Norwegian School of Economics
Bergen, Spring 2020

The Air Passenger Tax

An empirical analysis of the effect of the Air Passengers Tax on air-traffic volumes for domestic routes in Norway

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Acknowledgement

Firstly, we would like to thank our supervisor Professor Øivind Anti Nilsen for giving us guidance and valuable feedback. Special thanks should also be given to Torolf Holte at Avinor for giving us access to flight data and support from the beginning. Without this data material, the analyses would not have been possible. Lastly, we would also thank friends and family for supporting us throughout the process of writing this master's thesis.

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Abstract

This master's thesis seeks to analyse the effect of the Air Passenger Tax, introduced by the Norwegian government in 2016 on all flights departing a Norwegian airport. The future of the Air Passenger Tax is of current political interest with potential change of the tax toward a greener agenda as a frequently discussed topic.

This thesis employs panel data techniques where we have designed econometric models that are based on a dataset where we follow the development of the number of daily passengers on a route with a specific airline. The models estimate the effect of the Air Passenger Tax on the air-traffic volume in terms of number of daily passengers in the 2012 to 2019 period. To isolate the effect of the tax, we have included variables that we assume explain the variation in demand for flights.

The results of the study show the effect of APT to be insignificant when evaluating the air-traffic volumes. Furthermore, when considered individually, Norwegian is shown to be the only airline with a change in passenger volume that is significantly different from zero at positive 6.87 %. This is surprising as similar studies conducted in other European countries have shown significant reductions in passenger volume following the introduction of similar taxes. This thesis explores possible explanations based on the high level of domestic competition and the heavy reliance on flying as a means of domestic transport as found in past research on adjacent topics.

Contents

1 Introduction

1.1 Background and motivation

The Air Passenger Tax (APT) was introduced on June 1st, 2016 by the Norwegian Ministry of Finance during state budget negotiations. This was done as a primarily fiscal measure, but officials in the Norwegian government also cited environmental concerns to justify this tax. The decision was met with strong reactions, both among passengers as well as within the Norwegian aviation industry. The discussions centred on increased ticket prices and a subsequent reduced demand for flights. The airlines, in turn, warned that the fee would provide a reduced route network, especially in the districts. The imposition of the APT was the one of the reasons for the closing of Moss airport Rygge, which became a political issue with many people in the area around the airport losing their jobs.

The introduction of APT has attracted much media attention, being discussed as recently as December 2019 in an official government report (NOU, 2019). Current debate centres around whether the tax should be kept in its current form, or whether to change it to a "greener" tax with a more specific environmental goal. Although many have an opinion about APT, its actual effects on air-traffic volumes have not been analysed thoroughly yet. This makes the effects of APT both a relevant and current topic and thus we want to investigate in more detail.

In this master thesis, we seek to determine the consequence of the APT on domestic air-traffic volumes, more specifically the number of daily passengers on different routes. In particular, we aim to determine the significance and magnitude of impact as well as the potential for asymmetric impact across routes and airlines.

1.2 Research question

The purpose of this study is to investigate the effects APT on air-traffic volumes. We will analyse data material comprised of the number of daily passengers travelling on a given route, with a specific airline, on a set of Norwegian domestic routes. The research question will therefore be:

"*How has the Norwegian Air Passenger Tax affected air-traffic volumes on domestic routes?*"

Our research question is of interest for several reasons. The debate as to whether to keep the current design of the tax or change it for something with a more environmental focus, remains a debated topic. Defenders of the current iteration of APT argue that the imposition of the tax yields positive environmental externalities as air-traffic volumes have decreased. Whilst it is not the purpose of this thesis to take a political stance, it is of public interest to determine the factual basis of such claims.

1.3 Delimitation

In this thesis we are interested in the effect of APT on air-travel volumes. Potential environmental effects and other socioeconomic externalities may be briefly considered where they arise, but it is not the purpose of this thesis to take a stance on such issues.

1.3.1 Domestic air-travel

We have chosen to limit our analysis to domestic air-travel in Norway. The reasoning behind this is that we expect larger effect in domestic air-travel than in international air-travel due to the fact that the APT is imposed twice on a domestic roundtrip travel, unlike international travel where the APT is only imposed once. In addition, the APT will in most cases represent a larger share of the ticket price for domestic travel as these are usually cheaper than their international counterparts. Within domestic travel, there are alternatives to air-travel between the big cities such as Oslo, Bergen, Trondheim, Kristiansand, and Stavanger. When there is an alternative, we believe that the impact of an APT will be greater. In domestic traffic, the APT is also subject to VAT, and the burden of APT will therefore be correspondingly higher.

By limiting our analysis to domestic air travel we also mitigate the effect of the APT changing over the years as the APT for domestic travel has remained roughly the same with small changes over the years[1], while the APT for international travel had a large increase in 2019. For simplicity we will assume that the changes in APT for domestic air travel have no effect.

The Norwegian domestic market is dominated by SAS, Norwegian and Widerøe, which together account for 99.4 % of all domestic air-traffic in Norway (NOU, 2019). These three airlines are the only ones that have been operating continuously throughout the years in the time period analysed. Therefore, we will also limit our analysis to only include flights operated by SAS, Norwegian and Widerøe. We are aware that this may eliminate outliers whereby one

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[1] APT was introduced in 2016 at a rate of 80 NOK one-way and was adjusted for inflation to 82 NOK and 83 NOK in 2017 and 2018 respectively. On 1st of January 2019 the tax was raised to 84 NOK until the 1st of April 2019 when it was lowered to 75 NOK.

or more airlines have been disproportionately affected by APT. For example, a smaller route on which one of these excluded carriers operate may witness a significant reduction in air-traffic volumes. The total effect of this is however considered to be sufficiently low to proceed with the removal of these airlines.

1.3.2 Non-PSO routes

In addition to limiting the analysis to domestic air travel, we further limit the analysis to non-PSO routes. The PSO routes are operated with state subsidies where the government has a decisive influence on supply and demand. PSO routes are unprofitable on a commercial basis and are different from commercial routes that do not receive subsidies. PSO routes are also less sensitive to changes in the airline industry as observed in April 2020 during the COVID-19 pandemic. At one time Widerøe had the most departures of all commercial airlines in Europe. Widerøe’s flight volume in this timespan was driven by PSO routes and intermediate governmental paid domestic routes in Norway (Isaksen, 2020; Elnæs, 2020). Hence, it is likely that the imposition of APT will have had a lesser effect on PSO routes. We therefore believe that PSO and non-PSO routes are not directly comparable, and we will only focus on the non-PSO routes such that the analysed routes are operated under the same commercial conditions.

2 Institutional Background

For many years, the Norwegian airline industry has experienced growth in traffic volume and the major routes are currently dominated by two airlines, SAS and Norwegian. These have been the primary drivers of growth in recent history, with air-traffic volumes almost doubling since 2002 as shown in figure 1.

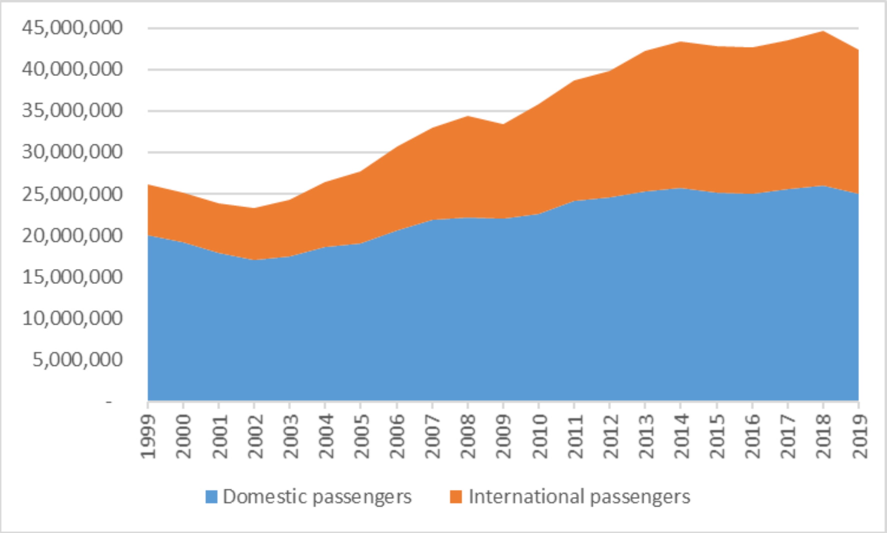

Figure 1 - Number of passengers 1999-2019 (Avinor, u.d.)

The growth in air-traffic has been important both for the Norwegian economy and society, as well as more widely. Travel by air is the fastest way to move passengers and goods over the long and oftentimes challenging topography separating Norway's scattered population centres. As such, it also fulfils an important role in facilitating Norwegian business. For certain parts of the country, air travel is the only realistic transport alternative. Therefore, a sufficient network of routes at acceptable prices is important in enabling people to live throughout the country while also having access to important public institutions. A well-connected network of routes is also crucial for trade and cooperation with the rest of the world.

In recent years we have witnessed significant factors which have affected air-traffic volumes, among them the latest development due to the rapid spread of COVID-19. The timespan for this study, 2012 – 2019, does not include the effects of COVID-19 as these effects were first observed at the start of 2020. We will therefore not evaluate this matter and its effect on air-traffic further in this thesis, although it remains a critical topic for the industry in the months and years to come. On the other hand, during the timespan considered for this thesis we have experienced societal pressure to fly less ("flight-shame"). The flight-shame movement originated in Sweden in 2017 and argues that the emissions caused by air-traffic are so severe that the mode of transport should be shunned. This movement has had significant impact in Sweden, which observed a subsequent 4% drop in air air-traffic volumes (BBC, 2020). Harald Thune-Larsen, Researcher at the Norwegian Institute of Transport Economics, has stated that this phenomenon has yet to affect Norwegian travel habits (Frøsland, 2019). Nevertheless, figure 1 demonstrates that the total number of passengers has stagnated since 2014.

2.1 Historical development in the Norwegian Airline industry

Norwegian airports were historically classified as either major airports or Short Take-off and Landing (STOL) airport, based on whether the airport was serviced by the main route network or the STOL network.

Major Airports		STOL Airports			
IATA Code	City	IATA Code	City	IATA Code	City
AES	Aalesund	ANX	Andøya	RVK	Rørvik
ALF	Alta	BJF	Båtsfjord	SDN	Sandane
BDU	Bardufoss	BNN	Brønnøysund	SKN	Stokmarknes
BGO	Bergen	BVG	Berlevåg	SOG	Sogndal
BOO	Bodø	DLD	Dagali	SOJ	Sørkjosen
EVE	Evenes	FDE	Førde	SSJ	Sandnessjøen
HAU	Haugesund	FRO	Florø	SVJ	Svolvær
KKN	Kirkenes	HAA	Hasvik	VDB	Fagernes
KRS	Kristiansand	HFT	Hammerfest	VDS	Vadsø
KSU	Kristiansund	HOV	Ørsta/Volda		
LKL	Lakselv	HVG	Honningsvåg		
LYR	Longyearbyen	LKN	Leknes Vardø		
MOL	Molde	MEH	Mehamn		
OSL	Oslo	MJF	Mosjøen		
RRS	Røros	MQN	Mo i Rana		
SVG	Stavanger	NVK	Narvik		
TOS	Tromsø	OLA	Ørland		
TRF	Sandefjord	OSY	Namsos		
TRD	Trondheim	RET	Røst		

Table 1: Overview of STOL and major airports in Norway, 1982 (Thune-Larsen, 2019)

The Norwegian network of airports gradually expanded from the mid-1930s, and during the 1960s most of today's major airports were linked to the route network (Thune-Larsen, Luftfartstilbudet i, til og fra Norge før og etter liberaliseringen, 2019). In 1982, Norway had 18 major airports and 21 STOL airports. SAS, Widerøe and Braathens accounted for 99.1% of domestic air-traffic (Thune-Larsen, Luftfartstilbudet i, til og fra Norge før og etter liberaliseringen, 2019). In 1992 the number of STOL airports had risen to 31, yet the market remained highly concentrated as the three largest airlines retained 98% market share.

The Norwegian route network servicing the main airports was deregulated in 1994. In the period before deregulation, SAS held a monopoly on the routes between Oslo and the major airports in the northern part of Norway, while Braathens held a monopoly on the routes between Oslo and Kristiansand, Aalesund, Molde, Kristiansund and Røros (Thune-Larsen, Luftfartstilbudet i, til og fra Norge før og etter liberaliseringen, 2019). Other routes displayed varying degrees of competition.

Following deregulation, airlines could operate all routes linking major airports in Norway. Both air-traffic and capacity expanded, yet there were no new airlines entering the market. SAS and Braathens were the only airlines that operated routes between major airports (Steen & Sørgard, 2003). Steen & Søgard (2003) argued that the reasons for this may be that foreign airlines did not gain permission to operate domestic routes until 1997, as well as the fact that SAS and Braathens had almost equal market shares in the domestic market. Therefore, it was natural for SAS and Braathens to maintain initial market shares following deregulation. Additionally, there remained limited capacity at Oslo airport (Fornebu) for expansion. The capacity problems were solved in 1998 when a new main airport was opened in Oslo at Gardermoen, and all air-traffic was moved from Fornebu. The slot capacity at Gardermoen was higher and allowed for expansion and the new entry of airlines (Steen & Sørgard, 2003).

Color Air entered the market in the summer of 1998 as a low-cost carrier (LCC) and started to operate routes between Oslo and Bergen, Aalesund and Trondheim (Thune-Larsen, Luftfartstilbudet i, til og fra Norge før og etter liberaliseringen, 2019). The deregulation of the industry in 1994 and the opening of Gardermoen airport generated a large supply of seats. In 1999, 3 of the 22 largest domestic routes had three competitors in SAS, Braathens and Color Air. Many other routes had two competitors and the number of monopoly routes was decreasing (Thune-Larsen, Luftfartstilbudet i, til og fra Norge før og etter liberaliseringen, 2019).

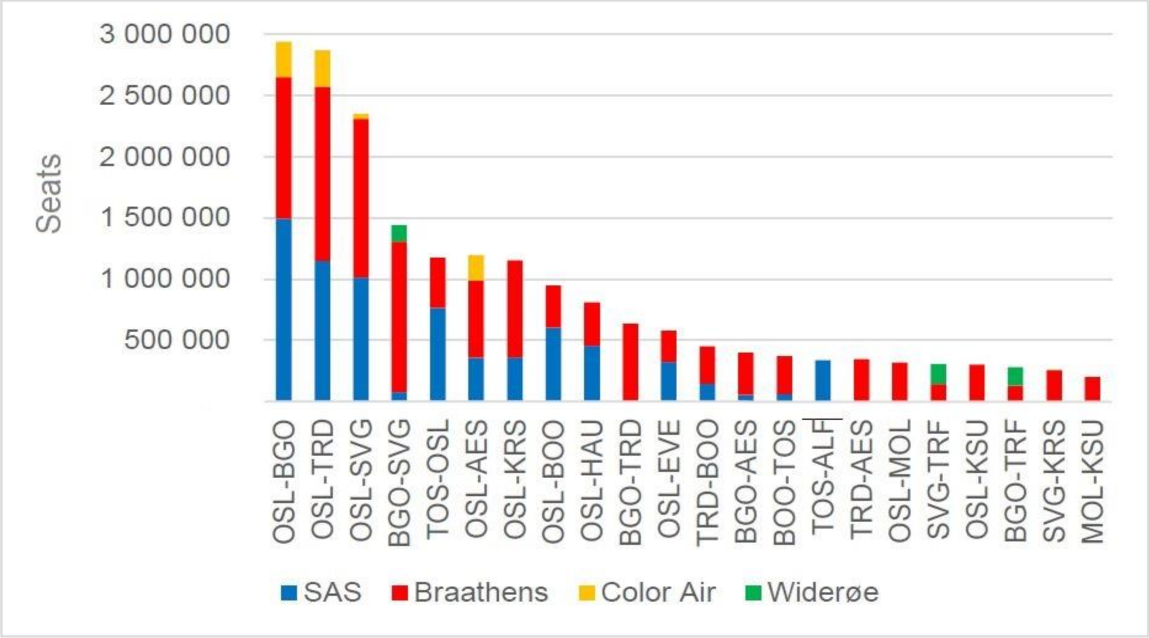

Figure 2 - Supply of seats on domestic routes (aggregate for both ways) in 1999 for routes with seat capacity of minimum 200 000 (Thune-Larsen, 2019).

SAS and Braathens response to Color Air's entry was to aggressively increase capacity in a bid to pressure Color Air out of the market (Steen & Sørgard, 2003). In 1999, one year after Color Air's entry, they went bankrupt and ceased their operations. In response to this collapse and with the threat of a new entrant temporarily dispersed, both SAS and Braathens scaled down their capacity.

In 2001 it was announced that SAS acquired Braathens. The competition authority in Norway approved this merger as they believed that Braathens was on the brink of bankruptcy (Norwegian Competition Authority, 2001). A monopolisation of the domestic airline industry was bad for competition, but the Norwegian competition authority's view was that bankruptcy remained a worse alternative in terms of competition (Norwegian Competition Authority, 2001). Following the acquisition of Braathens, SAS maintained near monopoly of domestic routes until Norwegian Air Shuttle (NAS) began operating domestic routes in 2002. In 2003, SAS accounted for 67 % of seat capacity. Widerøe and Norwegian accounted for 18 % and 12 % respectively (Thune-Larsen, Luftfartstilbudet i, til og fra Norge før og etter liberaliseringen, 2019).

Domestic air-traffic volume as a whole decreased after Color Air's bankruptcy in 1999, and by 2003, air-traffic was substantially lower. It was not until Norwegian's entry into the domestic market spurred growth that air-traffic increased and by 2007 Norwegian accounted for 20 % of domestic seat capacity. In 2007, competition was extended to several routes and the competitive balance between Norwegian and SAS on the largest routes was substantially improved from 2003.

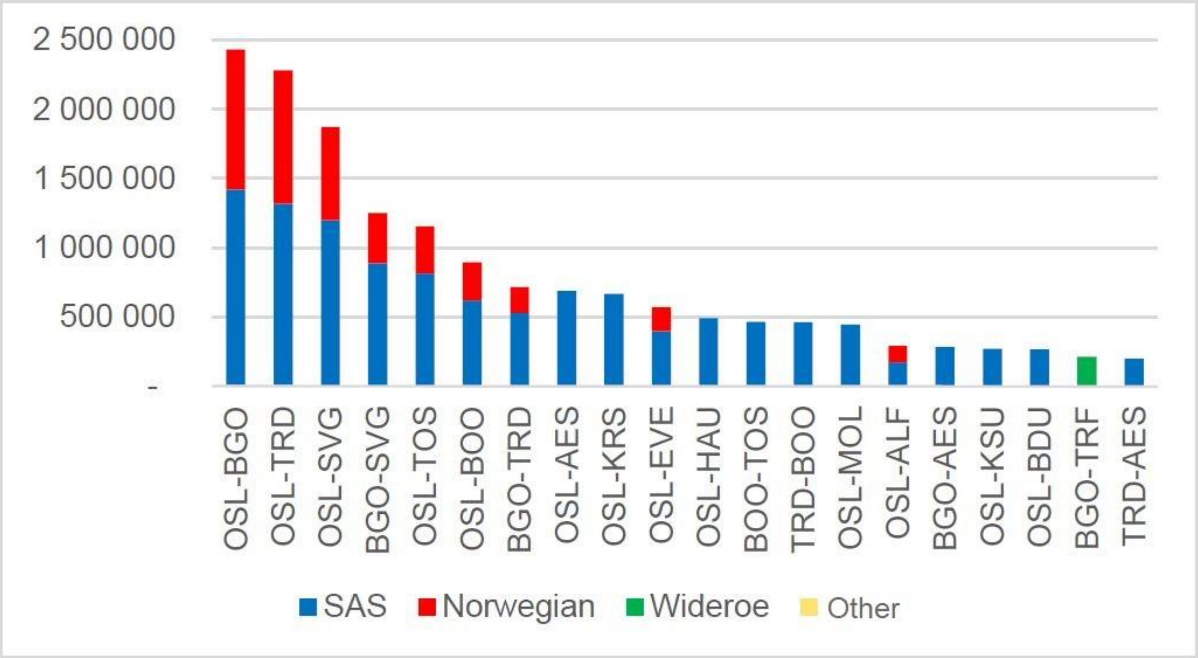

Figure 3 - Supply of seats on domestic routes (aggregate for both ways) in 2007 for routes with seat capacity of minimum 200 000 (Thune-Larsen, 2019).

In 2002, Norwegian established itself in the domestic market and emerged as a strong competitor. When Norwegian entered the market, there was only one other major competitor in the market. The Norwegian Competition Authority also implemented a ban on loyalty programs in the same year (Norwegian Competition Authority, 2002). Loyalty programs had been historically important for SAS and thus the ban facilitated competition in the marketplace. The ban remained in place until 2013 when ESA ruled that the ban was in conflict with the EEA agreement (Takla, 2013). By this point Norwegian had established itself as a major competitor.

The introduction of a low-cost carrier like Norwegian and its subsequent success pushed full-service carriers like SAS to cut costs and reduce prices. Hence, traffic increased whilst prices decreased. The deregulation of the industry and the emergence of low-cost carriers have been significant factors which have driven growth in air-traffic volume since the 1990s. It was these two factors, combined with an open Norwegian economy and increased population growth, which led to air-traffic volumes increasing 140% from 1995 to 2017 (NOU, 2019). It is worth noting that much of this growth has taken place at Oslo Airport, where the number of domestic flights has risen by 91 % from 1992 to 2017. Other airports on the other hand handle 8 % fewer flights now than prior to deregulation (NOU, 2019).

2.2 PSO routes

Whilst PSO routes are excluded from the analysed dataset, they are more common in Norway than internationally. As such this segment provides a brief description. Most of Norway's air-traffic is operated commercially. In order to ensure good transport alternatives across the country, the government subsidises air transport on certain routes which are not profitable on a commercial basis (The Norwegian Government, 2020). These routes are Public Service Obligation (PSO) routes and are mainly between regional airports in the western and northern parts of Norway. The government regularly invites airlines to tender, where they offer exclusive access to a given route for a given time period with requirements for capacity, price, and frequency. All airlines within the EEA area can bid on these PSO routes as Norway is a part of the EEA agreement (The Norwegian Government, 2020).

PSO routes are common in Europe, but no country operates more PSO routes than Norway. Among European countries with PSO routes it is common that few, and almost exclusively national airlines participate in the bidding for the routes, and that only one airline ends up operating the routes. High establishment costs, economies of scale as well as asymmetric information are cited as causes for this lack of competition (Bråthen, et al., 2015). All of the PSO routes in Norway are today operated by Widerøe, with the exception of the route between Røros and Oslo where Air Leap will take over from April 1st, 2020. From this date there will be PSO routes at 29 airports, divided into 21 routes (NOU, 2019).

2.3 The major participants

Today, there are three major participants in the Norwegian domestic market. These area SAS, Norwegian and Widerøe. In addition, we will present Avinor because they operate a large majority of the airports and it represents a crucial framework for the industry in Norway.

2.3.1 Avinor

Avinor is a Norwegian state-owned company that operates 44 state-owned airports and is responsible for air-traffic control services in Norway. Their operations are financed through aviation fees and sales at airports. Avinor's mission is to ensure aviation services throughout

Norway. This responsibility consists of owning, operating and developing a nationwide network of civilian sector airports, and a combined security service for civil and military aviation (Avinor, u.d.). 50 million passengers travel through Avinor's airports yearly, about half of these travel through Oslo Airport Gardermoen (Avinor, u.d.).

Avinor's two biggest competitors in Norway was for several years Moss airport Rygge, and Sandefjord airport Torp. These two airports competed with Oslo airport Gardermoen for the traffic in the central Oslo area. Today, Sandefjord airport Torp is the only competitor as Moss airport Rygge ceased operations 1. November 2016.

2.3.2 SAS – Scandinavian Airlines Systems

SAS was in 1946 formed from Det Danske Luftfartselskab A/S, Det Norske Luftfartselskap A/S and Svensk Interkontinetal Lufttrafik AB (SAS, u.d.). Originally, the Swedish government owned 21.4 %, while the Danish and Norwegian government owned 14.3 % each. In 2016, both the Swedish and Norwegian government reduced their ownership, and in June 2018, the Norwegian state sold the rest of its shares in SAS (NOU, 2019).

SAS has a joint Scandinavian air operator certificate (AOC), which gives them access to all the traffic rights of the three countries, including EU's Open Sky agreements (NOU, 2019). SAS also established an AOC in Ireland in 2017 (SAS, 2017).

SAS carries over 28 million passengers annually (SAS, u.d.) and their business strategy is aimed at the business market and frequent travellers where they reward loyal travellers through their EuroBonus program. Since the introduction of low-cost carriers, such as Norwegian, SAS has faced strong competition and cut ticket prices to adapt the service offered to different customer groups (NOU, 2019).

In 2009 and 2010, SAS had to issue shares of SEK 6 billion and SEK 5 billion respectively to ensure continued operations (SAS, 2009; SAS, 2010). In 2012, they had to undergo a restructuring of the company to avoid bankruptcy and improve profitability. In the "4Excellence" restructuring plan a number of measures were initiated to reduce costs. Operating costs were significantly reduced, partly through a reduction in the number of employees and salaries (SAS, 2012).

The "4Excellence" restructuring plan included asset disposal and financing plan to increase liquidity. This meant, among other things, that SAS would sell the majority of their shares in Widerøe (SAS, 2012). The sale went through in 2013 when a group of investors acquired 80

% of the shares in Widerøe (Lorentzen, Landre, & Lorch-Falch, 2013). SAS sold the rest of their shares in 2016 and despite the sale, Widerøe remained a regional partner for SAS (Budalen, 2016). The collaboration means, among other things that passengers may participate in their loyalty program EuroBonus when traveling with both airlines.

2.3.3 Widerøe

Widerøes Flyveselskap AS was founded in 1934, which makes them the oldest airline in Norway. From 2002 to 2013 Widerøe was a subsidiary of SAS, today they the largest regional airline in Scandinavia and carries over 2.8 million passengers annually (Widerøe, u.d.). Widerøe's route network is comprehensive with over 40 domestic destinations. The network is focused on shorter flights through local and regional airports along the coast of Norway. Hence, Widerøe's fleet is different from SAS and Norwegian which mainly operate jet-planes. Widerøe mainly operates Bombardier Dash-8 turboprop planes which has far less capacity and can operate on STOL airports.

Over 1/3 of Widerøe's flights operates the STOL network (NOU, 2019). Most of these routes are public service obligation (PSO) routes which are compensated by the government to maintain an air-transport alternative in certain areas as these routes are commercially unprofitable. Widerøe play an important role for the development of air transport in the districts and all PSO routes are today operated by Widerøe. In 2017, 37 % of Widerøe's passengers travelled on the PSO routes and 63 % travelled on commercial routes (NOU, 2019).

2.3.4 Norwegian

Norwegian was founded in 1993 and operated small routes before they began operating bigger aircrafts in 2002 and has since then grown significantly (Norwegian, u.d.). Norwegian's business model is to operate as a low-cost carrier and they have a vision of "*offering affordable fares for all*" (Norwegian, u.d.). As a low-cost carrier Norwegian offers lower ticket prices and fewer amenities and services to its passengers. Since 2002, Norwegian has experienced greater relative growth than all comparable European airlines (NOU, 2019). Today they are the biggest competitor to SAS on the domestic market and the world's fifth largest low-cost airline, carrying over 37 million passengers in 2018 (Goldstein, 2019).

Norwegian currently holds five AOC to secure their traffic rights and have a fleet consisting of around 160 aircraft which is young and fuel-efficient with an average age of just 4.6 years (Norwegian, u.d.). The young and fuel-efficient fleet is key to Norwegian's strategy to keep low operating costs. Nevertheless, their fleet has caused them problems as Norwegian has experienced several issues with their newly purchased aircrafts. Norwegian acquired several

787 Dreamliner aircrafts from Boeing to expand their long-haul services, but they have faced disruptions over the last decade with engine problems on these aircrafts. Norwegians former CEO, Bjørn Kjos, has stated that "*The long-haul business would have been very good if it weren't for the engine problems that we encountered. It put a lot of strain on us and it cost us a lot of money*" (Buyck, 2018). Along with the long-running problems with Rolls-Royce's engines on Boeing 787 Dreamliners Norwegian has also suffered from the global grounding of the Boeing 737 MAX aircraft which Norwegian has 18 of in its fleet and has 92 on order (Reuters, 2019). Norwegian recently changed their strategy from growth to profitability, and the 737 MAX aircraft was supposed to play a significant role (Ekeseth, 2019; Hussain, 2019).

2.4 Competition and market share

The Norwegian domestic market is dominated by SAS, Norwegian and Widerøe, which together account for 99.4 % of all domestic air-traffic in Norway (NOU, 2019). Figure 4 shows how the market shares of SAS, Norwegian and Widerøe has developed during the period 2002-2017, based on number of transported passengers.

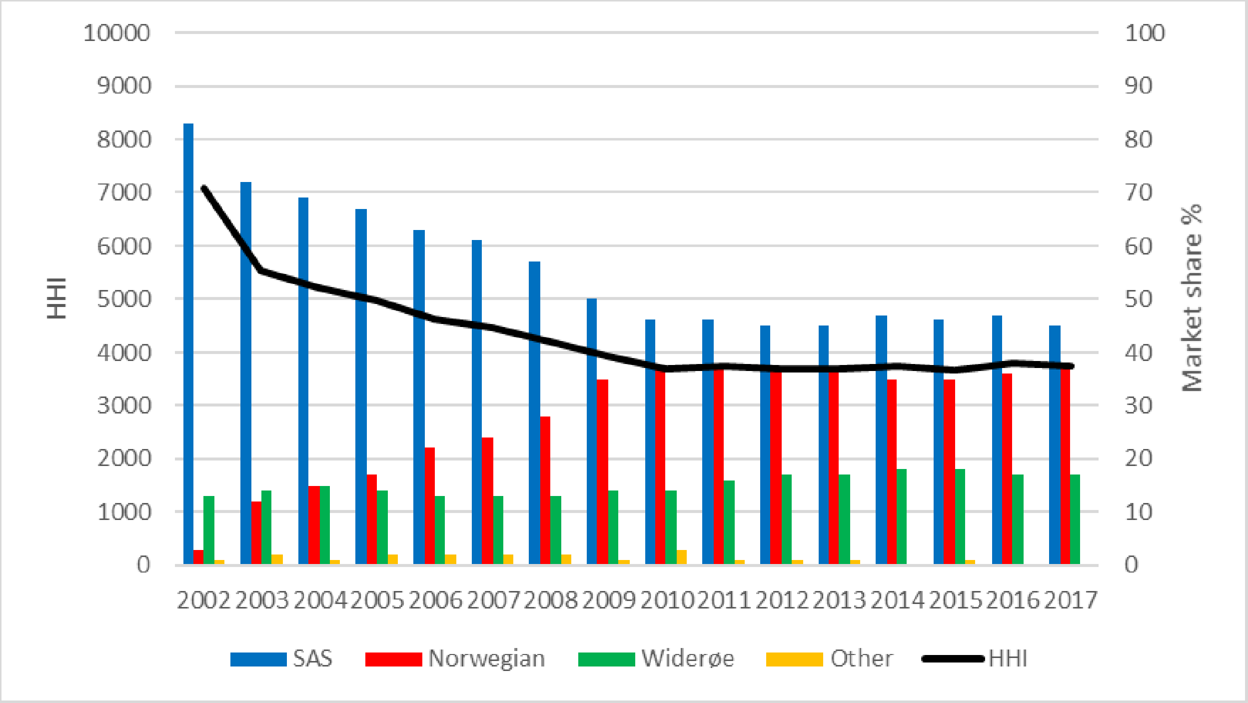

Figure 4 - Market shares and HHI index for the domestic market 2002-2017. Market shares collected from Thune-Larsen & Farstad, Reisevaner på fly 2017 (2017).

SAS has historically been the largest operator on the domestic network and in 2017 they transported 7 million passengers, giving a market share of 45 %. The second largest operator is Norwegian with 5.8 million transported passengers domestically in 2017, giving a market share of 38 % (Thune-Larsen & Farstad, Reisevaner på fly 2017, 2017). In the period 2002-

2010, Norwegian continued to capture market shares from SAS. The growth in air-traffic has mainly been driven by the expansion of Norwegian (Grünfeld L. A., Myklebust, Underthun, Elnæs, & Thune-Larsen, 2019). Since 2010, SAS's market share has remained stable around 46 %. Widerøe had 17 % of the domestic market in 2017 with 2.6 million passengers (Thune-Larsen & Farstad, Reisevaner på fly 2017, 2017). It is higher than at the beginning of the 2000s, but roughly in line with the years 2011-2016.

A commonly accepted measure of market concentration and competition among market participants is the Herfindahl-Hirschman Index (HHI). HHI is calculated by summing the square the market shares of each firm in the market. The index ranges from close to zero, that indicates perfect competition, to 10 000 which indicates a monopolist market. Markets with a HHI between 1500 and 2500 are generally considered to be moderately concentrated, and markets with HHI above 2500 to be highly concentrated (The United States Department of Justice, 2018). Figure 3 show how HHI for the domestic market in Norway has develop in the period 2002-2017. Since Norwegian got established, HHI has gone from 5528 in 2002 to 3758 in 2017. This indicates that the market concentration has declined and that the competition between the three major airlines has increased. Even though competition has increased, the HHI is still above 2500 which indicates that the domestic market in Norway is still highly concentrated.

On the major domestic routes, the market is almost equally divided between SAS and Norwegian (NOU, 2019). Some of the them are big enough to draw more competition as 7.1 million passengers were transported in 2018 on the four biggest routes (Grünfeld L. A., Myklebust, Underthun, Elnæs, & Thune-Larsen, 2019). These numbers are high even in a European context. In terms of number of passengers, in 2016 Oslo–Trondheim ranked fifth in Europe. Oslo–Bergen ranked in eight place, while Oslo–Stavanger ranked in 16th place (Grünfeld L. A., Myklebust, Underthun, Elnæs, & Thune-Larsen, 2019).

	City pair		Number of passengers (2016)
1	Toulouse	Paris	2 358 917
2	Madrid	Barcelona	2 328 726
3	Nice	Paris	2 124 792
4	Catania	Roma	1 998 352
5	Oslo	Trondheim	1 988 105
6	Berlin	München	1 939 820
7	Frankfurt	Berlin	1 935 465
8	Oslo	Bergen	1 881 960
9	München	Hamburg	1 805 211
10	Athen	Thessaloniki	1 803 733

Table 2 - Table of the 10 largest routes in Europe in 2016, measured in total number of passengers (Grünfeld L. A., Myklebust, Underthun, Elnæs, & Thune-Larsen, 2019).

2.5 Profitability in the airline industry

In terms of profitability, it may be appropriate to present it in the form of EBIT margins[2] (Grünfeld L. A., Myklebust, Underthun, Elnæs, & Thune-Larsen, 2019). In figure 5 we see the development in EBIT margin for SAS, Norwegian and Widerøe from 2009-2019[3]. Widerøe has had positive margins over the whole period. One reason may be that Widerøe has no competition on many routes, and the fact that Widerøe mainly operates the PSO routes that the government subsidise.

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[2] EBIT margin is a financial ratio that measures the profitability of a company calculated by dividing EBIT (earnings before interest and taxes) by net income.

[3] Data retrieved from the airline’s annual reports **Invalid source specified.**

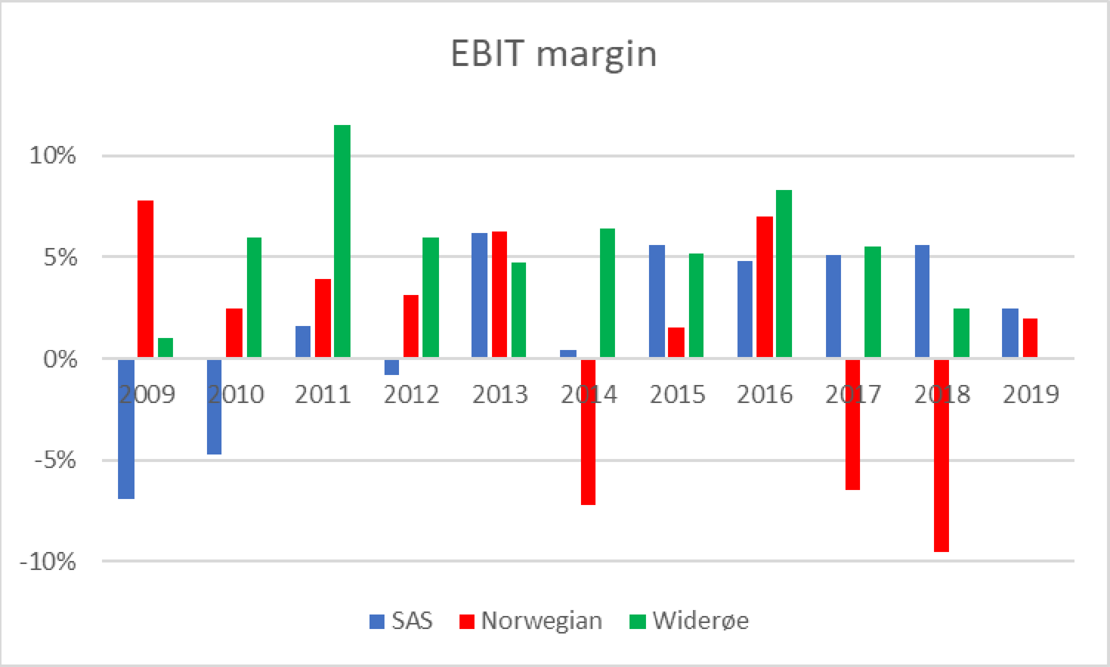

Figure 5 - Development in EBIT margins from 2009-2019[4]

In the last two decades the European short-haul market has been highly competitive. The entry of low-cost carriers has increased competition in the market, driving prices down (Powley, 2017). This have been highlighted in the recent years by several bankruptcies among European airlines such as Monarch (UK), Thomas Cook (UK) and Air Berlin (Germany) among others. According to International Air Transport Association (IATA), it was not until 2014 that investments in airlines produced as good returns as funds invested in another business with similar risk (NOU, 2019, ss. 29-30).

We have not seen bankruptcies in the Norwegian airline industry in the last two decades. However, as profitability in the industry is under pressure, additional fees, and taxes, such as the Air Passenger Tax, could have major consequences in the future. Some routes may become unprofitable due to reduced demand. The regional routes are particularly vulnerable because the customer base is smaller. Thus, the implementation of the Air Passenger Tax may threaten some of these routes. Widerøe has already announced that they are cutting 15 % of their flights on the STOL network. CEO of Widerøe, Stein Nilsen, stated in a press release that these cuts will affect much needed transport in the regional parts of Norway (Indsetviken, Budalen, Helness, & Hykkerud, 2020). He further elaborated that since the introduction of the Air Passenger Tax, Widerøe has struggled to find profitability on the STOL network. (Indsetviken, Budalen, Helness, & Hykkerud, 2020).

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[4] Financial statement for Widerøe 2019, not available as of May 2020.

3 The Air Passenger Tax (APT)

The first Air Passenger Tax (APT) was introduced in Norway in 1978 as a tax on charter flights and in 1994 made into a tax for every international flight. In 1995, APT was imposed on flights between the biggest cities in Norway, where travel by railroad was a realistic alternative. These fees and taxes were later abolished in 2002 (Grünfeld L. , Myklebust, Underthun, Elnæs, & Thune-Larsen, 2019).

The APT in question for this thesis was introduced June 1st 2016 by the ministry of finance following a decision made by the Norwegian parliament in late 2015 as a part of the negotiation for the 2016 state budget (Regjeringen, 2016). The APT is a tax imposed on every passenger departing from a Norwegian airport. The tax obligation covers all commercial flights, except flights from the continental shelf, Svalbard, and Jan Mayen. Military flights, emergencies or ambulance services are also exempt from the APT (The Norwegian Tax Administration, u.d.). Transit and transfer passengers are exempt from being taxed twice on the same journey. Because of this, exempt for transit passengers, the APT was in March 2016 postponed by the ministry of finance due to concerns about the exempt for transit and transfer passengers constituting unlawful state aid. Later, the EFTA surveillance agency (ESA), decided that the APT does not constitute unlawful state aid (EFTA Surveillance Authority, 2017) and the APT was imposed June 1st 2016.

From June 1st, 2016, the APT was NOK 80 per departing passenger. It was later adjusted to NOK 82 in 2017, NOK 83 in 2018 and from April 1st, 2019 the APT is split between short-haul flights and long-haul flights. The APT was split due to a request from the Norwegian parliament in 2018 to give the APT a more environmentally friendly profile by for example differentiating by the flights distance (NOU, 2019). Short haul flights are considered flights to destinations which have its capital within 2500 km from Oslo. Flights within in the European Economic Area (EEA) are also considered as short haul due to regulations against discrimination in the EEA (Grünfeld L. , Myklebust, Underthun, Elnæs, & Thune-Larsen, 2019). The APT from April 1st, 2019 is NOK 75 for short-haul flights and NOK 200 for long-haul flights. Today these have been adjusted to NOK 76.50 and NOK 204, respectively. In the government account for 2018, the revenue generated from the APT were NOK 1.87 billion, where approximately half of it comes from domestic travel (NOU, 2019).

When the APT was introduced, it sparked a debate about the effects of the APT with both positive and negative reactions. A major controversy around the privately owned Moss Airport Rygge arose when the plans for the APT were announced. Ryanair, which was the main airline carrier at Moss Airport Rygge, announced that Ryanair intended to reduce their traffic if the APT was imposed (NRK, 2015).Ryanair's margins at Rygge were low and one of the poor-performing airports in Ryanair's network. The imposition of the APT cut the margins lower and would make Ryanair's base at Moss Airport Rygge unprofitable (Elnæs, 2020). Moss Airport Rygge closed November 1st, 2016 as Ryanair wanted to reduce their traffic through the airport. The owners of Rygge airport considered the traffic to be too low to continue operating the airport (Elnæs, 2020). It may be difficult to identify the effects of the closure on air-traffic volume as some of the routes from Rygge were transferred to Oslo airport, some to Torp and some were closed down. The closure of Moss Airport Rygge and Ryanair's reduced traffic may be the biggest consequence of the APT that comes to people's mind. The closure of the airport has had a negative impact as Moss Airport Rygge was Ryanair's hub in Norway with over 1.9 million passengers annually. The closure of the airport became a political issue with over 500 people losing their jobs when the airport closed (NRK, 2019).

3.1 The purpose of the tax

Former minister of finance, Siv Jensen, stated in 2016 that the APT is primarily a fiscal tax created to generate revenue for the government, but that it may also yield environmental effects if it contributes to reducing the number of flights (Regjeringen, 2016). Whilst APT is not defined as an environmental tax, but it may affect the supply and demand for air travel and therefore reduce air-traffic and pollution. However, the APT is not designed to have an efficient environmental impact. It may reduce the demand for air travel and slow down the growth in air-traffic, but only to a limited extent.

3.2 Passthrough rate

The APT will be collected by the airlines on behalf of the government. Therefore, the individual airlines are able to decide how much of the APT is passed on to the passengers, and how much if any of the burden they carry themselves. Practices differ between airlines as well as within routes for any given airline as each airline aims to maximise the profitability of their total route network. It is difficult and complex to estimate the passthrough rate without detailed price data as airlines have been hesitant to share this information publicly. When the introduction of APT was first announced the airlines stated bluntly that any such tax would be fully passed on to the consumers. This remains the official position of the airlines although they have ceded that this tax may be applied more so to some routes than others (Haugan, 2016). An interesting question arises in the consideration of whether a tax applied directly to the supplier (airline) would yield a different result. This is thought to be less disruptive to pricing dynamics compared to the current iteration of APT as it is added on top of the ticket price. With regard to APT, airlines are however able to employ differing passthrough rates to different routes and flights and thus may offer different results.

3.3 Other fees and taxes within the Norwegian air industry

There are several fees and taxes imposed on the Norwegian air industry. A number of fees are imposed by Avinor to cover the ownership and operation of the aviation infrastructure. Avinor's customers paid in 2018 NOK 5.51 billion in fees (NOU, 2019). Additional fees are also imposed by the Norwegian government and the EU.

CO_2 emissions from aviation within the EEA have been included in the EU emissions trading system (EU ETS) since 2012 (European Commission, u.d.). This means that the price of CO_2 emissions from aviation in this area depend on the quota price of CO_2 emissions (Grünfeld L. A., Myklebust, Underthun, Elnæs, & Thune-Larsen, 2019). In addition, Norwegian air-traffic is subject to fees for emissions of greenhouse gases such as carbon dioxide (CO_2) and nitrogen oxides (NOx). This implies that airlines have an obligation to purchase quotas for their emissions, on top of the CO_2-fee.

Norway is the only country that imposes a CO_2-fee on fuel for aviation. The CO_2-fee has increased substantially from NOK 0.42 per litre in 2012 to NOK 1.3 per litre in 2019 (Grünfeld L. A., Myklebust, Underthun, Elnæs, & Thune-Larsen, 2019). This translates to a fee of NOK 510 per tonne CO_2. In the proposal for the 2020 state budget, the government proposes to increase it to NOK 545 per tonne CO_2 (NOU, 2019).

On top of all the fees imposed, value added tax (VAT) also applies. The VAT rate for aviation was 10 % in 2016 and increased in 2018 to 12 % (NOU, 2019). The introduction of APT and the increase in the VAT rate and CO_2-fee has resulted in a higher taxation level for the aviation industry in recent years. SAS has seen their fees grow from NOK 153 million in 2015 to more than NOK 1 billion in 2019 (Ytreberg & Trumpy, 2020).

4 Theoretical framework

The effects of taxation on market equilibria has always been a much-debated topic in pricing theory. Tax systems play a crucial role in influencing the rates of both short- and long-term economic growth in the economy. This thesis does not seek to comment on the merits of taxation as a mechanism for market control or as a tool to eliminate defects. Rather, it will focus on the theoretical framework underlying our analysis of APT in the Norwegian aviation market. It presumes a base understanding of market equilibrium on the part of the reader, allowing us to focus on how taxation is expected to impact suppliers and consumers.

Taxes, such as APT, create distortions in the market by increasing the price of the good to which the tax is charged. Households and business will in turn adjust their behaviour which will reduce the quantity traded. The magnitude of this reduction, as well as the burden of taxation on suppliers and consumers respectively, will however depend on the elasticities of demand and supply within the given market. We will first consider the effect of taxation on market equilibriums. Secondly, we will highlight the factors impacting the incidence of taxation before considering the potential for a sub-optimal allocation of resources and deadweight loss.

4.1 Effect of taxation on market equilibrium

Taxes are imposed on markets for a multitude of reasons, the simplest of which will be as a fiscal measure aimed at financing public spending. This was the stated purpose behind the introduction of the APT at its inception (Skatteetaten, 2015). More specific taxes may also be imposed in order to manipulate markets and limit negative externalities, with recent debate regarding APT pivoting toward its role in Norway’s green vision through reducing air-traffic volumes.

A tax levied on a given product will have to be carried by the consumers and suppliers of that product and this is usually done jointly. The apportioning between the different actors may vary depending on the characteristics of the market, but it is a burden seldom borne by one group exclusively. We therefore proceed on the assumption that neither supply nor demand are perfectly inelastic in the market for passenger seats.[5] We will now illustrate the applicable theory through example.

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[5] Although certain domestic routes with few alternative modes of transport, only serviced by a single carrier, may be close to inelastic.

We assume that a tax *t* is levied on a product. This will reduce the quantity of the product demanded as the price of the product has been raised by the amount of the tax (Nordhaus & Samuelson, 2009). This is illustrated in figure 6 by a shift in the demand curve D to D_1, where the magnitude of the shift is equivalent to the size of the imposed tax *t*. It is assumed that the supply curve remains constant as the supply side costs remain unaffected. The supplied quantity at any unit price will therefore remain constant. These changes will cause the market equilibrium to shift from E^* to E_1, with the corresponding quantity demanded having fallen from Q^* to Q_1. Consumers in this market will now be charged the higher price per unit of P^C, while suppliers will be charging a reduced price of P_s. The difference between the price paid by consumer P^C and the price received by the supplier P_s will be equal to the size of the tax levied.

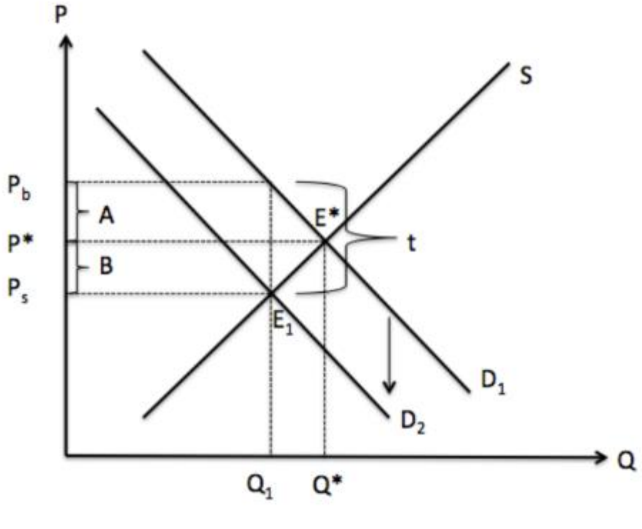

Figure 6 - Market equilibrium post tax (Nordhaus & Samuelson, 2009)

The burden of any given tax is seldom borne solely by the group they are levied at. As shown in figure 6, portion A will be carried by the consumer while portion B will be taken out of the suppliers cut. In order to maintain an optimal demand for the product, although at a lower quantity sold, the supplier will be compelled to reduce their price (Pindyck & Rubinfeld, 2013). Thus, the expectation is that APT, although aimed primarily at consumers, will cause airlines to reduce their prices by way of the same distribution mechanisms. The collection mechanism puts the burden of collection on the airlines, enabling them to factor this into the rest of their cost spectrum and raising the prices to the extent and on the routes where it is most profitable. It is therefore possible that the effect of the tax would be the same if aimed directly at the supplier, provided the scope of the tax remained constant.

4.2 Elasticity and market competition

As shown, imposition of a tax will impact the price of both buyer and seller. The degree by which it is distributed between the two will however vary greatly as a result of the relative elasticity facing each party, as well as the degree of competition in the given marketplace. Customers with inelastic demand will have a quantity demand that is less sensitive to changes in price. In the context of APT a consumer of this kind would be someone who is required to fly, whether for work or because there are few viable alternatives to flying. Conversely, an inelastic consumer could be someone looking to purchase holiday tickets or someone with viable alternative modes of transportation. Figure 7 demonstrates how consumers with inelastic demand will carry a larger proportion of the tax in relation to suppliers. It is worth noting that supply may also be elastic, and so the relative elasticities between the parties will decide impact the distribution, with the less elastic party expected to carry the larger proportion of the tax.

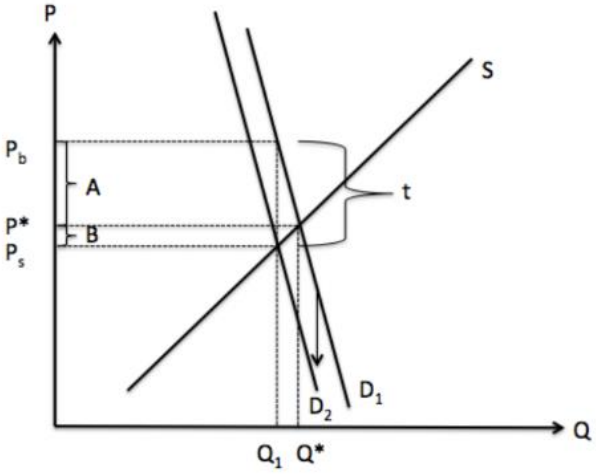

Figure 7 - Effect of tax on inelastic demand (Pindyck & Rubinfeld, 2013)

The incidence of taxation may also be impacted by the level of competition in the marketplace. The Norwegian air passenger market is predominantly dominated by monopolies and duopolies and thus we will dwell on these. Turning first to monopolies we observe that the proportion of the tax or fee which the single supplier is able to apportion to the consumer will depend on two factors; the shape of the demand curve as well as the company’s cost structure (Goolsbee, Levitt, & Syverson, 2013). Should the demand curve be linear, whilst the marginal cost to the producer remains constant, then exactly half the tax will be passed on to the consumer (figure 8). A monopolist will refrain from apportioning a larger share of the tax onto the consumer as this would reduce the demand for the product to a less profitable level. The price increase is illustrated by area A. It is worth noting that this assumes that the demand curve facing the monopolist is not perfectly inelastic.

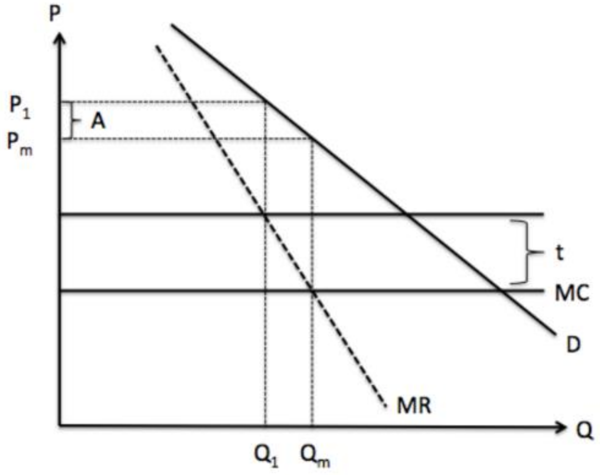

Figure 8 - Effect of tax in a monopoly (Goolsbee, Levitt, & Syverson, 2013)

Whilst several routes in the Norwegian airspace operate as monopolies, this type of competition remains limited to smaller routes by air-traffic volume. The majority of passengers will be taking to the skies on routes where the two dominant players in Norwegian aviation, SAS and Norwegian, both operate. The added element of competition alters the outcome as suppliers must consider the actions available to their competitor when deciding how much of the tax to attribute to consumers. This type of price-setting, where expectations of the price of a competitor is factored in, is known as Bertrand competition.

The equilibrium in such markets will depend largely on the type of product offered. Suppliers offering homogenous products will aim to price low as the only distinguishing feature between suppliers is price. Where there is some level of product differentiation there is however more leeway for the producer to maintain a higher price level than competitors. The level to which such a price premium can be maintained will depend on the degree of product differentiation.

We have previously touched on the history of the Norwegian airfare market and how product differentiation once played a significant role. This differentiation has however faded with the removal of popular SAS loyalty programmes, as well as SAS offering low price alternatives.

Differing service levels will soon remain the final bastion of product differentiation and so theory would suggest that airlines are incentivised to carry a larger portion of APT.

4.3 Deadweight loss

Levying a tax on a market will distort its natural equilibrium and results in a sub-optimal allocation of resources. This situation in which part of the potential benefit to society is omitted is known as a deadweight loss and is illustrated by area B+D in figure 9 (Pindyck & Rubinfeld, 2013). We observe that consumers will lose out on A+B while the producer loses out on C+D. Levying the tax will result in some income to the state equivalent to A+C. The new market equilibrium at Q_1 (previously Q^*) will settle at a lower quantity in which the tax income gained by the state is not sufficient to offset the loss to producers and consumers. The magnitude of the deadweight loss will depend on the elasticities of the suppliers and consumers involved, with higher elasticities on either part resulting in a more severe deadweight loss.

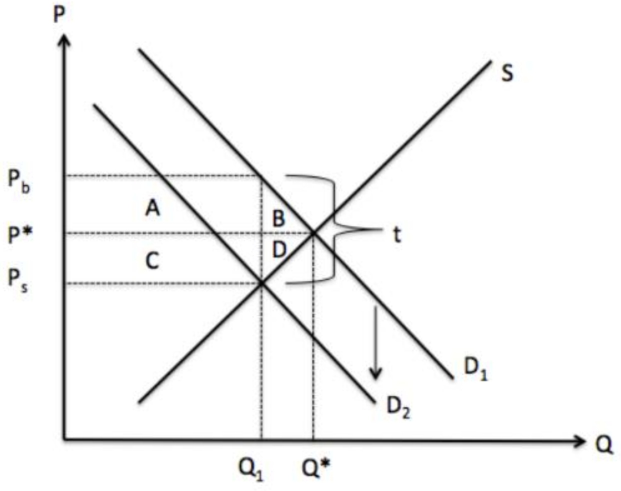

Figure 9 - Deadweight loss (Pindyck & Rubinfeld, 2013)

5 Literature Review

This chapter aims to provide a brief overview of relevant literature on the topics of air travel demand, as well as APT specifically and its effect on air-traffic volume. Studies on the latter have predominantly been carried out in other countries and we anticipate that the response in the Norwegian market may differ in some respects due to the lack of viable transport alternatives for many routes. Nevertheless, we expect there to be sufficient overlap for these studies to provide valuable insight and provide a starting point for our analysis.

5.1 Demand for air travel

Throughout the years there have been a wide range of studies carried out to determine the driving factors behind changes to the demand for air travel. Past studies generally fall into one of two broad groups: Those focused on geo and socioeconomic factors outside of the airlines control (Carson, Cenesizoglu, & Parker, 2010) and those focused on the product offered by the airlines in terms of price and quality. It is worth noting that quality in this instance denotes the quality of supply, in terms of frequency and airplane capacity, and not the service levels of any given airline (Jorge-Calderon, 1997). These groups will be considered separately after which we will consider studies concerned specifically with the price elasticity of demand in the market for air travel. Taken jointly, this should provide an informed starting point for our own hypotheses.

The key socioeconomic metrics found in the literature are GDP, population and income (Jorge-Calderon, 1997). Past studies have demonstrated significant correlation between air-traffic volume and GDP (Holloway, 2008) whilst increases to population size result in increased demand for airfare as one might expect. Lastly, air fare is a normal good and as such increases to income result in an increased demand for passenger seats. Increased income levels will also result in reduced price sensitivity as any given change in price will be relatively smaller. These variables will be included and controlled for as part of this study in an attempt to isolate the effect of the APT.

The second grouping of significant factors are those within the control of the airlines. Chief among these are the quality of departures as defined by Jorge-Calderon whereby more frequent and higher capacity departures correlated positively with demand. A lower price level will also have significant impact on the demand for air travel (Sivrikaya & Tunç, 2013).

5.2 Price elasticity of demand

This thesis seeks to control for the significant external factors mentioned above in order to analyse the effect of APT on air-traffic volume. It is hypothesised that the majority of this effect occurs through the price mechanism, although societal sentiment also plays a role as witnessed in the Netherlands and explored later in this chapter. The mechanism measuring the responsiveness of demand to changes in price is known as the price elasticity of demand and measures the %age change in demand to a 1% increase in the price of the good (Nordhaus & Samuelson, 2009). In this chapter we will first consider international studies insofar as they inform our own analysis, before moving our attention to those detailing the Norwegian market.

Throughout the years we have witnessed a host of studies seeking to ascertain the price elasticities within the aviation industry. Chief among these is the comprehensive study carried out on the Canadian and peripheral markets (Gillen, Morrison, & Stewart, 2007). The findings of this study are presented in order of ascending price elasticity in table 3 below.

Route type	**Price elasticity of demanc**
Short-haul business	-0.7
Long-haul domestic leisure	-1.1
Long-haul domestic business	-1.15
Short-haul leisure	-1.52

Table 3: Price elasticity of demand by route type (Gillen, Morrison, & Stewart, 2007)

With the exception of short-haul business travel, all of the observed route types displayed elastic demand in which changes to price result in a proportionally larger negative change in demand. It is worth noting that business travel, perhaps surprisingly, is generally more elastic than its leisure counterpart. This can however be explained by the fact that the general purpose of business travel is more amenable to substitution through electronic alternatives.

Next, we will briefly compare these findings to those of the meta study conducted by InterVISTAS (Estimating Air Travel Demand Elasticities, 2007), considering 23 previous studies carried out across the 25 years prior. The findings generally mirror that of the Gillen study, concluding that both short and long-haul domestic travel are elastic, with the former being slightly more elastic than its long-haul counterpart.

The Norwegian market is however unique in several respects as there are many routes with few viable transport alternatives. As such it is meaningful to consider the contemporary study conducted by Mueller in 2015, analysing the elasticities within the Norwegian domestic market. The study also takes a nuanced approach insofar as it considers the impact on demand in both the short and long-term perspective. Interestingly, these were estimated to be -0.23 in the short term and -0.48 in the long term. These findings of inelasticity contrast with international findings (with the exception of short-haul business travel in the Gillen study) and lends weight to the argument that the Norwegian market is inherently different for the reasons previously mentioned.

Having considered the literature with regard to the price elasticity of demand, this study will approach the Norwegian market remaining diligently cautious of applying international findings too broadly.

5.3 APT in other countries

APT has experienced widespread implementation, both as a fiscal and environmental policy measure, within the European Economic Area (EEA). Some of these have been in place for a long period, with the United Kingdom implementing it as early as 1994. The taxes are generally similar in nature owing to EEA anti-discrimination rules. As of 2019 a total of 10 countries within the EEA, the United Kingdom included, had some form of APT in place. These are outlined in table 2 below. Consequently, several bodies have been tasked with analysing and evaluation the effect of these measures on air-traffic volumes as well as other key metrics. This section aims to outline the findings of some of these studies, as well as their anticipated implications on our own study of APT in Norway. It is worth noting that some of these countries may offer a weaker comparison, as both the Netherlands and Ireland offer a lesser degree of domestic routes than Norway.

Country	Tax Rate	Currency	NOK equivalent	Note
United Kingdom	13/26	GBP	149/299	Economy/1st Class
Greece	12	EUR	117	
Norway	84	NOK	84	NOK 75 from April 1st 2019
Germany	7.38	EUR	72	
Italy	6.5/7.5	EUR	63/73	Italy/Rome
Sweden	61	SEK	57	
France	13.55/18.05	EUR	132/176	Nice/Paris
Austria	3.5	EUR	34	
Croatia	1.37	EUR	13	
Finland	1	EUR	10	

Table 4: Air passenger tax per departing flight to domestic/international destinations within the EEA March 2019 by country. Source (Secure Airport Charges, 2020)

5.4.1 Netherlands

Gordijn & Kolkman (Effects of Air Passener Tax: KiM Netherlands Institute for Transport Policy Analysis, 2011) carried out an analysis of the Dutch air passenger tax implemented in 2008. The study was carried out on behalf of KiM[6] and focuses on the effect of the tax on the demand for air transport in the Netherlands. The Dutch APT provides a clear example of the sensitivity of air travel market, with relatively low levels of taxation resulting in unexpected and disproportionate falls in air-traffic volume. Consequentially the Dutch APT was a short-lived affair, seeing implementation in July 2008 before being set to zero (0.00 euro) in July 2009 and conditionally abolished in January 2010. It is however worth noting that a significant part of this effect must be attributed to the concurrent economic crisis, the unique geographic features of the Netherlands, as well as public sentiment and principled opposition to the notion of the tax at the time.

Prior to the implementation of the APT it was expected that Amsterdam Airport Schiphol would experience a reduction of 8 to 10% in air-traffic volume. In the seven years leading up to the implementation of the tax, Schiphol Airport had experienced an average growth in air-traffic volume of 3% (Schiphol Group, 2009). The year immediately following the imposition of the tax saw air-traffic volumes at the airport decline by more than 8% (Gordijn & Kolkman, 2011). Regional airports were impacted to varying degrees as most, but not all, Dutch air-traffic flow occurs via Schiphol. Airports in Groningen and Rotterdam experienced few repercussions in the wake of the tax, whilst Maastricht and Eindhoven both observed significant declines in air-traffic volume. This difference can be explained in part by the type of airline operating out of each group of airports. The KiM report notes the rise of low-cost carriers such as Ryanair and Easyjet in the period in question. Maastricht and Eindhoven were both hotspots for low cost carriers at the time the tax was imposed and so the resulting price increase as a result of the tax would be proportionally larger in these areas.

As previously mentioned, the KiM report found several confounding factors to have impacted the unexpected severity of the decline in Dutch air-traffic volume. The proximity and availability of alternative means of transportation and the existence of cross-border airports at which no similar tax was in effect, played a significant part in the observed results. A survey among 3 000 Dutch travellers was conducted as part of the KiM study, in which 14% confirmed that their travel habits were affected by the tax (Gordijn & Kolkman, 2011). The

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[6] KiM Netherlands Institute for Transport Policy Analysis

majority of these had transitioned to alternative means of transport or airports located in neighbouring countries. It is estimated that approximately 1 million Dutch passengers elected to use neighbouring airports as opposed to domestic ones as a result of the APT. By contrast Norway has few cross-border airports which can be utilised as viable alternatives. The topography of the land also lends itself poorly to alternative modes of transportation as these are often both cumbersome and slow. As a result, we would expect several of the amplifying factors observed in the Netherlands to be mostly absent in Norway. On this analysis the resulting decrease in air-traffic volume should also be lessened in our own study.

It is worth noting that the specific causal relationship between the APT and air transport demand remains unclear in this descriptive study. It is argued that a significant portion of the ensuing decline stems from the imposition of the tax, but this causal link is weakened by the existence of several significant confounding factors. In addition to the ones previously discussed it is also known that the concurrent financial crisis impacted the Dutch economy severely. Several of the driving developments were also already in progress prior to the imposition of the tax. An influx of low-cost carriers, operating primarily from regional airports, into the market had already begun diverting traffic away from Schiphol Airport with which the study was primarily concerned. Consequentially it is challenging to isolate the effect of the APT and we must exercise restraint in applying these findings broadly.

5.4.2 Ireland

SEO Economic Research carried out an extensive study on Air Travel Tax (APT) and its impact on the Irish economy in 2009 (Veldhuis & Zuidberg, 2009). The study focused in part on the relative elasticities of supply and demand and the consequent passthrough rate. For the purposes of the study, elasticities of -1.0 and -0.3 were employed for leisure and business travellers, respectively. In the event that the airlines could pass the entirety of the tax onto their customers the corresponding passenger loss was estimated to be in the region of 0.5 to 1.2 million passengers in the initial year. The study argues that significant reductions in yield on the part of the airlines would suggest an incidence of taxation whereby some of the burden is carried by the suppliers. It was also noted that the imposition of APT caused certain routes to become unprofitable. This lead in turn to a reduction in the route network as airlines, and in particular domestic carrier Ryanair, to reprioritise and reposition their network. The study estimates the combined reduction in demand as a result of these factors to be in the region of 1.3 million passengers in the initial year.

Furthermore, the study also considered the wider impacts of APT on the Irish economy. The losses experienced by the tourism and peripheral industries were estimated to be in the region of 428 to 482 million euro, far outweighing the estimated tax gains of approximately 120 million euro (Veldhuis & Zuidberg, 2009)Extended economic effects such as resultant unemployment and reductions in tourism and corporate settlement were also considered to be negative but were not quantified as part of the study.

This descriptive study reinforces the point made repeatedly in the literature that APT is likely to result in a deadweight loss. It does however fail to fully demonstrate the causal relationship between APT and air-traffic volumes through the price mechanism as a significant portion of the observed decline could be explained by the reductions in capacity and supply. It is also worth noting that other macroeconomic variables, such as GDP, are not accounted for in the study. Such variables have been shown to directly impact air-traffic volumes and as such this is considered a weakness in the above study. With regards to the study conducted in this thesis it is also worth noting that the aforementioned study was carried out in the same year as the imposition of APT in Ireland and as such will capture short term effects. This thesis will seek to address some of the above shortcomings by including an extended four-year timeframe and accounting for key macroeconomic variables.

6. Data and methodology

In this chapter we will further elaborate on the data and methods used in the analysis. First, we will describe our dataset and then look at the variables and methods used.

6.1 Dataset

The panel data set for this thesis is collected from Avinor, Bloomberg and SSB. It is based on daily observations for the 2012 to 2019 period. Avinor has provided us with access to flight data for all flights departing or arriving at airports operated by Avinor in the period from 2012 to 2019.

With the imposition of APT occurring in 2016 and 2019 being the last full year of available data, we sought to extend our sufficiently far back to analyse an equally large time interval before and after the event. It is also worth noting that as of 2020 APT has been suspended due to the ongoing COVID-19 pandemic and thus data from this year would not provide a viable basis for comparison (Skatteetaten, 2020). This thesis will also be employing regression discontinuity in time (RDiT) as one of its analytical frameworks for which an 8-year interval is commonly employed. As such, 2012 provided a meaningful starting point.

This flight data contains information on every commercial flight in the given timespan. The flight data includes date, flight number, destination, origin, seat capacity, number of passengers and airline of each flight. This means that we are able to separate air-traffic into specific routes and split the traffic between the different airlines operating those routes. For our analysis, we aggregate the number of passengers for every route daily such that we separate between airlines. Hence, we get the daily number of passengers travelling on a route with a specific airline. One observation can for example be a number of passengers that travelled from Oslo to Bergen with SAS on a given date. Therefore, passengers travelling on a given route on the same day with different airlines will be separated into different observations. The reasoning behind separating routes between airlines is to control for different competitive situations. Some routes are operated by only one or two airlines, but the competitive situations change over time. In addition, different airlines operate differently and have different corporate structure which can affect supply and demand after air-travel. By separating the routes by airlines, we also exploit more of the variation in the data set. We do not have data on the composition of business and leisure travellers. Hence, we cannot separate between different types of passengers.

6.2 Airports

To exclude the PSO flights we limit our data set to only include airports that can handle jet aircrafts. In this way we exclude the STOL network that includes the PSO routes and flights between regional airports operated by Widerøe that involve stopovers. Therefore, there may be cases where we have omitted airports in the STOL network that in reality operates some non-PSO routes. The airports included in the analysis is listed in table 5. These airports are mainly operated by SAS and Norwegian and some of them are also operated by Widerøe. Many of the airports where Widerøe is the only operating airline are excluded from the analysis as Widerøe mainly operates on the STOL network dominated by PSO routes.

Airports			
AES - Aalesund	BOO - Bodø	KRS - Kristiansand	SVG - Stavanger
ALF - Alta	EVE - Harstad/Narvik	KSU - Kristiansund	TOS - Tromsø
BDU - Bardufoss	HAU - Haugesund	MOL - Molde	TRD - Trondheim
BGO - Bergen	KKN - Kirkenes	OSL - Oslo	TRF - Sandefjord

Table 5: Airports with associated IATA airport code

6.3 Municipalities

Each flight connects two geographical areas. To properly control for different municipalities linked to the different geographical areas, it is appropriate to gather data from the different areas around the origin and destination airport. From SSB, we have data for population and income for all Norwegian municipalities. Therefore, we need to decide which municipalities that are linked with the different airports in our dataset. To decide this, we used SSB's "*standard for centrality*" that defines the term *centrality* for a municipality. Municipalities are scored on an index between 0 and 1000. The most central municipality (Oslo) have a centrality score of 1000 and the least central municipalities have a score around 300. The score is based on the municipality's proximity to workplaces and service functions (SSB, u.d.). The index consider how many workplaces and service functions the inhabitants of a municipality can reach within 90 minutes of travel by car (Høydahl, 2017). Hence, municipalities that are within 90 minutes of travel from an airport by car will be linked with that airport. If a municipality is within 90 minutes of several airports, we have determined the affiliation of the municipality based on the shortest travel time. Municipalities located more than 90 minutes away from an airport are thus excluded from the analysis. Therefore, there may be cases where we have omitted municipalities that in reality use a specific airport.

The list of municipalities and their affiliated airport included in the analysis is listed in appendix A1.

6.4 Variables

Descriptive statistics of the variables for the period 2012–2019 is shown in table 6.

Table 6:

Variable	Mean	Std.Dev.	Additional description
lnPAX	5.814	1.27	Natural log of daily passengers on a given route
APT	.448	.497	
MONDAY	.155	.362	
TUESDAY	.15	.357	
WEDNESDAY	.15	.357	
THURSDAY	.152	.359	
FRIDAY	.153	.36	
SATURDAY	.099	.298	
OilPrice	539.763	108.643	Brent oil price quoted in NOK
TREND	1460.821	842.161	
JANUARY	.084	.277	
FEBRUARY	.077	.266	
MARCH	.083	.276	
APRIL	.08	.272	
MAY	.084	.278	
JUNE	.084	.277	
JULY	.089	.284	
AUGUST	.088	.283	
SEPTEMBER	.084	.278	
OCTOBER	.087	.282	
NOVEMBER	.082	.275	
lnPopFrom	12.473	1.417	Natural log of total population for municipalities around the origin airport
lnPopTo	12.487	1.417	Natural log of total population for municipalities around the destination airport
GDP	801.327	52.539	Quarterly GDP for mainland Norway, in BNOK.
lnIncFrom	6.432	.093	Natural log of average median income in thousands for households’ in municipalities around the origin airport
lnIncTo	6.433	.094	Natural log of average median income in thousands for households’ in municipalities around the destination airport
Holiday	.117	.321	

6.4.1 Macroeconomic variables

Our macroeconomic variables are variables that are constant across routes, but vary over time, which may explain some of the variation in air-traffic volumes. We have included oil price and GDP as macroeconomic variables. As the GDP data is reported quarterly, we assume linear growth between the datapoints such that we get datapoints for GDP for all observations.

6.4.1.1 Oil price

The oil price may be correlated with air-traffic volumes in two ways. Firstly, airlines' profitability is dependent on jet fuel prices as it is the largest variable operating cost for airlines. In 2019, the global airline industry's estimated fuel bill was in total USD 188 billion, which accounts for around 23.7% of operating expenses (IATA, 2019). Jet fuel is a petroleum product from processed crude oil and historically the price of jet fuel has seen a mark-up of 24% over crude oil prices (European Parliament, 2009, ss. 39-40). As jet fuel is a major expense for the airlines, an increase in oil price is likely to be passed on to consumers through higher fares and thus affect air-traffic volumes.

Secondly, the oil price has an effect on economic activity in certain areas in Norway. The area around Stavanger is known for its petroleum activity. Around 40% of all workplaces in this area have some connection to the petroleum industry (Senneset, 2015). When the oil price dropped from above USD 100/barrel to below USD 50/barrel in late 2014, the activity in the oil industry decreased and economic activity in the Stavanger area decreased and almost 50,000 workplaces were cut (Barstad, 2018). Such situations may affect the air-traffic volumes and therefore we believe that the oil price can explain some of the variation in air-traffic volumes to and from such areas.

If the oil price has a negative correlation with air-traffic volumes, it can be said that the oil price is a cost/price proxy and it affects air-traffic volumes negatively by representing higher ticket prices leading to lower air-traffic volumes. If the oil price has a positive correlation with air-traffic volumes, it may be an activity proxy and represent higher activity in the economy due to high oil prices thus seeing higher air-traffic volumes or vice versa.

In order to control for the effect of change in oil price, we have collected historical daily oil prices in the period 2012-2019 from the Bloomberg terminal. Because the dollar price is quoted in USD, we have also collected the NOK/USD exchange rate for the period from Bloomberg to get the oil price quoted in NOK.

6.4.1.2 GDP

Air-traffic can be a factor and an indicator of economic growth. Air-traffic can be seen as a factor as it facilitates transportation in areas where there are no other alternatives. Air-traffic volumes depends on the level of economic activity and can therefore also be seen as an indicator of economic growth. It is documented that air-traffic affect economic growth in an area positively, direct and indirect by creating jobs and revenues and making the economy more efficient (NOU, 2019). However, the causal relationship can go both ways in the sense that economic growth in a country can also affect demand for flights and thereby growth in associated activities. To control for the correlation between air-traffic volumes and economic activity we have gathered quarterly data for gross domestic product from SSB[7].

6.4.2 Variables across municipalities

We have collected data that vary across municipalities and time that are affiliated with the airports in our dataset. Such data may explain some of the variation in air-traffic volumes to and from the affiliated airports.

6.4.2.1 Income

The relationship between income and demand after flights are well documented. Previous analyses concludes with an income elasticity between one and three, in other words, an income growth of 1% will increase the demand for flights with between 1-3 %[8] (NOU, 2019, s. 22). We have collected data for median income in all selected municipalities from SSB. The income data is reported annually, and we assume that the income remains constant within the reported year.

6.4.2.2 Population

We assume that the size of the population around each airport and air-traffic volumes has a positive relationship as we believe that higher population implies more passengers travelling to and from the area. We have gathered population data from SSB for the selected municipalities. As the population data is reported quarterly, we assume linear growth between the datapoints such that we get datapoints for population for all observations.

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[7] There are available data from SSB for monthly GDP data from 2016. We stick to quarterly data as there is no monthly data for the entire 2012 to 2019 period. There are methods to convert quarterly to monthly data, but in this thesis the value of the information is limited, and we chose to keep quarterly data for the entire period analysed.

[8] The literature concludes that the elasticity decreases with income and air-traffic volume, so that a given income growth will be more pronounced in increased demand in a relatively poor country with small air-traffic volumes than in a relatively rich country where one is flying a lot initially.

6.4.3 Dummy variables

6.4.3.1 APT

To identify the effect of APT we included a dummy variable which takes value of 0 for observations before the introduction of the APT (June 1st, 2016), and takes the value of 1 for observations after.

6.4.3.2 Weekdays

To control for the effect of which weekday each observation is on, we include a dummy variable for Monday through Saturday. If every dummy variable equals 0, the observations happened on a Sunday.

6.4.3.3 Months

To control for the effect of which month each observation is on, we include a dummy variable for January through November. If every dummy variable equals 0, the observations happened in December.

6.4.3.4 Holidays

A dummy variable for holidays has been included to account for the difference in air-traffic volumes caused by a variety of national holidays. The key holidays included in this variable are Winter, Easter, Autumn holidays in Norway. When determining whether to include a holiday in this variable, we have considered the air-traffic volume relative to the daily average across the year, as well as relative to the remainder of that month. For all of the holidays we have included the official dates of the holiday as well as any Saturday or Sunday either preceding or superseding the holiday, this to account for many electing to leave the previous weekend or stay the following weekend. It was also observed in the data that some elect to depart on the Friday preceding a holiday continuing on from a weekend. This number was however sufficiently low to exclude. It was expected that travel volumes would be weighted toward the start and end of a holiday period. The data does however indicate that travel volumes fluctuate throughout the holiday periods (see figure 10 as an example), and as such it has been decided to include all dates within the holiday into our variable.

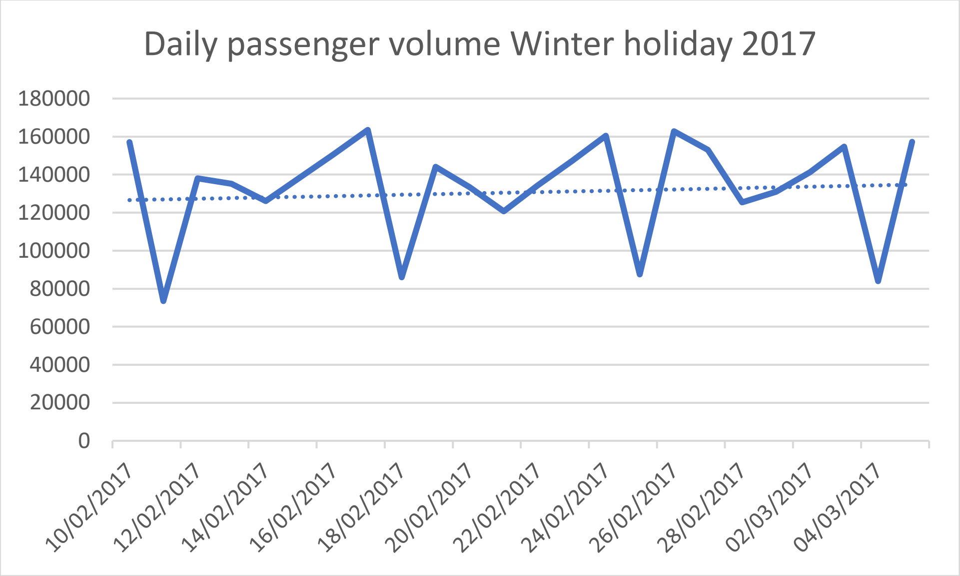

Figure 10 - Daily air-traffic volume winter holiday 2017

Individual holiday dates, such as the 17th of May and Ascenscion day ("Kristi Himmelfartsdag") have been excluded from the variable due to negligible increases in air-traffic volumes when compared to other holidays. Christmas and summer holidays usually fall on the same period every year, so we expect that the dummy variable for July and December will pick up the variation linked to these two holidays. Therefore, we have left these two holidays out of the holiday variable as we expect it to be captured by the July and December dummy variable.

6.4.4 Trend variable

Our data set contains 2922 daily observations for each route. To pick up possible trends, we have generated a variable for the timespan from 1 to 2922. The variable will take the value 1 for January 1st, 2012, 2 for January 2nd, 2012 etc., up to 2922 for December 31st, 2019.

7 Econometric specification

To answer our research question on how the APT has affected domestic air-traffic volumes in Norway, we employ a model that controls for several factors which can explain changes to domestic air-traffic volumes in Norway.

7.1 Research method

7.1.1 Panel data

The data set used in our analysis is a panel data set. By having a panel data set we can estimate more extensive models and more accurate inference of model parameters than if it was pure cross-sectional data or time series. Panel data also usually contain more degrees of freedom and more sample variability than cross-sectional data. We have cross-sectional data for routes for the 2012 to 2019 period. This enables us to control for the development in other variables that we assume to influence the air-traffic volumes on these routes and isolate the effect of the APT as the dependent variable.

Panel data models may include variables that vary across individuals and over time. In our data set, such variables are the variables for population and income. Models may also include variables that are constant for all individuals but vary over time. Our data set includes GDP and oil price which are examples of such variables. Lastly, models with panel data may also contain variables that vary across individuals but are constant over time. Such variables can often be difficult to observe and are referred to as unobserved heterogeneity, which is the part of the model's error term that refers to route-specific effects that are constant over time.

In this case, such unobserved heterogeneity can be demography in the areas around the airport, the composition of business and leisure travellers, supply of alternative transportation methods and/or characteristics of each route with a specific airline and which are factors that are nearly constant over time. These factors will be picked up by route-specific terms α_i, which is part of the error term in the model and capture the effect of omitted variables that do not vary over time. Pooled OLS ignores unobserved heterogeneity by assuming that error terms and the explanatory variables are independent. In most cases, this assumption is unrealistic, and the estimators will therefore be biased and inconsistent using pooled OLS. Thus, we need another type of estimator that allows for unobserved route-specific effects. Issues related to unobserved heterogeneity are commonly fixed by applying fixed or random effect estimator models.

7.1.1.1 Fixed effect estimator

The *fixed effect estimator* (FE) is a method that takes unobserved heterogeneity into account by transforming the model such that route-specific effects are removed. FE is useful if there are many cross-sectional units in the data set such that the leas square dummy variable approach (LSDV) is cumbersome. The drawbacks with the FE method are that it cannot estimate explanatory variables that do not vary over time and it consumes degrees of freedom.

7.1.1.2 Random effect estimator

The *random effect estimator* (RE) is a method that takes advantage of the variation between routes. RE are able to utilise some of the variation between routes as the route-specific effect is not removed completely. Therefore, RE can only be used if individual specific effect is uncorrelated with the explanatory variables in all periods.

Both FE and RE allows for individual specific effect. The most important distinction between the two methods are the assumption of zero conditional mean (ZCM), which assumes that there is no systematic variation in the error term that is associated with variation in explanatory variables. FE allow for correlation between explanatory variables and unobserved route-specific effects because it is completely removed. RE does not allow for such correlation. RE are able to estimate effect of variables that are constant over time, where FE cannot. RE consumes less degrees of freedom compared to FE, which makes RE a more efficient estimator if the assumption of ZCM holds. On the other hand, it is unlikely that there is no correlation between route-specific effects and explanatory variables. To achieve this the model has to control for many variables such that the route-specific effects becomes very small, which happens in a minority of cases. If the assumption of ZCM fail, the RE estimator is inconsistent and there are other models that gives better estimations. Therefore, a Hausman specification test is conducted, to see whether the explanatory variables are independent of the unobserved route-specific effects. If this is the case, the RE estimates are preferred over FE.

7.2 Alternative approaches

Other models beyond the employed panel data model were also considered for analysing the effects of APT on Norwegian Air-traffic volumes. The widely utilised differences-in-differences (DD) method as well as the more novel RDiT technique were both considered. This section will outline the reasoning for electing not to include the DD method, as well as the extent to which RDiT has been employed.

7.2.1 Differences-in-Differences (DD)

DD estimation has become an increasingly popular way to estimate causal relationships. It consists of identifying a specific intervention (“treatment”) after which the difference in outcomes before and after the intervention are compared. In the context of analysing APT it can initially seem very appealing due to its potential to circumvent endogeneity problems (Bertrand, Duflo, & Mullainathan, 2003). The challenge lies in the need for a control group against which the treatment group can be compared. The golden standard is for such a group to be identical to the treated group in every regard with the exception of the applied treatment. In order to employ DD estimation to the analysis of APT in Norway one would have to employ all air-traffic following the imposition of the tax as the treatment group, while air-traffic prior to taxation would be defined as the control group. This was deemed an unrealistic assumption due to the host of other factors likely to influence the treatment group with the passage of time.

A second approach was also considered wherein countries similar to Norway in which no APT was introduced could be used as a control group. A comparison could potentially have been made with Sweden. Unfortunately, the Swedish government enacted APT at an early point in the timeseries under evaluation and so this was deemed an unviable option. There is also the issue that Swedish topography is significantly different from that of Norway and thus alternative methods of transport are available to a higher degree. Denmark and the Netherlands were also considered but discarded due to a low volume of domestic flights rendering them a poor choice of control group. In similar studies researchers have examined an untreated subsample of routes. With APT applied universally and simultaneously across domestic flights this was unfortunately not a viable option. Given there being no remaining countries both close enough in similarity to Norway to act as a control and without APT we were unable to find a control group of high enough quality and so we discard the DD approach.

7.2.2 Regression Discontinuity

Regression discontinuity (RD) designs have rapidly grown in popularity within the field of empirical economics as a means by which to estimate treatment effects (Lee & Lemieux, 2010). The power and appeal of the RD framework can most clearly be seen by its intuitive similarity to the golden standard of the Randomised Controlled Trial (RCT). In their 2010 paper, Lee and Lemieux go so far as to describe RD designs as “local randomized experiments” (Lee & Lemieux, 2010).

RD designs are commonly used as a way to estimate treatment effects in a nonexperimental setting where treatment is determined by whether an observed “assignment variable” (also referred to in the literature as the “forcing variable”) exceeds a known cut-off point. As a result, there is a sharp discontinuity in the “treatment” at the given cut-off point, allowing for estimation of the treatment effect provided that all factors other than the assignment variable evolve smoothly around the given point.

The popularity of the method stems from the comparatively mild assumptions required in an RD designs as opposed to those required by its other nonexperimental counterparts, coupled with its highly credible and transparent way of estimating program effects. Proponents of the method have gone so far as to argue that the causal inferences from RD designs are potentially more credible than those from typical “natural experiments” (e.g. differences-in-differences or instrumental variables) as randomised variation is a natural consequence of the agents inability to precisely control the assignment variable near the known cut-off (Lee & Card, 2008).

7.2.3 RDiT

This thesis seeks to employ a recent adaptation of the regression discontinuity framework in order to analyse the effects of APT on air-traffic volumes. Known as “Regression Discontinuity in Time” (RDiT), this framework utilises time as the running variable where the cut-off employed is the particular threshold in time at which the treatment effect is employed. Although this increasingly popular application of the RD design has been employed chiefly to estimate the effect of environmental regulation, it is rapidly being deployed in a wider array of fields where the traditional RD toolkit is rendered unavailable to the researcher. For the purposes of this thesis and due to the limited time available, RDiT will be explored briefly as a supplemental approach in support of our panel data model.

One key difference between the RD and RDiT frameworks is the way in which a researcher can grow the sample size available to him. The standard RD is identified in the dimension N observations, allowing the sample size to be expanded whilst simultaneously maintaining or shrinking the corresponding bandwidth (the proximity of the data to the threshold c). In contrast, RDiT relies on an identifier in the T dimension whereby any expansion of sample size will necessarily widen the corresponding bandwidth. The solution to this is commonly found in high frequency data in the T dimension by which a meaningful N can be obtained while maintaining the vulnerability to unobservable confounders within acceptable levels. The dataset underpinning this thesis is comprised of the kind of high frequency data suitable for the RDiT framework.

By knowing the date *c* of the policy implementation, 1st June 2016, we know that for all dates following to this cut-off the unit is treated, and that for all dates prior it was not. Unlike the majority of previous studies employing the RDiT framework this poses a challenge insofar as the likelihood of an unknown lag effect in treatment and effect is high. More often than not, consumers will purchase their flight weeks if not months prior to departure. As such the full effect of the treatment may not be observed until a period of time after implementation.

8 Hypotheses

This chapter will detail the hypotheses we seek to test and analyse with our models. We will first look at the hypothesis related to the market and demand as a whole, before decomposing this into impact on individual carriers.

8.1 Hypothesis 1: The demand for air travel

As previously mentioned in this thesis, the Air Passenger Tax is issued on a per passenger basis and aimed at the consumer but is charged by the airlines on behalf of the state. Hence, some or all of this tax is passed onto their consumers through raising their prices. As detailed in the economic theory portion of this thesis, a price increase will cause the quantity demanded to drop as the demand curve shifts backward and a new market equilibrium is settled upon. This theory is extensively supported by the previous literature on this topic wherein the elasticity of demand is consistently negative. As such an increase in price should result in a reduction in demand.

8.1.1 Hypothesis 1:

H_0: APT has not reduced air-traffic volume.

H_A: APT has reduced air-traffic volume.

8.2 Hypothesis 2: The impact on individual carriers

On domestic flights, APT is charged at a fixed rate regardless of the cost of the journey itself. Assuming that the portion of the tax passed on to the consumer is constant, lower priced flights will see a larger %age price increase as a result of the tax. This should result in a greater reduction in demand for lower priced tickets and thus impact low cost carriers such as Norwegian to a greater extent.

8.2.1 Hypothesis 2:

H_0: APT has caused the same reduction in air-traffic volumes for all airlines.

H_A: APT has caused a greater reduction in air-traffic volumes for low cost carriers (Norwegian).

9 The model

We have created an econometric model to analyse our research question on whether APT has decreased air-traffic volumes on domestic flights. Before moving to the model itself, we discuss the issue of estimating air-traffic volume with regard to supply and demand.

9.1 Problem with simultaneous equations

As discussed in chapter 4, price and quantity are determined by the interactions between supply and demand. With regards to APT these are not static but interact with and influence one another. As such demand side changes will encourage a supply side response and vice versa. This gives rise to a challenge when analysing the domestic market for Norwegian air-travel as price and quantity emerge from a system of two equations. This creates simultaneity issues as quantity is a function of price. Price itself is determined by quantity such that there is a form of feedback between price and quantity in the market clearing process. Such form of interaction between equations for supply and demand gives jointly determination through an equilibrium mechanism (Woolridge, 2009).

The problem with estimating such systems of equations with ordinary least squares (OLS) is that it creates simultaneity bias as a consequence of explanatory variables being correlated with the error term. Thus, causing endogeneity in the model (Woolridge, 2009). In this thesis we do not estimate both the supply and the demand equation, but we still have to consider the problems with simultaneous equations and simultaneity bias because it causes endogeneity, which results in biased and inconsistent estimators. We could have dealt with this kind of bias if we had instruments to perform an instrument variable estimation, but we do not have access to price data. Even with price data we would have had problems with endogeneity because price is responding to quantity and vice versa. The problem with endogeneity may become even greater as we do not have the price variable in our model, and it is expected that the imposition of APT have affected the price level.

In our model we estimate quantity instead of price using explanatory variables such as income and population growth that drive the demand. We also control for variables that affect demand such as weekdays, month and holidays. Therefore, we conclude that our model equation is a demand equation.

9.2 Model equation

To identify the effect of the APT on air-traffic volumes, and control for relevant time-varying and time-constant variables, as well as observed, and unobserved effects, the following model is estimated:

$$\begin{aligned} lnPAX_{it} = {} & \beta_0 + \beta_1\, APT + \beta_2\, MONDAY + \beta_3\, TUESDAY + \beta_4\, WEDNESDAY \\ & + \beta_5\, THURSDAY + \beta_6\, FRIDAY + \beta_7\, SATURDAY + \beta_8\, JANUARY \\ & + \beta_9\, FEBRUARY + \beta_{10}\, MARCH + \beta_{11}\, APRIL + \beta_{12}\, MAY + \beta_{13}\, JUNE \\ & + \beta_{14}\, JULY + \beta_{15}\, AUGUST + \beta_{16}\, SEPTEMBER + \beta_{17}\, OCTOBER \\ & + \beta_{18}\, NOVEMBER + \beta_{19} ln\, PopFrom_{it} + \beta_{20} ln\, PopTo_{it} \\ & + \beta_{21} lnIncFrom_{it} + \beta_{22} lnIncTo_{it} + \beta_{23} GDP_t + \beta_{24} OilPrice_t \\ & + \beta_{25} HOLIDAY + \beta_{26} TREND + u_{it} \end{aligned}$$

The subscript *i* denotes route with a specific airline, and *t* denotes day. The dependent variable $lnPAX_{it}$ is the natural log of aggregated number of passengers travelling on a specific route with a specific airline *i* on day *t*. In this model we use lnPAX instead of PAX which is the number of aggregated number of passengers travelling on a specific route with a specific airline, because the observations of lnPAX is closer to a normal distribution than PAX[9]. The independent variable $lnPopFrom_{it}$ and $lnPopTo_{it}$ show log transformed population for the municipalities affiliated with the origin and destination airport. We have log transformed these variables in order to focus on relative change and avoid routes servicing larger population centres rendering changes occurring in routes servicing smaller ones negligible. The independent variables $lnIncFrom_{it}$ $lnIncTo_{it}$ show the average median income for the municipalities affiliated with origin and destination airports. The independent variable GDP_t is GDP for mainland Norway. The independent variable $OilPrice_t$ is the daily brent crude oil price quoted in NOK. The independent variable *APT* is the dummy variable for the *APT*. The independent variable *MONDAY* to *SATURDAY* is dummy variables for weekdays, with exception of Sunday to avoid perfect multicollinearity. The independent variable *JANUARY* to *NOVEMBER* is dummy variables for months with exception of December, again to avoid perfect multicollinearity. The *HOLIDAY* variable is a dummy variable for holidays. The *TREND* variable controls for possible trends. The error term u_{it} is decomposed into a route-specific term, α_i, and an idiosyncratic error term ε_{it}, thus $u_{it} = \alpha_i + \varepsilon_{it}$.The unobserved route-specific component, α_i, is a way to control for the unobserved heterogeneity.

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[9] Appendix A5

10 Empirical results

10.1 Panel Data Regression Results for Hypothesis 1

The results of the RE and FE models and pooled OLS are shown in table 7.

Table 7:

Empirical results

	(1) RE	(2) FE	(3) Pooled OLS
APT	0.0184	0.0191	-0.0624***
	(0.0151)	(0.0149)	(0.00641)
MONDAY	0.0131	0.0131	-0.0317***
	(0.0271)	(0.0271)	(0.00570)
TUESDAY	-0.0799*	-0.0798*	-0.112***
	(0.0315)	(0.0315)	(0.00576)
WEDNESDAY	-0.00403	-0.00402	-0.0380***
	(0.0311)	(0.0311)	(0.00575)
THURSDAY	0.0581*	0.0582*	0.0130*
	(0.0272)	(0.0272)	(0.00573)
FRIDAY	0.0988***	0.0988***	0.0530***
	(0.0233)	(0.0233)	(0.00573)
SATURDAY	-0.910***	-0.910***	-0.898***
	(0.0479)	(0.0479)	(0.00644)
JANUARY	-0.101***	-0.101***	0.0964***
	(0.0218)	(0.0225)	(0.00787)
FEBRUARY	0.0666**	0.0669**	0.233***
	(0.0222)	(0.0227)	(0.00855)
MARCH	0.0783***	0.0784***	0.228***
	(0.0180)	(0.0183)	(0.00789)
APRIL	0.0731***	0.0730***	0.187***
	(0.0159)	(0.0161)	(0.00815)
MAY	0.108***	0.107***	0.207***
	(0.0151)	(0.0153)	(0.00834)
JUNE	0.187***	0.187***	0.259***

	(0.0157)	(0.0157)	(0.00840)
JULY	-0.00904	-0.00927	0.0105
	(0.0323)	(0.0323)	(0.00864)
AUGUST	0.0952***	0.0949***	0.104***
	(0.0163)	(0.0163)	(0.00905)
SEPTEMBER	0.181***	0.180***	0.182***
	(0.0136)	(0.0137)	(0.00970)
OCTOBER	0.193***	0.192***	0.176***
	(0.0144)	(0.0145)	(0.00932)
NOVEMBER	0.115***	0.115***	0.108***
	(0.0138)	(0.0138)	(0.00816)
lnPopFrom	0.273	0.568	0.627***
	(0.161)	(0.791)	(0.00139)
lnPopTo	0.242	0.409	0.636***
	(0.152)	(0.769)	(0.00139)
lnIncFrom	0.872	0.861	-3.196***
	(0.741)	(0.760)	(0.0254)
lnIncTo	1.288	1.292	-3.155***
	(0.744)	(0.759)	(0.0252)
GDP	0.000473**	0.000467**	-0.000399**
	(0.000170)	(0.000173)	(0.000128)
OilPrice	0.000120*	0.000130*	-0.000122***
	(0.0000506)	(0.0000547)	(0.0000286)
Holiday	-0.0463***	-0.0464***	-0.0372***
	(0.0113)	(0.0114)	(0.00594)
TREND	-0.000168*	-0.000179*	0.000446***
	(0.0000702)	(0.0000704)	(0.00000992)
_cons	-15.36**	-20.43	30.63***
	(5.118)	(15.46)	(0.221)
N	314078	314078	314078

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable: lnPAX. All the reported standard errors are clustered at the for each route with a specific airline, making them robust to heteroskedasticity and serial correlation. Dummy variables for Monday to Saturday and January to November are used to control for weekday and monthly effects.

We start briefly with the results from the RE model, reported in column 1. The effect of the APT is insignificant and we cannot reject the null hypothesis that the effect of the APT is different from zero. Significant variables include OilPrice and some of the dummy variables for weekdays and dummy variables for month.

The results from the RE model are unbiased under the assumption that the explanatory variables and the unobserved route-specific effects are independent of each other. The conducted Hausman specification test gave a p-value of 0.000 ($\chi^2_{df=17} = 75.733$)[10] and we rejects the null hypothesis of no difference in the coefficient vectors of RE and FE. Therefore, the FE estimates in column 2 are preferred over the RE estimates.

The FE model estimates in column 2 also show that the APT has had an insignificant effect on air-traffic volumes and we cannot reject the null hypothesis that the effect of the APT is different from zero. According to this model, there are no basis for claiming that the APT have affected air-traffic volumes in the 2012 to 2019 period.

The coefficients for weekday dummy variables show that there are typically fewer passengers on Tuesdays and Saturdays compared to Sundays. Tuesdays and Saturdays see a 7.98 % and 91 % drop in passengers compared to Sundays, respectively. The coefficients are significant on 5 % level for TUESDAY and 0.1 % level for SATURDAY. Fridays and Thursdays generally has more passengers than Sundays. Thursdays see a 5.82 % increase in passengers while Fridays see an increase of 9.88 %. The coefficients are significant on 5 % level for THURSDAY and 0.1 % level for FRIDAY. Mondays and Wednesdays are not significantly different from Sundays.

All the coefficients for the different months are positive and significant on 0.1% level except from January, which is negative and July which is insignificant. This indicates that all months except January and July generally sees higher air-traffic volumes than December. The coefficient for holidays is negative and strongly significant. The coefficient shows that on holidays the daily air-traffic volumes on domestic flights generally drops with 4.64 %. This may indicate that most of the holiday traveling by air are to international destinations and not domestic.

The coefficient for the trend variable is significant on a 5 % level, but very small. It shows that for every day the air-traffic volume of passengers decreases by 0.0179 % and therefore

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[10] Appendix A4

we consider it to be a negligible factor. The coefficient for GDP is also small and significant. It shows that an increase in GDP of one billion NOK are associated with an increase in daily air-traffic volume of 0.0467 %. Therefore, we also consider that GDP have had a negligible effect on air-traffic volumes in the 2012 to 2019 period.

The coefficient for oil price shows a positive and significant relationship between oil price and air-traffic volumes on a 5 % level. An increase in the oil price of NOK 1 are associated with an increase in daily number of passengers of 0.013 %. As the coefficient is positive, this might indicate that the oil price may be a proxy for activity and not for costs. One possible explanation of this is the prevalence hedging future fuel prices in the aviation industry. As such this significant aspect of the industry's costs does not fluctuate with oil prices in the short to medium term.

It is hard to find empirical support for a negative effect of the APT on air-traffic volumes. The results from the pooled OLS estimations show a negative and significant effect of the APT, but the potential for unobserved route-specific effects makes this pooled OLS an inferior estimator and will therefore not be emphasized further. For the sake of comparison, the results from the pooled OLS estimations are reported in column 3.

Our preferred fixed effects estimates in column 2 indicates that the effect of APT on air-traffic volumes is weak or non-existing, and that the data does not provide strong enough evidence to reject the first null hypothesis of negative effect of the APT on air-traffic volumes. With the APT resulting in a small average price increase in airfares, and most routes offering few real substitutes in terms of transport, there is a possibility that the imposition of the tax has little effect on consumers directly.

10.2 RDiT Regression Results for Hypothesis 1

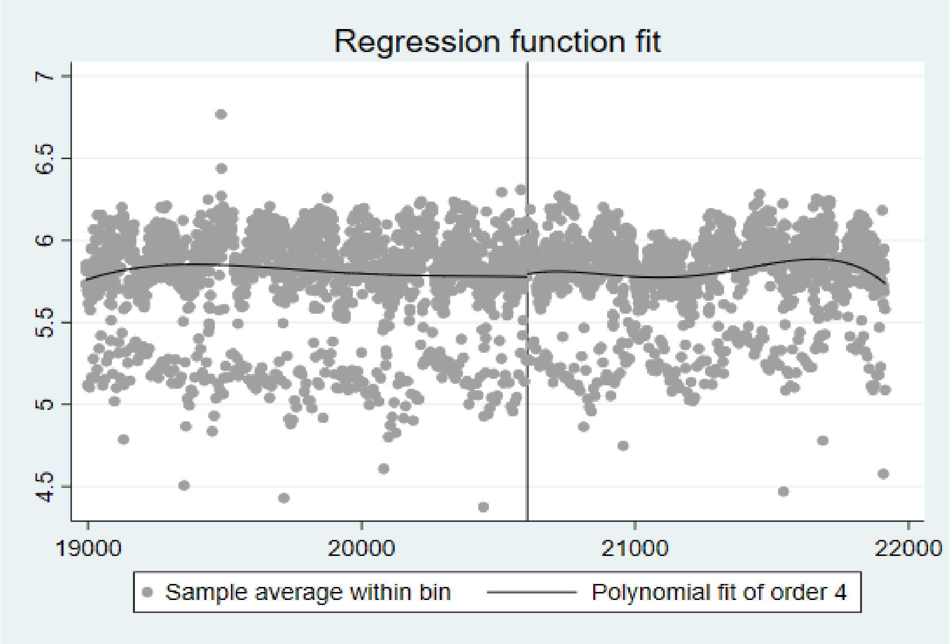

Figure 11: RDiT of lnPAX with threshold 1st June 2016

Regression discontinuity was briefly employed in a supplemental capacity. By conducting a regression discontinuity plot function with lnPAX as the dependant variable and time as the running variable we observe very slight variation at the threshold of July 1^{st}, 2016. Reducing the timespan examined to two years either side yielded similar results and as such we return our focus to panel data as our chosen method for examining the effect of APT. It is reassuring to observe that this model yields similar results to the panel data model specified above.

10.3 Panel Data Regression Results for Hypothesis 2

Table 8 displays the results of our regression when divided into each of the three main airlines.

Table 8:

Results by airlines

	(1) SAS	(2) Norwegian	(3) Widerøe
APT	-0.00281	0.0687**	-0.000483
	(0.0124)	(0.0229)	(0.0368)
MONDAY	0.107**	-0.156***	0.0782
	(0.0384)	(0.0277)	(0.0598)
TUESDAY	0.0443	-0.328***	0.0157
	(0.0451)	(0.0318)	(0.0633)
WEDNESDAY	0.124**	-0.259***	0.0942
	(0.0457)	(0.0312)	(0.0608)
THURSDAY	0.163***	-0.122***	0.117*
	(0.0433)	(0.0247)	(0.0549)
FRIDAY	0.161***	0.0207	0.110*
	(0.0379)	(0.0242)	(0.0496)
SATURDAY	-1.018***	-1.040***	-0.662***
	(0.0565)	(0.0620)	(0.111)
JANUARY	-0.0820***	-0.0673*	-0.138**
	(0.0230)	(0.0274)	(0.0462)
FEBRUARY	0.162***	0.0640*	-0.0216
	(0.0256)	(0.0286)	(0.0425)
MARCH	0.160***	0.0754***	0.00192
	(0.0186)	(0.0194)	(0.0351)
APRIL	0.106***	0.120***	0.00236
	(0.0185)	(0.0193)	(0.0295)
MAY	0.133***	0.167***	0.0321
	(0.0169)	(0.0194)	(0.0280)
JUNE	0.263***	0.174***	0.121***
	(0.0172)	(0.0301)	(0.0263)

JULY	-0.0617	0.0572	-0.00315
	(0.0503)	(0.0686)	(0.0504)
AUGUST	0.110^{***}	0.118^{***}	0.0633^{*}
	(0.0245)	(0.0332)	(0.0262)
SEPTEMBER	0.253^{***}	0.189^{***}	0.0958^{***}
	(0.0204)	(0.0222)	(0.0224)
OCTOBER	0.268^{***}	0.172^{***}	0.128^{***}
	(0.0242)	(0.0230)	(0.0228)
NOVEMBER	0.202^{***}	0.0578^{**}	0.0688^{**}
	(0.0215)	(0.0209)	(0.0229)
lnPopFrom	0.658	0.961	-0.759
	(0.772)	(0.885)	(2.068)
lnPopTo	0.382	1.018	-1.030
	(0.795)	(0.793)	(2.062)
lnIncFrom	1.053	-0.0265	1.175
	(0.697)	(0.623)	(1.809)
lnIncTo	1.469^{*}	0.382	1.617
	(0.571)	(0.706)	(1.807)
GDP	-0.0000440	0.000375	0.00102^{**}
	(0.000206)	(0.000290)	(0.000366)
OilPrice	0.000129	0.0000258	0.000185
	(0.0000733)	(0.0000747)	(0.000123)
Holiday	-0.119^{***}	-0.00165	-0.00726
	(0.0181)	(0.0206)	(0.0139)
TREND	-0.000168^{***}	-0.0000881	-0.000197
	(0.0000462)	(0.0000681)	(0.000138)
_cons	-22.87	-21.37	7.300
	(14.12)	(17.16)	(37.14)
N	114432	94915	104731

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable: lnPAX. All the reported standard errors are clustered at the for each route with a specific airline, making them robust to heteroskedasticity and serial correlation. Dummy variables for Monday to Saturday and January to November are used to control for weekday and monthly effects.

The results for each airline show that Norwegian is the only airline to have an APT coefficient significantly different from zero. This coefficient is positive for Norwegian, which is counterintuitive and not what we expected. It shows that the air-traffic volume for Norwegian have seen a 6.87 % increase after the imposition of APT.

Weekday and monthly effects seem weaker for Widerøe as they have fewer significant coefficients than SAS and Norwegian. The variables for income and population are insignificant for all three airlines as in the original model in column 2 of table 7. The variable for holiday is only significant for SAS, it is negative and show that SAS generally see a decrease of 11.9 % in air-traffic volumes during holidays. This may indicate that SAS does have more business travellers than Norwegian and Widerøe and that business travellers fly less during holidays.

The results show that we cannot reject our null hypothesis that APT has caused the same reduction in air-traffic volumes for all airlines.

11 Robustness

Having tested our model, we now aim to ascertain the robustness of our model and thus ensure the reliability of the results. The effect of the APT may depend on certain route characteristics, such as the length and size of a route. We will therefore see if one of these characteristics drive the result.

When differentiating between short and long flights, the previous literature on this topic has consistently shown the former to be more elastic. The proposed reasoning for this is twofold. Firstly, it arises from the diminishing availability of real alternatives means of transport as the length of the route increases. This effect may be lesser in Norway than in some of the other countries analysed as the relationship between flight time and other alternatives such as driving is not always linear owing to the country's peculiar topography.

Secondly any set fee, such as APT in the domestic context, will constitute a larger %age increase for routes with a lower base price. While this may not be true for every domestic route it is expected to remain true that the average longer flight will cost more than the average shorter flight.

The routes within the Norwegian air-travel network vary greatly with regard to flight frequency and the availability of alternative methods of transportation. The most trafficked routes are usually the ones connecting larger cities and as such there are buses, trains and sometimes even boats offering alternative methods of transportation. While the extent to which these public transport alternatives are meaningful substitutes will vary (owing to their increased travel time), previous literature has shown that some passengers will opt for alternative methods of transportation with the introduction of APT. One can therefore expect passengers on larger routes to be more sensitive to a price increase, as a result of which the imposition of taxation will result in a larger decrease in air-traffic volumes.

We refer to routes under 700 km as short routes, while routes over 700 km are long routes. We refer to the five largest domestic routes (both ways, for example OSL – BGO and BGO-OSL) as large routes. The large routes include routes between Oslo and the four major cities Trondheim, Bergen, Stavanger and Tromsø. It also includes the route between Bergen and Stavanger. We have run the regression from the original fixed effect model in table XX and separated the results for the four different characteristics large, small, long and short route. The results are shown in table 9.

Table 9:

Results by route characteristics

	(1) Large	(2) Small	(3) Long	(4) Short
APT	0.0369	0.0194	-0.00332	0.0213
	(0.0253)	(0.0166)	(0.0180)	(0.0183)
MONDAY	-0.0000314	0.0158	-0.0737*	0.0365
	(0.0652)	(0.0298)	(0.0271)	(0.0327)
TUESDAY	-0.0442	-0.0883*	-0.248***	-0.0377
	(0.0773)	(0.0343)	(0.0362)	(0.0368)
WEDNESDAY	0.0476	-0.0162	-0.187***	0.0416
	(0.0765)	(0.0340)	(0.0391)	(0.0359)
THURSDAY	0.111	0.0457	-0.0951*	0.0966**
	(0.0711)	(0.0291)	(0.0382)	(0.0311)
FRIDAY	0.143*	0.0886***	-0.0112	0.127***
	(0.0575)	(0.0253)	(0.0374)	(0.0263)
SATURDAY	-0.847***	-0.929***	-1.037***	-0.880***
	(0.0980)	(0.0538)	(0.0864)	(0.0559)
JANUARY	-0.0132	-0.146***	-0.140***	-0.0774**
	(0.0358)	(0.0290)	(0.0275)	(0.0239)
FEBRUARY	0.214***	0.00876	0.00719	0.0949***
	(0.0432)	(0.0275)	(0.0292)	(0.0244)
MARCH	0.137***	0.0464	0.0915***	0.0876***
	(0.0371)	(0.0239)	(0.0236)	(0.0197)
APRIL	0.0987**	0.0524*	0.0977***	0.0786***
	(0.0331)	(0.0203)	(0.0184)	(0.0175)
MAY	0.118***	0.0922***	0.171***	0.102***
	(0.0315)	(0.0191)	(0.0225)	(0.0164)
JUNE	0.183***	0.177***	0.338***	0.159***
	(0.0283)	(0.0193)	(0.0256)	(0.0161)
JULY	-0.195**	0.0282	0.428***	-0.108***
	(0.0635)	(0.0358)	(0.0410)	(0.0298)
AUGUST	0.0381	0.104***	0.294***	0.0510***
	(0.0236)	(0.0194)	(0.0352)	(0.0146)

SEPTEMBER	0.236^{***}	0.166^{***}	0.196^{***}	0.180^{***}
	(0.0278)	(0.0153)	(0.0269)	(0.0156)
OCTOBER	0.294^{***}	0.166^{***}	0.0877^{***}	0.218^{***}
	(0.0331)	(0.0149)	(0.0216)	(0.0158)
NOVEMBER	0.211^{***}	0.0908^{***}	-0.0173	0.145^{***}
	(0.0280)	(0.0147)	(0.0214)	(0.0146)
lnPopFrom	-2.390	0.0981	0.872	0.687
	(4.982)	(0.950)	(0.568)	(1.098)
lnPopTo	-1.474	-0.0687	1.014	0.323
	(4.652)	(0.927)	(0.519)	(1.068)
lnIncFrom	1.299	1.208	-0.0622	0.714
	(1.531)	(0.990)	(0.403)	(0.894)
lnIncTo	1.178	1.766	0.335	1.212
	(1.567)	(0.954)	(0.258)	(0.887)
GDP	-0.000163	0.000733^{***}	0.000690^{*}	0.000353
	(0.000232)	(0.000212)	(0.000288)	(0.000199)
OilPrice	0.000247^{*}	0.0000826	-0.000116^{**}	0.000173^{**}
	(0.000106)	(0.0000657)	(0.0000384)	(0.0000660)
Holiday	-0.180^{***}	-0.0113	0.0566^{**}	-0.0705^{***}
	(0.0205)	(0.0104)	(0.0189)	(0.0119)
TREND	0.00000907	-0.000237^{**}	-0.0000331	-0.000169^{*}
	(0.000181)	(0.0000825)	(0.0000412)	(0.0000779)
_cons	42.62	-14.25	-19.41	-19.47
	(84.30)	(18.04)	(11.35)	(19.68)
N	61317	252761	59051	255027

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable: lnPAX. All the reported standard errors are clustered at the for each route with a specific airline, making them robust to heteroskedasticity and serial correlation. Dummy variables for Monday to Saturday and January to November are used to control for weekday and monthly effects.

The coefficients for APT, income and populations are not significant for any of the four route characteristics, which is the same result as in the original model in table 7. The variable for GDP is positive and strongly significant for small routes, indicating that activity in the economy increases air-traffic volumes on small routes. Many of the variables for weekdays and months are still significant. This show that none of the four route characteristics drives the result in the original fixed effect model and again it is difficult to find a negative impact on air-traffic volumes of the APT.

11.1 Omitting variables - potential problem with multicollinearity

If two of the explanatory variables are correlated, statistical inference may become more difficult. Therefore, it is appropriate to test if some of the explanatory variables are correlated. We tested if different variables were correlated with each other with several simple linear regressions and found that income and GDP showed some correlation with each other[11]. To encounter this potential issue, we tried to omit variables from the original FE model from column 2 in table 7 to see if it would impact the results. Omitting a variable may lead to omitted variable bias and it will be a trade-off between precision versus bias. The results are shown in table 10.

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[11] Appendix A6

Table 10:

Results with omitted variables for GDP and income

	(1) lnPAX	(2) lnPAX	(3) lnPAX	(4) lnPAX
APT	0.0191	0.0142***	-0.00416	-0.00658*
	(0.0149)	(0.00326)	(0.00321)	(0.00316)
MONDAY	0.0131	0.0131***	0.0135***	0.0135***
	(0.0271)	(0.00286)	(0.00286)	(0.00286)
TUESDAY	-0.0798*	-0.0799***	-0.0795***	-0.0795***
	(0.0315)	(0.00288)	(0.00289)	(0.00289)
WEDNESDAY	-0.00402	-0.00402	-0.00361	-0.00362
	(0.0311)	(0.00288)	(0.00288)	(0.00288)
THURSDAY	0.0582*	0.0581***	0.0586***	0.0585***
	(0.0272)	(0.00287)	(0.00287)	(0.00287)
FRIDAY	0.0988***	0.0988***	0.0996***	0.0996***
	(0.0233)	(0.00287)	(0.00287)	(0.00287)
SATURDAY	-0.910***	-0.910***	-0.909***	-0.909***
	(0.0479)	(0.00327)	(0.00327)	(0.00327)
JANUARY	-0.101***	-0.0958***	-0.0519***	-0.0498***
	(0.0225)	(0.00426)	(0.00391)	(0.00388)
FEBRUARY	0.0669**	0.0688***	0.111***	0.111***
	(0.0227)	(0.00455)	(0.00425)	(0.00425)
MARCH	0.0784***	0.0754***	0.117***	0.115***
	(0.0183)	(0.00416)	(0.00392)	(0.00388)
APRIL	0.0730***	0.0660***	0.107***	0.102***
	(0.0161)	(0.00414)	(0.00406)	(0.00390)
MAY	0.107***	0.0971***	0.136***	0.129***
	(0.0153)	(0.00405)	(0.00416)	(0.00386)
JUNE	0.187***	0.176***	0.212***	0.205***
	(0.0157)	(0.00403)	(0.00419)	(0.00388)
JULY	-0.00927	-0.0231***	0.0104*	0.00196
	(0.0323)	(0.00395)	(0.00433)	(0.00384)
AUGUST	0.0949***	0.0779***	0.108***	0.0974***
	(0.0163)	(0.00390)	(0.00452)	(0.00383)

SEPTEMBER	0.180***	0.159***	0.187***	0.175***
	(0.0137)	(0.00390)	(0.00484)	(0.00385)
OCTOBER	0.192***	0.175***	0.195***	0.185***
	(0.0145)	(0.00399)	(0.00465)	(0.00397)
NOVEMBER	0.115***	0.106***	0.116***	0.111***
	(0.0138)	(0.00387)	(0.00407)	(0.00387)
lnPopFrom	0.568	0.592***	0.829***	0.838***
	(0.791)	(0.0880)	(0.0869)	(0.0869)
lnPopTo	0.409	0.435***	0.751***	0.760***
	(0.769)	(0.0892)	(0.0881)	(0.0881)
lnIncFrom	0.861	0.827***		
	(0.760)	(0.0692)		
lnIncTo	1.292	1.259***		
	(0.759)	(0.0688)		
GDP	0.000467**		0.000269***	
	(0.000173)		(0.0000638)	
OilPrice	0.000130*	0.000214***	0.0000668***	0.000117***
	(0.0000547)	(0.00000910)	(0.0000146)	(0.00000831)
Holiday	-0.0464***	-0.0485***	-0.0466***	-0.0479***
	(0.0114)	(0.00295)	(0.00296)	(0.00295)
TREND	-0.000179*	-0.000144***	-0.0000294***	-0.0000115**
	(0.0000704)	(0.00000645)	(0.00000582)	(0.00000398)
_cons	-20.43	-20.32***	-14.13***	-14.18***
	(15.46)	(1.746)	(1.732)	(1.732)
N	314078	314078	314078	314078

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable: lnPAX. All the reported standard errors are clustered at the for each route with a specific airline, making them robust to heteroskedasticity and serial correlation. Dummy variables for Monday to Saturday and January to November are used to control for weekday and monthly effects.

Column 1 show the results for the original FE model in table 7. In column 2, when we omit the GDP variable the APT coefficient becomes significant and positive. The coefficients for the income and population variables also become strongly significant. This indicates problems with multicollinearity. Coefficients for oil price become more significant and is larger than in column 1. In column 3, we have omitted only the income variables and the coefficient for APT becomes insignificant again. When we omit the income variables, the GDP variable becomes more significant on a 0.1 % level. In column 4, when both GDP and income variables are omitted, the model gives a negative and significant APT coefficient on 5 % level. The results vary when we omit variables for income and GDP, indicating once again that our model does not show reliable signs of a negative impact of APT on air-traffic volumes.

12 Implications of findings

Previous international studies on the effect of price changes on the demand for air travel have shown passengers to be sensitive to even small increases in price. This was observed across a range of studies analysing the effects of APT specifically as detailed earlier in this thesis. Domestically, it is worth noting that models employed by The Norwegian Tax Administration note an expected reduction of 10 % (Skatteetaten, u.d.). The findings of our analysis may therefore surprise at first glance as they show that the imposition of APT on the Norwegian aviation industry has had no significant effect on Norwegian domestic air-traffic volumes.

In reasoning why the observed effect is lesser in Norway than found in comparative international studies, one could speculate that Norwegian consumers are less price sensitive. The reasoning supporting this is threefold. Firstly, the Norwegian market has fewer readily available substitutes to air-travel owing to its particular topography and so it may be more price inelastic than countries such as The Netherlands. In 2016 it was estimated by SAS that 70 % of the Norwegian population had no alternative to flying for medium to long distance travel (Flaatten, 2016). Secondly, Norway may be a wealthier country and thus less responsive to a relatively minor tax. Thirdly, one could argue that prices for domestic travel are at a price point where the tax imposed is relatively smaller than its international counterparts and as such the effect on air air-traffic volumes is smaller. This final strand of argumentation would require price data currently unavailable to explore.

It is also possible that the airlines operating in the Norwegian market have effectively absorbed the majority of the tax despite their continued insistence that it will fall to the passengers. The Norwegian airline industry has a long history of competing fiercely on price, with an extensive system in place whereby the airlines can communicate and respond to price changes (Salvanes, Steen, & Sørgard, 2005). It is worth noting that airlines operating in the Norwegian airspace have voiced their opposition to APT and the economic necessity of a high passthrough rate since its introduction, citing a high degree of competition and low margins (Barstad, 2018). In recent years we have however observed airlines looking to cut costs elsewhere, moving bases abroad, increasing efficiency and pressuring working conditions and wages in order to continue to compete on price (Reinholdtsen, 2017). With the likelihood of airlines absorbing APT, we have repeatedly approached airlines operating domestically with requests for information pertaining to their passthrough rates as part of our study, but with no success.

The stated goal of APT has been of a fiscal nature, with the Norwegian Tax Administration noting proceeds of NOK 1.87 billion in 2018. As such the stated objective of the tax would be considered fulfilled, with revenue exceed the expected proceeds modelled initially. It is also important to recognise the factors which may impact the wider net effect of such an incidence of APT, both within the aviation market and generally.

13 Discussion of the APT

Our results show that the APT has no significant effect on air-traffic volumes. It has however been shown from other sources that APT contributes to reducing the airlines' margins. There are discussions about the design of APT and if it should exist with the purpose it has today. In a recent Norwegian official government report, the majority of the appointed committee recommends that the APT is replaced with a more precise environmental tax (NOU, 2019). In the view of the committee, there is little doubt that the APT make it less profitable for airlines to offer routes, especially domestically in Norway. However, this must be weighed against the climate effects.

Today, the APT is primarily a fiscal tax created to generate revenue for the government. The revenue from the APT only cover ordinary government spending and are not earmarked for special projects within the aviation industry or environmental initiatives (Trumpy, 2020). Hence, it is difficult to label the APT as an environmental tax, as labelled by some government officials when it was first introduced. Given the results presented in this thesis it is also difficult to find support for the argument that APT, in its current iteration, provides environmental benefits through reducing air-traffic volumes.

The APT is not designed to have an efficient environmental impact and may therefore also explain why it is difficult to see effects in air-traffic volumes of it. As the APT stands today, it does not incentivise people to become more environmentally friendly and travel less by air as it is a flat tax that does not take the amount of emissions into consideration. Hence, we believe that also the design of APT is a contributing factor to not finding significant effect in the air-traffic volumes.

13.1 Alternative design of APT

Current political debate on this topic is centred around the environmental impact of APT in its current form and whether a more targeted tax should be employed. Several commentators have argued that APT in its current form reduces air-traffic volume and as such it has a positive environmental effect. This is not supported by our findings. If the purpose of the tax should extend beyond its original specific purpose of raising government revenue, then it could be argued that it should be designed in a way which incentivised the fulfilment of this intended purpose. This section aims to explore some alternative approaches to APT wherein environmental impact could be a key consideration.

When addressing the question of an alternative design of APT, we asked the question; *what incentives are needed to accelerate the development of low-emission aircrafts and operational procedures*? APT is added directly to the ticket price and disrupts the airline’s pricing dynamics and can affect airlines adversely. We believe that the design should give incentives to push the behaviour of people and airlines in a more environmentally friendly direction. If the APT was designed to tax fuel consumption directly such that it targets what really drives the emissions of greenhouse gases, it will be a more accurate tax that incentivise airlines to cut emissions. In this way, airlines with fuel-efficient aircrafts will be better off and airlines are incentivised to cut emissions. With such a design, APT could be classified as an overhead cost for the airlines such that it impacts the bottom line, and not the ticket price directly.

Environmental organisations in Norway have advocated that the proceeds from APT should be earmarked for initiatives that can reduce emissions in aviation (Trumpy, 2020). It could be invested in a fund that is used to promote in new technology and more efficient fuel solutions. We also believe that the revenue generated from APT could be used to expand and improve alternatives to air-travel such as the railroad system. As discussed earlier the alternatives to air-travel in Norway are very limited, especially in the northern and western part of Norway. If the travel alternatives were better, a well-designed APT could increasingly shift traffic from air to railroad and accelerate the transition over to environmentally friendly transportation habits in Norway.

14 Limitations

Time and data constraints have necessitated certain assumptions and simplifications which may limit our model. This chapter aims to outline these potential weaknesses and discuss how they may impact our findings.

The model is flawed due to the problem with simultaneous equations as discussed earlier. This results in issues with regard to endogeneity which will bias the results. Therefore, one should be careful to interpret the causal effect of the variables as we have endogeneity problems in our model.

The lack of availability of ticket prices means we are only able to speculate on the real passthrough rate of APT. Without price data this cannot be concluded with certainty as there could be other factors affecting air-traffic volumes which our model fails to account for.

The model employed in this thesis utilises highly detailed air-traffic data. This data is reported at time intervals of a single day whilst certain controlling variables such as population and income are reported at quarterly intervals. The model therefore assumes linear growth in variable level between the data points in order to bring it down to a daily level. Income is assumed to stay constant for a whole year as the majority of the working population receive adjustments to their salary on a yearly basis. This may not reflect the real changes in population and income and can therefore influence the results in a way that does not reflect the real effect. The income data available also requires the model to rely on the average median income of all counties connected to an airport. This simplification fails to account for the relative population size of the counties observed and as such this variable may be skewed too high or low for any given airport.

15 Future research

Based on our results and the limitations of the thesis, we would like to propose further research on this topic.

We encourage future researchers to analyse the supply side changes following the imposition of APT, both in terms of ticket prices and passthrough rates as well as capacity changes. To this effect it could also be useful to employ a suitable simultaneous equation model in order to interpret demand and supply jointly and therefore avoid the challenges pertaining to simultaneous equations and endogeneity encountered in this thesis.

It would be interesting to consider the effects of APT on air-traffic volumes on a larger scale. This includes the PSO routes in Norway. As mentioned, PSO routes are of a different nature and are not directly comparable to commercial routes. Nevertheless, it would be interesting to consider the impact of APT on PSO routes in isolation as this can inform important policy decisions in rural regions. Future researchers may also look at the effect of APT on international routes. A significant share of flights to and from Norwegian airports includes international destinations and it would be informative to see the effect of the APT on international air-travel. International air-travel is probably more skewed towards leisure travel, which we expect to be more sensitive to price changes and therefore we might observe a greater impact of APT than our results for domestic air-travel.

With regards to price data it would be interesting to ascertain the exact passthrough rates of APT. Such data would also serve to illuminate whether the conclusions drawn about APT in this thesis are correct. In the case that the passthrough rate has been of significant magnitude it would also illuminate the need for a more detail model wherein further factors drive changes in air-traffic volumes. With such a study it would be of interest to investigate the passthrough rate of APT to see if it affects the results with respect to different routes and airlines. This requires a broader data set that is particularly challenging to obtain as airlines are unwilling to share sensitive information regarding their pricing strategy.

16 Conclusion

The purpose of this thesis has been to analyse the effect of APT on air-traffic volumes for domestic flights in Norway. This study was conducted across a timespan of eight years, four of which were prior to the introduction of APT and four including the effects of APT. The model employed analyses the change across all three major airlines operating in Norwegian airspace, as well as the effect on each individual airline.

The results of the study show the effect of APT to be is insignificant and we are unable reject the null hypothesis that the effect of the APT is different from zero. Furthermore, when considered individually, Norwegian is shown to be the only airline with a change in air-traffic volume that is significantly different from zero at positive 6.87 %. This is surprising and may suggest that there are other factors at play outside of the scope of the model.

Given the lack of access to price data we are unable to conclude the precise cause of these findings. Some potential causes can however be discussed, albeit under a veil of caution. One possible explanation could be that demand for flights is inelastic and as such a fee of 80 NOK is insufficient to change the travel habits of passengers. Due to the high level of price competition in the Norwegian flight market it would also be reasonable to assume that the airlines cover a portion of the fee themselves and that passengers, as a result, experience a dampened price increase. This could be a contributing factor to the prevalence of cost cutting initiatives within the industry in recent years.

The future of APT remains a highly debated topic in Norwegian politics, it is not shown from our results to significantly decrease air-traffic volumes. If lowering air-traffic volumes is a priority, then a more specific policy may therefore be worth considering.

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Appendix

A1 – List of municipalities linked to each airport

Airport	Municipality
Aalesund (AES)	Aalesund
	Ulstein
	Hareid
	Ørsta
	Sykkylven
	Sula
	Giske
	Fjord
Alta (ALF)	Alta
	Kvænangen
	Kautokeino
Bardufoss (BDU)	Lavangen
	Bardu
	Salangen
	Målselv
	Sørreisa
	Dyrøy
	Senja
	Balsfjord
	Storfjord
Bergen (BGO)	Bergen
	Tysnes
	Voss
	Kvam
	Samnanger
	Bjørnafjorden
	Austevoll
	Øygarden
	Askøy
	Vaksdal
	Osterøy
	Alver
	Austrheim
	Masfjorden
Bodø (BOO)	Bodø
	Gildeskål
	Beiarn
	Saltdal
	Fauske - Fuossko
	Sørfold
Harstad/Narvik (EVE)	Narvik
	Lødingen
	Evenes
	Harstad
	Kvæfjord
	Tjeldsund
	Gratangen
Haugesund (HAU)	Haugesund
	Bokn
	Tysvær
	Karmøy
	Vindafjord
	Etne
	Sveio
	Bømlo
	Stord
	Fitjar
Kirkenes (KKN)	Vadsø
	Unjárga-Nesseby
	Sør-Varanger
Molde (MOL)	Molde
	Vestnes
	Rauma
	Aukra
	Sunndal
	Hustadvika

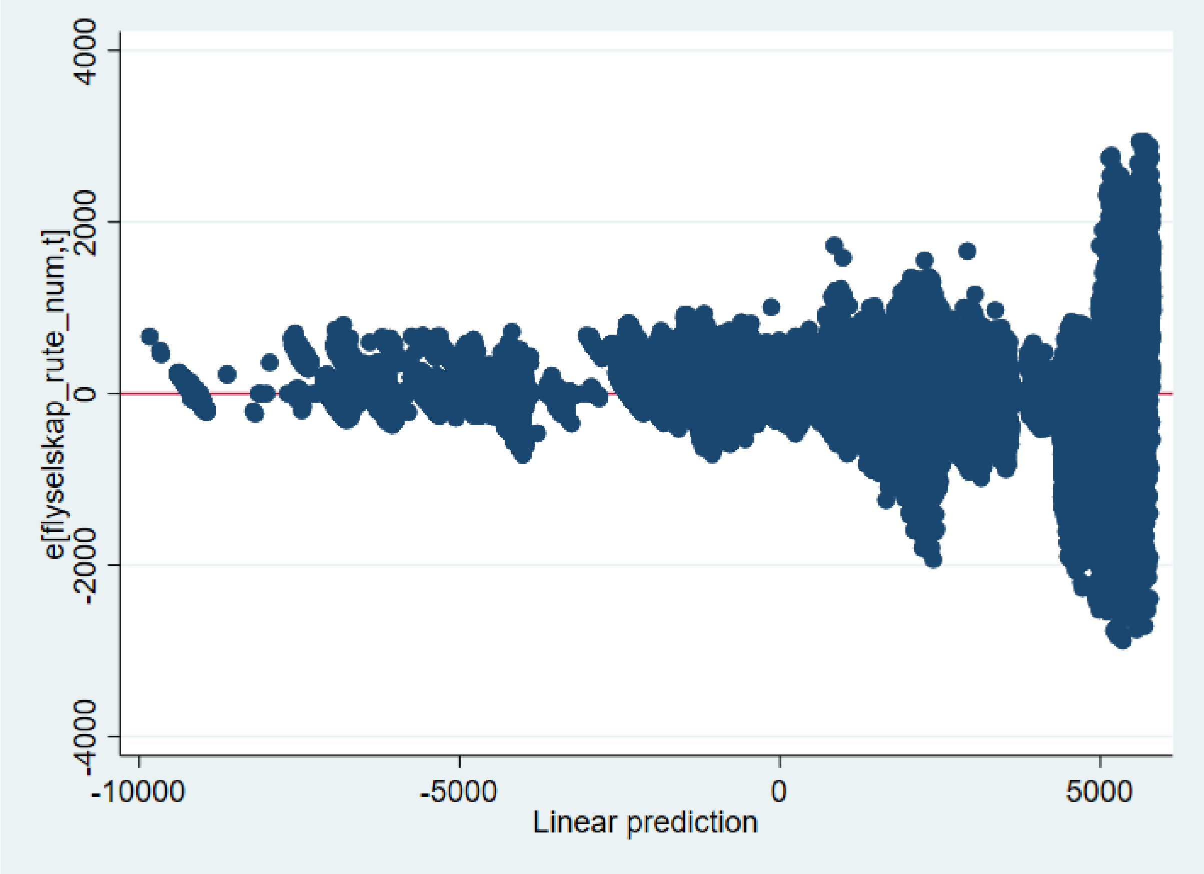
Airport	Municipality
Oslo (OSL)	Moss
	Sarpsborg
	Drammen
	Ringerike
	Marker
	Indre Østfold
	Skiptvet
	Rakkestad
	Råde
	Våler (Viken)
	Vestby
	Nordre Follo
	Ås
	Frogn
	Nesodden
	Bærum
	Asker
	Aurskog-Høland
	Rælingen
	Enebakk
	Lørenskog
	Lillestrøm
	Nittedal
	Gjerdrum
	Ullensaker
	Nes
	Eidsvoll
	Nannestad
	Hurdal
	Hole
	Modum
	Øvre Eiker
	Lier
	Jevnaker
	Lunner
	Oslo
	Kongsvinger
	Hamar
	Gjøvik
	Ringsaker
	Løten
	Stange
	Nord-Odal
	Sør-Odal
	Eidskog
	Grue
	Elverum
	Østre Toten
	Vestre Toten
	Gran
	Søndre Land
	Holmestrand
	Sande
Kristiansand (KRS)	Risør
	Grimstad
	Arendal
	Kristiansand
	Lindesnes
	Gjerstad
	Vegårshei
	Tvedestrand
	Froland
	Lillesand
	Birkenes
	Åmli
	Iveland
	Evje og Hornnes
	Bygland
	Vennesla
	Åseral
	Lyngdal
	Hægebostad
Kristiansund (KSU)	Kristiansund
	Averøy
	Gjemnes
	Tingvoll
	Aure

Airport	**Municipality**
Trondheim (TRD)	
	Trondheim
	Steinkjer
	Rennebu
	Midtre Gauldal
	Melhus
	Skaun
	Malvik
	Selbu
	Tydal
	Meråker
	Stjørdal
	Frosta
	Levanger
	Verdal
	Inderøy
	Heim
	Orkland
Tromsø (TOS)	
	Tromsø
	Karlsøy
	Lyngen
Sandefjord (TRF)	
	Horten
	Holmestrand
	Tønsberg
	Sandefjord
	Larvik
	Porsgrunn
	Skien
	Færder
	Siljan
	Bamble
	Kragerø
	Nome
Stavanger (SVG)	
	Sirdal
	Eigersund
	Stavanger
	Sandnes
	Sokndal
	Lund
	Bjerkreim
	Hå
	Klepp
	Time
	Gjesdal
	Sola
	Randaberg
	Strand

A2 - Heteroskedasticity

Heteroskedasticity can occur as the differences in the size of observations between the routes are large and therefore the variation may be larger for larger routes. This may result in non-constant variance for the error term across routes. To check for the existence of heteroskedasticity, we plotted the variation in the residuals and conducted a Breusch-Pagan test. The plot below indicates non-constant variance and the Breusch-Pagan test gives a p-value of 0.000. Hence, we reject the null hypothesis of constant variance, and assume that heteroskedasticity is present.

The plot below shows that there is a large variation in the spread of the residuals. This indicates that the assumption of constant variance in the error term does not hold. We therefore conduct out a Breusch-Pagan test for heteroskedasticity. Here we reject H_0 of constant variance in the error term, and we therefore use clustered standard errors in the model. This applies for all estimations.



```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of PAX
        chi2(1)      =110592.66
        Prob > chi2  =    0.0000
```

A3 - Wooldridge test for autocorrelation in panel data

Autocorrelation can occur in time series and panel data and may be a potential problem in our models as the number of passengers for a given time may depend on the number of passengers in previous periods. To test for autocorrelation, we use a Wooldridge test for autocorrelation in panel data. The test gives a p-value of 0.1139, which indicates borderline autocorrelation but means that we keep the null hypothesis of no first-order autocorrelation.

To account for potential problems with heteroskedasticity and autocorrelation we use clustered standard errors in our models. Clustered standard errors accounts for heteroskedasticity across clusters of observations such as different routes in our data set.

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,     167) =      2.526
           Prob > F =      0.1139
```

We keep H_0 of no first-order autocorrelation.

A4 – Hausman test

Hausman (1978) specification test

	Coef.
Chi-square test value	75.733
P-value	0

A5 – Density plot for lnPAX and PAX

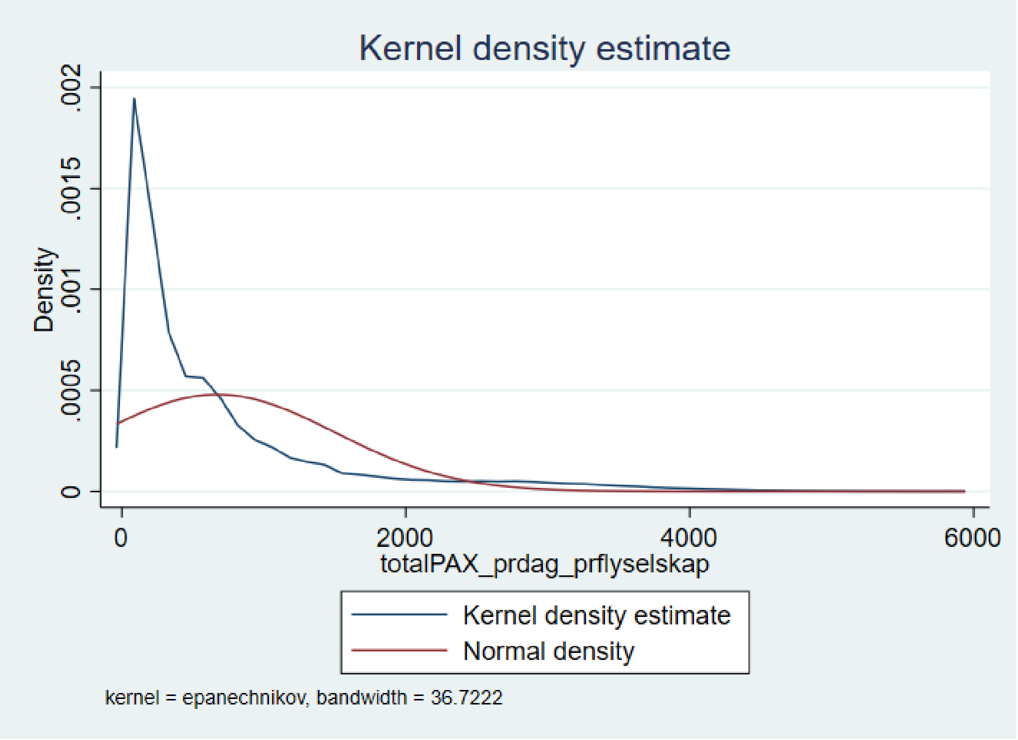


Figure 12: Distribution of PAX observations compared to the normal distribution

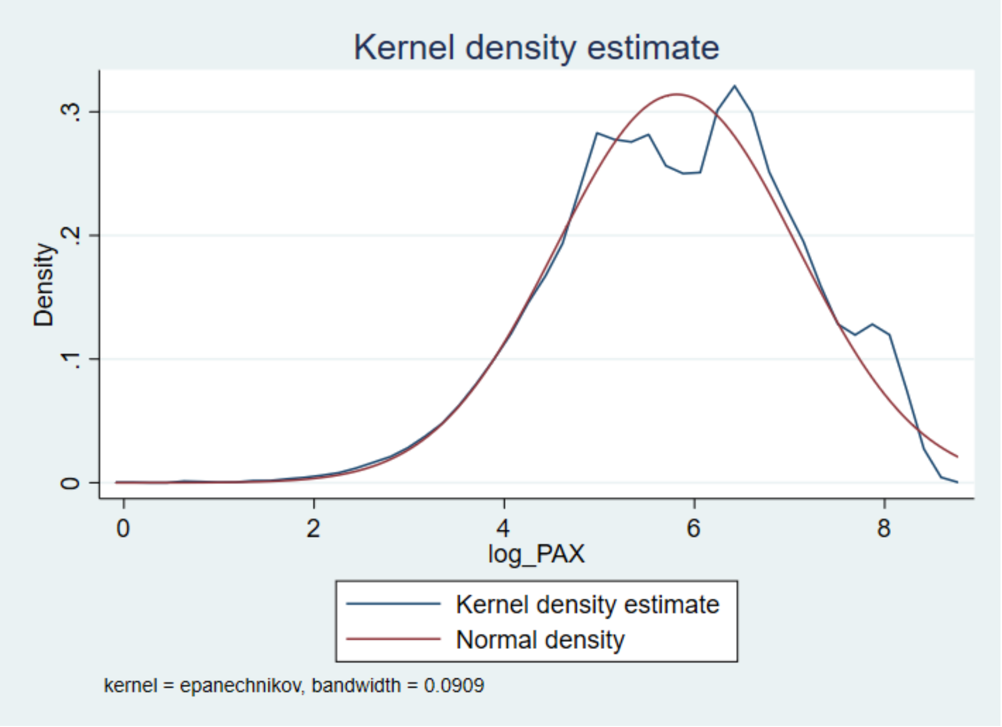


Figure 13: Distribution of lnPAX observations compared to the normal distribution

A6 – Regressions - Check for multicollinearity

Linear regression

lnIncFrom	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
GDP	0.001	0.000	330.50	0.000	0.001	0.001	***
Constant	5.710	0.002	2606.74	0.000	5.706	5.714	***

Mean dependent var	6.432	SD dependent var	0.093
R-squared	0.258	Number of obs	314078.000
F-test	109231.553	Prob > F	0.000
Akaike crit. (AIC)	-692771.531	Bayesian crit. (BIC)	-692750.216

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

Linear regression

lnIncTo	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
GDP	0.001	0.000	328.44	0.000	0.001	0.001	***
Constant	5.712	0.002	2594.99	0.000	5.707	5.716	***

Mean dependent var	6.433	SD dependent var	0.094
R-squared	0.256	Number of obs	314078.000
F-test	107875.425	Prob > F	0.000
Akaike crit. (AIC)	-689742.469	Bayesian crit. (BIC)	-689721.154

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