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Prices of Tickets in the U.S. Airline Industry: An Analysis of the Effect of the Oil Price on the Price of Airline Tickets Between 1993 and 2014

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Abstract

This research focuses on the effect of the oil price on the price of airline tickets. In this study two hypotheses are tested to estimate two different effects. Panel data on ticket prices from 1993 to 2014 on 24 routes with varying levels of competition is collected to estimate the effects. A pooled Ordinary Least Squares regression model is run on the 50th percentile of prices of airline tickets to test the first effect. Evidence is provided that a change in the oil price does not result in a different effect in competitive and non-competitive routes. By running a Seemingly Unrelated Regression model, evidence is provided for the effect of the oil price to be stronger for the lower segment of ticket prices than for the higher segment of ticket prices on a route.

Contents

I. Introduction

Throughout the last 30 years the average price of airline tickets has dropped by over 50% when adjusted for inflation (United States Department of Transportation, 2015). The deregulation of the US airline industry in 1978 is considered the main driver for the increased competition among airlines, leading to lower airfares (Morrison & Winston, 1990). With the ticket revenue stream coming under pressure due to increased competition, airlines are increasingly looking to manage their cost side. Ranging between 21% and 46%, and averaging 33.4%, the proportion of oil and fuel contributes largely to an airline's total operating expenses (International Air Transport Association, 2014). Due to technological advancements, productivity and efficiency will rise, resulting in a rising proportion of oil and fuel in the total operating expenses. Over the last 25 years there has been a significant fluctuation in the price of jet fuel, as can be seen in Appendix A. These fluctuations can severely affect an airline's profit, as margins in the airline industry are typically very thin. As fuel and oil are a large part of total operating expenses, airlines often 'hedge' between one-third and two-thirds of their expected future expenses (Morrell & Swan, 2006). By hedging, airlines protect themselves from unexpected gains or losses due to changes in oil prices. The rationale is that there will be more stability in the cost side of the airline. More stable costs will also lead to more stable profits, resulting in a higher price of an airline's stocks (Morrell & Swan, 2006). Appendix B shows jet fuel prices almost perfectly follow oil prices. In this study oil prices will be taken as a commodity to estimate effects.

Airline prices are known to fluctuate through dynamic pricing. The theory of menu costs leading to nominal price rigidity (Sheshinski & Weiss, 1977) is no longer applicable as airline tickets can nowadays be bought online, making real-time adjustments of prices possible. However, airlines do seem to follow price-band mechanisms (Puller, Sengupta, & Wiggins, 2009), limiting the magnitude of a price change (Coady, et al., 2012), called price-smoothing. Changes in production costs are found to be passed through onto passengers in higher proportions than non-production-related costs (RBB Economics, 2014), leading to higher ticket prices.

The aim of this study is to examine the relationship between oil prices and airline ticket prices. By examining this relationship, the passthrough of oil price changes in the cost of airline tickets can be determined. This gives more insight in how prices are passed through to customers and what the magnitude of the effect is. This relationship characterises the pass-through of commodity prices, explicitly the effect of the commodity oil on the price of airline tickets. Pass-through of commodity prices differs between countries and sectors (Rigobon, 2010). This study aims to gain more insight in the pass-through of the commodity price of oil in the U.S. Airline industry.

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With recovering – and expected to rise – jet fuel prices (Airbus, 2017), oil being a non-renewable resource and air passenger transport expected to grow by 4.4% on yearly basis for the next 20 years (Airbus, 2017), both airlines and their customers should pay attention to changes in oil prices leading to a change in prices of airfares. This reasoning leads to the research question:

"What is the effect of the oil price on the price of airline tickets?"

To answer this research question, two hypotheses will be tested, which will be discussed in section two. Section three will discuss which data will be used to test the hypotheses mentioned in section two and how this data is collected. Section four discusses the type of analysis used to test the formed hypotheses. Section five will describe the results of the analysis. The conclusion in section six will answer the above-mentioned research question. Finally, section seven will discuss several limitations of this research paper which arise by certain ways of data collection, the way variables are measured and used methodology. Section seven will conclude with recommendations for further research.

II. Theoretical framework

The first hypothesis will look at the difference between competitive and non-competitive routes. More competitive routes have lower margins than less competitive routes. Lower margins result in the proportion of costs in an airline ticket being higher. Previous research indicates that when firms compete aggressively on prices in more competitive markets, cost shocks will trigger quick adjustments to optimal prices throughout the whole market, as margins are lower and there is less room for absorbing the increases of costs (Gayle & Lin, 2017). This is consistent with findings from Koopmans and Lieshout (2016) and Malina, et al. (2012) that a cost shock is likely to be passed through into new equilibrium prices in higher proportion when markets are more competitive. This would imply that a change in the oil price will have a stronger effect on the ticket price on a competitive route in terms of dollars, where non-competitive routes will respond less, as a result of price-smoothing.

Hypothesis 1: *"The effect of the oil price on the price of airline tickets is larger on competitive routes than on non-competitive routes."*

The second hypothesis will look at the differences in the ticket prices on a route. Due to dynamic pricing, airfares change constantly. Differences in pricing are primarily driven by differences in customer dynamics (McAfee & Te Velde, 2006). Airlines charge different prices to different types of customers. Leisure travellers typically book their tickets further in advance than business travellers, who book their tickets closer toward the departure date. Business travellers' demand is more price-inelastic compared to leisure travellers, and have a willingness to pay which is six times higher for the same seat than leisure travellers (Lazarev, 2013). Both McAfee and Te Velde (2006) and Lazarev (2013) have found that ticket prices rise as the departure date approaches, meaning business travellers buy the more expensive tickets.

Previous research on this topic has not yielded a conclusive result. When markets change from a monopoly to a market with imperfect competition, by increasing the number of airlines, prices do not largely fall, but they increase in spread (Borenstein & Rose, 1994). Later research by Carbonneau, McAfee, Mialon and Mialon (2004) supports this finding. Increased competition will lead to airlines employing a more effective yield management, meaning there will be more price discrimination. Borenstein and Rose (1994) also find competition will lower the average price, but airlines will solely compete on the discount prices of air tickets, meaning the effect does not hold for other tickets. However, different research finds there is less room for price dispersion in a competitive market, since airlines must offer competitive pricing (Gerardi & Shapiro, 2009). Gerardi and Shapiro (2009) follow the common macroeconomic theory and argue that prices will fall with increasing competition over the whole of the price range of tickets as pricing must be more competitive. As there is yet to be found a conclusive result, following the theory of dynamic pricing and the reasoning of Borenstein and Rose (1994), it is expected that effects of oil price will be larger in the lower segment of tickets.

Hypothesis 2: *"The effect of the oil price on the price of airline tickets is larger in the lower segment of ticket prices on a route than in the higher segment of ticket prices on a route."*

To test the first hypothesis, competitive routes will be compared to non-competitive routes. Four airports on competitive routes and several airports on non-competitive routes will be examined. The routes corresponding to these airports will result in 12 competitive routes and 12 non-competitive routes that will be examined for this research. The dataset contains quarterly prices for all these routes. The median prices will be compared to the quarterly average price of oil to estimate the effect. The effect of the oil price is expected to be stronger on the competitive routes than on the non-competitive routes. How the data is collected, which variables are included in the dataset and how the competitive and non-competitive routes are selected is explained in section three. The methodology will be further discussed in section four.

To test the second hypothesis, the same four competitive airports as discussed in the first hypothesis, as well as the 12 selective non-competitive routes will be used. The routes can be found in Appendix C. The dataset contains quarterly data of the 10% lowest fares, median fares and 10% highest fares for each route. The quarterly panel data of these three segments of fare prices will be compared to the quarterly average oil price to estimate the effect. The effect of the oil price is expected to be stronger in the segment of 10% lowest fares. As mentioned above, section three will give a more in-depth view of the data and how the data is selected and section four will further discuss the methodology.

As this research focuses on the U.S. domestic market and both the ticket prices and the oil price are measured in dollars, exchange rates, volatility of exchange rates and exchange rate pass-throughs are not applicable.

III. Data

A. Sources of data

To test the hypotheses, and consequently to answer the research question as mentioned in the introduction, panel data from the U.S. airline industry between 1993 and 2014 will be used. This panel data is mainly collected through merging several existing databases and adding specific variables.

The main body of the data is provided by the Transtats database of the Bureau of Transportation Statistics of the U.S. Department of Transportation. The Origin and Destination Survey (DB1B) is comprised of 10% of airline tickets from reporting carriers. This 10% sample contains information regarding the origin and destination of the ticket, the route, the carrier of operation, the price of the ticket, the class of travel and other itinerary details of the tickets sold (Bureau of Transport Statistics).

For each route additional variables are added by using the T-100 Domestic Segment (T-100) databank. The T-100 databank is also provided by the Transtats database of the Bureau of Transportation Statistics of the U.S. Department of Transportation. The T-100 databank contains monthly, domestic non-stop segment data, as carrier, origin and destination, aircraft type and service class for transported passengers, freight and mail, available capacity, scheduled departures, departures performed, aircraft hours and load factor (Bureau of Transport Statistics). The domestic databank is chosen to match the routes of the DB1B database, as the research is specifically aimed at the U.S. market. The T-100 databank added to the sample will mainly be used to obtain control variables for the statistical tests described in section four.

The West Texas Intermediate oil price is added as a variable. The quarterly crude oil price is matched to each route's corresponding year and quarter. The West Texas Intermediate oil price is measured in dollars per barrel. The two main oil standards are West Texas Intermediate and Brent Crude. As West Texas Intermediate is the benchmark crude for North America (Investopedia), this standard will be used in this research.

B. Constructing the final sample

To construct the final sample, only non-stop, direct flights will be used. Return flights are converted to one-way flights by dividing the ticket by price two and dropping the return part of the flight – consistent with existing literature by Borenstein & Rose (1994), Gerardi & Shapiro (2009) and Dai, Liu & Serfes (2014) – to avoid double-counting and therefore biasing the sample. The final sample will only restrict itself to domestic flights, meaning both the origin as well as the destination city must be located within the United States. For this research the fare class will be limited to coach. As more expensive fare classes – as business class or first class – provide more luxury, this increase in luxury comes at a price. As this price increase solely affects the comfort of travelling, and not the actual transportation from A to B, these observations will be dropped from the final sample.

After dropping the observations, as described above, the T-100 databank is transformed. The DB1B database consists of quarterly data, as opposed to the monthly data in the T-100 databank. The T-100 databank will be converted from monthly to quarterly data to match the DB1B database.

After the observations have been dropped and the T-100 databank has been transformed, both databases will be merged together to create the final sample. By merging the databases not all observations are perfectly matched. These observations are dropped and will thus be excluded from the final sample. The oil price data will also be merged, but here no observations are dropped, as the quarters are a perfect match.

C. Selecting the routes from the sample

1. Competitive routes

The four competitive airports are selected based on the passenger count, domestic flights and number of airlines flying to and from these cities (United States Department of Transportation, 2015). The selected airports for the competitive routes are Hartsfield-Jackson Atlanta International Airport (ATL), New York John F. Kennedy International Airport (JFK), Los Angeles International Airport (LAX) and Chicago O'Hare International Airport (ORD). The selected competitive routes are the 12 possible routes between these 4 airports and can be found in Appendix C.

2. Non-competitive routes

Because it is unlikely to find four cities which have a monopoly on all the routes to and from the three other cities during all years and quarters included in the database, 12 individual routes will be examined. These 12 routes are selected according to the percent market share of the largest carrier on a route (United States Department of Transportation, 2018). A route is selected if the largest carrier has a market share larger than or equal to 90% in the last quarter of 2017. The selected non-competitive routes can be found in Appendix C.

The routes are shown in Appendix C. The effects will be corrected for distance of routes, as the routes will be compared to each other. The non-stop distances of the selected routes are determined from the Department of Transportation's Domestic Airline Consumer Airfare Report. Each year entry and exit of airlines on these routes will be evaluated and corrected if needed. If an airline no longer operates as a monopolist on a non-competitive route, the observation will be used as a competitive route in that quarter.

IV. Methodology

This section will describe how the hypotheses mentioned in section two will be tested to answer the research question "*what is the effect of the oil price on the price of airline tickets*?". To test the hypotheses the following model will be used to estimate the parameters leading to the price of airline tickets. The model will be run as a pooled Ordinary Least Squares regression to test the first hypothesis, and a Seemingly Unrelated Regression to test the second hypothesis.

$LnP_{ijt} = \beta_0 + \beta_1$ Ln(Oil $price_{t-1}$) + β_2 Ln(Oil $price_t$) + β_3 (Ln(Oil $price_t$) × $Competition_{ijt}$) + γ_1 Average quarterly load $factor_{ijt}$ + γ_2 Ln(Total available seat $miles_{ijt}$) + δ $Competition_{ijt}$ + η_1 $distance_{ij}$ + η_2 $distance_{ij}^2 + \varepsilon_{ijt}$

In the above-mentioned equation, the indexes i denote the airline carrier, indexes j denote the route and indexes t denote the time period which is measured in quarters. The dependent variable in this model is the natural logarithm of the price of airline tickets. β_0 denotes the intercept or constant term. 'Ln(Oil $price_{t-1}$)' is an independent variable which denotes the natural logarithm of the 1-period-lag of the oil price, with β_1 denoting its corresponding coefficient. 'Ln(Oil $price_t$)' is an independent variables which denotes the natural logarithm of the main effect of the oil price, with β_2 denoting its corresponding coefficient. '(Ln(Oil $price_t$) × $Competition_{ijt}$)' is an independent variable which denotes the natural logarithm of the interaction effect of the oil price and competition on the price of airline tickets, with β_3 denoting its corresponding coefficient. 'Competition' is a dummy variable, assuming value 1 for a competitive route – the benchmark value – and value 0 for a non-competitive route. 'Average quarterly load $factor_{ijt}$' is added as control variable to control for the size of an airline carrier, measuring the quarterly percentage of filled seats on an airline carrier's route, with γ_1 denoting its corresponding coefficient. 'Ln(Total available seat $miles_{ijt}$)' is added as control variable to control for the size of an airline carrier, measuring the total carrying capacity of an airline carrier in a year, with γ_2 denoting its corresponding coefficient. '$Competition_{ijt}$' is added as dummy control variable to control for the route characteristic competition, assuming value 1 for competitive routes and value 0 for non-competitive routes, with δ denoting its corresponding coefficient. Finally, '$distance_{ij}$' and '$distance_{ij}^2$' are added as control variables to control for distance of the routes which are measured in miles, with η_1 and η_2 denoting the corresponding coefficients respectively. The error term of the regression is denoted by ε_{ijt}.

The model estimates the parameters leading to the price of airline tickets. The dependent variable will be the natural logarithm of the price of airline tickets in a percentile. The first hypothesis will test the model up to the median price of airline tickets; the 50^{th} percentile (called 'LnP50'). As the data is right-skewed the median price of airline tickets will be examined, which does not equal the average price of airline tickets.

Following research by Morrell and Swan (2006), the 1-period-lag of the oil price is taken, as they find that very few hedges of jet fuel by airlines cover more than 12 months of expected consumption and 80% of hedges cover the period of three months ahead.

In the interaction effect the main effect will be examined for the competitiveness of routes. As mentioned in section two, Gayle and Lin (2017) have found that cost shocks will trigger quick adjustments in competitive markets. For this reason, not the 1-period-lag of the oil price but the main effect is examined for the interaction term.

The coefficient β_1 is expected to be positive, as the 1-period-lag of the oil price is expected to have a positive effect on the price of airline tickets through hedging; an increase in the quarterly average oil price is expected to drive up the price of airline tickets in the next period, whereas a decrease in the quarterly average oil price is expected to lower the price of airline tickets in the next period. The coefficient β_2 is expected to be positive as the oil price is also expected to have a direct effect on the price of airline tickets. The coefficient β_3 is expected to be positive, as the interaction effect with competition is also expected to have a positive effect on the price of airline tickets, following the reasoning in section two leading to the first hypothesis.

To test the first hypothesis ("*The effect of the oil price on the price of airline tickets is larger on competitive routes than on non-competitive routes*.") the model will be run as a pooled Ordinary Least Squares regression. If β_3 is statistically significant[1] and larger for the interaction with competitive routes which must also be statistically significant, the first hypothesis is supported, and the effect of the oil price is found to have a larger effect on competitive routes than on non-competitive routes. As robustness, the pooled Ordinary Least Squares regression will also be run with the 1-period-lag of the oil price and competition for the interaction effect, where the magnitude and significance of β_3 will compared to the β_3 of the model with the main effect of the oil price and competition for the interaction effect. This will be done to determine if the effect is larger for the lag of the oil price.

To test the second hypothesis ("*The effect of the oil price on the price of airline tickets is larger in the lower segment of ticket prices on a route than in the higher segment of ticket prices on a route*."), the model will be run as a Seemingly Unrelated Regression for both the 10^{th} and 90^{th} percentile of the prices of airline tickets. The 10^{th} percentile of the prices of airline tickets contains the 10% cheapest tickets and is called 'LnP10'. The 90^{th} percentile of prices of airline tickets contains the prices of the 90% cheapest tickets, when ranked from cheapest to most expensive, and is called 'LnP90'. The coefficients β_1 of the 1-period-lag of the oil price for both percentiles will be compared. By using the Seemingly Unrelated Regression model, the coefficients for both percentiles will be estimated through one model and the error terms in both percentiles are allowed to correlate. By estimating through one

[1] A significance level of 5% will be used for all statistical tests.

model the coefficients can be compared to each other. Finally, the found coefficients of the 1-period-lag of the oil price for both percentiles will be tested for equality. If β_1 is statistically significant and larger for the 10^{th} percentile of the prices of airline tickets than β_1 for the 90^{th} percentile of the prices of airline tickets and the test of equality of coefficients is rejected, the second hypothesis is supported and the effect of the oil price on the price of airline tickets is found to be larger in the lower segment of ticket prices on a route than in the higher segment of ticket prices on a route.

If the second hypothesis is supported, the Seemingly Unrelated Regression model will be run on the 1^{st} quarter (25% cheapest airline tickets, called ‘LnP25’) and 3^{rd} quarter (75% cheapest airline tickets, called ‘LnP75’) of the prices of airline tickets as robustness. Here, β_1 is again expected to be statistically significant and larger for the model of the 1^{st} quarter of prices of airline tickets compared to the model of the 3^{rd} quarter of prices of airline tickets. Both coefficients will again be tested for equality.

V. Results

To test the first hypothesis ("*The effect of the oil price on the price of airline tickets is larger on competitive routes than on non-competitive routes*."), the interaction effect of the oil price with competition on the median price of airline tickets is estimated through the pooled Ordinary Least Squares regression model as mentioned in section four. The results of the pooled Ordinary Least Squares model can be found in Appendix D. The constant of 0.719 can be interpreted as the mean effect of variables that are not included in the model but do affect the price of airline tickets. For example, the constant can represent a partial of landing slot-costs or marketing-costs. The 1-period-lag of the oil price is a statistically insignificant variable at a 5% significance level, meaning the 1-period-lag of the oil price does not affect the median price of airline tickets. The effect of the current oil price on the price of airline tickets is found to be positive and statistically significant; an increase of 1 percent in the oil price will lead to a 0.083 % increase in the median price of airline tickets. However, the interaction effect appears to be statistically insignificant, meaning no effect has been found. With finding an insignificant interaction effect the first hypothesis is rejected. The oil price has not been found to have a larger effect on the price of airline tickets in competitive routes than in non-competitive routes. When running the model for robustness with the 1-period-lag in the interaction effect instead of the direct effect, the coefficient β_3 is also found to be insignificant (P-value = 0.817). The 1-period-lag of the oil price has also not been found to have a larger effect on the price of airline tickets in competitive routes than in non-competitive routes.

The control variables 'Average quarterly load factor', 'Total available seat miles', 'Competition', 'distance' and 'distance^2' were added to reduce biases to the model caused by omitted variables and therefore give the model a higher explanatory power and more accurate coefficients. Control variables are not meant to estimate a causal effect. However, the sign of the coefficients of control variables can be examined. The coefficients of 'Average quarterly load factor', 'Total available seat miles', 'distance', and 'distance^2' are found to be positive[2]. This sounds plausible, as through supply and demand tickets get more expensive as less tickets are available ('Average quarterly load factor'), the larger the capacity of an airline the more destinations or flight opportunities are available ('Total available seat miles') increasing the price, and the longer the distance of a route the more fuel is used and staff hours are paid also increasing price ('distance' and 'distance^2'). The dummy variable 'Competition' is found to be negative, meaning airline tickets on competitive routes are cheaper than on non-competitive routes. This is in line with expectations, as competition is known to put pressure on prices, driving prices down to marginal costs in the most extreme case.

[2] The control variables 'distance' and 'distance^2' have been found to be small (0.0000687 and 0.0000000811, respectively). After rounding the coefficients are reported to be 0.000. Control variables are not meant to estimate a causal effect.

To test the second hypothesis ("*The effect of the oil price on the price of airline tickets is larger in the lower segment of ticket prices on a route than in the higher segment of ticket prices on a route*.") the Seemingly Unrelated Regression model, as mentioned in section four, will be run for both the 10th and 90th percentile to estimate the parameters leading to the price of 'LnP10' and 'LnP90' (as described in section four). The results of the Seemingly Unrelated Regression model run for 'LnP10' and 'LnP90' can be found in Appendix E. As can be seen in Appendix E, the constant for the 'LnP10' model is positive at 1.156 and significant, following the same interpretation as above, only differing in value. In the 'LnP90' model the constant is negative and insignificant, making it not meaningful to interpret its value. The 1-period-lag of the oil price is significant and positive in the 'LnP10' model and insignificant and positive in the 'LnP90' model, 0.122 and 0.014 respectively. As the 1-period-lag of the oil price is only significant in the 'LnP10' model the coefficient can be interpreted as a 1 percent increase in the oil price will lead to a 0.122% increase in the 10th percentile price of airline tickets in the next period. The 1-period-lag of the oil price is found to have no effect on the 90th percentile of prices of airline tickets. The interaction effects are found to be insignificant for both tested percentiles, so there is no causal effect of the oil price and degree of competitiveness of a route on the 10th or 90th percentile of prices of airline tickets.

As mentioned previously, the control variables are not used to estimate a causal effect. Not all control variables are found to be significant. In both the 'LnP10'- and 'LnP90' model 'Total available seat miles' and 'distance' are found to be significant and positive[3]. The sign of these control variables follows the same reasoning as above in the first hypothesis. Additionally, for the 'LnP90' model 'Average quarterly load factor' and 'Competition' are found to be significant and negative. The reasoning for the control variable 'Competition' is the same as mentioned above. A possible explanation for the negative value of 'Average quarterly load factor' for the 90th percentile of prices of airline tickets may be that prices drop at this point as these tickets are typically the last to be sold; airlines sell so-called last-minute tickets against lower prices to fill up the aeroplane before departure. For the other control variables, no attempt will be made to explain their sign, as these variables are found to be insignificant in determining the prices of airline tickets for said percentiles.

The correlation of error terms is shown in Appendix F. The correlation between the error terms for the 'LnP10' and 'LnP90' model is found to be 0.2645. This, along with the Breusch-Pagan test's P-value, finds that error terms are correlated and running a Seemingly Unrelated Regression model is beneficial over running two separate pooled Ordinary Least Squares regressions.

Both coefficients for the 1-period-lag of the oil price are tested for equality. Results can be found in Appendix G. We reject the test of equal coefficients, and therefore – along with found results mentioned

[3] Again, the significant values found for 'distance' are small but positive ('LnP10' 0.0003885 and 'LnP90' 0.0004213). After rounding, the values are reported to be 0.000. Control variables are not meant to estimate a causal effect.

above – we find support for the second hypothesis. The effect of the oil price on the price of airline tickets is found to have a stronger effect on the lower segment of ticket prices than on the higher segment of ticket prices[4]. As robustness-check the model is also run for the 1st and 3rd quarter ('LnP25' and 'LnP75' respectively), as described in section four. The results are shown in Appendix H. The coefficients for β_1 are again found to be statistically significant and positive for the lower segment ('LnP25') and insignificant for the higher segment ('LnP75'), similar to the findings in the 'LnP10' and 'LnP90' model which was tested above. Appendix I shows that the correlation in error terms for the 'LnP25' and 'LnP75' model is found to be 0.6510. According to this result and the found Breusch-Pagan P-value the error terms are correlated. Running the Seemingly Unrelated Regression model has again been found beneficial over running two separate pooled Ordinary Least Squares regressions. However, the test of equal coefficients – found in Appendix J – cannot be rejected for the 'LnP25' and 'LnP75' model. There is insufficient evidence that the effect of the oil price is stronger in the 'LnP25' segment compared to the 'LnP75' segment.

[4] As the effect of the 1-period-lag of the oil price is insignificant in the 90th percentile of the prices of airline tickets, the 1-period-lag of the oil price has no effect on the 90th percentile of the prices of airline tickets. Therefore, the coefficient β_1 is 0 in the 'LnP90'-model. As the coefficient β_1 in the 'LnP10'-model is significant, the 1-period-lag of the oil price has an effect on the 10th percentile of prices of airline tickets. This means the effect is indeed stronger in the lower segment of ticket prices on a route than in the higher segment of ticket prices on a route. As a result, support has been found for hypothesis two.

VI. Conclusion

To test the research question *"What is the effect of the oil price on the price of airline tickets?"*, two hypotheses were tested.

Hypothesis 1: *"The effect of the oil price on the price of airline tickets is larger on competitive routes than on non-competitive routes."*

Hypothesis 2: *"The effect of the oil price on the price of airline tickets is larger in the lower segment of ticket prices on a route than in the higher segment of ticket prices on a route."*

Based on the results discussed in section five, the first hypothesis is rejected. The interaction effect is found to be insignificant, resulting in no different effect of the oil price being found between competitive and non-competitive routes. The interaction effect is also found to be insignificant for the 1-period-lag of the oil price.

Based on the results discussed in section five, support is found for the second hypothesis. As the 1-period-lag of the oil price is statistically significant in the 10^{th} percentile model, and statistically insignificant in the 90^{th} percentile model, changes in the 1-period-lag of the oil price have an effect on the 10^{th} percentile of prices of airline tickets but do not have an effect on the 90^{th} percentile of prices of airline tickets. After testing for equality of coefficients, there is sufficient evidence to believe there is an effect. Therefore, the effect is indeed stronger for the lower segment of ticket prices on a route than for the higher segment of ticket prices on a route; a 1 percent increase in the oil price, will lead to a 0.122% increase in the price of the 10 percent lowest prices of airline tickets in the next period. As a result, it seems consumers can anticipate a price change for the lower segment of ticket prices on a route; an increase in the oil price of this period will result in higher ticket prices next period, whereas a decrease in the oil price of this period will result in lower ticket prices in the following period. This implies that consumers can react to a change in the oil price of this period as it is possible to estimate the price of the ticket in the next quarter. Running the model for the 1^{st} and 3^{rd} quarter of prices of airline tickets as robustness test, the 1-period-lag of the oil price also appears positive and significant for the lower segment and the higher segment once more appears insignificant. However, after testing for equality of coefficients there seems to be insufficient evidence to conclude that the effect is larger for the 1^{st} quarter than for the 3^{rd} quarter of prices of airline tickets.

To reduce the omitted variable bias of the model several control variables were added. However, the existence of more variables that could influence the price of airline tickets is likely. Without adding these variables, a spurious correlation may exist. Therefore, it cannot be said with certainty that the found relationships are causal. As it is not sure if a causal relationship exists, no conclusive advice can be given with respect to the price of airline tickets.

To answer the research question *"What is the effect of the oil price on the price of airline tickets?"*, the oil price has been found to have no different effect between competitive routes and non-competitive routes. The oil price has also been found to have a stronger effect on the price of airline tickets in the next period for the lower segment of ticket prices than for the higher segment of ticket prices; a 1 percent increase in the oil price will lead to a 0.122% increase in the lower segment of prices of airline tickets in the next period and no effect on the higher segment of prices of airline tickets. However, there is not enough evidence to conclude the relationship is causal.

VII. Limitations and Discussion

This section aims to address limitations of this research and recommendations for future research.

The first limitation of this research is that it is not certain if the found effect is caused by a causal relationship. Therefore, no conclusive recommendations can be made to either consumers or airlines. Control variables ‘Average quarterly load factor’ and ‘Total available seat miles’ have been added to control for airline size. Variables ‘Competition’, ‘Distance’ and ‘$Distance^2$’ have been added to control for route characteristics. Additional control variables as ‘Cash’, ‘Assets’ or ‘Operating expenses’ could be added to control for financial soundness of airlines. However, as adding more control variables to the regression model may reduce the omitted variable bias, causality cannot be determined by adding more variables, as it is impossible to measure or select all possible independent variables that may have an effect on the dependent variable.

A second limitation may be the accuracy of the found results. The Adjusted R-squared values of the regressions lie between 0.5448 and 0.6452. Adding more meaningful variables will increase the Adjusted R-squared value. As these variables are more meaningful, the coefficients of the significant variables will be more accurate, resulting in better estimations of the effects.

Another limitation may be the selection of routes. The model examines 12 competitive routes and 12 non-competitive routes. After deleting observations with missing values, 3,445 observations are left. As routes can change from being competitive to non-competitive, or vice versa, through other airlines entering or exiting on that route, the number of competitive and non-competitive observations change for every observed quarter. Even though millions of tickets are examined to determine the prices used in the dataset, the dataset only contains a total of 24 routes – with corresponding airlines on those routes – for 84 quarters. Further research should focus solely on comparing the degree of competitiveness without first selecting routes on competitiveness in a certain year, as the degree of competitiveness is likely to change throughout the years. This will result in more observations for both competitive and non-competitive routes, making the results more accurate.

A recommendation for further research is including capacity constraints. Koopmans and Lieshout (2016) have found that pass-through of costs may be delayed when input costs change, especially when they decrease. This may also occur in the airline industry, as the airline industry is characterised by capacity constraints. Capacity of airlines on a route is limited by the size of aircraft and fixed well in advance through landing slots. In the short-term it is impossible to significantly increase or decrease capacity on a route. Further research may want to include the interaction effect between the oil price and capacity of a route on the price of tickets. However, as explained above it seems unlikely that a change in the oil price will directly lead to additional or less aircraft flying on a route.

Based on results found in this study, a recommendation for airlines is investigating the possibility of resale of airline tickets. As the oil price has been found to have an effect on the price of airline tickets in the next period, arbitrage opportunities may exist. However, under the current system, the resale of airline tickets is not (yet) possible. If airlines implement a system allowing consumers to 'sell back' their tickets in periods when oil prices rise, airlines could sell the tickets in the next period against a higher price, making a profit. This may be interesting for airlines, as airlines have lower margins they seek every increase in profits.

It should be noted, that even though the found coefficients of the effects appear to be very small, following The West Texas Intermediate oil price, fluctuations of 20% with respect to the previous quarter are not uncommon. Following the estimated coefficients, this would lead to a 2.5% increase in the price of the 10 percent lowest prices of airline tickets in the next period. Economically, this is a significant effect.

It should also be noted that the results found in this study may not be applicable to other countries. The model is only tested for domestic flights in the United States. If this research is to be duplicated for different countries, international flights or international airlines, the effect of exchange rate volatility and exchange rate pass-through should be considered.

Based on results found in this study, another recommendation for further research is to expand the number of the lagged periods. As stated in the introduction, the proportion of oil and jet fuel costs are on average 33.4%. Therefore, the total effect of the oil price is expected to be at least 0.3% on the price of airline tickets for every 1% increase in the oil price. However, the effect only appears in the lower segment, and is only found to be 0.122%. As a result, it is evident that airlines use price smoothing, spreading the effect over more than 1 quarter. Further research should focus on more than one quarter; examining the 2-period-lag, 3-period-lag etc., until the full effect is estimated. Further research should give more insight in the time span needed before the full effect is passed through in the ticket price, especially as this study has shown the effect does not hold for all ticket segments.

Another limitation to this research is the fluctuation in trends over the examined period. This study examines the period between 1993 and 2014. All found effects are averages over this period. In Appendix A various trends are visible; more-or-less constant jet fuel prices between 1993-1997, 2011-2014 and rising jet fuel prices between 2004-2008, 2009-2011. If further research examines these periods separately, the full effect may be determined.

Finally, it should be noted that technological increases have occurred between 1993 and 2014. In the period of relatively constant jet fuel prices 1993-1997 airline tickets were purchased through travel agencies at with nominal price rigidity through menu costs (Sheshinski & Weiss, 1977). However, during the period of relatively constant jet fuel prices in 2011-2014 dynamic pricing techniques were used. Further research may want to examine these two periods to estimate the effect of dynamic pricing on the price of airline tickets. Further research may also want to shorten the time span examined in this study. By doing this, the effect is estimated more accurately as dynamic pricing is now used during the entire period.

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IX. Appendices

Appendix A:

Figure 1 Historical jet fuel prices in U.S. dollars per Gallon in the last 25 years (Index Mundi, 2018). Jet fuel prices fluctuate largely, affecting an airline's profits.

Appendix B:

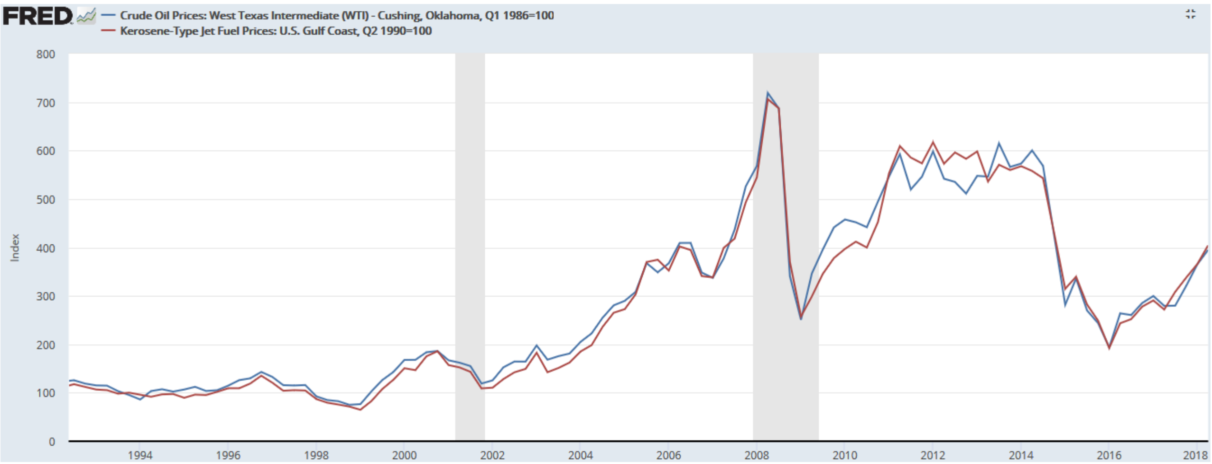

Figure 2 Jetfuel (Red line) and West Texas Intermediate oil price (Blue line) seem to be near perfectly correlated (U.S. Energy Information Administration, 2018)

Appendix C:

Competitive	**Non-competitive**
ATL – JFK	ACY – MCO
ATL – LAX	ATL – BNA
ATL – ORD	ATL – CHS
JFK – ATL	ATL -CVG
JFK – LAX	ATL – MEM
JFK – ORD	ATL – ORF
LAX – ATL	ATL – SDF
LAX – JFK	BNA – STL
LAX – ORD	CVG – SFB
ORD – ATL	MCI – BNA
ORD – JFK	MCI – STL
ORD – LAX	PHL - PIT

Table 1 Competitive (left) and non-competitive (right) routes used to test the first and second hypotheses. The competitive routes are Hartsfield-Jackson Atlanta International Airport (ATL), New York John F. Kennedy International Airport (JFK), Los Angeles International Airport (LAX) and Chicago O'Hare International Airport (ORD). The non-competitive routes are Atlantic City International Airport (ACY) – Orlando International Airport (MCO), Hartsfield-Jackson Atlanta International Airport (ATL) – Nashville International Airport (BNA), Hartsfield-Jackson Atlanta International Airport (ATL) – Charleston International Airport (CHS), Hartsfield-Jackson Atlanta International Airport (ATL) – Cincinnati/Northern Kentucky International Airport (CVG), Hartsfield-Jackson Atlanta International Airport (ATL) – Memphis International Airport (MEM), Hartsfield-Jackson Atlanta International Airport (ATL) – Norfolk International Airport (ORF), Hartsfield-Jackson Atlanta International Airport (ATL) – Louisville International Airport (SDF), Nashville International Airport (BNA) – Lambert-St. Louis International Airport (STL), Cincinnati/Northern Kentucky International Airport (CVG) – Orlando Sanford International Airport (SFB), Kansas City International Airport (MCI) – Nashville International Airport (BNA), Kansas City International Airport (MCI) – Lambert-St. Louis International Airport (STL) and Philadelphia International Airport (PHL) – Pittsburgh International Airport (PIT).

Appendix D:

Pooled Ordinary Least Squares regression on the 50th percentile of prices of airline tickets (LnP50)				
Variable	Coefficient	Standard Error	T-statistic	P-value
Constant	0.719	0.130	5.55	0.000
Ln(Oil price$_{t-1}$)	0.056	0.032	1.78	0.075
Ln(Oil price$_t$)	0.083	0.033	2.50	0.013
x Competition$_{ijt}$	0.001	0.015	0.07	0.948
Average quarterly load factor$_{ijt}$	0.136	0.049	2.75	0.006
Ln(Total available seat miles$_{ijt}$)	0.151	0.005	30.61	0.000
Competition$_{ijt}$	-0.188	0.056	-3.33	0.001
distance$_{ij}$	0.000	0.000	2.17	0.030
distance$_{ij}^2$	0.000	0.000	7.44	0.000
Number of observations: 3,444				

Table 2 Pooled Ordinary Least Squares regression on the 50th percentile of prices of airline tickets ('LnP50'). 'x Competition$_{ijt}$ denotes the interaction effect of the variable 'Ln(Oil price$_t$)' with 'Competition$_{ijt}$'. Adjusted R-squared 0.5448. Coefficients and standard errors are rounded to three decimals.

Appendix E:

Seemingly Unrelated Regression for the 10th and 90th percentile of prices of airline tickets ('LnP10' and 'LnP90')				
Variable	Coefficient	Standard Error	Z-statistic	P-value
LnP10				
Constant	1.156	0.133	8.67	0.000
Ln(Oil price$_{t-1}$)	0.122	0.032	3.74	0.000
Ln(Oil price$_t$)	0.050	0.034	1.47	0.141
x Competition$_{ijt}$	-0.029	0.015	-1.76	0.079
Average quarterly load factor$_{ijt}$	0.022	0.051	0.44	0.659
Ln(Total available seat miles$_{ijt}$)	0.095	0.005	18.79	0.000
Competition$_{ijt}$	-0.029	0.058	-0.50	0.618
distance$_{ij}$	0.000	0.000	11.94	0.000
distance$_{ij}^2$	0.000	0.000	-1.31	0.191
LnP90				
Constant	-0.137	0.150	-0.91	0.361
Ln(Oil price$_{t-1}$)	0.014	0.037	0.38	0.706
Ln(Oil price$_t$)	0.005	0.039	0.13	0.898
x Competition$_{ijt}$	0.005	0.017	0.31	0.755
Average quarterly load factor$_{ijt}$	-0.145	0.057	-2.55	0.011
Ln(Total available seat miles$_{ijt}$)	0.230	0.006	40.14	0.000
Competition$_{ijt}$	-0.140	0.065	-2.14	0.032
distance$_{ij}$	0.000	0.000	11.50	0.000
distance$_{ij}^2$	0.000	0.000	1.41	0.158

Table 3 Seemingly Unrelated Regression for the 10th and 90th percentile of prices of airline tickets ('LnP10' and 'LnP90'). The adjusted R-squared is 0.5558 for the equation of 'LnP10' and 0.6452 for the equation of 'LnP90'. Coefficients and standard errors are rounded to three decimals. Number of observations is 3,444 for both equations.

Appendix F:

Correlation of error terms	
Correlation error terms 'LnP10' and 'LnP90'	0.2645
Value Chi^2	240.887
P-value	0.000

Table 4 Correlation of error terms for the Seemingly Unrelated Regression for equations 'LnP10' and 'LnP90'.

Appendix G:

Test of equality of coefficients	
Value Chi^2	6.58
P-value	0.010

Table 5 Test of equality of coefficients for the 1-period-lag of the oil price in the Seemingly Unrelated Regression for equations 'LnP10' and 'LnP90'. We can reject the hypothesis of equal coefficients at a 5% significance level.

Appendix H:

Seemingly Unrelated Regression for the 1st and 3rd quarter of prices of airline tickets ('LnP25' and 'LnP75')				
Variable	Coefficient	Standard Error	Z-statistic	P-value
LnP25				
Constant	1.090	0.116	9.35	0.000
Ln(Oil price$_{t-1}$)	0.082	0.028	2.88	0.004
Ln(Oil price$_t$)	0.118	0.030	3.94	0.000
x Competition$_{ijt}$	-0.053	0.014	-3.94	0.000
Average quarterly load factor$_{ijt}$	0.008	0.044	0.17	0.863
Ln(Total available seat miles$_{ijt}$)	0.112	0.004	25.22	0.000
Competition$_{ijt}$	0.019	0.051	0.38	0.705
distance$_{ij}$	0.000	0.000	8.10	0.000
distance$_{ij}^2$	0.000	0.000	3.32	0.001
LnP75				
Constant	0.250	0.149	1.67	0.095
Ln(Oil price$_{t-1}$)	0.046	0.036	1.27	0.203
Ln(Oil price$_t$)	0.013	0.038	0.33	0.740
x Competition$_{ijt}$	0.013	0.017	0.77	0.442
Average quarterly load factor$_{ijt}$	-0.104	0.057	-1.83	0.067
Ln(Total available seat miles$_{ijt}$)	0.200	0.006	35.14	0.000
Competition$_{ijt}$	-0.241	0.065	-3.70	0.000
distance$_{ij}$	0.000	0.000	7.33	0.000
distance$_{ij}^2$	0.000	0.000	3.38	0.001

Table 6 Seemingly Unrelated Regression on the 1st and 3rd quarter of prices of airline tickets ('LnP25' and 'LnP75') as robustness-check. The adjusted R-squared is 0.5963 for the equation of 'LnP25' and 0.5565 for the equation of 'LnP75'. Coefficients and standard errors are rounded to three decimals. Number of observations is 3,444 for both equations.

Appendix I:

Correlation of error terms	
Correlation error terms 'LnP25' and 'LnP75'	0.6510
Value Chi^2	1,459.794
P-value	0.000

Table 7 Correlation of error terms for the Seemingly Unrelated Regression for equations 'LnP25' and 'LnP75'.

Appendix J:

Test of equality of coefficients	
Value Chi^2	1.60
P-value	0.207

Table 8 Test of equality of coefficients for the 1-period-lag of the oil price in the Seemingly Unrelated Regression for equations 'LnP25' and 'LnP75'. We cannot reject the hypothesis of equal coefficients at a 5% significance level.