkar inte ha en effekt på totala passagerarantal. Effekten är inte heller signifikant på flygplatser som huvudsakligen trafikeras av lågprisflyg. Detta betyder att de har misslyckats som miljöskatter. Detta kan bero på ländernas geografiskt sett isolerade läge jämfört med Centraleuropa, eller skatternas relativt låga summa.

Intressant nog minskar skatterna på mängden passagerare på inrikesflyg, men inte totala mängden passagerare. Flygresor verkar vara mer elastiska på kortare sträckor.

Pigouvianska skatter är även idag relevanta i kampen mot negativa externaliteter. Ytterligare studier med tillgång till mer detaljerade data behövs för bättre estimat på effekterna av flygskatterna i Norden.

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Appendix

Appendix I: Additional regressions

Table 1 The effect of the Swedish aviation tax on passenger numbers. Alternative control group: Denmark. Concerning regression (A2): Denmark has no airports in the category "Low-cost dominated".

	(A1) All airports	(A2) Low-cost dominated	(A3) Low-cost present
*sweden*after*	-0.134**	-0.090	-0.047
	(0.051)	(0.064)	(0.067)
aftertax2018	0.115	-	0.004
	(0.081)		(0.080)
ln(p_total)$_{it-12}$	0.650***	0.682***	0.727***
	(0.062)	(0.047)	(0.022)
ln(gdp_cap)	-0.818	0.112	0.402
	(0.510)	(0.393)	(0.235)
airfare_index	-0.003**	0.003	0.001
	(0.001)	(0.001)	(0.001)
hotelprice_index	0.004***	0.008	-0.000
	(0.001)	(0.009)	(0.000)
Constant	11.60**	0.658	-1.636
	(5.242)	(4.439)	(2.549)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	5 120	324	756
R-squared	0.381	0.824	0.819
Number of airports	49	3	7

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*sweden*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2018*: after April 2018. *ln(p_total)$_{it-12}$*: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

Table 2 The effect of the Swedish aviation tax on passenger numbers. Alternative control group: Finland

	(A1) All airports	(A2) Low-cost dominated	(A3) Low-cost present
*sweden*after*	0.035	0.116	-0.025
	(0.080)	(0.174)	(0.069)
aftertax2018	-0.087	-0.024	0.012
	(0.088)	(0.180)	(0.066)
ln(p_total)$_{it-12}$	0.671***	0.527*	0.663***
	(0.057)	(0.209)	(0.148)
ln(gdp_cap)	-0.515	0.966	0.983*
	(0.731)	(0.644)	(0.469)
airfare_index	-0.001	0.005**	0.005**
	(0.002)	(0.001)	(0.001)
hotelprice_index	0.004	-0.016	-0.008
	(0.004)	(0.010)	(0.008)
Constant	7.964	-5.034	-6.728
	(7.390)	(8.142)	(5.118)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	6 147	490	706
R-squared	0.425	0.659	0.655
Number of airports	63	5	7

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*sweden*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2018*: after April 2018. *ln(p_total)$_{it-12}$*: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

Table 3 The effect of the Norwegian aviation tax on passenger numbers. Alternative control group: Finland and Sweden

	(D1) All airports	(D2) Low-cost dominated	(D3) Low-cost present
*norway*after*	-0.071**	-0.106	-0.068
	(0.033)	(0.115)	(0.073)
aftertax2016	0.139**	0.213***	0.130**
	(0.066)	(0.052)	(0.050)
$ln(p\_total)_{it-12}$	0.704***	0.513**	0.599***
	(0.044)	(0.196)	(0.151)
ln(gdp_cap)	-0.864	-0.762	-0.288
	(0.546)	(0.482)	(0.320)
airfare_index	-0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
hotelprice_index	-0.002	-0.015	-0.007
	(0.002)	(0.009)	(0.006)
Constant	12.19**	14.28*	7.973*
	(5.886)	(7.108)	(4.233)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	9 502	650	998
R-squared	0.444	0.615	0.619
Number of airports	116	8	12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*norway*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2016*: after June 2016. $ln(p\_total)_{it-12}$: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

Table 4 The effect of the Norwegian aviation tax on passenger numbers. Alternative control group: Denmark and Sweden

	(D1) All airports	(D2) Low-cost dominated	(D3) Low-cost present
*norway*after*	-0.012	-0.114	-0.042
	(0.032)	(0.105)	(0.070)
aftertax2016	0.074	0.157***	0.082**
	(0.066)	(0.031)	(0.032)
ln(p_total)$_{it-12}$	0.683***	0.629***	0.677***
	(0.054)	(0.042)	(0.046)
ln(gdp_cap)	-0.771	-0.617	-0.190
	(0.541)	(0.308)	(0.226)
airfare_index	-0.001***	0.001	0.000
	(0.001)	(0.001)	(0.000)
hotelprice_index	0.001	0.002	-0.001
	(0.002)	(0.005)	(0.001)
Constant	11.19*	10.14**	5.634**
	(5.670)	(3.378)	(2.303)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	8 741	505	1 114
R-squared	0.396	0.749	0.776
Number of airports	103	6	13

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*norway*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2016*: after June 2016. *ln(p_total)*$_{it-12}$: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

Table 5 The effect of the aviation tax in Sweden on international passenger numbers. Monthly and airport fixed effects for the time period 2011-2019.

	(E1) All airports	(E2) Low-cost dominated	(E3) Low-cost present
*sweden*after*	0.131	-0.944	-0.167
	(0.169)	(0.989)	(0.137)
aftertax2018	-0.054	1.198	0.169
	(0.187)	(1.287)	(0.202)
$ln(p\_total)_{it-12}$	1.092***	1.492*	1.420**
	(0.147)	(0.566)	(0.465)
ln(gdp_cap)	-0.531	5.149	0.659
	(0.822)	(2.627)	(0.843)
airfare_index	0.004	0.013	0.004
	(0.003)	(0.010)	(0.004)
hotelprice_index	-0.002	-0.076	-0.008
	(0.006)	(0.058)	(0.007)
Constant	1.873	-53.88	-11.49
	(8.850)	(28.39)	(6.398)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	7 351	502	1 042
R-squared	0.186	0.304	0.275
Number of airports	74	5	10

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*norway*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2016*: after June 2016. $ln(p\_total)_{it-12}$: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

Table 6 The effect of the aviation tax in Norway on international passenger numbers. Monthly and airport fixed effects for the time period 2011-2019.

	(F1) All airports	(F2) Low-cost dominated	(F3) Low-cost present
*norway*after*	-0.072	-2.590	-1.763
	(0.165)	(2.320)	(1.638)
aftertax2016	-0.053	0.654	0.101
	(0.096)	(0.388)	(0.121)
$ln(p\_total)_{it-12}$	1.145***	1.544**	1.675***
	(0.143)	(0.513)	(0.549)
ln(gdp_cap)	-0.567	-0.562	-0.067
	(0.661)	(2.804)	(1.065)
airfare_index	-0.001	0.007	0.005
	(0.002)	(0.006)	(0.003)
hotelprice_index	-0.000	-0.082	-0.013
	(0.005)	(0.048)	(0.008)
Constant	0.898	7.771	-6.274
	(7.330)	(29.82)	(8.387)
Monthly fixed effects	YES	YES	YES
Airport fixed effects	YES	YES	YES
Observations	10 620	674	1 370
R-squared	0.163	0.259	0.219
Number of airports	128	8	16

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*norway*after*: DiD variable for an airport located in Sweden after the tax. *aftertax2016*: after June 2016. $ln(p\_total)_{it-12}$: a 12-month lag term. *ln(gdp_cap)*: logarithmic GDP per capita. *airfare_index*: index for average airfare prices. *hotelprice_index*: index for average hotel prices. Includes fixed effects by month and airport.

Appendix II: Airport data

Table 7 Airports serviced mainly by low-cost airlines.

Lappeenranta	FIN
Tampere	FIN
Stockholm Skavsta	SWE
Stockholm Västerås	SWE
Växsjö Småland	SWE
Haugesund	NOR
Sandefjord	NOR
Moss rygge	NOR

Table 8 Airports with a low-cost airline presence.

Helsinki airports	FIN
Lappeenranta	FIN
Tampere	FIN
Göteborg Landvetter	SWE
Malmö airport	SWE
Stockholm Skavsta	SWE
Stockholm Västerås	SWE
Växsjö Småland	SWE
Haugesund	NOR
Oslo Gardermoen Airport	NOR
Sandefjord	NOR
Moss rygge	NOR
Aalborg	DEN
Aarhus	DEN
Billund	DEN
Copenhagen	DEN