Master's degree thesis

LOG950 Logistics

Estimating Own-Price Elasticities of Air Travel Demand: The Case of Norway

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Number of pages including this page: 177

Molde, 25.05.2015

Molde University College
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Preface

This thesis is submitted in partial fulfillment of the requirements for the MSc. degree in Logistics at Molde University College, specialized University in Logistics, Molde, Norway.

This work has been carried out in the period between January and June 2015 with Professor Svein Bråthen, Molde University College, as supervisor.

The thesis analyzes the own price elasticity of air travel demand in Norway. It consists of introductory, theoretical and methodological chapters, followed by three analysis chapters that represent the core of the thesis.

Acknowledgements

First and foremost I thank my supervisor, Professor Svein Bråthen, for his guidance and encouragement. His patience, knowledge and experience have supported me throughout this project.

I would also like to thank Terje A. Gjertsen and Simen Sæterdal from Statistics Norway, who supported the project by providing data and answering related questions. For the same reasons, I owe thanks to Jens Veberg, Norwegian Ministry of Transportation and Communications, and Jon Inge Lian, Avinor.

My special gratitude goes to Fredrik Kopsch, Royal Institute of Technology Stockholm, for giving me valuable insights in his own research. My sincere thanks also go to Nils Fearnley, Institute of Transport Economics, for his helpful comments on demand elasticities.[1]

I owe thanks to the staff of the IT-department and the library personnel of Molde University College for their kind cooperation and continuous support.

Finally, I wish to thank my wife and my two children for their love and their sacrifices.

[1] The interpretation and use of data and information provided by the informants are the sole responsibility of the author.

Summary

Research Design

The thesis analyzes the own price elasticity of air travel demand in Norway. The thesis is guided by the following overall research question:

How price elastic is the demand for passenger air travel in Norway?

This research question is further disaggregated into six sub-research questions, which address different characteristics of price elasticities in air passenger transportation and related issues. A quantitative research method is applied and a time series analysis research design is used to generate the findings. A special focus is put on the stationarity quality of the underlying data and their consequences for the analysis.

The thesis comprises of two parts. Part I introduces the case of air passenger transportation in Norway and establishes the necessary theoretical foundation for the later analyses. This includes a discussion of the elasticity concept, a literature study on air passenger transportation demand and an elaboration on methodological issues.

Part II is concerned with the empirical analysis of own-price elasticities of demand. Three separate sub-analyses are conducted:

Analysis 1: Domestic Aggregated Demand - Annual Data 1981-2013

This analysis strives to identify the price elasticity of the domestic Norwegian market. A static model in "double-log" configuration is estimated as the primary approach. Following the concept of co-integration, an autoregressive-distributed-lag model is employed in addition.

Analysis 2: National Aggregated Demand - Quarterly Data 2006-2014

This analysis addresses the national aggregated demand and its price elasticity. An unbalanced regression approach, using a distributed-lag model is performed. Furthermore, this analysis elaborates on differences in price elasticities among the traveller segments.

Analysis 3: Route Demand - Bimonthly Data 2004-2014

This analysis treats the own price elasticity on the route level and uses the city-pair Lakselv-Tromsø as example.

Air Passenger Transportation in Norway

Norway is among the European countries with the highest trip rate by air per inhabitant (eurostat 2014). The reasons for that can be found in the combination of the overall topographical conditions of the country, the existence of remote settlements and the limited existence of ground based, inter-regional transportation infrastructure. Consequently, air passenger transportation plays a prominent role and is assessed as "*…one of the key elements in domestic transport in Norway as well as a vital international link*" (Regjeringen 2015).

The demand for air travel in Norway has seen a quite stable growth over the last 30 years. The domestic sub-segment has increased by on average 4.1% per year; the demand for international flights even more, with approximately 6% per year (Denstadli, Thune-Larsen, and Dybedal 2014). In 2014, roughly 21 million international and 12.5 distinct domestic air trips were counted (Avinor 2015c), a tremendous change compared to combined 6 million trips in the year 1981. Especially the international segment has increased it's growth rate even more in the period past 2003. One reason for that seems to be the market entry of Norwegian Air Shuttle AS and the related increase in competition over prices.

The development of airfares in Norway on the aggregated national level followed the growth in general prices until the end of the last century. It was for the period from 1999 until 2004, that airfares decoupled 'upwards' from the overall price development in Norway, a phenomenon that can be linked to the temporary increase in monopoly power of Scandinavian Airlines. With the increase in competition for the years to follow, airfares have started to 'underperform' compared to the overall price development. Since 2008, prices for air travel have on average decreased nominal and relatively to the general price development. In this context, the international segment has shown a stronger decline than the domestic segment and business traveller airfares decreased more than fares for the leisure segment. Recent statistics however, indicate that the decline in airfares has come to a stop in the later years (Denstadli, Thune-Larsen, and Dybedal 2014). Anyway, as of 2013 airfares were still on average cheaper in nominal prices than in 2003.

Elasticities

A widely used method in economics to express the general responsiveness of one variable to a change in another variable is the elasticity concept. If one analyses demand changes as consequence of price changes, one is interested in the *own-price elasticity of demand*. This elasticity is defined as the '… percentage change in quantity demanded of a good resulting from a percentage change in its price' (Pindyck and Rubinfeld 2013).
It can be represented algebraically as:

$$\mathcal{E}_p = \frac{\%\ \Delta Q_X}{\%\ \Delta p_X};$$

where Q_X = quantity of X demanded,
p_X = price of good X and
'%Δ' means *percentage change.*

Owing to downwards-sloping demand functions, the ratio of a percentage change in price and a percentage change in quantity demand is negative, indicating that with an increase in price, demand falls.

Price elasticities for air travel demand vary with regard to several factors. For example, business traveller are less sensitive to price changes than leisure traveller and the existences of substitutes for air travel tend to increase the price elasticity of demand (InterVISTAS 2007). Both facts are partly related to the travel time dimension and it's valuation. A crucial determinant of price elasticity is also the share of an individual's budget that a customer has to invest to purchase an air ticket. The Slutsky equation in elasticity form contributes to the explanation of this phenomenon by clarifying how for example a small budget share needed to by a ticket reduces the price sensitivity of demand. Furthermore, price elasticities vary with respect to a short-term and long-term time dimension. On short notice, the consumers' flexibility to adjust their behaviour as a response to increases in price is rather limited. The full demand adjustment effect arising from a price change is therefore delayed (Fearnley and Bekken 2005). It is however this long-run effect, which is especially important to know for policy makers to base their decisions on.

Studies on Price Elasticity for Air Travel Demand

Earlier studies on price elasticity in aviation have yielded to a wide range of estimates. Values as extreme as -3.2 and +0.21 have been reported (Brons et al. 2002), with median estimates around unity. Controlling for the specific determinants of price elasticities sketched on above, scholars were able to significantly narrow the range of estimates down (Gillen, Morrison, and Stewart 2003).

Recent surveys seem to be more concerned about the unwanted and disturbing impact of the so-called "spurious regression problem" on the estimates, than earlier papers. This casts a cloud on the findings of older papers, especially since this problem typically leads to an overestimation of price elasticities. A more and more popular approach to estimate price elasticities in aviation is the use of the co-integration concept. For example Chi and Baek (2012) report an elasticity of -1.5 for the US market and UK-DfT (2013) reports for domestic and international air travel in the UK price elasticities of -0.2 to -0.7.

For the Norwegian market, elasticity estimates are quite scarce. The most recent results yield from cross-sectional research designs and indicate an inelastic aggregated demand with elasticities of -0.3 to -0.5.

Results

Analysis 1:

The demand for domestic air travel in Norway is found to be price inelastic. The own price elasticity of demand is estimated to be -0.36, implying that an increase in prices by 10% reduces demand for air travel by 3.6%. Since this result was derived from a static model specification, the estimated elasticity is seen from a mathematical standpoint a short-run (SR) elasticity. The findings are fostered by an additionally applied Autoregressive-Distributed-Lag model (ADL), which yields the same SR-elasticity. A significant long-run (LR) price elasticity was based on the data at hand not derivable.

The income elasticity of demand is estimated to be +0.41 in the SR, indicating that changes in GDP have slightly higher impacts on domestic air travel demand than price changes.

Analysis 2:

The demand for air travel in Norway on a national aggregated level is found to be price inelastic. The own price elasticity of demand is estimated to be -0.23 in the short-run and -0.48 in the long-run. This implies that the long-run effect is more than twice the magnitude of the short-run effect, indicating that consumers indeed need time to adjust their behaviour in response to price changes.

The estimated short-run elasticity is in magnitude slightly smaller than the respective value in analysis one. This could be an indication for less or equally price elastic demand on the aggregated level in the last decade as compared to earlier years.

The income elasticity of demand is found to be +0.52, implying again that an one-percentage increase in GDP leads to a larger demand growth than an one-percentage decrease in airfares.

Contrary to the general line of argumentation in the literature, demand for business and demand for leisure air travel in Norway are found to have insignificant different price elasticities. There is however, a high likelihood that this finding suffers from a combination of unfavourable factors in the analysis, such as small sample size issues and estimated demand figure.

Analysis 3:

The demand for air travel on the route level, here for the PSO-route Lakselv-Tromsø, is found to be price inelastic. The own-price elasticity of demand is estimated to be -0.27 in the short-run. This indicates that contrary to the general line of argumentation in the literature, demand for this route is only marginally more price elastic than demand on the aggregated level. The special characteristics of the PSO-route have to be taken into account however. A significant long-run elasticity could not be estimated.

All Analyses:

Significant cross-price elasticities of air travel demand in respect to car ownership costs, and costs for travel by rail and bus are not found throughout all analyses, implying that price changes for substituting modes of passenger transport in Norway do not significantly influence the demand for air travel.

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Part II

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Abbreviations

ADF-test	Augmented Dickey-Fuller unit root test
ADL-model	Autoregressive Distributed Lag model
AIC	Akaike Information Criterion
AR-model	Autoregressive model
ASK	Available Seat Kilometres
BIC	Bayesian Information Criterion
CPI	Consumer Price Index
DL-model	Distributed Lag model
DW	Durban - Watson statistics
ECM	Error Correction Model
IV	Instrument Variable
LCC	Low Cost Carrier
LKL	Lakselv airport
LR	Long-Run
NAS	Norwegian Air Shuttle ASA
NTS	National Travel Survey (Norway)
pax	passenger(s)
PPI	Producer Price Index
PP-test	Phillips-Perron unit root test
PSO	Public Service Obligation
RPK	Revenue Passenger Kilometres
SAS	Scandinavian Airlines
SR	Short-Run
SSB	Statistics Norway
STOL	Short Take-Off/Landing
TOS	Tromsø airport

1.0 Introduction

Norway's topographical conditions and the low population density of less than 17 inhabitants per square km (SSB 2013) have limited the development of the nation's road and rail network ever since. Intercity high-speed train and road links merely exist, which results in long surface travel times even between the country's larger cities. In some extreme cases, remote communities are not at all connected with a suitable link to the national surface transportation infrastructure. Consequently, Norway is among the European countries with the highest trip rate by air per inhabitant (eurostat 2014).

The general contribution of air transportation to the social development of inhabitants, economic growth and location-based decisions of businesses is widely recognized (Halpern and Bråthen 2010). There is no doubt about the overall importance of air passenger transportation for the Norwegian society and the country's government understands aviation as "*...one of the key elements in domestic transport in Norway as well as a vital international link*" (Regjeringen 2015).

1.1 Choice of Research Topic and Research Questions

Studying and living in Norway inevitably means coming into contact with air passenger transportation. Air transportation is an almost omnipresent mode of transportation in Norway and some special features of the Norwegian setting are eye-catching for foreigners. For example, the high density of airports in some parts of the country and the presence of airfields in very remote 'micro'-communities are striking. For someone who is already attracted by issues pertaining to air transportation, the research field of air transportation becomes even more interesting in the Norwegian setting. It therefore motivated me to write my Master Thesis on the research topic of Air Transportation.

It was in the summer of 2014 that I first tried to identify a concrete topic for the thesis. During an earlier discussion with my designated supervisor, I became aware of the fact that the distribution of air traffic among the existing airports in the Oslo-area might change in the future, because of emerging constraints on capacity. One consequence of such a change would presumably be the need for investments into additional infrastructure. The costs of such investments would most likely have an impact on the price of air travel. The question that then arises is whether the change in airfare negatively affects the demand for air passenger transportation? Would the resulting decrease in demand make the entire restructuring obsolete? To answer these questions, one has to study the effect of price changes on the demand for air travel. Since existing studies on own-price elasticity of air

passenger transportation demand in Norway are somehow out-dated, the idea was born to make this the subject of my Master Thesis.
The thesis is guided by the following overall research question (RQ):

How price elastic is the demand for passenger air travel in Norway?

After an initial literature review, it became evident that answering this question was not as simple as it seemed. In fact, a reasonable answer would rather start with ‘It depends…’. Accordingly, the need has arisen to further disaggregate the main research question into more specific sub-questions, which will be addressed in the three sub-analyses of this thesis. These are as follows:

RQ 1: How price elastic is the demand for passenger air travel in Norway on the national aggregated level?

RQ 2: How price elastic is the demand for passenger air travel in Norway on the route level?

Moreover, during the extensive literature review and while preparing the analysis, additional questions emerged. The clarification of these supplementary issues was essential for detailed solutions to the above-mentioned research questions. The additional research questions to be addressed and the motivations to raise the questions are:

RQ 3: Do the price elasticities differ between the business and the leisure segment?

Literature suggests for different reasons that demand for business related air travel should be less sensitive to price changes than demand for leisure related travel. Consequently both segments should be addressed separately.

RQ 4: Has the price elasticity changed in the recent past?

Considering changes in the Norwegian market structure, their effects on average airfares and general market maturity effects, one could assume that the price elasticities have changed compered to the pre 2002-period. Market maturity effects and cheaper airfares (i.e. Slutsky equation) would argue in favour of a decrease in elasticities (absolute values), the attraction of additional highly price sensitive customers on the other hand, would favour increased price elasticities.

RQ 5: Is the demand for air travel in Norway significantly influenced by price changes for other modes of passenger transportation?

Literature suggests that price changes for other modes of passenger transportation can influence the demand for air travel. This however, requires the consumers to assess the other modes of transport as 'suitable'. Considering the special topographical conditions of Norway, one could question the fulfilment of this requirement on the aggregated national level.

RQ 6: Are the demand for air travel in Norway and its price co-integrated processes?

This research question is linked to several methodological issues of time series analysis, which could be overcome if air travel demand and its price were co-integrated processes. The existence of a co-integration relationship between variables requires the underlying data to satisfy distinct requirements. So far, only a few applications of co-integration for the analysis of air travel demand have been reported. Considering that 'negative findings' are very likely not reported in the literature, it does not seem self-evident that co-integration is an in general suitable analysis approach for air travel demand in Norway. This research question strives therefore to clarify, whether or not air travel demand and its price in Norway are co-integrated processes.

1.2 Limitation of the Research

This thesis strives to give a picture of price elasticities of air travel demand in Norway. The focus is hereby put on scheduled air passenger transportation within Norway. Even though other types of air transportation such as cargo operations, non-scheduled passenger operations and so-called general-aviation flights might also be interesting to be analysed in respect to their price elasticity of demand - they are not considered in this thesis. Furthermore, the quite extensive helicopter offshore activities in Norway are also excluded from the elaborations. Theses limitations are mainly placed to keep the size of this thesis within a manageable range. For the same reason, I decided to answer the RQs by the limited amount of three distinct sub-analyses, rather than striving to give an entirely comprehensive picture for all existing settings within the Norwegian scenario.

Unfortunately, the very meaningful and clear differentiation in price elasticities for the domestic sub-market and the international market segment could not be made.[2] The outcomes of the first two sub-analyses reflect rather the situation on a domestic and a "mixed" national aggregated level where both, domestic and international air travel figures contributed to the analyses. This was inevitable because of the very restrictive information policy on past airfares and the resulting constraint put on data availability. The third sub-analysis on the other hand, depicts the situation in the very special setting of a Public-Service-Obligation (PSO) route. Knowing about the particular characteristics of PSO-operations, the findings of this sub-analysis can hardly be generalized. The reader should be attentive not to consider the specific results of this sub-analysis as transferable to other routes, especially not to commercially operated domestic routes.

1.3 Thesis Structure

Figure 1-1 on the next page shows the outline of this thesis.

The thesis is divided in two parts. Part I introduces the case of air passenger transportation in Norway and establishes the necessary theoretical foundation for the later analyses. Besides a brief discussion of the elasticity concept in general, a literature study on air passenger transportation demand and its price elasticity is provided. Then, the methodology of this thesis is presented with an intense elaboration on different aspects of time series analysis. Based on the findings of the previous chapters, Part I closes with a summary and the formulation of expectations regarding the outcomes of the analyses.

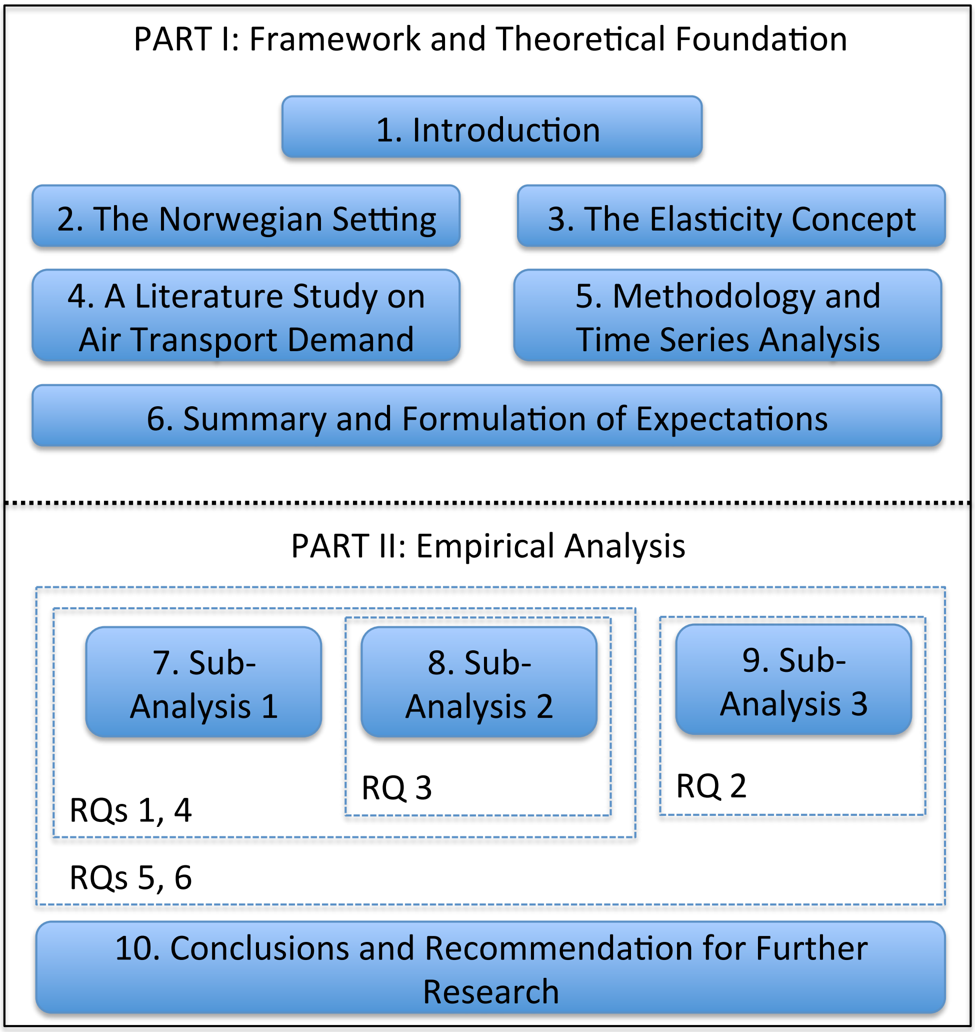
[2] Please see Appendix 22 for updating comments.

The second part of this thesis is concerned with the empirical analysis of own-price elasticities of demand within the three distinct sub-analyses:

1: Domestic Aggregated Demand - Annual Data 1981-2013,
2: National Aggregated Demand - Quarterly Data 2006-2014,
3: Route Demand - Bimonthly Data 2004-2014.

From Figure 1-1, one can see how the individual sub-analyses address the different research questions. Part II closes with a final discussion of the findings and gives some recommendation for further research work.

Figure 1-1: Outline of the Thesis and Relationship between RQs and Sub-Analyses



Source: Own Work

2.0 Air Passenger Transportation - the Norwegian Setting

This chapter aims to provide a comprehensive overview of air passenger transportation in Norway and by doing this, to establish the necessary case-related framework for the later analysis part of this thesis. The focus is put on the elaboration of several supply- and demand-side characteristics.

First, the supply side key players are briefly introduced. Then, the market structure for air passenger transportation is discussed. Second and turning towards the demand side, some important geo-economic determinants of air travel are addressed, before the general development of air travel demand in Norway is analysed. It follows a minor section that sets air travel in relation to it's substituting modes of passenger transportation and finally, the development of airfares separated for purely domestic flights and for international services are analysed. The chapter closes with a brief summary of the key findings.

2.1 Key Players

Avinor AS (Avinor) is the 100% state-owned company under the Norwegian Ministry of Transport and Communications, which is responsible for operating 46 of Norway`s airports, providing air navigation services and running the necessary infrastructure. In total, Avinor's airports accounted for approximately 92% of all terminal passengers on scheduled traffic in 2013 (Avinor 2014), which makes the company to the dominant infrastructure provider in Norway. By far the most important single airport in the portfolio is Oslo Gardermoen. The company is self-financed, generating its income by charging rent for space to non-airside businesses and by collecting fees from airline passengers (Avinor 2015a), what will ultimately also impact the price for air travel.

Scandinavian Airlines (SAS) was formed in 1946 when the flag carriers of Norway and Denmark formed a partnership with the Swedish airline Svensk Interkontinental Lufttrafik AB to coordinate their intercontinental operations. The airlines officially merged in 1951 to form the SAS consortium. In the following years, SAS became the dominant airline in the Scandinavian market. In 1999, the majority ownership of Widerøe was obtained, just three years prior to a second important competitor in the Norwegian domestic market, Braathens, was acquired in 2002. These acquisitions in the domestic market temporarily turned SAS into a monopolist. In the beginning of the last decade, SAS has started to come under severe financial pressure. In fact, the future existence of SAS in its current form is seen to be uncertain (Bråthen, Halpern, and Williams 2012). One consequence of the necessary restructuring process was that SAS sold its ownership in Widerøe in 2013 (SAS

2015b), losing direct control over a major share of the Norwegian domestic market. There are, however, still intense ties to Widerøe. In 2013, SAS served 125 destinations (16 in Norway) and was operating 138 airplanes with 43 additional orders placed (SAS 2015a). The same year, SAS produced almost 50 billion available seat kilometres (ASK) and achieved an average load factor of 75.3%[3](SAS 2015c). The airline has a substantially higher share of business travellers than its competitor Norwegian Air Shuttle. Furthermore, SAS transports an over-proportional share of foreign travellers, whereas Norwegian citizens seem to travel more with Norwegian Air Shuttle (Underthun and Bergene 2014).

Norwegian Air Shuttle ASA (NAS) was founded in 1993. After the initial years of serving some regional routes along the west coast of Norway, NAS entered the domestic market in 2002. In 2005, NAS achieved the first year in profit operating with a 'quasi' low-cost business model. NAS does not follow the pure form of a low-cost business model, since they for example do not primarily serve secondary airports. NAS has become the major competitor for SAS in the Scandinavian market, expanding its route network aggressively. In 2013, NAS served 125 destinations (18 in Norway) and operated 85 aircraft, with more than 200 additional orders placed. The same year, the airline produced 34 billion ASK and achieved an average load factor of 78.3% (Norwegian 2014).

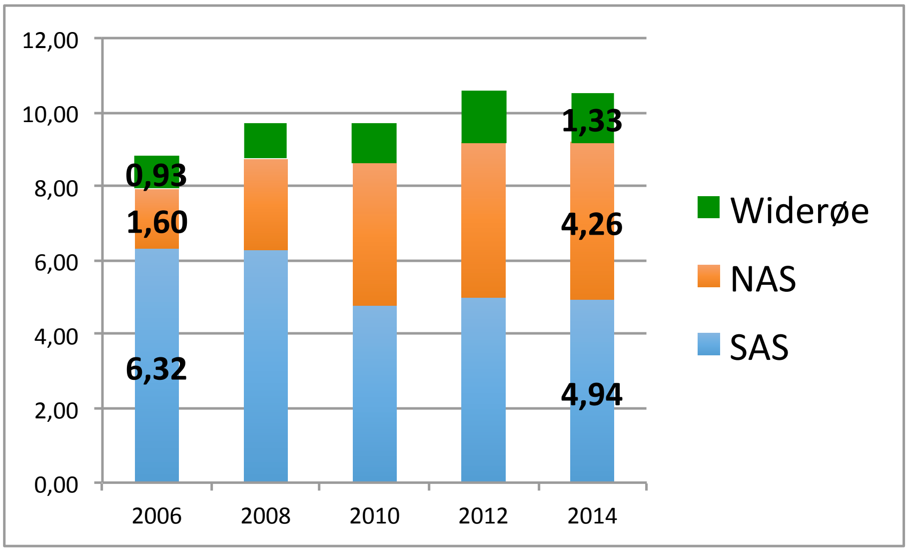
Widerøes Flyveselskap AS (Widerøe) was founded in 1934 and initially focused on general aviation activities. After World War II, Widerøe's activities started to increase by providing for several sea-plane services. Starting from 1968, Widerøe shifted focus to the emerging Norwegian short-field network and has ever since been the dominant actor in this sector (Widerøe 2015a). Widerøe has adapted to the special requirements of serving this network by exclusively operating aircraft with short take-off and landing (STOL) capabilities. Between 1999 and 2013, Widerøe was the major feeder airline for SAS. In 2013, Widerøe served 44 domestic and four international destinations, with 56% of its operations on commercial routes and 44% on subsidized routes, the so-called *anbudsruter* or *PSO-routes*. In compliance with European regulations, member states of the European Union can impose Public-Service-Obligation (PSO) on specific routes, if this is vital for economic development. Such a PSO usually comes along with the facts that the operating airline is protected from competition on the respective route and that the state compensates losses arising from the operation of the route[4]. One characteristic of PSO-routes in Norway

[3] Numbers include SAS`s affiliate Blue1.
[4] For general details on PSO see Williams and Bråthen (2010) and EU (2008); for an practical application of PSO regulations in Norwegian air passenger transportation see Samferdselsdepartment (2011).

is that they usually connect remote cities with national or regional hub-airports and that the "remote ends" of the PSO-routes only dispose over STOL-runways. Being one of only a few suitable airlines to serve STOL-airports in Europe, Widerøe benefits from this situation, as analysed by Bubalo (2012), who discusses costs and profits related to PSO-routes in Northern Norway.

In 2013, Widerøe was able to produce 1.24 billion ASK (CapStat 2015). Figure 2-1 gives an overview of the amount of ASK produced by each of the three above mentioned airlines in the domestic market in the recent past. The figure enables the estimation of the scale between Widerøe and the two other airlines. It becomes clear that Widerøe is capacity-wise the smallest of the three airlines in the domestic market. Furthermore, the illustration gives the first indication of the development of the market structure, which will be discussed in detail in the next section.

Figure 2-1: Domestic Sub-Segment - ASKs Provided by Airlines



Source: CapStat (2015); (ASK in billion)

Several other airlines offer domestic services in Norway. However, their significance in the domestic network has been negligible so far. This is because of the relatively strong barriers to market entry created by the combination of a successful player in the low-cost market (NAS), a strong network carrier (SAS) and a very experienced STOL airline on the PSO network. On the other hand side, 39 different airlines connected Norway with international destinations in 2013, with KLM, Lufthansa and British Airways being the most important ones serving out of Avinor-owned airports (Denstadli, Thune-Larsen, and Dybedal 2014) and Ryanair serving from the non-Avinor airports of Moss and Sandefjord.

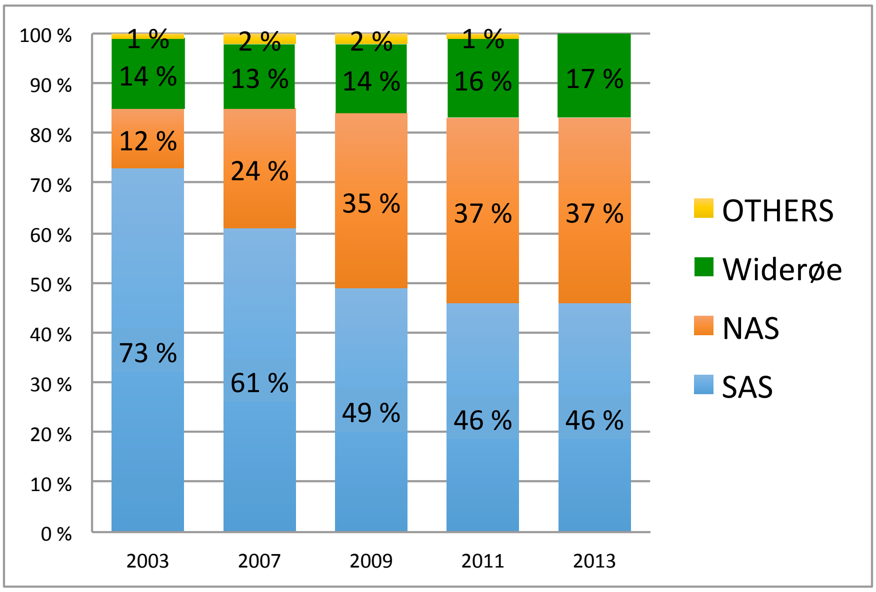
2.2 Market Structure

A discussion of the market structure of the Norwegian air transport market calls for a differentiation into the domestic and international sub-segments. This seems appropriate as the market shares of the key players differ significantly between the sub-segments.

The number of airlines operating in the *domestic sub-segment* at the same time has been low, ever since. In the 1990's, the market was dominated by only two airlines, Braathens and SAS. In 2001, SAS became a monopolist temporarily (Lian et al. 2002). After that, the domestic market has almost exclusively been served by the three airlines SAS, NAS and Widerøe. The competition for market shares has mainly been a race between the 'newcomer' NAS and the 'incumbents' SAS/Widerøe.

The structure of the domestic market and development of the market shares (in terms of pax transported) in the recent past is illustrated in Figure 2-2. What attracts attention is the constant growth of market share for NAS. This growth has been almost exclusively at the expense of SAS. The extent of this shift in market structure becomes even more obvious if one is aware of the fact that the domestic market grew from 10.9 million passenger (pax) to 14.9 million pax between 2003 and 2013.

Figure 2-2: Airline Market Shares - Domestic Market

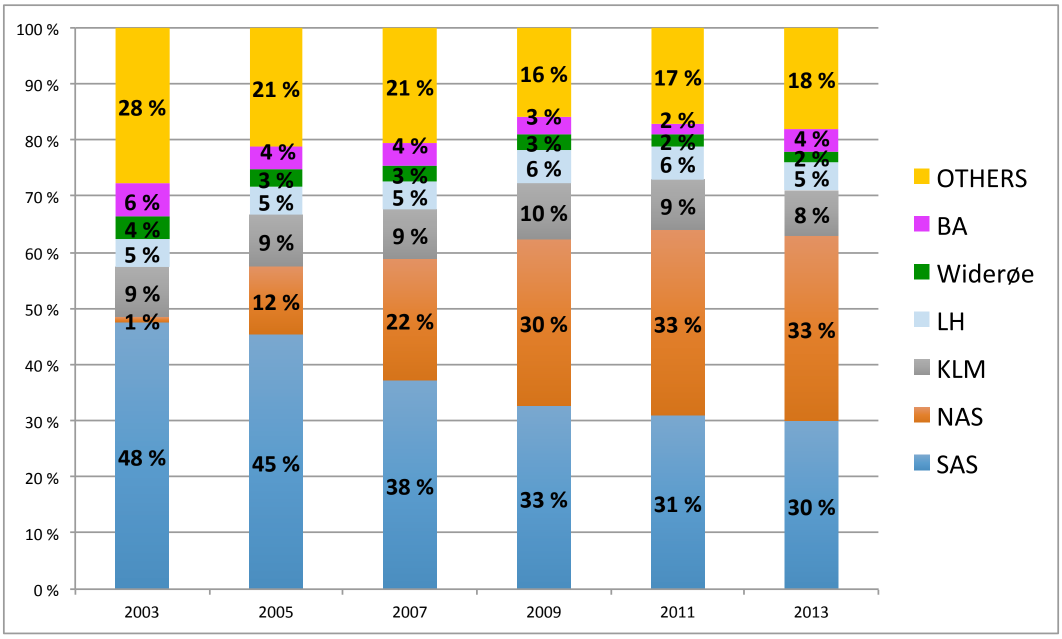


Source: Denstadli, Thune-Larsen, and Dybedal (2014)

In fact, SAS transported fewer pax (6.8 million) in 2013 than it did in 2003 (7.5 million) (Denstadli, Thune-Larsen, and Dybedal 2014). Widerøe, on the other hand, has been able to retain its market share stability with some growth in recent years. The stability of its market share seems to be linked to several market entry barriers to STOL and PSO operations. NAS and SAS cannot compete with Widerøe on large sections of its route network because of insufficient equipment. Other airlines with STOL aircraft have tried to gain significant market share, but so far without success. Therefore, Widerøe can be considered as a monopolist on large portions of its network

On the other hand, the *international sub-segment* has been subject to competition among Norwegian airlines and international competitors for a long time. Until 2003, SAS dominated the market with almost 50% of the market share. Figure 2–3 depicts the market for scheduled international services and the development of market shares at Avinor-airports for the years after 2003 (traffic to and from Moss and Sandefjord is not included).

Figure 2-3: Airline Market Shares - International Services



Source: Denstadli, Thune-Larsen, and Dybedal (2014)

Between 2003 and 2013, the market grew by an average of 9.5% annually. The massive growth of NAS at the expense of SAS is again striking. Contrary to the domestic market, NAS has managed to overtake SAS. The cumulated market share of the three most important foreign airlines has been stable with around 17% over the last few years. Widerøe is only a marginal actor in this market and has slightly lost market share. International competitors have also been losing market share since 2003, dropping from a cumulated 48% to 35%.

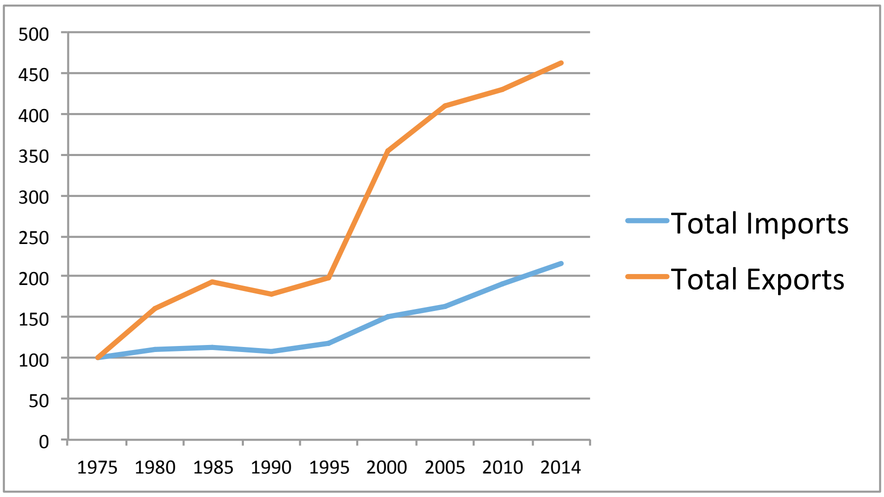
2.3 Geo-Economic Factors

The *population* of Norway exceeded five million inhabitants for the first time in 2013. This means that in comparison to the year 1975 with about four million residents, there was a population increase of 25% by 2013. A major contributor to the growth since 1990 has been the net migration of 40,000–50,000 per year. Overall, Statistics Norway (SSB) predicts a smooth decline in annual population growth rate for the years to come. The researchers expect to see a population of about six million in Norway in 2031 and seven million in 2065 (SSB 2015d). The growth of population has come along with a parallel significant increase in income.

The available *income* of Norwegian households has been increasing constantly since the end of the last century. Measured in average after tax income per Norwegian household, the income increased by 63% between 1990 and 2013 (in 1990's prices) (SSB 2015c).

In addition, the *Norwegian economy* in general has witnessed a substantial growth in the last decade. Norwegian companies have become increasingly engaged in inter-regional and international markets. Business activities, especially of large-scale companies, stretch far beyond local and regional markets. Figure 2-4 indicates that process, by showing the development of Norwegian imports and exports starting in 1975. One can see that the imports had more than doubled until 2014 and that the exports had increased by more than 450% (in 1975' prices). This is a clear indication that international trade has become more

Figure 2-4: Growth of Norwegian International Trade 1975 – 2014



Source: SSB (2015b); (year 1975 = 100%)

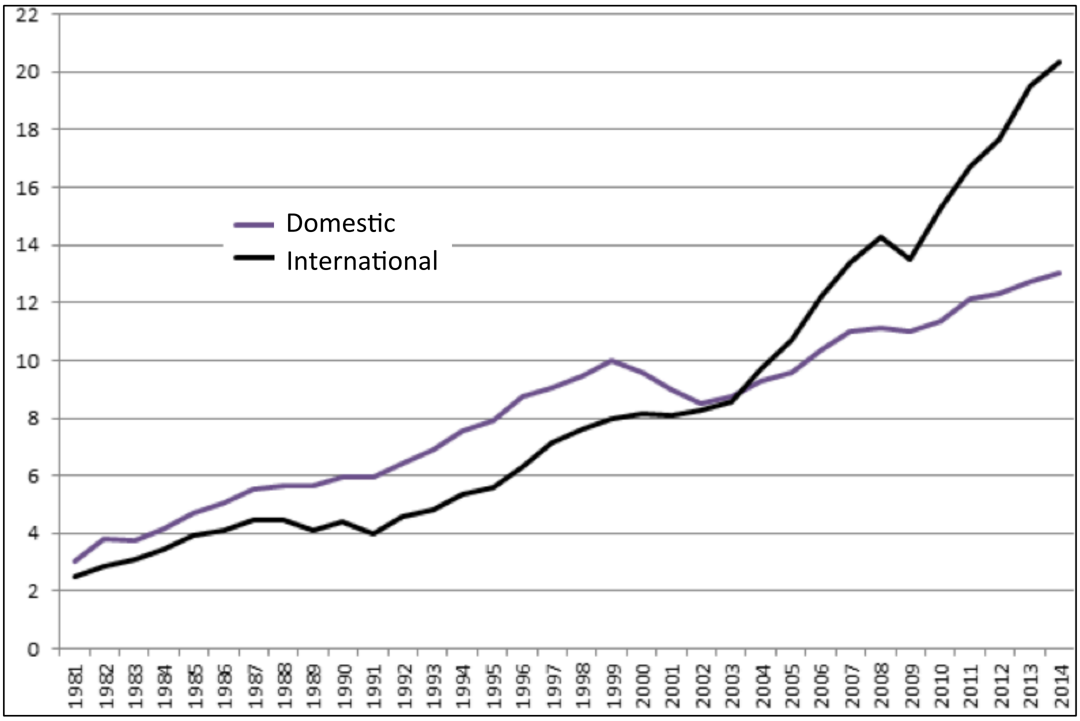
for the Norwegian economy. As a consequence of the economy's increasing engagement on inter-regional and international market places, the demand for communication with business partners across regional and international boundaries has enlarged. An increase in business related travel is one logical result.

Both, the development in population, the increase in income and the orientation of the Norwegian economy towards distant markets have manifested in an increased demand for passenger transportation. This accounts for domestic as well as for international travel.

2.4 Development of Demand for Air Passenger Transportation

In total, Avinor had reported more than 50 million terminal passengers at its airports in 2014. Broken down into single trips, this means that approximately 21.4 million international air trips and 12.5 million distinct domestic air trips were counted. The growth of demand for air passenger transportation in Norway is illustrated in Figure 2-5, with passengers (in millions) travelling by air represented on the y-axis and the time period from 1981 to 2014 on the x-axis. The graph lines are separate for the domestic and international sub-segments, and it can be seen that more passengers have been traveling on international services than on domestic services since 2003. Denstadli, Thune-Larsen, and Dybedal (2014) have calculated that the demand for international services have increased

Figure 2-5: Demand for Air Travel in Norway - Domestic/International Services

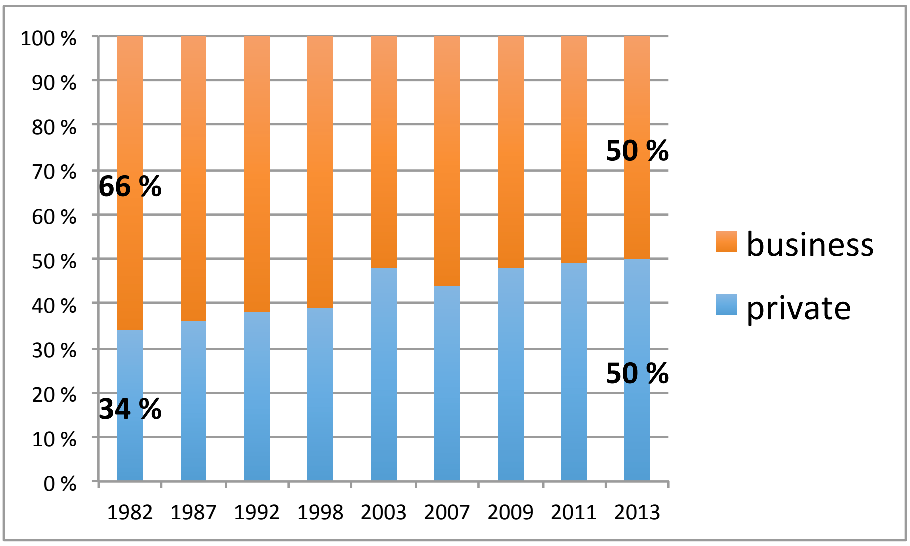


Source: Avinor (2015b); (in million pax, without transfer pax)

on average by 6% per year in the last 30 years, whereas the demand for domestic air passenger transportation has increased by ‘only’ 4.1% annually. The authors conclude that the domestic market has grown linearly, but the market for international services follows an exponential growth path. The domestic market seems closer to a maturity stage than the market for international services.

In 2014, more than 12.5 million trips were recorded for the *domestic sub-segment*. Figure 2-5 shows that the demand for domestic air travel has increased in a continuous manner for most of the past years. However, there was a distinctive decline in demand after 1999, followed by a recovery after 2003. Denstadli, Thune-Larsen, and Dybedal (2014) link this decline in demand for domestic air travel to a reduction in capacity provided and the emerging monopoly power of SAS after it had purchased its competitor Braathens in 2002. The authors claim that the available capacity was reduced during this period of time and airfares were increased. On the other hand, the trend reversal from 2003 can be directly linked to the emergence of NAS in the domestic market and the reduction in prices as a consequence of increasing competition. In the context of this thesis, it is also important to make a distinction between work related and private travel demand. For the domestic sub-segment, the development of the market share for the two travel purposes can be seen in Figure 2-6. The proportions of business-related and private travel have been quite stable since 2003 in the domestic segment, with a slightly higher share for business-related travel.

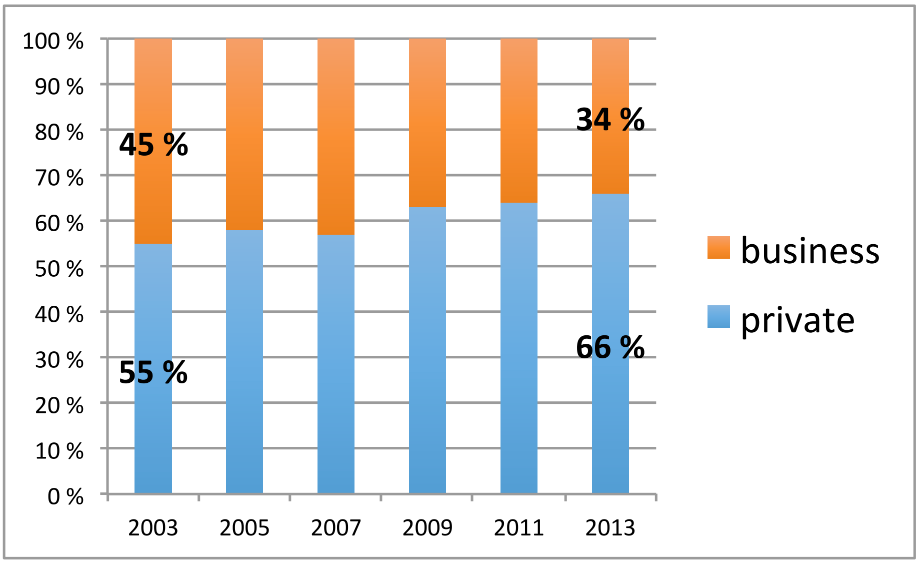
Figure 2-6: Domestic Sub-Segment - Distribution for Travel Purposes



Source: Denstadli, Thune-Larsen, and Dybedal (2014)

In 2014, more than 21 million trips were recorded for the *international sub-segment*. This includes both scheduled and chartered flights. Charter operations accounted for approximately 11% of all international trips by air in 2013. The market share of charter operations has continuously fallen since the 1980's. Approximately 86% of all international services connect Norway with a European destination. The exponential growth of demand for the international sub-segment is strongly linked to an increase in scheduled operations, as well as to the growth of the private travel segment. Figure 2-7 indicates the distribution of business-related and private travel at Avinor airports and how

Figure 2-7: International Sub-Segment - Distribution for Travel Purpose



Source: Denstadli, Thune-Larsen, and Dybedal (2014)

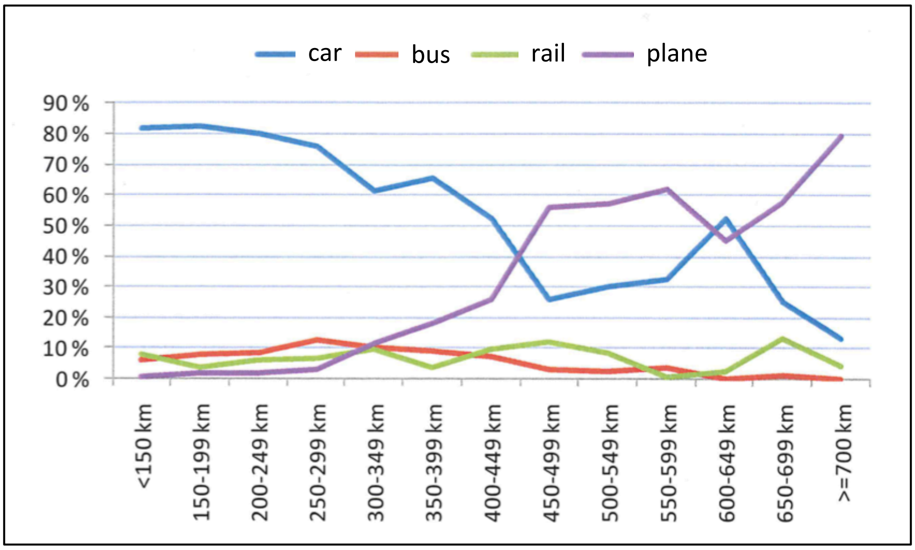
this distribution changed between 2003 and 2013. During this period, business-related international air travel increased from 3.3 million in 2003 to 5.4 million trips in 2013, but private air travel increased from 4.3 to 10.5 million trips. Keeping in mind the strong growth of NAS and its over-proportional share of leisure passengers, one can link this development directly to the airline's operations

2.5 Substitutes to Air Travel in Norway

Button (2010) raises the point that the importance of individual substitutes for air travel will differ in respect to distance and the specific topographical conditions of the analysed market, which will ultimately influence the travel time. One considers usually passenger rail and passenger road transport as the most suitable transport substitutes to air travel.

Denstadli and Rideng (2012) show empirically how the market share of air travel in Norway increases significantly once the travel distance becomes more than 300 km. The authors claim that on distances longer than 700 km, air transportation is the preferable mode of transportation for 80% of all travellers in Norway. Figure 2-7 indicates how the market share of different travel modes change with increasing distance. One can see that

Figure 2-8: Domestic Passenger Transportation Norway - Market Share Modes



Source: Adopted from Denstadli and Rideng (2012)

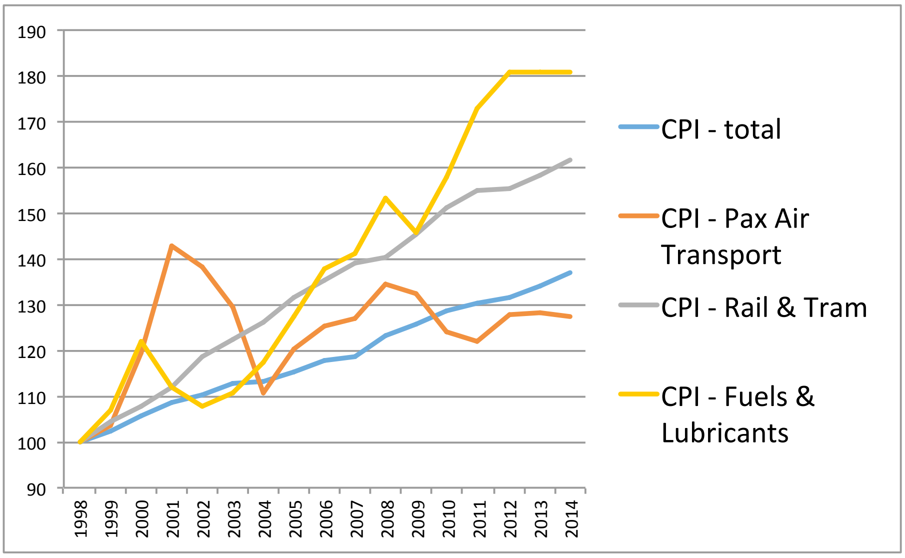
on shorter distances, the car is the preferred mode of transportation. Bus and rail seem to be less important in the Norwegian setting. Several authors have included rail as suitable substitutes to air travel in their analysis. The graph in figure 2-8 for instance is based on the 2009' Norwegian Travel Survey (NTS) and suggests that rail is not a suitable substitute for long-distance travel at an aggregated market level. Voldmo, Nordang, and Hamre (2007), provide a cross-price elasticity for rail of only +.05, which also indicates a rather weak correlation at the national level. However, one has to bear in mind that the low market share for rail is partly linked to the fact that the intercity rail network in Norway is very thin. For some particular city-pairs, for example OSL-TRD, the market share of rail might be significantly higher, which could lead to higher cross-price elasticities.

2.6 Airfares

Following the overview of the developments on the supply and demand sides, this section will now present how prices for air travel in Norway have emerged over time. This is done in the context of the two market sub-segments, domestic and international services, as well as differentiated according to travel purposes. When I discuss airfares in the remainder of this thesis, the consumer's final price approach is followed, meaning that unless otherwise specified, an airfare is understood as the total monetary amount a consumer has to pay in order to purchase an air ticket (i.e. including taxes, fees etc.)

Figure 2-9 shows how the total consumer price index (CPI) and three transport-related sub-CPIs have developed since 1998. For the four indexes, the reference year is 1998 and equals 100%. The sub-index 'Pax Air Transportation' represents the development in average airfares that consumers had to pay and is derived from airfare variations on particular domestic and international routes identified by Statistics Norway (SSB). Until 1998, all four indexes had run in a common trend channel, fluctuating slightly.

Figure 2-9: CPI 'Pax Air Transport' and Comparison



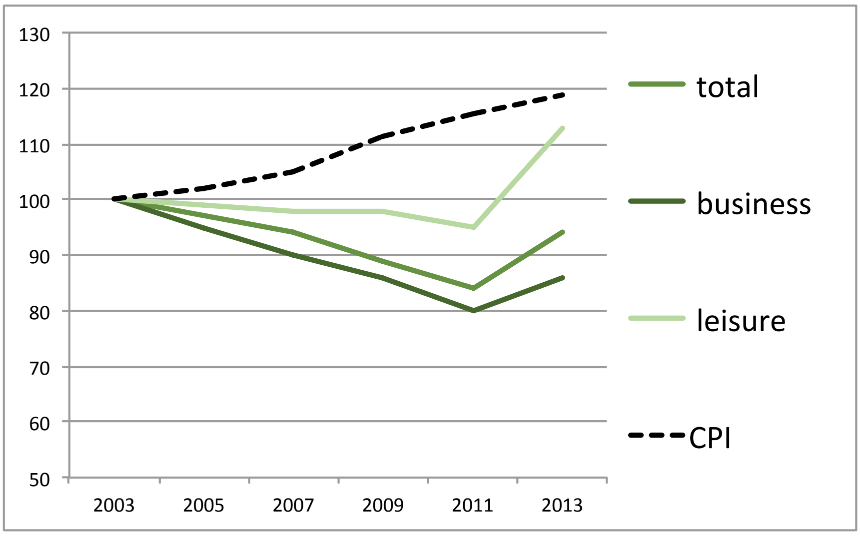
Source: SSB (2015f)

It is for the year 1999, that the sub-index for passenger air transportation indicates a significant increase of airfares relative to the 'CPI–total'. In the years 2001 and 2002, the prices 'peaked' in relative terms. This means that the prices for air passenger transportation decoupled 'upwards' from the overall price development in Norway between 1999 and 2002. Beginning in 2002, the airfares dropped again, coming back to the total CPI in 2004. Until 2008, airfares increased again with a higher rate than the basket representing the total CPI[5]. In the following period from 2008 until today, the prices for air travel on an average decreased both nominally and relatively to the total CPI. Figure 2-9 also depicts the price development of two substitutes for air travel: ‘Train & Tram’ as proxy for rail transport and ‘Fuels & Lubricants’ as proxy for use of private cars. These sub-indexes are included in the figure to contrast the price development of air travel compared to the passenger transportation sector. It can be seen that both substitutes have seen, on average, stronger price increases between 1998 and 2014. This means that in terms of price alone, air travel should have become more attractive for travellers compared to the substitutes.

Examining the price development for air transportation differentiated for the ‘domestic’ and ‘international services’ sub-segments as well as for travel purpose leads to some interesting additional insights. The underlying data is gained from several additions to the National Travel Survey, which significantly differs in the methodology applied compared to the one used by SSB.

Starting with the *domestic market*, Figure 2-10 shows the development of airfares for the total domestic market and its traveller segments between 2003 and 2013, and compares it with the development of the Norwegian CPI.

Figure 2-10: Development of Airfares - Domestic Sub-Segment



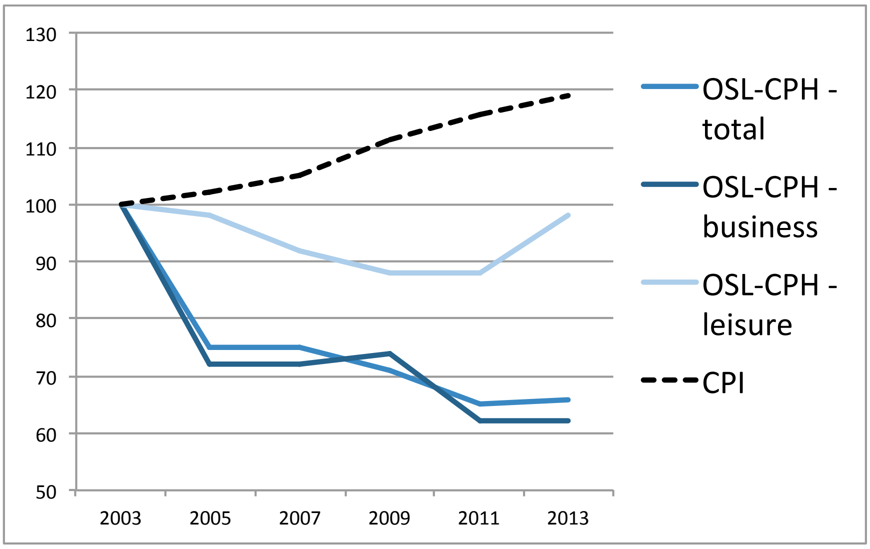
Source: Denstadli, Thune-Larsen, and Dybedal (2014); (data 2005 interpolated)

[5] The price development for this period (2004–2008) presented by SSB is contradicted by the findings of Denstadli, Thune-Larsen, and Dybedal (2014), who source their data from an interview-based National Travel Survey (NTS). They see for this period a price development of airfares below the general price trend at an aggregated level.

What attracts attention is that all three airfare indexes developed behind the general price increase. This means that domestic air travel relative to the CPI-basket became cheaper. Between 2011 and 2013, however, the price development for domestic air travel converged towards the CPI again. One could guess the reason for this trend-recovery is that the competition between SAS and NAS in the domestic market might have lost its intensity in the last years - an assumption which is shared by Thune-Larsen (2015). Anyway, by the end of 2013, the price level of the total domestic market was still 5% below the 2003 value in nominal terms. A second interesting feature is the spread in the development of airfares among the traveller segments. The prices for business travellers declined significantly more than the prices for leisure travellers. In 2013, prices for leisure travellers almost reached the level of the CPI, indicating that leisure air travel in real prices was almost as expensive as it was in 2003. On the other hand, business travel by air was still significantly cheaper than it was in 2003. On the route level, the development has varied widely. The prices for leisure travel on the route Oslo-Trondheim for instance had an index value of 132, well above the CPI in 2013. On the other hand, the prices for Oslo-Kristiansand reached an index value of only 90.

Figure 2-11 on the next page indicates the situation for the *international sub-segment*. Owing to a lack of aggregated data, the international route with the most passengers in 2013, Oslo–Copenhagen (OSL-CPH), is used to exemplify the situation. The development for OSL-CPH follows a general price trend, which is shared by the majority of international services between Norway and Europe. What is special compared to the

Figure 2-11: Development of Airfares - International Sub-Segment; OSL-CPH



Source: Denstadli and Rideng (2010); Denstadli, Thune-Larsen, and Dybedal (2014)

domestic setting is the level of prices in 2013 relative to the year 2003. While the total domestic market in 2013 reached 95% of the 2003 nominal prices, the prices for OSL-CPH reached less than 70% of the 2003 level in nominal prices. Thus, compared to 2003, international air travel has become relatively cheaper compared to domestic air travel. Furthermore, business fares have significantly remained 'underdeveloped' compared to leisure fares. This can be best seen if one expresses the leisure airfare for a specific route as the percentage of a business fare for the same route.

On the nine major international routes, a leisure traveller in 2003 had to pay on an average between 38% and 58% of the business fare. Ten years later, a leisure traveller had to pay on an average between 56% and 81% of the business airfare (Denstadli, Thune-Larsen, and Dybedal 2014).

I have now addressed the general setting of air passenger transportation in Norway.

I started to present the supply side actors and the respective market structure. It became clear that the markets for domestic services and international services differ in respect to competition issues. Furthermore, the shifts in market share caused by NAS's market entry in the last decade were indicated. As a second step, I turned towards the discussion of three geo-economic determinants of demand for air travel. I showed that population, personal income and the economic activity level have seen substantial growth rates in the past. Next, I presented the two different growth paths of the domestic and international markets, indicating that international travel has become the major driving force behind the demand growth. In addition, I was able to display how the leisure segment gained market share (i.e. in terms of demand) compared to the business segment. Then, I discussed the relative strength of air travel compared to other long-distance passenger transportation modes in Norway. Considering the topography of Norway, it seems reasonable that road transportation is the major competitor. The importance of rail transport might be significant for individual cases, but not for the national aggregated level. Finally, I turned towards the development of airfares in Norway. I identified two earlier periods with 'relative increase' in airfares and a later period, when airfares remained behind the CPI's development. Furthermore, I specified that in both the domestic and international sub-segments, airfares for business travel developed relatively below leisure fares.

3.0 The Concept of Elasticity

This chapter serves as a starting point for the establishment of the theoretical foundation for the analysis part of this thesis. The focus here is put on the discussion of the elasticity concept in general and some special applications of it that are important for this thesis.

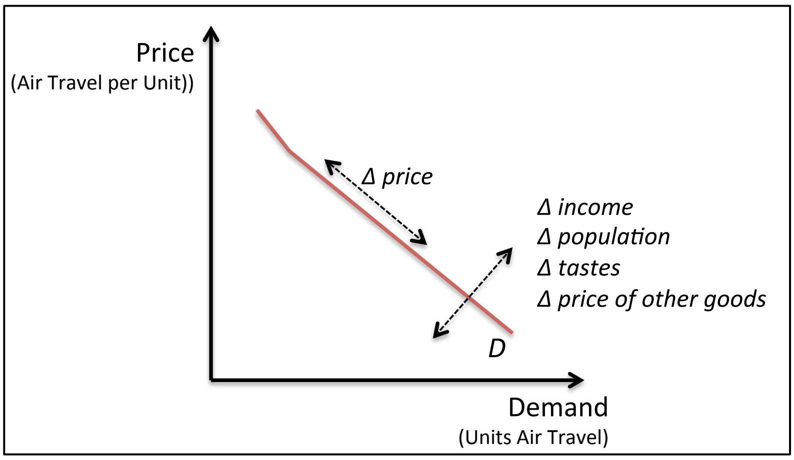
At first, in accordance with consumer demand theory, the distinction between a change in quantity demanded and the change in demand is briefly discussed. The relevance of this distinction for this thesis is shown. Then, the elasticity concept is introduced and different types of elasticities are presented. Next, two different measures of elasticity are briefly sketched on, before some essential points on the determinants of own-price elasticity of demand are made. This chapter closes with summing up of the key elements.

3.1 Point of Departure: Theory of Consumer Demand

The theory of consumer demand, as one of the major elements of microeconomics, is an integral part of basic economic science. The theory explains how a rational consumer makes choices among alternative commodities available (Clarkson 1962). Several texts, e.g. Riis and Moen (2010) or Pindyck and Rubinfeld (2013), discuss in detail how consumer preference, budget constraint and consumer choice determine the individual's demand curve. Furthermore, consumer demand theory explains how a simple summation of all the individual's demand curves (i.e. demand for air travel of individuals $j_{1 \ldots n}$) form an aggregated *market demand curve* (e.g. overall market demand for domestic air travel). A market demand curve illustrates the relationship between a good's price (e.g. airfare) and the quantity demanded (e.g. trips by air per capita per year) by all market participants (Katz and Rosen 1994). Changes in the price-demand relationship because of movements of such a market demand curve represent a change in quantity demanded.

Among others, Hensher and Brewer (2001) emphasize the importance of differentiating the term *change in quantity demanded* from the term *change in demand*. This is because the first term is associated with price-related demand changes, but the latter term is linked to non-price-related sources for demand changes. The authors claim that '… a failure to allow for other sources of change can result in misleading inferences about the role of price'. Other sources of change could, for instance, be represented by a variation in income, population, prices of other goods and individual tastes. Figure 3–1 illustrates the two different situations, where the effect of a change in price on demand is measured along

Figure 3-1: Price- and Non-Price-Related Changes in Demand



Source: Adopted from Button (2010)

a demand curve, but a variation in non-price-related sources of change is across a shift of the demand curve. It is the *change in quantity demanded* that is relevant for this thesis in the first place, because a movement along the demand curve can be expressed in terms of own-price elasticity of demand.

Nevertheless, the particular effects of non-price related sources of change and related impacts on the own-price elasticity of demand are also important for the analysis in this thesis, and will also be addressed in one of the successive sections. At first, however, it seems appropriate to establish a sound foundation for the concept of elasticity.

3.2 Types of Elasticities

Having briefly outlined the underlying theory of demand, it is now essential to discuss in detail how a change in an explanatory variable (i.e. a variable which determines demand) influences the market demand for a good. A widely used method in economics to express the general responsiveness of one variable to a change in another variable is the elasticity concept. Elasticity consequently, measures the sensitivity of one variable X to a change in another variable Z. Elasticity can be written in the general form as:

$$\mathcal{E} = \frac{\%\,\Delta X}{\%\,\Delta Z}\,; \quad \text{where '}\%\Delta\text{' means } \textit{percentage change,}$$

which means that elasticity expresses how a dependent variable X changes as a result of a percentage change in an explanatory variable Z. The advantage of using the concept of elasticity to express inter-variable sensitivity is that elasticity is independent of the variables' unit of measurement. In practice, the most relevant elasticities with regard to the demand of a good are the own-price elasticity of demand, the cross-price elasticity of demand and the income elasticity of demand.

The *own-price elasticity of demand* is defined as the '… percentage change in quantity demanded of a good resulting from a percentage change in its price' (Pindyck and Rubinfeld 2013). This means that the own price elasticity is the measure of the sensitivity of consumers' demand to changes in price. Here, the cause (i.e. change in airfare) and the effect (i.e. demand for air travel) under consideration are related to the *same* good. In a basic form, it can be represented algebraically as:

$$\mathcal{E}_p = \frac{\%\,\Delta Q_X}{\%\,\Delta p_X};$$

where Q_X = quantity of X demanded,
p_X = price of good X.

This elasticity refers to a *change in quantity demanded* as explained in the previous chapter. Owing to downwards-sloping demand functions, the ratio of a percentage change in price and a percentage change in quantity demand is usually negative. Consequently, $\mathcal{E}_\mathrm{p}$ takes values of $\mathcal{E}_\mathrm{p} \leq 0.$[6] The magnitude of own-price elasticity of demand is closely related to the shape of the demand curve for a particular good. In the special case of the so-called iso-elastic demand curve, the slope of the demand curve follows a rectangular hyperbolic pattern (Katz and Rosen 1994). This means that $\mathcal{E}_\mathrm{p}$ remains constant over the entire shape of the demand curve.
For the remainder of the thesis, the own-price elasticity of demand would be referred to with the abbreviated terms *price elasticity* and *own-price elasticity.*

The *cross-price elasticity of demand* expresses '… the percentage change in quantity of X demanded that is induced by a percentage change in price of Y' (Katz and Rosen 1994). Here, the cause and the effect under consideration are related to *different* goods. In a basic form, it can be represented algebraically as:

$$\mathcal{E}_{Q_X p_Y} = \frac{\%\,\Delta Q_X}{\%\,\Delta p_Y};$$

where p_Y = price of good Y.

[6] Demand with an own-price elasticity of $-1 \leq \mathcal{E}_\mathrm{p} \leq 0$ is said to be price inelastic - demand with an own-price elasticity of $\mathcal{E}_\mathrm{p} \leq -1$ is said to be price elastic.

The cross-price elasticity can be seen as an indicator for the degree to which two goods are substitutes or complements[7]. In the case of substitutes, the cross-price elasticity of demand for X is positive. In the opposite case of complementary goods, an increase in the price of good Y would lead to a decrease in demand for good X.

Finally, the *income elasticity of demand* is defined as '…the percentage change in quantity demanded with respect to a percentage change in income' (Katz and Rosen 1994). An algebraic representation of this elasticity looks like:

$$\mathcal{E}_I = \frac{\%\,\Delta Q_X}{\%\,\Delta I}; \qquad \text{where } I = \text{Income.}$$

The income elasticity is positive in cases of normal goods, meaning that with increasing income, the demand for a good also increases. The income elasticity of demand is concerned with a change in demand, rather than with a change in quantity demanded. For several reasons, $\mathcal{E}_\text{I}$ is important for the further analysis in this essay anyway. Graham (2000), for example, discusses how income elasticities of demand alter in the face of market maturity and UK-DfT (2013) links that phenomenon to a change in price elasticities over time.

3.3 Measures of Elasticities

So far, all the concepts of elasticity presented above used the abstract term '%Δ = *percentage change of a variable*' to describe the before-after relationship of the variables. Calculating this term implies the practical issue of determining whether the 'before change' or 'after change' value should serve as the reference (i.e. should be used in the denominator). The resulting percentage changes and, consequently, the subsequent elasticities might differ significantly. Literature, as for example Fearnley and Bekken (2005), suggests different elasticity measures to account for this problem. The two most common elasticity measures applied to the concept of own-price elasticity of demand are briefly presented below.

When the changes in demand and price are only marginal, the above mentioned 'denominator issue' is negligible. In such a case, the so-called *point elasticity* (of demand) can be used to express the relationship. Point elasticity here is defined as ' … the price

[7] Two goods are defined as substitutes if '… an increase in the price of one leads to an increase in quantity demanded of the other'. On the contrary, two goods are called complements if '… an increase in price of one leads to an decrease in the quantity demanded of the other one'(Pindyck and Rubinfeld 2013).

elasticity at a particular point on the demand curve' (Pindyck and Rubinfeld 2013). It can be expressed as:

$$\mathcal{E}_p^{point} = \left(\frac{\frac{\Delta Q_X}{Q_X}}{\frac{\Delta p_X}{p_X}} \right) \qquad = \frac{\Delta Q_X}{\Delta p_X} \frac{p_X}{Q_X}$$

Where ΔQ_X describes the change of quantity demanded for X, and Δp_X represents the change in price for X. Q_X and p_X represent the quantity and price of X before *or* after the change respectively. Since the changes are only marginal, the before/after distinction is not vital. The resulting elasticity, however, only holds 'true' for the specific *point* of the demand function for which it was calculated. The overall shape of the demand function is not accounted for by the formula above.

The second widely applied elasticity measure, the so-called *arc elasticity*, can be used to overcome some limitations opposed to the point elasticity measure. This is particularly because the arc elasticity is not restricted in use to only marginal changes, and moreover it accounts for the shape of the demand function to a certain degree. The arc elasticity (of demand) is defined as '… price elasticity calculated over a range of prices' (Pindyck and Rubinfeld 2013). Algebraically, it can be expressed as:

$$\mathcal{E}_p^{arc} = \left(\frac{\frac{\Delta Q_X}{\bar{Q}_X}}{\frac{\Delta p_X}{\bar{p}_X}} \right) = \frac{\Delta Q_X}{\Delta p_X} \frac{\bar{p}_X}{\bar{Q}_X}$$

Here, $\bar{Q}_X$ and $\bar{p}_X$ represent the average quantity and the average price of X calculated from the demand and price before and after the change respectively. Consequently, the arc elasticity measure provides an average elasticity for that particular portion of the demand curve, which is covered by the interval of the price change.

Fearnley and Bekken (2005) draw a comparison of the advantages and disadvantages between the arc-elasticity and point-elasticity measures. In respect to the application of the measures to a 'usual demand function'[8], the authors claim that both measures provide approximately the same results if the changes in price do not become too large.

[8] Here the authors refer to an iso-elastic demand function in power form.

3.4 Determinants of Own Price Elasticity

The magnitude of a market's own price elasticity of demand is influenced by numerous determinants. The existence of these determinants and the underlying cause-and-effect relationships emerge from mechanisms that can be explained within the framework of consumer demand theory. A general outline of these determinants is found, for example, in Mankiw (2009) and Brons et al. (2002). The most important determinants of own price elasticity of demand and their resulting implications for the magnitude of price elasticities can be summarized as follows:

(1) *The demand for a good tends to be more elastic if the acquisition of the good can easily be postponed or totally abandoned.*
Individuals have to finance their consumption within their existing budgetary constraints. Literally, nobody disposes of unlimited resources. Assuming that consumers purchase goods within the setting of a constraint budgets, but at the same time strive to maximize their utility level, a price increase of a good will inevitably result in the need to reduce quantity-wise consumption. Such a reduction in consumption will result in an undesired decrease in individual satisfaction levels. Consumers may resort to postponing or cancelling an acquisition as possible behavioural adjustment strategies to tackle such a situation. Customers with the flexibility to postpone or totally abandon the acquisition of a good, find it easier to adjust their behaviour to price changes as compared to the consumers without this option.

(2) *A good's demand tends to be more elastic in the long run, than in the short run.*
On short notice, the consumers' flexibility to adjust their behaviour as a response to increases in price is rather limited. Often, a consumer faces the choice between totally resigning from consumption and accepting the price increase in the short run. As stated above, this is because either there is no flexibility to postpone the travel plans or there are no suitable substitutes at hand. As consumers get more time to adjust their behaviour, they are able to explore more options of modification (e.g. relocation, additional car ownership, trip rate reduction). Consequently, the total effect of a price change on demand can only be monitored in the long run. This implies that demand in the short run is usually less elastic than in the long run - a differentiation between

partial effects occurring in the short-run and the total effect in the long-run is consequentially meaningful.

(3) *A good's demand tends to become less price elastic as the market for the good reaches a maturity stage.*

Graham (2000) claims that income elasticities decline as a market reaches its maturity stage. In fact, the author defines a fully matured market as a market with an income elasticity of $\mathcal{E}_I < 1$. UK-DfT (2013) links this statement and assumes that market maturity will also lead to declining price elasticities of demand. A maturity stage is reached when people already travel very often and further growth is limited because of time constraints. Even though a price decrease will still present an incentive to travel more, the time available to do so becomes scarce. Furthermore, the rising importance of the time-constraint budget shifts the consumers' preference towards faster modes of transportation. Consequently, air passenger transportation becomes favourable because the trade-off between higher airfares and higher time costs related to alternative modes of transportation favours air travel.

(4) *A good's demand tends to be more elastic if the acquisition of the good requires a high share of a consumer`s total budget.*

As the price of a good increases, a consumer has to spend a higher share of his or her disposable income in order to hold the consumption of this good as constant. Consequently, there emerges the obligation to reduce the consumption of other goods. The context can be explained by the well-known *Slutsky Equation,* which can be transformed into an *elasticity form*[9]. In this form, the equation shows how the own price elasticity of demand can be disaggregated into a substitution elasticity-term and an expenditure proportion-term multiplied with the income term. Algebraically the equation looks like:

$$\mathcal{E}_{xp} = Subst_{xp} - \mathcal{E}_{xI} * s_p$$

where $\mathcal{E}_{xp}$= Price elasticity for X; (<0)

$Subst_{xp}$= Substitution elasticity; (<0)

$\mathcal{E}_{xI}$= Income elasticity for X; (>0)

s_p = Share of X in total expenditures

(Gravelle and Rees 1992).

[9] For derivation of the Slutsky Equation and transformation in elasticity form, see Gravelle and Rees (1992).

Having the own-price elasticity of demand disintegrated into this form allows highlighting the importance of the budget share used to purchase the good for the price elasticity of demand. If, for instance, the expenditure share s_p is very small (close to zero), the effect of the income elasticity proportion on the price elasticity also becomes very small. In other words, the smaller the share of a budget used to purchase a good, the less elastic will be the demand for the good (all other equal). On the contrary, if the share of total income spent to buy a good is very large, the income term of the equation will become large (in absolute terms), resulting in a sensitive demand.

(5) *The existence of suitable substitutes tends to make a good's demand more elastic.* The existence of substitutes allows consumers to fulfil their demand through different means. The consumers are not 'locked' in a particular buyer-seller relationship because there is the flexibility to turn towards other goods, which will satisfy the underlying demand in quite a similar way. The existence of substitutes, however, will only impact customers' behaviour and thereby the price elasticity of demand for air travels if those substitutes are considered to be 'suitable'. An existing railway between two cities might apparently look like a suitable substitute to air travel. But this is only true as long as the customers view the additional journey time in train travel as acceptable. Some travellers may consider travel time as less important. But others prefer to accept a price increase in air travel than switching to time-consuming alternatives. This implies that the existence of substitutes not only determines the magnitude of price elasticities, but that different customer segments (in regard to assessing substitutes as suitable) also influence the magnitude of price elasticities.

I have now addressed the concept of elasticity and presented the concept's most relevant elements that form the basis for the further analysis in this thesis. I started by introducing the concept as such and its establishment in consumer demand theory. I presented different types of elasticities and stated whether they are usually positive or negative. Furthermore, I made the reader familiar with two unequal measures of elasticity, before moving on to discuss how different factors influence the magnitude of the own-price elasticity of demand. I will come back to the findings of this later discussion, because they will be essential for the formulation of expectations in chapter 6.

4.0 Literature Study on Air Travel Demand and its Price Elasticity

This chapter aims to review the literature on relevant aspects of demand for air passenger transportation and the related elasticities. In doing this, the focus is put on gaining insights of how air travel demand can structurally be explained in the later analysis part of the thesis. Furthermore, studying how and with which results other researchers have analysed air travel demand in different setting will give valuable reference for this thesis.

The chapter starts with a brief discussion of how air travel demand has been operationalized in the literature and which key explanatory variables for demand have been used. Then, two sub-sections will treat some special characteristics of own-price elasticities in the context of air travel. After that, the literature will be reviewed on previous studies that specifically elaborated on own-price elasticities of demand in several air transport settings. The chapter closes with a brief summary of the key findings.

4.1 Operationalization of Air Travel Demand and it's Determinants

The demand for air passenger transport is a derived demand. It can be characterized as an intermediate service that contributes to the satisfaction of some other underlying needs. This makes the demand for air passenger transportation dependent on demand variations of *other activities*[10] and on the development of factors that are not related to the industry (Doganis 2002). Furthermore, the dependence on other activities induces some special characteristics, such as seasonal and cyclic demand fluctuations (Holloway 2008). The next lines strive to present how previous studies operationalized demand for air travel and which factors are usually used to explain changes in demand.

Referring to the literature, the demand for air passenger transportation is usually operationalized in two different manners: first, by the counted number of people boarding airplanes, and second, by the amount of so-called revenue passenger kilometres (RPK)[11] per time unit. Carson, Cenesizoglu, and Parker (2011) claim that both measures are good proxies for air travel demand. Ultimately, choosing one of the two variables to operationalize demand for air passenger transportation is not only a question of practicality or preference, but rather a manner of accessibility of data - as it is the case for demand explanatory variables.

[10] E.g. business activities/holiday trips

[11] RPK '… is obtained by multiplying the number of fare-paying passengers by flight distance' (Doganis 2002).

Reviewing the literature on demand determinants for air transport reveals that various explanatory variables are used to explain the demand for air passenger transport. In order to systemize these variables, their classification into *geo-economic* and *service-related variables* suggested by Jorge-Calderón (1997) is widely used. Geo-economic variables are characterized by the fact that they cannot be influenced by an airline and are determined by the economic activity and location characteristics. On the other hand, service-related variables can be affected by an airline and are determined by quality and price characteristics.

Sivrokaya and Tunc (2013) provide a summary of commonly used variables in the literature and state that *population size, GDP* and personal *income* are the most commonly used geo-economic variables.

Changes in population size have a direct impact on demand because a market demand curve is derived by the summation of all individual demand curves, and therefore each additional individual will contribute to an increase in demand..

The variables of GDP and income are somehow used interchangeably in the literature. Disposable income is often employed when demand for leisure travel is modelled, whereas GDP seems to be the preferred variable for modelling business-related travel (Holloway 2008). In an alternative to GDP, Chi and Baek (2012) use the NASDAQ-share index as a proxy for the economic activity when modelling business travel demand. The two variables of GDP and income are often employed in 'per-capita form' to reduce a possible correlation with the population variable.

Among others, Castelli, Pesenti, and Ukovich (2003) use *cost for other modes of transportation* as the measure to operationalize the impact of inter-modal competition on air transport demand. The authors assume that fuel prices are reasonable proxies. Kopsch (2012a) employs an index that reflects the development of average train ticket prices to cover cross-price effects between rail travel and air travel. Finally, Helgheim (2002) indicates that the relevant costs for other modes of transportation are not limited to monetary expenses alone. Rather, the changes in the total costs (including time costs) related to the alternative modes of transportation are relevant.

The most important service-related variables presented in the literature are *airfare* and *service frequency* (Sivrokaya and Tunc (2013). There is no doubt that airfare variations are important for air passenger transportation demand. Depending on the aggregation level of the analysis, airfares are usually expressed in either direct ticket prices or in more abstract manner as in aggregated index form. Some authors, e.g. Clewlow, Sussman, and

Balakrishnan (2014), use several forms of kerosene prices in the absence of suitable airfare data. Carson, Cenesizoglu, and Parker (2011) even include futures on kerosene as proxy for airfares. On the other, the service-frequency variable relates to the stimulating effect that an expansion of supply can have on demand. Both variables have to be treated with care, because of their likely endogenous character.

Beside geo-economic and service-related variables, a third category of demand influencing variables is also prominently reported in the literature. These variables usually take the form of a dummy variable. A dummy variable is used to represent a specific event in time that has an impact on the demand at least temporarily; as for example the `9/11` terror attacks.

In accordance with the above findings, the demand for air passenger transportation for a general setting can be expressed as:

$$D_X = f\left(Pop, GDP, Inc, P_x, P_{y\ldots z}, Freq, X_{1\ldots n}\right) \qquad [4.1]$$

where D_X is the demand for air travel, *Pop* represents population, *GDP* is the Gross Domestic Product, *Inc* symbolizes the disposable income of individuals, *Freq* donates service frequency and $X_{1\ldots n}$ represents a variety of other determinants. P_x denotes the price for air travel (airfare) and $P_{y\ldots z}$ are prices of the substitutes to air travel.

Carson, Cenesizoglu, and Parker (2011), however, stress that the concrete application of several variables has to be oriented in accordance with a study's individual level of analysis.

In terms of expectations for the further analysis, it can be concluded here that an increase in the variables *Pop, GDP, Inc, Freq* and $P_{y\ldots z}$ are expected to increase the demand for air travel. Consequently, the regression coefficients for these variables should have a positive prefix. In contrast, the coefficient for P_x should have a negative prefix. The expected prefix for the various dummy variables differs according to the nature of the represented event.

4.2 Characteristics of Own-Price Elasticity in Air Travel

The magnitudes of price elasticities in air passenger transportation follow the general pattern presented in section 3.4. For example, there is no doubt that demands for air travel is more elastic in the long-run than it is in the short-run. In a summation of the earlier findings, two important implications can be drawn that are somehow special in the context of air passenger transportation and are widely discussed in the academic literature. The implications are that price elasticities significantly differ among *travel purposes* and in respect to *travel distance and the related role of substitutes* (Litman (2013), Smyth and Pearce (2008). The following sub-sections are indented to elaborate on the details and reasons for these phenomena.

4.2.1 Travel Purpose

When analysing travel purposes as elasticity influencing factor, the literature suggests a distinction between *business-related air travels* on the one hand and *leisure-related air travels* on the other hand side. In general, it is found that business-related travel is less sensitive to price changes than leisure travel. The literature suggests several reasons for such a phenomenon. First, business-related travel is perceived as a necessary input factor for the production of other goods and services. Therefore, different flexibilities to avoid postponement or cancelation of travel between the two groups arise (InterVISTAS 2007). A leisure traveller can react to large price increases by totally abandoning travel plans, which is however not a realistic choice for a business traveller. According to Holloway (2008), '… some level of business travel is always non-discretionary if an enterprise is to prosper'.

Second, businesses evaluate trips as per the *total cost approach*. One major contributor to the total costs of travel is time costs. Although leisure travellers also consider journey time as an important selection criterion for the mode of travel, their valuation of time differs significantly with that of business travellers. In other words, time spent for business travel is assigned a higher monetary value than time spent for leisure travel. For example, Vegvesen (2014) calculates with 520 NOK/hour time cost for a business traveller using airplanes, but assigns only 210 NOK/hour for a leisure traveller. Following this assumption, Brons et al. (2002) claim that the airfare contributes less to the total travel costs for a business traveller than it does for a leisure traveller. Consequently, an airfare increase will have comparably less impact on the total travel costs of the business traveller. Hence, the business traveller is less sensitive to airfare changes than the leisure traveller.

Also related to different valuations of time is the fact that business travellers are less likely to turn towards other modes of transportations in the case of an airfare increase. This is intuitive because air travel is the fastest available mode of passenger transportation (in the assumption that there are certain minimum travel distances).

Finally, different funding sources contribute to diverting price elasticities (Holloway 2008). Leisure travellers have to cover their travel expenses out of their own budgets, whereas a business traveller is funded by his or her company. This implies that an airfare increase reduces the overall satisfaction level of travelling for a budget-constraint leisure traveller, because he or she has to either travel less, cut expenses for other goods or combine both alternatives. On the other hand, the business traveller does not experience impacts on his or her individual budget due to price increase, and hence has fewer incentives to adjust travelling behaviour. Furthermore, companies financing air travel are assumed to use a smaller proportion of their total budget for air travel as compared to private travellers. Therefore, an increase in airfares for business travellers has relatively less impact on a company's total budget than that on a private traveller's budget. Hence, companies will react less to airfare increases than private travellers.

4.2.2 Travel Distance and the Impact of Substitutes

In order to express different travel distances in air transportation, the terms *short-haul, medium-haul* or *long-haul flights* are usually used. UK-CAA (2007) indicates that a wide variety of definitions exists for these categories. For example, EUROCONTROL (2005) uses the airport-to-airport distance to define the categories[12].

Increasing travel distance should theoretically lead to two contradicting effects on price elasticities. First, airfares for long-distance flights are usually more expensive than the fares for short-distance flights. The acquisition of a long-distance ticket therefore requires a traveller to invest a comparably higher proportion of his or her individual available budget. Following the earlier argumentation about the impact of budget shares on price elasticities, the demand for long-haul flights should be more sensitive to price changes than demand for short-haul travel.

Empirical evidence, however, indicates that it is usually the other way round[13]. This is because there is a negative correlation between travel distance and availability of transportation substitutes. The larger the travel distance, the fewer are the number of transportation substitutes. The non-existence of transport substitutes is the major reason for lower elasticities in the long-haul market. So, travel distance in combination with the existence of alternative modes of transportation between two cities directly influences a customer's ability to avoid air travel in the event of an increase in airfares. Hence, the demand for long-distance travel is less sensitive to price changes than the demand for short-distance air travel.

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[12] Up to 1500 km = short-haul; more than 4000km = long-haul; in between = medium-haul (EUROCONTROL 2005)

[13] See Gillen, Morrison et al. (2003)

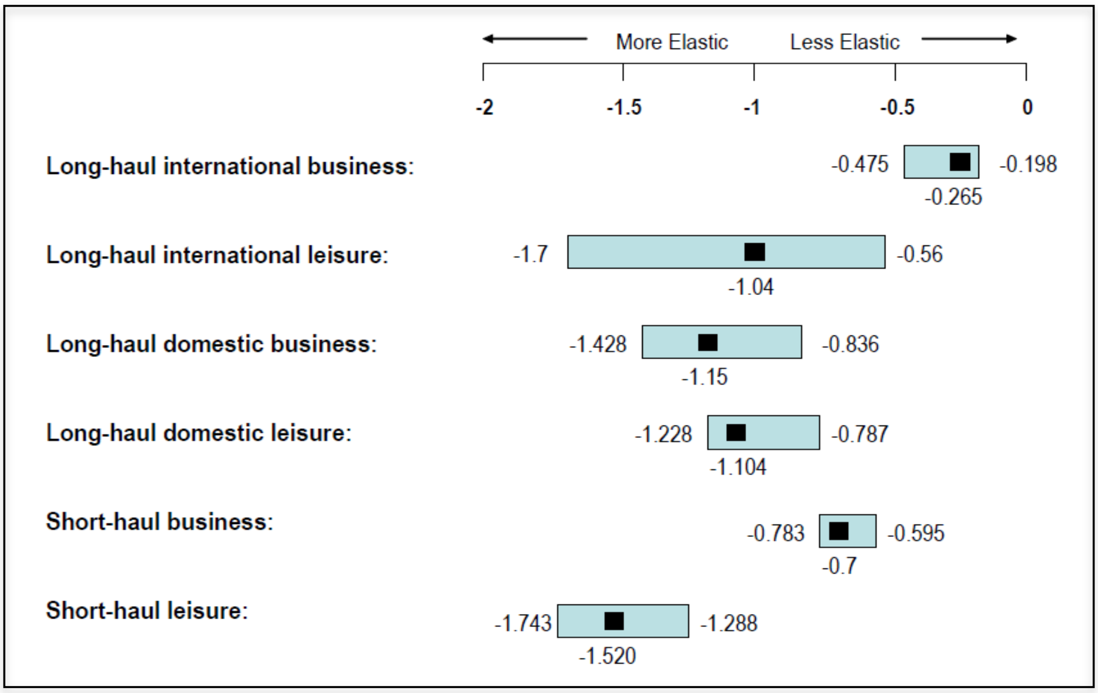
4.3 Reported Elasticities in Earlier Studies

The following paragraph strives to provide a comprehensive summary of price elasticities in air passenger transportation that can be found in the academic literature. The findings of this review will serve as a comparative reference for the analytical results of this thesis. First, some international studies are addressed, whereas the focus of the second part will be on the findings of research in the context of the demand in the Norwegian market.

Several international studies have investigated the demand for air passenger transportation, but in very different settings. They vary, for instance, in respect to the modelling methodology, the time period analysed and the particular geographic market studied. Consequently, a range of price elasticity estimates has been reported. On the other hand, review articles that can help to assess and compare different estimates are quite scarce and rather old.

One of the best known and still most cited review studies in the literature is Gillen, Morrison, and Stewart (2003). This paper reviews 21 different cross-sectional and time series studies covering the air transport markets in Canada and other developed countries. Figure 4-1 summarizes the findings, with elasticities ranging relatively wide from -0.198 to -1.743. The major contribution of this paper is that it identifies the different

Figure 4-1: Variations in Price Elasticity Estimates



Source: InterVISTAS (2007) reproduced from Gillen, Morrison and Stewart (2003)

pattern among the estimates, with respect to travel purpose and distance. By doing so, the authors are able to substantially narrow the range of elasticities. For the short-haul segment[14], the study concludes with an elastic demand of -1.52 (median) for leisure travellers and an inelastic demand of -0.7 for business travellers respectively.

Brons et al. (2002) conducts a meta-analysis of 37 earlier studies, including as many as 204 estimate observations. The elasticity estimates range again widely from +0.21 to -3.2. The overall mean price elasticity is reported to be -1.14. One of the main contributions of this meta-analysis is that the authors prove a significant difference between short-run and long-run elasticities, with more elastic demand in the long-run.

InterVISTAS (2007) performs a review of 22 previous papers and combined this assessment with some of its own econometric analysis. The analysis is run in the context of defined geographical aviation markets. The authors suggest a system to approximate the price elasticity of a market. Following the proposed scheme, the domestic market of a European country would have a price elasticity of approximately -1.23 on short-haul routes and -1.12 on long-haul routes. Furthermore, the study clearly indicates that demand becomes more price elastic as the level of aggregation of a study is reduced.

Table 4-1 on the next page reports the results of some individual, case-specific studies. I chose the individual studies for two reasons. First, they represent very recent contributions to the field and second, they combine this with an interesting methodological approach/application. The context of the respective international study is briefly sketched on in the second column, whereas column three reports the findings in terms of elasticities and column four points to some special findings or applications. The reported elasticities can be understood as long-run elasticities. The studies are ordered in respect to the geographical market. All studies used time series analysis to analyse the underlying data. For further detailed information about the methodology applied in the individual studies, the reader might be referred to the given sources. The models and methodologies applied in UK-DfT (2013) and Kopsch (2012a) will partly also be used in this analysis.

[14] Here defined as less than 2400 km one way.

Table 4-1: Previous Studies of Elasticities of Air Travel Demand

Source	Context	Elasticities	Finding/Special Feature
Bhadra and Kee (2008)	US domestic market, in respect to different demand volumes[15]	-1.3	- "Thinner" routes are found less price elastic than "thick" routes
Chi and Baek (2012)	US domestic market	-1.56	- Airfare is identified as endogenous; - Johansen co-integration methodology[16] used
Mumbower, Garrow, and Higgins (2014)	US domestic market on flight level	-0.58 OLS -1.32 2SLS	- Elasticity is found to be higher when endogenity[17] of airfare is accounted for
Njegovan (2006)	UK leisure market, in respect to airfare and non-airfare holiday expenditures	- 0.7	- Air travel demand might be insensitive to airfare changes alone, if other travel expenses are significant
UK-DfT (2013)	UK domestic and international market segments	-0.2 to -0.7	- Airfares were found to be insignificant determinants for the domestic market - Co-integration approach used
Kopsch (2012a)	Swedish domestic market	-1.0 to -1.2	- Business airfares less elastic than leisure airfares; - Unbalanced Regression technique employed

As the studies reported in table 4-1 indicate, demand for air travel generally goes down when airfares are increased. The uniformly valid statement that demand is either elastic or inelastic to price changes however, seems not possible based on the reported estimates. In fact, looking at the reported estimates makes clear that price elasticities vary significantly. The impression remains that the geographical market covered by, the aggregation level of and the distinct methodology applied in a study contributes significantly to the magnitude of the reported price elasticities. This seems relevant when it comes to benchmark and compare my own finding with those of earlier papers. One logical approach to minimize

[15] The authors differentiate super-thin (<10 pax/day), thin (10-50 pax/day), semi-thick (50-100 pax/day) and thick markets (>100 pax/day).

[16] For details, see Bjørnland and Thorsrud (2015), STATA (2013b)

[17] The authors here refer to a situation when the price not only determines the demand, but the demand also determines the price (bi-directional causal relationship).

the range of relevant estimates could therefore be to additionally focus on studies that have covered air travel demand in Norway.

Fridström and Thune-Larsen (1989) were among the first to investigate price elasticities in the Norwegian domestic market. Using an intercity gravity model, they forecast air transportation demand for the national network. The effects of alternative modes of transportation as well as changes in travel time over the years are included in their model. In the absence of detailed origin–destination data, the authors corrected for possible double counting of transfer passengers. The study employs data of 95 city-pairs covering the period from 1972–1983. Using OLS regression, the authors estimate price elasticity of '… -0.69 in the short and medium terms, and -1.63 in the very long-term' (Fridström and Thune-Larsen 1989). During the discussion of the results, the authors point out that price elasticity of individual city-pairs could deviate from the aggregated results. They especially address city-pairs that benefit from increasing oil-related business travel, and claim that the expected price elasticities will be lower because of the higher share of business travellers.

Helgheim (2002) studies two Norwegian domestic routes with a time series analysis based on data from 1985–2002. She analyses price elasticities in respect to business and leisure travellers for discount and full price tickets. The price elasticities are reported in the range between -0.57 for full price business travel tickets to -1.04 for discount leisure travel tickets.

TØI (2002) developed the Norwegian National Transport Model for long distance travel (NTM5). The model covers one-way trips with distances greater than 100 km. Following calculations of the demand for different modes of passenger transportation in Norway, the author finds the price elasticity for air travel to be -0.35 (total demand), -0.21 (business traveller) and -0.47 (leisure traveller).

Rekdal (2006) analyses the NTM5 to assess the model's results. Different network scenarios for the years 1998, 2001 and 2004 are simulated. The national price elasticity for air transportation is found to be -0.34. The study further identifies price elasticities for air travel between the country's nine largest airports. The estimated elasticities range between -0.41 and -0.76.

Voldmo, Nordang, and Hamre (2007) develop forecasts about future travel patterns and future demand for passenger transportation services. The calculations are based on the NTM5, one regional transport model and one model covering international travels to and from Norway. In this setting, the authors estimate the price elasticity for air travel on a national level to be -0.54.

In this chapter, I reviewed the literature on air passenger transport demand and it's price elasticity. After a brief look at the operationalization of air travel demand, I started with review on the main explanatory variables discussed in the literature. I indicated the need to pick "case-specific" variables for individual demand models, depending on the aggregation level of the analysis. I furthermore formulated expectations concerning the prefix of regression coefficients. Then, I indicated that price elasticities of air travel differ will in respect to travel purpose and travel distance.

In the second part of this chapter I reported the findings of previous studies on price elasticities in air passenger transportation. Starting with three international meta-studies, I was able to show that the earlier presented general determinants of price elasticity (chapter 3.4) have significant effects on the magnitude of price elasticities in air passenger transportation. Then, on the basis of several international studies, I displayed how different authors have derived heterogeneous elasticity estimates for miscellaneous scenarios. Finally, I addressed the body of literature concerned with the Norwegian market.

In terms of concrete elasticity values to be expected for this thesis, I think the findings of the UK and the Norwegian papers are most relevant. This means that for the aggregated national level, I expect to find long-run elasticities in a range between -0.2 and -0.54, with estimates for business travel gathering at the lower bound and leisure traveller having elasticities close to -0.54. For lower aggregation level analysis, I expect to find more elastic demands.

5.0 Methodology

Creswell (2012) defines research as '*... a process of steps used to collect and analyse information to increase our understanding of topic or issue'*. This broad and process-oriented definition can be interpreted in a twofold manner. First, one can understand this process as the general evolution of knowledge in a specific research field. Second, on a more individual level, one can relate this process to a singular scholar's research project. Both levels are connected in such a way that the individual researcher's work contributes to the overall progress in a field of research and that the scholar builds his or her project on the basis of findings of earlier research. One consequence of this is that the researcher has to become familiar with the state of affairs in his or her particular field of research. This is what I have started to do in the previous chapters of this thesis. A second implication is that the presented research should in turn enable other academics to understand how the researcher's 'individual' findings were derived and why these findings lead to the respective conclusions. This means that the research process has to be transparent and the *steps used to collect and analyse* the *information* have to be traceable.

This chapter aims to create this necessary transparency and to enable the reader to follow the different methods and models employed in the second part of the thesis. The chapter starts with a positioning of this thesis in terms of the philosophical stance as prerequisite for the further discussion. Then, it dwells on the research design so as to provide an extensive overview of several aspects of time series analysis and related issues. Because of the size of this sub-section an intermediate summary is given at the end of this sub-section. Next, the several issues related to data collection for this thesis are described and the need to divide the analysis into three sub-parts is explained. Subsequently, an analysis scheme is developed and I will present how all three sub-analysis will follow this common pattern. Finally, the issue of quality assurance is addressed, before the chapter ends with a short summary.

5.1 Philosophical Assumptions

Before scholars begin to work on a research project, they have to take up a stance on the nature of social science and on the nature of the society (Creswell 2007). This means that they have to be sure about the particular philosophical assumptions that would form the basis of their research[18]. This is important because the way a researcher 'understands' the

[18] For a summary of the different philosophical assumptions and how they are related to each other, see e.g. (Goles and Hirschheim 2000).

nature of science and society affects his or her work and the outcomes of the project. Different 'understandings' can be categorized into so called research paradigms[19]. I position my research in accordance with the category of the functionalist research paradigm.

The *functionalist paradigm* assumes a regulatory nature of the society and an objective nature of science. It tries to explain the status quo of a society rather than striving for change. The paradigm takes up that only *one* 'given' reality exists and that this reality is external to an individual. Science is seen as objective and free from individual interpretations, and the researcher should focus on empirical evidence and look for causal relationships (Goles and Hirschheim 2000). Burell and Morgan's functionalist research paradigm corresponds with the ontological view of *realism* and the epistemological understanding of *positivism,* which are discussed by Easterby-Smith, Thorpe, and Jackson (2012). The authors link the different research paradigms to suitable research designs. Researchers that follow the realism/positivism stream are proposed to use surveys designs, which rely on inputs of numbers and facts. Furthermore, the authors suggest correlation and regression analysis as a methodological tool to study and interpret the data.

5.2 Research design

Research design is referred to as '… the overall plan relating the conceptual research problem to relevant and practicable empirical research' (Ghauri and Grønhaug 2010). The starting point of designing the research project is formulating the key research questions that need to be answered. Keeping this in mind, one has to first analyse which *type of research* is appropriate to solve the questions. The present thesis analyses the causal relationships among different variables, with the focus on demand and prices. Studying and investigating into what an extent a cause results in effects is typically referred to as 'causal' or *explanatory research* (Ghauri and Grønhaug 2010). Being clear on that, it is then to decide how the cause-effect relationships are best studied, meaning that it is necessary to select an appropriate technique to collect and analyse the data.

Easterby-Smith, Thorpe, and Jackson (2012) offer a discussion about the different aspects of qualitative and quantitative *research methods*. The authors pose the problem that qualitative research usually yields findings, which can hardly be generalized. This is because qualitative methods aim to understand a phenomenon and base their knowledge generating process on the exploration of individual sensations and observation of

[19] For a systematization and discussion of the different paradigms see e.g. Burrell and Morgan (1985)

behaviours of single individuals or limited-sized groups. On the other hand, quantitative methods strive to answer the research questions by relying on a large number of observations. The aim is to find 'representative' answers that can be generalized. Bearing in mind the research questions for this thesis, it seems suitable to choose a quantitative approach to study the underlying causal relationships.

Johannessen, Tufte, and Christoffersen (2004) provide a broad overview of diverse research designs and allow studying how these research designs are linked to the different types of research and the two research methods. In this context, a *research design* that allows serving an explanatory research project and combines that with the advantages of a quantitative method is the time series analysis research design.

As per the argumentation in this section so far, it seems to be a natural choice to use the time series analysis research design for this thesis.

5.3 Time Series Analysis

Econometric data comes in various types and requires the adoption of econometric methods to be analysed (Wooldridge 2010). Given the data available for this thesis, time series analysis is the appropriate method to be used in this research. Time series analysis is concerned with "… the examination of datasets that consist of observations of variables over time" (Chatfield 2000). It is characterized by the fact that the findings come from data, sourced at different moments in time and from different individuals. The shift of an individual's preferences is not observed, but it is rather to examine processes for larger, more aggregated levels of analysis. One special feature of time series data is that successive observations are not independent from each other. This allows assuming that previous values of a variable will very often have an impact on the future observations of the same variable. Moreover, the time component itself becomes an essential part of the analysis and has to be accounted for.

The remainder of this section will elaborate on time series analysis and related issues. The discussion thereby tries to focus on the most essential points, but is still rather extensive. This is because of the overall complexity of the subject as well as the arising need to employ different methods and models in the three sub-analysis of this thesis.

The first sub-section introduces the mathematical method of regression analysis, which will be used to analyse the data in this thesis. Furthermore, two basic models are presented that allow separating short-run from long-run effects within a regression analysis. Then, the importance of data-stationarity is elaborated on next and the implications of using non-stationary variables in regression analysis are illustrated. This includes an explanation of how non-stationary variables can be transformed into stationary processes[20]. Thereafter, the co-integration methodology is introduced, before the last sub-section deals with the unavoidable restrictions placed on an analysis if data is non-stationary and not co-integrated at the same time.

5.3.1 Regression Analysis and Dynamic Model Specifications

In one of the preceding section of this thesis, the relationship between the demand for air passenger transport and its determinants was elaborated upon. A change in demand for air transport can be explained by so called *explanatory* variables. These variables are also called *independent* variables or *regressors*. In order to derive the own-price elasticity of demand, the impact of the regressor *airfare* has to be studied by assuming that the other independent variables also influence the demand.

Regression analysis is one mathematical method to do this. It allows investigating the impact of price variations on demand, controlling for other independent variables at the same time. A regression analysis that includes more than two explanatory variables is called *Multiple Regression Analysis* (Wooldridge 2010). The generalized *economic model* of demand [4.1] indicated how demand for air travel can be explained. Under the assumption of an iso-elastic demand function, this relationship can be modelled as:

$$D_x = \alpha * POP^{\beta_1} * GDP^{\beta_2} * INC^{\beta_2} * \ P_x^{\beta_4} * \dots \qquad [5.1]$$

After a logarithmic transformation of both sides, a linearized relationship can be *econometrically* modelled in the following way:

$$lnD_x = \ \beta_0 + \ \beta_1 lnPop + \ \beta_2 lnGDP + \beta_3 lnINC + \ \beta_4 \ lnP_x + \cdots + u, \qquad [5.2]$$

where the variables represent the demand for air travel (D_x), the population (*Pop*), the Gross Domestic Product (*GDP*), the income (*Inc*) and the airfare (P_x). The term β_0 is called intercept or constant term and plays an important role in fitting the regression line. The value of β_0 itself is not important for further analysis. The terms $\beta_{1\dots4}$ are called *coefficients* and measure the ceteris paribus effect of their respective independent variables on demand. The most relevant coefficient for this thesis is β_4, which would give the own price elasticity of demand. The term u is called the *error term* of the model and represents

[20] The term process is used in this context to describe the development of a variable over time.

all effects on demand, which are not explained by the included independent variables (Wooldridge 2010).

The econometric model [5.2] can be estimated. Based on several observations over time, the Ordinary Least Squares (OLS) method allows for the approximation of the coefficients by calculating a so-called regression line. The regression line is determined by minimizing the sum of the squared residuals. A residual represents the difference between the predicted value in the model and the actual value for each observation of the time series (Knoke, Borhnstedt, and Mee 2002). Several critical assumptions have to be matched however, before accepting the results of an OLS analysis as unbiased. In particular, the time series must be linear in its parameters, the independent variables must not be highly correlated (i.e. multi-collinearity), and the residuals of a regression have to be *homoscedastic*, *normal distributed* and *not auto-correlated*. If one or more of these assumptions do not hold, the results of the OLS will be biased. A more detailed elaboration of this matter can be found in Bjørnland and Thorsrud (2015) and Wooldridge (2010).

The quality of the results of a regression analysis crucially depends on the properties of the datasets employed in the analysis. In addition to the preferable inclusion of all demand-explaining variables to avoid the so-called 'omitted variable bias'[21], the datasets should also include a large number of observations. The access to airfare data for this thesis has been restricted and the available datasets in terms of observations are rather 'short'. This limits the quantity of explanatory variables that can be included in a model, since every explanatory variable will 'consume' several observations. Even though, there is no general rule about how many observations are necessary to cover one explanatory variable; the consensus is that more observations are better[22]. A constraint on the amount of explanatory variables to be included in the model might lead to misspecification issues and biased results in the analysis part of the thesis - a weakness that is unavoidable due to the data constraints of this thesis.

Since it is important for this thesis to differentiate between short-run and long-run elasticities, models of the form $Y_t = \beta_0 + \beta_1 X_{1t} + \cdots + \beta_n X_{nt} + u$, are not entirely satisfactory. The reason is that such a *static* model will only allow the derivation of long-run elasticities if the entire effect of a variation in a regressor on demand materializes

[21] 'The bias that arises in OLS estimators when a relevant variable is omitted from the regression'(Wooldridge 2010).

[22] Helgheim (2002) for instance claims that a "rule of thumb" asks for at least five observations per regressor. Other authors argue in favour of ten or even twenty observations per regressor variable. In order to account for the small sample sizes available for this thesis, I adopt Helgheim's approach.

instantaneously (Fearnley and Bekken 2005). As elaborated earlier in this thesis, economic theory suggests the opposite. Therefore, it seems appropriate to use whenever possible dynamic models in the regression analyses in this thesis. Two of them will be introduced next.

First, a so called *autoregressive model* (AR) implies that the value of the dependent variable *Y* is related to the value(s) of the dependent variable in previous time periods (Y_{t-n}) (Hanke and Wichern 2009). In a simple linear relationship with only two independent variables and one lagged term for the dependent variable, an autoregressive model can be written as:

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 Y_{t-1} + u_t. \qquad [5.3]$$

The coefficients in such a model can be interpreted as follows: β_1 and β_2 represent the short-run response (i.e. short run-elasticities if data is in logs) of *Y* resulting from a change in the respective independent variables X_1 and X_2. The coefficient β_3, on the other hand, allows calculating the respective long-run elasticities with the following equation:

$$LR\ effect^{23} = \beta_1/(1-\beta_3) \qquad [5.4]$$

The AR-model type comes with some shortcomings, which are discussed in Fearnley and Bekken (2005) and (STATA 2013b). Especially the application of one "lagged" coefficient uniformly to all short-run regressors and the failure of standard tests (i.e. Durbin-Watson-d-test) to detect serial-correlation raises some concerns. An AR-type model will be employed in sub-analysis three of this thesis.

A *second* model that allows the separation of the short-run from long-run effects is the so-called *distributed lag model* (DL). Such a model *distributes* the effect of a change in a regressor over several lags. In a simple linear relationship with only one independent variable and two related lagged terms, a distributed lag model can be written as:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_{t-1} + \beta_3 X_{t-2} + u_t. \qquad [5.5]$$

The value of the dependent variable *Y* in period *t* is thus explained by the value of an independent variable *X* in period *t* and *X*'s values in the two lagged periods, plus the error

[23] Here the LR-effect of a permanent change of X_1 on Y (long-run elasticity if data is in logs).

term u. The coefficients $\beta_{1...3}$ are called lag weights and collectively comprise the lag distribution (Parker 2014a). The summation of all lag weights gives an estimate of the long-run effect, compared to the short-run effect represented by the coefficient β_1 alone. Kopsch (2012a) emphasizes that in a regression analysis, one or more of these lag weights might turn out to be individually insignificant; hence, it is not straight forward to assess whether the cumulative effect of all lag weights (i.e. the long-run effect) is statistically significant or not. Wooldridge (2010) provides a variable transformation procedure by defining the long-run effect as $LR = \theta = \beta_1 + \beta_2 + \beta_3$ leading to the reinterpretation of expression [5.5] as:

$$Y_t = \beta_0 + \theta_0 X_t + \beta_1(X_{t-1} - X_t) + \beta_2(X_{t-2} - X_t) + u_t. \qquad [5.6]$$

where the coefficient θ_0 now directly gives the long-run effect and allows an ease of checking its significance. Two of the major challenges related to a distributed lag model of this kind are to specify the 'right' amount of lags to include in the model (Fearnley and Bekken 2005) and that DL-models by their very nature 'consume' degrees of freedom[24].
A DL-type model and procedure [5.6] will be employed in sub-analysis two of this thesis.

5.3.2 The Stationarity Issue and Dealing with Non-Stationary Data

Stationarity is nowadays a fundamental concept in time series analysis. The identification of a time series as being either a stationary or a non-stationary process is seen as crucial for choosing the appropriate analysis method (see Parker (2014b) and Charemza and Deadman (1997)). In fact, the regression analysis of two or more non-stationary time series under the assumption that they were stationary, will likely lead to biased results. A commonly used definition of the term stationary is given by Lütkepohl and Krätzig (2004), who claim that a process is stationary if its *mean is constant over time* and if its *variance and covariance are not dependent on the time dimension* of the process[25]. Using non-stationary time series in a regression analysis can lead to the problem of 'spurious regression'. The discovery of the phenomena is linked to the work of the researchers Granger and Newbold (1974), who indicated that OLS regression will often indicate a significant relation among variables where in reality no such relationship exists. The problem is either caused by a common *deterministic trend* among the variables or a less obvious *stochastic trend*[26], which

[24] The number of observations in a multiple regression analysis minus the number of estimated parameters (Wooldridge 2010).
[25] For a detailed discussion of different degrees of stationarity, see Hamilton (1994).
[26] For a detailed discussion of the different non-stationary processes, see Bjørnland and Thorsrud (2015).

'moves' the variables into the same direction over time (Wooldridge 2010). Two typical indications of a time series analysis suffering from a spurious regression problem are models with very high R-square values[27] (> 0.95) and almost unitary significant model coefficients (Goodliffe 2015). Reviewing the literature on studies about own price elasticities of demand in air transport leads to the finding that most of the 'older' studies do not dwell on the stationary properties of the data used. It does not seem far-fetched to assume that some of their results suffered from spurious regression. This, however, means that studies that carefully consider the stationarity issue might yield to deviating results.

Literature suggests several methods to treat non-stationary data. The concrete application of one of these methods is dependent on the specific type of non-stationarity in a time series. Several statistical tests along with the inspection of a variable plotted against time assist in identifying the specific underlying type of non-stationarity.

First, in the case of a *stochastic trending process*, the problem of spurious regression can be avoided if non-stationary data is made stationary by a technique called *differencing*. Such data is then said to be 'difference-stationary'. The differencing technique takes the first difference of a process in the following way:

$$\Delta y_t = y_t - y_{t-1} \quad [5.7]$$

where Δ donates the differencing operator, y_t the value of *y* at a particular period of time *t* and y_{t-1} the value of *y* at the previous period of time. Lütkepohl and Krätzig (2004) argue that using exactly the value of y_{t-1} is not a dogma in differencing. It can rather be useful to utilize another term to cover the special properties of an individual time series. A process that is made stationary by one-time-differencing is said to be integrated of order one, donated by I(1). In borderline cases, when differenced data still contains a unit root, additional differencing seems adequate, because '…the consequences of an unnecessary over-differencing are much less serious than those of under-differencing…' (Wei 2006). A time series which requires the additional step of differencing to reach stationary properties is said to be integrated of order two, I(2) (Wooldridge 2010).

Second, for a deterministic trending time series, several applications are available to separate the 'trending' part of the time series from the non-time dependent component of

[27]The R^2-value of an estimated regression model indicates the overall fit of the model. The value expresses the amount of variation in the dependent variable explained by the independent variables in a regression model (Knoke, Borhnstedt, and Mee 2002).

the process. Such processes are then often said to be '*trend-stationary*'. A detailed discussion of these de-trending techniques is beyond the scope of this thesis, but detailed discussion can be found in Bjørnland and Thorsrud (2015).

Third, methods to produce unbiased results in the presence of non-stationary data have been developed. A very prominent approach of this kind is that of co-integration.

The concept of co-integration offers a methodology of analysis, which allows the direct use of non-stationary data. The concept assumes that a combination of two non-stationary processes of the same order, e.g. two processes of order I(1), *can* sometimes be stationary. This is the case if both non-stationary variables '… share the same common trends, which cancel each other out through a linear combination of the variables' (Bjørnland and Thorsrud 2015). This linear combination is represented by the error term, which in the case of a co-integration relationship is stationary, I(0). If the error term is non-stationary, the variables are not co-integrated and the method cannot be used. This means, that before a co-integration technique can be applied, the actual existence of at least two co-integrated processes has to be proved.

In practice, the starting point for such an analysis is the assumption that two processes (let's say the dependent variable *Y* and the regressor *X*) exist in a long-term equilibrium relationship. This assumption has to be motivated by economic theory. Then, as a second step, the stationary properties of the 'level' variables have to be checked, using statistical tests at hand like the Augmented Dickey–Fuller unit-root test (ADF) or the Phillips–Perron unit-root test (PP)[28]. If both variables are integrated of the same order, e.g. I(1), a regression of *Y* against *X* is the next stage. The residuals of this regression (i.e. representing the error term) finally have to be tested again for whether they are stationary (the underlying processes Y and X are co-integrated) or not (no co-integration exists among the processes). For reasons that are beyond the scope of this thesis, the critical values of these tests cannot be used directly. One should rather compare the values of the t-statistics with critical values proposed by Mac Kinnon.[29] If the residuals are stationary, the approach presented in the next sub-section, 'Analysing Co-Integrated Data', can be followed.

[28] For details on ADF and PP tests as well as other suitable tests, see STATA (2013b) and Charemza and Deadman (1997)

[29] For a detailed discussion on this issue and the critical values to use, see Enders (2004).

5.3.3 Analysing Co-Integrated Data

As suggested earlier, the co-integration methodology is a widely used approach to analyse non-stationary data and to avoid the problem of spurious regression. Several 'non-aviation' applications of this methodology can be found in the literature (e.g. Inglesi (2010)). Demand for air travel on the other hand, has rarely been analysed with the co-integration methodology so far. However, a few examples of such analyses do exist, e.g. UK-DfT (2011), Chi and Baek (2012) and Ekanayake and Ledgerwood (2014).

In the presence of a co-integration relationship, several alternative time series techniques are available. So-called *multi equation co-integration techniques*, such as vector error correction models, are highly sophisticated, but have been proved to be too complex for a small data time series, as available for this thesis (UK-DfT 2011). A single co-integration methodology is chosen in this thesis, which is called *Single Equation Error Correction Model* (ECM) and was applied by UK-DfT (2011). Therefore, the further explanation will be restricted to this special application of the co-integration analysis.

ECMs assume that two (or more) variables share a long-term equilibrium relationship. Once such a relationship seems reasonable, it is assumed that deviations from the long-term equilibrium state (e.g. caused by shocks) will be corrected by an idiosyncratic error correction mechanism. A basic ECM involving only one regressor can be written as:

$$\Delta Y_t = \beta_0 + \beta_1 \Delta X_t + \delta(Y_{t-1} - \beta_3 X_{t-1}) + u_t \qquad [5.8]$$

where the term in the parenthesis is the so-called error correction term (Wooldridge 2010). This term equals zero if the relationship between the dependent and its regressor is in the equilibrium state. If the term is not equal to zero, then the coefficient δ represents the adjustment process towards the equilibrium state. Several authors, e.g. Bjørnland and Thorsrud (2015) and Best (2008), illustrate that a special form of an Autoregressive Distributed Lag model (ADL)[30] can be used alternatively to catch the same dynamics as the error correction term of a single equation ECM. The distinct error correction term can be dropped because the error correction effect is now directly expressed by the two lagged terms (Enders 2004).

[30] The abbreviation ARDL is used interchangeably in the literature.

In a simple linear relationship with only one independent variable, a distributed lag model can be written as:

$$\Delta Y_t = \beta_0 + \beta_1 \Delta X_t + \beta_2 Y_{t-1} + \beta_3 X_{t-1} + u_t. \quad [5.9]$$

Coefficient β_1 represents the short run response of Y resulting from change in X. The total long-run effect is represented by $\frac{-\beta_3}{\beta_2}$(UK-DfT 2011). Finally, coefficient β_2 alone can be interpreted as adjustment speed of the cointegrated system, to correct for the disequilibrium state in the long-term relationship.
An ADL-model type and the underlying co-integration method will be employed in sub-analysis one of this thesis.

5.3.4 Analysing Differenced-Stationary Data

Recent literature addressing the analysis of non-stationary data almost exclusively focuses on the above presented cointegration technique, but remains almost "silent" about how to derive long-run elasticities from non-stationary variables, which are not cointegrated. The application of dynamic models in such a case is often stated to be meaningless. This is because a major shortcoming of the differencing technique is that it leads to a loss of the long-run information (Bjørnland and Thorsrud 2015) (HU-Berlin 2014). The analysis of differenced stationary data is therefore said to be restricted to static model applications, meaning that no long-run elasticities can be derived. In the context of this thesis, analysing differenced-stationary data is therefore problematic. Contrary to this common understanding Odeck and Bråthen (2008), used an AR-type model with differenced data for the analysis of different toll-funded infrastructure projects in Norway. The authors were able to derive reasonable SR- and LR-elasticities. Knowing about the controversy, the analysis of this thesis will in the presence of differenced-stationary data employ static models and in addition test a dynamic AR-type model specification. If the latter one yields valuable insights, the findings will be reported. Otherwise, the weakness of static models of giving only SR-elasticities has to be accepted.

One possible way to circumvent this problem is to employ non-stationary data directly in dynamic models. This however means to replace one problem with another problem - the resulting risk of creating spurious regression estimates was discussed earlier. The literature fails to provide a general solution to this issue. This is maybe related to the fact, that the necessity of differentiation in short- and long-run elasticities for non-stationary, not

cointegrated processes is a very scare and has therefore not attracted enough scholarly attention so far.
In one very special case however, Kopsch (2012a) solved the problem by running an unbalanced regression. An unbalanced regression in general means that the variables on the different sides of the regression equation have different stationarity properties. Referring to Pagan and Wickens (1989) and Baffes (1997) Kopsch claims that under certain requirements a dynamic model (here a DL-model) might lead to reliable long-run elasticities if the dependent variable is stationary, but some of the regressors are non-stationary. This approach will be followed in sub-analysis two of this thesis.

I have used this *sub-section* to briefly present the theoretical foundation of the statistical methods used and the econometric models of analysis employed in this thesis. I started with a short introduction of the mathematical method of regression analysis and introduced two dynamic models that allow deriving short and long-run own-price elasticities of demand. In addition, I indicated the issues related to the small sample size for this analysis. Next, I addressed the problem of spurious regression and showed how different types of non-stationary variables can be either transformed for or directly applied in an analysis. This included a description of the standard practice to test for co-integration between variables. Already at this stage it became clear that based on different stationarity properties of the datasets, multiple analysis approaches/models might have to be employed in the analysis part of this thesis. Finally, I discussed the challenge of deriving long-run elasticities from non-stationary data, which is not cointegrated.
For the rest of this methodology chapter it remains to present how the aspects discussed above are applied within the analysis of this thesis. This includes a short discussion of data collection issues, the development of an analysis scheme and a brief debate about the quality assurance of this work.

5.4 Data Collection

The majority of data used for this research project is *secondary data*. Data is called secondary when the needed information '… already exists in the form of publications or other electronic media…' (Easterby-Smith, Thorpe, and Jackson 2012). The main advantage of using secondary data for an analysis is the savings in both time and money because third parties have already collected the data. However, using secondary data has some critical drawbacks that must be kept in mind. For instance, the secondary data might not completely 'fit' the actual problem. A researcher then has to decide, whether the data still satisfies his or her needs to a degree that the overall research aim can be achieved or whether it is necessary to collect primary data. Furthermore, data accuracy and equivalence of secondary are beyond the direct influence of the particular researcher (Ghauri and Grønhaug 2010), which sets the quality of the own findings at risk. Appropriate preventive measure, such as carefully choosing the sources of the secondary data, might mitigate these problems.

Reflecting on both the sheer size of the data needed to answer the research questions and the time period available to do so, it was almost inevitable to employ secondary data in this thesis. Consequently, several attempts were made to source appropriate secondary data from the period between December 2014 and April 2015. The primary data sources for this thesis are Avinor AS, Statistics Norway (SSB), Eurostat and the Norwegian Ministry of Transportation and Communications (MfTC) in cooperation with Widerøe AS.

The major challenge related to collecting data has been the sourcing of suitable airfare data. There are various reasons for this. First, airfare data is considered to be highly classified information. In addition to airlines refusing to provide sufficient airfare statistics, state agencies too had restrictions in place when it came to provide micro data. This led to the situation that a major share of the airfare information had to be sourced from two different aggregated national indexes. Some weaknesses come along with index data, which have to be addressed.

The airfare indexes are constructed by a combination of price information of particular city-pairs. The contributing share of a particular city-pair to the overall index is known. However, it remains unclear how the prices of the particular city-pairs have actually developed, since these information 'vanish' in the index. This aspect poses the problem that city-pair level analysis is not possible based on the indexes. Furthermore, the particular city-pairs that constitute the indexes were picked by SSB to represent the major share of passengers traveling in Norway by air (Johansen 2007). This in turn means that the indexes may not give a representative picture for all passengers, especially not for those who mostly travel on secondary routes or to remote airports. In order to partly address this fragment of the Norwegian air travel network as well, I decided to run a separate analysis for a PSO route[31]. Finally, the two airfare indexes differ in respect to the specific information that can be extracted and to the methodology according to which the

[31] I chose a PSO-route instead of a commercial secondary route because of price and demand data availability.

indexes were constructed. This means that the two indexes cannot be used within the same analysis.

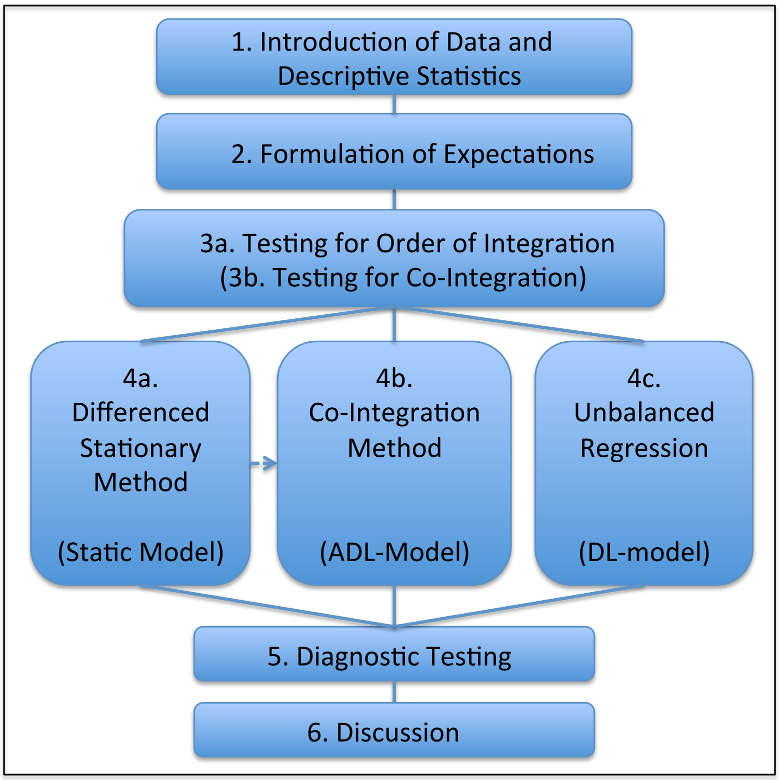
Accounting for the factors above, it was necessary to split up the analysis into the three independent sub-analyses:

1. Domestic Aggregated Demand - Annual Data 1981-2013,
2. National Aggregated Demand - Quarterly Data 2006-2014,
3. Route Demand - Bimonthly Data 2004-2014.

5.5 Data Analysis

The data analysis in this thesis is determined by the quantitative approach of this project. As indicated earlier, it was necessary to employ different datasets (i.e. airfare data). Unfortunately, the datasets appear to have different stationarity properties, which have to be accounted for in separate ways. Drawn from the findings presented in section 5-3, a sequence of steps is designed, which will serve as guidance for all sub-analyses. The graphical illustration of this sequence is shown in Figure 5-1. Additional steps necessary or actions deviating from this general schedule will be highlighted within the distinct sub-analysis. The first step in the analysis sequence is the presentation of the datasets

Figure 5-1: Sequence of Analysis



Source: Own Work

employed (1). Based on descriptive statistics and graphical illustrations the dependent and independent variables are initially discussed. Second, expectations concerning the results of the analysis are formulated (2). Then, the stationary properties of the variables are analyzed, as prerequisite to ensure the correct analysis methodology (3a). In case of non-stationary variables, it is further analysed as to what kind of trend (i.e. stochastic or deterministic) is present and the resulting order of integration is determined. In addition it is tested, whether the variables are co-integrated or not (3b). In this stage, several statistical tests, such as the Augmented Dickey–Fuller unit-root test (ADF) and the Phillips–Perron unit-root test (PP) are employed. The results of these tests determine the analysis approach to be applied. This could either be first (4a), the estimation via a static model specification (supplemented by tests with a AR-type model) or second (4b), the utilization of the co-integration methodology (ADL-model) or third (4c), the application of an unbalanced regression approach (DL-model).

The second mentioned methodology requires that the previously employed tests indicated a co-integration relationship between the respective variables. UK-DfT (2011) claims that in the presence of datasets with few observations, statistical test for unit-roots might be biased - indicating no co-integration were theory suggest a co-integration relationship between variables. The authors propose to nevertheless employ the co-integration methodology in such cases. I adopted this approach and analysed the data in cases of short dataset[32] with both the static as the primary model and the ADL as a secondary model (indicated by the small arrow in Figure 5-1). The results of the ADL are then compared with those of the static model.

The next step is then to check accuracy of the model estimates (5). The overall fitness of the models is assessed using plots of predicted versus actual values and R^2-statistics. Furthermore, the estimated residuals are tested for homoscedasticity (White's test), normal distribution (Shapiro-Wilk test) and auto-correlation (Durbin-Watson/Breusch-Godfrey test). In addition, a so-called RESET-test is run, which tests the estimated models for omitted variables[33].

The last step of the analysis (6) is finally, the discussion and interpretation of the results.

[32] Short datasets are for the purpose of this thesis defined as datasets, which consist of less than 10 observations per significant explanatory variable.

[33] For details see UCLA (2015).

The analysis was conducted with the statistical software package Stata SE13 provided by Molde University College. In addition, the software SPSS was used to extract information from the NTS-dataset.

5.6 Quality Assurance

Halldórsson and Aastrup (2003) provide insights into how the selection of research quality criteria is related to the ontological and epistemological position of the research project. Drawing on Kvale (1996), the authors claim that the 'normal' quality criteria *internal validity*, *external validity*, *reliability* and *objectivity* are consonant with research projects with a realism/positivism stance. Since this thesis was positioned according to the related research paradigm, it seems reasonable to discuss the quality assurance using this systematic approach.

In the context of a quantitative research project, *internal validity* is defined as '…the extent to which observed effects can be attributed to the independent variables' (Frambach, van Der Vleuten, and Durning 2013). Applied to the subject of this thesis, a high internal validity means that the variations in demand for air travel are to a high degree caused by the chosen explanatory variables. The effects of other, unrecognized variables have to be minimized.
The first step towards increasing the internal validity of this thesis is to recognise the issues related to the implementation of non-stationary data in the regression analysis. As described earlier, spurious regression can lead to biased t-statistics; hence, effects could falsely be attributed to independent variables. Non-stationary data is not going to be used in OLS regression. Second, the implemented explanatory variables are picked on the basis of an extensive literature review. The application of 'new' or 'intuitive' variables is abandoned. The final step of each sub-analysis is to assess the overall fitness of the model by statistical methods. This provides an additional mechanism to ensure internal validity.

The *external validity* of a research project concerns '…the extent to which the results can be generalized from the research sample to the population' (Frambach, van Der Vleuten, and Durning 2013). A high external validity for this thesis would be reached, if the calculated price elasticities of demand mirror the reality.
The major part of the analysis treats data at the highest possible level of aggregation for a single country. The overall sample size is extensive and should already be close to the 'population'. The aim of this thesis is not to generate findings that are transferable to a

more generalized setting. In this context, the external validity should not be threatened. On the other hand, some sub-analyses employ short datasets, differ in the time periods they cover or consider special cases. These will potentially challenge the degree to which the findings can be generalized. It is therefore important to clearly distinguish case by case the RQs that need to be addressed and the datasets that will be employed. This is why I decided to divide the investigation into different sub-analyses. By doing this, the "sample population" will converge towards the population and the issue of external validity will decline.

The *reliability* of a quantitative study is referred to as 'the extent to which the results are consistent if the study would be replicated' (Frambach, van Der Vleuten, and Durning 2013). Thus, reliability addresses the stability of the data over time. A high reliability of this thesis would be achieved if another researcher could carry out the same analysis and find the same answers to the research questions, exactly using the same data and methodology for the analysis.

All data was sourced from large institutions with long experience in data generation and processing. The data is not expected to become subject to major amendments. Additionally, all steps of data processing and data analysis performed for this thesis are described. Johannessen, Tufte, and Christoffersen (2004) recommend two methods to test the reliability of a study. First, they advise researchers to repeat the same analysis for a second time. The authors claim that if the results of the two independent analyses are the same, a high 'test-retest-reliability' is assured. This method seems less suitable for this thesis since the time at disposal does not allow an entire 'second run', and furthermore, it seems unlikely that the data would change within a couple of weeks.

Second, Johannessen, Tufte, and Christoffersen (2004) propose to test the 'inter-rater-reliability', which can be achieved if several researchers study the same phenomena independently and come up with the same results. The nature of a Master Thesis usually does not allow the realization of this concept in a pure form. I, however, tried to adopt some aspects of this thinking to increase the reliability of my work. First, a second Master Student studies the demand for air travel in Norway on a general basis for his Master Thesis. For this purpose, he will design demand models for which airfare are an important explanatory variable. Assuming that the student will employ data similar to the one used for this thesis, the calculated price elasticities can be compared.

Second, at all stages of this project, I have held discussions with my supervisor, other staff of Molde University College and researchers from other institutions about how they would handle certain issues. The feedbacks provided by these parties were implemented in the project and helped to increase reliability of the findings.

The term *objectivity* is defined as 'the extent to which personal biases are removed and value free information is gathered' (Frambach, van Der Vleuten, and Durning 2013). A study is therefore considered to be highly objective if its findings are not dependent on the specific person who carried out the research.

Since this research project relies on quantitative data, one could assume that objectivity is not a major issue for this thesis. Nevertheless, it seems reasonable that a personal bias can be induced due to the researcher's preferences concerning data collection and data analysis. In an effort to prevent this bias, all data used for this thesis is stored and can be made available for assessment. Furthermore, the analysis methodology conducted is based on an extensive literature review.

In this chapter, I familiarized the reader with the methodological approach of this thesis. I started with a discussion of the philosophical stance and positioned this thesis in the functionalist research paradigm. Based on this assumption, I referred to explanatory research designs and concluded that a time series analysis should suitably serve to answer the research questions of this thesis. Next, I comprehensively treated the time series analysis research design and debated related issues - I already summarized the findings concerning this sub-section separately. Subsequently, I addressed the data collection issues of this thesis and developed an analysis scheme, before I last explained how I plan to satisfy the different dimensions of quality assurance for a quantitative research design.

6.0 Summarizing Remarks and Formulation of Expectations

This chapter strives to summarize the previous discussions and to link the theoretical findings to the setting of air travel demand in Norway as described in Chapter 2. Hereby, the aim is to derive expectations in terms of elasticity estimates for the analysis part of this thesis. This will be done in a sequence in line with the research questions 1-5 of this thesis.

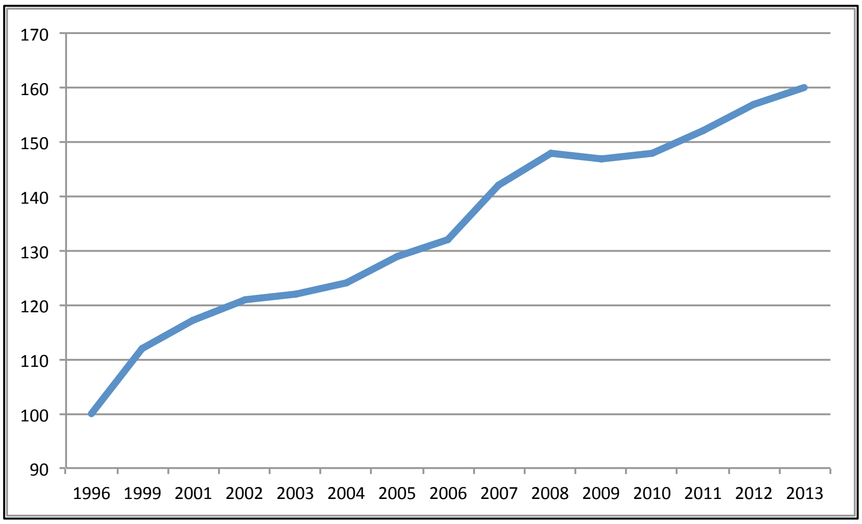
RQ 1: How price elastic is the demand for passenger air travel in Norway on the national aggregated level?

RQ 4: Has the price elasticity changed in the recent past?

A good starting point to address these questions is to use the findings of previous studies, covering the same or a similar market, as a reference. According to the summary of chapter 4, I expected to find demand on the aggregated national level to be price inelastic. The respective range was established from -0.2 to -0.54 in the long run. However, keeping the survey of Kopsch (2012a) covering the neighbouring Swedish market in mind, higher elasticities also seem imaginable.

It was shown that the Norwegian market for air travel has seen a quite stable growth path with some disturbances in the years following 1999. The temporary decline in demand was partly explained by the monopolistic position of SAS. With the market entry of NAS, the former growth pattern re-emerged. The airfare development in this period showed a contradicting pattern. Before 1999, airfares developed in line with the development in general prices. Between 1999 and 2003, the airfares increased more than the general prices, and after 2003, the airfares developed on average 'behind' the general price development. At the same time, the average household income in Norway saw constant growth, as visualized in Figure 6-1 in the next page. With regard to constant consumption rates, the overall income increase as well as the relative price-reduction for air travel point towards a general decline in the budget shares needed to finance air travel for the period after 2003. Following the implications of the Slutsky equation presented in section 3.4, one would expect to see stability or a slight increase in elasticities for the period 1999–2003 and a decrease of elasticities for the period after 2003. On the other hand, if one assesses the overall growth in demand for air travel as a consequence of the price development, one could assume that the 'savings' from the cheaper airfares have been invested in additional air travel (non-constant assumption). In such a case, the budget share necessary to finance the air travel 'per annum' might have not dramatically changed and the overall price elasticity might have not gone down significantly.

Figure 6-1: Index for Median After-Tax Income per Consumption Unit 1996-2013



Source: SSB (2015c); (in constant 1996-prices, year 1996=100)

On the other hand, the Norwegian air travel market was described as a well-developed market. Notwithstanding a stable growth of more than 4% per year, at least the domestic market is expected to see declining growth rates. In accordance with the discussion on market maturity and its effects on income and price elasticities, this could point towards demands that are less price-sensitive.

Finally, recalling the market structure in Norway, one has to acknowledge that contrary to other European countries; low-cost carriers (LCC) have not become major actors in the market so far. NAS is usually said to be an LCC, but it has clearly not adopted the most extreme form of this business model. This means that airfares on average have not seen the lowest possible limits, as commonly associated with airlines such as Ryanair. Hence, the competition between SAS and NAS has driven the airfares down, but not as far as in an intensive LCC-competition scenario. This, however, implies that extremely price-sensitive travellers, who exclusively target the low-cost segment and generate additional air travel demand out of minimum airfare levels, might not have played such an important role in the Norwegian setting as they have in other countries. This would then have limited the potential for a sharp increase in price elasticities on the aggregated level.

Consequently, I expect to find price elasticities for the aggregated level somewhere in the range of the earlier Norwegian and UK papers. In terms of a change in elasticities, I do not expect to necessarily find a significant change for the recent past.

RQ 2: How price elastic is the demand for passenger air travel in Norway on the route level?

In general, the above comments seem also valid to answer this research question. One has to respect the fact that price elasticities for a route level may significantly differ in magnitude from those on the aggregated level. According to the trend, air travel demand seems to be more elastic on the route level than on the aggregated level (InterVISTAS 2007). This is especially so if there is intra-route airline competition or other modes of transportation can serve as substitutes to air travel for the customers. In the very special setting of sub-analysis 3, the two cases will not apply; hence, the potential for a very price-sensitive market is limited.

Therefore, I expect to find the demand on the route level to be only slightly more sensitive than for the aggregated market.

RQ 3: Do the price elasticities differ between the business and the leisure segments?

In theory, the budgetary share necessary to finance air travel for a private passenger is larger than for the business traveller, resulting in more sensitive leisure travel demand. It was shown that after 2003, airfares for leisure travellers and business travellers have developed differently. In nominal prices, leisure airfares seem to converge on business fares. This means that leisure travellers have to invest an even higher share of their available income.

This could point towards the fact that the already existing spread in elasticities among the traveller segments should have been enlarged after 2003. On the other hand, some authors, such as Mason (2001), have reported an increasing trend among business travellers to shift to leisure airfares. This could have at least dampened the above-described tendency.

In total, I expect to find a difference in price elasticity for the two traveller segments

RQ 5: Is the demand for air travel in Norway significantly influenced by price changes for other modes of passenger transportation?

According to the literature review concerning the role of road and rail passenger transport in Norway as substitute to air travel; I do not expect to find significant cross-price elasticities for rail on the aggregated national level. For car-use, it seems reasonable to expect to find such a significant relationship.

PART II: Empirical Analysis

The following chapters cover the analysis part of this thesis. Three different sub-analyses are presented. It starts with an examination of own-price elasticities of demand on the aggregated Norwegian level, covering the period between 1981 and 2014. The focus here is on the domestic market. Then, a second analysis treats again the aggregated level, but for the more recent period beginning 2004, with data that entails a higher share of international air travel. Furthermore, this second sub-analysis addresses the price elasticities in the context of different traveller segments. The third sub-analysis elaborates on the price elasticities on the route level. Here, the analysis is performed in the special setting of a PSO-route.

Each sub-analysis follows the distinct sequence of analytical steps, which were already presented in section 5.5. In order to save pages, details about the individual steps of the analysis, such as brief explanations of the applied statistical tests and the underlying null-hypotheses, will only be discussed in the first sub-analysis. For the same reason, most of the graphs, figures and test results will be presented in the appendix.

7.0 Analysis 1 - Domestic Aggregated Demand - Annual Data from 1981-2013

The overall aim of this thesis is to provide a broad picture of own-price elasticities of demand for passenger air transportation in Norway. Following a 'deductive' approach, this first analysis strives to derive own-price elasticities of demand from an annual dataset that covers the aggregated Norwegian domestic market for the period between 1981 and 2013. By doing this, the following research questions are addressed:

RQ 1: How price elastic is the demand for passenger air travel in Norway on the national aggregated level?

RQ 5: Is the demand for air travel in Norway significantly influenced by the price for other modes of passenger transportation?

RQ 6: Are the demand for air travel in Norway and its price co-integrated processes?

The dataset for this analysis contains 33 observations, restricted by the demand data that has been available only with annual observations for the period before 2002. The small sample size imposes limitations on the number of explanatory variables that can be included in a possible demand model[34]. The analyses will therefore in the first place, focus on the most commonly used explanatory variables mentioned in the literature: airfare (*fare*), Norwegian GDP per capita as proxy for income (*gdp*), Norwegian population (*pop*), price for travel by train (*rail*) and price for travel by car (*car*). Furthermore, several dummy variables are considered. All explanatory variables are assumed to be exogenous[35].

In order to improve the quality of the models, I ran some 'pre-tests' with both a DL-type and an ADL-type model. I tried, for example, to replace the variable *gdp* by the alternative explanatory variable 'disposable income per capita'. This did not increase the performance of the models. Including both variables was not an option because it would lead to multi-collinearity issues. Thus, I decided to use *gdp* as a variable. Moreover, the tests included different functional forms as mathematical specification of the regression equations (i.e. 'linear', 'log-linear', 'linear-log' and 'double-log'). This did not lead to significant differences in the results nor did it have a dramatic impact on the explanatory power of the tested models. The 'double-log' specification turned out to give a slightly better fit for both models. Considering the ease of interpretation of a 'double-log' model, I decided to use this specification for the final analysis. Addressing the possible issue of multi-collinearity, I inspected the correlation coefficients of all the relevant variables before the start of the analysis. As shown in Appendix 2, care must be taken when the variables *gdp* and *pop* are used in combination with each other. Moreover, I visually inspected the scatter plot also illustrated in Appendix 2 to identify possible outliers in the dataset - there is no evidence of such an issue in the dataset.

Finally, I adjusted all the variables reflecting monetary values with the consumer price index (1998=100%) sourced from SSB.

7.1 Introduction of Data and Descriptive Statistics

The data for the analysis stems from different sources.

The airfare dataset was obtained from Statistics Norway. The dataset is based on the CPI-subindex "passenger transport by air", which describes the monthly development of airfares in Norway (SSB 2015f). The index reflects "end-consumer" prices. To construct this index, the price development on a mixture of different routes served by Widerøe, SAS and NAS are monitored and combined[36] - airfare information of other airlines are not

[34] See discussion in sub-section 5.3.1.
[35] For a discussion and testing of endogeneity see Appendix 1.
[36] For further details about methodology used to construct the index see Johansen (2007).

utilized for the index. Until 2007 airfares from *seven domestic* and *two international* routes formed the base of the index. In the later years, additional international routes have been included in the construction of the index and the methodology of sourcing the airfare data has changed. This creates a weakness for this analysis, since the available demand data exclusively reflects domestic passengers and does not allow adjusting for the post-2007 international routes. In absence of access to more suitable price datasets, I have decided to use this index as proxy for the development of airfares in the domestic network anyway, because the overwhelming share of the observations (until 2007) will suffer from this inaccuracy only marginally. The index uses the year 1998 as reference year (i.e. 100%). In order to employ this dataset, the annual average values of the index were calculated.

The data for rail ticket prices, GDP per capita and population were all obtained from Statistics Norway. The rail ticket prices are based on the CPI sub-index 'passenger transport by railway' with 1998 as the reference year. The values for GDP per capita were sourced in nominal NOK and adjusted with the CPI. The population numbers, as gathered from the Statistics Norway website, were amended by information sourced from several older editions of the annual Statistisk Årbok available on the SSB's website. The population numbers include all age cohorts.

The costs of travel by car were obtained from OFV (2014). The authors map car-ownership costs for different classes of cars and calculate average ownership-costs in NOK/km. I decided to implement the costs for a medium-sized, petrol engine car, with an annual mileage of 15,000 km, as this is most representative of the population (OFV 2011).

Three dummy variables were included in the analysis. First, a dummy variable was designed as a proxy to the drop in demand after the terror attacks in 2001(*terror*). I used this dummy for the years 2001 and 2002. A second dummy (*comp*) was used as a proxy for the period of low competition after SAS bought Widerøe in 1999 until NAS entered the market and gained significant market share in 2003. Finally, I introduced a dummy representing a structural break in the dataset from 2000 onwards (*break*). A detailed discussion of this dummy and the structural break follows in Section 7.5.

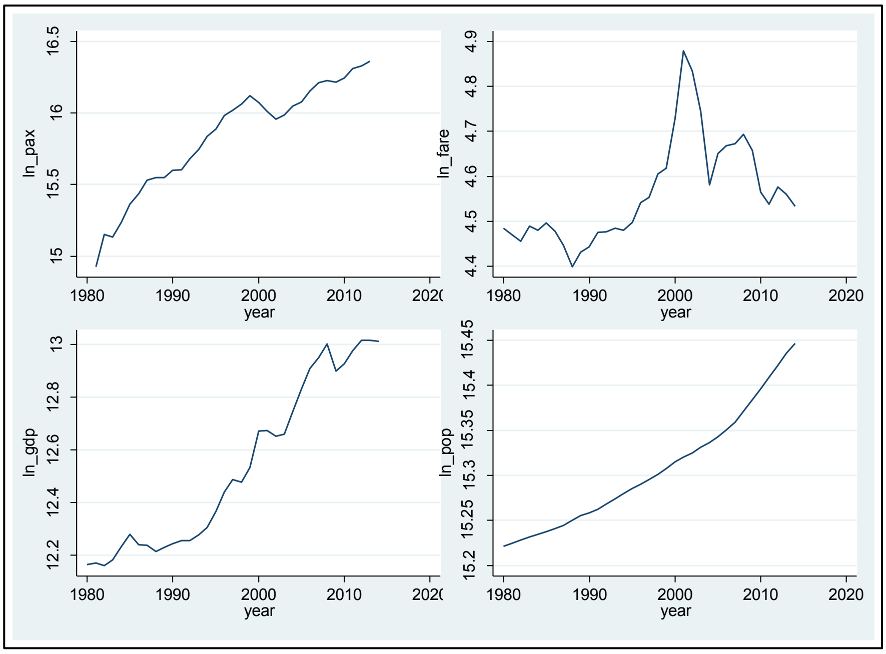
The annual aggregated demand data for domestic trips was gathered from Avinor (Avinor 2015c). It gives the number of domestic *passenger trips* in Norway. The number of passenger trips is derived from the monthly count of *terminal passengers* at Avinor-owned airports (reduced by transfer pax and adjusted for double counting). The index does not allow separation for different travel purposes. A brief descriptive summary of all the variables is given in Table 7-1.

Table 7-1: Analysis 1 - Descriptive Statistics - Yearly Averages

Variable	Mean	Standard Deviation
Domestic passenger trips (pax)	8062389	2755731
Index of airfare (fare)	96.47	11.79
Population (pop)	4451823	295121
GDP per capita in NOK (gdp)	291582	94768
Index of train ticket prices (rail)	102.86	11.16
Car ownership costs in NOK/km (car)	3.93	2.7

For further analysis, all the variables were transformed into their logarithmic form to benefit from the effect that after such a transformation all resulting coefficients can directly be interpreted as elasticities. The time plots of the logged form for the variables *pax, fare, gdp* and *pop* can be seen in Figure 7-1.

Figure 7-1: Analysis 1 -Time-Plot Main Variables



A first look at those plots leaves the impression that all variables follow a trend.

7.2 Formulation of Expectations

Having in mind the theoretical discussion of price elasticities in air passenger transportation and the results of previous studies covering Norway, I expect to find a price inelastic demand. Furthermore, it seemed reasonable to assume that the elasticity in magnitude is somewhere in the range of -.2 and -.54. This low sensitivity is partly related to the aggregation level of the analysis and partly to the fact that the Norwegian domestic market can be described as highly developed, with first indications of a decline in market growth rates. In terms of substituting modes of transportation, I anticipate positive prefixes for the cross-price elasticities, indicating that a price increase for a substituting mode of transportation will lead to an increase in demand for air travel. However, deriving highly significant cross-price elasticities is beyond expectations. For the variables *gdp* and *pop* the expectations are to find positive prefixes as well, signifying that a growth in these variables would also lead to a growth in demand air passenger transportation.

7.3 Testing for Order of Integration

Statistically, the stationarity properties of the variables are tested by the *Augmented Dickey-Fuller test* (ADF) and the *Phillips-Perron test* (PP). Both tests assume in the null-hypothesis (H_o) the existence of a unit root. Rejection of $H_o$indicates that a process is stationary. Appendix 3 reports the test results for level data, the logged data and for the differentiated form of the logged data. In order to reject H_o, the value of the t-statistics has to be smaller than the critical value given at the bottom of the table.

The null hypothesis for the variables *ln(fare)*, *ln(pop)*, *ln(gdp)* and *ln(car)* cannot be rejected, meaning that these processes are not stationary. The variables can be made stationary by differentiation once; in the case of *ln(pop)*, a second differentiation is necessary, because the variable follows an exponential growth pattern.

The variable *ln(rail)* appears to be stationary already in logged form. The t-statistics for the PP-test however is close to the critical value at 5% significance level. I decided therefore to conduct an additional test to back-up the results of the ADF and PP-tests. The DF-GLS unit-root test (DF-GLS) has the same H_o as ADF, but tests with a slightly other methodology (STATA 2013b). Here, H_o cannot be rejected for *ln(rail)* at 5% significance level. Following the argumentation of Wooldridge (2010) the consequences of "under-differencing" raise more concerns than a possible "over-differentiation". In order to avoid the shortcomings of an "under-differencing", I decide to difference the variable once.

The results for the core-variable *ln(pax)* are inconclusive for the ADF and PP. The standard ADF-test indicates a rejection of H_o, but the PP-test slightly cannot reject the existence of unit-root at the 5% significance level. A closer look at the figure 7-1 were the variable is plotted against time seems to prove that the mean of the variable is not constant over time; hence the process is not stationary. Since *ln(pax)* is one of the two most important variables in the analysis, I decide therefore to employ additional tests. The results of the DF-GLS-test gives no evidence for a stationary process. Performing additional versions of the ADF-test could lead to the assumption that the process follows a so-called "stochastic trend with drift"; hence it is non-stationary. On the other hand side, a visual inspection of the graph could also lead to the conclusion that the process follows a deterministic trend. Therefore an additional Kwiatkowski-Phillips-Schmidt-Shin test (KPSS) was employed[37]. This test assumes the existence of a trend-stationary process in H_o. Here, the critical value at 5% significance level is .146. The test result is .196, which means for this test that H_o can be rejected. I concluded that *ln(pax)* has a unit root and has to be differenced. The test of Δln(pax) finally leads to the finding that *ln(pax)* is integrated of order I(1).

It can be claimed that all considered variables are non-stationary in their level and log-level forms. The resulting order of integration for all variables is summarized in table 7-2.

Table 7-2: Analysis 1 - Order of Integration

Variable	Order of Integration
ln(pax)	I(1)
ln(fare)	I(1)
ln(pop)	I(2)
ln(gdp)	I(1)
ln(rail)	I(1)
ln(car)	I(1)

In regard to the analysis scheme presented in section 5.5, the discovered stationarity properties allow to check next for a co-integration relationship between demand and price.

[37] For details about KPSS see Bjørnland and Thorsrud (2015).

7.4 Testing for Co-Integration

The first step of co-integration testing for the variables *ln(pax)* and *ln(fare)* is to determine their order of integration and to verify that both processes are integrated of the same order. This was done in the previous section, where I concluded that both variables are I(1).

The next step is to regress *ln(pax)* against *ln(fare)* and to test the resulting residuals again for their stationarity properties employing a DF-test. It turns out that H_o cannot be rejected at any acceptable significance level. The respective regression outputs can be found in appendix 4. The results of the testing procedure do not point towards the existence of a cointegration relationship between *ln(pax)* and *ln(fare)*.

Therefore, the own-price elasticity of demand has to be derived with a static model, based on differenced-stationary data, next[38].

7.5 Model Building and Estimation: Static Model

As discussed earlier, the short dataset limits the amount of explanatory variables that can be used to determine the demand. The resulting shortcomings in terms of possible omitted variable bias and reduced goodness of fit for the model have to be accepted as weaknesses of the analysis.

In order to find the best possible model under the given circumstances, I started to estimate the static model in an 'over-specifics' form, including all the variables mentioned in Table 7-2 in differenced form and the dummy variables *terror* and *comp*. My intention was to use this over-specified model as a starting point for a further stepwise reduction of the model, which satisfies the condition of including at least 5 observations per explanatory variable, but at the same time has a high possible explanatory power. The regression result of this over-specified model can be found in Appendix 5. As expected, this model does not yield very meaningful results. None of the coefficients is significant at 5% significance level and shows a "correct" prefix at the same time. The coefficient representing the own-price elasticity of demand shows the expected prefix and a magnitude of -.21 but is significant only at the 10% level. The coefficient for population is indicated to be significant but clearly shows an unrealistic magnitude, combined with the "wrong" prefix.

Starting with this over-specified model, I proceed by testing several variations of it.

[38] In addition an AR-type model with a lagged term of the dependent variable as found in Odeck and Bråthen (2008) was estimated. Supplementary insights could not be drawn from this estimation, since the dynamic term of the model turned out to be insignificant. The estimation results are therefore not reported here.

One challenge in doing this is related to the dummies. Both dummies turn out to be highly significant if I use them individually in the different variations of the model, but 'disturb' all other variables in the models. They 'draw' the effects away from other variables. Jointly used, none of the dummies is significant at any acceptable level. Knowing about the events represented by the dummies, this outcome is not entirely in line with the intuition. One reason for this could be the overlapping time periods represented. Another reason could be that the dummy variables reflect entire years, but the represented events did in reality not. This could lead to a 'blurring' effect.
Looking at the time plot of *ln(pax)* in Figure 7-1 once again, one can see that between 1999 and 2004 'something' led to a significant drop in demand. This drop in demand, however, was not instantaneously recovered after 2004. Maybe other events like the credit crunch from 2007 and the subsequent financial crises dampened a recovery. Whatever be the combination of events that led to the demand drop, it seemingly had a long-term impact on demand. In fact, the post-2004 development in demand follows the pattern of the pre-1999 era, but at a lower 'level'. Ignoring this 'level' shift would reduce the model's explanatory power. I therefore decided to account for this structural break in the dataset by including a dummy variable 'break'. I tested the dataset with a 'Zivot-Andrews unit root test'[39], which suggested the year 2000 as the break point. Replacing the dummies *terror* and *comp* by the variable *break* instantaneously led to model versions with higher explanatory power and a highly significant t-value for *break* for all the models estimated further.

Throughout the further stepwise derivation of the model variations, it turned out that neither *ln(rail), ln(car)* nor *ln(pop)* have a significant impact on demand. This is not surprising for *ln(rail),* keeping in mind the findings in section 2.5. For *ln(car)* on the other hand, one could expect to find a significant cross price elasticity, knowing that car use is the strongest competitor for air travel in Norway. In the case of *ln(pop)* though, theory suggests that the variable *should* clearly have an impact on demand. Having a look at this variable plotted against time in Figure 7-1 may lead to the impression that the population variable does not 'contain' enough variance to become a significant determinant of demand in this analysis. In order to further test the role of population for this analysis, I ran some model variations where I introduced the new demand variable "demand per capita" (*paxcap*). This variable is built by dividing the variable *pax* by *pop* and it allows catching

[39] For details and application, see (STATA 2015).

the effects of *pop*. Interestingly, replacing *ln(pax)* by *ln(paxcap)* changes the model fit only slightly and keeps the coefficient for ln(*fare)* constant. Finally, I tested some model specifications where all the variables are differenced twice to meet the order of integration of *ln(pop)*. The variable *ln(pop)* still remained insignificant.

I nevertheless include the two variables *ln(pop)* and *ln(car)* in the model, because economic theory suggests that both variables are most likely determinates of air travel demand. By including those insignificant variables, I hope to avoid a possible "omitted variable bias". Interestingly, even if I estimate models without those two variables, the coefficient for airfare remains almost unchanged and stays significant.

The linearized form of the model used after logarithmic transformation and differencing can therefore be specified as:

$$\Delta \ln\,(pax_t) = \beta_0 + \beta_1 \Delta \ln(fare_t) + \beta_2 \Delta \ln(gdp_t) + \beta_3 \Delta \ln(car_t) + \beta_4 \Delta \ln(pop_t) + \beta_5\, break + \varepsilon$$

Output 7-1 provides a look at the regression results.

Output 7-1: Analysis 1 - Estimated Static Model

```
. regress d_lnpax d_lnfare d_lngdp d_lncar d_lnpop break

      Source |       SS       df       MS              Number of obs =      31
-------------+------------------------------           F(  5,    25) =    4.59
       Model |  .03081774      5  .006163548           Prob > F      =  0.0042
    Residual |  .033573682    25  .001342947           R-squared     =  0.4786
-------------+------------------------------           Adj R-squared =  0.3743
       Total |  .064391422    30  .002146381           Root MSE      =  .03665

------------------------------------------------------------------------------
     d_lnpax |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    d_lnfare |  -.3574862   .1199705    -2.98   0.006    -.6045701   -.1104022
     d_lngdp |   .4157005   .1597667     2.60   0.015     .0866548    .7447461
     d_lncar |   .1339678   .1321456     1.01   0.320    -.1381912    .4061268
     d_lnpop |   3.154743   2.872168     1.10   0.283    -2.760599    9.070084
       break |  -.0634597   .0189473    -3.35   0.003    -.1024824   -.0244369
       _cons |   .0365559   .0169542     2.16   0.041     .0016381    .0714737
------------------------------------------------------------------------------
```

The regression results indicate that demand for air passenger transportation in Norway at an aggregated national level is price inelastic. The short-run price elasticity is estimated to be -.357 and is highly significant. Knowing that the analysis employs annual data, one could question whether the estimated elasticity gives indeed short-run value or rather represents an intermediate-term elasticity. One could argue that behavioral adjustment processes are at least partly implied in the annual dataset. Anyway, accepting the limitations of a static model, there is no suitable way to prove such an assumption.

The coefficient denoting the income elasticity of demand is estimated to be +.41 and is highly significant. The coefficient has the expected prefix, but in magnitude seems to be well within expectations if one compares this value with those by of Kopsch (2012a), who estimated values of around +.45.

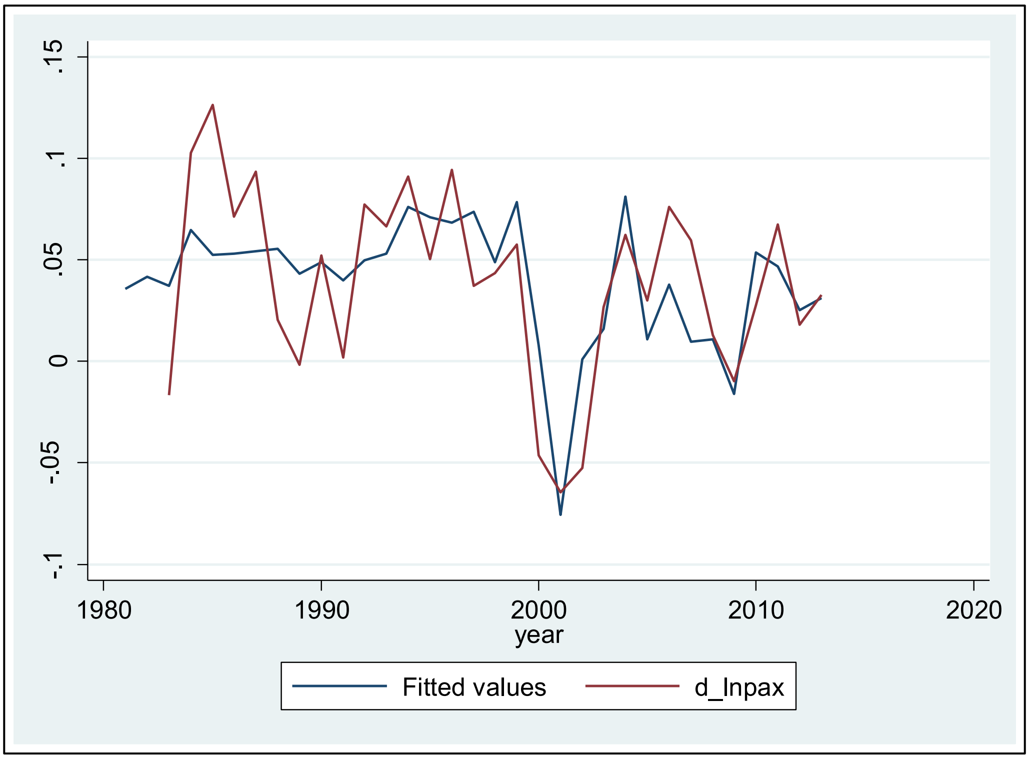
The coefficient denoting the cross-price elasticity of air travel demand in respect to car ownership cost is very small in magnitude and not significant. The prefix of the coefficient thus, points into the right direction. The population coefficient also shows the expected prefix, but is very high and not significant. This might be caused be a multicollinearity issue arising from the combined application of the gdp and population variable. Finally, the dummy variable representing the break in the dataset is significant and indicates that the demand in the post-2000 years developed on a lower level than before.

7.6 Test Diagnostics

The estimated model has a rather limited model fit. Adjusted-R^2 is only .37, which means that more than 60% of the variation in demand is not explained by the model. Benchmarking this model fit with reported values in the literature, however, proves complicated since the value of R^2-adjusted is heavily dependent on the details of the model specifications and studies comparable to this analysis are scarce. Kopsch (2012a), for instance, reports for quite a similar analysis a R^2 of .70. The value seems high, but the author includes insignificant variables in the model, which inflates the value of R^2. An adjusted value of R^2 is not reported.

Output 7-2 plots both the predicted values (Fitted Values) and the observed values of variable $\Delta\ln\,(pax_t)$ (d_lnpax) over time. It can be seen that the model's predictions are fairly weak in the initial years, but seems to improve in fit in the second half of the observation period.

Output 7-2: Analysis 1 - Predicted Values vs. Observed Values



For several reasons, I think the reduced goodness of fit does not necessarily disqualify the model and the derived elasticities. First, since the data in the model is differenced-stationary, high R^2 values comparable to those of traditional regression with non-stationary data cannot be expected. Second, the number of observations in the dataset is rather limited, resulting in a limited amount of explanatory variables that can be included and a low variance in the dependent variable that can be 'catched' by the independent variables. Last, throughout the entire analysis and for all the tested model variations, the coefficients representing the short-run price elasticity came up with consistently narrow results.

In order to check the model for the homoscedasticity assumption, 'White's test for heteroskedasticity' is applied[40]. The test assumes that the variance of the residuals is constant in H_0. The p-value, as shown in Appendix 6, is far from being significant; hence, H_0 cannot be rejected. The plot of residuals vs. fitted values on the right side of Appendix 6 does not show a regular pattern, which confirms the findings of White's test that the model does not suffer from heteroskedasticity.

[40] For details, see STATA (2013a).

Next, applying a 'Shapiro-Wilk test for normal distributed data' tests the normal distribution of the residuals[41]. The test assumes in H_0 that the residuals are normally distributed. The p-value, as shown in Appendix 6, does not indicate significance, which can be confirmed by the normality plot at the lower right of the appendix. Hence, the residuals are normally distributed.

Finally, the model is tested for serial correlation. A Durbin-Watson test is conducted. The Durbin-Watson (DW) statistic ranges from zero to four, whereas a value close to two indicates no serial correlation and values close to either zero or four denote strong positive or negative serial correlation. The critical values of the test depend on the number of observations and the number of explanatory variables. For the estimated model, the value of the DW statistics should be between 1.82 and 2.18 to indicate that there is no serial correlation (STANFORD 2015). The actual value for the model is 1.88, thus the existence of serial correlation can be ruled out.

Last, I test the model for omitted variables by employing a so-called RESET-test[42]. This test assumes in H_0 that no variables are omitted. As can be seen in Appendix 6, the p-value of this test is large; indicating that H_0 cannot be rejected.

The estimated model thereby has passed all diagnostic tests and can finally be expressed as:

$$\Delta \ln (pax_t) = 0.03 - 0.36\Delta \ln(fare_t) + 0.42\Delta \ln(gdp_t) + 0.13\Delta \ln(car_t) + 3.15\Delta \ln(pop_t) + \beta_5\, 0.06 break$$

with the coefficients for *ln(car)* and *ln(pop)* not significant.

The estimated short-run own-price elasticity of demand is -0.36. A long-run elasticity cannot be derived within this model.

7.7 Model Building and Estimation: ADL-model

The above-presented static model was estimated in this analysis as the primary model because earlier co-integration tests could not prove the existence of a cointegrated relationship between the non-stationary variables demand and price for air travel. With regard to the argumentation of UK-DfT (2013), less weight should be placed on unit root tests in the presence of small sample sizes, because the test results can be incorrect and more emphasis should be given to the visual inspection of variable plots. For this distinct

[41] For details see UCLA (2015).
[42] For details see UCLA (2015).

analysis, the plotted residuals (Appendix 4) however, confirm the findings of the tests that no co-integration exists.

Cuddigton and Dagher (2011) claim that in such a case, no reliable long-run elasticities can be derived with an ADL-model. But the authors further argue that using an ADL under such circumstances still enables deriving correct short-run elasticities. Consequently, I decided to estimate an ADL and hoped to find an additional result, which either supported or disproved the results of the static model.

In order to do that, it seems appropriate to use a model specification for the ADL, which contains the same explanatory variables as the DL model. Because of the limited sample size and the fact that every variable is represented two times in an ADL-model, this is not possible here. Accordingly, I limited the ADL to the most significant variables of the static model. Consequently, [5.9] takes the form:

$$\Delta \ln(pax_t) = \beta_0 + \beta_1 \Delta \ln(fare_t) + \beta_2 \Delta \ln(gdp_t) + \beta_3 \ln(pax_{t-1}) + \beta_4 \ln(fare_{t-1}) + \beta_5 \ln(gdp_{t-1}) + u_t \, .$$

The regression results can be seen in Output 7-3.

Output 7-3: Analysis 1 - Estimated ADL-Model

```
. regress d_lnpax d_lnfare d_lngdp lag_lnpax lag_lnfare lag_lngdp

      Source |       SS       df       MS              Number of obs =      31
-------------+------------------------------           F(  5,    25) =    4.05
       Model |  .02883398      5  .005766796           Prob > F      =  0.0078
    Residual | .035557442     25  .001422298           R-squared     =  0.4478
-------------+------------------------------           Adj R-squared =  0.3374
       Total | .064391422     30  .002146381           Root MSE      =  .03771

------------------------------------------------------------------------------
     d_lnpax |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    d_lnfare |  -.3900955   .1308819    -2.98   0.006    -.6596518   -.1205392
     d_lngdp |   .3214684   .1622703     1.98   0.059    -.0127336    .6556703
   lag_lnpax |  -.0359595   .0452352    -0.79   0.434    -.1291231    .0572042
  lag_lnfare |  -.2082435   .0808619    -2.58   0.016    -.3747818   -.0417053
   lag_lngdp |   .0384788   .0549698     0.70   0.490    -.0747336    .1516913
       _cons |   1.070849   .3273444     3.27   0.003     .3966708    1.745028
------------------------------------------------------------------------------
```

Coefficient β_1 representing the short-run price elasticity indicates an elasticity of -0.39 and is significant at the 5% level. This elasticity is only marginally different from the SR elasticity calculated in the static model and confirms the previous findings. The theoretical derivable LR-elasticity of the ADL-model would be -6.6, which is not a reasonable value. I interpreted this finding as conformation of the assumption that there is no co-integration relationship.

Coefficient β_1, denoting the income elasticity of demand has a value of +.32, which is somehow away from the estimates of the static model and is maybe related to the exclusion of *ln(pop)* as interacting variable. The coefficient of *ln(gdp)* this time though, marginally fails to be significant at 5% level.

In terms of model fit, the ADL model does not perform better than its static counterpart. The value of R^2-adjusted is .34, leaving again more than 60% of the variation of the dependent variable unexplained. Compared to UK-DfT (2011), which estimates analogous models and has model-fits of above .6, the model underperforms.

The model passes all diagnostic tests as shown in Appendix 7.

7.8 Discussion of the Results

Addressing RQ1 it can be stated, that the estimated *own-price elasticity of demand* for air passenger transportation in the domestic Norwegian network is:

-0.36 in the short-run.

This estimate is derived from the static model at a high significance level. The demand for air travel on an aggregated domestic level can therefore be described as price inelastic.

The estimated short-run elasticity is backed up by the findings of the ADL model, which yielded to a similar estimate. Moreover, following the implementation of *break* as a dummy variable, all the model specifications tested indicate significant short-run price elasticity in the narrow range of -.34 and -.39. This increases my confidence in the robustness of the estimated SR-elasticity. Compared to previous research findings discussed in the literature review, this elasticity is within the expected margin (i.e. -0.2 and -0.54) when it comes to benchmark it with studies referring to the same market (Rekdal (2006), TØI (2002) and Voldmo, Nordang, and Hamre (2007)). Those studies report almost equal or slightly higher elasticities, which can however, contrary to my findings, directly be interpreted at long-run elasticities. If one interprets my finding strictly as short-run elasticities, one can argue that the demand is slightly more price elastic than indicated by the previous studies.

Early in the analysis the variable representing *population* turned out to be insignificant or showed an incorrect prefix. I was not able to identify a model specification for which

population has been a significant explanatory variable for demand with the “right” prefix. Moreover, the implementation of the variable *paxcap* did not yield to deviating coefficients for other regressors. An additional test with the dependent variable and all regressors in a “two-times differenced configuration” did not change the situation. This led me to the conclusion, that the *ln(pop)* is indeed not a relevant determinant of demand in the particular setting of this analysis.
The two variables representing *substituting modes of transportation*, *ln(rail)* and *ln(car)* have also not turned out to be significant explanatory variables. After the brief discussion of substituting modes for long-distance travel in Norway in section 2.5, this result is not surprising for rail passenger transport. Travelling by car should intuitively be more important in this context. This analysis however, does not provide an indication that would foster such an assumption. Addressing RQ 5, it can be summarized that the present analysis does not find evidence for a significant impact of price variations in rail tickets or car ownership costs on the demand for air travel in Norway.

The *income elasticity of demand* for air passenger transportation was estimated to be approximately +.41. Regarding the actually used model specifications, this elasticity had to be interpreted as short-run elasticity. Benchmarking the derived elasticity to a vast body of previous findings reported in the literature gives the impression that the value is at the lower end of the scale. This low income elasticity would indicate a “fully matured” market with only minor growth rates (Graham 2000), which would not be in line with the reported average growth rates of 4.1% for the domestic segment (section 2.4). On the other hand, Gallet and Doucouliagos (2014) study “… the disparity in estimates of the income elasticity of air travel across the literature” by performing a meta-analysis and claim that different model specifications and data estimation techniques significantly determine the magnitude of the income elasticities found. Starting with a ‘baseline’ income elasticity of +1.186, several adjustments for controlling study characteristics drive the elasticity up or down. Applied to the characteristics of my analysis (i.e. linear and dynamic model specifications, airfares included, time series analysis), the baseline elasticity declines drastically and the value of +.41 as SR-elasticity seems reasonable.
In reference to RQ 6, it can be stated that this analysis does not find evidence for the existence of a co-integration relationship between demand for air passenger transportation in the Norwegian domestic sector and airfares. First, following the recommended testing procedure, I was not able to find a stationary linear combination of both processes. Second,

the additional estimation of an ADL model did not yield significant results for the LR elasticity. Significant LR-elasticities could have been interpreted as indicative of an existing co-integration relationship, and hence would have fostered the assumption that the unit root tests in this analysis simply failed to detect the stationary linear combination.

7.9 Conclusion and Limitations

This analysis examined the own-price elasticity of demand for air passenger transportation on the Norwegian domestic network, on the basis of secondary, annual, aggregate time series data for the period between 1981 and 2013. A double-logarithmic static model was applied. The demand model revealed that demand was price inelastic in the short-run with an elasticity estimate of -0.36. The result is consistent with the findings of previous studies.

The findings of this analysis updated the scarce knowledge about elasticities on the national aggregated level in Norway and indicated that the demand was only slightly more price elastic than what was assumed in the NTM/RTM calculations.

The findings of this analysis come along with a quite high degree of uncertainty, caused by the small sample size of the data at hand. Better conclusion might have been drawn if the available data would have allowed a bigger sample size. For example, monthly observations would have permitted to benefit from higher variance in variables and may have “linked” changes in e.g. car ownership costs to demand changes for air travel. Furthermore, the phenomena jointly represented by the variable *break* might have been disaggregated and associated to a specific event, in an analysis with monthly observations. Likewise, another more powerful methodology to analyse co-integration relationships between several variables at the same time could have been used. Unfortunately, this “Johansen Methodology” consumes many degrees of freedom (Sørensen 2005) and was therefore not applicable here. The earlier discussed issue of the partial “mismatch” between demand and airfare data poses another weakness of this analysis. The airfare data is sourced from a distinct group of routes, whereas the demand information for particular routes is not available for the years before 2002. Finally, the data employed here do not allow estimating separate elasticities with regard to travel purpose.

Therefore, it seems appropriate to continue with the analysis by employing post-2002 datasets, which have other shortcomings but permit the avoidance of the limitations of this particular analysis.

8.0 Analysis 2 - National Demand - Quarterly Data from 2006-2014

The following sub-analysis examines the differences in own-price elasticity of demand between the two distinct traveller groups, business and leisure travellers. Economic theory suggests that the demand for leisure air travel should be more price elastic than the demand for business-related travel. A discussion of the underlying causes was provided in section 4.2. This sub-analysis focuses on answering the following question:

RQ 1: How price elastic is the demand for passenger air travel in Norway on the national aggregated level?
RQ 3: Do the price elasticities differ between the business and the leisure segment?
RQ 4: Has the price elasticity changed in the recent past?
RQ 5: Is the demand for air travel in Norway significantly influenced by the price for other modes of passenger transportation?
RQ 6: Are the demand for air travel in Norway and its price co-integrated processes?

The dataset for this analysis has a limited sample size and comprises 36 quarterly observations extending from Q1/2006 to Q4/2014. The restricting factor here is the availability of airfare data, which is distinguished in business and leisure rates. The low sample size limits the amount of explanatory variables that can be included in a possible demand model to seven. The analysis will therefore focus on commonly used explanatory variables mentioned in the literature: airfare (*fare*), Norwegian GDP as proxy for economic state (*gdp*), mean household income as income proxy for leisure traveller (*inc*), Norwegian population (*pop*), price for travel by train (*rail*) and fuel costs as proxy for car travel costs (*fuel*). Furthermore, several dummy variables are considered. All explanatory variables are assumed to be exogenous[43].

The 'pre-tests' for this sub-analysis included the testing of different functional forms as mathematical specification of the regression equations (i.e. 'liner', 'log-linear', 'linear-log' and 'double-log'). I decided to use the 'double-log' model again. I furthermore inspected the correlations coefficients of all the relevant variables before starting the analysis. As shown in Appendix 8, care must be taken when the variable *inc* is used in combination with *gdp* or *pop* as possible multi-collinearity issues may arise. Next, I visually inspected the scatter plots also shown in Appendix 8 to identify possible outliers in the dataset, separated for the aggregated and the segmented markets. There is no evidence for outliers

[43] For a discussion and testing of endogeneity see Appendix 1.

in the dataset. Finally, I adjusted all the variables reflecting monetary values with the consumer price index (2010=100%) sourced from SSB.

8.1 Introduction of Data and Descriptive Statistics

The data for the analysis stems from different sources.

The airfare dataset was obtained from Statistics Norway (SSB 2015e). The dataset is based on the producer price index (PPI) 'passenger air transport', which describes the quarterly development of airfares offered by the Norwegian airlines Widerøe, SAS and NAS. Charter airlines or other internationally scheduled airlines do not contribute information to the index. With respect to the travel purpose, the index can be further divided into three sub-indexes:

–'business travel' (denoted by the variable *fareb*),

–'leisure travel' (denoted by the variable *farel*), and

–'total/without segmentation' (denoted by the variable *faret*).

To construct this index, price information from a mixture of 11 national and nine international routes are collected. The airlines are obliged to report data uniquely separated for travel purposes and domestic/international travels[44]. Unfortunately, only the data separated for travel purpose has been published. According to Gjertsen (2015), the distinction in business and leisure fares is a one-to-one representation of full-flexible vs. non-flexible airfares.

Contrary to the airfare index used in the previous sub-analysis, the PPI-based index does not reflect the 'end-prices' that consumers have to pay when they purchase a ticket. The index rather describes the development of producer prices that are used to express the turnover of a producer not including monetary amounts, which have to be collected on behalf of a third party (i.e. taxes, security fee). This practically means that an increase in security fee would not impact the PPI-index. The SSB-sourced index is not price adjusted and uses 2010 as base year (i.e. 100%). Figure 8-1 visualizes the development of all three sub-indexes after price adjustment for 2010.

[44]For further details about methodology used to construct the index see (SSB 2015h).

Figure 8-1: Analysis 2 - Development Segmented Airfares between Q1/2006 - Q4/2014

Source: Adopted from (SSB 2015e)

It can be seen that business rates (fareb) underperformed in comparison to the leisure segment fares (farel) and the cumulated market (faret). Following the adjustment of prices, business fares were cheaper in 2014 than they were in 2006, a conclusion which was already drawn from the National Travel Survey data as discussed in section 2.6.

The data underlying the variables *gdp, inc, pop, rail* and *fuel* were all obtained from Statistics Norway. The variable *gdp* reflects the Norwegian (total industry) GDP, whereas the variable *inc* maps the mean average household income in Norway. The population numbers, which were gathered from the Statistics Norway website, include all age cohorts. The rail ticket prices are based on the CPI sub-index 'passenger transport by railway' with 1998 as the reference year. The development of car fuel costs is derived from the CPI sub-index 'fuels and lubricants for personal transport equipment' also available on SSB's website. The index does not depict the total car ownership costs, since it is limited to the observation of fuel price fluctuations. Anyway, I decided to use the fuel index as proxy for car ownership costs, since the other and more precise information on a quarterly basis are not obtainable.

The dummy variable *crisis* represents the period between Q3/2008 and Q3/2010. Although the global financial crisis, as seen, had actually started much earlier and even as some authors argue that the crisis still persists, I chose this distinct period after a look at the variables *paxt* and *gdp* plotted against time (Figure 8-2 and Appendix 10). The decrease in demand after Q3/2008 and a decline in Norwegian-GDP after Q4/2008 are obvious. After Q3/2010, a trend-recovery seems to have occurred. Finally, three other dummy variables—*quart1, quart2 and quart3*—are included in the analysis representing Q1, Q2, and Q3 of each year.

The quarterly demand datasets are a combination of data sourced from eurostat (2015) and several editions of the Norwegian National Travel Survey (NTS) (TØI 2013). I first collected the route-specific passenger numbers from the Eurostat database, which records the number of passengers on board as reported by aircraft pilots prior to departure.
The explicit routes are the same as used in the construction of the airfare price index. Unfortunately, the available passenger numbers are not differentiated into business and leisure travellers. Therefore, in a second step, I used the percentage share of business and leisure traffic as given in the NTS to calculate the number of passengers for each segment and each quarter. In this process, I accounted for the different distribution of business and leisure passengers on domestic and international flights. The resultant differentiated quarterly demand is illustrated in figure 8-2, where:

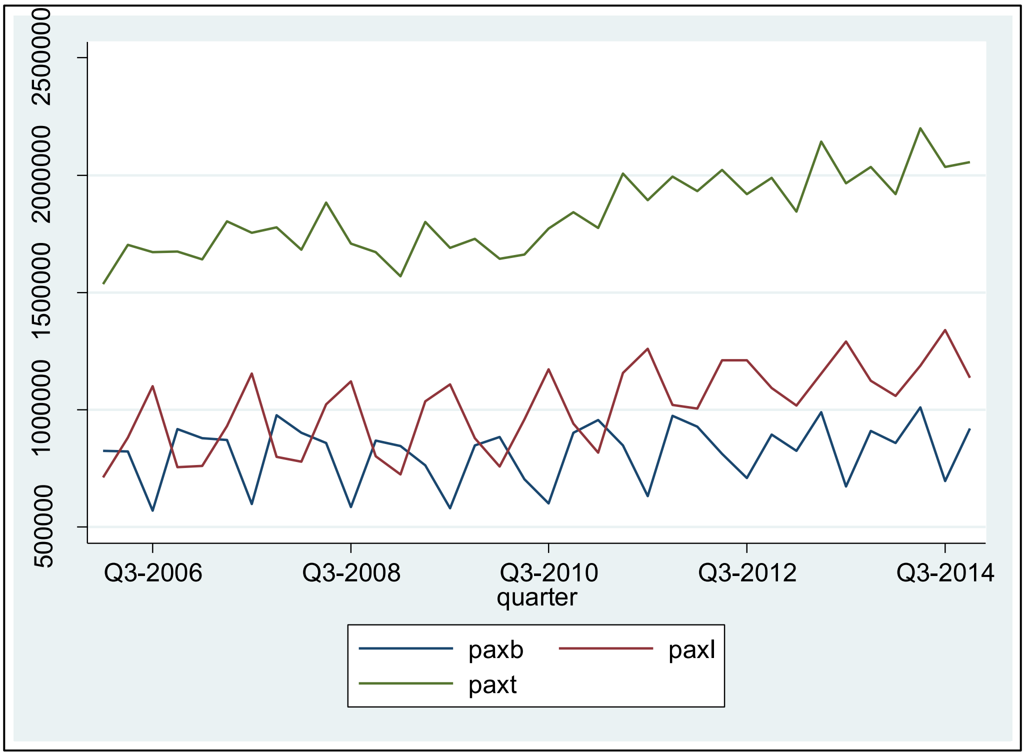
–*paxb* denotes the demand for business travel,

–*paxl* denotes the demand for leisure travel, and

–*paxt* denotes the total demand.

One can observe that the demand within the two traveller segments fluctuates significantly and follows a seasonal pattern. As demand for leisure travel usually rises in Q2 and peaks in Q3, business travel demand sees its absolute low in Q3. The opposite holds for Q4 and Q1. Consequently, the aggregated total demand dampens the contrary fluctuations of the two sub-segments.

Figure 8-2: Analysis 2 - Quarterly Demand Q1/2006 to Q4/2014 for Segments



Source: Adopted and combined from eurostat (2015) and TØI (2013); (in pax on board during departure)

It is furthermore eye-catching that the demand for leisure travel has ‘disconnected’ from the development on the business market since 2006, a phenomenon already discussed earlier. In Appendix 9, an additional graphic visualises the demand fluctuations of the business segment. Owing to the other scale in that graphic, one can clearly observe a significant decline in the demand for business travel in the years that are identified as *crisis*.

Since the NTS datasets contain only observation for the years 2005, 2007, 2009, 2011, 2012 and 2013, I was forced to interpolate the values for the missing years. The share of business-related vs. leisure-related travel for the missing quarters was thereby calculated as the average of the same quarter the year before and the year after the missing observation. This creates some degree of uncertainty for the analysis. It was not possible to avoid this weakness due to the lack of alternative sources of segment-specific data. However, the inter-year fluctuations of traveller segment distributions have changed quite slowly in the years under consideration. I therefore decided to continue with the analysis by accepting this shortcoming.

A brief descriptive summary of all the variables that are intended to be used in this sub-analysis is given in a table, which is in order to save space provided in Appendix 9.
For the further analysis, all the variables were transformed into their logarithmic form. This was done to benefit from the fact that after such a transformation all estimated coefficients can be directly interpreted as elasticities. The time plots of the logged form for the variables *gdp, inc,* and *pop* can be seen in Appendix 10.
A first look at those plots leaves the impression that all variables follow a trend.

8.2 Formulation of Expectations

The expectations for this analysis concerning the prefixes and the magnitude of the coefficients for the total demand are in line with the prospects formulated for the first sub-analysis. For the aggregated level, I do not expect to find dramatic changes compared to sub-analysis 1. In addition, I expect to find higher price sensitivity of demand for the leisure market than for the business market. As a prerequisite for this, I have to be able to find significant differences in elasticities among the segments. Moreover, I expect to see significant impacts of the seasonal dummy variables. Keeping in mind the segmented demand plotted over time, I expect to find opposing prefixes for the dummies between the two segments. Finally, seeing the small sample size and considering the expected strong influence of the dummy variable, I anticipate having only a minor amount of variation left in the dependent variables that could be explained by other regressors.

8.3 Testing for Order of Integration

Appendix 11 provides an overview of the stationary test results (ADF; PP) for the logged level data and, where necessary, for the differenced form of the logged data. In order to reject H_o, the value of the t-statistics has to be smaller than the critical value given at the bottom of the table.

The null hypothesis can be rejected for most of the independent variables. Only ln(*rail*) already appears to be stationary in their level forms. The three sub-variables ln(*fareb*), ln(*farel*) and ln(*faret*) follow a unit root process, and are thus non-stationary. The results for ln(*pop*) and the variable represents the total demand ln(*paxt*) are somehow special. Both variables appear to be trend-stationary, which means that their mean changes with time at a constant rate and that once the time trend is 'removed', both variables are stationary. In the case of ln(*pop*), this result is not surprising owing to the fact that the Norwegian population increases in a stable manner over time and also because this analysis covers a rather short period of time, which will not allow the population to fluctuate significantly. In the case of ln(*paxt*), the short time period under consideration might also have led to these test results. However, this outcome can be questioned. First, it does not seem intuitive why ln(*paxt*) is trend stationary, while its constituting parts ln(*paxb*) and ln(*paxl*) are stationary without trend. One could therefore assume that at least ln(*paxb*) or ln(*paxl*) must also contain a trending component, which was not detected by the tests. Second, knowing about the test results of the previous sub-analysis, one could assume that ln(*paxt*) also contains a drift moment. A longer sample size might have allowed discovering that. However, owing to data limitation, I will have to accept this uncertainty and continue the analysis on the basis of the test findings.

It can be summarized that only the one variables ln(*rail*) is stationary in level. Furthermore, ln(*pop*) and ln(*paxt*) could be made stationary after de-trending. All other variables reach stationarity properties after one time-differencing. The resulting order of integration for all the variables is summarized in Table 8-2.

Table 8-1: Analysis 2 - Order of Integration

Variable	Order of Integration
ln(*paxb*), ln(*paxl*)	I(0)
ln(*paxt*)	I(0)*
ln(*fareb*), ln(*farel*), ln(*faret*)	I(1)
ln(*pop*)	I(0)*
ln(*gdp*)	I(1)
ln(*inc*)	I(1)
ln(*rail*)	I(1)
ln(*fuel*)	I(1)

*** After removing the deterministic trend.**

The possible existence of a co-integrated relationship between the demand and the fare variables can be already ruled out here because of the indicated stationarity properties of the demand variables. As discussed earlier, the first requirement for cointegration testing is that the variables in mind have to be integrated in the same order. It has to be concluded that the datasets used in this sub-analysis did not provide evidence of a cointegration relationship. The second step of cointegration testing, which is the search for a stationary linear combination of the variables, becomes pointless.

In regard to the developed analysis scheme presented, the further analysis will employ an unbalanced regression approach first and then estimate static models separated for the total market and the two traveller sub-segments.

8.4 Model Building and Estimation: Unbalanced Regression

'Unbalanced regression' means a regression equation for which the dependent and independent variables have different orders of integration. In an early discussion on this, Pagan and Wickens (1989) claimed that an unbalanced regression equation in general is not problematic, but that one has to be careful against creating a 'mis-specified' model. The authors argue that an unbalanced regression model makes sense only when a *stationary error term is achieved*. Otherwise, the model suffers from mis-specification, because the left and the right side of the regression equation do not match in their 'growth accounting'. The authors furthermore suggest that such an unbalanced regression might yield to meaningful results, if at *least two non-stationary independent variables* are included in the regression. This is needed to explain the trending component of one non-stationary variable by the trending component of the second I(1)-variable and thus make the two I(1)-variables suitable regressors for the dependent variable. On the basis of this elaboration, Baffes (1997) focuses on the special case where a dependent variable is stationary (or trend-stationary) and shall be explained by non-stationary variables. The researcher claims that in order to consider the results of the unbalanced regression as reliable; two additional properties should be achieved. First, *the* predicted value of the dependent variable should have the same *stationarity properties* as the observed variable, and second, the *variance* of the observed values and the predicted dependent variable should be equal.

Following this reasoning, the estimated model of my subsequent unbalanced regression analysis has to be tested for *(1)* stationarity of the error term, *(2)* inclusion of at least two non-stationary regressors, *(3)* equal stationarity properties of the predicted and observed dependent variable and (4) equal variances for the predicted and observed values of the dependent.

In the concrete application of this unbalanced regression approach to the datasets, it turned out to be extremely complicated to design a model, which yields stringent results for the the two sub-segments. In fact, it was not possible to design unbalanced models for the segmented demands, which showed significant effects of price fluctuations on demand and meaningful estimates for others included regressors at the same time. I therefore dropped the application of an unbalanced regression analysis for the business and leisure markets. The only remaining possibility to analyse both sub-segments in respect to different elasticities is therefore the application of a static model specification, which will be done in a later section.

For the total market, however, the unbalanced regression was performed. The results were very sensitive to the concrete application of the explanatory variables because of the very limited sample size of 36 observations. Assuming that the model will have a DL-specification (i.e. in order to derive LR-elasticities), the amount of available observations is reduced by one for every lagged term of the regressor ln(*faret*) included in the regression equation. Furthermore, the dataset consists of quarterly data, which means that one has to account for this seasonality in the regression. This is done by including dummies in the regression equation, which again are 'observation-consuming' and reduce the amount of 'life' regressors that can be included in the regression even more. These limitations led me to the conclusion that a high amount of uncertainty has to be attributed to the findings of the analysis. Nevertheless, I hoped to generate some insights in order to foster or disprove the results of the previous sub-analysis and to demonstrate the application of the unbalanced regression approach in my analysis.

I started again with an 'over-specified' model specification to get a basic 'idea' of possible cause and effect relationships. In order to avoid disturbances from the lagged terms of ln(*faret*), I started without a dynamic component. The regression result of this 'over-specified' model can be seen in Appendix 12. What is particularly interesting is the very high R^2- adjusted of .92 and that a lot of the regressors are significant at the 5% level. This is in line with the argumentation so far, and points towards the problem of spurious regression.

During the further stepwise regression of the model, several regressors had to be excluded to bring the "regressors/number of observations-ratio" down. In order to meet the requirements of having at least five observations per explanatory variable, accounting for seasonality and having ‘space’ for the inclusion of lagged terms, I had to drastically reduce the number of independent variables to only one. I decided to choose the most commonly used regressor ln(*gdp*). Alternatively, I replaced ln(*gdp*) by ln(*inc*), which led to the general finding that demand was more sensitive to the changes in income than to the changes in gdp. The results for the airfare coefficient, however, were not affected by this replacement. I therefore decided to stick to ln(*gdp*), because the interpretation of the coefficient gdp could then be done in the light of the findings of the previous sub-analysis. Furthermore, I was able to exclude the dummy variable for Q3 since the demand in Q3 was not significantly different from the reference quarter Q4.

The linearized form of the DL-model after logarithmic transformation and differencing can then be specified as:

$$\Delta\ln(paxt_t) = \beta_0 + \beta_1\Delta\ln(fare_t) + \beta_2\Delta\ln(gdp_t) + \beta_{3\ldots n}\Delta\ln\left(fare_{t-1\ldots t-(n-2)}\right) + \beta_{n+1}quart1 + \beta_{n+2}quart2 + \varepsilon$$

It remains to determine the exact amount of lagged fare terms that should be included in the model so as to derive the long-term price elasticities. Economic theory suggests the existence of such lagged effects, but there is a lack of a common understanding on how long it takes for a price variation to completely materialize in demand. Considering that this analysis treats quarterly data, the effect should be captured within a few lagged terms. I therefore decided to test the model with three different specifications:

Model A: One lagged term $\beta_3\Delta\ln(fare_{t-1})$,
Model B: Two lagged terms $\beta_3\Delta\ln(fare_{t-1}), \beta_4\Delta\ln(fare_{t-2})$,
Model C: Three lagged terms $\beta_3\Delta\ln(fare_{t-1}), \beta_4\Delta\ln(fare_{t-2}), \beta_5\Delta\ln(fare_{t-3})$

The models are than compared by using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The assessment of different lag lengths for DL models with these criterions is popular in the literature (e.g. Kopsch (2012a). The different results of the three models are reported in Output 8-1.

Output 8-1: Analysis 2 - DL-Model Comparison with Information Criterion

```
. estimates table Model_A Model_B Model_C, stats (r2_a aic bic)

------------------------------------------------------------
    Variable |   Model_A       Model_B       Model_C
-------------+----------------------------------------------
     ln_faret |
          --. |  -.25393716    -.27369583    -.29037376
          L1. |  -.15840278     .00154513    -.01822836
          L2. |               -.18408673    -.03744338
          L3. |                              -.1672636
             |
      ln_gdp |    .6261263      .5972658     .54700768
      quart1 |  -.04888557    -.05032797    -.04497074
      quart2 |   .06160538     .06208962     .06145628
       _cons |   7.6014761     8.2057384     9.1674795
-------------+----------------------------------------------
        r2_a |   .86629627     .87307422      .8759448
         aic |   -128.8485    -129.81072    -129.85991
         bic |  -119.86946    -119.33517    -117.88785
------------------------------------------------------------
```

In order to account for the sensitivity of AIC and BIC towards different numbers of observations, I restricted the dataset for this comparison to 33 observations. It can be seen that AIC prefers the models with more leg length, but BIC tends to prefer the model with only one lagged term. The differences in the information criterions, however, are only marginal. The same counts for R^2- adjusted. Faced with the situation that one period in the dataset represents one quarter of a year, it seemed reasonable to me to choose the model with two lagged terms. The first reason was because of the on average good scores in AIC, BIC and R^2- adjusted. Second, economic theory suggests that consumer behaviour adjustments need time. Consequently, only one lagged term (Model A) may not be enough to capture the entire long-run effect. Last, comparing the coefficients of Model B with those of Model C, it becomes obvious that a third lagged term does not lead to an increased total long-run effect. With regard to the study's objective, deriving short- and long-run price elasticities both, Models B and C produced almost the same estimates. Since Model B contains the same information with less regressors and scores better in the information criterions, I chose it for further analysis. The specified DL model therefore finally takes the form:

$$\Delta \ln(paxt_t) = \beta_0 + \beta_1 \Delta \ln(fare_t) + +\beta_2 \Delta \ln(fare_{t-1}) + \beta_3 \Delta \ln(fare_{t-2}) \\ + \beta_4 \Delta \ln(gdp_t) + \beta_5 quart1 + \beta_6 quart2 + \varepsilon$$

Output 8-2 reports the regression results for this model, after I relaxed the constraint of only 33 observations to again utilize the maximum of the available observations.

Output 8-2: Analysis 2 - Estimated DL Model

```
. regress ln_paxt ln_faret  L.ln_faret L2.ln_faret  ln_gdp  quart1 quart2

      Source |       SS       df       MS              Number of obs =      34
-------------+------------------------------           F(  6,    27) =   39.69
       Model |  .223696865     6  .037282811           Prob > F      =  0.0000
    Residual |  .025359792    27  .000939252           R-squared     =  0.8982
-------------+------------------------------           Adj R-squared =  0.8755
       Total |  .249056656    33  .007547171           Root MSE      =  .03065

------------------------------------------------------------------------------
     ln_paxt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_faret |
         --. |  -.2474817   .1184683    -2.09   0.046    -.4905585   -.0044048
         L1. |  -.0442433   .1652575    -0.27   0.791    -.3833237     .294837
         L2. |  -.1807949   .1169683    -1.55   0.134     -.420794    .0592042
             |
      ln_gdp |   .5546996   .0964085     5.75   0.000     .3568857    .7525135
      quart1 |  -.0521874   .0130706    -3.99   0.000    -.0790062   -.0253687
      quart2 |    .059016   .0135891     4.34   0.000     .0311334    .0868986
       _cons |   8.875119   1.615875     5.49   0.000     5.559617    12.19062
------------------------------------------------------------------------------
```

The regression results indicate that demand for air passenger transportation in Norway at an aggregated national level is price inelastic. The short-run price elasticity is estimated to be -.25. The coefficients representing the long-run component have the expected prefixes. Surprisingly, the coefficients somehow indicate a weaker effect for the first lagged term and a stronger adjustment effect for the second period. This means that most of the customers either react instantaneously to price changes (within the period) or after a period longer than one year. The same phenomenon can be found in Kopsch (2012a). The coefficients, however, are not individually significant, which raises the question of whether the total long-run effect is significant or not. In order to prove the significance of the coefficients, I performed the variable transformation procedure as described with [5.6]. The resulting regression output can be seen in Appendix 13. The decisive coefficient is significant and contains the entire long-term effect, which is -.47.

The coefficient denoting the responsiveness of demand to changes in GDP is estimated to be +.55. The coefficient has the expected prefix and, in magnitude, seems not too far from the results in the first sub-analysis. The coefficients of the dummies indicate that in Q1 the average demand is below and in Q2 above the demand in Q4. This is consistent with the impression gained during a look at the variable *paxt* plotted against time.

8.5 Diagnostic Tests: Unbalanced Regression

It remains to elaborate whether the presented model satisfies the above-discussed requirements for an unbalanced regression. Appendix 14 summarizes the results, which are not entirely conclusive.

In terms of requirements for an unbalanced regression, one can state that first the residuals of the regression are stationary, which is an initial requirement drawn from (Pagan and Wickens 1989). Second, the requirement of having two non-stationary variables in the regression equation is satisfied with ln(*faret*) and ln(*gdp*). Third, the predicted values for the dependent seem to be trend-stationary as desired by Baffes (1997). Last, however, the statement that the variances of the fitted and the observed values are equal cannot be supported by the results of the variance ratio test. The f-statistic is 1.22, which is not far, but still somehow off the wanted value of '1'. Kopsch (2012a) argues in a comparable case that his model still seems reliable.

During the diagnostic tests (Appendix 15), I discovered that the residuals of the model are likely not normally distributed, which casts a shadow on the reliability of the estimates. Furthermore, I noticed that the model suffers from serial correlation. In order to correct this drawback, I applied a Prais-Wisten regression, as suggested by Kopsch (2012a). Output 8-3 illustrates the results.

Output 8-3: Analysis 2 - Prais-Winsten Regression: DL-Model corrected for Serial Correlation

```
Prais-Winsten AR(1) regression -- iterated estimates

      Source |       SS       df       MS              Number of obs =      34
-------------+------------------------------           F(  6,    27) =  629.88
       Model |  3.49829913     6  .583049855           Prob > F      =  0.0000
    Residual |  .024992552    27   .00092565           R-squared     =  0.9929
-------------+------------------------------           Adj R-squared =  0.9913
       Total |  3.52329168    33  .106766415           Root MSE      =  .03042

------------------------------------------------------------------------------
     ln_paxt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_faret |
         --. |  -.2275967   .1192874    -1.91   0.067    -.4723543    .0171609
         L1. |  -.0890015   .1564441    -0.57   0.574    -.4099983    .2319953
         L2. |  -.1662479   .1157595    -1.44   0.162    -.4037667    .0712709
             |
      ln_gdp |   .5239063   .1026645     5.10   0.000     .3132562    .7345564
      quart1 |  -.0506901   .0126628    -4.00   0.000     -.076672   -.0247081
      quart2 |   .0570882   .0132176     4.32   0.000     .0299678    .0842085
       _cons |   9.351437   1.722663     5.43   0.000     5.816824    12.88605
-------------+----------------------------------------------------------------
         rho |   .1456527
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    1.776568
Durbin-Watson statistic (transformed) 1.993782
```

The resulting coefficients for the short-run and long-run price elasticities are only slightly different from those of the regression with serial correlation. The short-run coefficient now indicates an elasticity of -.23 and the long-run coefficient gives an elasticity of -.48. The income elasticity is now estimated to be +.52, which is also only a slight deviation from the previous finding. The dummy variables points towards the right direction, as they did in the serial correlated model.

Summarizing this section, one can state that I have derived a short-run as well as a long-run elasticity of demand for air passenger transportation, which match with the findings of the previous sub-analysis. Keeping in mind that the former analysis yielded to an elasticity of -.36 and assuming that this value might represent medium-term elasticity rather than a purely short-run elasticity, the results of the unbalanced regression analysis are fostered. Nevertheless, one cannot ignore the fact that this analysis contains a high degree of uncertainty. This ambiguity is for several reasons. First, the unbalanced regression approach is not very prominently discussed in the literature and the reliability of this approach seems questionable. In the worst case, the unbalanced regression approach exemplifies nothing other than the application of a 'traditionally' regression analysis, meaning the analysis is suffering from spurious regression. Second, the diagnostic tests of the model did not yield perfectly satisfying results. Finally, the small sample size of the dataset at hand limited the possibility to design more complex and more reliable demand models.

Next, I turn towards the static model specification to elaborate on the possible existence of deviating price elasticities for leisure and business travellers.

8.6 Model Building and Estimation: Static Model

As stated earlier, the unbalanced regression approach did not come up with meaningful results for the analysis of the separated traveller segments. Therefore, I had to take recourse to an analysis with static model specifications.

The starting point of the investigation was to find an appropriate way to generate results, which enabled me to answer the research task at hand, namely finding evidence for different price elasticities among the two traveller segments.

One core limitation was again posed by the small sample size of the available dataset. This was for several reasons. First, the dataset treats quarterly data. In order to account for that seasonality, usually, quarterly dummies have to be included. This is a standard procedure often applied in a comparative analysis (e.g. Helgheim (2002), who accounted for monthly seasonality). The utilization of seasonal dummy variables in regression equations thus has one major disadvantage—it consumes degrees of freedom and reduces the number of explanatory variables that can be included in the equation. Second, with only a small number of observations, the variation in the dependent variable over time is reduced; hence there are only a few variations that can be explained by the variation in regressor variables. However, the inclusion of dummy variables for the quarters will naturally yield regression results in which the dummies explain the overwhelming part of the variation in the dependent variable and 'draw away' cause and effect relationships from other explanatory variables (e.g. airfare).

In order to curb these issue as much as possible, one of my first concerns was to avoid seasonal dummies in the regression equation, and consequently 'save' the variation of the dependent for other demand determining factors. Besides the inclusion of seasonal dummies to account for seasonality in data, literature suggests the application of seasonal differencing (Wei 2006) as an alternative method. Contrary to the standard differencing equation [5.7], the seasonal difference is created by:

$$\Delta y_t = y_t - y_{t-4}$$

where the difference is formed in respect to the seasonal dimension of the dataset. In the case of quarterly data, the value of observation at time *t* is compared with the value of the variable at *t-4*. One consequence of this procedure is that the intra-year fluctuation in demand caused by seasonal effects disappears. Dummy variables in a de-seasonalized regression equation would turn out to be insignificant. This means that the purely seasonal effects of the quarters are removed, but the non-seasonal variations in demand are still present in the demand variable. Another effect described in the literature concerning seasonal differencing is that this procedure sometimes helps to transform non-stationary processes to stationary processes (Charemza and Deadman 1997). In the early stages of the analysis, I had assumed that the seasonal differencing of my data would lead to the stationarity of the dataset, similar to the stationarity achieved with 'standard' differencing technique (shown in Appendix 11).

The second concern that I tried to address before starting the analysis was to determine a procedure that would allow me to compare the two coefficients representing the price elasticities of the two segments. Both coefficients cannot stem from the same model, because one model is concerned with explaining the demand for leisure travellers, whereas the other model explains the demand for business travel by air. The implication is that the two models may contain different regressors. The question rises as to which are the ‘right’ regressors that can be included. For example, in order to explain demand for leisure traveller, household income seems to be a reasonable regressor. At the same time, GDP per capita may serve as a better explanatory variable for the business segment (Holloway 2008). Using different regressors in the two demand models may thus influence the estimates for the price coefficient in a way that they are hardly comparable. The only way to avoid this drawback is by designing entirely ‘complete’ models, which refer to models where all the contributing explanatory variables are included, whether they are significant in the regression equation or not (Kopsch 2015). This would come along with the property by which single coefficients (e.g. the airfare coefficient) would become insensitive to the addition or removal of other regressors. Consequently, the required ‘complete’ models would have to include a considerably high amount of explanatory variables, something that cannot be ensured with the short dataset available.

Because of this issue, I decided to try to indirectly identify the existence of different elasticities for the segments in the following way: I first designed a separate demand model for each segment. I chose the model specification that led to the highest possible R2-adjusted, included airfare as an explanatory variable and stayed within the limitation of five observations per explanatory variable. Diverting the use of explanatory variables between the two models was of no concern in this initial setting. The results of these two models are combined in Output 8-4. The term ‘S4.’ implies that the variables are seasonal-differenced.

It can be seen that the changes in leisure segment airfares significantly contribute to changes in demand for the leisure model. The respective coefficient has a value of -.241 and a t-statistics of -2.07, which correspond with significance at the 5% level. On the other hand, changes in business airfares were not found to significantly impact the demand for business travel. The coefficient of -.19 comes along with a t-statistics of -1.53, which indicates no significance at the 10% level.

Output 8-4: Analysis 2 - Static Demand Models with De-Seasonalized Data

	Model_leis~e b/t	Model_busi~s b/t
S4.ln_farel	-.2413099	
	-2.079003	
S4.ln_inc	1.565417	
	2.246854	
S4.ln_fuel	.0249179	-.6038002
	.1126615	-1.677694
S4.ln_pop	19.37708	-3.141874
	1.520524	-.2606128
S4.ln_rail	.1065442	
	.1786394	
S4.ln_fareb		-.197377
		-1.534909
S4.ln_gdp		.9665179
		2.873355
S4.ln_exrate		-.2770682
		-1.388649
_cons	-.2350276	.0256925
	-1.416779	.1719349
r2	.3674798	.3550971

(Leisure Demand = 1st column; Business Demand = 2nd column)

What became obvious by trying the different model specifications, however, was that both the magnitude of the coefficient for leisure airfare and the magnitude of the coefficient for business airfare were quite 'stable'. For leisure travel, an elasticity of -.24 was indicated, and an elasticity of around -.19 was estimated for business travel. Even though not significant, the coefficient for business travel had the correct prefix, and seemed in magnitude 'at the expected side' in comparison to the leisure coefficient.

Subsequently, I isolated the airfare coefficients of both models and compared the coefficients using the respective STATA applications[45]. The null-hypothesis of equal elasticities could not be rejected (Appendix 16); hence, the assumption that the two price elasticities are significantly different was not supported in this first analytical approach.

In the next step, I tested a variety of model pairs (i.e. business demand/leisure demand), in which only the dependent and the airfare variables differed. All other explanatory variables included were identical in the two models. Consequently, the demand model specifications were almost equal. Knowing that this would likely lead to omitted variable bias, I was interested to see how the estimated price elasticity in the two models changed with respect to the simultaneously changing regressors. I did this on purpose to account for the issue of different favourable explanatory variables for the two travel segments. Based on the findings of the earlier discussed separated demand models, my intuition behind this approach was as follows: If I failed to find significant differences in price elasticities across the model pairs (using a variety of equal demand model pairs), then I would take this as a good indicator of the fact that the present dataset does not provide evidence for different own-price elasticities of demand for the traveller segments.

[45] See STATA (2013b) for detailed information about the application of the 'surest' command to compare coefficients across different models.

The results of this approach gave no indication for a significant difference between the elasticities for leisure and business travellers. Actually, I was unable to identify one model specification for which the airfare coefficients turned out to be significantly different.
I concluded that based on the available data, no evidence could be found for diverting elasticities for the different traveller segments in Norway. This, however, does not mean that such a difference does not exist in the Norwegian air passenger transport market. It rather indicates that such a difference cannot be detected with the distinct data employed.

8.7 Diagnostic Tests: Static Models

Performing the diagnostic test for the two segmented demand models, I detected some 'unwanted' characteristics of the residuals. For example, the demand model for business travel suffered from serial correlation and indicated a tendency for abnormal distribution of the residuals. In an attempt to find the underlying issue for this, I finally turned towards the stationary properties of the data again. As discussed earlier, I initially assumed the stationarity of the processes after seasonally differentiating the data. However, I had missed confirming this assumption by employing the respective tests. In fact, performing test on the seasonal differenced variables ln(*fareb*), ln(*farel*), ln(*fuel*), ln(*gdp*) and ln(*inc*), it turned out that seasonal differencing had not made the processes stationary. Hence, it was likely that the use of these variables in an OLS had produced spurious regression results. I report my mistakes here, because I think that some additional insights can be gained from my failures.

In order to account for the shortcomings of the analysis, I turned towards the two initial model specifications for the two traveller segments again. This time, however, I applied a 'standard differencing procedure' and made all the variables stationary. Then, I re-ran the regression with the differenced forms of the variables - once including quarterly dummies and once without the dummies. The regression outputs are provided in Appendix 16.

One can see that the appropriate differenced models yield completely different results. In none of the models was airfare significant at the 5% level. Furthermore, in three out of the four models, the airfare coefficient has the 'wrong' prefix, which indicates that an increase in airfare leads to an increase in demand. Consequently, I tried to re-design the models so as to come up with some meaningful models that could explain demand with a combination of differenced variables. Ultimately, I was unable to identify such a model, neither for leisure nor for business travel demand.

I interpreted this in a twofold manner. First, the general finding that there were no indications for the different elasticities among the travel segments was still valid. Second, the analysis with the 'only' seasonal differenced data most likely suffered from spurious regression. Keeping in mind that most of the former studies on own-price elasticity of demand in air transportation did not report on how the stationarity properties of the employed variables were addressed or whether they were addressed at all, increased my scepticism towards their reported results.

8.8 Discussion of the Results

Addressing RQ1, it can be stated that the *own-price elasticity of demand* for air passenger transportation in Norway is estimated to be:

-0.23 in the short run and
-0.48 in the long run.

These estimates were derived from the DL-type model specification, using an unbalanced regression approach. Both estimates were found at a significance level of 5%. Therefore, the demand for air travel on an aggregated domestic level can again be described as price inelastic.

The estimated elasticities are thereby within the expected range - in regard to previous research findings as well as with respect to the results of the first sub-analysis. However, the previously derived short-run elasticity (-.36) seems to be exactly in between the estimated SR- and LR-values here. Several reasons could have influenced this mismatch between the two short-run elasticities. First, I have already suggested that the analysis of the annual data (as in sub-analysis 1) may have caught some long-run effects; even though mathematically seen, the derived elasticity is a short-run elasticity. If such a conclusion is valid, then one should expect to find a 'true' SR elasticity of $0>\varepsilon_{SR}>-.36$. Second, one has to keep in mind that the airfare data used here differs from the price data used in analysis 1. It would therefore be surprising to see exactly the same elasticity estimates. Third, this sub-analysis treats a period of time that is far more recent than analysis 1. Keeping in mind the argumentation concerning the effects of mature markets on income and price elasticity, it seems not far fetched to see a slightly lower elasticity for this analysis.

Exclusively seen from the mathematical perspective however, it remains to state that the estimated SR elasticity of this analysis indicates a slightly less price-elastic demand than the average elasticity estimated for the period 1981–2013. I think it would be unsound to state on the basis of only this single analysis result that the own-price elasticity in general has decreased in the last couple of years. Thus, what can be best claimed is that this analysis has found indications for such a tendency (RQ 4).

In the context of Research Question 3, it has to be stated that no indication was found in favour of significantly different price elasticities with respect to different travel purposes. Two fundamental causes could explain this finding. First, there is indeed no difference in price elasticity between business and leisure travellers, and second, the method of this analysis was not able to reveal the different elasticities. The latter explanation is supported by the fact that only a short dataset was used in the analysis, which limited the degree to which cause-and-effect relationships could be measured. For the alternative explanation that no significant difference exists, might argue that business travellers have increasingly started to change their travel behaviour. As early as in the beginning of this century, Mason (2000) and Mason (2001) described the tendency of business travellers on intra-European flights to switch from traditional business- and first-class tariffs to economy rates. The motivation behind this tendency is the need to cut corporate travel budgets as well as to accept low-cost carriers as suitable substitutes for traditional full service carrier business travel on short-haul flights. If such a switch has indeed occurred, it would be accompanied by two important implications for price elasticities. First, the reduction of corporate travel budgets as such would have increased the sensitivity to price changes for business tickets. Second, a noteworthy shift of business travellers to leisure airfares would at the same time have reduced the price sensitivity in the leisure market. Both facts point towards the same direction - the convergence of business and leisure price elasticities.

As for the results of my analysis, I would assume that both the data issue and the changing travel behaviour might have contributed to a certain degree. In order to clarify the situation, there is a need for additional research.

The *income elasticity of demand* for air passenger transportation was estimated to be approximately +.52 on the aggregated level. Regarding the actual model specifications used, this elasticity had to be interpreted as short-run elasticity. Compared to the findings of the first sub-analysis, this estimated elasticity is slightly higher and well within the range of expectation.

The two variables representing the *substituting modes of transportation*, here *ln(fuel)* and *ln(rail)*, have again turned out to be no significant explanatory variables for air travel demand (RQ 5). This is in line with the expectations and the earlier findings.

In reference to RQ 6, it can be finally stated that this analysis does not find evidence for the existence of a cointegration relationship between demand for air passenger transportation and airfares in Norway. The analysis of the two decisive variables revealed different orders of integration among the processes; hence, the first requirement for cointegrated processes was not satisfied.

8.9 Conclusion and Limitations

This sub-analysis examined the own-price elasticity of demand for air passenger transportation in Norway, on the basis of secondary, quarterly, and aggregate time series data for the period between 2006 and 2014. First, the aggregated national level, without separation for travel purpose, was studied by employing an unbalanced regression approach. This analysis revealed that demand was price inelastic both in the short run as well as in the long run. Subsequently, several attempts were made to reveal a significant difference in price sensitivity among the traveller segments in Norway. However, no such dissimilarity could be reliably identified.

The findings of this analysis come along with quite a high degree of uncertainty, which is because of the small sample size of the data at hand. Better conclusion might have been drawn if the available data was of a bigger sample size.

Furthermore, having demand and price data ‘out of one hand’ would have improved the quality of the analysis. This seems especially true for the examination of the travel segments, for which the demand data had to be ‘estimated’ by employing NTS data. The analysis could have been further improved if the provided price datasets for the segments were in addition made separately accessible for domestic and international travel. Knowing the different developments of demand for domestic and international services within the last 10 years, valuable insights might have been drawn from doing so.

A certain amount of uncertainty is furthermore related to the application of the unbalanced regression methodology. In the light of the ‘overwhelming’ popular co-integration technique, only a few references for unbalanced regressions exist.

9.0 Analysis 3 - Route Demand - Bimonthly Data from 2004-2014

The following sub-analysis tries to estimate the own-price elasticities of demand on the route levels. In accordance with the discussion in the theoretical part of this thesis, the magnitude of such route specific price elasticities should be larger than those of an aggregated market. This sub-analysis focuses on answering the following question:

RQ 2: How price elastic is the demand for passenger air travel in Norway on the route level?

RQ 5: Is the demand for air travel in Norway significantly influenced by the price for other modes of passenger transportation?

RQ 6: Are the demand for passenger air travel in Norway and its price co-integrated processes?

In order to answer these research question, this sub-analysis employs data for the PSO-route Lakselv-Tromsø (LKL-TOS). A brief overview of general PSO-routes characteristics was already given in section 2.1. The details under which specifically LKL-TOS has to be operated in the current PSO-period can be found in Samferdselsdepartment (2011).

Lakselv is the administrative centre of the Porsanger municipality. The city is located in the district of Finnmark and has a population of about 2,300 inhabitants. Lakselv is connected to the interstate road network via the E6. A one-way car trip to the nearest 'larger-scale' city Alta takes about 2.5 hours. A flight trip from Lakselv to Tromsø needs approximately 45 minutes. In Tromsø, the passengers have access to a wide variety of regional, national and international connecting flight routes. Recent statistics show that more than 50% of all passengers on the route are transit passengers (Widerøe 2015b). The importance of LKS-TOS as a 'feeder route' for connecting flights till Oslo is however limited, because the nearby airport of Alta offers direct services to Oslo. Owing to the quite acceptable travel time by car to Alta, one could assume that a significant number of travellers originating from Lakselv prefer to travel to Alta and cut out the PSO-leg of the LKL-TOS route.

I have chosen to analyse the route LKL-TOS for two reasons. First, the same company (i.e. Widerøe) has been operating on the route since 2004. Consequently, a cohered dataset is available. Second, the route connects a regional hub airport (TOS) with a 'very' remote city. Lakselv airport is thereby located in a way that the catchment areas of the airport can be defined in reference to existing municipality borders.

The dataset for this analysis contains 60 bi-monthly observations for the route LKL-TOS, covering the time period between February/March 2004 and February/March 2014. The fact that the dataset consists of observations for periods of less than one year creates the necessity of seasonal adjustments. That will again lead to the problem of small sample size.

The analyses will therefore focus on the explanatory variables: airfare (*fare*), regional gross value added proxy for income (*gva*), population of the catchment area (*pop*), price for travel by road (*bus*), price for travel by car (*car*), load factor (*LF*) and the index of airfares for the national aggregated level as proxy for ticket prices of connecting flights (*air*). The reasoning behind choosing the latter variable is as follows: If the PSO-route connects the remote region with the regional hub TOS, then one could expect that not only the 'price-capped' PSO-flight fare is important for the consumer to decide pro or contra air travel. One could rather assume that in the case of transit flights, the price of the connecting flight is also an important determinant for the demand for the PSO-flight. Even though it is not reported in the literature, one could assume that consumers pay comparably less attention to fluctuations in the quite stable, price-capped PSO-fare, but react noticeably to price changes for the 'connecting' fare. To account for this assumption and the fact that approximately 50% of all passengers on the LKL-TOS route are transfer pax, I tried to include the variable *air* in the estimation. This variable represents the general airfare development in the commercial Norwegian network.

Finally, I included five dummy variables (*I, II, III, IV* and *V*) to represent the bi-monthly observations, with the dummy '*I*' denoting the period December/January, '*II*' denoting February/March, etc. All explanatory variables are assumed to be exogenous[46].

In order to improve the quality of the models, I tried to replace the variable *gv*a by the alternative explanatory variable 'average wage' for the catchment areas. I, however, failed to source the respective data for the pre-2005 period. The tests of different functional forms as mathematical specification of the regression equations again led me to choose the 'double-log' specification. Addressing the possible issue of multi-collinearity, I inspected the correlation coefficients of all the relevant variables before starting the analysis. As

[46] For a discussion and testing of endogeneity see Appendix 1.

shown in Appendix 17, care must be taken when the variable *gva* is used in combination with *road* and *pop*.

In terms of substituting modes of transport, I checked whether there have been changes in the setting of substitutes that have had significant impacts on travel times (e.g. construction of new roads) and hence on the total travel costs for the traveller. Consequently, a total cost approach would have had to be included in the analysis. I was, however, not able to identify such a change, meaning that I assumed that no significant changes with regard to travel time have occurred and hence there is no need to account for this in the analysis.

Last, I visually inspected the scatter plot (also illustrated in Appendix 17) to identify possible outliers in the dataset. There seemed to be an outlier for the period Dec09/Jan10, a finding, which can be confirmed by a look at appendix 18. The demand in these two months is well below average and the resulting airfare way above what can be expected by looking at the other periods. Since I was forced to calculate the average airfare by dividing the total revenue by total demand in the period, a failure in the demand figures would automatically lead to an overestimated airfare numbers. I therefore tried to double-check the numbers. First, I re-checked the sourcing papers again, without a refuting outcome. I furthermore compared the average airfare of 931NOK with the valid maximum one-way airfare at that time, as defined in the contract between Widerøe and the Norwegian government. This maximum was 1144NOK, which is clearly above the calculated airfare. On the other hand, knowing that at this time the share of passengers paying the maximum air fare was only 30%, one could doubt 931NOK. Since I failed to find definite proof for or against the calculated airfare, I estimated the route LKL-TOS twice. Once with the dataset corrected for the possible outlier, which I assume is the 'correct' dataset, and in addition, once without removing/substituting the outlier to crosscheck with the results of the corrected dataset. Consequently, two models are estimated:

Model A: Outlier corrected and denoted by an additional subscript 'a' in the pax and fare variables (i.e. '*paxa'*, '*farea*')

Model B: Inclusion of the outlier and denoted by 'b' as subscript for the pax and fare variables (i.e. '*paxb*', '*fareb*')

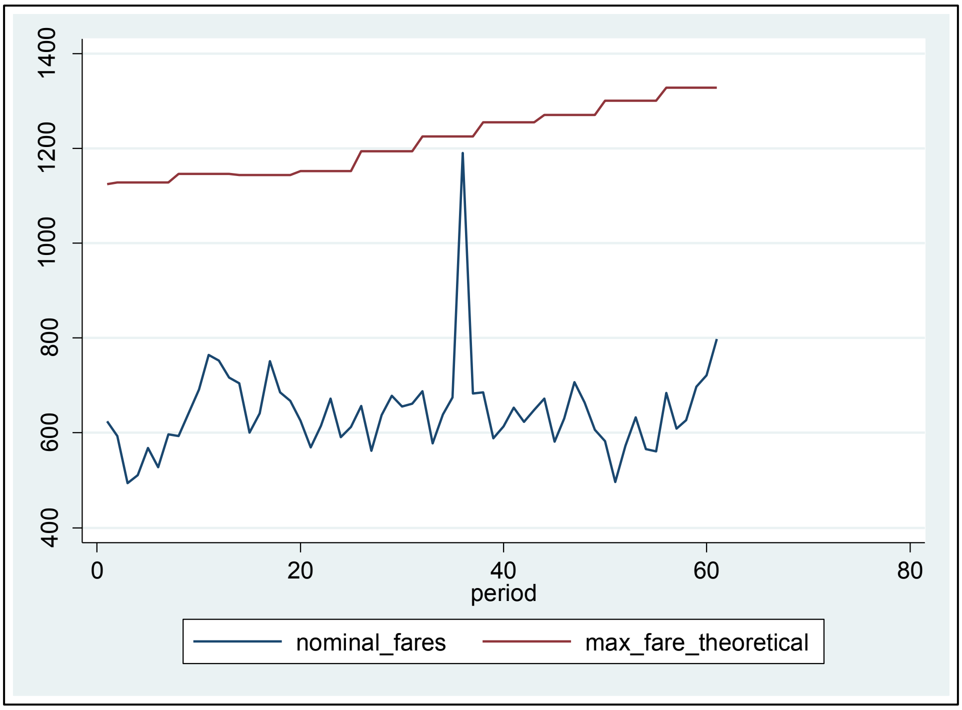
All the variables reflecting monetary values were adjusted with the consumer price index (1998=100%) sourced from SSB.

9.1 Introduction of Data and Descriptive Statistics

The data for the analysis stems from different sources.

The demand, airfare and load factor variables were obtained from Widerøe's bi-monthly reports (Widerøe 2015b) and were accessible via the Norwegian Ministry of Transportation. Unfortunately, airfares and their magnitudes for different traveller segments are not reported directly. In order to derive an average airfare, I divided the revenue of a period by the number of passengers transported. This, however, meant that all airfare information used in this analysis are average numbers for the entire population (i.e. all travellers), without taking into consideration the fluctuations for different segments. Theoretically, the airfares are 'capped', as regulated in the PSO-tender documents. A cap in prices might have a ('disturbing') impact on the analysis. In order to check that, I created a variable that reflects the price cap over time and regressed that on fare variables and on the demand variable. It turned out that a change in price cap does not impact fares and the demand. This seems to be because the contracted maximum airfare as defined in the tender documents is valid for a full-fare/full-flexi, one-way price ticket. A traveller buying such a ticket is called a 'C-class-traveller'. The share of C-class-travellers on the LKL-TOS route, however, has been very low ever since. In the period between April 2011 and March 2012, only 24% of all travellers were C-class passengers. For the corresponding period a year later, the share had dropped to only 11% (Widerøe 2015b). Even though it is reasonable to expect that the price cap has an impact on the price elasticity of C-class passengers, I assume that such an effect does not exist for the aggregated average fare calculated from the available data. The relation between the calculated average fare (i.e. based according to (Widerøe 2015b)) and theoretical possible 'capped' maximum fare is visualized in Figure 9-1. Here, one can see that the calculated average airfare is far off the price cap, except for the month with the assumed outlier problem.

Figure 9-1: Analysis 3 - Average Airfare vs. Maximum Airfare LKL-TOS



Source: (Widerøe 2015b); (in nominal NOK)

Furthermore, it is not obvious that the average airfare 'follows' the upward trend of the regulated maximum fare in nominal value.

The numbers for the average load factor are also subject to uncertainty. This is because the numbers do not represent the actual situation on the route. They rather picture the setting of an entire 'routeområde'. In the absence of more route specific numbers, I decided to include these network numbers in the analysis.

The data for road travel prices, commercial network air travel prices, GVA and population were all obtained from Statistics Norway. The road ticket prices are based on the CPI sub-index 'passenger transport by road', which summarizes the price developments of bus and yellow cab services.

In order to calculate the population numbers, I defined the catchment area for the 'remote ends' of the route. I did not include the population of the 'non-remote end' Tromsø. This is because I think the major demand for air travel on the route originates from the remote end. I defined the municipalities of Porsanger, Karasjok and Lebesby as the catchment area of LKL. I did that with respect to travel time by car from the administrative centre of the municipality to the nearest airport. For the ease of data sourcing and interpretation, I did not consider the travel time for each individual settlement within a municipality. I rather decided to assign the whole municipality to a catchment area.

In the absence of more disaggregated data, the GVA numbers depict the economic development of the entire districts (i.e. fylke). For Lakselv, I used the data of the Finnmark district as a proxy. Therefore, specific events that might have changed the economic situation in the catchment area would be 'underrepresented' in this data. In order to check for such important singularities for the catchment areas, I searched the Internet but was not able to identify specific events that might have significantly impacted the economic situation in the catchment area. To double-check, I examined the full time employment statistics as given by (SSB 2015a) and did not discover noticeable 'peaks'.

The costs of travel by car were obtained from OFV (2014). Since this publication provides only annual data and regression analysis is sensitive to fluctuations in the dataset, I decided to distribute the annual chances in car ownership costs over the six bi-monthly periods of a year. In particular, I implemented the costs for a medium-sized petrol-driven car with an annual mileage of 15,000 km, as this is most representative of the population (OFV 2011).

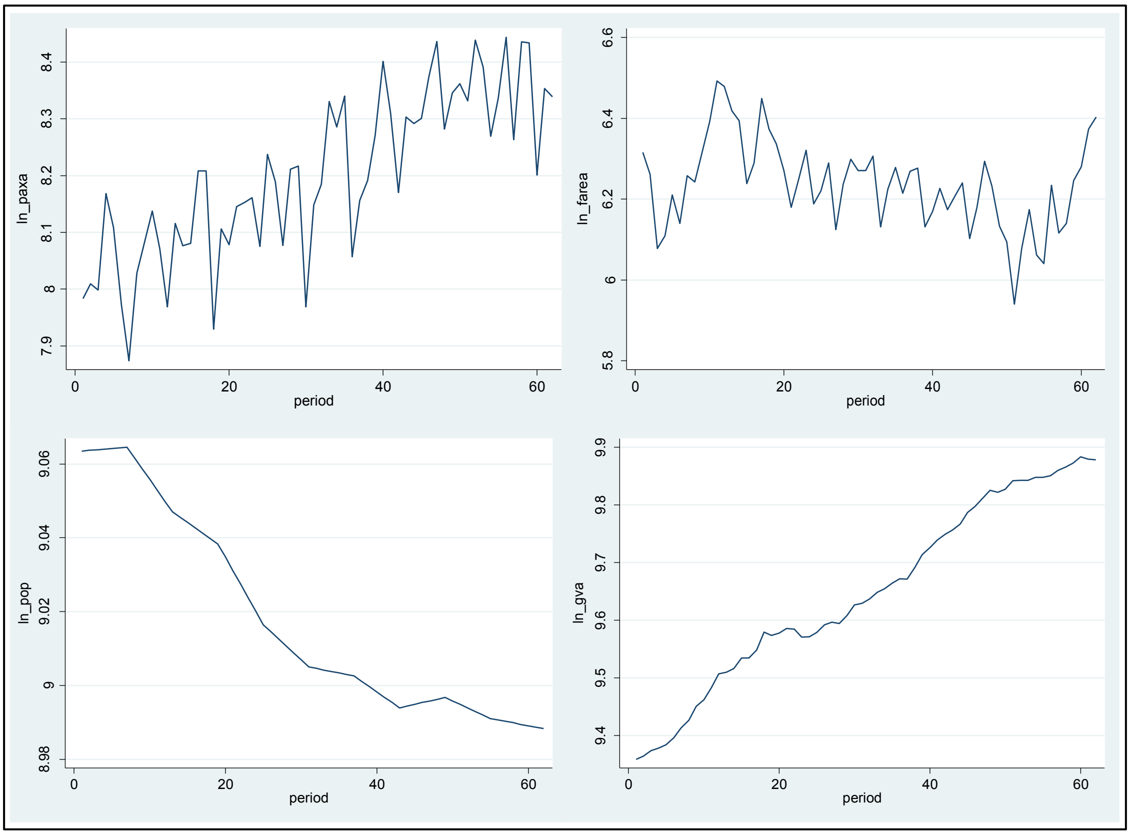
A brief descriptive summary of all the variables is given in Table 9-1 for LKL-TOS. The values for the outlier corrected dataset are used.

Table 9-1: Analysis 3 - Descriptive Statistics LKL-TOS -- Bi-Monthly Averages

Variable	Mean	Standard Deviation
Passengers (*pax*)	3686	529
Average airfare in NOK (*fare*)	513	57
Population catchment area (*pop*)	8251	222
GVA in million NOK (*gva)*	15688	2471
Index of road ticket prices (*bus*)	122	5.7
Load Factor in %	50	5.2
Airfare index overall network (air)	100	5.5
Car ownership costs in NOK/km (*car*)	3.66	1.4

For further analysis, all the variables were transformed into their logarithmic forms to benefit from the fact that all resulting coefficients can be directly interpreted as elasticities after such a transformation. The time plots of the logged form for the variables *pax, fare, gva* and *pop* can be seen in Figure 9-2.

Figure 9-2: Analysis 3 -Time-Plot Main Variables



A first look at these plots gives the impression that at least the variables ln(*pax*), ln(*pop*), and ln(*gva*) follow a trend. Interestingly, the population plot indicates a negative growth. This trend is opposed to the national development, but in line with the well-described depopulation phenomenon of the Northern district. For the fare variable, a visual inspection of the time plot is not entirely conclusive. There seems to be a slight downward trend, which however appears to recover in the later periods.

Therefore, the next step is to test the data's stationarity properties by employing statistical testing procedures.

9.2 Formulation of Expectations

In accordance with the theoretical discussion of price elasticities in air passenger transportation, I expected to find more price-elastic demand on the route level than on the earlier analysed aggregated level. On the other hand, substitutes to air transport are only partly suitable. For instance, a one-way car trip from Lakselv to Tromsø takes more than eight hours. This should dampen a traveller's willingness to change to other modes of transportation and hence reduce their sensitivity to increases in airfare.

Consequently, I expected to find positive coefficients, which may turn out to be non-significant, for the substitutes. In terms of GVA and population, I anticipated significant positive coefficients. For the population variable, this seems hardly achievable due to the minor changes in the period under consideration. For the coefficient representing the price development for air travel in the commercial network, I was likely to find a negative prefix, indicating that an increase in 'connecting' airfares decreases the demand on the PSO-route.

9.3 Testing for Order of Integration

Appendix 19 provides an overview of the test results for the logged data and for the differenced form of the logged data where necessary.

It turned out that all the variables, notwithstanding *ln(pax)*, *ln(fare)* and *ln(LF)*, required differencing to become stationary. The result of stationarity for the two *ln(pax)* variables already in their levels is somehow surprising. Looking at the variable plotted against time clearly reveals that the variables have a non-constant mean; hence, they should not be stationary if the testing procedure does not allow for a trend (which was not applied to reach the results in Appendix 19). I treated the test results for the *ln(pax)* variables with a certain amount of scepticism and assumed that the small sample size led the test to mistakenly come up with the conclusion of stationarity. Consequently, I considered the two variables

Table 9-2: Analysis 3 - Order of Integration

Variable	Order of Integration
ln(*paxa*), ln(*paxb*)	I(1)
ln(*farea*), ln(*fareb*)	I(0)
ln(*pop*)	I(1)
ln(*gva*)	I(1)
ln(*road*)	I(1)
ln(*car*)	I(1)
ln(*air*)	I(1)
ln(LF)	I(0)

as non-stationary in levels. This assumption makes the demand and price variables integrated of different orders and, hence, do not allow the variable to be treated for

cointegrated processes. At the risk of falsely excluding a valuable analysis methodology (i.e. cointegration analysis) as a consequence of 'overruling' the test results, I decided to perform the second step of co-integration anyway. I regressed the demand on price and checked the residuals, resulting in the non-constant mean process again. Therefore, I finally concluded that the *ln(pax)* and *ln(fare)* variables are not cointegrated.
The resulting order of integration for all the variables is summarized in Table 9-2.

9.4 Model Building and Estimation: Static Model and AR-Model

The existence of a possible cointegration relationship has already been ruled out above. Furthermore, an unbalanced regression procedure involving a non-stationary dependent variable, as per my knowledge, has not been reported in the literature. Therefore, it remains to differentiate all variables to analyse them with a static model configuration first and try to isolate a long-run effect by employing a dynamic model specification.

As before, I started the analysis by including all the variables in a static model. The total amount of regressors in the model was consequently 13, which included the five dummy variables. Keeping in mind the number of available observations, there was the need to exclude non-significant or 'meaningless' regressors. Accordingly, I first turned my focus on the two 'problematic' variables ln(*pop*) and ln(*LF*).
The population variable turned out to be 'problematic' across all the model variations that were tested. Usually, the coefficient of this variable was negative, with an unrealistic magnitude and not significant at the 10% level. In fact, the coefficient indicated (even though not significant) an elasticity of demand in respect to population changes of -5, implying that a one per cent increase in population in the catchment area results in a 5% decrease in demand for air travel on the PSO-route. This result is contra-intuitive and I interpret it in a way that, based on the dataset available, there is no evidence of population changes being a demand-influencing factor for air travel on the LKL-TOS route. Since from a theoretical standpoint population should have an impact on demand, I decided to include the population effect by expressing demand in per capita terms. Thereby, I created the new variables ln(*paxapop*) (outlier corrected) and ln(*paxbpop*) (non-corrected) as dependent variables for the two models. The variable ln(*pop*) was thereafter excluded from the analysis.
The load factor variable turned out to show significant coefficients, but with an unexpected prefix throughout all the tested model specifications. Actually, I had expected to see negative prefixes, implying that with increasing load factors passengers perceive air travel

to be less comfortable, and hence passengers tend to turn towards substitutes in such a scenario. The amount of suitable substitutes is limited in the case of LKL-TOS, which might explain the wrong prefix. Furthermore, the overall load factor on this route is quite low with an average of 50%, which might be below a certain ('behavioural') boundary level where the consumers would start to react to increasing load factors. In such a case, however, one could also expect to get an *insignificant* coefficient. Thus, a significant positive coefficient cannot be explained by this reasoning. There remain two possible explanations for the finding. First, one could argue that the small sample size and the related low amount of variations in the variables led to the observed effect. On the other hand, if there is something like a minimum load factor that is needed to see passenger-adjustment effects, than one could argue that load factors below that limit are nothing else than a 'mirrored' demand in a regression analysis. The load factor then becomes a meaningless and quasi-endogenous variable, because an increase in LF describes an increase in demand, but an increase in demand causes an increase in LF, at the same time (ceteris paribus). Therefore, I decided to exclude the variable from further analysis.

Consequently, the static model takes the form:

$$\Delta\ln(paxapop_t) = \beta_0 + \beta_1\Delta\ln(farea_t) + \beta_2\Delta\ln(gva_t) + \beta_3\Delta\ln(air_t) + \beta_4\Delta\ln(car_t) + \beta_5\Delta\ln(road_t) + \beta_6\, I + \beta_7 II + \beta_8 III + \beta_9 IV + \beta_{10}\, V + \varepsilon$$

For the dynamic specification of the model, an additional lagged term is included and the model takes the form:

$$\Delta\ln\,(paxapop_t) = \beta_0 + \beta_1\Delta\ln(farea_t) + \beta_2\Delta\ln(gva_t) + \beta_3\Delta\ln(air_t) + \beta_4\Delta\ln(car_t) + \beta_5\Delta\ln(road_t) + \beta_6\, I + \beta_7 II + \beta_8 III + \beta_9 IV + \beta_{10}\, V + \beta_{11}\Delta\ln(paxapop_{t-1}) + \varepsilon$$

Output 9-1 presents the results for the outlier corrected dataset used in Model A. Since the regression suffered from some degree of serial correlation first, the results from a serial correlation robust Prais-Winsten regression are reported.

Output 9-1: Model A - Static Specification - Prais-Winsten Regression

Source	SS	df	MS
Model	.528068973	10	.052806897
Residual	.214039716	48	.004459161
Total	.742108689	58	.012794977

Number of obs =	59
F(10, 48) =	11.84
Prob > F =	0.0000
R-squared =	0.7116
Adj R-squared =	0.6515
Root MSE =	.06678

D.ln_paxapop	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
ln_farea						
D1.	-.2741818	.1631525	-1.68	0.099	-.6022219	.0538584
ln_gva						
D1.	.000235	1.10613	0.00	1.000	-2.223789	2.224259
ln_air						
D1.	-.4060502	.4491717	-0.90	0.371	-1.30917	.4970701
ln_car						
D1.	.0434845	.4117714	0.11	0.916	-.7844375	.8714065
ln_road						
D1.	.7079223	.7775937	0.91	0.367	-.8555346	2.271379
I	-.221739	.0570229	-3.89	0.000	-.3363912	-.1070867
II	.1106603	.031995	3.46	0.001	.0463301	.1749905
III	.0168875	.0408518	0.41	0.681	-.0652506	.0990256
IV	-.0685002	.0524154	-1.31	0.197	-.1738884	.036888
V	.1144431	.0451403	2.54	0.015	.0236825	.2052037
_cons	.011162	.0307196	0.36	0.718	-.0506039	.0729279
rho	-.523054					

Durbin-Watson statistic (original) 2.850789
Durbin-Watson statistic (transformed) 2.115860

The regression results indicate that the demand for air passenger transportation on the LKL-TOS route is price inelastic. The short-run price elasticity of per capita demand is estimated to be -.274 and is significant at the 10% level. Furthermore, the demand in the bi-monthly periods of December/January, February/March and August/September significantly differ from the reference period October/November. The coefficient representing the income elasticity of demand is not significantly different from zero. In fact, the results indicate that changes in the GVA of the district do not have an impact on the demand for the LKL-TOS route. Moreover, the coefficients for the two substituting modes of transport, that is car and bus, are also not significant. They, however, show the expected prefixes, indicating a substituting relationship to travel by air. Finally, the coefficient representing the demand change on the LKL-TOS route resulting from a price change in the Norwegian commercial air travel network shows the expected sign, but is not significant.

Output 9-2 presents the results of the additionally estimated dynamic specified model. Contrary to the static model, the coefficient for the SR own-price elasticity is not significant at the 10% level. The magnitude of the coefficient with -.21 is not very far from its counterpart in the static model. Interestingly, the coefficient of the lagged price term is significant at the 1% level.

Output 9-2: Model A - Dynamic Specification - OLS Regression

Source	SS	df	MS		
Model	.626411814	11	.056946529	Number of obs =	57
Residual	.214432095	45	.004765158	F(11, 45) =	11.95
Total	.840843909	56	.01501507	Prob > F =	0.0000
				R-squared =	0.7450
				Adj R-squared =	0.6826
				Root MSE =	.06903

D.ln_paxapop	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_farea D1.	-.2156583	.1909112	-1.13	0.265	-.6001732	.1688566
ln_gva D1.	-.1906009	1.510382	-0.13	0.900	-3.232666	2.851464
ln_air D1.	-.2699704	.5405876	-0.50	0.620	-1.35877	.818829
ln_car D1.	.0009321	.4902114	0.00	0.998	-.9864043	.9882685
ln_road D1.	1.117708	.8835548	1.27	0.212	-.6618632	2.897278
I	-.2876873	.0535308	-5.37	0.000	-.3955038	-.1798708
II	-.0328385	.0514787	-0.64	0.527	-.1365219	.0708449
III	.0252692	.0347463	0.73	0.471	-.0447134	.0952518
IV	-.1039886	.0606954	-1.71	0.094	-.2262355	.0182583
V	.05502	.0354533	1.55	0.128	-.0163866	.1264266
ln_paxapop LD.	-.5057218	.1338778	-3.78	0.000	-.7753654	-.2360782
_cons	.064871	.0330563	1.96	0.056	-.0017079	.1314499

Using this coefficient and the SR coefficient, one could theoretically calculate the LR-elasticity. In this case, however, this is meaningless because the prefix of the lagged term is negative, resulting in a smaller long-run than short-run effect. Finding a proper interpretation for this result seems difficult. First, one could argue that the specific datasets used in this analysis does not provide conclusive results in terms of long-run and short-run effects. Second, one could question the applicability of an AR-type model to this dataset, in accordance with the discussion on using differenced data in AR-type models.

Ultimately, it can be concluded that no evidence was found for a distinct long-term price effect on demand for the PSO-route LKL-TOS.

All other regression coefficients of the dynamic model support the findings of the static model: The income proxy does not seem to represent a significant demand-influencing factor and price fluctuations of the substitute modes of transportation do not significantly influence the demand for air passenger transportation on the LKL-TOS route. Furthermore, the price fluctuations in the commercial network are not significant. The prefix of the coefficient, however, indicates a complementary relationship between the variable and the demand for the PSO-route.

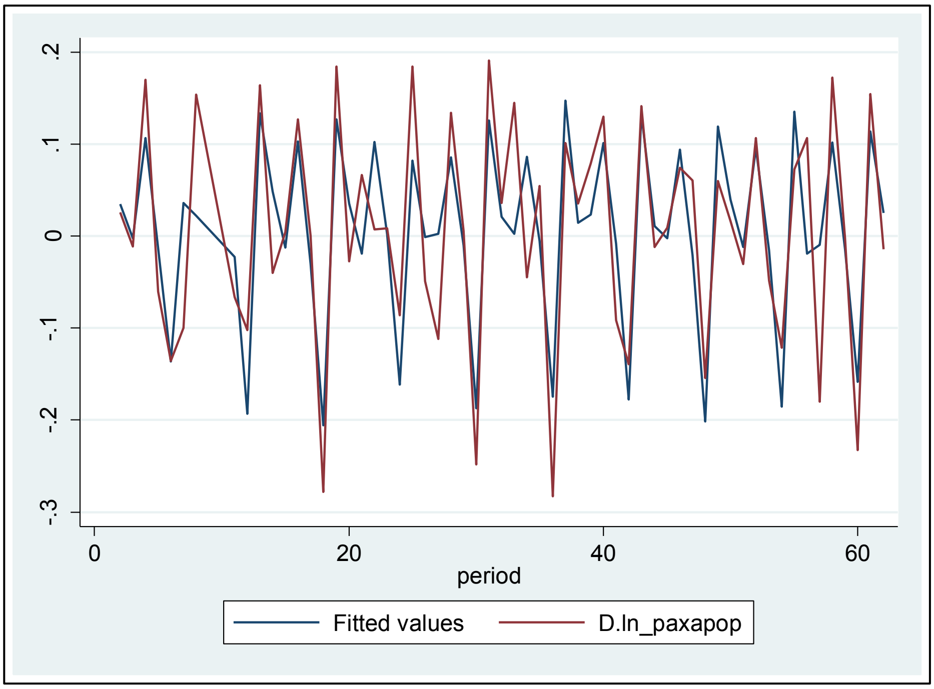
The respective regression outputs for the static and dynamic specifications for Model B are shown in Appendix 20. One could suggest that the regression results differ only marginally, compared to the outlier-corrected dataset. The reason for this is that only a single observation in demand and average fare was identified and corrected for in Model A. The results, however, indicate the opposite for the airfare variable ln(*fareb*). In both the static and the dynamic configurations, the SR-elasticity is now highly significant and has a magnitude of -.85. Even though it still indicates an inelastic demand, the difference in magnitudes between Model A and Model B is remarkable. The degree to which the outlier influences the results, however, shows the sensitivity of OLS-regression results for small sample sizes. My interpretation of this finding is that all the regression results derived in this thesis come along with a high degree of uncertainty, because all the sub-analyses more or less suffer from the same issue - that is, small sample size.

9.5 Test Diagnostics

The estimated models have a rather acceptable model fit. The static specification of Model A achieves a R^2- adjusted of .59 and the dynamic specification a value of .68.[47] A look at Figure 9-3 confirms this impression. Here, both the predicted values ('fitted values') and the observed values ('D.ln_paxapop') of the dependent variable are plotted over time. Thus, it has to be stated in a restrictive manner that this comparably good model fit is to a major degree related to the overall significances of the dummy variables in the model.
Apart from a certain impact of the price variable, all the other regressors were found to have no significant impact on demand; hence, the resulting demand model is in a large part

[47] Values are provided for models before serial correlation adjustments.

Figure 9-3: Analysis 3 - Predicted Values vs. Observed Values



a function of seasonality. This is not surprising, keeping in mind the time plot of the original demand variable ln(*pax)*. Taking away the seasonal variation from that plot leaves only a minor amount of variation in the dependent variable that can be represented by other regressors. This issue could be mitigated with longer datasets.

With regard to the additional diagnostic tests that were applied, it can be said that both the static as well as the dynamic model specifications pass all tests. The respective outputs can be inspected in Appendix 21. As already indicated, the existence of serial correlation in the static model required the application of a Prais-Winston regression. This was not the case for the dynamic model because the lagged term reduced the issue of serial correlation. The residuals of the regressions appear to be distributed normally and are homoscedastic. The omitted variable tests do not indicate the issue of model under-specification.

9.6 Discussion of the Results

Addressing RQ 2, it can be stated that the estimated *own-price elasticity of demand* for air passenger transportation for the specific route Lakselv-Tromsø is:

-0.27 in the short-run.

This estimate is derived from a static model and significant at the 10% level. No model specification was found for which the airfare coefficient had a higher significance. The dynamic AR-type model neither confirmed the findings of the static model, nor was it possible to derive a long-run elasticity from this model specification.

Contrary to the formulated expectation, the magnitude of the derived short-run elasticity seems rather small. In theory, one would expect significantly higher elasticities on the route level than on a national aggregated level (Smyth and Christodoulou 2011); (InterVISTAS 2007). Obviously, this is not the case here. Several reasons can be behind this phenomenon. First, the regression results indicate that in this case neither cars nor buses are suitable substitutes for air travel. This means that demand for air transport should automatically be less price-sensitive than in a scenario with suitable substitutes. This argumentation is fostered by Bhadra and Kee (2008), who discuss the relationship between "thin" routes and low price elasticities and link that relationship to reduced levels of inter-model competition.

Second, a certain share of demand for air travel on PSO-routes can be naturally assumed to be price insensitive. This is because a PSO-route was established and has been subsidized to ensure lifeline functions. Compared to commercial routes, I would claim that a higher share of total traffic on a PSO-route is 'un-avoidable travel' and, hence, less price sensitive. Third, PSO-routes are operated with price-capped airfares. Even though it is not possible to prove an effect of 'connecting' fares on the demand for the PSO-route, one could still assume that travellers perceive the PSO-airfare as somehow given externally and pending within a fixed framework. The travellers may pay less attention to changes in the PSO-airfare than in fluctuations of the connecting airfare, which in addition may represent a higher share of the total travel costs involved. I tried to elaborate a little more on this effect and to foster this assumption by analysing the demand on the two additional PSO-routes Bodø-Lekenes and Oslo-Førde with respect to the commercial airfare development. However, I found no evidence for such an interaction between PSO-demand and commercial fare.

Concerning the coefficient serving as a proxy for *income elasticity of demand,* the results are not in line with the earlier formulated expectations—it was not possible to derive a significant result. Several interpretations are possible for this. First, the regional GVA-numbers are not precise enough representations of the actual economic development in the catchment area. In such a case, it would be natural to find only non-significant values. Second, the demand response for air travel on the route could indeed be not significantly different from zero to changes in income. This could be the case, for example, if a large share of air travel is ‘unavoidable’ and, hence, insensitive to income changes. Furthermore, one could ask as to which traveller group would induce a certain amount of ‘income-sensitivity’ into the system. In case of business travellers and their sensitivity to changes in the economic state of affairs, the special employment situation in the Northern districts would dampen their effect. An over-proportional share of the total employment in Finnmark is associated with public administration, defence and local government (SSB 2015a). Their dependence on the economic business cycle is traditionally low; therefore, business-related travel in Finnmark would be less dependent on the actual economic situation. On the other hand, the leisure traveller originating from Lakselv might already be time constrained given the city’s very remote location. Even though the citizens could afford to travel more by air, they are too far away from international-hub airports to be able to benefit from an increase in income, in terms of travel-quantity.

According RQ 5, it was already stated that the analysis has not indicated the existence of significant *cross-price elasticity* for car and bus use. This might be related to the sheer distance between the two cities and the time needed to overcome this distance by road.

Addressing Research Question 6, it can be stated that this sub-analysis did not provide evidence of demand being a *cointegrated process* of airfares. This is related to the fact that the two decisive variables were found to be integrated in different orders.

9.7 Conclusion and Limitations

This analysis examined the own-price elasticity of demand for air passenger transportation on the PSO-route Lakselv-Tromsø. Secondary, bi-monthly time series data for the period between 2004 and 2014 was used. A double-logarithmic static model was applied to derive short-run elasticities and a dynamic specification was used to elaborate on long-run effects. It turned out that only short-run elasticities could be estimated, which in addition were found to be significant only at the tolerant 10% level. With these remarks, the demand model revealed that demand was price inelastic in the short-run with an elasticity of -0.27.
Comparing and benchmarking my findings with earlier scholarly work meant identifying the projects that have researched the Norwegian PSO-network in a comparative manner. To the best of my knowledge, such a work is not mentioned in the extant literature. Consequently, the findings of this analysis cannot be compared seriously and it remains for future scientific work to form a sound foundation for the price-demand relationship in the Norwegian PSO-network.

The findings of this analysis come along with quite a high degree of uncertainty, which is caused by the small sample size of the data at hand. A better conclusion could have been drawn if the available data had allowed for a bigger sample size, containing more variation in the processes. The diverting results of the analysis of Model B impressively demonstrated the sensitivity of such an analysis in the light of the small sample size.
Furthermore, the absence of original airfare data and segmented demand figures forced me to calculate an average airfare and use that figure for the entire passenger range. More detailed, class-specific demand and price data might have had a positive impact on the quality of the results of the analysis. Next, LKS-TOS has temporarily been part of a so-called 'ruteområde'. It seems reasonable that the interaction effects between demand and price fluctuations on different routes of the same 'område' exist, and that such effects are implied in the dataset, but cannot be contributed to the specific cause-and-effect relationship. For example, if the demand for a connecting leg is high (i.e. load factor at this leg is high), the price for the previous leg is likely to increase as well, even though the demand for this leg remains low (i.e. not considering the additional price effect).

Besides all the limitations of this analysis, I think that the special application of price-elasticities in the PSO-network provided some insights and raised some interesting questions, which could be addressed by further research activities. For example, a comprehensive analysis of price-elasticities for all PSO-routes in Norway could lead to some valuable intelligence for Norwegian state agencies on the potential of individual PSO-routes to become commercial, un-subsidized routes. Second, the impact of commercial network airfares on the demand for PSO-routes should also gain scholarly attention, because a proven causal relationship between these two variables might offer an additional adjustment mechanism for the state to influence the demand on PSO-routes. Finally, and in order to circumvent the shortcomings of a single, small sample size dataset, it seems promising to use data of multiple routes combined in one analysis. Such a panel-data analysis could lead to more reliable results.

10.0 Conclusion and Recommendation for Further Research

This chapter will conclude this thesis by giving a short summary of the findings of this paper, recalling the most significant limitations and making recommendations for further research.

10.1 Main Findings

In this Master Thesis, I have tried to analyse how sensitive is the demand for air travel in Norway to changes in airfares. The overall research question was formulated as:

How price elastic is the demand for passenger air travel in Norway?

Based on this problem, six separate research questions were derived. In order to address the research questions, an extensive literature review and three different sub-analyses were undertaken.

While reviewing the literature, I learnt that earlier estimates of own-price elasticities of air travel demand vary remarkably. Not only do case-related characteristics, such as the existence of substitutes, affect the magnitude of the estimates, but methodological details of the specific survey also seem to influence the findings. Attempts to generalize across different settings or to develop a 'handy' method to estimate the price elasticities as proposed by InterVISTAS (2007) seem therefore less promising.

For the specific Norwegian case, the findings of the analysis indicate that demand for air travel in Norway is generally price inelastic. Even though associated with a degree of uncertainty, combining the results of sub-analyses 1 and 2 led me to conclude that demand for air travel on the aggregate level in Norway has an own-price elasticity of approximately:

-0.23 in the short term and
-0.48 in the long term.

This means that a 10% increase in airfares will lead to an instantaneous decline of demand of 2.3% and that the final demand adjustment will be a negative 4.8%. These values are well within the expected range, based on previous studies focusing on the Norwegian market.

In addition, no indications were found for a dramatic change in own-price elasticity of demand in the last decade, compared to the earlier years, which could be followed by significantly diverting estimates between sub-analysis 1 and 2. The findings of the analysis indicate though, a slight tendency of less sensitive demand for the more recent past than compared to the longer period between 1981 and 2013. Some uncertainty is connected to this finding however, since this finding is seen from a mathematical perspective only based on short-run elasticities and the underlying data covers slightly different populations.

For the route level, the estimates of sub-analysis 3 indicated an own-price elasticity of approximately:

-0.27 in the short run,

which is only slightly more price elastic than that for the aggregated level. This is not in line with the suggestions found in the literature. A long-run elasticity could not be estimated for the analysed Lakselv-Tromsø route. Thus, one has to keep in mind the very special characteristics of the PSO-setting for this route and, therefore, should not assume this result to be valid for the other routes as well. In order to find more representative results, I tried to analyse the demand for one of the major trunk-routes. Owing to the market situation in the domestic setting, access to the necessary datasets was denied.

The research question concerning different price elasticities of demand for business and leisure travellers based on the available data could not be fully answered satisfactorily. The findings of the analysis indicated that, contrary to the general line of argumentation in the literature, demand for business and leisure air travel in Norway do not have significant difference in price elasticities. A discussion of the possible reasons for this finding was given in section 8.8.

Addressing the question of whether price changes for other modes of transportation in Norway significantly impact the demand for air travel, I have to conclude that no indication for such a cross-price effect could be discovered in this analysis. This would mean that demand for air travel in Norway does not change as a consequence of price changes for other modes of passenger transportation. Seen in the context of the aggregated national level, this finding for rail passenger transport is in line with the general discussion in respective papers, where either no or very low cross-price elasticities are reported for

Norway. For private car use, however, the finding is somehow contradictory to the earlier result.

Finally, addressing the methodology-linked research question of whether demand for air travel in Norway and its price are co-integrated processes, I can state that no indication was found of the existence of such a long-term equilibrium relationship between the processes. Notwithstanding its popular use for demand analyses of other goods, the co-integration technique has been scarcely applied to air travel demand so far. Therefore, a comparison of my finding with previous studies is tricky, especially if one assumes that 'negative findings' are underrepresented in the literature. Beside the technical aspects of identifying a co-integration relationship, I think a more fundamental discussion of whether economic theory indeed suggests such a relationship for air travel demand and airfare needs to be answered in the future.

10.2 Limitations and Further Research

The first limitation of this thesis conserned with the quality and quantity of the data employed in the quantitative analysis. Quantity-wise, I have already claimed that the small sample sizes posed severe restrictions on the analysis and induced a considerable degree of uncertainty. This accounted for both the 'intermediate test results' (e.g. tests for stationarity and endogeneity), the final coefficient estimates and their significance, as well as for the diagnostic tests. Furthermore, the lack of data might have led to misspecification bias in the models, hampering the application of more advanced methods of analysis. In terms of data quality, the data sources can be considered to be reliable. However, uncertainty is induced if information of several datasets has to be merged to generate suitable data records. This was the case in sub-analysis 2, in which I created two demand datasets for the different traveller segments.

Another limitation of thesis concerns the different methodologies and models employed. This is, for example, related to the issue of deriving long-run elasticities from non-stationary, non-co-integrated variables. In the context of this thesis, one approach taken to circumvent this problem was to employ an unbalanced regression procedure. This method is scarcely discussed in the literature. The same goes for an application of the co-integration technique to explain demand changes from airfare adjustments. More fundamental and related to the time series research design, one could question whether a cross-sectional or panel design might have led to significantly other or maybe more reliable results. Given the available data, time series analysis was the natural choice for this analysis. However, it cannot be ruled out that one potential shortcoming of this research design - the spurious regression issue - might have also led to bias in the result of this analysis (i.e. sub-analysis 2).

Another important shortcoming of this thesis is the omitted separation of elasticities for the domestic and the international sub-segments. The demand data, as discussed in section 2.4 suggest different price elasticities for the segments. The available CPI-based fare datasets, however, were rather short and showed intense fluctuations, which are related to the sourcing methodology. Notwithstanding the application of several smoothing techniques, it was not possible to relate the demand changes in the segments to the price changes. Therefore, it was not possible to analyse the different elasticities for the segments.[48]

Finally, Easterby-Smith, Thorpe, and Jackson (2012) claim that quantitative research designs are the means to produce results that can be generalized. The findings of this analysis are thus only partly generalizable. First, this is because the aggregated level analyses are based on data of the most popular domestic and international routes, leaving out a large part of the route network in and from Norway. Second, the route-level analysis treats a rather special case. Consequently, the results of this thesis can only reflect the situation partially, rather than providing a compressive picture of the Norwegian setting.

In terms of recommendations for further research, it could be interesting to evaluate the findings of this thesis based on ‘longer’ datasets. Especially, the comparatively ‘young’ PPI-index and its respective sub-parts seem to be a promising data-source for a comprehensive analysis at the aggregated level.

Alternatively, it could be interesting to perform an in-depth analysis of the PSO-network in Norway with regard to its price elasticity of demand. Employing a panel analysis over the entire network might reveal some elasticity pattern, which could be valuable in use. For example, the impact of the price changes of ‘connecting’ flights on the PSO-route demand might yield interesting insights and additional adjustment mechanisms for policy makers.

In a more generic approach, it also seems tempting to address the topic of price elasticities of air travel demand by writing a state-of-the-art review article. Besides the conventional differentiation of price elasticities (i.e. traveller segment, etc.), such an article should especially strive to categorize the reported findings with respect to methodological issues. The consideration of aspects like ‘(non-) accounting for stationarity properties of data’ might substantially change the traditional picture of price elasticities of air travel demand.

[48] Please see Appendix 22.

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Analysis 1, 2, 3: Identification Problem and Endogenity of Airfare

Exogenous explanatory variables are by definition '… uncorrelated with the error term…', whereas endogenous explanatory variables in a multiple regression model are '… correlated with the error term, either because of an omitted variable, measurement error, or simultaneity'(Wooldridge 2010). Dealing with demand equations usually raises concerns about the latter cause for *endogeneity*. In the context of this thesis, the demand for air travel is assumed to be influenced by the airfares. But in fact, the opposite causal relationship also seems to hold true; that is, the prices will increase in the presence of increasing demand. Furthermore, since price is usually the result of an equilibrium state between demand and supply, it may give rise to the problem of model *identification*. Wooldridge (2010) combines both issues and resumes that '… when we estimate a model by OLS, the key identification condition is that each explanatory variable is uncorrelated with the error term'. Consequently, OLS regression will be biased and inconsistent when endogenous variables are present.

Several techniques are at hand to deal with the problem of endogeneity. One popular approach is to use the so-called Instrument Variables (IV) and the Two-Stage-Least-Square (2SLS) Estimation. The key issue here is to identify and utilize good instrument variables. A 'good' IV by nature needs to be highly correlated with the assumed endogenous variable, but uncorrelated with the error term (Villas-Boas and Winer 1999). This means that in a 'complete' specified demand model, an IV has to be an 'excluded' variable - it cannot be one of the already existing demand explanatory variables.

Literature on air transportation demand and endogeneity is quite scarce. It seems that a lot of the studies have accepted the possibility of biased OLS results arising from price endogeneity, because only view applications have reported how they addressed the issue. One reason for this is perhaps the difficulties in finding valid instrument variables (Mumbower, Garrow, and Higgins 2014).
InterVISTAS (2007), for example, have tried to employ flight distance and jet-fuel prices to instrument the airfare variable, but have found that fuel prices were only marginally

correlated with airfares and distance was an explanatory variable for demand, and therefore an invalid instrument. Chi, Koo, and Lim (2010) circumvented this issue by simply applying a lagged term of airfare as instrument for the endogenous airfare term. The same approach, but in an non-aviation setting, has also been used by other authors, such as Villas-Boas and Winer (1999) or by Chi, Koo, and Lim (2010), who employed the lagged terms of each assumed endogenous variable as instruments to correct for endogeneity. Mumbower, Garrow, and Higgins (2014) contributed a comprehensive discussion on IVs in the air transport literature and suggested to use supply-side variables (e.g. jet-fuel prices) or 'Hausmann-type-IVs'. The latter type of IVs could be, for example, an airfare in another geographical market.

Once a suitable IV is identified, one can follow Wooldridge (2010) in testing for endogeneity of the airfare variable in the following manner:
(1) Regressing airfare on all exogenous variables of the structural equation and the IV,
(2) Obtaining the residuals of this equation,
(3) Regressing the structural equation including the derived residuals as regressor, and
(4) Checking the coefficient of the residual for significance that would indicate the endogeneity of airfare in the demand equation.

I followed this approach for sub-analyses 1, 2 and 3. As IVs, I employed (1) the kerosene-prices in NOK per gallon as sourced from EIA (2015) and adjusted with Norges_Bank (2015), (2) the airfare development of the domestic market in Sweden as provided by Kopsch (2012b), and (3) the lagged terms of the airfare variables already used in the models.

It turned out that the development of airfares in Sweden were not sufficiently correlated with the airfares in my analysis, which would lead to a 'poor instrument variable issue' (Wooldridge 2010). On the other hand, prices of jet fuel and the lagged terms of airfares, seemed to be stronger correlated with the airfare variables. Consequently, I tried both variables as IVs and checked for endogenity of airfare in the structural equation. The results are reported in the outputs for sub-analysis 1 and for sub-analysis 2 on the next two pages.

Appendix 1- Output 1: Structural Equation with "jet_res" as residuals of reduced form (jet-fuel prices as IV) in Sub-Analysis 1

```
. regress d_lnpax d_lnfare jet_res d_lngdp d_lnpop d_lncar break

      Source |       SS       df       MS              Number of obs =      31
-------------+------------------------------           F(  6,    24) =    4.14
       Model |  .032764423     6  .005460737           Prob > F      =  0.0054
    Residual |  .031626999    24  .001317792           R-squared     =  0.5088
-------------+------------------------------           Adj R-squared =  0.3860
       Total |  .064391422    30  .002146381           Root MSE      =   .0363

------------------------------------------------------------------------------
     d_lnpax |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    d_lnfare |   .0417138   .3492868     0.12   0.906    -.6791787    .7626063
     jet_res |  -.4518271   .3717475    -1.22   0.236    -1.219076     .315422
     d_lngdp |   .2760774   .1955607     1.41   0.171    -.1275399    .6796948
     d_lnpop |   3.028556   2.847035     1.06   0.298    -2.847435    8.904546
     d_lncar |   .1279487   .1309957     0.98   0.338    -.1424132    .3983106
       break |   -.056523   .0196176    -2.88   0.008    -.0970117   -.0160342
       _cons |   .0372279   .0168038     2.22   0.036     .0025467    .0719092
------------------------------------------------------------------------------
```

Appendix 1- Output 2: Structural Equation with "fare_res" as residuals of reduced form (lagged airfares as IV) in Sub-Analysis 1

```
. regress d_lnpax d_lnfare fare_res d_lngdp d_lnpop d_lncar break

      Source |       SS       df       MS              Number of obs =      31
-------------+------------------------------           F(  6,    24) =    3.69
       Model |  .030893516     6  .005148919           Prob > F      =  0.0097
    Residual |  .033497906    24  .001395746           R-squared     =  0.4798
-------------+------------------------------           Adj R-squared =  0.3497
       Total |  .064391422    30  .002146381           Root MSE      =  .03736

------------------------------------------------------------------------------
     d_lnpax |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    d_lnfare |  -.4346271   .3529418    -1.23   0.230    -1.163063    .2938089
    fare_res |    .087697   .3763769     0.23   0.818    -.6891068    .8645008
     d_lngdp |   .4411256    .196051     2.25   0.034     .0364963     .845755
     d_lnpop |   3.154781   2.928085     1.08   0.292    -2.888489     9.19805
     d_lncar |   .1334635   .1347356     0.99   0.332    -.1446172    .4115442
       break |  -.0648448   .0202103    -3.21   0.004    -.1065568   -.0231328
       _cons |     .03674   .0173023     2.12   0.044     .0010298    .0724503
------------------------------------------------------------------------------
```

The decisive coefficients for the residuals "*jet_res*", "*fare_res*" and "*faret_res*", which were derived from the regression of the reduced form equations, were not found to be significant at the 10% level; hence, the airfare variables in all the structural models can be considered exogenous and an estimation of these models with OLS will most likely not suffer from the bias of endogeneity. Thus, one has to keep in mind that the small sample size might have biased the entire testing procedure and/or that the chosen IVs might not have been optimal.

Appendix 1 / page 4

Appendix 1 - Output 3: Structural Equation with "jet_res" as residuals of reduced form and jet fuel prices as IV in Sub-Analysis 2

```
. regress D.ln_paxt D.ln_faret jet_res D.ln_gdp quart1 quart2

      Source |       SS       df       MS              Number of obs =      35
-------------+------------------------------           F(  5,    29) =   20.12
       Model |  .135607585     5  .027121517           Prob > F      =  0.0000
    Residual |  .039088574    29  .001347882           R-squared     =  0.7762
-------------+------------------------------           Adj R-squared =  0.7377
       Total |  .174696159    34  .005138122           Root MSE      =  .03671

------------------------------------------------------------------------------
    D.ln_paxt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_faret |
         D1. |  -.0756492   .1470534    -0.51   0.611    -.3764072    .2251089
             |
     jet_res |  -.1525967   .4732277    -0.32   0.749    -1.120456    .8152627
             |
      ln_gdp |
         D1. |   .7186598   .2204906     3.26   0.003     .2677058    1.169614
             |
      quart1 |   .0084714   .0211103     0.40   0.691    -.0347039    .0516467
      quart2 |   .1506506   .0240718     6.26   0.000     .1014182    .1998829
       _cons |  -.0383446   .0136359    -2.81   0.009    -.0662331   -.0104561
------------------------------------------------------------------------------
```

Appendix 1 - Output 4: Structural Equation with "faret_res" as residuals of reduced form and lagged airfares as IV in Sub-Analysis 2

```
. regress D.ln_paxt D.ln_faret faret_res D.ln_gdp quart1 quart2

      Source |       SS       df       MS              Number of obs =      34
-------------+------------------------------           F(  5,    28) =   19.71
       Model |  .128993253     5  .025798651           Prob > F      =  0.0000
    Residual |  .036643168    28  .001308685           R-squared     =  0.7788
-------------+------------------------------           Adj R-squared =  0.7393
       Total |  .165636421    33  .005019285           Root MSE      =  .03618

------------------------------------------------------------------------------
    D.ln_paxt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_faret |
         D1. |  -1.123444    .766117    -1.47   0.154    -2.692764    .4458752
             |
   faret_res |   1.074444   .7791195     1.38   0.179      -.52151    2.670398
             |
      ln_gdp |
         D1. |     1.0143   .2959377     3.43   0.002     .4080995    1.620501
             |
      quart1 |   .0285199   .0248851     1.15   0.261     -.022455    .0794948
      quart2 |   .1889595   .0370752     5.10   0.000     .1130143    .2649047
       _cons |  -.0562962   .0182499    -3.08   0.005    -.0936794    -.018913
------------------------------------------------------------------------------
```

For sub-analysis 3, the results of the tests were somehow inconsistent. With jet-fuel prices as IV, airfare was found to be exogenous. With the lagged term of airfare, the results differed in respect to the "outlier"-issue (see sub-analysis 3). Using the uncorrected dataset, airfares appeared to be exogenous, but once I used the corrected dataset, airfares were reported to be endogenous.

Using both instruments in combination, lagged airfare and jet-fuel, airfare was found to be exogenous again. In order to check the issue more in detail, I performed a complete 2SLS-regression on the "endogenous" model. I found that this approach did no yield to any meaningful results. This led me to conclude, that either the chosen instrument variable was not appropriate for this sub-dataset or that the specific test of the "corrected" dataset yielded to wrong results, based on the small dataset issue. I therefore decided for sub-analysis 3 to trust the prevailing part of the test results that indicated exogeneity of airfare.

To sum up, for all three sub-analyses I have not found evidence for airfares being an endogenous variable. An estimation of the structural models with OLS will most likely not suffer from endogenity biasness. In the absence of better IVs and/or indications for endogenity, the airfare variables in all three sub-analyses were considered to be exogenous.

Appendix 2

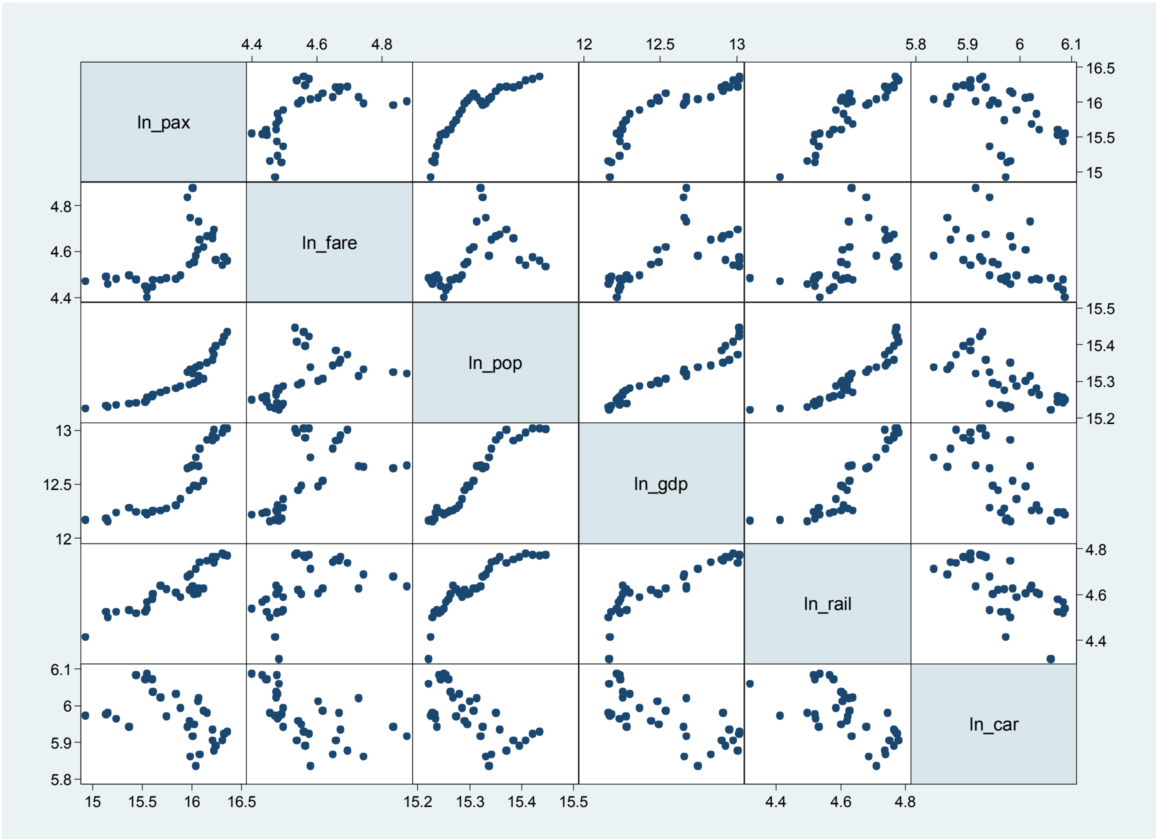
Analysis 1: Correlogram and Scatter Plot for Outlier Detection

1st: Correlogram

```
. correlate ln_fare ln_pop ln_gdp ln_rail ln_car terror comp break
(obs=34)
```

	ln_fare	ln_pop	ln_gdp	ln_rail	ln_car	terror	comp	break
ln_fare	1.0000							
ln_pop	0.5522	1.0000						
ln_gdp	0.6580	0.9676	1.0000					
ln_rail	0.5330	0.9151	0.8938	1.0000				
ln_car	-0.5823	-0.6591	-0.7137	-0.6448	1.0000			
terror	0.6353	0.0828	0.1171	0.0774	-0.1558	1.0000		
comp	0.7112	0.1175	0.1606	0.1043	-0.1621	0.6021	1.0000	
break	0.7579	0.8516	0.9149	0.7901	-0.7138	0.2988	0.3276	1.0000

2nd: Scatter-Plot



Appendix 3

Analysis 1: Test of Stationarity Properties of the Variables

	ADF test	PP test	DFGLS test
Variable	t-stat	t-stat	t-stat
pax	-.686	-.713	
ln(pax)	***-3.186***	*- 2.977*	*-1.396*
Δln(pax)	**-5.680**	**-5.561**	**-4.468**
fare	-1.537	-1.675	
ln(fare)	-1.453	-1.592	
Δln(fare)	**-4.249**	**-4.127**	
pop	13.422	8.934	
ln(pop)	12.023	8.119	
Δln(pop)	-.681	-.709	
ΔΔln(pop)	**-4.413**	**-4.272**	
gdp	.476	.566	
ln(gdp)	.201	.222	
Δln(gdp)	**-4.542**	**-4.425**	
rail	0.037	-2.438	
ln(rail)	*-3.399*	*-3.016*	*-2.667*
Δln(rail)	**-4.928**	**-4.414**	**-3.786**
car	-2.604	-.312	
ln(car)	-0.141	-0.538	
Δln(car)	**-4.431**	**-5.213**	
5% critical value	-2.98	-2.98	-3.411

Appendix 4

Analysis 1: Testing for Cointegration - Regression Output

1st: Regression

```
. regress ln_pax ln_fare

      Source |       SS       df       MS              Number of obs =      33
-------------+------------------------------           F(  1,    31) =   16.75
       Model |  1.68184922     1  1.68184922           Prob > F      =  0.0003
    Residual |  3.11278517    31  .100412425           R-squared     =  0.3508
-------------+------------------------------           Adj R-squared =  0.3298
       Total |   4.7946344    32  .149832325           Root MSE      =  .31688

------------------------------------------------------------------------------
      ln_pax |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     ln_fare |   1.946106   .4755177     4.09   0.000     .9762812    2.915931
       _cons |   6.950777   2.171841     3.20   0.003     2.521279    11.38028
------------------------------------------------------------------------------

. predict r, resid
(3 missing values generated)
```

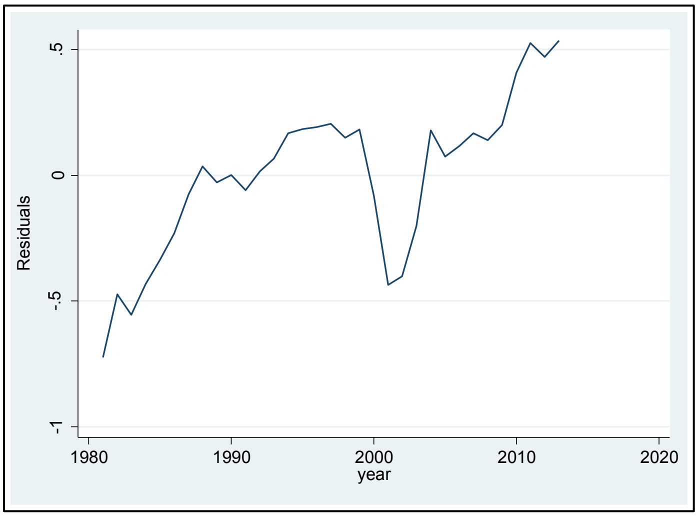
2nd: DFuller test of residuals, r

```
. dfuller r

Dickey-Fuller test for unit root                   Number of obs   =        32

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.873            -3.702            -2.980            -2.622
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.3449
```

3rd: Residuals plotted vs. Time



Appendix 5

Analysis 1: Overspecified Static-Model - Regression Output

```
. regress d_lnpax d_lnfare d_lngdp d_lncar d_lnrail d_lnpop terror comp

      Source |       SS       df       MS              Number of obs =      31
-------------+------------------------------           F(  7,    23) =    3.80
       Model |  .034517586     7  .004931084           Prob > F      =  0.0070
    Residual |  .029873836    23  .001298862           R-squared     =  0.5361
-------------+------------------------------           Adj R-squared =  0.3949
       Total |  .064391422    30  .002146381           Root MSE      =  .03604

------------------------------------------------------------------------------
     d_lnpax |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    d_lnfare |  -.2170151   .1246906    -1.74   0.095    -.4749572     .040927
     d_lngdp |   .1845273   .1657129     1.11   0.277    -.1582758    .5273305
     d_lncar |   .0152958   .1348673     0.11   0.911    -.2636984    .2942901
    d_lnrail |  -.2930562   .3865043    -0.76   0.456    -1.092601    .5064888
     d_lnpop |  -4.640049   2.064899    -2.25   0.035    -8.911618   -.3684796
      terror |  -.0501357   .0371718    -1.35   0.191    -.1270315    .0267601
        comp |  -.0413551   .0230942    -1.79   0.087    -.0891292    .0064189
       _cons |   .0781362   .0172058     4.54   0.000     .0425432    .1137291
------------------------------------------------------------------------------
```

Appendix 6

Analysis 1: Diagnostics Tests DL Model

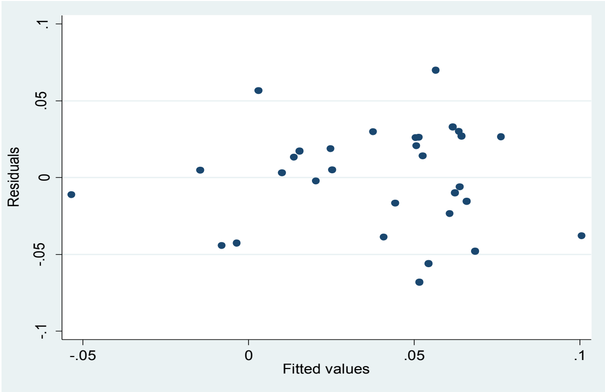
1st: Test for Homeoskedasticty

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(19)      =     17.91
         Prob > chi2   =    0.5281

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	17.91	19	0.5281
Skewness	3.63	5	0.6036
Kurtosis	1.09	1	0.2971
Total	22.63	25	0.5989

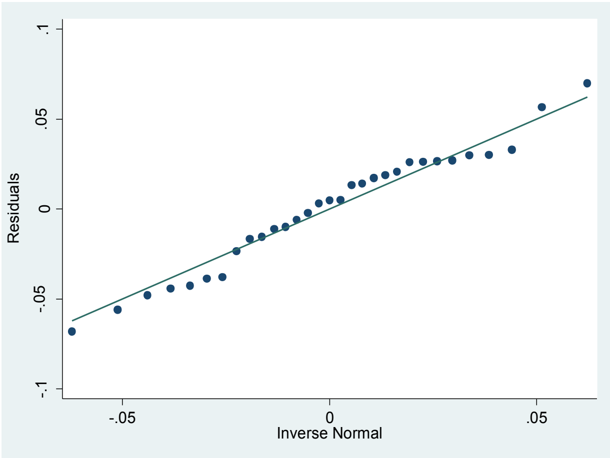


2nd: Test for Normality

```
. swilk e

                   Shapiro-Wilk W test for normal data
```

Variable	Obs	W	V	z	Prob>z
e	31	0.97050	0.961	-0.082	0.53279



3rd: Test for Serial Correlation:

```
. dwstat

Durbin-Watson d-statistic(  6,    31) =  1.886509
```

4th: Test for Omitted Variables:

```
. ovtest

Ramsey RESET test using powers of the fitted values of d_lnpax
       Ho:  model has no omitted variables
                 F(3, 22) =      0.19
                 Prob > F =      0.9018
```

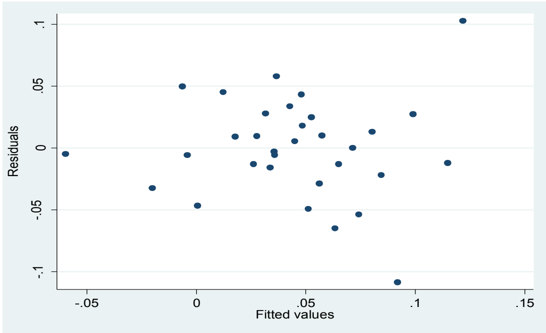
Appendix 7

Analysis 1: Diagnostics Tests ADL Model

1st: Test for Homeoskedasticty

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	26.54	20	0.1486
Skewness	1.48	5	0.9150
Kurtosis	1.72	1	0.1891
Total	29.75	26	0.2780

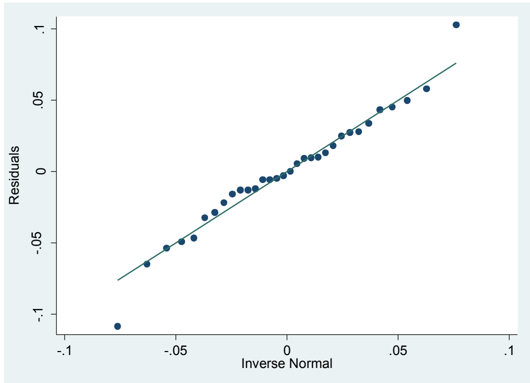


2nd Test for Normality

. swilk z

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
z	32	0.98146	0.618	-0.998	0.84081



3rd: Test for Serial Correlation

. estat bgodfrey

Breusch-Godfrey LM test for autocorrelation

lags(*p*)	chi2	df	Prob > chi2
1	0.204	1	0.6511

H0: no serial correlation

4th: Test for Omitted Variables

```
Ramsey RESET test using powers of the fitted values of d_lnpax
       Ho:  model has no omitted variables
                  F(3, 22) =       0.53
                  Prob > F =       0.6647
```

Appendix 8 / page 1

Analysis 2: Correlogram and Scatter Plot for Outlier Detection

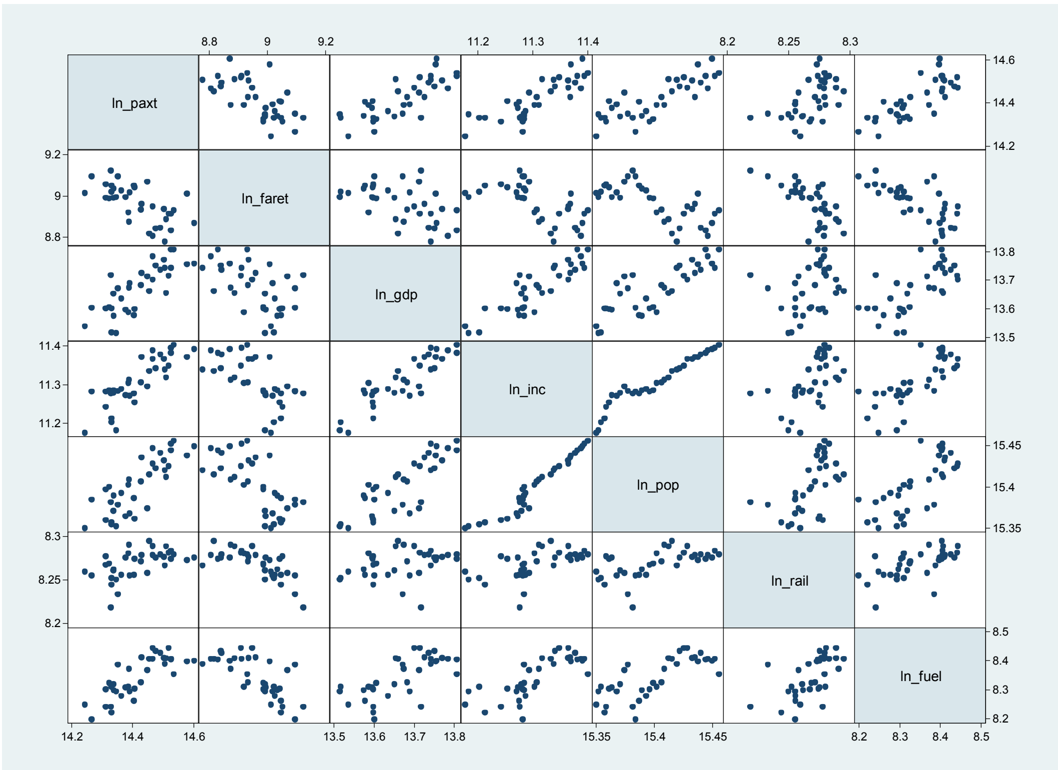
Correlogram

```
. correlate ln_faret ln_fareb ln_farel ln_gdp ln_inc ln_pop ln_fuel ln_rail quart1 quart2 quart3 crisis
(obs=36)
```

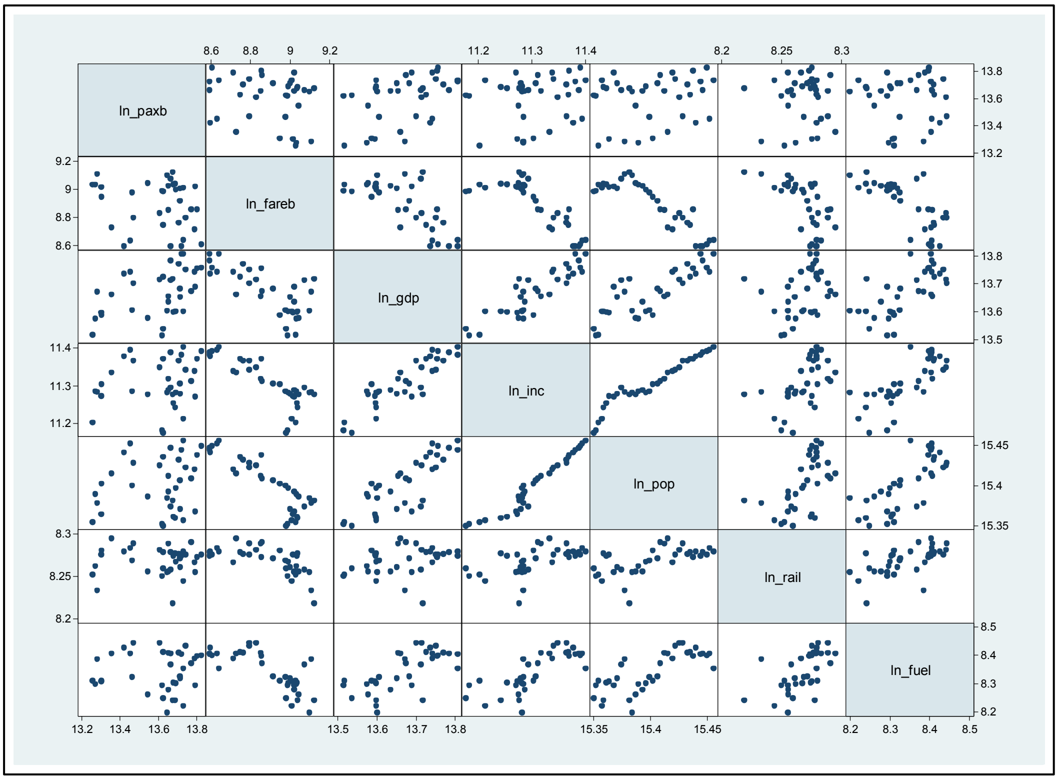
	ln_faret	ln_fareb	ln_farel	ln_gdp	ln_inc	ln_pop	ln_fuel	ln_rail	quart1	quart2	quart3
ln_faret	1.0000										
ln_fareb	0.8677	1.0000									
ln_farel	0.6587	0.2183	1.0000								
ln_gdp	-0.5265	-0.7221	-0.0480	1.0000							
ln_inc	-0.6335	-0.8132	-0.1530	0.8818	1.0000						
ln_pop	-0.7038	-0.8799	-0.1652	0.8172	0.9598	1.0000					
ln_fuel	-0.6716	-0.7249	-0.3199	0.6902	0.7424	0.7506	1.0000				
ln_rail	-0.6025	-0.5711	-0.3815	0.2617	0.5161	0.4931	0.4204	1.0000			
quart1	-0.0051	0.0492	-0.0718	-0.0457	-0.0652	-0.0801	-0.1693	0.0808	1.0000		
quart2	0.0932	0.0881	0.0479	-0.1187	-0.0719	-0.0291	0.0124	-0.0338	-0.3333	1.0000	
quart3	-0.0606	-0.0520	-0.0446	-0.1864	0.0539	0.0219	0.2457	0.2219	-0.3333	-0.3333	1.0000
crisis	0.2896	0.3724	-0.0238	-0.4307	-0.1719	-0.1296	-0.4672	-0.1746	0.0405	0.0405	0.0405

	crisis
crisis	1.0000

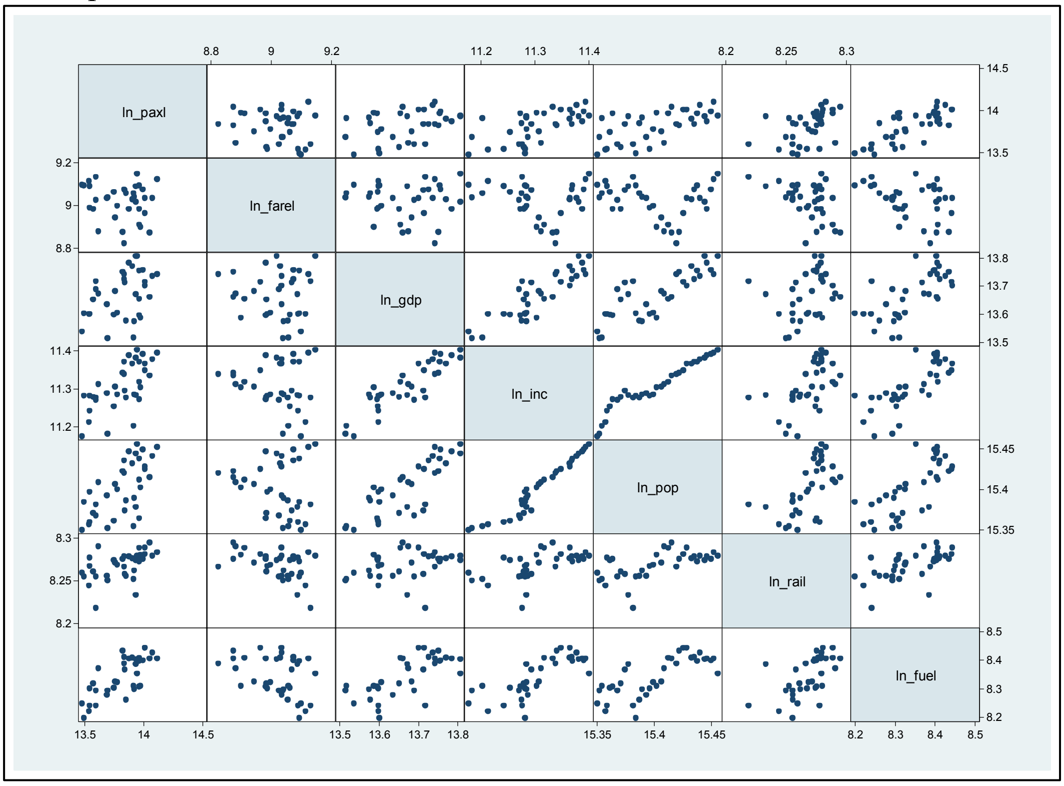
Scatterplot total demand



Scatterplot Demand for Business Travel



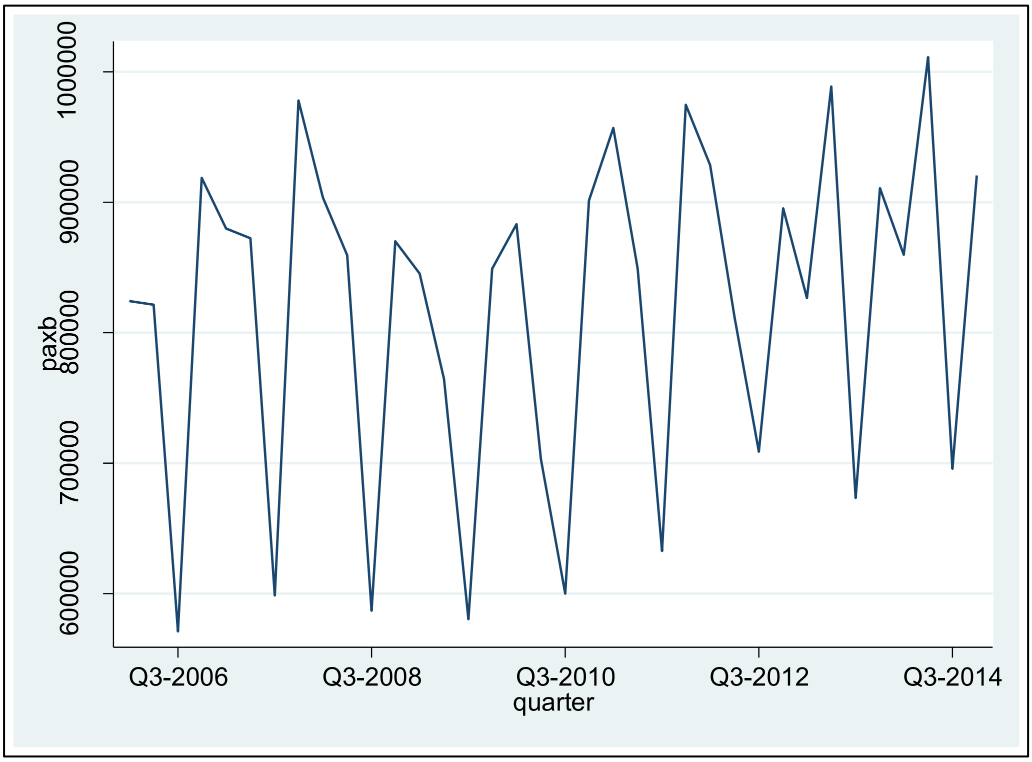
Scatterplot Demand for Leisure Travel



<u>Appendix 9</u>

Analysis 2: Timeplot Business Travel by Air Q1/2006 - Q4/2014 and Descriptive Statistics

1st: Time-Plot



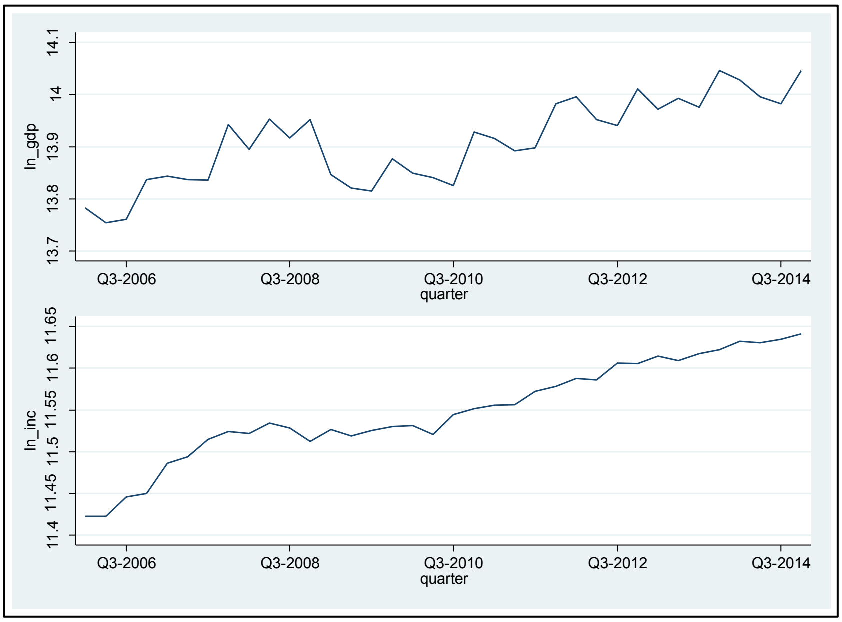
2nd: Descriptive Statistics

Variable	**Mean per Quarter**	**Standard Deviation**
business passengers on board (*paxb*)	818259	128934
leisure passengers on board (*paxl*)	1013434	177850
total passengers on board (*paxt)*	1831693	166366
airfare index business traveller (*fareb*)	93.7	15.1
airfare index leisure traveller (*farel*)	105.6	8.3
airfare index total (*faret*)	99.8	8.9
population (*pop*)	4886643	160266
Norwegian-GDP in million NOK (*gdp*)	1102068	88992
household income NOK (*inc*)	103831	6156
train ticket prices index (*rail*)	148.8	2.5
fuel price index (*fuel*)	160.6	11.4

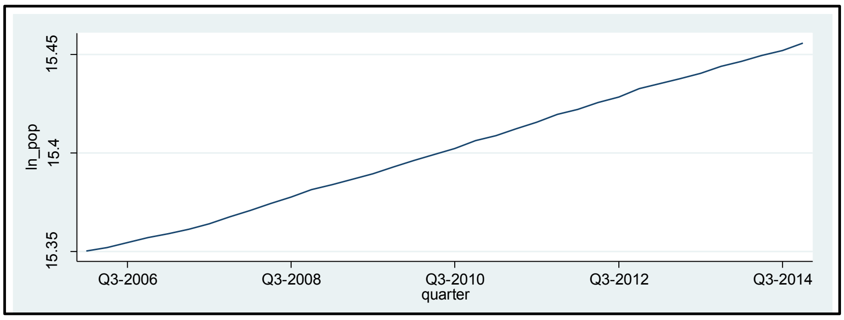
Appendix 10

Analysis 2: Timeplots Main Explanatory Variables

ln(*gdp*) and ln(*inc*)



ln(*pop*)



Appendix 11

Analysis 2: Test of the Variable's Stationarity Properties

Variable	ADF-test t-stat	PP--test t-stat	ADF-test including trend t-stat
ln(*paxb*)	**-7.193**	**-8.263**	
ln(*paxl*)	**-4.132**	**-4.010**	
ln(*paxt*)	-2.797	-2.621	**-5.473**
Δln(*paxt*)	**-13.074**	**- 16.673**	
ln(*fareb*)	-.583	-.362	
Δln(*fareb*)	**-6.79**	**-6.906**	
ln(*farel*)	-1.61	-1.881	
Δln(*fare*)	**-5.949**	**-5.944**	
ln(*faret*)	-1.615	-1.730	
Δln(*faret*)	**-5.517**	**-5.516**	
ln(*pop*)	1.493	1.362	**-3.945**
Δln(*pop*)	**-5.458**	**-5.455**	
ln(*gdp*)	-1.776	-1.340	
Δln(*gdp*)	**-7.594**	**-8.435**	
ln(*inc*)	-1.615	-1.657	
Δln(*inc*)	**-7.081**	**-6.937**	
ln(*rail*)	**-3.133**	**-3.105**	
ln(*fuel*)	-2.270	-2.089	
Δln(*fuel*)	**-6.354**	**-6.962**	
5% critical value	-2.98	-2.98	-3.560

Appendix 12

Analysis 2: Overspecified Model

```
. regress ln_paxt ln_faret  ln_gdp ln_pop ln_fuel ln_rail quart1 quart2 quart3

      Source |       SS       df       MS              Number of obs =      36
-------------+------------------------------           F(  9,    26) =   47.04
       Model |  .268520031     9  .029835559           Prob > F      =  0.0000
    Residual |  .016491999    26  .000634308           R-squared     =  0.9421
-------------+------------------------------           Adj R-squared =  0.9221
       Total |   .28501203    35  .008143201           Root MSE      =  .02519

------------------------------------------------------------------------------
     ln_paxt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_faret |  -.1650869   .0851543    -1.94   0.063     -.340124    .0099503
      ln_gdp |   .4285881   .1558208     2.75   0.011     .1082939    .7488824
      ln_pop |   1.100064   .4140453     2.66   0.013     .2489822    1.951147
     ln_fuel |  -.1655679    .141085    -1.17   0.251    -.4555722    .1244364
     ln_rail |   .6410501   .4039007     1.59   0.125    -.1891796     1.47128
      quart1 |  -.0440235   .0136041    -3.24   0.003    -.0719871   -.0160599
      quart2 |    .066837   .0155423     4.30   0.000     .0348894    .0987846
      quart3 |   .0178059   .0186578     0.95   0.349    -.0205457    .0561574
      crisis |  -.0442157    .017116    -2.58   0.016    -.0793982   -.0090332
       _cons |  -10.09592   4.700631    -2.15   0.041    -19.75821    -.433638
------------------------------------------------------------------------------
```

Appendix 13

Analysis 2: Regression Output after Variable Transformation

```
. regress ln_paxt ln_faret ln_gdp dif1 dif2 quart1 quart2

      Source |       SS       df       MS              Number of obs =      34
-------------+------------------------------           F(  6,    27) =   39.69
       Model |  .223696865     6  .037282811           Prob > F      =  0.0000
    Residual |  .025359792    27  .000939252           R-squared     =  0.8982
-------------+------------------------------           Adj R-squared =  0.8755
       Total |  .249056656    33  .007547171           Root MSE      =  .03065

------------------------------------------------------------------------------
     ln_paxt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_faret |  -.4725199   .0824727    -5.73   0.000    -.6417399   -.3032998
      ln_gdp |   .5546996   .0964085     5.75   0.000     .3568857    .7525135
        dif1 |   .0442433   .1652575     0.27   0.791     -.294837    .3833237
        dif2 |   .1807949   .1169683     1.55   0.134    -.0592042     .420794
      quart1 |  -.0521874   .0130706    -3.99   0.000    -.0790062   -.0253687
      quart2 |    .059016   .0135891     4.34   0.000     .0311334    .0868986
       _cons |   8.875119   1.615875     5.49   0.000     5.559617    12.19062
------------------------------------------------------------------------------
```

$$Y_t = \theta_0 X_t + \cdots + \beta_1(X_{t-1} - X_t) + \beta_2(X_{t-2} - X_t) + \cdots + \beta_0$$

$$\text{Long Run} - \text{effect} = \theta = \beta_1 + \beta_2 + \beta_3;$$

“Coef. ln_faret” $= \theta$

“Coef. dif1” $= \beta_1$

“Coef. dif2” $= \beta_1$

Analysis 2: Tests for Unballanced Regression Requirements

1st: Stationarity of Residual

Dickey-Fuller test for unit root — Number of obs = 33

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(t)	-5.060	-3.696	-2.978	-2.620

MacKinnon approximate p-value for Z(t) = 0.0000

2nd a: Stationarity of Fitted Values

```
. dfuller fittet
```

Dickey-Fuller test for unit root — Number of obs = 34

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(t)	-2.825	-3.689	-2.975	-2.619

MacKinnon approximate p-value for Z(t) = 0.0548

2nd b: Stationarity of Fitted Values Allowing for Trend

```
. dfuller fittet, trend
```

Dickey-Fuller test for unit root — Number of obs = 33

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(t)	-5.454	-4.306	-3.568	-3.221

MacKinnon approximate p-value for Z(t) = 0.0000

```
. pperron fittet, trend
```

Phillips-Perron test for unit root — Number of obs = 33, Newey-West lags = 3

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(rho)	-40.216	-23.524	-18.508	-15.984
Z(t)	-5.601	-4.306	-3.568	-3.221

MacKinnon approximate p-value for Z(t) = 0.0000

Analysis 2: Tests for Unballanced Regression Requirements

3rd: Variance Ratio Test

Variance ratio test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
ln_paxt	36	14.41678	.0150399	.0902397	14.38625	14.44731
fittet	35	14.42168	.0138067	.0816818	14.39362	14.44974
combined	71	14.41919	.0101526	.0855473	14.39895	14.43944

```
    ratio = sd(ln_paxt) / sd(fittet)                        f =   1.2205
Ho: ratio = 1                                  degrees of freedom =   35, 34

    Ha: ratio < 1              Ha: ratio != 1              Ha: ratio > 1
  Pr(F < f) = 0.7186        2*Pr(F > f) = 0.5629          Pr(F > f) = 0.2814
```

Appendix 15

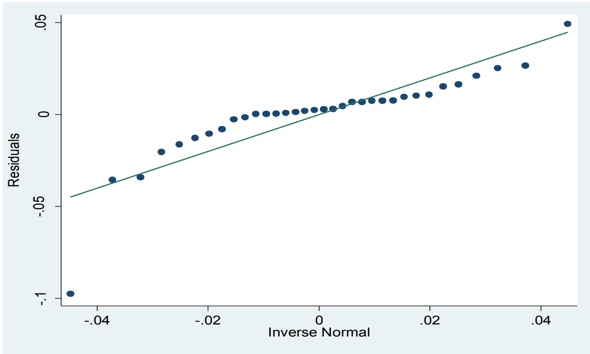
Sub-Analysis 2: Diagnostics Tests

1st: Normal Distribution of Residuals

```
. swilk q

                   Shapiro-Wilk W test for normal data

    Variable |    Obs       W           V         z       Prob>z
-------------+--------------------------------------------------
           q |     34    0.92406      2.652     2.032    0.02108
```



2nd: Homeoskedasticity of Residuals

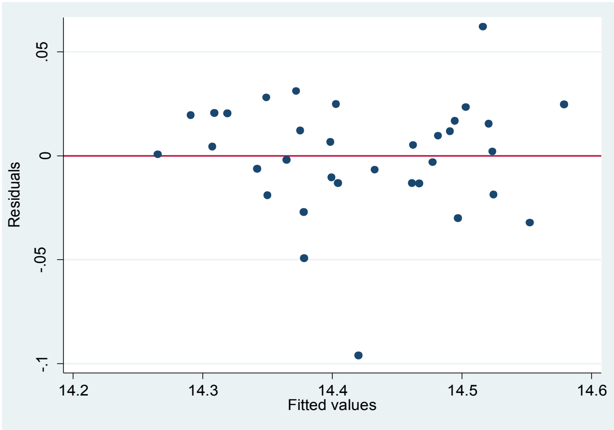
```
Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |      13.62     24    0.9547
            Skewness |       6.19      6    0.4025
            Kurtosis |       1.43      1    0.2316
---------------------+-----------------------------
               Total |      21.24     31    0.9054
---------------------------------------------------

. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of ln_paxt

         chi2(1)      =     0.39
         Prob > chi2  =   0.5333
```



3rd: Test for Serial Correlation

```
. dwstat

Durbin-Watson d-statistic(  7,    34) =  1.776568
```

4th: Test For Omitted Variables

```
. ovtest

Ramsey RESET test using powers of the fitted values of ln_paxt
       Ho:  model has no omitted variables
                 F(3, 24) =      1.14
                 Prob > F =      0.3548
```

Appendix 16

Analysis 2: Test for Equal Coefficients / Regression Output: Comparison Seasonal Differenced and "Standard" Differenced Data

Test for Equal Coefficients:

H_0 =Equal Coefficients

```
. test [leisure_mean]S4.ln_farel = [business_mean]S4.ln_fareb

 ( 1)  [leisure_mean]S4.ln_farel - [business_mean]S4.ln_fareb = 0

          chi2(  1) =    0.09
        Prob > chi2 =    0.7682
```

Model Comparison: 1st column leisure demand w/o seasonal dummies / 2nd with dummies
3rd column business demand w/o seasonal dummies / 4th with dummies

	Model_leis~e b/_star/t	Model_l_qu~1 b/_star/t	Model_busi~s b/_star/t	Model_b_qu~t b/_star/t
D.ln_farel	.3907717	-.4242694		
	.6976634	-1.495703		
D.ln_inc	-1.512778			
	-.4716258			
D.ln_fuel	2.476949	.7078677	-3.108116	-1.017314
	***	*	***	*
	4.397957	2.052933	-4.651624	-2.52267
D.ln_pop	-88.31332	20.90189	174.5795	-21.56276
			**	
	-1.700828	.6636089	3.033937	-.5706677
D.ln_rail	1.992209			
	.8262626			
D.ln_exrate		.2923135	.0994411	-.4962713
		.7629277	.1101535	-1.06102
quart1		.1601066		-.4107514
		**		***
		2.888844		-6.078646
quart2		.4486241		-.3846195
		***		***
		8.415125		-6.086226
quart3		.3275781		-.6353865
		***		***
		6.17145		-9.706224
D.ln_fareb			.8968293	.2812325
			1.689357	1.023001
_cons	.2794816	-.2886778	-.5042761	.4321169
		*	**	**
	1.734546	-2.348738	-2.878238	2.93372

Appendix 17

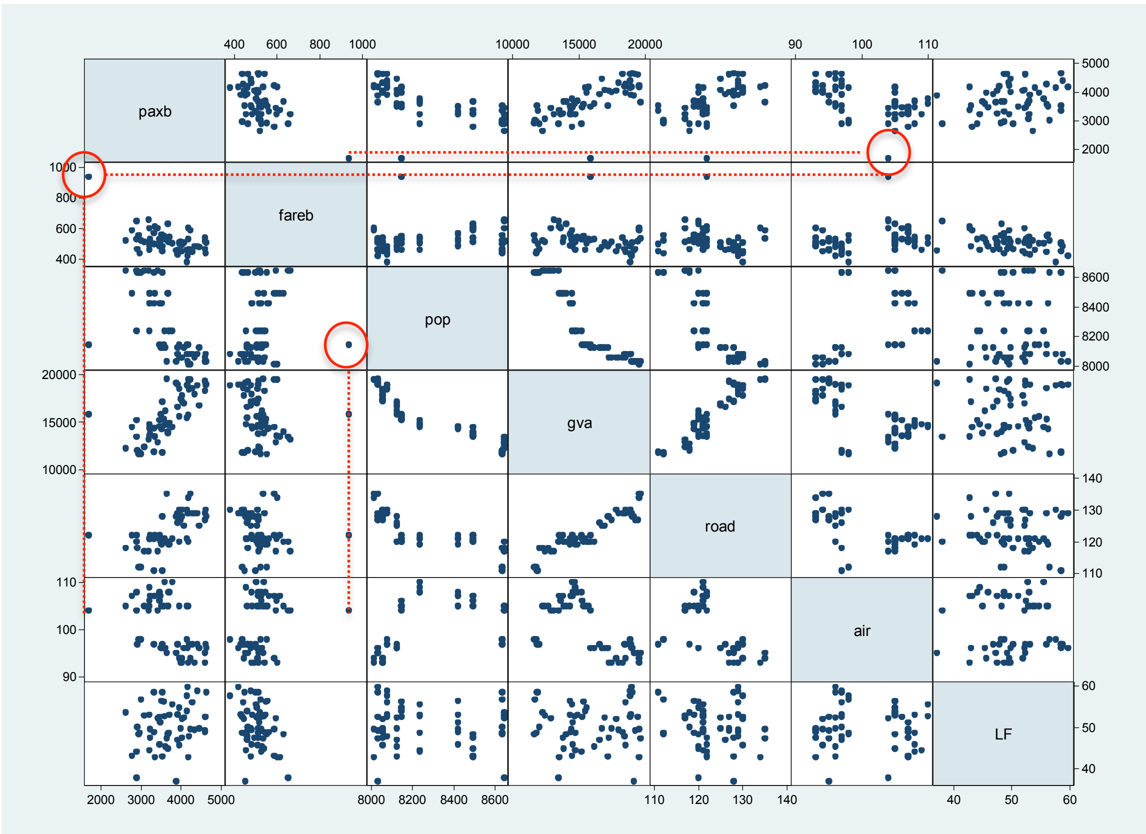
Analysis 3: Correlogram, Outlier Plot and Demand/Airfare Data Plot

1st: Correlogram

```
. correlate farea fareb pop gva car road air LF
(obs=56)
```

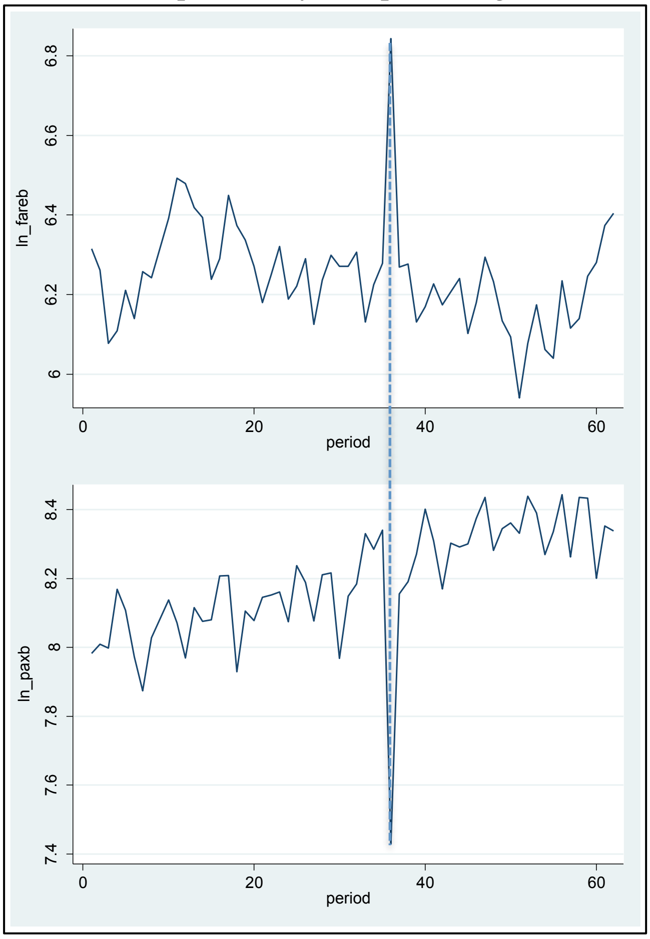
	farea	fareb	pop	gva	car	road	air	LF
farea	1.0000							
fareb	1.0000	1.0000						
pop	0.3041	0.3041	1.0000					
gva	-0.2971	-0.2971	-0.9287	1.0000				
car	0.1109	0.1109	-0.3589	0.4224	1.0000			
road	-0.1811	-0.1811	-0.8428	0.9388	0.4675	1.0000		
air	0.3307	0.3307	0.4255	-0.5932	0.1103	-0.5137	1.0000	
LF	-0.3607	-0.3607	0.0094	-0.0323	-0.1325	-0.1639	-0.0334	1.0000

2nd: Outlier Plot



Appendix 18

3rd: Variables *paxb* and *fareb* plotted against time



Appendix 19

Analysis 3: Test of the Variable's Stationarity Properties

	ADF-test	PP--test
Variable	t-stat	t-stat
ln(*paxa*)	**-3.423**	**-3.174**
ln(*paxb*)	**-4.848**	**-4.855**
ln(*farea*)	**-3.552**	**-3.432**
ln(*fareb*)	**-4.573**	**-4.513**
ln(*pop*)	-2.682	-1.750
Δln(*pop*)	**-3.382**	**-3.510**
ln(*gva*)	-1.793	-1.604
Δln(*gva*)	**-6.085**	**-6.129**
ln(*road*)	-1.424	-1.190
Δln(*road*)	**-8.849**	**-9.227**
ln(car)	-2.051	-2.133
Δln(*car*)	**-7.788**	**-7.790**
ln(*LF*)	**-5.543**	**-5.530**
ln(*air*)	-0.982	-0.960
	-7.360	**-7.351**
5% critical value	-2.98	-2.98

Analysis 3: Regression Outputs Model B - Not Corrected for Outlier

Static Model - Prais-Winsten

Source	SS	df	MS		
				Number of obs =	59
				F(10, 48) =	23.17
Model	1.39030923	10	.139030923	Prob > F =	0.0000
Residual	.287982559	48	.005999637	R-squared =	0.8284
				Adj R-squared =	0.7927
Total	1.67829179	58	.028936065	Root MSE =	.07746

D.ln_paxbpop	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_fareb						
D1.	-.8549923	.0990397	-8.63	0.000	-1.054125	-.6558595
ln_gva						
D1.	.7795531	1.309769	0.60	0.555	-1.853914	3.41302
ln_air						
D1.	-.9581684	.5307811	-1.81	0.077	-2.025375	.1090385
ln_car						
D1.	-.1427547	.4821914	-0.30	0.768	-1.112265	.8267561
ln_road						
D1.	1.349155	.8982885	1.50	0.140	-.4569751	3.155285
I	-.3393928	.0551185	-6.16	0.000	-.450216	-.2285695
II	.0819003	.0381393	2.15	0.037	.0052161	.1585845
III	-.0263006	.043391	-0.61	0.547	-.1135441	.0609429
IV	-.2174454	.0445535	-4.88	0.000	-.3070263	-.1278646
V	.1043011	.0498403	2.09	0.042	.0040904	.2045118
_cons	.0594726	.0325263	1.83	0.074	-.005926	.1248711
rho	-.4800884					

Durbin-Watson statistic (original) 2.813501
Durbin-Watson statistic (transformed) 2.039475

Analysis 3: Regression Outputs Model B - Not Corrected for Outlier

Dynamic Model - Prais-Winsten

Source	SS	df	MS
Model	1.38461712	11	.125874283
Residual	.281569724	45	.006257105
Total	1.66618684	56	.029753336

Number of obs	=	57
F(11, 45)	=	20.12
Prob > F	=	0.0000
R-squared	=	0.8310
Adj R-squared	=	0.7897
Root MSE	=	.0791

D.ln_paxbpop	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_fareb						
D1.	-.8652578	.101778	-8.50	0.000	-1.070249	-.6602663
ln_gva						
D1.	.6589107	1.390143	0.47	0.638	-2.140981	3.458803
ln_air						
D1.	-.9854588	.5701391	-1.73	0.091	-2.133778	.1628604
ln_car						
D1.	-.2337681	.5016201	-0.47	0.643	-1.244083	.7765467
ln_road						
D1.	1.283765	.939745	1.37	0.179	-.6089784	3.176509
I	-.3307844	.0614024	-5.39	0.000	-.4544551	-.2071137
II	.0890737	.0529568	1.68	0.099	-.0175868	.1957341
III	-.0203003	.0482387	-0.42	0.676	-.1174581	.0768575
IV	-.2143381	.0474098	-4.52	0.000	-.3098264	-.1188499
V	.1085931	.054406	2.00	0.052	-.0009862	.2181724
ln_paxbpop						
LD.	.0336056	.1017473	0.33	0.743	-.171324	.2385353
_cons	.0565025	.035694	1.58	0.120	-.0153888	.1283938
rho	-.5057344					

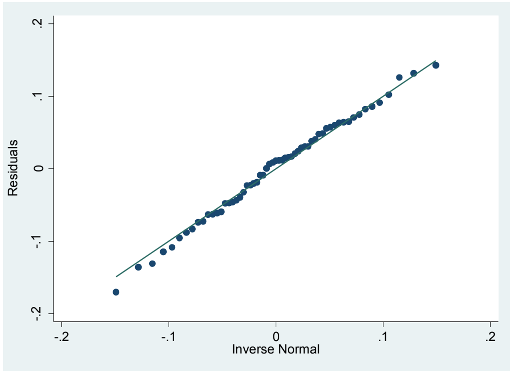
Durbin-Watson statistic (original) 2.507940
Durbin-Watson statistic (transformed) 2.017150

Analysis 3: Diagnostic Tests Static Model A

1st: Normal Distribution of Residuals

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
r	59	0.98944	0.566	-1.225	0.88964



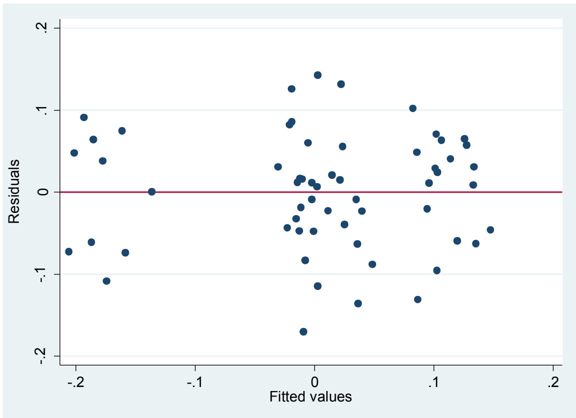
2nd: Homeoskedasticity of Residuals

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of D.ln_paxapop

chi2(1) = 0.21
Prob > chi2 = 0.6497

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	55.11	45	0.1437
Skewness	9.73	10	0.4647
Kurtosis	1.23	1	0.2667
Total	66.07	56	0.1681



3rd: Test for Omitted Variables

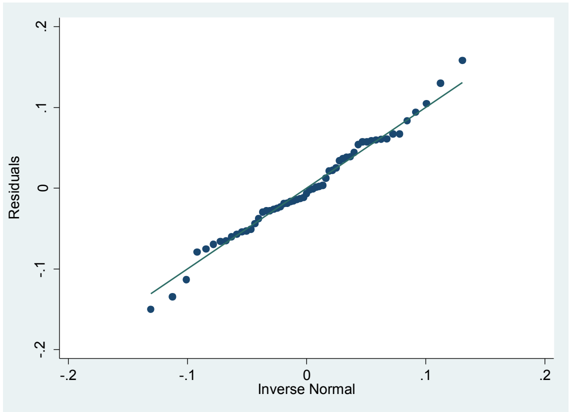
Ramsey RESET test using powers of the fitted values of D.ln_paxapop
Ho: model has no omitted variables
F(3, 45) = 0.87
Prob > F = 0.4624

Analysis 3: Diagnostic Tests Dynamic Model A

1st: Normal Distribution of Residuals

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
d	57	0.98908	0.570	-1.209	0.88660



2nd: Homeoskedasticity of Residuals

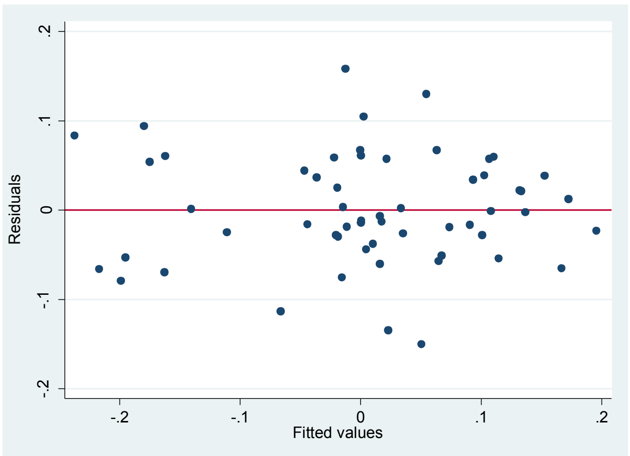
```
. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of D.ln_paxapop

         chi2(1)      =     1.31
         Prob > chi2  =   0.2520


  Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	56.66	54	0.3760
Skewness	7.85	11	0.7266
Kurtosis	0.04	1	0.8414
Total	64.55	66	0.5274



3rd: Test for Serial Correlation; Breusch-Godfrey-Test to Account for Lagged Dependent

Breusch-Godfrey LM test for autocorrelation

lags(*p*)	chi2	df	Prob > chi2
1	0.549	1	0.4587

H0: no serial correlation

4th: Test for Omitted Variables

```
Ramsey RESET test using powers of the fitted values of D.ln_paxapop
       Ho:  model has no omitted variables
                  F(3, 45) =        0.87
                  Prob > F =        0.4624
```

A. Supplementary Analysis – Segmented Domestic and International Demand – Quarterly Data from 2006-2014

Three days prior submission deadline for this thesis, Statistics Norway published a producer-price based airfare index that allows seperating the price development of the domestic air travel market from the development in fares for international services (SSB 2015g). In order to utilizes this new data, I decided to perform an supplementary sub-analysis, which addresses the additional research question:

RQ 7: Do the price elasticities differ between the domestic and the international segment?

In addition, this analysis strives to generate findings, which can be used to foster or to disprove the results of the privious three sub-analysis.
Because of the limited time avialable to perform this supplementary anlysis, I decided to deal with it exclusively in this appendix. Besides the footnotes on pages 5 and 117 no cross-references can be found in the main document. Should this supplementary analysis yield to diverting results, I will discuss them only within this appendix.
This supplementary analysis can be assessed as an extension/continuation of sub-analysis 2. In fact, the new airfare dataset employed here is a further refinement of the price data used in sub-analysis 2. Therefore, the discussion in this appendix will focus on new aspects arising fom the new dataset. For points already discussed in sub-analysis 2, such as the 'pretests' and the introduction of the data, the reader may be referred to chapter 8.
The dataset for this analysis comprises 36 quarterly observations extending from Q1/2006 to Q4/2014.

A.1 Introduction of Airfare and Demand Data

The airfare dataset was obtained from Statistics Norway (SSB 2015g). The dataset is based on the producer price index (PPI) 'passenger air transport', which describes the quarterly development of airfares offered by the Norwegian airlines Widerøe, SAS and NAS. Charter airlines or other internationally scheduled airlines do not contribute information to the index. With respect to the type of flight (domestic vs. international), the index is further divided into two sub-indexes:

–'domestic air travel' (denoted by the variable *faredom*),

–'international air travel' (denoted by the variable *fareint*).

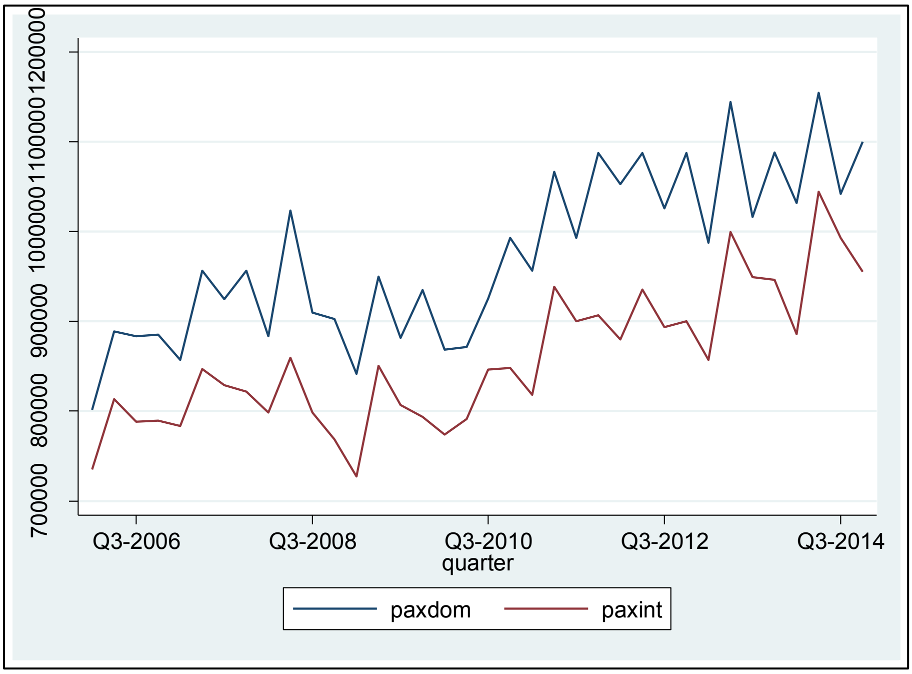
Price information of 11 domestic routes build '*faredom*' and airfare information of nine international routes are used to construct '*fareint*'. The two sub-indexes do not allow separating for travel purposes. Figure A-1 plots the development of the two airfares against time with the year 2010 as 100%-reference year. One can see that the

*** Figure A-1: Airfare Development Domestic vs. International Sub-Segment**

international fares have developed 'behind' the domestic fares in the recent past and that both airfares have increased since the year 2011. The same phenomena were already described in chapter 2.

The demand data on the other hand side was sourced from eurostat (2015). The data depicts the development of boarding passengers for the specific routes, which build the airfare sub-indexes. Figure A-2 shows the aggregated demand for the domestic routes '*paxdom*' and the aggregated demand for the international routes '*paxint*' plotted against time. One can see that the segmented demands follow quite equal pattern. The amount of pax measured on domestic flights is larger than the number of international flights. This is a consequence of SSB's underlying route selection and is therefore not in contrast to the findings in section 2.4.

* **Figure A-2: Demand for Domestic and International Services Regarding to SSB Route Selection**



For information concerning all other explanatory variables used in this analysis, the reader may be referred to chapter 8.

One new regressor variable has been tested for this supplementary analysis. This variabel (*exrate*) depicts the development of the currency exchange rate NOK-EUR. The data was sourced from (Norges_Bank 2015). The intention behind this variable is as follows. I presented in an earlier chapter, that the increase in international travel is to a high degree related to leisure travel. Since most of the international routes depict in '*fareint*' connect Norway with an Euro-currency destination, one could assume that changes in the currency exchange rates make leisure trips to Euro-counties more or less expensive/attractive. This could then have an effect on demand for international air travel.

For none of the models tested thus, '*exrate*' turned out to have a significant impact on demand - neither in current terms nor in delayed terms.

A.2 Formulation of Expectations

For the domestic segment it seems reasonable to assume that the own-price elasticity should turn out to be somehow similar to the findings presented in sub-analysis 1. This means that I expect to find an inelastic demand with a SR-elasticity of approximately -0.36.

For the international sub-segment, the formulation of expectations is a little more tricky. On the one hand side, prices for international flights are likely to be influenced by more than the three Norwegian airlines that are used to construct '*fareint*'. Especially if LCCs serve the same international routes, one could assume that some consumers are highly price sensitive. Furthermore, it was shown that the international travel segment has been pushed by leisure related travel in the recent past. This should point towards slightly higher elasticities as compared to the domestic segment, where business related travel is more important. On the other hand, international airfares have 'underperformed' compared to domestic fares, what should have relieved the individual bugdets. Next, literature suggests that international services tend to have less price elastic demand, because of less suitable substitutes at hand.

A.3 Testing for Order of Integration

Both airfare and pax variables in 'logged form' are tested for stationarity first, employing DF and PP. H_o for all four variables can be rejected, indicating that all variables are non-stationary. The test results are confirmed by the impression gained by a look at the variables plotted against time. All variables reach stationarity after differencing once. Consequently, all four variables are integrated of order I(1).

A.4 Testing for Co-Integration

Since all variables are intergrated of the same order, it is the next step to test whether the fare and demand variables share a long term equilibrium relationship. Therefore, the demand variables are regressed against the fare variables and the residuals of the two regressions are checked for their stationarity properties employing DF and PP. The results of these tests are not entirely consistent. While the tests for the international sub-segment indicate a rejection of H_o at 5% significance level, the tests for the domestic sub-segment do not indicate a co-integration relationship between demand and airfare.

Having in mind that '*paxint*' and '*paxdom*' on the one hand side and '*fareint*' and '*faredom*' on the other hand side, differ in their development over time only marginally, I assume that the diverting test results might be caused by the overall small sample size. In order to cover this possibility, I do not ultimately conclude in favour for or against the existence of a co-integration relationship. I rather continue to consider both versions and model demand with a static and a ADL-type model for both segments.

A.5 Model Building and Estimation: Static Model

The model building starts again with an 'over-specified' model for each segment (results are not reported). During a conducted step-wise regression, I find that only a very limited amount of the considered regressor variables contribute to the explanation of demand. Variables representing substitutional modes of transportation for instance, do not significantly impact the demand for the domestic and the international segment. Moreover, the population coefficient is not found to be significant and shows in addition a counter-intuative prefix. The alternative implementation of population changes via the expression of *per capita demand*, does not influence the resulting coefficients for other variables and is therefore not implemented.

For the domestic segment, the finally specified model takes the form:

$$\Delta\ln(paxdom_t) = \beta_0 + \beta_1 \Delta\ln(faredom_t) + \beta_2 \Delta\ln(gdp_t) + \beta_3 quart1 + \beta_4 quart2 + \beta_5 \, quart3$$

Output A-1 reports the regression results, here after correction for serial correlation.

*** Output A-1: Static Model - Domestic Segment**

Source	SS	df	MS		
Model	.08974395	5	.01794879	Number of obs =	35
Residual	.0368264	29	.001269876	F(5, 29) =	14.13
Total	.12657035	34	.003722657	Prob > F =	0.0000
				R-squared =	0.7090
				Adj R-squared =	0.6589
				Root MSE =	.03564

D.ln_paxdom	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_faredom D1.	-.29744	.1483738	-2.00	0.054	-.6008985	.0060185
ln_gdp D1.	.7459325	.2256897	3.31	0.003	.2843453	1.20752
quart1	-.0443091	.0316605	-1.40	0.172	-.1090621	.0204439
quart2	.1124032	.0246814	4.55	0.000	.061924	.1628823
quart3	-.0569501	.0287614	-1.98	0.057	-.1157737	.0018736
_cons	.0007037	.0209245	0.03	0.973	-.0420917	.0434991
rho	-.3766374					

Durbin-Watson statistic (original) 2.708158
Durbin-Watson statistic (transformed) 2.237610

The regression results for the domestic sub-segment indicate a price inelastic demand. The SR own-price elasticity is estimated to be -0.30, which is only slightly below the findings reported for the domestic segment in sub-analysis 1. Considering the fact that the airfare data of sub-analysis 1 and the data of this supplementary analysis stems from different sources, my confindence in both estimates is strenghten. The derived SR-elasticity implies in addition, that no significant change in price elasticities has occurred in the post 2002 period, compared to earlier years. A long-run elasticity can not be derived within this static model setting.

For the international segment, the finally specified static model takes the form:

$$\Delta \ln\,(paxint_t) = \beta_0 + \beta_1 \Delta \ln(fareint_t) + \beta_2 \Delta \ln(gdp_t) + \beta_3 quart2 + \beta_4 quart3$$

Output A-2 reports the regression results, here after correction for serial correlation.

*** Output A-2: Static Model - International Sub-Segment**

Source	SS	df	MS		
Model	.092439044	4	.023109761	Number of obs =	35
Residual	.030167016	30	.001005567	F(4, 30) =	22.98
				Prob > F =	0.0000
				R-squared =	0.7540
				Adj R-squared =	0.7211
Total	.12260606	34	.003606061	Root MSE =	.03171

D.ln_paxint	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_fareint						
D1.	-.1641504	.1030185	-1.59	0.122	-.3745423	.0462415
ln_gdp						
D1.	.3044205	.14651	2.08	0.046	.0052071	.6036339
quart2	.1420353	.0162763	8.73	0.000	.1087946	.1752759
quart3	-.0038925	.0133354	-0.29	0.772	-.031127	.023342
_cons	-.0299108	.0073675	-4.06	0.000	-.0449573	-.0148643
rho	-.4102138					

Durbin-Watson statistic (original) 2.797430
Durbin-Watson statistic (transformed) 2.185728

The regression results for the international sub-segment indicate that changes in airfares do not have a impact on demand, which is significantly different from zero. The coefficient shows the expected prefix, is in magnitude below it's domestic counterpart, but is found to be insignificant at the 10% significance level.

A.6 Model Building and Estimation: ADL-Model

In order to stay within the limits concerning the amount of explanatory variables to include in the model, the ADL-model for the domestic demand takes the form:

$$\Delta \ln(paxdom_t) = \beta_0 + \beta_1 \Delta \ln(faredom_t) + \beta_2 \Delta \ln(gdp_t) + \beta_3 \ln(paxdom_{t-1}) + \beta_4 \ln(faredom_{t-1}) + \beta_5 \ln(gdp_{t-1}) + \beta_3 quart1 + \beta_3 quart2 .$$

The regression results can be seen in Output A-3.

*** Output A-3: ADL-model - Domestic Segment**

```
      Source |       SS       df       MS              Number of obs =      35
-------------+------------------------------           F(  7,    27) =   24.41
       Model |  .191418572     7  .02734551            Prob > F      =  0.0000
    Residual |   .03024302    27  .001120112           R-squared     =  0.8636
-------------+------------------------------           Adj R-squared =  0.8282
       Total |  .221661592    34  .006519459           Root MSE      =  .03347

------------------------------------------------------------------------------
 D.ln_paxdom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  ln_faredom |
         D1. |  -.3344014   .1760926    -1.90   0.068    -.6957136    .0269107
             |
      ln_gdp |
         D1. |    1.01958   .1848894     5.51   0.000     .6402188    1.398942
             |
   ln_paxdom |
         L1. |  -.6541155   .1630171    -4.01   0.000    -.9885989   -.3196321
             |
  ln_faredom |
         L1. |  -.2035117   .1076652    -1.89   0.070    -.4244225    .0173991
             |
      ln_gdp |
         L1. |   .7323781   .1983944     3.69   0.001     .3253064     1.13945
             |
      quart1 |  -.0369329   .0210191    -1.76   0.090    -.0800605    .0061947
      quart2 |   .0938321    .023749     3.95   0.001     .0451031    .1425611
       _cons |  -.2364016   1.190861    -0.20   0.844    -2.679846    2.207043
------------------------------------------------------------------------------
```

The regression output indicates that demand for the domestic sub-segment is price inelastic both, in the short- and in the long-run. The short-run coefficient gives a price elasticity of -0.33, which is significant at the 10% level. The entire long-run effect, calculated with [5.9], gives an LR-estimate of -0.31, which is marginally lower than the SR-estimate. This is not inline with theory, which suggests the opposite. Considering the minor difference in SR- and LR-estimates, I conclude that SR- and LR-effects do not differ significantly, what would imply that the consumers' SR- and LR-adjustment effects to airfare changes are equal.

The SR- and LR-estimates for the income elasticity of demand are higher than in all previous analyses (i.e. around unity), indicating that the income variable possibly "tags along" effects of other repressors.

Furthermore, during the later diagnostics tests, it turns out that the residuals of this regression are most likely not normally distributed. Together with the two other, previously mentioned issues, this raises concerns about the estimated ADL-model and its results.

The ADL-model for the international segment takes the form:

$$\Delta \ln(paxint_t) = \beta_0 + \beta_1 \Delta \ln(fareint_t) + \beta_2 \Delta \ln(gdp_t) + \beta_3 \ln(paxint_{t-1}) + \beta_4 \ln(fareint_{t-1}) + \beta_5 \ln(gdp_{t-1}) + \beta_3 quart1 + \beta_3 quart2\ .$$

The regression results can be seen in Output A-4.

*** Output A-4: ADL-model - International Sub-Segment**

```
. regress D.ln_paxint D.ln_fareint D.ln_gdp L.ln_paxint L.ln_fareint L.ln_gdp qu

      Source |       SS       df       MS              Number of obs =      35
-------------+------------------------------           F(  7,    27) =   16.60
       Model |  .128168586     7  .018309798           Prob > F      =  0.0000
    Residual |  .029772785    27  .001102696           R-squared     =  0.8115
-------------+------------------------------           Adj R-squared =  0.7626
       Total |  .157941371    34  .004645334           Root MSE      =  .03321

------------------------------------------------------------------------------
 D.ln_paxint |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  ln_fareint |
         D1. |  -.1782041   .1320452    -1.35   0.188    -.4491385    .0927303
             |
      ln_gdp |
         D1. |   .2654139   .1768363     1.50   0.145    -.0974242     .628252
             |
   ln_paxint |
         L1. |   -.382358   .1657814    -2.31   0.029    -.7225134   -.0422025
             |
  ln_fareint |
         L1. |  -.1576245   .0849734    -1.85   0.075    -.3319755    .0167264
             |
      ln_gdp |
         L1. |   .2576241   .1579979     1.63   0.115    -.0665608    .5818089
             |
      quart1 |  -.0341272     .02206    -1.55   0.134    -.0793906    .0111362
      quart2 |    .103287   .0236818     4.36   0.000      .054696    .1518781
       _cons |   2.356393   1.558576     1.51   0.142    -.8415406    5.554327
------------------------------------------------------------------------------
```

The results indicate again that the short-run elasticity of demand for the international segment is not significantly different from zero. The respective coefficient shows the expected prefix, but is found to be insignificant at the 10% significance level. The LR-coefficient can be calculated at the 10% significance level and indicates a LR-price elasticity of -0.39. The estimates for the income elasticity are ‘back’ on the normal level.

A.7 Diagnostics Tests Static and Dynamic Models

The test results for all four models are reported at the end of this appendix. In general, most of the tests do not give reasons for conserns.

Both static models suffered in there original form from serial correlation and were estimated with Prais-Winston. In addition, H_o for normal distributed residuals for the static international model, is only marginally rejected, with a p-value of 0.06.

Suprisingly and despite the fact of very 'short' models, none of the omitted variable tests indicate a problem.

A.8 Discussion of the Results

The discussion of the finding is not straight forward. This is because the results are not entirely conclusive and some question marks related to the model specifications, sample sizes and diagnostic tests exist. Ignoring those limitations first, the results can be intepreted in the following way:

The static models indicated that the domestic segment has a SR-elasticity of -0.30 and that for the international segment airfare changes have no effects on demand, which are significantly different from zero. The dynamic models on the other hand indicated that for the domestic model the LR-elasticity equals the static SR-estimate. An adjustment rate of 65% per period is found. For the international segment, the LR-elasticity is estimated to be -0.39, with an adjustment rate of 38% per period.

Combining these results, one could state that the demand for international services is slightly more price elastic than the demand for domestic services. This could be caused by the fact that leisure traveller are 'overrepresented' on international routes and that the minor importance of substituting modes of passenger transportation in Norway does not 'increase' the elasticities for the domestic segment.

The different adjustment rates and the existence of LR-, but no significant SR-elasticities for the international segment, could indicate that air travel to international destinations is planned/purchased longer in advance than domestic air travel. Again, having in mind the high share of leisure travellers on interantional routes, it seems not far fetched that SR-demand effects resulting from price increases are small.

A.9 Conclussion

Turning back to the limitations and concerns mentioned earlier, one has to admit that the results of this supplemantary analysis should not be treated as fail-safe. Consequently RQ 7 has to be answered conservative in the way, that this analysis indicates a slightly higher price elasticity of demand for the international sub-segment as compared to the domestic sub-segment, but that because of the data properties and the models used, a direct statistical comparison of the derived elasticities has not been possible here.

Anyway, the results of this analysis support some of the findings presented in the main body of this thesis. This is first that demand for air travel in Norway on the aggregated level is rather price inelastic with elasticity estimates below -0.50 (absolute values). Next, no indications were found for dramatically changes in price elasticities compared to earliere decades. Furthermore, the minor importance of substituting modes of passenger transportation on the aggregated level was confirmed and no conclusive proof was found for demand being a co-integrated process with airfares.

Diagnostic Tests - Results

Static model *paxdom*

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
q	35	0.97261	0.978	-0.047	0.51882

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	11.20	11	0.4265
Skewness	6.06	4	0.1945
Kurtosis	2.07	1	0.1504
Total	19.33	16	0.2517

Ramsey RESET test using powers of the fitted values of D.ln_paxdom
Ho: model has no omitted variables
F(3, 27) = 1.06
Prob > F = 0.3835

Static model *paxint*

. swilk w

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
w	35	0.94227	2.061	1.509	0.06563

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	11.62	11	0.3925
Skewness	5.86	4	0.2099
Kurtosis	2.54	1	0.1108
Total	20.03	16	0.2191

Ramsey RESET test using powers of the fitted values of D.ln_paxint
Ho: model has no omitted variables
F(3, 27) = 0.58
Prob > F = 0.6356

ADL-model *paxdom*

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
y	35	0.93086	2.468	1.886	0.02967

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	32.11	32	0.4611
Skewness	5.59	7	0.5879
Kurtosis	0.98	1	0.3231
Total	38.68	40	0.5295

Ramsey RESET test using powers of the fitted values of D.ln_paxdom
Ho: model has no omitted variables
F(3, 24) = 0.73
Prob > F = 0.5432

ADL-model *paxint*

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
m	35	0.95286	1.683	1.086	0.13869

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	28.31	32	0.6540
Skewness	4.70	7	0.6965
Kurtosis	1.60	1	0.2058
Total	34.61	40	0.7111

Ramsey RESET test using powers of the fitted values of D.ln_paxint
Ho: model has no omitted variables
F(3, 24) = 0.62
Prob > F = 0.6094