European Flight Ticket Taxes: a Green Dream or a Flying Illusion?

A Panel Analysis on the Effects of Flight Ticket Taxes in the European Union and European Free Trade Association

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Abstract

Present research examines the effects of national flight ticket taxes on the number of departing air passengers in the European Union and European Free Trade Association. To facilitate route-level panel analyses of the effects of levying a flight ticket tax and the amount of tax levied on the number of departing air passengers from the main European airports in 2005-2018, extensive pre-research on national legislation and classification of airports is executed. After controlling for air transport intensity estimated by the gravity equation, jet fuel prices and seasonality in air transport demand, an expected decrease of 8.2% in air transport demand resulting from flight ticket taxes is found. Moreover, a decrease of 0.8% and 11.5% is found for hub airports and low-cost airports, respectively. Furthermore, a 1% increase in the amount of tax is associated with a 0.034% reduction in air transport demand. Again, hub airports and low-cost airports demonstrated to have a different effect of -0.003% and -0.051%, respectively. Therefore, it is concluded that national flight ticket taxes serve the instrumental function of taxation by decreasing the number of departing air passengers.

Keywords: Air transport economics, European Union, European Free Trade Association, Flight ticket taxes, Greening of taxation

Preface

Before you lies the thesis 'European Flight Ticket Taxes: a Green Dream or a Flying Illusion?', my thesis to complete the MSc Urban, Port and Transport Economics at the Erasmus School of Economics. I am grateful for the result and hope you will enjoy reading as much as I enjoyed writing this thesis.

From the start of the MSc, it was clear to me that I wanted to write a thesis on an aviation economics-related topic. This motivation further increased during the course in Air Transport Economics. Moreover, I searched for a societal relevant subject where an economic and a legal viewpoint could be integrated so that I could apply my knowledge obtained during the LLB Tax Law and LLB Law at the Erasmus School of Law. Therefore, I was immediately enthusiastic about the topic of flight ticket taxes, especially due to its relevance in combating climate change. Although this thesis has been written to conclude the MSc Urban, Port and Transport Economics, this thesis feels like an integrated completion of my five years study at the Erasmus University Rotterdam.

I would like to thank Zsolt Csáfordi for his outstanding guidance and his thoughtful advice during this process. Furthermore, I would like to thank Floris de Haan for his insights during the course Air Transport Economics that created my enthusiasm for the air transport sector and his help at the beginning of the process that inspired me to write a thesis related to flight ticket taxes. Besides, I would like to thank Mieke Jansen for all the fruitful sessions during which we worked on and discussed our theses. Lastly, I would like to thank all my friends, fellow students and relatives that supported me in various ways during the writing process and my studies at the Erasmus University Rotterdam.

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List of Used Abbreviations

Abbreviation	Meaning (Translation)
Chicago Convention	Convention on International Civil Aviation, signed in Chicago on 7 December 1944
CO_2	Carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
EEA	European Economic Area
EFTA	European Free Trade Association
ETS Directive	Directive 2008/101/EC of 19 November 2008
EU	European Union
EU ETS	European Union Emissions Trading System
FlugAbgG	Flugabgabegesetz (Austrian Air Transport Levy Act)
FSCs	Full-service carriers
GDP	Gross domestic product
HS	Hub-and-spoke
ICAO	International Civil Aviation Organization
ICAO Taxation Policy	International Civil Aviation Organization's Policies on Taxation in the Field of International Air Transport – Third Edition
Lag om Flygskatt	Lag (2017:1200) om Skatt på Flygresor (Swedish Act on Air Travel Tax)
LCCs	Low-cost carriers
Lov om Afgift af Visse Flyrejser	Lov nr. 389 af 6. Juni 1991 om Afgift af Visse Flyrejser (Danish Act of 6 June 1991 on Air Passenger Tax)
Lov om Særavgifter	Lov 19. Mai 1933 nr. 11 om Særavgifter of Stortingets Avgiftsvedtak (Norwegian Act of 19 Mai 1933 on Excise Duties)
LuftVStG	Luftverkehrsteuergesetz (German Aviation Tax Act)
OLS	Ordinary least squares
PP	Point-to-point
VAT	Value Added Tax
VAT Directive	Directive 2006/112/EC of 28 November 2006
Wbm	Wet Belastingen op Milieugrondslag (Dutch Environmental Taxes Act)

1. Introduction

On November 7th, 2019, a collaboration of nine European Union (EU) Member States presented a joint statement to call for an EU aviation tax (Government of the Netherlands, 2019).[1] They demanded to levy a European aviation tax to create a level playing field in the aviation sector, a sector that has been undertaxed so far and is responsible for 2.5% of the global carbon dioxide (CO_2) emissions according to the statement (Ministers of Finance, 2019). However, no consensus has been reached so far due to differing political opinions and the required unanimous vote of EU Member States (Kavelaars, 2020). Furthermore, other initiatives on an EU level to address the aviation sector, such as the tradable emission allowances of the European Union Emission Trade Scheme (EU ETS), appear to have no significant effect on the aviation market (Anger & Köhler, 2010). Therefore, Member States are dependent on national taxation policy to address the aviation sector.

As a result, several European countries have decided to implement flight ticket taxes in recent decades on a national level for various reasons. Recently, the greening of the tax system – i.e., polluters must compensate for their behaviour – seems to be the most relevant motivator for national governments, whereas the purpose of augmenting the national governments' tax revenue tends to move to the background. Even though the public support for ambitious climate policies has increased due to shifting social norms, the implementation of flight ticket taxes has led to severe national and international criticism stemming from various stakeholders (Gössling, Humpe & Bausch, 2020). For instance, Kavelaars (2020) describes the *Vliegbelasting* (Dutch Aviation Tax) as a form of symbol politics since only an increase in tax revenue and a minimal environmental effect will be achieved. Besides, the disparities between countries will lead to a shift of passengers towards neighbouring countries in border regions instead of a decreasing number of air transport passengers (Falk & Hagsten, 2019). Due to these negative effects, three European countries – out of nine countries that implemented a flight ticket tax – decided to repeal their national flight ticket tax.

Therefore, the research question of this thesis is:

What is the effect of flight ticket taxes on the number of departing air passengers within Europe?

To provide an answer to this research question, the following hypotheses will be tested:

Hypothesis 1a: Levying a flight ticket tax is negatively associated with the number of departing air passengers.

[1] The collaborating EU Member States were Belgium, Bulgaria, Denmark, France, Germany, Italy, The Netherlands, Luxembourg and Sweden.

Hypothesis 1b: The amount of levied flight ticket tax is negatively associated with the number of departing air passengers.

Hypothesis 2a: Hub airports are associated with a smaller decrease of departing air passengers than other airports if a flight ticket tax is levied.

Hypothesis 2b: Hub airports are associated with a smaller decrease of departing air passengers than other airports if a higher amount of flight ticket tax is levied.

Hypothesis 3a: Low-cost airports are associated with a larger decrease of departing air passengers than other airports if a flight ticket tax is levied.

Hypothesis 3b: Low-cost airports are associated with a larger decrease of departing air passengers than other airports if a higher amount of flight ticket tax is levied.

Hypothesis 4a: Airports subject to a flight ticket tax while having a proximate foreign competitor airport not subject to a flight ticket tax are associated with a larger decrease of departing air passengers than other airports.

Hypothesis 4b: Airports subject to a higher flight ticket tax while having a proximate foreign competitor airport not subject to a flight ticket tax are associated with a larger decrease of departing air passengers than other airports.

Hypothesis 5a: Short-haul flights are associated with a larger decrease of departing air passengers than other flights if a flight ticket tax is levied.

Hypothesis 5b: Short-haul flights are associated with a larger decrease of departing air passengers than other flights if a higher amount of flight ticket tax is levied.

To examine the hypotheses, ordinary least squares (OLS) analyses will be performed on a panel dataset containing all departing carried passenger from airports in the European Union and European Free Trade Association (EFTA) within the period 2005-2018.[2]

This research contributes to the existing literature by performing an analysis on a European level, whereas many articles in the field of aviation taxes have a focus on a specific country (e.g., Austria and Germany by Falk & Hagsten, 2019; The Netherlands by Gordijn & Kolkman, 2011; The United Kingdom by Seetaram, Song & Page, 2014). Besides, this thesis will be an addition to the existing literature by performing an extensive over-time analysis based on national legislation for the specific case of flight ticket taxes, in contrast to studies capturing an average effect of all European

[2] Since the scope of this research is 2005-2018, the composition of the EU and EFTA will be considered as the situation was within this timeframe – e.g., the UK is considered a Member State for the entire timeframe and Croatia will be considered as Member State as from 2014.

aviation taxes for a fixed point in time (e.g., European Commission, 2019). Moreover, specific effects for different types of airports and routes will be estimated. The outcomes of this research can be used by policymakers designing a flight ticket tax, which can be considered relevant in the current European environment where multiple countries are implementing, abolishing and amending their taxation policy regarding aviation.

This thesis is structured as follows: firstly, a theoretical framework is constructed where previous literature on flight ticket taxes' economic and legal background is reviewed and hypotheses will be formulated. Secondly, the collection and transformation of the data will be discussed and the data will be described. Thirdly, the econometric approach to test the hypotheses will be elaborated. Fourthly, the results of the empirical analysis will be presented. Finally, the findings and limitations of the research will be discussed. Besides, relevant questions for further research will be formulated.

2. Theoretical Framework

2.1. Taxation on Aviation

2.1.1. Functions of Aviation Taxes

Before diving deeper into the analysis of aviation taxes, the functions that taxes serve in general should be examined. Stevens and De Smit (2017) identify three main functions of taxation: the budgetary, the instrumental and the support function.[3]

Traditionally, taxes are levied to finance government expenditures – i.e., the budgetary function (Stevens & De Smit, 2017). Although aviation taxes are estimated to have a relatively low contribution to a country's tax income in general, several European countries implemented taxation on aviation for budgetary purposes. For instance, the *Vliegbelasting* (Dutch Aviation Tax) is expected to yield 200 million euro in 2021, while the total Dutch government income is estimated at 293 billion euro in the same year (Kavelaars, 2020; Rijksoverheid, n.d.). A special form of budgetary-driven taxation can be observed in France where the *Taxe de soldarité sur les billets d'avion* (French Solidarity Tax on Aircraft Tickets) is levied to contribute to the Solidarity Fund for Development that provides development aid to developing countries in the field of healthcare (Ministère de la Transition Écologique, 2021). The latter tax is an exceptional case since taxes are not earmarked in general – i.e., the revenue collected is not allocated to specific goals (Kavelaars, 2020). Lastly, it should be remarked that even though some countries present aviation taxes under a cloak of environmental policy, these taxes serve budgetary purposes to a large extent in practice, as argued by Chote, Emmerson, Miles and Shaw (2008) regarding *UK's Air passenger duty*.

Besides financing government expenditures, taxation can be implemented to serve as a policy instrument – i.e., the instrumental function (Stevens & De Smit, 2017). For instance, incentives are provided to encourage or discourage certain behaviour by levying a differentiated tax rate, tax object or taxable amount. Nowadays, the instrumental function can be observed in various fields such as transportation, environment and health (e.g., Boyd, Krutilla & Viscusi, 1995; Smed, Jensen & Denver, 2007). In the 1990s, numerous countries have already shown to levy taxes as an integrated part of their policies to combat environmental pollution (Barde & Owens, 1993). This so-called *greening of taxation* has become even more prominent in recent years since climate change became a more urgent topic (Kavelaars, 2020). Moreover, the public support for ambitious climate policies by, amongst others, taxing pollution activities has grown due to shifting social

[3] No elaboration will be provided on the support function of taxation since this function is not relevant for the taxation of aviation. For information on the support function, reference is made to Stevens and De Smit (2017).

norms (Gössling, Humpe & Bausch, 2020). As a result of the greening of taxation by policymakers and increased public acceptance, aviation taxes are considered a justified tool to protect the environment (Álvarez-Albelo, Hernández-Martín & Padrón-Fumero, 2017).

2.1.2. Pigouvian Taxation

The economic justification for levying an instrumental tax on aviation can be found in the market failure caused by the negative externalities of aviation. An *externality* can be defined as a cost or benefit of a transaction incurred by a third party without being included in the market price ("Externality", n.d.). Within the field of aviation, the main externalities are air and noise pollution. For instance, Dings et al. (2002) suggested that noise externalities amount to 5% or 20 to 30% of the price for long-haul and short-haul flights, respectively. Regarding environmental pollution, 3% of the EU's total greenhouse gas emission was attributable directly to aviation in 2016 (Schep, Van Velzen & Faber, 2016). Moreover, this share is expected to increase further since the emissions of carbon dioxide by aviation are growing faster than the total emissions of CO_2 (Bows-Larking, Mander, Traut, Anderson & Wood, 2010). Nevertheless, flight ticket prices do not reflect these negative externalities despite the threats of global warming (Duval, 2013; Dwyer, 2018).

When governments respond to the above-mentioned market failure by setting an instrumental tax, a so-called Pigouvian tax is levied de facto. A Pigouvian tax aims to internalise external costs into the market price (Tax Foundation, n.d.). The intuition behind a Pigouvian tax is graphically depicted in Figure 1. In a market without government intervention, an equilibrium would occur where marginal private costs equal the marginal private benefits. However, if a government sets a tax rate equal to the marginal external cost at the social optimum, a social optimum where the external costs are fully internalised will be achieved (Pigou, 1920). As a result, a net benefit – compared to the private equilibrium – is obtained by the reduction of negative externalities minus the declined consumer surplus due to a higher equilibrium price. Moreover, further welfare gains could be realised depending on the allocation of the tax revenues (Kallbekken, 2013).

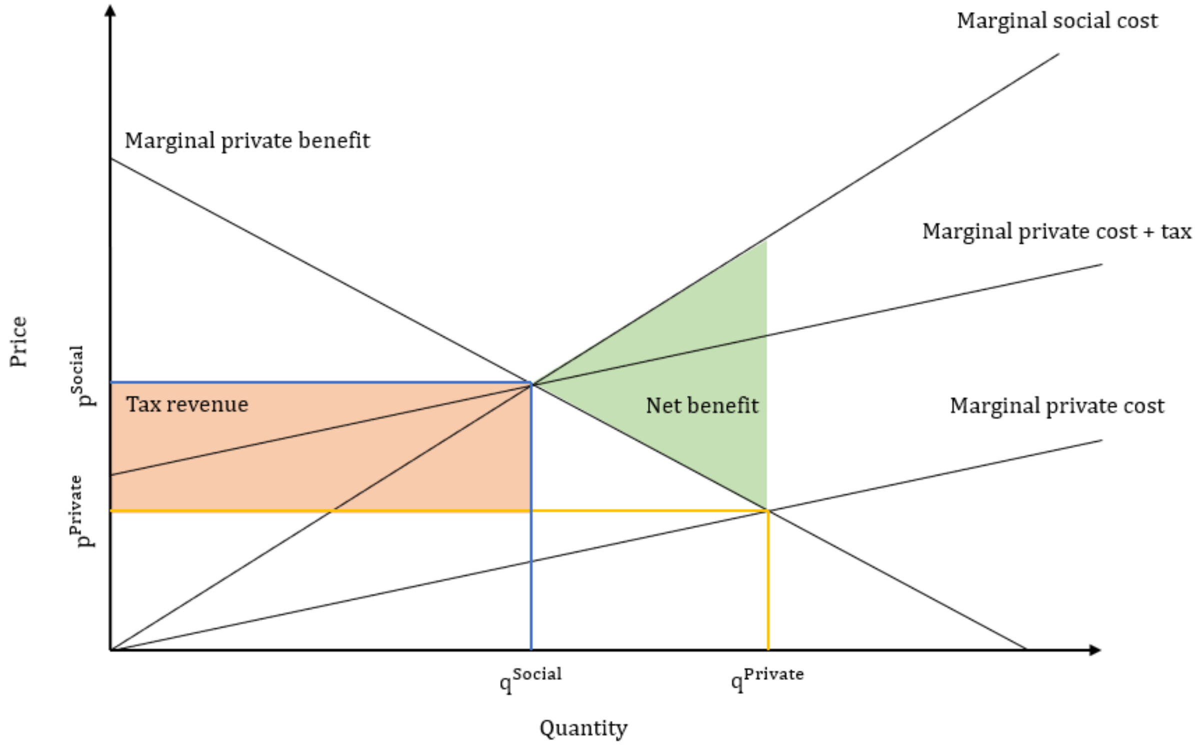

Figure 1: Economic Analysis of Pigouvian Taxation[4]

2.2. Legal Framework

So far, aviation has always had a unique fiscal regime defined by a low level of taxation compared to other economic activities – including other modes of transportation – due to the interaction of national, bilateral, European and supra-national legislation (Faber & Huigen, 2018). The most prominent – but not exclusive – legal barriers in Europe can be found in the Convention on International Aviation (Chicago Convention) that established the International Civil Aviation Organization (ICAO) and the EU VAT Directive[5] supported by ICAO's Policy Document 8632 (ICAO Taxation Policy) (European Union, 2006; ICAO, 2000; ICAO, 2006):

Article 15 Chicago Convention (excerpt): *"No fees, dues or other charges shall be imposed by any contracting State in respect solely of the right of transit over or entry into or exit from its territory of any aircraft of a contracting State or persons or property thereon."*

Article 148 VAT Directive (excerpt): *"Member States shall exempt the following transactions:*

> *(e) the supply of goods for the fuelling and provisioning of aircraft used by airlines operating for reward chiefly on international routes;*

[4] Figure 1 is based on Figure 1 of Kallbekken (2013).
[5] Directive 2006/112/EC of 28 November 2006.

(f) the supply, modification, repair, maintenance, chartering and hiring of the aircraft referred to in point (e), and the supply, hiring, repair and maintenance of equipment incorporated or used therein;

(g) the supply of services, other than those referred to in point (f), to meet the direct needs of the aircraft referred to in point (e) or of their cargoes.''

Article 16 ICAO Taxation Policy (excerpt): *"Since VAT or other consumption taxes are often widely cast by fiscal authorities, with only limited exemptions permitted, the normal practice with respect to the sale or use of international air transport is to zero rate (i.e., where the tax rate is set at zero) rather than specifically exempt international air transport from these consumption taxes.''*

As a result of the above-mentioned regulatory framework, countries should refrain from levying excise duties on aviation fuel and Value Added Tax (VAT) on international flight tickets, amongst others (European Commission, 2019). Therefore, countries have rather limited space for imposing taxation on aviation. Nonetheless, so-called flight ticket taxes seem to be allowed under this strict regime. In this research, *flight ticket taxes* are defined as all taxes imposed on commercial origin-destination passengers departing from an airport in the country where the tax is applied to the benefit of the national or regional government's treasury (European Commission, 2019; Faber & Huigen, 2018). Even though various researchers have shown the sub-optimality of a ticket tax and argued that other forms of taxation provide better incentives for airlines to serve environmental purposes, ticket taxes have been adopted as common practice by various countries last decades (Faber & Huigen, 2018; Kavelaars, 2020).[6]

The introduction of flight ticket taxes has caused a lot of controversy and opposition by airlines, airports and tour operators (Gordijn & Kolkman, 2011). They argue that flight ticket taxes are illegal since they form infringements of several laws and, therefore, started several lawsuits. In the first lawsuit, the Belgian Council of State argued that article 15 of the Chicago Convention does not comprise the prohibition of discriminations of foreign airlines relative to domestic airlines exclusively. They continued by stating that article 15 of the Chicago Convention does entail that no tariffs, dues or other costs can be levied on foreign airlines for just flying over, landing or departing from a treaty country and that the taxes could not be connected to the usage of the airport and airport facilities too (Raad van State, 2005). In contrast, more recent lawsuits confirmed that ticket taxes could be legally implemented under current regulation, but some conditions need to be fulfilled (Faber & Huigen, 2018). For example, the European Court of Justice

[6] An example of such better taxation is a per flight tax that stimulates airlines to use their capacity as efficiently as possible and enables to tax transfer and transit passengers. However, countries are hesitant towards this type of taxation since little is known about the legality yet. Despite this uncertainty, Faber and Huigen (2018) point out some indications favouring and against the legal position of per flight taxes.

stated in the case of the *Irish air travel tax* that tax rate differentiation within the EU contributes to unlawful state aid, but exemptions for transit and transfer passengers are allowed to avoid double taxation (European Court of Justice, 2014). Moreover, the German Fiscal court highlighted that flight ticket taxes could not be linked directly or indirectly to fuel consumption to be in accordance with the Chicago Convention (Hessisches Finanzgericht, 2012). Lastly, the Supreme Court of the Netherlands decided that the *Vliegbelasting* (Dutch Aviation Tax) is not incompatible with article 15 of the Chicago Convention since the term *charges* does only comprise taxes that are in exchange for a certain effort or benefit (Mok, 2009; Hoge Raad der Nederlanden, 2009).

In conclusion, it seems that flight ticket taxes can be implemented as a legal instrument to tax the aviation sector based on the legal framework and case law. However, from an efficiency and effectiveness perspective, criticism occurs regarding the low levels of incentives that stem from this form of taxation compared to other forms.

2.3. Flight Ticket Taxes in Europe

As mentioned in the research question, the territorial scope of this research is Europe. Before having a closer look at the developments of flight ticket taxes, the scope needs to be refined more. Within this research, Europe is defined as all the EU and the EFTA Member States. There are two main reasons to opt for this set of countries. Firstly, provisions regarding the EU's internal market are extended to EFTA Member States (Álvarez López & Rakstelyte, 2020).[7] Especially relevant is that Norway, Iceland and Switzerland are part of the EU's Single Aviation Market, ensuring a level playing field in the air transport market (Debyser & Pernice, 2020). Secondly, EFTA countries form competition with airports located within the EU due to their geographical location. For instance, the Swiss airport of Geneva is a main competitor to the French airport of Lyon (CAPA, 2016).

2.3.1. Developments in Europe

In Europe, several initiatives to deal with the negative externalities of the aviation sector have been implemented. As part of the so-called *Green Deal* – an ambitious package of measures to combat climate change – attempts are made to reduce CO_2 emission at least by 50% by 2030. The most evident step is the EU's ETS Directive[8], including aviation in the EU's Emission Trading System as from 2012 (European Union, 2009). This system works on the so-called *cap and trade principle* that – in line with the Coase Theorem – is based on the idea that a market can solve the market failure due to negative externalities by selling and buying emission allowances resulting

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[7] For the European Economic Area (EEA) Member States Iceland, Liechtenstein and Norway the internal market is extended based on article 217 Treaty on the Functioning of the European Union. For Switzerland, this is the case based on several bilateral agreements.

[8] Directive 2008/101/EC of 19 November 2008.

in an efficient allocation of emission rights given a certain cap (Coase, 1937; European Commission, n.d.).

According to Anger and Köhler (2010), such a trading scheme has the potential to change travel behaviour in the short and medium run and foster technological changes in the long term without reducing the competitiveness of countries and companies. However, multiple articles have demonstrated that the inclusion of aviation in the EU ETS will not reduce the growing air transport demand or CO_2 emissions significantly due to the relatively low share of aviation within the EU ETS and the low price of emissions allowances because of this framework (e.g., Anger & Köhler, 2010; Kavelaars, 2020). On the contrary, they argued that a closed trading scheme solely for aviation is likely to have these effects.

Besides the market-based mechanism introduced by the EU, the ICAO is developing such a system as well. Resolution A40-19 introduced the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to globally achieve carbon-neutral growth (ICAO, 2019). Currently, CORSIA is still in its pilot phase, where countries can opt to participate voluntarily. As from 2027, CORSIA starts its second phase, where participation under some conditions is mandatory (ICAO, n.d.).

Besides these non-fiscal instruments, increasing attention is paid to a European aviation tax. As mentioned in the introduction, a collaboration of nine EU Member States presented a joint statement to call for European taxation of aviation in November 2019 (Government of the Netherlands, 2019). So far, higher taxes on polluting industries have been a hotly discussed topic amongst EU Member States and unanimity is required when deciding on policy instruments such as taxation (Ekblom, 2019). Due to the required unanimity and differing political views, taxation on a European level seems to be not feasible at this moment (Kavelaars, 2020).

2.3.2. Developments on a Single Country Level

Despite the efforts made on a European level, no consensus has been reached so far concerning flight ticket taxes. Therefore, countries are involved in setting flight ticket taxes on a national level. This section presents a brief overview of countries introducing, amending and abolishing flight ticket taxes.[9]

Germany – Luftverkehrsteuer

As from January 2011, the *Luftverkehrsteuer* (German Aviation Tax) is implemented. This tax was part of an extensive saving plan to recover from the economic crisis (Gordijn & Kolkman, 2011). Although the Luftverkehrsteuer was initially implemented for budgetary purposes, the German

[9] Amendments to flight ticket taxes as a response to the COVID-19 pandemic are not considered.

government augmented the tax rate from April 1st, 2020, onwards to meet their climate goals (Zoll, n.d.).

Austria – Flugabgabe

After Germany's announcement to introduce the Luftverkehrsteuer, the Austrian government decided to follow its neighbour by levying *Flugabgabe* (Austrian Air Transport Levy) as from April 2011 (Gordijn & Kolkman, 2011). Nonetheless, the Austrian government decided to reduce the tax rate significantly as from 2018 and, ultimately, imposed a uniform tax rate as from September 2020 – with a small exception for ultra-short haul flights – to protect the competitive position of Vienna airport relative to other hubs and the neighbouring Slovakian airport of Bratislava (Hodoschek, 2016).

Ireland – Air travel tax

As part of the Irish budget for 2009, the *Irish* a*ir travel tax* was effective as from March 30th, 2009. This flight ticket tax had a unique tax rate differentiation where all flight departing from Dublin airport were facing a higher rate than flights departing from other Irish airports (Veldhuis & Zuidberg, 2009). However, this distinction was judged unlawful since unlawful state aid was provided to domestic airlines (European Union, 2013). As from that judgement, a flat rate was applied (Faber & Huigen, 2018). Ultimately, the *Irish air travel tax* was abolished in April 2014 (BBC, 2013).

Norway – Flypassasjeravgift

Norway can be considered a pioneer in the field of aviation taxes. As early as 1978, the Norwegian government introduced a tax on charter flights. In the meantime, several taxes were implemented on different taxable objects and, consequently, abolished. Since Norway is not an EU member, they could experiment with a fuel tax as introduced in 1999 (OECD, 2005). On December 14th, 2015, the Norwegian parliament decided to implement a flight ticket tax as from 2016 for commercial flights consisting of a single tax rate, the so-called *Flypassasjeravgift* (Norwegian Air Passenger Tax) (Regjeringen, 2018; Skatteetaten, n.d.). As from April 2019, a differentiated tax rate is levied to emphasise the environmental function (Skatteetaten, 2018). At first, the implementation was obstructed by the EFTA Surveillance Authority, suspecting unlawful state aid resulting from the exemption for transfer passengers. Nevertheless, the EFTA Surveillance Authority judged that the exemption did not provide illegal state aid and, consequently, the flight ticket tax went into force on June 1st, 2016 (Skatteetaten, n.d.).

The Netherlands – Vliegbelasting

In July 2008, the Dutch government implemented the *Vliegbelasting* (Dutch Aviation Tax) to green the tax system (Gordijn & Kolkman, 2011). Due to the economic crisis and defection to Belgian and German airports, the *Vliegbelasting* was abolished in July 2009 and, thereby, is the record holder of being the tax with the shortest existence in the Netherlands (Gordijn & Kolkman, 2011; Kavelaars, 2020). Nevertheless, the Dutch parliament accepted an act to re-introduce the *Vliegbelasting* as from 2021. This flight ticket tax is implemented on the conditions that a European tax should prevail, airports sensitive to substitution by neighbouring countries are monitored strictly and further research is performed on incentivising usage of international train connections (Vakstudie Nieuws, 2020).

Sweden – Flygskatt

Since April 2018, the Swedish government decided to levy *Flygskatt* (Swedish Tax on Air Travel). In line with its instrumental purpose, a three-level distinction is made with regard to the tax rate depending on the destination (Skatteverket, n.d.). In response to the implementation of this tax, severe criticism appears. For instance, Lindman & Stage (2018) argue that Swedish inhabitants living in rural areas will be severely affected since they do not have an alternative for air travel.

United Kingdom – Air passenger duty, Air departure tax & UK emission trade scheme

The UK was one of the first European countries to introduce a flight ticket tax in 1994 (Gordijn & Kolkman, 2011). The motivation for introducing the *UK's Air passenger duty* was compensating for the under-taxed position of aviation compared to private means of transportation (Chote et al., 2008). The tax is differentiated based on destination and travel class (BBC, 2020). Moreover, plans are made to introduce a *Scottish air departure tax* to partially replace the *UK's Air passenger duty* to account for the special position of the Scottish Highlands and Islands with regard to connectivity (Scottish Government, n.d.). Although the Scottish Parliament passed the act in 2017, the *Scottish air departure* tax has not entered into force yet (Revenue Scotland, n.d.). Since the UK left the EU, they are no longer involved in EU ETS. However, they replaced the EU ETS for a national UK emission trade scheme to further augment the UK's ambition for a carbon pricing policy (Department for Business, Energy & Industrial Strategy, 2021).

France – Taxe de l'aviation civile, Taxe de solidarité sur les billets d'avion, Taxe d'aéroport & Taxe sur les nuisances sonores aériennes

Undoubtedly, France is the country using the highest quantity of tax instruments to address aviation. The eldest form is the in 1999 introduced *Taxe de l'aviation civil* (French Civil Aviation Tax), a flight ticket tax differentiated based on a flight's destination (FCC Aviation, n.d.). Furthermore, the *Taxe de solidarité sur les billets d'avion* (French Solidarity Tax) is levied from 2006 to contribute to the French Solidarity Fund for Development. The rate is differentiated based on destination and travel class. Lastly, a *Taxe d'aéroport* (French Airport Tax) and *Taxe sur les nuisances sonores aériennes* (French Airport Tax) are levied to raise tax revenue based on the size of an airport and noise emission (Ministère de la Transition Écologique, 2021).

Denmark – Passagerafgiften

Denmark is comparable to the UK and Norway by being one of the first countries in Europe to levy a flight tax. The Danish government introduced the *Charterafgiften* (Danish Charter Tax) as early as 1977 (Regeringens Økonomiudvalg, 2005). In 2005, the Danish government abolished and changed the Danish Charter tax into a more general flight ticket tax called *Passagerafgiften* (Danish Air Passenger Tax). Initially, there was a uniform tax rate on international flights. However, the EU Commission judged that domestic flights should be included to prevent disturbance of the internal market (Regeringens Økonomiudvalg, 2005). Furthermore, adjustments to tax rate were made to incorporate the exceptional position of several Danish airports. In 2006, the tax rate of 75 Danish crowns was reduced by 50% and, ultimately, abolished in 2007.

Switzerland – Flugticketabgabe & Swiss emission trading scheme

Currently, there is no flight ticket tax in force in Switzerland on commercial aviation. However, under the pressure of Paris climate goals, the Swiss government plans to levy a distance differentiated *Flugticketabgabe* (Swiss Ticket Tax) as from 2022 (FCC Aviation, n.d.). Noteworthy is that the Swiss government is planning to earmark the revenue to subsidise airlines investing in sustainable aviation fuel (Die Bundesversammlung, 2020). Besides, as a non-EU Member State, Switzerland established a Swiss emission trading scheme and agreed to link it as an integral part of the EU ETS (European Union, 2017).

Belgium – Vliegbelasting Zaventem

In 1996-2000, the *Vliegbelasting Zaventem* (Zaventem's Ticket Tax) was levied by the municipality of Zaventem on all passengers departing from Brussels National Airport (Faber & Huigen, 2018). A lawsuit was started and the tax was judged unlawful since it infringed article 15 of the Chicago Convention (Raad van State, 2005). This tax will not be considered since it falls outside the time scope of this research and is judged unlawful.

Italy – Imposta erariale sui voli dei passeggeri di aerotaxi

Italy is levying *Imposta erariale sui voli dei passeggeri di aerotaxi* (Italian Air Taxi Tax). This tax will not be considered since it is only imposed on passengers flying executive air charter flights (Ministero dell'Economia e delle finanze, n.d.).

A summary and graphical overview are provided in Table 1 and Figure 2, respectively, to summarise the European flight ticket taxes within 2005-2018.

Table 1: Summary of Flight Ticket Taxes (2005-2018)

Country	Flight ticket tax	Time period	Tax rate structure
Austria	Flugabgabe	04/2011 – end of timeframe	3 level differentiation based on distance
Denmark	Passagerafgiften	Beginning of time frame – 12/2006	Uniform tax rate
France	Taxe de l'aviation civile	Entire timeframe	3 level differentiation based on distance
	Taxe de solidarité sur les billets d'avion	06/2006 – end of timeframe	4 level differentiation based on distance and travel class
	Taxes d'aéroport	Entire timeframe	3 level differentiation based on airport of departure
	Taxe sur les nuisances sonores aériennes	Entire timeframe	3 level differentiation based on airport of departure
Germany	Luftverkehrsteuer	01/2011 – end of timeframe	3 level differentiation based on distance
Ireland	Air travel tax	04/2009 – 03/2014	April 2009 – February 2011: 2 level differentiation based on distance March 2011 – March 2014: uniform tax rate
The Netherlands	Vliegbelasting	07/2008 – 06/2009	2 level differentiation based on distance
Norway	Flypassasjeravgift	06/2016 – end of timeframe	Uniform tax rate
Sweden	Flyskatt	04/2018 – end of timeframe	3 level differentiated based on distance
United Kingdom	Air passenger duty	Entire timeframe	4 level differentiation based on distance and travel class

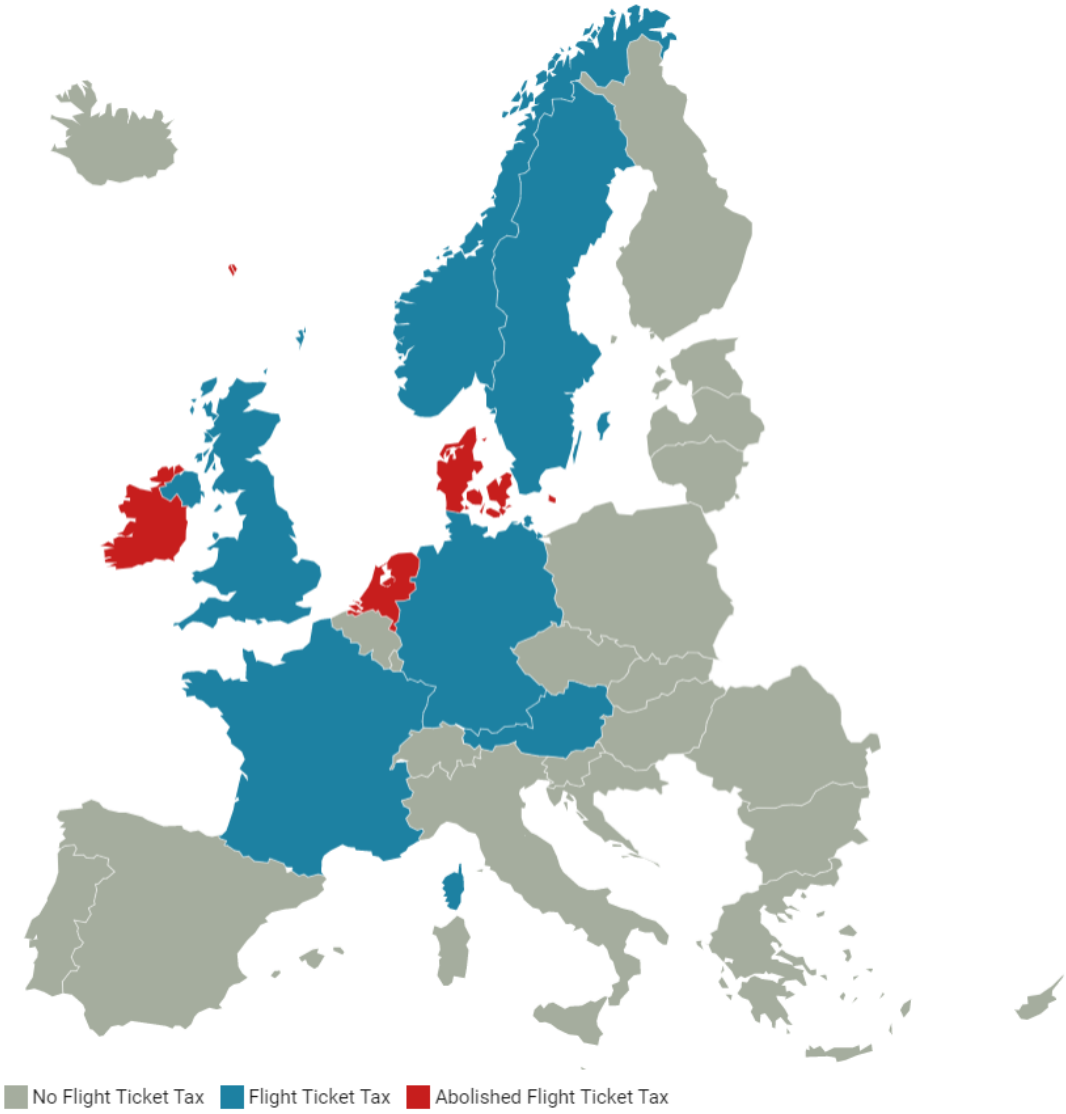

Figure 2: Flight Ticket Taxes in Europe (2005-2018)

2.4. Economic Consequences of Flight Ticket Taxes

The introduction of a flight ticket tax can cause multiple effects within the market for air passenger transport. Douben (1969) distinguished three main effects resulting from taxation: passing through of taxation, avoidance of taxation and compensation of taxation.[10]

2.4.1. Passing Through of Taxation – Income Effect

The first effect that may occur as a response to flight ticket taxes is the so-called income effect. The income effect entails, in this case, a change in demand for flight tickets due to changing purchasing power caused by higher fares (Estevez, 2021). To determine the rise of a fare, a distinction needs to be made between the taxation's legal and economic incidence. The legal tax incidence is the subject obliged to pay the taxes by law – i.e., the subject that pays taxes *de jure*. In contrast, the economic tax incidence is the subject who experiences a decrease in disposable income or profit – i.e., the subject that pays taxes *de facto* (Entin, 2004). In the case of flight ticket taxes, legal tax incidence is primarily assigned to airlines who are obliged to monitor and pay taxes to the national tax authorities. The extent to which airlines pass through the flight ticket taxes is more difficult to assign and depends on multiple factors such a market power and type of market (European Commission, 2019). The academic literature provides multiple perspectives on this topic. For instance, Boon, Davidson, Faber and Van Velzen (2007) argue that the aviation market demonstrates a Bertrand-alike competition, resulting in cost-pass through rates of 100%. On the other hand, Koopmans and Lieshout (2016) show that, assuming the aviation market has a Cournot-alike competition, industry-wide costs will be passed through to the passengers by more than 50%.

Once a part of the flight ticket tax is passed through to the consumers, the decrease in demand is determined by the price elasticity of demand in the air transport market. As shown in Equation 1, the price elasticity shows how sensitive the quantity demanded in a market reacts to a changing price.

$$\varepsilon_{Demand} = \frac{\Delta Quantity}{\Delta Price} * \frac{Price}{Quantity}$$

Equation 1: Price Elasticity of Demand

[10] In this research, compensation of taxation – increasing the taxed activity to compensate for tax burden – will not be discussed since no proof or suggestion is found in the academic literature that this practice is present in the air passenger transport market.

The price elasticity for air transport has been researched by many studies and showed high heterogeneity across various types of passengers and airports (Falk & Hagsten, 2019). Goetz and Vowles (2009) argued that the demand for air travel is relatively elastic in general and, therefore, substantial increases in flight ticket prices will have a negative effect on demand. An example is provided by Gurr and Moser (2017), analysing that an increase of the *Luftverkehrsteuer* (German Aviation Tax) by 1 euro is associated with a decrease of 0.2% in boarding passengers. Therefore, the first hypotheses are:

Hypothesis 1a: Levying a flight ticket tax is negatively associated with the number of departing air passengers.

Hypothesis 1b: The amount of levied flight ticket tax is negatively associated with the number of departing air passengers.

Traditionally, two airline business models can be distinguished in the airline industry: hub-and-spoke (HS) and point-to-point (PP). When having an HS network, airlines have a central airport, the so-called hub, through which all other airports are connected. In a PP network, airlines operate without a hub and fly directly to the destinations served (Alderighi, Cento, Nijkamp & Rietveld, 2007). The business models are graphically described in Figure 3. As a result of the unique function of the hub, a high share of transfer passengers will travel via the hub airport to reach their destination.

Transfer passengers have an interesting position within the legal framework of flight ticket taxes since they are exempted from taxation. This exemption is justified by the avoidance of double taxation. However, as illustrated in Figure 4, the opposite effect – no taxation at all or a lower level of taxation – may occur in some situations due to the transfer passenger exemption when the first part of an indirect flight is not subject to tax or subject to lower tax. Several critical remarks have been placed on this practice. For instance, after implementing the *Vliegbelasting* (Dutch Aviation Tax), the number of origin-destination passengers started to decrease, whereas the number of transfer passengers continued growing at Amsterdam Schiphol Airport (Gordijn & Kolkman, 2011). In response, the Dutch consumers' association started a petition to include transfer passengers since the taxation should benefit the environment (Gordijn & Kolkman, 2011). Therefore, the second hypotheses are:

Hypothesis 2a: Hub airports are associated with a smaller decrease of departing air passengers than other airports if a flight ticket tax is levied.

Hypothesis 2b: Hub airports are associated with a smaller decrease of departing air passengers than other airports if a higher amount of flight ticket tax is levied.

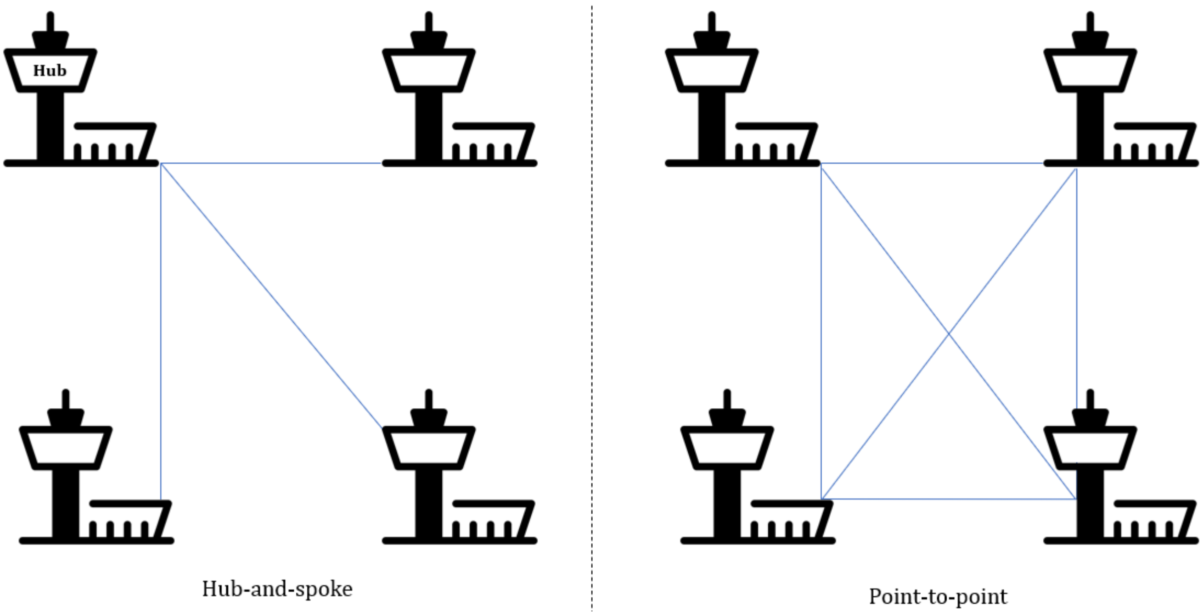

Figure 3: Hub-and-Spoke and Point-to-Point Network

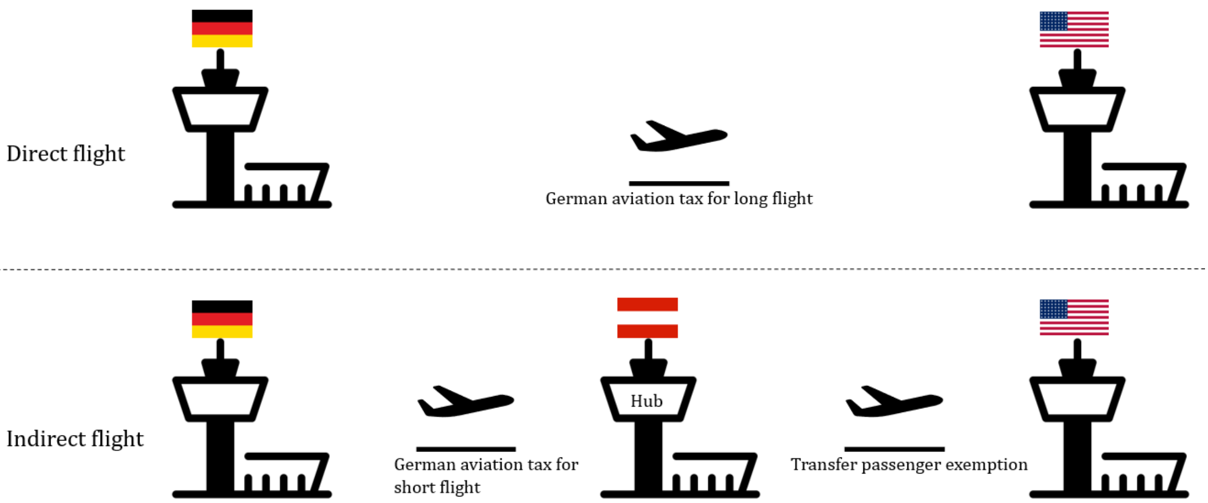

Figure 4: Example of the Transfer Passenger Exemption

With the distinction in airlines' business model, a differentiation of airlines can be made. The first type of airlines are the full-service carriers (FSCs) such as British Airways and Lufthansa. This type of airline is characterised by, amongst others, HS networks operating into primary airports, high service quality and complex fare structures. The second type of airlines are the low-cost carriers (LCCs) such as EasyJet and Ryanair. LCCs typically operate a PP network, have low fares, have short stopovers and operate mainly into secondary airports (O'Connell & Williams, 2005). Those secondary airports served to a large extent by LCCs are also known as low-cost airports.

The literature indicates that passengers served by LCCs are more sensitive to price increases. Falk and Hagsten (2019) estimated that a decrease in departing passengers caused by Germany's and Austria's flight ticket taxes was predominantly driven by a reduction of LCCs' passengers. This finding could be illustrated by Ryanair scrapping 150 of 532 flights per week from Frankfurt Hahn

Airport and cancelling several flights departing from Weeze Airport (Gordijn & Kolkman, 2011). Furthermore, Zuidberg (2015) argues that LCCs are more likely to stop certain operations when facing taxation since they have fewer opportunities of passing through the tax burden onto the passengers. Therefore, the third hypotheses are:

Hypothesis 3a: Low-cost airports are associated with a larger decrease of departing air passengers than other airports if a flight ticket tax is levied.

Hypothesis 3b: Low-cost airports are associated with a larger decrease of departing air passengers than other airports if a higher amount of flight ticket tax is levied.

2.4.2. Avoidance of Taxation – Substitution Effect

The second effect that may occur as a result of flight ticket taxes is the so-called substitution effect. The substitution effect, in this case, entails a change in demand for flight tickets due to consumers switching to relatively cheaper alternatives (Boyle, 2021). The magnitude of the substitution of flights caused by an increased price is determined by the cross elasticity of demand in the air transport market. As shown in Equation 2, the cross elasticity of demand shows the change in quantity demanded of good Y in response to a changing price of good X. When product X and Y are substitutes, the cross elasticity of demand has a positive value indicating a negative relationship – i.e., if good X becomes more expensive, consumers will demand a higher quantity of good Y.

$$\varepsilon_{XY} = \frac{\Delta Quantity_X}{\Delta Price_Y} * \frac{Price_Y}{Quantity_X}$$

Equation 2: Cross Elasticity of Demand

The first form of substitution identified is the shift of passengers from a domestic airport to a proximate airport located in a foreign country. This substitution is driven by the disparities in the national government's flight ticket tax policy and could be avoided by a unified European-level taxation policy. This effect of flight ticket taxes has been an important topic of discussion and research last decades. Wojahn (2010) argued that the efficiency of instrumental taxes is reduced by one third due to the international leakage effects. Furthermore, the European Commission (2019) warned that flight ticket taxes levied on a unilateral level could deteriorate a country's connectivity and competitiveness. This has been a major reason to abolish flight ticket taxes or to grant airports nearby borders an exceptional tax position.

When looking at evaluations of current and past national flight ticket taxes, strong indications are found regarding defection to foreign airports. A study conducted by the German State of Rheinland-Pfalz demonstrated that out of the 5 million passengers decrease at Frankfurt Hahn Airport, 1.8 million passengers opted to depart from a foreign airport (Berster et al., 2010). Furthermore, after the implementation of the Dutch Aviation Tax, decreasing passenger volumes at, especially, Amsterdam Schiphol Airport and Maastricht-Aachen Airport were observed, while several German and Belgium airports faced a strong increase of Dutch passengers (Veldhuis, 2009). These shifts can be considered even more problematic since movements of passengers to foreign airports may have long-term effects – even if a national flight tax is abolished or a foreign country introduced a flight ticket tax due – to learning effects (Gordijn & Kolkman, 2011).

Besides the initial shift of passengers driven by tax disparities, the shift has become more eminent due to foreign airlines, airports and travel agencies deploying marketing strategies and publicity paying attention to flight ticket taxes. For instance, since October 2010, Transavia – a Dutch airline – advertises on German sites explicitly stating that no German Aviation Tax will be levied on flights departing from The Netherlands (Gordijn & Kolkman, 2011).

As argued, substitution to foreign airports is largely dependent on the foreign country's tax policy and the reaction of foreign market players in the air transport market. For instance, the fact that Germany has a flight ticket in force was a prerequisite for the Dutch government to re-implement the Dutch Aviation Tax (Tweede Kamer der Staten-Generaal, 2019). Therefore, one could argue that countries are stuck in a prisoner's dilemma: from a societal and environmental it is efficient to implement flight ticket taxes. However, the dominant strategy is not implementing a flight ticket tax because of international leakage effects (Krenek & Schratzenstaller, 2017). Therefore, the fourth hypotheses are:

Hypothesis 4a: Airports subject to a flight ticket tax while having a proximate foreign competitor airport not subject to a flight ticket tax are associated with a larger decrease of departing air passengers than other airports.

Hypothesis 4b: Airports subject to a higher flight ticket tax while having a proximate foreign competitor airport not subject to a flight ticket tax are associated with a larger decrease of departing air passengers than other airports.

In 1994-2004, the average annual growth rate of high-speed rail passengers was 15.6% and, even though maturity effects are observed, demand for high-speed rail travel will augment further (Campos & De Rus, 2009). For example, Kroes and Savelberg (2019) predict – assuming a further reduction of train travel time and increased frequency of train operations – a reduction of 2.5% to 5% of all flight movements at Amsterdam Schiphol Airport attributable to the substitution by high-speed train connections. This development has created a second substitution effect to air transport, namely shift of transport mode. Whereas substitution by foreign airports was considered problematic due to undermining of the flight ticket tax's environmental function and harm to national connectivity, substitution by train is perceived more desirable since it provides a more environmentally friendly mode of transport (Clewlow, Sussman & Balakrishnan, 2014).

Although the shift of transport is considered preferable, some substantial limitations are in place. Firstly, there is a constraint regarding the distance. Several studies concluded that high-speed rail transport provides effective competition to air transport in short-haul markets up to 500 kilometres but very little to no competition is provided by train travel in medium-haul and long-haul markets (GAO, 2009). This finding is supported by Falk and Hagsten (2019), demonstrating long-haul travellers to be relatively price inelastic due to the lack of alternatives, whereas short-haul travellers show stronger demand effects due to the availability of other means of transportation. Secondly, substitution by high-speed rail travel is highly dependent on airport and city characteristics such as the geographical location and infrastructure (Clewlow, Sussman & Balakrishnan, 2014). Thirdly, a large share of the (ultra) short-haul flight passengers consists of transfer passengers. Their short flights serve to feed or de-feed a hub airport. Train travel has a disadvantage compared to an inter-terminal flight transfer due to more travel time and inconvenience. Therefore, so-called open transit areas between aviation and railway sectors on airports should be integrated. Although Lufthansa and Deutsche Bahn – a German airline and German rail operator, respectively – corporate on transporting passenger between their hubs of Frankfurt Airport and Munich Airport, these collaborations and open transit areas are no common practice within Europe (Van Donselaar, 2021).

Besides the market-driven developments, several national governments are setting policies to incentivise other modes of transport further. The most prominent example is the French government prohibiting short domestic flights recently (Reuters, 2021). Furthermore, several European countries implemented subsidies or tax reductions to train travel. Lastly, a unique tax rate structure can be observed in Austria, where a higher tax rate is in place for flights shorter than 350 kilometres, whereas the general practice in Europe is to have a higher rate if the distance increases (BGBI, 2020). Therefore, the fifth hypotheses are:

Hypothesis 5a: Short-haul flights are associated with a larger decrease of departing air passengers than other flights if a flight ticket tax is levied.

Hypothesis 5b: Short-haul flights are associated with a larger decrease of departing air passengers than other flights if a higher amount of flight ticket tax is levied.

3. Data

3.1. Dependent Variable

Departing Air Passengers

In this research, *Departing Air Passengers* is the dependent variables in the analysis. For all EU and EFTA Member States, data on air passenger transport between the main airports in the respective country and their main partner airports is retrieved from Eurostat (2021).[11] This database contains data on 'commercial air services and civil aircraft movements for the airports with traffic in excess of 15,000 passenger units annually' (Eurostat, 2021). Although data is available until very present times, data is retrieved up to and including 2018 to exclude the disturbing effects of the COVID-19 pandemic on air travel and national taxation policies. The beginning of the time frame retrieved is 2005.

The data is aggregated on a route level – i.e., number of passengers from airport X to airport Y. With regard to time, data is retrieved aggregated on a monthly level. The unit of measurement applied is the number of departing passengers carried. This measure includes all passengers on a specific flight counted only once and not for every single stage of a flight. Hence, direct transit passengers are excluded.

Several data transformations and cleaning operations have been performed. The most important amendments are:

- Observations where NA is reported are excluded from the dataset;
- Routes starting in the United Kingdom and France are excluded since it was not possible to assign the correct amount of taxation due to the differentiation on travel class;[12]
- Routes starting in the Czech Republic are excluded since these routes are only reported on a more aggregated level – i.e., airport-to-country level;
- Routes to unspecified countries and/or to unspecified airports are excluded;
- Several airports have been adjusted since their ICAO codes have changed over time or were not reported consistently by some countries. A complete overview is provided in Appendix A; and
- Several airports are excluded since it was impossible to match the reported ICAO codes with an airport. A complete overview of excluded airports is provided in Appendix A.

[11] Main (partner) airports are all airports handling over 15,000 passengers yearly.

[12] This practice is not considered problematic with respect to the examination of whether flight ticket taxes have an effect at all, because these countries had a flight ticket tax in force during the entire timeframe and, therefore, will not contribute to the identification of this effect when country-level, airport-level or route-level fixed effects are applied.

Resultingly, a dataset of 502,494 observations was created consisting of 209 unique airports of departure located in 27 countries and 465 unique airports of arrival located in 112 countries.

3.2. Independent Variables

To test the hypotheses, several independent variables are retrieved and created. Moreover, several control variables are included in the analysis. At the end of this section, all variables are summarised in Table 2 and descriptive statistics are provided in Table 3.

Flight Ticket Tax Policy

To capture the national flight ticket tax policy, a comprehensive analysis of national legislation has been performed as described in Appendix B. Based on this data, two variables are created to proxy flight ticket taxes. Firstly, *Tax Dummy* is created, a dummy indicating whether a flight ticket tax was in force at a given point in time in a specific country. By indicating the presence of a flight ticket tax, there is adhered to the economic presence of a flight ticket tax instead of the legal presence – e.g., the period when the Dutch Aviation Tax was in force, but the tax rate was equal to €0,00 is not considered. Secondly, *Tax Amount* is constructed, a continuous variable indicating the amount of flight ticket tax levied on a specific flight route for a given point in time.

Since Denmark, Norway and Sweden do not have the euro as currency, *Tax Amount* is converted to the euro for these countries. Data on exchange rates of the Danish Krone, Norwegian Krone and Swedish Krona is retrieved from the European Central Bank (n.d.). The average euro foreign exchange reference rate of a particular year or part of a year where tax levied is used for conversion. The average rate is considered an appropriate measure since all exchange rates were relatively stable and no outliers were observed. The applied exchange rates and corresponding statistics can be found in Appendix C.

Hub Airport

To identify hub airports, data is retrieved from the OAG (2019). The dummy *Hub Airport* is created and indicates if an airport is included in the OAG's 2019 Megahub Index Top 50 for international airports. The index is calculated based on 'the total number of all possible connections between inbound and outbound flights within a six-hour window, where either inbound, outbound, or both flights are international, at the largest and busiest 200 airports in the world' (OAG, 2019). Besides, a maximum circuity factor of 1.5 is used as a constraint – i.e., relevant transfer markets are assumed to exist when the total travel time of an indirect flight does not exceed the time of direct flight by a factor of 1.5. In total, eleven European airports are listed in this top 50 and are summarised in Appendix D.

Low-cost Airport

In previous research, low-cost airports are described as secondary or regional airports used to have underutilised capacity but are fully functional with minor commercial services (Jimenez & Suau-Sanchez, 2020). A further specification is given by Barrett (2004), who listed the seven most essential airport characteristics for low-cost airlines: 'low airport charges, quick turnaround time, singly-storey airport terminals, quick check-in, good catering and shopping facilities, good facilities for ground transport and no business class lounges'.

Unfortunately, there is no publicly available data indicating the share of flights operated by LCCs at an airport. Therefore, an approach similar to Falk and Hagsten (2019), who operationalised low-cost airports as airports served by Ryanair, will be applied. Nonetheless, this research's approach differs in certain aspects. Firstly, the main LCCs serving the European air transport market are identified. Casey (2017) found that Ryanair, EasyJet, Vueling and Wizz Air are the LCCs with the largest market shares in Europe. These airlines had a market share in terms of available seats – relatively to the total number of seats offered in Europe by all airlines – of 9.86%, 6.54%, 2.84% and 2.27%, respectively, in July 2017. However, only Ryanair and Wizz Air will be considered for the operationalisation since EasyJet and Vueling concentrate their capacity in larger (primary) airports (Jimenez & Suau-Sanchez, 2020). Secondly, airports will be considered a low-cost airport when Ryanair or Wizz Air served at least three destinations from that airport in 2018. By doing so, primary airports such as Amsterdam Schiphol and Munich Airport served by a low number of Ryanair or Wizz Air flights are excluded.

Summarising, the dummy *Low-cost Airport* has a value of one when Ryanair or Wizz Air serves an airport by at least three routes in 2018. The data is retrieved from Ryanair (n.d.) and Wizz Air (n.d.). The selected airports are summarised in Appendix E.

Competition of Foreign Airports

When identifying international competition, the *Contested Airport* is defined as the airport assumed to face a decrease in passengers due to foreign substitution. The *Contesting Airport* is defined as the airport assumed to face an increase in passenger due to foreign substitution. In line with Falk and Hagsten (2019), the catchment area of contested airports is set at 150 kilometres. To proxy airports challenged by international competition, the dummy *Competition of Foreign Airports* is created. This dummy has a value of 1 if the following two conditions are met:

- A flight ticket tax is in force in the country of the contested airport; and
- For all airports located within 150 kilometres from the contested airport and in a different country than the country of the contested airport, there is no flight ticket tax in force.

To determine the locations of and, consequently, the distance between airports, the R package Airportr version 0.1.3 is used (Shkolnik, 2019). The package provides information on the latitude and longitude of airports based on the OpenFlights Database (OpenFlights, 2017). In Section 4, information on how the distance between airports is calculated and formulas to calculate the value of *Competition of Foreign Airports* are provided.

All contested and contesting airports are depicted in Figure 5 and summarised in Appendix F.

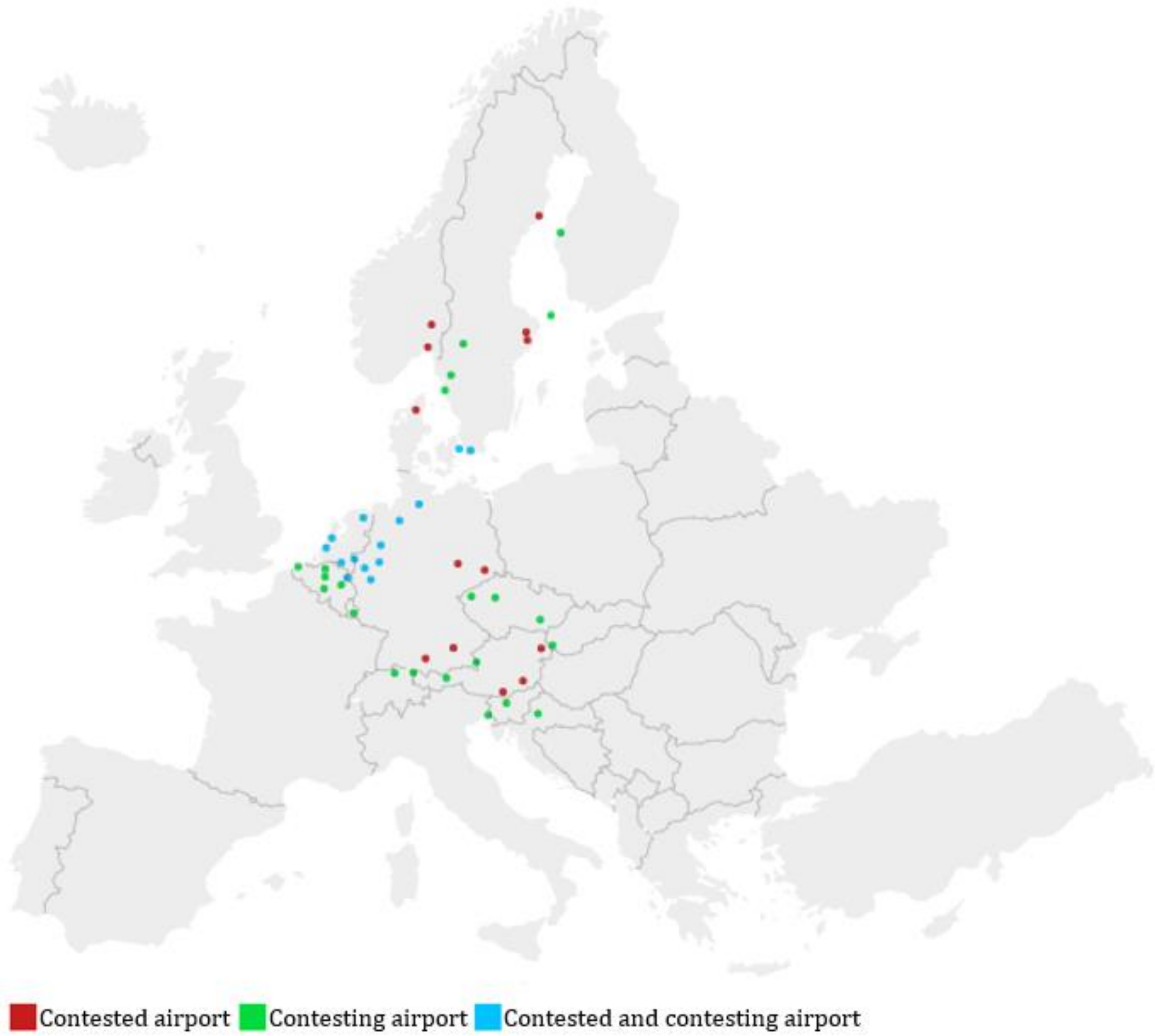

Figure 5: Competition of Foreign Airports

Short-haul Flights

In the academic and grey literature, no unified definition of short-haul flights is provided. In this research, short-haul flights are defined as routes shorter than 500 kilometres since this is considered the constraint to which rail transport forms a competitor to air transport (GAO, 2009).

To operationalise this definition, the dummy *Short-haul* is created, indicating whether the distance-related constraint is met.[13]

To determine the distance of a route, the same approach is used as for the *Competition of Foreign Airports* variable.

Control Variables

In addition to the above-mentioned variables, control variables will be added to the analysis. Firstly, the demand for air transport has shown strong relations with socio-economics variables such as the gross domestic product (GDP) in previous research (e.g., Goetz & Vowles, 2009). In traditional economic literature, it is commonly assumed when analysing bilateral trade flows that the 'gravitational force between two objects is directly proportional to the product of the masses of the objects and inversely proportional to the geographical distance between them' (Burger, Van Oort & Linders, 2009). This relationship is shown in Equation 3.

$$I_{ij} = \beta_0 * \frac{M_i^{\beta_1} * M_j^{\beta_2}}{D_{ij}^{\beta_3}}$$

Equation 3: Gravity Model

In this equation, I_{ij} denotes the bilateral interaction intensity of countries *i* and *j*, M_x denotes the mass of country *x* – e.g., the gross domestic product or population – and D_{ij} denotes the distance between countries *i* and *j*.

Based on this basic model, several different applications of the gravity model have been examined. Boonekamp, Zuidberg and Burghouwt (2018) have applied the gravity model to estimate the annual number of passengers between pairs of airports. Based on their model, a gravity model is created to control for developments in the intensity of air transport caused by changes in gross domestic product and population. In Equation 4 and Equation 5, the gravity model applied in this research is shown.

$$Intensity_{ijt} = \frac{GDP_{at} * GDP_{bt}}{D_{ij}}$$

Equation 4: Gravity Model for Air Transport

[13] In the analysis, it was tested whether an additional dummy indicating ultra-short flights would yield a significant distinction between short-haul and ultra short-haul flights. However, no significant effects or changes to other variables were found. Therefore, the distinction between short-haul and ultra short-haul flights is not considered in this research. For the definition of ultra short-haul flights, linkage was made to the Austrian policy, stating that routes up to 350 kilometres can be easily substituted by rail transport.

To obtain a linear model, the natural logarithm is taken of both sides of the equation, as Grosche, Rothlauf and Heinzl (2007) demonstrated. This resulted in the following equation:

$$Ln(Intensity\ of\ Air\ Transport_{ijt}) = ln(GDP_{at}) + ln(GDP_{bt}) - ln(D_{ij})$$

Equation 5: Log-log Gravity Model for Air Transport

In both equations, *Intensity of Air Transport*$_{ij}$ denotes the predicted intensity of air transport between airport *i* located in country *a* and airport *j* located in country *b*, GDP_x denotes the country-level gross domestic product per capita corrected for purchasing power parity in USD of country *x* and D_{ij} denotes the distance between airports *i* and *j*. To determine the distance between a pair of airports, the same approach is used as for the *Competition of Foreign Airports* variable.

Data on the annual GDP per capita corrected for purchasing power parity is retrieved for all countries of departure and arrival from the World Bank (n.d.).

Secondly, in this research, there will be controlled for the level of air ticket prices. Nonetheless, such information is only available through confidential industry databases. Therefore, a similar approach as adopted by Clewlow, Sussman and Balakrishnan (2014) will be applied to proxy fares by the cost of jet fuel. Literature indicates that the jet fuel costs are largely or entirely passed through on passengers (Anger & Köhler, 2010; Ferguson et al., 2011). Even though this measure has some limitations, Clewlow, Sussman and Balakrishnan (2014) found comparable price elasticities for ticket prices as for jet fuel. The data on the monthly spot price of jet fuel provided by the United States Energy Information Administration (n.d.) is used as an indicator for jet fuel.

Table 2: Description and Sources of Variables

Variable	Description	Source	Expected sign
Departing Air Passengers	The monthly number of departing passengers carried from airports having more than 15,000 passenger units annually on a specific route using commercial air services.	Eurostat (2021)	
Tax Dummy	Dummy indicating whether a flight ticket tax was in force.	Various national legal sources (see Appendix B)	H1a: -
Tax Amount	Variable indicating amount of flight ticket tax levied on a specific route.	Various national legal sources (see Appendix B)	H1b: -
Hub Airport	Dummy indicating whether an airport is listed in the Megahub Index Top 50 in 2019.	OAG (2019)	H2a and H2b: +
Low-cost Airport	Dummy indicating whether Ryanair or Wizz Air serves an airport by at least three routes in 2018.	Ryanair (n.d.), Wizz Air (n.d.)	H3a and H3b: -
Competition of Foreign Airports	Dummy indicating whether the two conditions of competition of a foreign airport are met.	OpenFlights (2017), Shkolnik (2019)	H4a and H4b: -
Short-haul	Dummy indicating whether a route is 500 kilometres or less.	OpenFlights (2017), Shkolnik (2019)	H5a and H5b: -
Intensity of Air Transport (ln)	Predicted air transport intensity of a pair of airports based on the gravity equation of a country's GDP and distance between the two airports.	World Bank (n.d.), Shkolnik (2019)	+
Jet Fuel	Monthly spot price of jet fuel in USD.	U.S. Energy Information Administration (n.d.)	-

Table 3: Descriptive Statistics

Variable	N	Mean	Standard deviation	Minimum	Maximum
Departing Air Passengers	502,494	7324.01	7954.83	0	116,241
Tax Dummy	502,494	0.1894	0.3918	0	1
Tax Amount	502,494	2.2273	6.6653	0	45
Hub Airport	502,494	0.2291	0.4203	0	1
Low-cost Airport	502,494	0.6859	0.4642	0	1
Competition of Foreign Airports	502,494	0.0699	0.2550	0	1
Short-haul	502,494	0.0521	0.2221	0	1
Intensity of Air Transport (ln)	501,186	13.7286	1.0875	8.1907	17.5317
Jet Fuel	502,494	2.1813	0.6776	0.93	3.886

4. Methodology

To test the effects of the independent variables on *Departing Air Passengers*, interaction terms will be created for the variables *Hub airport*, *Low-cost airport* and *Short-haul* interacting with the variables *Tax Dummy* and *Tax Amount* to measure the specific effect of levying a flight tax at these types of airports and routes. Besides, the variables *Departing Air Passengers, Tax Amount* and *Jet Fuel* are transformed into natural logarithms for two reasons.[14] Firstly, both variables show outliers, as depicted in Appendix G. Secondly, due to the log-transformations, a more economic meaningful coefficient is yielded – i.e., the elasticity. Since the variable *Tax Amount* has many 0 values – to be precise 81.1% –, the variable is transformed into ln(X+1).

As mentioned in Section 3, several variables are dependent on the distance between a pair of airports. The distance will be defined as the great-circle distance between two airports and is calculated by the Haversine formula as stated in Equation 6. This measure is considered appropriate since multiple countries applied this approach to determine the distance classes to distinguish tax rates.

$$Distance_{ij} = 2 * r * \sin^{-1}\left(\sqrt{\sin^2\left(\frac{\phi_j - \phi_i}{2}\right) + \cos(\phi_i) * \cos(\phi_j) * \sin^2\left(\frac{\lambda_j - \lambda_i}{2}\right)}\right)$$

Equation 6: Haversine Formula for Great-circle Distance (Agarwal, 2018)

In this equation, r denotes the radius of earth estimated at 6,371 kilometres, ϕ_x denotes the latitude and λ_x denotes the longitude of airport *x*.

Based on the above-mentioned transformations and criteria described in the data section, *Competition of Foreign Airports* is constructed as shown in Equation 7 and Equation 8.

$$Competition\ of\ Foreign\ Airports\ (Tax\ Dummy)_{it} = Tax\ Dummy_{at} * \prod_{b \in D_i} (1 - Tax\ Dummy_{bt})$$

Equation 7: Competition of Foreign Airports (Tax Dummy)

$$Competition\ of\ Foreign\ Airports\ (Tax\ Amount)_{it} = Ln(Tax\ Amount_{abt}) * \prod_{b \in D_i} (1 - Tax\ Dummy_{bt})$$

Equation 8: Competition of Foreign Airports (Tax Amount)

[14] Note that the variable *Intensity of Air Transport* is already transformed into a natural logarithm, as shown in Equation 5.

In both equations, *i* denotes the airport of departure located in country *a, j* denotes the airport of arrival located in country *b*, *t* denotes a specific month within 2005-2018 and D_i is the set of countries with an airport within 150 kilometres great-circle distance of airport *i*.

To observe whether the analysis possibly suffers from multicollinearity, the Pearson correlation coefficients of the independent variables are presented in Table 4. Due to the high correlation coefficient of *Tax Dummy* and *Ln Tax Amount* and the respective interaction terms, the risk of multicollinearity is present. Therefore, two models will be estimated including only *Tax Dummy* or *Ln Tax Amount* and the interaction terms based on the respective variable. Furthermore, variance inflation factors will be calculated and a sensitivity analysis will be performed. To represent the proportion of variance in *Departing Air Passengers* explained by the model, the corresponding adjusted R^2 instead of the R^2 will be presented since the number of included variables differs per model.

The hypotheses of this research will be examined by constructing ordinary least square regressions. The models include the variables and interaction terms as described in this section and Section 3. Furthermore, two types of fixed effects will be applied when estimating the models. Firstly, month-level fixed effects will be applied to take seasonality into account. Previous research has illustrated that the demand for air transport shows a high degree of heterogeneity across months due to seasonality (e.g., Xiao et al., 2014). Moreover, Figure 6 provides an illustration of the analysed dataset for some typical leisure routes that show a high degree of seasonality. Secondly, route-level fixed effects will be applied to control for effects that are constant over routes. By eliminating variables that are invariant over time or within a route, the risk of omitted variable bias is reduced and a better comparison within routes and months – rather than between routes and months – can be made.[15] The models estimated are shown in Equation 9 and Equation 10.

[15] Since route-level and month-level fixed effects are applied, no year-level fixed effects will be applied because no source of variation would be left in the data then.

Table 4: Pearson Correlation Coefficients of the Independent Variables

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*
(1) Tax Dummy	1														
(2) Ln Tax Amount	0.96	1													
(3) Hub Airport	0.18	0.22	1												
*(4) Hub Airport * Tax Dummy*	0.58	0.64	0.51	1											
*(5) Hub Airport * Ln Tax Amount*	0.56	0.67	0.5	0.96	1										
(6) Low-cost Airport	-0.1	-0.09	-0.23	-0.02	-0.02	1									
*(7) Low-cost Airport * Tax Dummy*	0.74	0.72	0.17	0.48	0.46	0.24	1								
*(8) Low-cost Airport * Ln Tax Amount*	0.71	0.74	0.2	0.53	0.55	0.23	0.97	1							
(9) Short-haul	0.01	-0.01	0.05	0.02	0	-0.13	-0.02	-0.03	1						
*(10) Short-haul * Tax Dummy*	0.27	0.22	0.07	0.19	0.15	-0.07	0.13	0.11	0.44	1					
*(11) Short-haul * Ln Tax Amount*	0.27	0.23	0.08	0.2	0.15	-0.07	0.14	0.12	0.43	0.99	1				
(12) Competition of Foreign Airports (Tax Dummy)	0.57	0.53	0.04	0.23	0.2	-0.01	0.49	0.43	0	0.13	0.14	1			
(13) Competition of Foreign Airports (Tax Amount)	0.56	0.54	0.05	0.24	0.22	-0.02	0.46	0.42	-0.01	0.12	0.13	0.98	1		
(14) Ln Intensity of Air Transport	0.08	0.01	-0.09	-0.01	-0.08	-0.01	0.05	0	0.45	0.22	0.22	0.06	0.03	1	
(15) Ln Jet Fuel	0.02	0.01	0	0	0	-0.02	-0.01	-0.01	0	0.02	0.01	-0.01	-0.01	-0.05	1

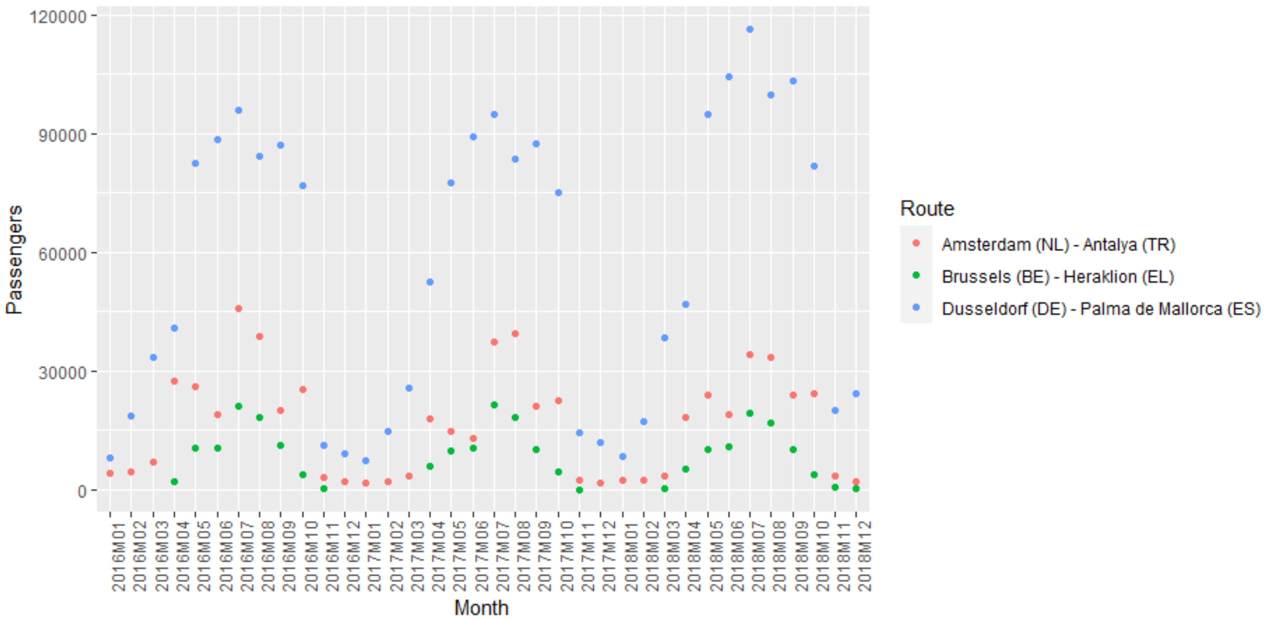

Figure 6: Illustration of Seasonality in Air Transport Demand

$$Ln(Departing\ Air\ Passengers_{ijt}) = \beta_1 * Tax\ Dummy_{at} + \beta_2 * Hub\ Airport_i + \beta_3 * (Hub\ Airport_i * Tax\ Dummy_{at}) + \beta_4 * Low - cost\ Airport_i + \beta_5 * (Low - cost\ Airport_i * Tax\ Dummy_{at}) + \beta_6 * Short - haul_{ij} + \beta_7 * \left(Short - haul_{ij} * Tax\ Dummy_{at}\right) + \beta_8 * Competition\ of\ Foreign\ Airport\ (Tax\ Dummy)_{it} + \beta_9 * Ln(Intensity\ of\ Air\ Transport_{ijt}) + \beta_{10} * Ln(Jet\ Fuel_t) + \alpha_{ijt} + \varepsilon_{ijt}$$

Equation 9: OLS Model Specification (Tax Dummy)

$$Ln(Departing\ Air\ Passengers_{ijt}) = \beta_1 * Ln(Tax\ Amount_{abt}) + \beta_2 * Hub\ Airport_i + \beta_3 * (Hub\ Airport_i * Ln\ (Tax\ Amount_{abt})) + \beta_4 * Low - cost\ Airport_i + \beta_5 * (Low - cost\ Airport_i * Ln\ (Tax\ Amount_{abt})) + \beta_6 * Short - haul_{ij} + \beta_7 * \left(Short - haul_{ij} * Ln\ (Tax\ Amount_{abt})\right) + \beta_8 * Competition\ of\ Foreign\ Airport\ (Tax\ Amount)_{ijt} + \beta_9 * Ln(Intensity\ of\ Air\ Transport_{it}) + \beta_{10} * Ln(Jet\ Fuel_t) + \alpha_{ijt} + \varepsilon_{ijt}$$

Equation 10: OLS Model Specification (Tax Amount)

In these equations, i denotes the airport of departure located in country a, j denotes the airport of arrival located in country b, t denotes a specific month within 2005-2018, α_{ijt} denotes route-month fixed effects and ε_{ijt} denotes the error term.

Lastly, a Breusch-Pagan test will be performed on all estimated models to test for heteroskedasticity. When a model suffers from heteroskedasticity, Huber-White standard errors will be applied.

5. Results

5.1. Sensitivity Analysis

In the sensitivity analysis, four different models were run. The A-models include only the variable *Tax Dummy* to measure the flight ticket tax policy. In contrast, the B-models only include the variable *Ln Tax Amount* to represent the tax policy. In both models, the interaction terms are created based on the included tax variable. Furthermore, C-models and D-models are created that include both tax variables. These models differ by the variable that is used to create interaction terms. The C-models consist of interaction terms with *Tax Dummy*, whereas the D-models contains interaction terms with *Ln Tax Amount.* Lastly, three subversions are made of every model to observe changes in the models' coefficients when more variables are included. All models were tested for heteroskedasticity by a Breusch-Pagan test. Since all models indicated to have heteroskedasticity at 1%-level significance, Huber-White standard error estimators are applied. The variance inflation factors of the respective models are presented in Table 5.

Table 5: Variance Inflation Factors

	Model A	*Model B*	*Model C*	*Model D*
Tax Dummy	3.84		19.1	20.35
Ln Tax Amount		4.38	18.27	26.27
Hub Airport	1.58	1.52	1.59	1.54
*Hub Airport * Tax Dummy*	2.16		2.44	
*Hub Airport * Ln Tax Amount*		2.58		3.18
Low-cost Airport	1.46	1.42	1.46	1.42
*Low-cost Airport * Tax Dummy*	2.94		2.95	
*Low-cost Airport * Ln Tax Amount*		2.89		2.9
Short-haul	1.54	1.52	1.56	1.55
*Short-haul * Tax Dummy*	1.38		1.42	
*Short-haul * Ln Tax Amount*		1.33		1.39
Competition of Foreign Airports (Tax Dummy)	1.54		1.54	
Competition of Foreign Airports (Tax Amount)		1.51		1.51
Ln Intensity of Air Transport	1.32	1.31	1.41	1.4
Ln Jet Fuel	1.02	1.02	1.03	1.03

In line with the Pearson correlation coefficients in Section 4, the variance inflation factors indicate the presence of multicollinearity when both *Tax Dummy* and *Ln Tax Amount* are included as independent variables*.* As a result, the precision of the estimated coefficients is lower in the C-models and D-models. Therefore, the A-models and B-models will be used to test the hypotheses. The estimated results for these models are presented in Table 6 and Table 7. The estimated results for the C-models and D-models are shown in Appendix H.

5.2. Effects of Levying a Flight Ticket Tax

Firstly, the hypotheses related to levying a flight ticket tax are tested – i.e., all a-hypotheses. When looking at the models' coefficients and their significance, it is concluded that model A3 will be used to examine the hypotheses, as these models control for month- and route-specific effects.

In line with hypothesis 1a, a negative relationship between levying a flight ticket tax and the number of departing are passengers is found. The coefficient can be interpreted as follows: if a flight ticket tax is in force, the number of departing air passengers is expected to decrease by 8.2% relative to a situation where no ticket tax is in force at 1% significance, ceteris paribus. Furthermore, outcomes in line with hypotheses 2a and 3a are observed. If a flight ticket tax is in force and the airport can be classified as a hub airport, the number of departing air passengers is expected to decrease by only 0.8% at 1% significance, ceteris paribus. On the contrary, if a flight ticket tax is levied and the airport can be classified as a low-cost airport, a decrease of departing air passengers of 11.5% is expected at 10% significance, ceteris paribus.

The regression model does not indicate any significant effect for short-haul flights and competition of foreign airports. Therefore, no evidence to support hypotheses 4a and 5a is found. Lastly, the control variables *Intensity of Air Transport* and *Jet Fuel* indicate a 1%-significant effect. Both effects show the predicted sign.

5.3. Effects of the Levied Amount of Flight Ticket Tax

Secondly, the hypotheses related to the levied amount of flight ticket tax are tested – i.e., all b-hypotheses. When looking at the models' coefficients and their significance, it is concluded that model B3 will be used to examine the hypotheses, as these models control for month- and route-specific effects.

First of all, it can be noticed that the same variables demonstrate a significant effect when *Ln Tax Amount* is introduced in the models instead of *Tax Dummy*, albeit at a different significance level. To start with, in correspondence with hypothesis 1b, a significant negative association between the amount of flight ticket tax and departing passengers is observed. This effect can be interpreted as follows: if the amount of flight ticket tax increases by 1%, the number of departing air passengers is expected to decrease by 0.034% at 1% significance, ceteris paribus. Nevertheless, when an airport can be classified as a hub airport, this effect is limited to -0.003%, at 1% significance, ceteris paribus. In contrast, when an airport can be classified as a low-cost airport, a decrease of 0.051% is expected at 5% significance, ceteris paribus. These effects confirm the predicted associations of hypotheses 2b and 3b.[16]

Furthermore, no significant effect for short-haul flights and competition of foreign airports is observed. Therefore, no evidence to support or contradict hypotheses 4b and 5b is found. Finally, the control variables *Intensity of Air Transport* and *Jet Fuel* demonstrate a 1%-significant effect and the predicted sign.

[16] Note that all interpretations of coefficients in Section 5.3 are approximations of the estimated effects since *Ln Tax Amount* is defined as *Ln(Tax Amount + 1)*.

Table 6: A-models

	Dependent variable: Ln Departing Air Passengers		
	(A1)	(A2)	(A3)
Tax Dummy	-0.017 (0.022)	0.113*** (0.042)	-0.082*** (0.016)
Hub Airport	0.869*** (0.029)	0.886*** (0.032)	
Hub Airport * Tax Dummy		0.011 (0.042)	0.074*** (0.018)
Low-cost Airport	0.052* (0.028)	0.105*** (0.030)	
Low-cost Airport * Tax Dummy		-0.234*** (0.045)	-0.033* (0.019)
Short-haul	0.021 (0.053)	0.021 (0.054)	
Short-haul * Tax Dummy		-0.016 (0.072)	-0.011 (0.025)
Competition of Foreign Airports (Tax Dummy)		0.019 (0.045)	0.027 (0.018)
Ln Intensity of Air Transport	0.142*** (0.012)	0.145*** (0.012)	0.434*** (0.012)
Ln Jet Fuel	-0.095*** (0.008)	-0.099*** (0.009)	-0.046*** (0.004)
Observations	501,064	501,064	501,064
Month FE	YES	YES	YES
Route FE	NO	NO	YES
Adjusted R^2	0.161	0.163	0.153
F Statistic	5,655.712*** (df = 17; 501046)	4,637.451*** (df = 21; 501042)	5,391.558*** (df = 18; 494706)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: the variables Hub Airport, Low-cost Airport *and* Short-haul *drop out in model A3 since they have no variation within route-month combinations.*

Table 7: B-models

	Dependent variable: Ln Departing Air Passengers		
	(B1)	(B2)	(B3)
Ln Tax Amount	0.005 (0.009)	0.049*** (0.018)	-0.034*** (0.007)
Hub Airport	0.864*** (0.029)	0.868*** (0.032)	
Hub Airport * Tax Amount		0.018 (0.017)	0.031*** (0.008)
Low-cost Airport	0.053* (0.028)	0.095*** (0.030)	
Low-cost Airport * Tax Amount		-0.083*** (0.018)	-0.017** (0.008)
Short-haul	0.023 (0.053)	0.028 (0.054)	
Short-haul * Tax Amount		-0.018 (0.034)	-0.006 (0.012)
Competition of Foreign Airports (Tax Amount)		-0.004 (0.018)	0.011 (0.007)
Ln Intensity of Air Transport	0.141*** (0.012)	0.144*** (0.012)	0.435*** (0.012)
Ln Jet Fuel	-0.096*** (0.008)	-0.097*** (0.008)	-0.046*** (0.004)
Observations	501,064	501,064	501,064
Month FE	YES	YES	YES
Route FE	NO	NO	YES
Adjusted R^2	0.161	0.162	0.153
F Statistic	5,654.673*** (df = 17; 501046)	4,623.890*** (df = 21; 501042)	5,389.560*** (df = 18; 494706)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: the variables Hub airport, Low-cost Airport *and* Short-haul *drop-out in model B3 since they have no variation within route-month combinations.*

6. Conclusion & Discussion

6.1. Conclusion

In November 2019, a collaboration of nine EU Member States demanded a European taxation policy to create a level playing field within the aviation sector. Until then, the aviation industry was characterised by an undertaxed position while responsible for a considerable share of the global CO_2-emissions. However, no consensus was reached and other EU-level initiatives had no significant effects on the aviation industry. Therefore, countries are dependent on national taxation policies to address the aviation sector. Consequently, several national flight ticket taxes were implemented. However, severe criticism occurred in response to these taxes. Furthermore, the political reasons for implementation and environmental effects of the flight ticket taxes remained unclear. Therefore, the following research question was formulated:

What is the effect of flight ticket taxes on the number of departing air passengers within Europe?

To this end, extensive literature research is performed on national tax policies, the legal position of flight ticket taxes and the functions that these environmental taxes serve. Thereafter, a dataset based on, amongst others, national legislation, detailed classification of airports and data on departing air passengers within Europe was created. After implementing controls for air transport intensity predicted by the gravity equation, jet fuel prices and seasonality in air transport demand, the analysis showed significant decreases in air transport demand resulting from national flight ticket taxes. Firstly, an expected decrease of 8.2% in air transport is observed for airports in countries that levy a flight ticket tax. Secondly, a decrease of 0.8% and 11.5% is found for hub airports and low-cost airports, respectively. Besides the presence of a flight ticket tax, the amount of tax demonstrated to have a negative effect on air transport demand. A 1% increase in the amount of tax is associated with an expected 0.034% reduction in air transport demand. Again, hub airports and low-cost airports demonstrated to have a different effect of -0.003% and -0.051%, respectively.

Therefore, it is concluded that national flight ticket taxes serve the instrumental function of taxation by decreasing the number of departing air passengers. Levying a flight ticket tax as well as levying a higher amount of tax showed to have a significant negative effect on the number of departing air passengers. Besides this direct effect, an additional indirect effect may occur depending on the allocation of flight ticket taxes' revenues.

Furthermore, an effect of a lower magnitude was found for hub airports relative to other airports. This finding is in accordance with the prediction based on the tax exemption for transfer passengers. Although this exemption is justified by preventing double taxation, it causes the opposite effect that transfer passengers are less or – in extreme cases – not taxed. Therefore, the environmental function of flight ticket taxes is served to a smaller extent in the case of transfer passengers, especially since indirect routes have a considerable environmental footprint relative to direct routes. On the contrary, low-cost airports demonstrated to face a stronger decrease of departing air passengers as a result of flight ticket taxes. This effect was predicted since it is likely that low-cost airlines pass on flight ticket taxes to a higher extent to their passenger. Furthermore, previous research indicated that low-cost carriers' passengers are more price sensitive.

Even though the majority of previous studies demonstrates a strong effect of taxation for airports facing competition of non-taxed proximate foreign airports, no general Europe-level effect is found in this research. This outcome could be clarified by the fact that such competition is a case-by-case study since various factors are crucial to this effect (e.g., Berster et al., 2010; Gordijn & Kolkman, 2011). For instance, Gordijn and Kolkman (2011) demonstrated that the defection of Dutch passengers to German airports is more likely than the reversed effect due to the location of population-dense areas.

Lastly, no significant effect is found for short-haul flights. As mentioned in the theoretical framework, this may be explained by the large share of short-haul flights that feeds or de-feeds a hub airport. Furthermore, these passengers benefit from the earlier-mentioned tax exemption that does provide an incentive to use air transport over other means of transportation. Furthermore, a share of air passengers is not likely to switch mode of transport due to a lack of other modes of transport.

6.2. Limitations & Further Research

Lastly, this study contains limitations that open the possibility for interesting further research. Firstly, more factors can be considered to yield a complete overview of the effect of flight ticket taxes on aviation's environmental footprint. For instance, the type of aircraft, the type of jet fuel and other innovations within the air transport industry are detrimental to the CO_2-emissions (e.g., Staples, Malina, Suresh, Hileman & Barrett, 2018). An interesting research approach would be linking the presence of flight ticket taxes directly to aviation's CO_2-emissions. Although Graver, Zhang and Rutherford (2019) started to create a database attributing CO_2-emissions to countries, this remains difficult and no extensive dataset is available yet.

Secondly, little is known of per flight taxes from an economic and legal viewpoint, while the literature indicates promising environmental gains. Therefore, research into various types of aviation taxes – including EU-level taxes – and their effects is recommended. In addition, it might be worthwhile to examine the various designs of flight ticket taxes. For example, many countries adhere to the 'polluter must pay' principle – i.e., levying a higher amount of tax if the travelled distance increases. In contrast, Austria recently decided to levy a higher amount on routes shorter than 350 kilometres since these passengers are assumed to have substitutes to air transport available.

Thirdly, hub airports are proxied by a time-invariant dummy. In further research, it is recommended to operationalise this variable by a continuous variable indicating the share of transfer passengers at a particular airport. By doing so, airports with a small share of transfer passengers are included and it is possible to control for changing shares of transfer passengers over time. Furthermore, the literature did not provide a clear-cut definition of low-cost airports. Therefore, an approach indicating airports served by the major low-cost carriers was applied. However, this methodology has several serious drawbacks. Therefore, a measure of the relative low-cost carrier passengers at a particular airport would be more appropriate but is unfortunately not publicly available. Besides, an index incorporating the characteristics listed by Barrett (2004) would be an interesting proxy to examine in further research.

Lastly, the analysis in this thesis faces a limitation by defining short-haul flights solely on a distance-based constraint. To create a more accurate viewpoint, more factors need to be considered when assuming intermodal substitution. Think of factors like travel time, frequency of train service and convenience. Besides, tax policies to encourage other modes of transport – such as subsidies for rail transport – and non-monetary policies could be taken into account as well.

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Appendix A: Adjusted and Excluded Airports

Table A.1: Adjusted Airports

Old airport (ICAO code)	New airport (ICAO code)	Country
CUUP	CYOW	Canada
DTNZ	DTNH	Tunisia
EBBS	EBBR	Belgium
EDDD	EDDF	Germany
EDVV	EDDV	Germany
EGRA	EGPF	UK
EGRY	EGNM	UK
EHAA	EHAM	The Netherlands
EIDB	EIDW	Ireland
ENCA	ENGM	Norway
ENOS	ENGM	Norway
ENTR	ENVA	Norway
EYKG	EYKA	Lithuania
FAJS	FAOR	South Africa
GCGC	GCLP	Spain
GMMC	GMMN	Morocco
GOOO	GOBD	Senegal
GVPR	GVNP	Cape Verde
GVSC	GVAC	Cape Verde
HKNA	HKJK	Kenya
KRNY	KJFK	USA
KZMA	KMIA	USA
LECL	LEVC	Spain
LECP	LEPA	Spain
LEPM	LEPA	Spain
LESJ	LEPA	Spain
LGAC	LGAV	Greece
LIMM	LIMC	Italy
LIVT	LIPQ	Italy
LKAA	LKPR	Czech Republic
LMMM	LMML	Malta
LOVV	LOWW	Austria
LPFU	LPMA	Portugal
LQBU	LQSA	Bosnia and Herzegovina
LRBB	LROB	Romania
LSZM	LFSB	Switzerland
LYPR	BKPR	Kosovo
RJNN	RJNA	Japan
SABA	SAEZ	Argentina
SBRE	SBRF	Brazil
SBWJ	SBGL	Brazil
SBWP	SBPA	Brazil
SBWR	SBBR	Brazil
SBWZ	SBFZ	Brazil
SBXS	SBSV	Brazil
SBXT	SBSG	Brazil
SEQU	SEQM	Ecuador
SPJC	SPIM	Peru
UUUU	UUEE	Russia

Table A.2: Excluded Airports

Airport (ICAO code)	Country
EDBB	Germany
EDLX	Germany
EDSO	Germany
EGCI	United Kingdom
EGDG	United Kingdom
EGGG	United Kingdom
EGGR	United Kingdom
EGGS	United Kingdom
EGQG	United Kingdom
EGQS	United Kingdom
EGQT	United Kingdom
EGRC	United Kingdom
EGRD	United Kingdom
ENBL	Norway
ESPC	Sweden
ETBS	Germany
ETLS	Germany
EVRS	Latvia
FNAN	Angola
GMAA	Morocco
LECH	Spain
LFBB	France
LHAA	Hungary
LHCC	Hungary
LIJJ	Italy
LNMC	Monaco
LPMO	Portugal
LPPO	Portugal
LROB	Romania
LTFG	Turkey
MDBC	Dominican Republic
RPMM	Philippines
UGGG	Georgia
ULTT	Russia
URRR	Russia
VAJJ	India
ZSSA	China

Appendix B: Tax Profiles

Appendix B1: Austria

General information

Tax: Flugabgabe (Austrian Air Transport Levy)

Taxable event: The departure of a passenger from a domestic airport using a motorised aircraft (§1 Flugabgabegesetz (FlugAbgG)).

Effective as from April 1st, 2011 until the end of the timeframe.

Main exemptions (§3 FlugAbgG):

- Transit and transfer passengers whose connecting flight departs within 24 hours;
- Passengers younger than two years who do not occupy a seat themselves;
- Departure for military, medical, humanitarian, sovereign or parachute jump purposes;
- Flight crew; and
- Departure of passengers in an aircraft having a maximum-permissible take-off weight up to and including 2,000 kilogrammes.

Tax rates

The Austrian Air Transport Levy is differentiated depending on the location of the airport of arrival (§4 FlugAbgG). The Austrian Air Transport Levy distinguishes three categories: short distance, medium distance and long distance (§5 FlugAbgG).

Table B1.1: Tax Rates of Austrian Air Transport Levy

Period	Short distance	Medium distance	Long distance
2011 (April - December)	€ 8,00	€ 20,00	€ 35,00
2012	€ 8,00	€ 20,00	€ 35,00
2013	€ 7,00	€ 15,00	€ 35,00
2014	€ 7,00	€ 15,00	€ 35,00
2015	€ 7,00	€ 15,00	€ 35,00
2016	€ 7,00	€ 15,00	€ 35,00
2017	€ 7,00	€ 15,00	€ 35,00
2018	€ 3,50	€ 7,50	€ 17.50

For classification of countries see Annex 1 and 2 of the FlugAbgG.

Legal source

Bundesgesetzblatt für die Republik Österreich I No. 111/2010 (Nationalrat: GP XXIV RV 981 AB 1026 S 90. Bundesrat: 8437 AB 8439 S. 792.)

Bundesgesetzblatt für die Republik Österreich I No. 112/2012 (Nationalrat: GP XXIV RV 1960 AB 1977 S. 179. Bundesrat: 8815 AB 8823 S. 815.)

Bundesgesetzblatt für die Republik Österreich I No. 13/2014 (Nationalrat: GP XXV RV 24 AB 31 S. 12. Bundesrat: 9140 AB 9141 S. 827.)

Bundesgesetzblatt für die Republik Österreich I No. 44/2017 (Nationalrat: GP XXV RV 1524 AB 1561 S. 171. Bundesrat: AB 9760 S. 866.)

Bundesgesetzblatt für die Republik Österreich I No. 76/2011 (Nationalrat: GP XXIV RV 1212 AB 1320 S. 114. Bundesrat: 8524 AB 8558 S. 799.)

Appendix B2: Denmark

General information

Tax: Passagerafgiften (Danish Air Passenger Tax)

Taxable event: The departure of passengers from a Danish airport by aircraft (§1 Lov nr. 389 af 6. Juni 1991 om afgift af visse flyrejser (Lov om afgift af visse flyrejser)).

Effective as from the beginning of the timeframe until January 1st, 2007.

Main exemptions (§2 Lov om afgift af visse flyrejser):

- Transit and transfer passenger under some conditions;
- Departure of passenger in an aircraft capable of carrying less than 10 passengers or having a lower allowed starting weight than 5,700 kilogrammes;
- Flight crew; and
- Children younger than two years old.

Tax rates

The Danish Air Passenger Tax has a differentiated tax rate. However, the specific rate for small aircrafts capable of carrying less than 10 passengers will not be considered. Therefore, a uniform tax rate is applied in this research (§2 Lov om afgift af visse flyrejser).

Table B2.1: Tax Rates of Danish Air Passenger Tax

Period	Exchange rate	Tax rate
2005	€1 = DKK 7.4518	DKK 75
2006	€1 = DKK 7.4591	DKK 37.50

Legal source

LBK nr 566 af 3. August 1998 bekendtgørelse af lov om afgift af visse flyrejser

Lov nr. 389 af 6. Juni 1991 om afgift af visse flyrejser

Lov nr 834 af 27. November 1998 om ændring af lov om afgift af visse flyrejser

Lov nr 1415 af 21. December 2005 om ændring og senere ophævelse af lov om afgift af visse flyrejser

Appendix B3: Germany

General information

Tax: Luftverkehrsteuer (German Aviation Tax)

Taxable event: A legal transaction that entitles a passenger to depart from a German airport and to travel to a destination on an aeroplane or helicopter operated by an aviation enterprise (§1 Luftverkehrsteuergesetz (LuftVStG)).

Effective as from January 1st, 2011 until the end of the timeframe.

Main exemptions (§1, 2, 4 and 5 LuftVStG):

- Transit and transfer passengers under some conditions;
- Passengers younger than two years who do not occupy a seat themselves;
- Departure for military, medical or sovereign purposes;
- Departure of passengers whose main place of residence is located on a German, Danish or Dutch North Sea island without rail or road connection to the mainland;
- Flight crew; and
- Departure of passengers for sight-seeing flights with a maximum weight of 2,000 kilogrammes.

Tax rates

The German Aviation Tax is differentiated depending on the location of the airport of arrival (§10 LuftVStG). The German Aviation Tax distinguishes three categories: short distance, medium distance and long distance (§11 LuftVStG).

Table B3.1: Tax Rates of German Aviation Tax

Period	Short distance	Medium distance	Long distance
2011	€ 8,00	€ 25,00	€ 45,00
2012	€ 7,50	€ 23,43	€ 42,18
2013	€ 7,50	€ 23,43	€ 42,18
2014	€ 7,50	€ 23,43	€ 42,18
2015	€ 7,50	€ 23,43	€ 42,18
2016	€7,38	€ 23,05	€ 41,49
2017	€ 7,47	€ 23,32	€ 41,99
2018	€ 7,46	€ 23,31	€ 41,97

For classification of countries see Annex 1 and 2 of the LuftVStG.

Legal source

Luftverkehrsteuergesetz vom 9. Dezember 2010 (BGBl. I S. 1885; 2013 I S. 81)

Luftverkehrsteuer-Absenkungsverordnung 2012 vom 16. Dezember 2011 (BGBl. I S. 2732)

Luftverkehrsteuer-Festlegungsverordnung 2014 vom 19. Dezember 2013 (BGBl. I S. 4383)

Luftverkehrsteuer-Absenkungsverordnung 2017 vom 24. Oktober 2016 (BGBl. I S. 2488)

Luftverkehrsteuer-Absenkungsverordnung 2018 vom 1. Dezember 2017 (BGBl. I S. 3858)

Luftverkehrsteuer-Festlegungsverordnung 2016 vom 10. November 2015 (BGBl. I S. 1978)

Luftverkehrsteuer-Festlegungsverordnung 2015 vom 24. November 2014 (BGBl. I S. 1822)

Luftverkehrsteuer-Durchführungsverordnung vom 22. August 2012 (BGBl. I S. 1812)

Appendix B4: Ireland

General information

Tax: Irish Air Travel Tax

Taxable event: The departure of a passenger from a domestic airport using an aircraft capable of carrying 20 or more passengers (articles 1 and 2 of Section 55 Finance (No.2) Act 2008).

Effective as from March 30th, 2009 until April 1st, 2014.

Main exemptions (article 1 of Section 55 Finance (No.2) Act 2008):

- Departure in an aircraft capable of carrying less than 20 passengers;
- Departure in an aircraft for state or military purposes;
- Departure from airports from which less than 50,000 passengers departed last year;
- Passenger under two years or disabled passengers under certain circumstances;
- Flight crew; and
- Transit and transfer passengers under some conditions.

Tax rates

The Irish Air Travel tax is differentiated depending on the location of the airport of destination compared to Dublin Airport. The low rate applies on flights to an airport located not more than 300 kilometres from Dublin airport. The high rate applies to all other flights (article 2b of Section 55 Finance (No.2) Act 2008.

Table B4.1: Tax Rates of Austrian Air Transport Levy

Period	Low rate	High rate
2009 (April-December)	€ 2,00	€ 10,00
2010	€ 2,00	€ 10,00
2011 (January-February)	€ 2,00	€ 10,00
2011 (March – December)	€ 3,00	
2012	€ 3,00	
2013	€ 3,00	
2014 (January-March)	€ 3,00	

Legal source

Air Travel Tax Regulation 2009 (S.I. No. 134 of 2009)

Finance (No. 2) Act 2008

Finance (No. 2) Act 2011

Finance Act 2009

Finance Act 2011

The Air Travel Tax Abolition Order (S.I. 130 of 2014)

Appendix B5: The Netherlands

General information

Tax: Vliegbelasting (Dutch Aviation Tax)

Taxable event: The departure of a passenger from an airport situated within the Netherlands using an aircraft (article 36ra Wet belastingen op milieugrondslag (Wbm)).

Effective as from July 1st, 2008 until July 1st, 2009 (legally until January 1st, 2010)

Main exemptions (article 36r and 36ra Wbm):

- Passengers departing in an aircraft with a maximum starting weight of 8,615 kilogrammes;
- Passengers younger than two years;
- Flight crew;
- Departure for military purposes; and
- Transit and transfer passengers under some conditions.

Tax rates

The Dutch Aviation Tax is differentiated depending on the location of the airport of arrival (article 36re Wbm). The Dutch Aviation Tax distinguishes two categories: reduced tariff (EU Member States and airports within 2,500 kilometres of airport of departure) and full tariff (all other destinations) (article 36re Wbm). Later, the Dutch government decided to include airports located in countries where some airports are within the 2,500 kilometres limit and some are not, in the short tariff. An exception to this rule are airports located further than 3,500 kilometres from the airport of departure, those airports remain taxed with the full tariff.

Table B5.1: Tax Rates of Dutch Aviation Tax

Period	Reduced tariff	Full tariff
2008 (July – December)	€ 11,25	€ 45
2009 (January – June)	€ 11,25	€ 45

Legal source

Besluit belastingen op milieugrondslag, vliegbelasting, toepassing laag tarief en begrip boordpersoneel (BWBR0024162)

Besluit op nul zetten tarieven voor de vliegbelasting (BWBR0026078)

Wet belastingen op milieugrondslag (Stb. 1994, 923)

Wet van 20 december 2007, houdende wijzigingen van enkele belastingwetten (Stb. 2007, 562)

Appendix B6: Norway

General information

Tax: Flypassasjeravgift (Norwegian Air Passenger Tax)

Taxable event: Departure from a Norwegian airport by a commercial flight (§3-22-1 (1) Lov 19. Mai 1933 nr. 11 11 om særavgifter og Stortingets avgiftsvedtak (Lov om særavgifter).

Effective as from June 1st, 2016 until the end of the timeframe.

Main exemptions (§3-22-1, 3-22-4 and 3-22-5 Forskrift om særavgifter):

- Passengers departing from the continental shelf and airports on Svalbard and Jan Mayen;
- Passengers of military flights;
- Passengers under the age of two; and
- Transit and transfer passengers under some conditions.

Tax rates

The Norwegian Air Passenger Tax has a uniform tax rate.

B6.1: Tax rates of Norwegian Air Passenger Tax

Period	Exchange rate	Tax rate
2016 (June-December)	€1 = NOK 9.1881	NOK 80
2017	€1 = NOK 9.3270	NOK 82
2018	€1 = NOK 9.5975	NOK 83

Legal source

Forskrift om endring av forskrift om særavgifter - Fastsatt av Finansdepartementet 13. mai 2016 med hjemmel i lov 19. mai 1933 nr. 11 om særavgifter og Stortingets avgiftsvedtak

Lov 19. Mai 1933 nr. 11 11 om særavgifter og Stortingets avgiftsvedtak

Lov 27. Mai 2016 nr. 14 om skatteforvaltning

Appendix B7: Sweden

General information

Tax: Flygskatt (Swedish Tax on Air Travel)

Taxable event: Departure from a Swedish airport by aircraft that is approved for more than ten passengers (§3 Lag 2017:1200 om skatt på flygresor (Lag om Flygskatt)).

Effective as from April 1st, 2018 until the end of the timeframe.

Main exemptions (§4 Lag om Flygskatt):

- Children under the age of two;
- Flighty crew on duty;
- Passengers who did not reach their destination airport caused by technical disturbance, bad weather or other unforeseen conditions and who are accompanied by a new departing flight; and
- Transit and transfer passengers under some conditions.

Tax rates

The Swedish Tax on Air travel is differentiated depending on the location of the airport of destination (§7 Lag om Flygskatt). The Swedish Tax on Air Travel distinguishes three categories: short distance, medium distance and long distance (§7 Lag om Flygskatt).

Table B7.1: Tax Rates of Swedish Tax on Air Travel

Period	Exchange rate	Short distance	Medium distance	Long distance
2018 (April-December)	€1 = SEK 10.3525	SEK 60	SEK 250	SEK 400

For classification of countries see Annex 1 and 2 of the Lag om Flygskatt.

Legal source

Lag (2017:1200) om skatt på flygresor

Appendix C: Exchange Rates

Table C1.1: Exchange Rates Danish Krone

Period	Average	Minimum	Maximum
2005	€1 = DKK 7.4518	€1 = DKK 7.4351	€1 = DKK 7.4640
2006	€1 = DKK 7.4591	€1 = DKK 7.4528	€1 = DKK 7.4674

Table C2.1: Exchange Rates Norwegian Krone

Period	Average	Minimum	Maximum
2016 (June-December)	€1 = NOK 9.1881	€1 = NOK 8.9175	€1 = NOK 9.5092
2017	€1 = NOK 9.3270	€1 = NOK 8.8070	€1 = NOK 9.9738
2018	€1 = NOK 9.5975	€1 = NOK 9.4145	€1 = NOK 10.0025

Table C3.1: Exchange Rates Swedish Krona

Period	Average	Minimum	Maximum
2018 (April-December)	€1 = SEK 10.3525	€1 = SEK 10.1360	€1 = SEK 10.6923

Appendix D: OAG Megahub Index 2019

Table D.1: European Airports Listed in the OAG Megahub Index Top 50 in 2019

Airport (ICAO code)	Country	Dominant carrier	Connectivity index
EGLL	United Kingdom	British Airways	317
EDDF	Germany	Lufthansa German Airlines	309
EHAM	Netherlands	KLM-Royal Dutch Airlines	279
EDDM	Germany	Lufthansa German Airlines	259
LFPG	France	Air France	250
LEMD	Spain	Iberia	154
LIRF	Italy	Alitalia – Societa Aerea Italiana S.p.A.	139
LSZH	Switzerland	SWISS	114
LOWW	Austria	Austrian Airlines AG dba Austria	109
LEBL	Spain	Vueling Airlines	102
ENGM	Norway	SAS Scandinavian Airlines	98

Appendix E: Airports Served by Ryanair and Wizz Air

E.1: Airports Identified as Low-cost Airports

Airport (ICAO code)	Country	Served by
BIKF	Iceland	Wizz Air
EBBR	Belgium	Ryanair
EBCI	Belgium	Ryanair & Wizz Air
EDDB	Germany	Ryanair
EDDF	Germany	Ryanair
EDDG	Germany	Ryanair
EDDH	Germany	Ryanair & Wizz Air
EDDK	Germany	Ryanair & Wizz Air
EDDN	Germany	Ryanair & Wizz Air
EDDV	Germany	Wizz Air
EDDW	Germany	Ryanair
EDFH	Germany	Ryanair & Wizz Air
EDJA	Germany	Ryanair & Wizz Air
EDLV	Germany	Ryanair
EDLW	Germany	Ryanair & Wizz Air
EDNY	Germany	Ryanair & Wizz Air
EDSB	Germany	Ryanair & Wizz Air
EETN	Estonia	Ryanair & Wizz Air
EFLP	Finland	Ryanair
EFTU	Finland	Wizz Air
EHBK	The Netherlands	Ryanair
EHEH	The Netherlands	Ryanair & Wizz Air
EKAH	Denmark	Ryanair
EKBI	Denmark	Ryanair & Wizz Air
EKCH	Denmark	Ryanair & Wizz Air
ENAL	Norway	Wizz Air
ENBO	Norway	Wizz Air
ENBR	Norway	Wizz Air
ENGM	Norway	Ryanair & Wizz Air
ENTC	Norway	Wizz Air
ENTO	Norway	Ryanair & Wizz Air
ENVA	Norway	Wizz Air
ENZV	Norway	Wizz Air
EPBY	Poland	Ryanair
EPGD	Poland	Ryanair & Wizz Air
EPKK	Poland	Ryanair & Wizz Air
EPKT	Poland	Ryanair & Wizz Air
EPLB	Poland	Wizz Air
EPLL	Poland	Ryanair
EPMO	Poland	Ryanair
EPPO	Poland	Ryanair & Wizz Air
EPRZ	Poland	Ryanair & Wizz Air
EPSC	Poland	Ryanair & Wizz Air
EPWA	Poland	Ryanair & Wizz Air
EPWR	Poland	Ryanair & Wizz Air
ESGG	Sweden	Ryanair & Wizz Air
ESKN	Sweden	Ryanair & Wizz Air
ESMS	Sweden	Ryanair & Wizz Air
ESMX	Sweden	Ryanair
ESOW	Sweden	Ryanair
ESSA	Sweden	Ryanair
EVRA	Latvia	Ryanair & Wizz Air
EYKA	Lithuania	Ryanair & Wizz Air

EYVI	Lithuania	Ryanair & Wizz Air
LBBG	Bulgaria	Ryanair & Wizz Air
LBSF	Bulgaria	Ryanair & Wizz Air
LBWN	Bulgaria	Wizz Air
LCLK	Cyprus	Wizz Air
LCPH	Cyprus	Ryanair
LDPL	Croatia	Ryanair
LDSP	Croatia	Wizz Air
LDZA	Croatia	Ryanair
LDZD	Croatia	Ryanair
LFSB	Switzerland	Wizz Air
LGAV	Greece	Ryanair & Wizz Air
LGIR	Greece	Ryanair & Wizz Air
LGKF	Greece	Ryanair
LGKL	Greece	Ryanair
LGKO	Greece	Ryanair
LGKR	Greece	Ryanair
LGMK	Greece	Ryanair & Wizz Air
LGPZ	Greece	Ryanair
LGRP	Greece	Ryanair & Wizz Air
LGSA	Greece	Ryanair & Wizz Air
LGSR	Greece	Ryanair
LGTS	Greece	Ryanair & Wizz Air
LGZA	Greece	Ryanair
LHBP	Hungary	Ryanair & Wizz Air
LHDC	Hungary	Wizz Air
LIBD	Italy	Ryanair
LIBR	Italy	Ryanair
LICA	Italy	Ryanair
LICB	Italy	Ryanair
LICC	Italy	Ryanair & Wizz Air
LICJ	Italy	Wizz Air
LICT	Italy	Ryanair
LIEA	Italy	Ryanair & Wizz Air
LIEE	Italy	Ryanair
LIEO	Italy	Wizz Air
LIMC	Italy	Ryanair & Wizz Air
LIME	Italy	Ryanair & Wizz Air
LIMF	Italy	Ryanair & Wizz Air
LIMJ	Italy	Ryanair
LIMZ	Italy	Ryanair
LIPE	Italy	Ryanair & Wizz Air
LIPH	Italy	Ryanair & Wizz Air
LIPQ	Italy	Ryanair
LIPR	Italy	Ryanair
LIPX	Italy	Wizz Air
LIPY	Italy	Ryanair
LIPZ	Italy	Ryanair & Wizz Air
LIRA	Italy	Ryanair & Wizz Air
LIRF	Italy	Ryanair & Wizz Air
LIRN	Italy	Ryanair & Wizz Air
LIRP	Italy	Ryanair & Wizz Air
LIRZ	Italy	Ryanair
LMML	Malta	Ryanair & Wizz Air
LOWS	Austria	Wizz Air
LOWW	Austria	Ryanair & Wizz Air
LPFR	Portugal	Ryanair & Wizz Air
LPPD	Portugal	Ryanair

LPPR	Portugal	Ryanair & Wizz Air
LPPS	Portugal	Ryanair & Wizz Air
LPPT	Portugal	Ryanair & Wizz Air
LRBC	Romania	Wizz Air
LRCL	Romania	Wizz Air
LRCV	Romania	Wizz Air
LRIA	Romania	Wizz Air
LROD	Romania	Ryanair
LROP	Romania	Ryanair & Wizz Air
LRSB	Romania	Ryanair & Wizz Air
LRSV	Romania	Ryanair & Wizz Air
LRTM	Romania	Wizz Air
LRTR	Romania	Wizz Air
LZIB	Slovakia	Ryanair & Wizz Air
LZKZ	Slovakia	Ryanair

Appendix F: Competition of Foreign Airports

Table F.1: Contested and Contesting Foreign Airports

Contested airport (ICAO code)	Country	Contesting airport(s) (ICAO code)	Country/Countries
EDDC	Germany	LKKV, LKPR	Czech Republic
EDDG	Germany	EHGG	The Netherlands
EDDH	Germany	EHGG	The Netherlands
EDDK	Germany	EHBK, EHEH, EBLG	The Netherlands, Belgium
EDDL	Germany	EHBK, EHEH, EBLG	The Netherlands, Belgium
EDDM	Germany	LOWI, LOWS	Austria
EDDP	Germany	LKKV	Czech Republic
EDDW	Germany	EHGG	The Netherlands
EDJA	Germany	LOWI, LSZH, LSZR	Austria, Switzerland
EDLV	Germany	EHAM, EHBK, EHEH, EHRD, EBAW, EBBR, EBLG	The Netherlands
EDLW	Germany	EHBK	The Netherlands
EHAM	The Netherlands	EBAW, EDLV	Belgium, Germany
EHBK	The Netherlands	EBAW, EBBR, EBCI, EBLG, EDDK, EDDL, EDLV, EDLW, ELLX	Belgium, Germany
EHEH	The Netherlands	EBAW, EBBR, EBCI, EBLG, EDDK, EDDL, EDLV	Belgium, Germany
EHGG	The Netherlands	EDDG, EDDH, EDDW	Germany
EHRD	The Netherlands	EBAW, EBBR, EBOS, EDLV	Belgium, Germany
EKCH	Denmark	ESMS	Sweden
EKYT	Denmark	ESGP	Sweden
ENGM	Norway	ESOK	Sweden
ENRY	Norway	ESOK, ESGT	Sweden
ESMS	Sweden	EKCH	Denmark
ESNU	Sweden	EFVA	Finland
ESSA	Sweden	EFMA	Finland
ESSB	Sweden	EFMA	Finland
LOWG	Austria	LJLJ, LDZA	Slovenia, Croatia
LOWK	Austria	LIPQ, LJLJ	Italy, Slovenia
LOWW	Austria	LKTB, LZIB	Czech Republic, Slovakia

Appendix G: Histograms

In this appendix, histograms of the variables *Departing Air Passengers, Tax Amount* and *Jet Fuel* are provided. The red line in the histogram indicates the mean value of the respective variable.

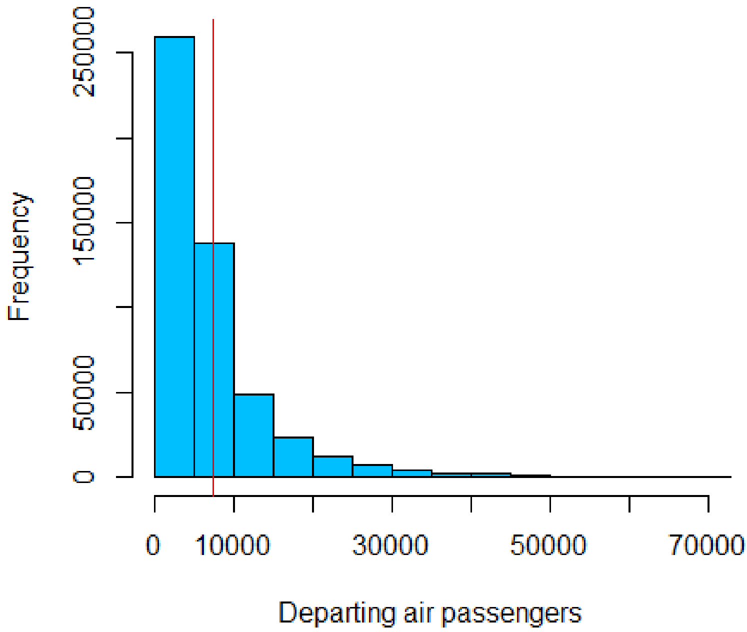

Figure G.1: Histogram of *Departing Air Passengers*

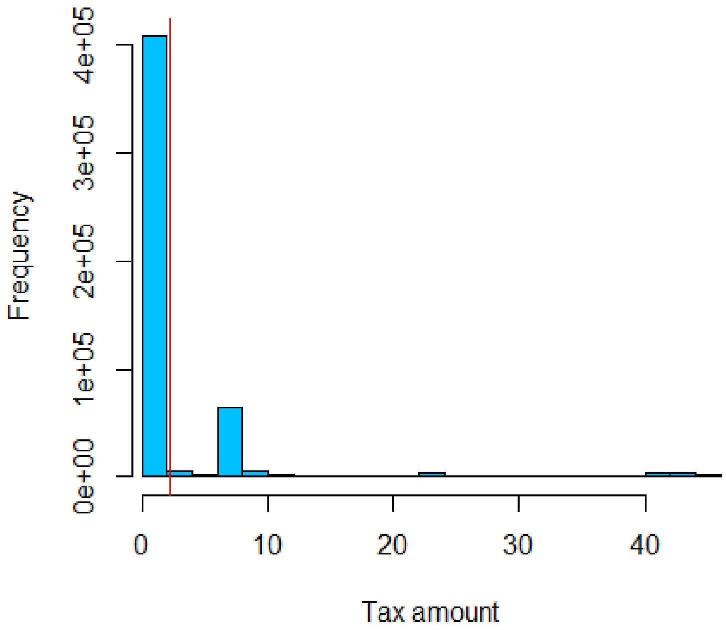

Figure G.2: Histogram of *Tax Amount*

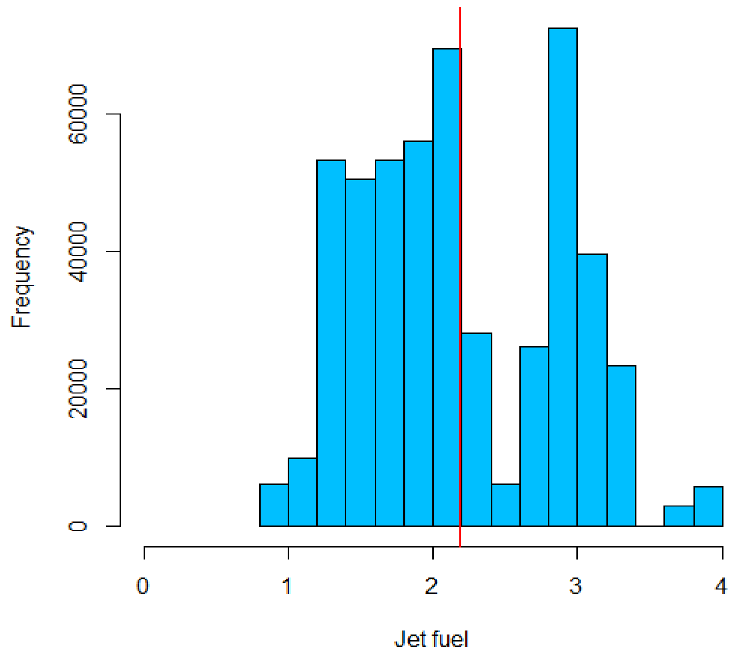

Figure G.3: Histogram of *Jet Fuel*

Appendix H: Regression Results Models C and D

Table H.1: C-models

	Dependent variable: Ln Departing Air Passengers		
	(C1)	(C2)	(C3)
Tax Dummy	-0.414*** (0.074)	-0.326*** (0.086)	-0.046 (0.033)
Ln Tax Amount	0.171*** (0.029)	0.200*** (0.033)	-0.017 (0.014)
Hub Airport	0.851*** (0.029)	0.891*** (0.032)	
Hub Airport * Tax Dummy		-0.079* (0.046)	0.082*** (0.019)
Low-cost Airport	0.049* (0.028)	0.108*** (0.030)	
Low-cost Airport * Tax Dummy		-0.235*** (0.044)	-0.033* (0.019)
Short-haul	0.013 (0.053)	-0.0004 (0.055)	
Short-haul * Tax Dummy		0.053 (0.072)	-0.017 (0.025)
Competition of Foreign Airports (Tax Dummy)		0.024 (0.044)	0.028 (0.018)
Ln Intensity of Air Transport	0.153*** (0.012)	0.157*** (0.012)	0.434*** (0.012)
Ln Jet Fuel	-0.089*** (0.009)	-0.093*** (0.009)	-0.046*** (0.004)
Observations	501,064	501,064	501,064
Month FE	YES	YES	YES
Route FE	NO	NO	YES
Adjusted R^2	0.163	0.165	0.153
F Statistic	5,402.840*** (df = 18; 501045)	4,485.775*** (df = 22; 501041)	5,108.431*** (df = 19; 494705)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: the variables Hub Airport, Low-cost Airport *and* Short-haul *drop-out in model C3 since they have no variation within route-month combinations.*

Table H.2: D-models

	Dependent variable: Ln Departing Air Passengers		
	(D1)	(D2)	(D3)
Tax Dummy	-0.414*** (0.074)	-0.462*** (0.086)	-0.025 (0.033)
Ln Tax Amount	0.171*** (0.029)	0.248*** (0.038)	-0.023 (0.016)
Hub Airport	0.851*** (0.029)	0.882*** (0.032)	
Hub Airport * Tax Amount		-0.026 (0.018)	0.028*** (0.008)
Low-cost Airport	0.049* (0.028)	0.094*** (0.030)	
Low-cost Airport * Tax Amount		-0.078*** (0.017)	-0.017** (0.008)
Short-haul	0.013 (0.053)	0.005 (0.055)	
Short-haul * Tax Amount		0.019 (0.034)	-0.004 (0.012)
Competition of Foreign Airports (Tax Amount)		-0.001 (0.018)	0.011 (0.007)
Ln Intensity of Air Transport	0.153*** (0.012)	0.155*** (0.012)	0.436*** (0.012)
Ln Jet Fuel	-0.089*** (0.009)	-0.091*** (0.009)	-0.046*** (0.004)
Observations	501,064	501,064	501,064
Month FE	YES	YES	YES
Route FE	NO	NO	YES
Adjusted R^2	0.163	0.164	0.153
F Statistic	5,402.840*** (df = 18; 501045)	4,462.658*** (df = 22; 501041)	5,106.118*** (df = 19; 494705)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: the variables Hub Airport, Low-cost Airport *and* Short-haul *drop-out in model D3 since they have no variation within route-month combinations.*