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On the Relationship Between Jet Fuel Price and Air Passenger Traffic Growth in Western Europe

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1. Abstract

This paper estimates the effect jet fuel price changes have on air passenger traffic growth in Western Europe between 2007 and 2017. Fuel is the largest and most volatile input cost for airlines, that incorporate changes in the price via air fare adjustments and dilution/contraction of seat capacity to maintain positive profit margins. Passenger growth is affected indirectly through adjustments in ticket price facing a price-sensitive demand. A negative relationship is shown between fuel prices and air passenger traffic growth and a fuel lag is present. The effect of a fuel price change is delayed and greater a year later (medium-term) than 3 to 6 months later (short-term) due to fuel hedging practices and the time-consuming implementation of capacity modifications. During the most recent financial crisis (2008 - 2010), the magnitude of this effect is more substantial and only a marginal difference is found between the short- and medium-term effects.

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2. Introduction

Over the years, air passenger traffic growth in Western Europe has been driven by a moderate momentum when coming out of a financial crisis. The industry is characterized by low or negative profit margins and by having high exposure to constant fluctuations in its environment, particularly in fuel price. Nevertheless, in the current low fuel price environment, airlines have started becoming more profitable and growth has accelerated. The low fuel price and a growing supply of seat capacity resulted in lower air fares, which has consequently stimulated demand. Passenger growth has further increased after an upturn in the economic cycle. Fuel is one of the airline industry's greatest operating expenses. In 2015 the fuel bill represented 27.3% of the average operating costs worldwide. In 2016, however, it accounted for only 19.2% (IATA, 2016) due to fuel price falling below €400/mt during 2016, from previous highs of €500-€600/mt. Fuel price is an exogenous supply side factor, and airlines have no influence on it as they are price takers (Malavolti & Podesta, 2015). Large swings in fuel price directly impacts airlines' earnings, and can push profit margins down to near zero or negative levels. By hedging fuel, airlines can reduce their exposure to the impact fluctuating fuel prices have on their earnings. However, hedging is only a temporary tool and airlines are impacted beyond the fluctuation in earnings.

Airlines incorporate fuel prices through operational and pricing adjustments, which include changing aircraft utilization rates and levying fuel surcharges on passengers in times of high fuel prices. At a low fuel price, through the cost advantage airlines can achieve higher operating margins. Yet, as the airline industry is highly competitive, any efficiency or cost advantage that is generated by a lower fuel price is quickly competed away by inflating the market with extra seat capacity. Airlines have to sell this extra seat capacity, and the fares are lowered to stimulate the price-sensitive demand and to gain market share. Hence, the fuel cost savings are partly translated into fare advantages for customers. This is a benefit for both airlines and customers, as despite intensifying competition the individual airline can grow and expand its markets and passengers can enjoy the lower fares. The aforementioned relationship shows that fuel price fluctuations affect passenger growth via consequent changes in air fares. This paper intends to quantify the effect of jet fuel price changes on air passenger traffic growth and analyzes how airlines incorporate fuel prices into their operations.

The analysis focuses on Western European countries. These are mature markets with significant air passenger traffic over both short-haul and long-haul and relatively stable growth rates. Europe's largest hub airports are located in these countries including London Heathrow and Paris Charles de Gaulle with nearly 75 million and 66 million passengers in 2016, respectively. Moreover, Europe's largest airlines operate in these countries, flag carriers such as British Airways, Lufthansa and Air France/KLM, and low cost carriers like Ryanair and EasyJet. In matured markets like these variation in passenger traffic and airline capacity is highly dependent on the level of economic growth. In Western European countries demand for air travel is constituted by high share of business travelers, frequent leisure travels due higher household incomes, more and more traffic generated by low-cost airlines and traffic related to commuting immigrants. Although the saturated Western European market has shown moderate passenger growth rates over the past decade, on average 4% year-over-year, there has been great level of volatility in the growth rates that has to be accounted for. Primary determinants of this volatility are changes in fuel price, GDP, exchange rate and event-related demand/supply shocks, such as what occurred during the recent financial crisis.

As fuel is an exogenous input cost accounting for a large part of the airlines' operating costs a steady decline or increase in it is considered as a supply shock. This supply shock in turn is incorporated by the airlines by passing-on the risk (or benefit) to the passengers through operational and pricing adjustments (Air Transport Department, Cranfield Univerisity, 2010). Past literature acknowledges this mechanism which in turn affects passenger demand (Morrell & Swan, 2006) (Klophaus, 2014). However, the link between the two was not yet empirically tested on a larger scale, but merely analyzed within the scope of a few routes (Klophaus, 2009). Hence, this paper aims to quantitatively estimate the effect of fuel price changes on air passenger traffic in eight Western European countries. Based on this the following research question is studied in this paper:

"What is the effect of jet fuel price changes on air passenger traffic growth in Western Europe between 2007 and 2017?"

This is the first paper that estimates the effect of fuel price on air passenger traffic growth using quarterly observations and airport-level passenger traffic. Two models are presented, each with a different fuel lag specification, estimating the passenger growth variance caused by a fuel price change in the short-term (3 months) and medium-term (1 year). Cheze et al. (2011) assume a time lag of one year, however, there is empirical evidence from airlines' operations suggesting that variation is caused already during the short-term, within the months following. Furthermore, the results are linked to various operational responses airlines can take to incorporate higher or lower fuel prices based on past literature. In the following section the hypotheses are formulated and a theoretical background is provided to the research context. This is followed by summarizing the data, presenting the methodology of estimating the effect and lastly, showing and discussing the obtained results.

3. Hypotheses

Past literature concludes an indirect and negative relationship between fuel price and passenger growth (Klophaus, 2009) (Malavolti & Podesta, 2015). Fuel price changes impact airlines' operating cost base, which in turn affects profitability, aircraft utilization rates and network planning. If the industry is more profitable in a low fuel price environment the higher margins stimulate airlines to grow. As airlines in turn inflate the market with extra capacity deployment demand has to be stimulated by lower fares to sell these extra seats. The competition for market share gains further intensifies this effect. In contrary, in times of high fuel prices the extra costs are passed-on to passengers in forms of higher ticket prices and fuel surcharges leading to passenger number reductions (Klophaus, 2014). Hence, the first hypothesis is formulated:

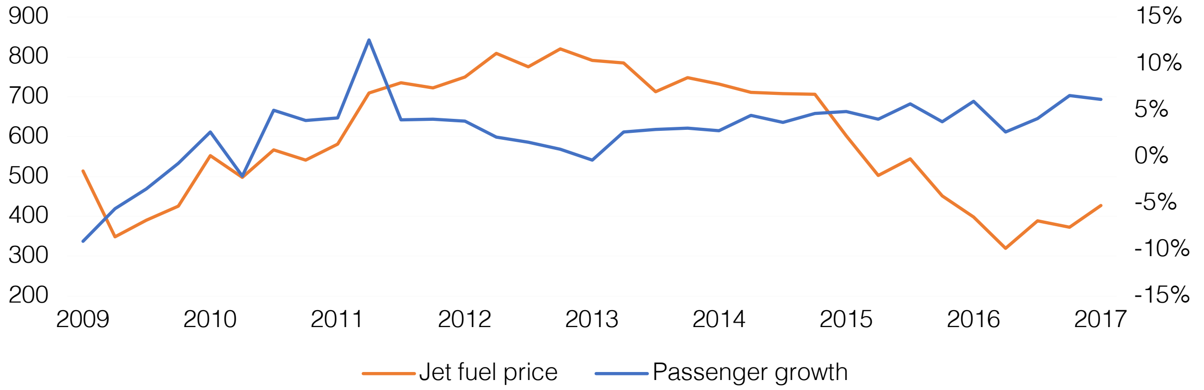
H1: There is a negative relationship between jet fuel price and air passenger traffic growth.

There is a time delay for the fuel price change to affect passenger growth as noted by past literature. The time lag comes from several sources. First, from the time it takes to adjust capacity by means of increasing the utilization rates of existing fleets (Eads, Nerlove, & Raduchel, 1961) or adding additional aircraft to the fleet. Second, discounted fares affect bookings for future travel, typically 3 to 6 months ahead. And lastly, fuel hedging practices lock-in fuel prices for some time ahead, predominately for 6 to 12 month, and covering one-or two-thirds of the fuel costs (Morrell & Swan, 2006). Moreover, fare adjustments or fuel surcharges can be made relatively quickly, thus an effect on passenger traffic can already prevail during the short-term (3 to 6 months). However, larger capacity adjustments can only be implemented in the medium-term (6 to 12 months) due to operational constraints. Thus, the second hypothesis is:

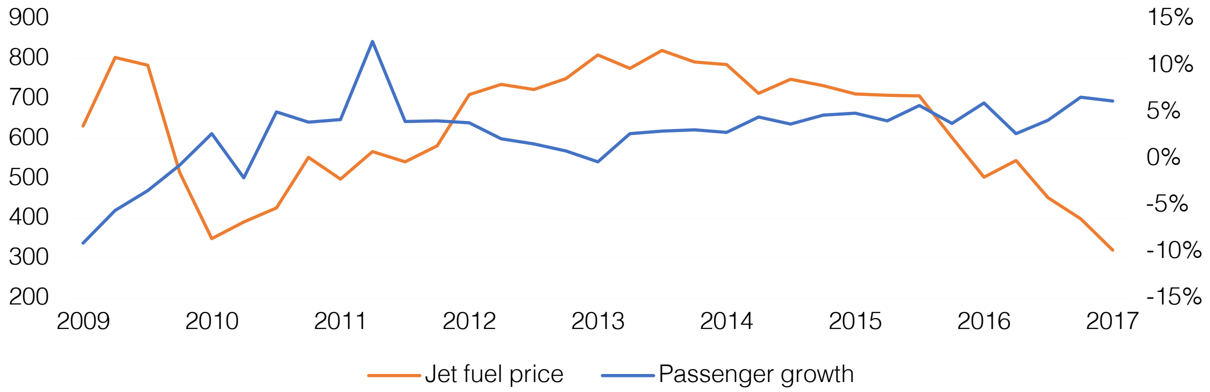
H2: The effect of jet fuel price change on air passenger traffic is greater over the medium term than over the short term.

In this study, two fuel lags are specified in the modelling of the effect of fuel price changes on passenger growth in order to distinguish between a short-term and a medium-term effect. To illustrate the two hypotheses two graphs are shown below that plot passenger growth in t_0 against fuel price at two different lags, at the first and fourth quarters lag (t_{-1} and t_{-4}).

Graph 1: Year-on-year air passenger traffic growth rate in t_0 and fuel price (€/mt) in t_{-1}



Graph 2: Year-on-year air passenger traffic growth rate in t_0 and fuel price (€/mt) in t_{-4}



The graphs indicate a negative relationship. During periods of high fuel price, such as between 2012 and 2014, passenger growth was around or below zero. Whereas, from the beginning of 2016, when fuel price dropped significantly, passenger growth rose above 5%. Regarding the differences in the relationship over the short-term and medium-term these charts are inconclusive however, wider gaps between the two lines are observable especially between 2009 and 2011.

As mentioned earlier, a negative relationship is suggested, however, the pattern becomes to a certain extent abnormal between 2009 and 2011. That is the period of the financial crisis, which started in already in the second half of 2008. Looking at Graph 2, the relationship holds up quite normal as the graph suggests that during the high fuel price environment in 2009 passenger growth was low or negative. However, on Graph 1, it can be observed that fuel prices and passenger growth rates follow each other closely. Inferring from the graphs low fuel prices are associated with low passenger growth rates, which suggests that they are positively correlated during that period. This positive correlation can be considered as an abnormality and is tested for in this paper. Past literature shows that during the financial crisis demand for air travel decreased and the economic situation greatly affected the airlines that consequently faced stagnating and decreasing passenger growth (Dobruszkes & Van Hamme, 2011). However, airlines benefitted from falling operating costs as fuel prices dropped sharply. Even though airlines could not fully exploit this sudden decrease in fuel price in the short-term due to their hedging contracts (Morrell, 2011), the low fuel price eventually translated into better operating performance, via the lower operating cost base. Whether or not the lower operating cost base was enough to counteract the falling demand for example through lower ticket prices is not clear. This study intends to only shed light on the effect of the financial crisis had on air passenger traffic via changing fuel prices while controlling for the economic situation. Hence, a third hypothesis is formulated:

H3: During the financial crisis, passenger growth is affected to a greater extent than otherwise by the sudden large changes in jet fuel price.

4. Theoretical framework

4.1. Determinants of air passenger growth

Determinants of air passenger growth and demand for air travel has been analyzed in previous literature. The following section describes what researchers in this field have found and what aspects this paper integrates. Cheze et al. (2011) analyzed the relationship between air passenger traffic and its main drivers and estimated the effect between 1980 and 2007 on a global level. They showed that GDP and jet fuel price play a central role determining air traffic growth. Their findings show that jet fuel price has a non-linear relationship with yearly air traffic growth which is negative below a price threshold of $300/mt, but positive above the threshold of $300/mt. The indication of a positive relationship is seemingly counter-intuitive as the authors acknowledge, but may reflect the increase in energy demand in the period between 2003 and 2008 resulting in a rapid increase in all energy prices. Firestine and Guarino (2012) studied the changes in airline operations in the U.S. that occurred between 2001 and 2011 with focus on those related to fuel price increases. They found that fuel price increases led to reduced profits or operating losses among the domestic carriers, and as a response, capacity on many routes was reduced. Dargay and Hanly (2001) analyzed the determinants of demand for air travel to and from United Kingdom, with 20 OECD country pairs. They found that airfares are the number one driver of leisure travel with fare reductions explaining around 40% of the increase in air travel. This is further supported by Graham and Shaw (2008) who also showed that there is a negative relationship between ticket prices and air traffic growth.

4.2. Determinants of fuel price

Jet fuel is a refinery product of crude oil and three elements affect its price: the price of crude oil, the refinery margin and into-plane premium. Jet fuel price follows the price of crude oil closely, but the increasing refinery margins can widen this gap (Klophaus, 2009). Into-plane premium is charged by the re-fueling company at the airport. Fuel is considered a highly volatile and significant input cost for the airlines. During the period of analysis (2007 – 2017), fuel bill accounted for between 19.2% (2016) and 35.7% (2008) of the average operating costs worldwide (IATA, 2016). Such difference is explained by high volatility inherent to fuel price, coming from a number of sources (Westbrooks, 2005). There are political and social influences such as political wars and government legislations. Moreover, refining capacity, supply disruptions and seasonality of demand also have an effect on the price of fuel.

4.3. Relationship between fuel price and air passenger traffic

4.3.1. Capacity and aircraft utilization

Malavolti and Podesta (2015) suggest that pricing and the number of passengers that airlines can carry depend on the technical efficiency of the aircrafts which refers to the aircrafts' fuel burn (kg/hour). A sustained change in fuel price can lead to modification in choice of aircraft and to changes in aircraft utilization rates, hence capacity. To understand why this is the case the following important operational dynamics are presented. An airline's fleet typically consists of a number of newer, more fuel-efficient airplanes that are more economical to operate and some older planes with lower fuel-efficiency and higher operating costs. Ownership costs for the former is significantly higher than for the latter. The cost of keeping and maintaining a few fully depreciated aircrafts is small, which allows the airlines to provide capacity increases in the short-run (Eads, Nerlove, & Raduchel, 1961). If fuel prices are high the newer airplanes are flown to maximum utilisation as airlines are incentivized to use more fuel-efficient solutions (Klophaus, 2009) and the older aircrafts are flown with lower frequencies or are grounded due to otherwise incurring too-high operating costs. Rising fuel prices and increased purchases of more fuel-efficient planes decrease the prospective value of less fuel-efficient aircrafts and tend to force them to be returned to the lessors as they become less economical to operate (Air Transport Department, Cranfield Univerisity, 2010). In effect, high fuel prices limit passenger growth as airlines are capacity-constrained due to the aforementioned operating-efficiency considerations.

In contrary, when fuel price goes down the cost and efficiency advantage of the newer plane become smaller at lower. Hence, the older airplanes are flown more hours as they now become more economical to operate and the efficiency constraints are relaxed (Malavolti & Podesta, 2015). This fuel price decrease translates into capacity increase relatively quickly as these older airplanes are readily available capacity that can be deployed. Moreover, there is market for leasing aircrafts where short-term lease agreements are possible. Although short-term leasing is expensive, the acquisition or leasing of cheaper and less efficient aircrafts can be a solution to grow when the airline's fleet is already utilized to the maximum.

As a result of the increased capacity, for loading the extra seat inventory fares are lowered in order to capture a larger passenger demand. By stimulating the demand on the passenger side airlines also aim to increase their market share and to maintain or improve their profit margins. This however, leads to airlines quickly competing away the cost advantage towards a fare advantage for the passengers through the price effect induced by the inflated market capacity.

The dynamics related to fleet management and aircraft utilisation mainly apply to hub carriers, as the business model of low-cost airlines is based on operating newer, more fuel-efficient aircrafts. While hub carriers usually operate a heterogeneous fleet of several aircraft types with mixed technical efficiencies low-cost carriers tend to have a more homogenous fleet consisting of mainly one aircraft family such as the Airbus A320 or Boeing 737. However, hub carriers are the ones carrying most of the passengers in Western Europe, thus this aspect is considered highly relevant. As far as low-cost airlines are concerned, with lower fuel input costs they are able to offer even lower fares, but adjusting their capacity above their average fleet growth rate is difficult for two reasons. First, there are no available additional aircraft to deploy as their business model suggests that they do not keep any aircraft grounded. Second, the aircrafts in operation are already flown on close to maximum utilisation[1]. However, through price reductions, low-cost airlines can grow by increasing their load-factor (percentage of seats sold per available seat capacity) or they enter into short-term lease agreements to increase capacity.

Additionally, in Western Europe there are many slot-constrained airports such as London Heathrow and Paris Charles de Gaulle. It is to a limited extent to which airlines can or willing to modify their capacity at such airports due to two reasons. First, growth opportunities are being capped by the difficulty of obtaining additional slots, hence airlines cannot easily dilute their capacity on these markets. Second, giving up these valuable slot when airlines face pressure to contract their capacity poses strategic risks as competitors could obtain the rights for the slots and gain market share.

[1] Especially during the high-demand summer season. During other seasons, utilization rates are lower and capacity adjustments are more possible.

4.3.2. Fuel surcharge

In Europe the application of fuel surcharges is common practice among airlines, especially among hub carriers like Lufthansa (Air Transport Department, Cranfield Univerisity, 2010). By recovering a part of the increased fuel costs directly from passengers, airlines can mitigate its impact in a flexible way. A fuel surcharge is added to the basic airfares and most airlines show this extra charge transparently. Major low-cost carriers such as Ryanair and EasyJet do not apply fuel surcharging, but increase the average fare level. In July 2008 when fuel price was around €800/mt Lufthansa for example added a fuel charge of €27 for its short-haul sectors and €97 for its long-haul sectors (Klophaus, 2009). Klophaus (2009) shows that as a result of passing-on part of the fuel costs to passengers, demand for flights decreases. Moreover, in terms of demand, low-cost carriers and long-haul routes are more negatively affected by a fuel price increase. Low-cost carriers due to the higher relative fare increase (as the base fare is low compared to the hub carrier's) and a more price sensitive demand. Long-haul routes due to the strong increase in prices from the added fuel surcharges based on the longer distance flown. In the absence of fuel hedging, a fuel price change has an even stronger effect on demand in the short-term (Klophaus, 2009).

4.4. Fuel lag

There is a time lag for the effect of the fuel price change to result in lower air fares and thus increased passenger growth. First, bookings made by passengers are typically made around 3 months ahead of time, hence the stimulated demand mainly manifests itself in passenger number growth a few months after the fares decline. Second, there is also a time delay for adjusting the capacity, as extra slots have to be obtained at the airports for adding frequencies and additional pilots and cabin crew have to be arranged. The stock of pilots and co-pilots is usually highly utilized and making short term changes is difficult (Eads, Nerlove, & Raduchel, 1961). Third, airlines purchase fuel in advance and hedge to lock in prices for a future time ahead.

Hedging practices involve using forward contracts, future contracts and financial derivatives (Morrell & Swan, 2006). Fuel hedging is not a tool to improve profitability, but a tool to reduce the impact on earnings from wide fluctuations in fuel prices. Airlines hedge fuel differently. Some airlines are hedged for a year ahead, while others only to a smaller extent. According to Morrell and Swan (2006), airlines typically hedge around 6 months ahead with few hedging contracts made in a year ahead and their hedging covers between one- and two-thirds of their fuel costs. Essentially, the fuel hedging practices delay the effect of a fuel price change for the airlines, which during an upward trend is beneficial as the airline locks-in a lower-than-market price. However, as fuel price movements are unpredictable, in many instances airlines cannot take full advantage of a declining fuel price trend as their hedges already locked-in a higher price. An example of that is Air Berlin's FY2015 net loss of €446.6 million[2], which according to the company was largely due to hedging transactions locking in high prices near €600/mt in the second half of 2014, while the fuel price dropped below €400/mt by the end of 2015. This missed opportunity cost the company around €200 million.

Furthermore, there is another larger level of lag in the fuel price decline, which also appears in the aircraft order book and delivery cycle. As airlines become more profitable and optimistic they tend to place large airplane orders, but since it is a slow process for the manufacturers to deliver these planes, it can take few years until delivery. Just by the time when the industry cycle changes its directions (higher fuel price and lower demand), these new planes are delivered, and airlines that ordered the airplanes now find themselves on the other side of the cycle and might not able to use the extra capacity in a profitable way. Thus, this fuel lag worsens the cyclical nature of the industry as during down-cycle the abundant capacity puts pressure on the ticket prices while airlines face high operating costs. This is not modelled for in this analysis, but nevertheless this is an important effect.

On the basis thereof, in the analysis of fuel price changes and air passenger growth, a change today mostly has an impact on the passenger growth rates later in the future. Moreover, short-term and medium-term effects can be distinguished. Hence, time lags have to be considered when modelling it.

4.5. Exchange rates

Many airlines have international operations, hence revenues and costs can be incurred across multiple currencies. Currency fluctuations are posing great risks to the airline industry. Foreign exchange risk impacts passenger demand, airlines supply decisions and their

[2] Air Berlin's financial results 2015
http://ir.airberlin.com/en/ir/financial-news/ir-releases/2016/2016-04-28_airberlin-s-financial-results-2015

financial accounts. Passenger demand is affected through relative price changes that can originate from either direction. This can also shift the balance of travel between the number of domestic and incoming passengers on the routes, depending on the direction of the exchange rate change (IATA, 2015). In the short term airlines may respond through price changes. However, over the longer term a significant exchange rate shift, such as that occurred to the British Pound as a result of United Kingdom's population vote to leave the European Union, can impact airlines network planning and capacity decisions as earnings are impacted. Moreover, on the input cost side, jet fuel for instance is usually priced in US dollars (Morrell & Swan, 2006), thus European airlines are exposed to the risk of exchange rate fluctuations in their fuel purchases too. The EUR/USD exchange rate also represents a natural hedge to fuel, meaning that higher fuel price tends to coincide with a weaker US dollar, and vice versa. Hence, for European airlines, two relevant exchange rates affecting their operations are EUR/USD and EUR/GBP.

4.6. Financial crisis

Airline passenger traffic and revenues have a cyclical nature, as they are closely correlated with GDP growth (Dobruszkes & Van Hamme, 2011). The industry recently experienced the financial crisis in 2008 – 2010 and developed countries including Western European countries were affected the most (Franke & John, 2011). Air passenger traffic in Western Europe was stagnating or declining during the period (Dobruszkes & Van Hamme, 2011) and the financial crisis caused both a demand and supply shock. During the crisis fuel price dropped significantly causing unit costs to decrease which benefitted the airlines. However, some airlines could not fully exploit this sudden drop in fuel price as they locked-in higher than market prices through forward contracts (Morrell, 2011). Furthermore, air travel demand deteriorated and due to falling passenger traffic many airlines had to reduce their capacity. This study aims to understand to overall effect of the financial crisis on passenger traffic in relation to fuel price changes.

5. Data

5.1. Dataset

A quarterly panel dataset is constructed from airport traffic and macroeconomic data for the time frame 2007 – 2017. European airport passenger statistics are obtained from anna.aero, an Airline Network News & Analysis website. It is the most comprehensive airport passenger statistics database available with monthly airport traffic data going back until 2007. In this study, Western European countries are considered. The United Nations defines the Western European geographical region as: Austria, Belgium, France, Germany, Liechtenstein, Luxembourg, Monaco, Netherlands and Switzerland. Monaco and Lichtenstein are excluded from the analysis, due to a lack of sufficient airport traffic data available. The United Kingdom is added to the analysis as the country accounts for the largest passenger traffic in Europe and shares similar growth patterns with the other countries included. Following, the monthly airport traffic data is transformed into quarterly observations and aggregated to country level passenger traffic. Moreover, airports with traffic of less than 1.5 million passengers a year (based on 2016 traffic numbers) are excluded due to a lack of data for some years or not being representative for the sample in this study. Many small airports are having declining passenger numbers or growth patterns abnormal to the general trends, meaning the variation in airport traffic is not due to the studied effects.

In addition, quarterly data for macroeconomic indicators are obtained from Trading Economics. These indicators are namely GDP growth, EUR/USD and EUR/GBP exchange rates. Historical jet fuel prices are obtained from Bloomberg (OTC prices), the daily price data is reported as the global average price paid at the refinery in dollar terms. Jet fuel price is transformed into Euro terms taking the same-day EUR/USD exchange rate. This is done, because the studied European airlines denominate their ticket prices mainly in Euro (except for airlines in the United Kingdom and Switzerland), thus fuel costs are relevant for them in Euro terms, which are determined by the actual exchange rates.

5.2. Summary statistics

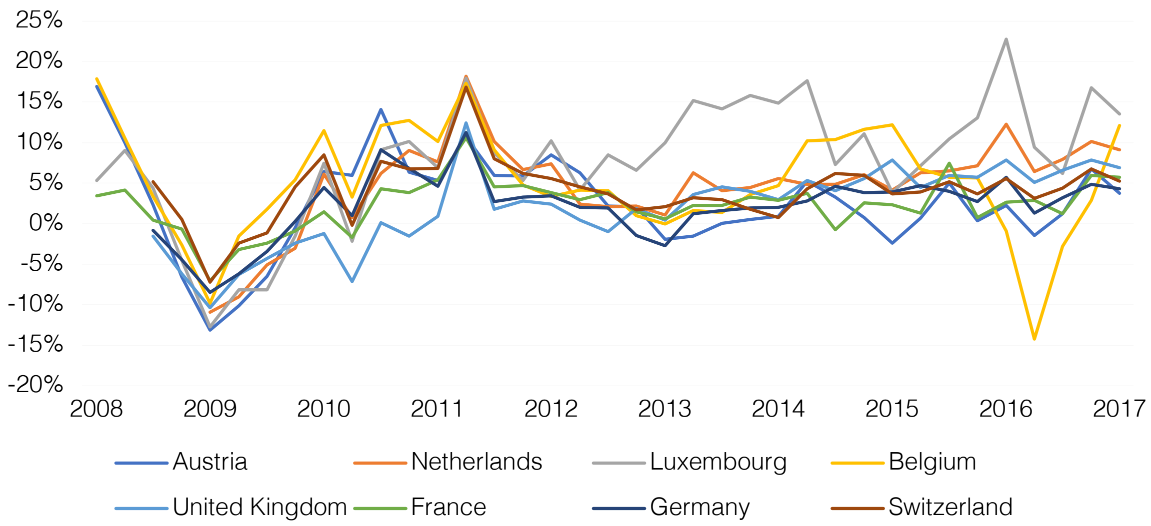
To summarize the set of observations in the model and to indicate the underlying relationships between the variables a summary statistics table is presented with two graphs plotting country-level passenger growth rates and jet fuel prices followed by a correlation matrix.

Table 1: Variable summary statistics

	Observations	Mean	Std. Dev.	Min	Max
Passengers (YoY)	286	0.039	0.057	-0.143	0.228
Fuel price (€/mt)	328	594.6	150.6	319.2	819.6
GDP (YoY)	328	0.013	0.025	-0.079	0.101
EUR/USD (YoY)	328	-0.009	0.094	-0.193	0.160
EUR/GBP (YoY)	328	0.025	0.092	-0.114	0.202

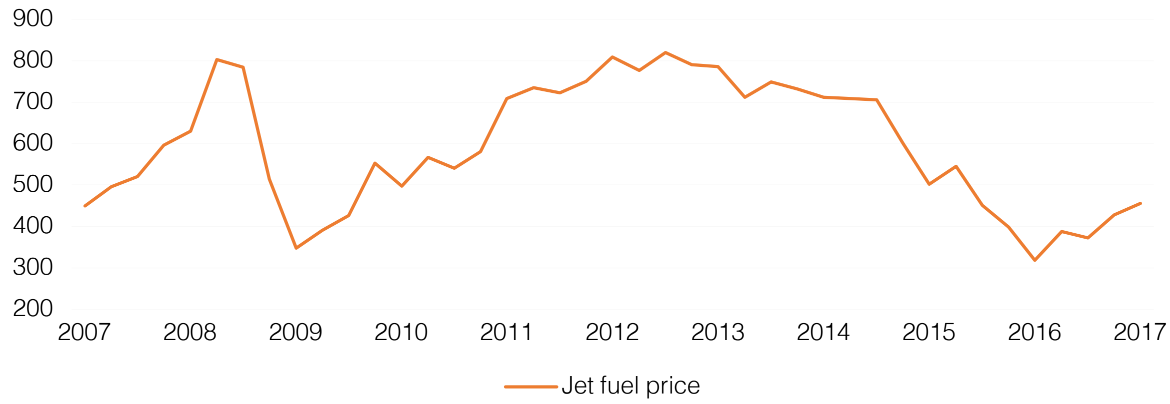
Passenger traffic growth rates vary largely ranging from -14.3% to 22.8% with a moderate average growth rate of 3.7% confirming the saturated state of the Western European market. To see the growth rate development and the between-country variation over the observation period, the growth rates of each country are plotted in the graph following.

Graph 3: Air passenger growth in Western Europe



The countries share approximately the same passenger growth patterns. During 2008 and 2010 all countries share negative growth rates which is likely due to the financial crisis. Following the crisis, growth accelerates reaching above 10% rates. There is more variation between countries from 2013 onwards with relatively moderate growth rates until 2016.

Graph 4: Jet fuel price (denominated in €/mt)



Regarding fuel price, the lowest and highest average quarterly fuel price is €319/mt and €820/mt, respectively, with a mean of €598/mt. Moreover, the average quarterly change in fuel prices throughout the period is approximately €60. Whereas during the financial crisis, this average quarterly change is €115. GDP on average grows 1.6%, where the lowest values coincide with the financial crisis. The dataset is slightly unbalanced due to the year-over-year specification of passenger growth and the inclusion of earlier fuel prices.

Table 2: Correlation matrix

	Passengers (YoY)	L1.Fuel price	L4.Fuel price	GDP (YoY)	EUR/USD (YoY)	EUR/GBP (YoY)
Passengers (YoY)	1.0000					
L1.Fuel price	0.1316	1.0000				
L4.Fuel price	-0.2267	0.4472	1.0000			
GDP (YoY)	0.6670	0.0160	-0.3161	1.0000		
EUR/USD (YoY)	0.2664	0.1136	-0.2644	0.2904	1.0000	
EUR/GBP (YoY)	-0.2549	-0.2494	-0.3341	-0.3287	0.3818	1.0000

Looking at the correlation matrix above, surprisingly, a positive relationship (0.1316) is suggested between the passenger traffic growth and fuel price a quarter before, hence on the short-term. In contrast, there is a relatively strong negative correlation (-0.2267) using the fuel price from four quarters before as a reference. This is in line with the initial expectations. Regarding GDP growth, a strong positive relationship is present with passenger growth. Whereas the two exchange rates have opposite effects the EUR/USD exchange rate is positively correlated with passenger growth and the EUR/GDP is negatively correlated.

6. Methodology

The aim of this analysis is to estimate the effect of fuel price changes on passenger growth in the short- and medium-term. As fuel price changes are an exogenous supply shock, the supply side effect is analyzed and demand variations are controlled for. The general empirical model used for this analysis can be described by the following equation system:

$$\Delta passengers_{c,t} = \alpha_c + \beta_1 L(1,4).fuel\ price_{c,t} + \beta_3 \Delta gdp_{c,t} + \beta_4 \Delta eurusd_{c,t} + \beta_5 \Delta eurgbp_{c,t}$$
$$+ D_1 financial\ crisis_{c,t} + D_2 terrorist\ attacks_{c,t} + D_3 icelandic\ ash\ cloud_{c,t} + \mu_{c,t} \qquad (1)$$

Passengers$_{c,t}$ is the dependent variable observed for country c in time t, and is reported as year-over-year percentage change in order to control for seasonality in passenger traffic. Moreover, by using year-over-year method the dataset is transformed into stationary time series by differencing. Fuel price$_{c,t}$ is a time variant regressor, the main variable of interest. To isolate the effect of passenger growth induced by economic growth, GDP growth is used as a demand control variable. GDP growth rate is an important explanatory variable since without its inclusion, differences in the economic situation of a country are not accounted for. Employment rate and labor force participation rate were also considered, but are not included in the model specification, as both their effects are highly insignificant when tested for, thus lack the explanatory power. Moreover, two currency exchange rates are included that both affect demand and airlines' operations: euro/dollar and euro/pound exchange rates. The set of control variables are also specified on a quarterly, year-over-year basis.

Further time dummy variables are created to capture variation caused by the financial crisis (2008/Q3 – 2010/Q1), several terrorist attacks (2015/Q4 – 2016/Q4), and the Icelandic ash cloud (2010/Q2). The financial crisis caused both a demand and supply shock, the passenger traffic fell and fuel prices declined simultaneously. The recent terrorist attacks in Western Europe had a negative, but temporary impact on airlines' international traffic, through a decrease in passenger demand (IATA, 2017). Furthermore, the eruption of an Icelandic vulcan and a subsequent large ash cloud resulted in a Europe-wide air traffic shut-down leaving millions of passengers stranded. Controlling for these events is necessary. α_c

represents the constant term, which is the average passenger growth if all the other variables are set to zero. Lastly, $\mu_{c,t}$ stands for the error term.

The effect the financial crisis had on passenger growth is estimated with a second model specification. The demand and supply effects are separated. By only including the 'financial crisis' time dummy, mostly the demand shock causing passenger growth decline is accounted for. To capture the effect caused by a significant decline in fuel prices an interaction term is generated between the time dummy variable and fuel price. With the inclusion of the interaction term, omitted variable bias is reduced, without the interaction effect, the fuel variable is expected to be underestimated with the initial specification. The empirical specification of this model is the following.

$$\Delta passengers_{c,t} = \alpha_c + \beta_1 L(1,4).fuel\ price_{c,t} + \beta_2 L(1,4).(fuel\ price * financial\ crisis)_{c,t} + \beta_3 \Delta gdp_{c,t} + \beta_4 \Delta eurusd_{c,t} + \beta_5 \Delta eurgbp_{c,t} + D_1 financial\ crisis_{c,t} + D_2 terrorist\ attacks_{c,t} + D_3 icelandic\ ash\ cloud_{c,t} + \mu_{c,t} \quad (2)$$

A Hausman test is run to choose between fixed effects or random effects model for the two panel data analyses. The test essentially checks if there is a correlation between the unique errors and the regressors in the model. Fixed effects model is preferred, as the null hypothesis that the preferred method is random effects is rejected at a 5% significance level. A fixed-effect model tests for the within-group variation across time. This way, all time-invariant country characteristics are captured by the constant term and a number of potential omitted variables unique to the group is controlled for. The fixed-effects model thus estimates the variation from the average country level growth. This methodological specification is in line with the methodology applied in past literature studying airline dynamics.

Simultaneous causality between fuel price and passenger growth is not an issue. This can be explained by an indirect relationship. The link between fuel price and passenger growth is via airlines, and fuel price for airlines is an exogenous input, they have no influence on it. Jet fuel price is derived from the price of crude oil, which is a heavily traded, liquid commodity. The price movements are mainly influenced by oil suppliers, fundamental trades and portfolio investors. Airline purchases are relatively small and in essence have no impact on the market price of fuel, thus airlines are only getting the market price[3] (Morrell & Swan, 2006).

To improve the accuracy of the coefficient estimations and mitigate possible heteroskedasticity problem, standard errors are clustered by country. By this, independence across clusters are assumed, but within clusters the standard errors may correlate. In order to control for outliers in the model, the dependent variable (passenger traffic growth) is winsorized at the 1 percent level in all model specifications to maintain model validity. This way the observations higher than the 99th and the lowest 1st percentile are not deleted, but replaced with values that are closer to the middle of the distribution. Moreover, it has to be noted that with the inclusion of two fuel lags and the fuel interaction term within the model, multicollinearity becomes a problem as the fuel lags are highly correlated with each other. This is detected using the variance inflation factor (VIF). Multicollinearity could potentially lead to slightly unreliable or unstable estimations for the regression coefficients, but even in this case the coefficients would not deviate considerably from their true value.

[3] Delta airlines in the U.S. acquired an oil refinery in 2012 to reduce their crude oil supply and refinery margin exposure. This is an example how an airline could reduce the exogeneity.

7. Results

The following table includes the regression outputs as specified in the methodology section, where the dependent variable is year-over-year passenger traffic growth rate.

Table 3: Fixed effects models

Model (1) with general specification and model (2) including the financial crisis interaction term. The fuel lags represent the effect of the average quarterly fuel price at t_{-1} and t_{-4} on passenger traffic growth at t_0. The remaining explanatory variables are controls only. Both regressions are clustered by country and the fixed effects are on country level. Significance level at 10%, 5% and 1% is shown by *, **, and ***, respectively.

	(1)	(2)
L1.Fuel price	-0.0000373** [0.036]	-0.0000777*** [0.004]
L4.Fuel price	-0.0000762** [0.019]	-0.0001154*** [0.001]
L1.Fuel price * Financial crisis		-0.0000931*** [0.000]
L4.Fuel price * Financial crisis		-0.0000671*** [0.001]
GDP (YoY)	0.8139931*** [0.001]	0.8296696*** [0.001]
EUR/USD (YoY)	0.1408099*** [0.001]	0.2055924*** [0.000]
EUR/GBP (YoY)	-0.1209836** [0.018]	-0.224951*** [0.001]
Financial crisis	-0.042827*** [0.008]	0.002936 [0.841]
Terrorist attacks	-0.0261492 [0.140]	-0.0396334** [0.042]
Icelandic ash cloud	-0.0914858*** [0.000]	-0.0402092*** [0.001]
constant	0.1185315*** [0.000]	0.1758234*** [0.000]
R-squared:	0.5608	0.5882
Corr(u_i, Xb):	0.0660	0.0647
Number of obs:	286	286

Model 2 seems to be a better model with higher explanatory power, explaining 58.82% of the variation in passenger traffic growth. The fuel coefficients in model 1 are underestimated as the coefficients are much lower than in model 2. By including the financial crisis interaction term, a more precise estimation is obtained as the effect financial crisis had on passenger growth through the abnormal fuel price changes is now separated.

In both model specifications, a negative fuel price coefficient is obtained. An increase in fuel price decreases the passenger growth rates. Interpreting the coefficient of the first fuel lag in Model 2, it can be predicted that if fuel price goes up by €1 at t_0, passenger growth at t_{+1} decreases by on average 0.00777 percentage points. To understand the magnitude of such an effect in a realistic context, the average fuel price change throughout the period is taken: an increase of €60 at today leads to on average a 0.466 percentage points decrease of passenger growth a quarter later. This is quite an adverse effect. Hence, hypothesis 1 is not rejected, suggesting that there is a negative relationship between jet fuel price and air passenger traffic growth.

The two fuel lags represent a short- and a medium-term effect. It is found that a fuel price change has a larger effect on the medium-term, an effect of 0.01154 percentage points per €1 change, as compared to 0.00777 over the short-term (Model 2). Thus, the second hypothesis suggesting that the effect of jet fuel price change on air passenger traffic is greater over the medium term than over the short term, is not rejected. The underlying explanation is that airlines can incorporate a fuel price change on the short term mainly with air fare adjustments or fuel surcharges that result in lower passenger bookings made usually around 3 months into the future. Airlines typically hedge at around 6 months ahead in time with some hedges made a year ahead (Morrell & Swan, 2006). Moreover, these hedges cover typically two-thirds of the fuel costs in the short-term (between 3 to 6 months) and cover less, around one-third between 6-12 months. Hence, a price change do not fully impact fuel costs in the short-term due to the hedging coverage, but more after half a year and following. Moreover, capacity decisions regarding aircraft utilization rates or bringing in new aircraft can be made in the short-term, but can mainly be implemented in the medium-term. This is due to airlines having to find available capacity, obtain slots at the airports, moreover additional crew and pilots have to be mobilized, and in some cases hired and trained. In addition if fuel price declines competition intensifies this effect as over-capacity is created in the market, which further drives down the fares and induce larger passenger growth. Thus, competing away the benefit the airlines have on their operating margins.

Regarding the effect of fuel price change during the financial crisis the coefficients of the interaction term are analyzed. A change in fuel prices has an even more negative effect on passenger growth during the period the effect is enlarged. By adding the two coefficients together, a €1 decline resulted in a 0.01708 percentage points increase in passenger growth during the crisis on the short-term. As far as the medium-term effect is concerned, interestingly the same €1 price decline resulted in an increase of 0.01825 percentage points, similar to the short-term effect. Given that the average quarterly fuel price change during the financial crisis was €115, a price decline this large results in an increase of 1.96 and 2.1 percentage points in passenger growth rates over the short- and medium-term, respectively. This effect can be considered substantial. Hence, the third hypothesis is not rejected, implying that during the period of the financial crisis, passenger growth is affected to a greater extent than otherwise by the sudden large changes in jet fuel price. The fact that the interaction term absorbed the effect of the financial crisis by making the financial crisis time dummy variable highly insignificant means that the crisis impacted passenger growth mainly via the fuel price change. This result suggests that airlines benefited from the financial crisis through this unit cost saving and were able to grow more than usual despite the adverse demand effects the financial crisis had. However, if fuel price had not declined sharply, passenger growth would have been affected more negatively due to airlines facing weakened demand and high input costs. Thus, the declining fuel price had an offsetting effect by presumably keeping operating margins from deteriorating greatly as demand fell.

Regarding the size of the short and medium-term effect during the financial crisis, it is hard to clarify. A possible explanation could be that airlines had to respond quicker than normally due the pressure from all sides as the crisis affected all aspects of the business. Moreover, another explanation could be that hedging transactions were relaxed due to fuel price falling sharply, thus airlines realized the fuel price changes in their operations sooner. Hence, air fares were adjusted earlier, closer to the fuel price change. This explanation is supported by Klophaus's (2009) suggestion that in the absence of fuel hedging, a fuel price change has an even stronger effect on demand on the short-term. Nevertheless, lower fares were inevitable and justified with the falling fuel costs. Competition could have induced a price war as in hard times like during the crisis an airline could fight for gaining market positions even at the cost of profits. In such cases all the players have to act fast to protect its positions and stay in business. On the passenger side this only meant lower air fares, hence stimulating travel.

8. Conclusion

Regarding the question, that what is the effect of jet fuel price changes on air passenger traffic in Western Europe between 2007 and 2017, various aspects are considered in this paper. First, it can be generally concluded that fuel price plays a significant role in facilitating or constraining air traffic growth. Fuel price changes primarily feed through into the fare environment with a time lag in the forms of consequent capacity dilution (costs decrease) or capacity contraction (cost increase), as a function of changing supply vs market demand. In times of higher fuel price, fuel surcharges are levied on passengers as airlines want to remain profitable. This is a common response, however, airlines have to price competitively, hence there is a limit to the extent a cost increase can be passed-on to passengers. At a high price, a highly fuel efficient aircraft fleet can be a competitive strength. If the airline is able to produce lower operating costs than its competitors then it can increase its traffic and market share by underpricing the competitor. A low fuel price is good for the industry as it accelerates market capacity growth and improves profitability through a better operating efficiency. The industry however, competes the cost advantage away as the market is inflated with the capacity, which turn into a fare advantage to the passengers due to a competitive pricing pressure to sell the extra seats. In effect, through a price-sensitive demand, growth is impacted by changes in fuel price in both directions. Given an input cost (fuel price) change an airline has to manage its capacity not only based on what its profit margins allow, but also with respect to the market growth potential. By knowing when and how fuel price movements improve or worsen passenger traffic growth, airlines can develop better capacity forecasting ability.

Regarding the fuel lag, the impact is more robust in the medium-term, a year following. Hedging contracts cover only a fraction of fuel costs in the second half of the year in advance, hence a cost induced price adjustment primarily manifests in the medium-term. As fuel price has very volatile nature a type of differentiated hedging strategy with greater hedging coverage in the short-term and limited in the medium-term appears to be justified by this paper's findings. This way exposure to short-term fluctuations are mitigated and margins are more predictable, hence also ticket pricing and passenger traffic accordingly. Moreover, by leaving the medium-term future fuel costs predominantly unhedged, opportunities arising from a possibly lower fuel price can be taken advantage of, hence achieving lower operating costs and better growth rates.

Furthermore, thanks to the current favorable low fuel price environment airlines and better margins airlines have become optimistic regarding their growth potential. Hence, large aircraft orders have been placed, for which the industry have to be cautious of as maybe these airlines will find themselves on the other side of the cycle when the aircrafts are delivered and will not be able to sell that capacity in a profitable way. Nevertheless, if the current low fuel price continues to persist high passenger traffic growth rates will be sustained. However, in the long term price is expected to structurally rise again due to the increasing world demand for fuel and the non-renewable nature of this resources. Hence, airlines are under constant pressure to find better use of fuel.

I acknowledge that this paper has some limitations to its scope. First, external validity of the results. The geographic choice of the analysis, Western Europe, was based upon having low/moderate traffic growth, relatively low volatility in growth rates, stable economic environment. Fuel price proves to be an import passenger traffic growth determinant in this market and time frame, but it may be that in less mature market such as in the Eastern European region other economic factors play a more important role in driving growth than fuel price. Hence, there is a limit to which these findings can be extrapolated to other markets. Idea for further research is to analyze this effect on a larger geographical domain such as the entire European market or in the USA. Moreover, as pointed out there are operational and fleet differences between low cost and hub carriers, hence one could separate passenger traffic into passengers carried by the two type of airlines. This way inferences could be made on to what extent the change in growth rates is accounted by the effect fuel price change has on low cost and hub carriers.

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