Impact of the entry/exit and presence of low-cost carriers (LCC) in the US airline network.

MSc Thesis

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Spatial transport and environmental economics
Vrije Universiteit Amsterdam

2023/2024

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Preface

This thesis was done as part of the master program Spatial, Transport and Environmental Economics at the Vrije Universiteit in Amsterdam. The thesis is a compulsory part in order to graduate from the master. This thesis was on the topic of fare competition due to entry/exit and presence of LCC's in the US air network. During the thesis I managed to handle large amount of data by efficiently processing the data. I also developed my skills in working with the statistical software STATA, by implementing an econometric model and to improve the results. For a research project, a critical mindset is necessary to have results that matter. This was also the case during this thesis project. In the end I managed to carry out a very beautiful project, sometimes very frustrating, but when you manage to solve problems, then you feel that you have achieved something.

I would like to thank my supervisor, dr. Vincent van den Berg for his kind support during this thesis period. He gave me feedback on my work, which was very valuable to improve the research, both in person and also by e-mail. During this master I also received courses in which many methods were discussed, which were very useful to apply during this thesis. In some of the courses, dr. Vincent van den Berg was also involved.

Finally, I would like to say that this thesis period was very enjoyable, and I learned a lot. This also marks the end of my master education at the Vrije Universiteit in Amsterdam.

Enjoy reading this report.

Bobby Kartoidjojo

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Abbreviations

2SLS Two stage least squares
AWA Airline within airline
BTS Bureau of Transportation Statistics
FE Fixed effects
FSC Full-service carrier
IATA International Air Transport Association
IV Instrument variable
LCC Low-cost carrier
MIN Minimum
MAX Maximum
MRQ Main-research-question
N number of observations
OLS Ordinary Least-Squares
Sd standard deviation
SRQ Sub research-question
ULCC Ultra-low-cost carrier
USA United States of America

Contents

1 Introduction

During this chapter, the research has been defined by first providing a background of this research and then the research questions has been defined and finally the structure of this report has been provided.

1.1 Background and motivation of this research

When the Airline and Deregulation Act was passed in 1978 in the USA, more market freedom was allowed in the airline market. This Act holds that more market access was allowed, flying was allowed between foreign areas and US ground (5th freedom of flying right), capacity constraints was removed, and airlines could set their own fares based on economic constraints. This led to legacy airlines to restructure their network towards the known hub-and-spoke network that is known nowadays (Ison, 2017). Due to the Act, more competition was allowed, and new airlines could enter to new markets or already existing markets with their own business models. As a result of the Act, a new type of airline emerged, the low-cost-carrier, which was pioneered by Southwest Airlines in and was characterized of its flight only product with no extra services. Extra services could be obtained by paying for it. Passenger demand grew and intra state travelling was now possible (Ison, 2017).

Recently, new type of airlines have emerged besides the LCC's and FSC's, namely ULCC's and hybrid airlines. The hybrid airlines are LCC's, but have implemented characteristics of FSC's, such as Alaska and JetBlue airlines who are low-cost airlines but offer also long-haul flights. The other newly emerged airline is the ULCC, which characterizes by lower based fares compared to LCC's, but also charges passengers who would like to have extra services (Bachwich & Wittman, 2017).

Considering the US airline market, competition happens between the four types of carriers. In this research only LCC and FSC's are considered. To make analysis easier, the ULCC's and hybrids are seen as LCC's. The competition has effect on several aspects, most notably fares as will be seen later during the literature review in chapter 3. The most occurring result from the literature is that when LCC's enter or are present on a route or at an airport, the average fare decreases. The competition was analysed for between the airline types LCC's and FSC's in the literature. To the authors "best knowledge" of this research, the entry and exit effects on fares of LCC's on routes where only LCC's operate has not been analysed before. This gap has been filled in this research. This gap is based on the literature review of chapter 3. Furthermore, also FSC's have been considered during this research to make comparison in competition between the airline types.

1.2 Research goal and research questions

The research goal of this research is to provide empirical evidence when LCC's enter or exits routes on which only LCC's operate. Based on this goal, the following research questions has been defined.

Main research question (MRQ):

> "What is the impact of the entry and exit of a LCC on routes where only LCC's operate "

Sub-research questions (SRQ):

1) Which type of competition exists between different type of airlines?
   This research question is necessary to:
   - become familiar with different types of airlines
   - understand the motivation of market entry
   - understand what the effects are of entry/presence of airlines
   - get familiar with different analysis methods
   - define a research gap

2) Which are relevant attributes for competition between LCC's?
   During this research question, different factors that influence competition between airlines are explored and afterwards the attributes that are relevant for the analysis are determined during this sub-research question.

3) What are the effects of the competition between LCC's based on relevant attributes?
   During this sub-research question, the competition between LCC's is analysed and the effects of the attributes is discussed during this sub-research question.

1.3 Report structure

Below, the different chapters are discussed shortly, and a research flow has been depicted.

Chapter 2 Methodology
In this chapter, the methodology has been described, which is necessary to answer the main-research question. During this section, the different methods applied for the three sub-questions has been discussed.

Chapter 3 Literature review
In this chapter, the literature review has been carried out, to identify the research gap and to identify relevant variables that will be needed for the third research question.

Chapter 4 Price competition analysis
In this chapter, the actual analysis has been carried out, giving answer to the third research question with inputs from the literature review.

Chapter 5 Conclusion
During this chapter, the main research question has been answered and limitations that had to deal with during this research has been mentioned as well.

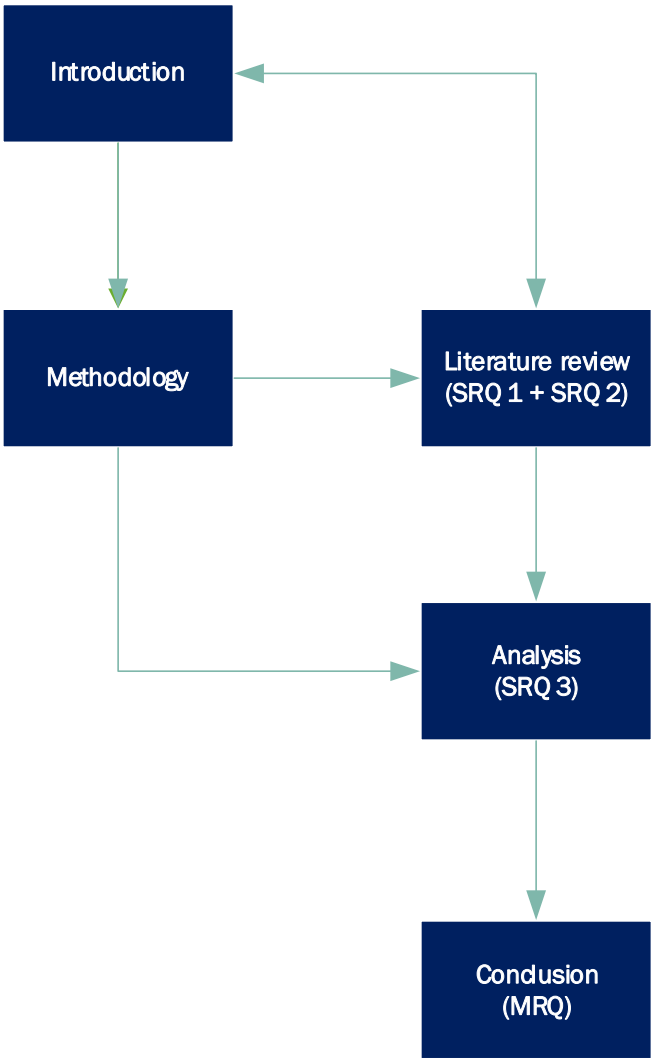

Figure 1 Research flow.

2 Methodology

In this chapter, the method to answer the sub-research questions has been discussed. This chapter first discusses the method to answer the first two sub-research questions, namely the literature review. Then the method to answer the third research question has been discussed. In between, the data source has been discussed that will be used for the analysis part.

To answer the main-research question, several sub-questions were formulated. Each sub-research-question has a suitable method, indicated in table 1. In chapter 3, sub-research question 1 and 2 are answered and in chapter 4, sub-research question 3 is answered and finally in chapter 5, the main-research question has been answered.

Table 1 Sub-research questions and methods

	Sub-research question (SRQ)	Method
1	Which type of competition exists between different type of airlines?	**Literature review**
2	Which are relevant attributes for competition between LCC's?	Literature review
3	What are the effects of the competition between LCC's based on relevant attributes?	**Regression analysis**

2.1 Literature review

The first two sub-research questions (SRQ) are answered through doing a literature review. Important for the literature review is the method of finding relevant literature. The literature in the field of competition between airlines is huge and so the literature search should be scoped to specific keywords. In table 1, the concept group, keywords and truncations are shown. Concept group is the more general themes with keywords specifying the direction. Truncations are combinations between keywords, which are formed by using logical operators such as "AND", "OR".

Table 2 Literature search method

Concept group	Airline type, competition factor
Keywords	Airline type: LCC, low-cost-carrier, ULCC, ultra-low-cost-carrier, FSC, full-service carrier Competition factor: competition, price, frequency, quality
Truncations	(Competition OR price) AND (LCC OR low-cost-carrier)

For the first SRQ, a general literature review has been carried out, to get familiar with the different type of carriers, the type of competition possible between these different types of carriers and what the effect is of these competition on aspects such as price and frequency.

For the second SRQ, a more specific literature review has been carried out, with the aim of identifying factors to include for the regression analysis and obtain inspiration of how to do the

regression analysis. These factors are necessary because they can have influence on the outcome of the regression analysis. The ideal case would be that factors are chosen that describe the data best.

The list of literature is exhaustive, meaning that there is a lot of literature available, each addressing a specific topic. There might be overlap in aspects, but each have a different research problem/research gap, that they have filled. It is not possible to review all the literature, and so it might be that when the research gap has been defined in this research, that there is literature that has not been reviewed in this research and so it might be that the research gap is not fully a gap, that is why the terms “till the authors knowledge” has been mentioned.

2.2 Data source and processing

In this section, the relevant data source has been discussed as well processing the data, to prepare the data for the regression analysis.

2.2.1 Data source

To be able to do the analysis, data on routes is necessary for the US airline network. In the USA, information on airlines is available for free as opposed to for example the European airline data where a high amount must be paid to obtain the dataset. The US airline data can be obtained through the website of the Bureau of Transportation Statistics (BTS). Considering fares data, only quarterly data is available. There are three versions of the fares data:

1) “DB1BCoupon”: this dataset is focused on coupon-specific information
2) “DB1BMarket”: this dataset provides itinerary directional information
3) “DB1BTicket”: this dataset is more of a summary dataset of each itinerary

The latter two versions of the fare dataset are more suitable, since only non-stop itineraries are considered. Difference is that the market data (DB1BMarket) contains more variables including both origin and destination airport, whereas the ticket data set (DB1BTicket), only has the origin airport mentioned besides other variables. The most suitable data source is the market data, which are called “Airline Origin and Destination Survey (DB1BMarket). This consists of variables such as origin airport, destination airport, number of passengers transported and other variables. The dataset is available per quarter, but with different prices for different itineraries per quarter. A part of the dataset with a few columns is shown in figure 2.

	Year	Quarter	Origin	Dest	RPCarrier	Passengers	MktDistance	MktFare
0	2023	1	SJU	MYR	NK	1.0	2412.0	176.5
1	2023	1	MYR	DTW	NK	4.0	636.0	6.0
2	2023	1	MYR	DTW	NK	2.0	636.0	15.0
3	2023	1	MYR	DTW	NK	1.0	636.0	16.0
4	2023	1	MYR	DTW	NK	5.0	636.0	17.0
5	2023	1	MYR	DTW	NK	3.0	636.0	20.0
6	2023	1	MYR	DTW	NK	4.0	636.0	26.0
7	2023	1	MYR	DTW	NK	20.0	636.0	27.0
8	2023	1	MYR	DTW	NK	26.0	636.0	28.0
9	2023	1	MYR	DTW	NK	1.0	636.0	32.0

Figure 2 DB1BMarket dataset

For the analysis, the LCC's indicated in the table below are considered. These are mentioned in the dataset based on the International Air Transport Association (IATA) codes. Only the airlines that are still in operation are considered. Information on when the airlines started operations has been retrieved from several sources, such as ICAO.

Table 3 LCC's still in operation in the USA

	Airline	IATA Code	Started operations
1	Aha! (ExpressJet Airlines)	EV	2021
2	Air Trans Airways	FL	1992
3	Allegiant Air	G4	1998
4	Avelo	XP	2020
5	Breeze Airways	MX	2018
6	Frontier Airlines	F9	1994
7	JetBlue Airways	B6	1998
8	Southwest Airlines	WN	1967
9	Spirit Airlines	NK	1980
10	Sun Country Airlines	SY	1982
11	ViaAir	VC	2015
12	Virgin America	VX	2007

2.2.2 Data processing

The dataset contains around six million observations for each quarter, with all types of airlines included such as LCC, FSC, hybrid and ULCC's, the name of the airlines and all origin destination pairs. To prepare the dataset for the analysis, the following data processing steps has been taken:

1) Collect data on the origin destination (OD) markets including the name of the carriers. Through the name of the carrier, the carrier can be categorized in the type of carrier namely LCC or FSC. Earlier was mentioned that hybrid and ULCC's are seen as LCC in this research.
2) Itineraries are excluded:
   - On which no airline operates
   - Which have fare lowers than 25 and higher than 1000.
   - Which have more than one coupon. If a coupon is one, then a person takes only one flight to reach its destination.
3) Group the airlines by OD pairs. So, an overview of OD-pairs is obtained including the airlines that serve these pairs. During the grouping, the following variables has been aggregated:
   - Fare: the mean of the fair of each od-pair
   - Passengers: the sum of the number of the passengers of each od-pair
   - Airlines: the airlines operating on the route have been grouped in the od-pair
4) Step 1 till 3 has done for each quarterly dataset. In this step, all the processed quarterly datasets have been grouped together and one large dataset consisting of several quarters was obtained.

This data processing is done by using the programming language Python in the online environment Jupiter. This data collection and processing method is a very computer intensive process considering runtime.

2.3 Econometrics methods and theory

Most of the literature have used econometric methods especially regression techniques to address the problem (Daraban & Fournier, 2008; Hüschelrath & Müller, 2013; Wittman & Swelbar, 2013). Some of the literature such as Britto et al. (2012); Fu et al. (2006); Valido et al. (2020) have used economic methods to address their research. But the availability and quality of the relevant data, can also have impact on the method applied and the purpose of the research.

For this research, regression methods will be applied since panel data is available on which a regression analysis is the most suitable form of method applicable to this data type. The reason for applying a regression method is because, the goal is to explore competition between only LCC's and between both LCC's and FSC's and eventually the competition effect on fare. So, a relationship should be established between fare and relevant indicators defining the competition. There are several types of panel regression methods possible with the most used, pooled ordinary-least squares regression (OLS), OLS with fixed effects (FE) and control variables, instrumental variable estimations (IV) and IV estimations with FE's, called two stages least squares regression (TSLS). In these regressions one or more variables are used, known as regressors, fixed effects and control variables. The choice for these variables in this research is based on a literature review, which has been done in chapter 3. The several regression models are shortly discussed below. The knowledge that has been used in sections 2.3.1, 2.3.2 and 2.3.3 has all been retrieved from the book of Stock and Watson (2020).

2.3.1 Ordinary least squares estimation (OLS)

This is the simplest form of regression. The OLS can be performed by using one regressor or multiple regressors. This type of regression establishes a linear relationship between the regressor X and the outcome Y. β_0 is the intercept and β_1 is the slope of the linear relationship. Y is the dependent variable, the outcome and X is the independent variable, the regressor. The β_1 indicates a difference in Y when X changes with a unit. ε_{it} is the error term, which is the difference between the actual value Y and the predicted value.

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \varepsilon_{it} \ (1)$$

There are three assumptions that the OLS should hold:

1. The conditional distribution of the error term ε_{it} given that the regressor X_{it} has a mean of zero $E[\varepsilon_{it}|X_{it}] = 0$.
2. The observations (X_{it}, Y_{it}) are i.i.d (independently and identically distributed), meaning that they are randomly drawn from a population.
3. Outliers of the observations should not be likely.

When all three assumptions hold, then the estimator $\widehat{\beta_1}$ is consistent and unbiased (have sampling distributions that are normal when the sample is large). Sometimes there is omitted variable bias, meaning that there is a variable which is correlated to the regressor X, captured in the error term and is a determinant of the dependent variable Y. Due to this, the estimator is biased and not consistent.

Adding more regressors to equation 1 is possible, calling it a multiple regression model. Besides the three assumptions for a single regression model, a fourth assumption should hold now for the multiple regression model:

4. No perfect multicollinearity, meaning that one of the regressors does not forms a perfect linear function with another regressor.

2.3.2 Fixed effects regression

In section 2.3.1, omitted variable bias was mentioned. To deal with this, the fixed effects regression is suitable. For the fixed effects regression two versions are possible, time variant FE regression and time invariant FE regression.

Time invariant FE regression
The time invariant FE regression holds that the omitted variable varies across entities (observations) but stays constant over time. The general equation to include time invariant fixed effects is shown below, equation 2. In this equation, the Z_i is the fixed effect, which is an unobserved factor, that varies across entities, but not over time. In aviation, this could be route specific fixed effects, meaning that the fixed effect takes variation into account considering route characteristics across the routes, but route characteristics stays constant across time. These fixed effects can be used when there are two or more-time observations of each entity. The fixed effect Z can be a binary or continuous variable.

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Z_i + \varepsilon_{it} \quad (2)$$

Equation 2 can also be written as

$$Y_{it} = \beta_1 X_{it} + \alpha_i + \varepsilon_{it}$$

With α_i being the entity fixed effect.

Time variant FE regression
Besides the time in-variant fixed effects, there is also the possibility to include fixed effects that vary over time but stays constant across entity.

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 S_t + \varepsilon_{it} \quad (3)$$

Equation 3 can also be written as

$$Y_{it} = \beta_1 X_{it} + \gamma_i + \varepsilon_{it}$$

With γ_i being the time fixed effect.
Both time and entity FE regression
It could be that the omitted variable, varies across entities, but also over time, then it is suitable to include both time and entity fixed effects, leading to equation 4.

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Z_i + \beta_2 S_t + \varepsilon_{it} \quad (4)$$

Equation 4 can also be written as

$$Y_{it} = \beta_1 X_{it} + \alpha_i + \gamma_i + \varepsilon_{it}$$

For the FE regression, the same four assumptions as for the multiple OLS regression should hold.

2.3.3 IV estimations

The OLS regression method is to establish causal relationship, explaining the outcome Y in terms of the regressor X, so the regression is from X to Y. Sometimes it is possible that there is also a relationship from Y to X, reverse causality, two-way causality. In 2.3.1, omitted variable bias was mentioned, when the error term is correlated with the regressor and is a determinant to the dependent variable Y. To be able to account for simultaneous causality bias and omitted variable bias, the instrument variable method is suitable. This is a method in which an instrument, extra variable is used, to get better estimations. Without the instrument, the regressor X is correlated with the error term. The part of X that is not correlated with the error term, can be explained by an additional variable, the instrument. The instrument thus isolates the part of X that is uncorrelated with the error term. There are two important variables when discussing IV estimations. Endogenous variables are variables that are correlated with the error term and exogeneous variables are variables that are not correlated with the error term, and which are the instruments. The important question is whether the instrument is valid. There are two conditions for this:

1) The instrument should be relevant, meaning that the instrument is correlated with the regressor X.
2) The instrument should be exogenous, meaning that the instrument is not correlated with the error term.

When a relevant and exogenous variable has been found, instrument, the coefficients can be estimated through the method called two stage-least squares regression (TSLS), which is done in two steps.

Base equation

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \varepsilon_{it} \ (5)$$

Step 1 (the X and instrument Z are linked):

$$X_{it} = \pi_0 + \pi_1 Z_{ij} + \nu_{ij} \ (6)$$

To estimate this equation, OLS is used, and the predictions are:

$$\widehat{X_{\iota J}} = \widehat{\pi_0} + \widehat{\pi_1} Z_{ij} \ (7)$$

Step 2 (The predictions are used to predict the outcome Y):

$$Y_{it} = \widehat{\beta_0^{TSLS}} + \widehat{\beta_1^{TSLS}} \, \widehat{X_{\iota J}} + \varepsilon_{it} \ (8)$$

And from this equation the predictions of Y are obtained. This instrument variable (IV) method should lead to better estimations. For the IV estimation, there should be exactly one instrument for the regressor or more instruments, but not less. In the general IV equation, regressors, both endogenous as exogenous can be used. The exogeneous regressors can also be seen as control variables, indicated with W. These are included to ensure that the error term is not correlated with the instruments, in other words, the controls ensure that variables that would otherwise cause correlation, are kept constant to ensure that there is no correlation. In a normal regression, when omitting the controls, then the regression can suffer from omitted variable bias. According to Stock and Watson (2020), the controls are generally biased and have no causal interpretation. The control variables can be included as regressors in a model. During the first stage and second stage of the TSLS, the W's should also be included.

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 W_{it} + \varepsilon_{it} \quad (5)$$

The IV estimation has four assumptions:

1) Error term should not be correlated with the exogeneous/control variables.
2) The regressors, endogenous and exogenous/control variables should be i.i.d., drawn randomly from a joint distribution.
3) Large outliers should be unlikely.
4) Instruments should be relevant and exogenous. When there is a single endogenous regressor, a first stage F-statistic less than 10 means that the instrument is weak and TSLS estimator is biased.

When all these four assumptions hold, the estimators are consistent, but biased. The IV estimation, by using TSLS, can be extended by including FE's as well to account for the panel structure of panel data.

3 Literature review

In this chapter, the research gap has been identified based on a comprehensive literature review considering competition in which LCC's are involved. The business models of FSC, LCC and partly of ULCC's has been discussed first to get an indication of characteristics of the three types of airlines. Then literature in which LCC's are involved has been reviewed. Furthermore, also literature has been reviewed considering methods to see how other research have done their analysis. At every section, the respective literature has been mentioned in a table that has been used to discuss the relevant topic.

3.1 Business models of FSCs, LCCs

Table 4 Literature on business models

Airline type	Literature
LCC	Alamdari and Fagan (2005); Bachwich and Wittman (2017); Bitzan and Peoples (2016); Camilleri (2018); Holloway (2016); O'Connell and Williams (2005); Wittman and Swelbar (2013)
FSC	Bachwich and Wittman (2017); Bitzan and Peoples (2016); Camilleri (2018); Holloway (2016); Hunter (2006); O'Connell and Williams (2005)
ULCC	Bachwich and Wittman (2017); Wittman and Swelbar (2013)

Differences in business models between LCC's and FSC's

Holloway (2016); O'Connell and Williams (2005) mentioned several differences between LCC's and FSC's. LCC's operate mostly from secondary airports with a point-to-point network while FSC's operate from premium airports with a hub-and-spoke network. The LCC's offers only a flight, but if a passengers would like to have extra service, they must pay for the extra's (unbundled products), while many extras are already included in the price of the FSC's, but nowadays the FSC's started to offer more unbundled products. Based on the network structure of the LCC and FSC, the schedule of the LCC is more reliable, considering punctuality because of its simple network structure, while the complex network structure of the FSC makes this airline type much less reliable. Considering labour circumstances, the workforce of LCC's are flexible and more intensive, while those of FSC's have more constraints. Another known difference is that LCC's have a standardized fleet, meaning that the fleet consists of mostly one type of airline such that extra training for personal to work on other type of airplanes is avoided. The FSC's on the other hand have a variety of airplanes in their fleet for different markets.

Costs

Considering costs, the LCC's follow a different strategy than the FSC's (Alamdari & Fagan, 2005). The original strategy as pioneered by Southwest airlines was the cost leadership strategy, which means that the airlines try to produce at the lowest possible cost in the market. This can be achieved by offering a core product, a flight only, and making customers pay if they want extra services. The strategy that has emerged recently is the differentiated strategy, meaning that airlines try to offer products that are different from other airlines and so they can ask higher prices for the products.

Alamdari and Fagan (2005) also mentioned that when wanting to increase the profit margins, following the cost leadership strategy is better than the differentiated strategy.

There are three type of costs involved (Camilleri, 2018). Direct operating costs, related to the aircraft, indirect operating cost, related to the season of flying and overhead costs related to personal and properties. Since FSC's follow a differentiated strategy and have a hub-and-spoke network, their overhead costs are high(Hunter, 2006). Through forming alliances, the overhead costs are shared. FSC's have a cost advantage because of the hub-and-spoke network such as larger airplanes, higher frequency and load factors (Bitzan & Peoples, 2016). On the other hand LCC's save on costs through also their point-to-point network structure, standardized fleet, flexible workforce and operating from less congested airports (Bitzan & Peoples, 2016; Camilleri, 2018; Wittman & Swelbar, 2013).

Convergence in business models
Nowadays convergence happens in business models between LCC's and FSC's (Tsoukalas et al., 2008). This holds that LCC's implement characteristics of FSC's such as offering long-haul flights by the LCC JetBlue, or FSC's offering unbundled products such as paying for extra luggage. One of the airlines, Alaska airlines offer also long-haul flights, and these are the so-called hybrid airlines. Because of the competition between FSC's and LCC's, the FSC's have set up a low-cost variant to compete with the LCC's (Hunter, 2006), which is more the case in Europe than in the USA. In the USA the FSC's own a subsidiary airline, to serve as a regional airline rather than a low-cost airline. Due to the competition between FSC's and LCC's another airline type has emerged, the ultra-low-cost carriers (ULCC) such as Spirit Airlines, Frontier airlines and Allegiant air. They have lower base fares and lower costs compared to the LCC's and offer also unbundled products (Bachwich & Wittman, 2017).

3.2 Competition in which LCC's are involved.

Competition in which LCC's are involved is discussed in this section. Competition in this section is defined as the entry/presence in a market in which LCC's are already present or not and competes with the other airlines in the market. Competition can have influence on for example price and frequency as will be clear in this section. First a section on motivation for market entry has been discussed and afterwards the effects of competition has been discussed.

3.2.1 Motivation for market entry

Table 5 Literature on market entry motivation

Aspect of entry	Literature
Motivation for market entry	Alderighi et al. (2004); Hüschelrath and Müller (2013)

There are two reasons why airlines would want to enter a market (Hüschelrath & Müller, 2013). Airline can choose to implement characteristics of other airlines to improve services and thus removing profits from incumbent airlines (imitative entry). The airline can also choose to innovate, by offering new products or services (innovative entry). The entry can be studied by four indicators, market yield, number of passengers, number of departures and number of seats (Hüschelrath & Müller, 2013). Market yield was already studied by Alderighi et al. (2004), in which two types of yield management (maximizing revenue) was discussed, namely the traditional yield management used by FSC's and the simplified yield management used by LCC's. Essentially, the traditional yield

management is optimizing revenue based on the segmented market of the FSC's. The simplified yield management is in its core a market which is not segmented, and so non-differentiated products are offered, opposed to the traditional yield management in which differentiated products are offered based on a segmented market. The airlines can also choose the type of market they enter, a monopoly market in which one firm is present, an oligopoly market without LCC's, but with FSC's, or an oligopoly market with LCC's and/or FSC's (Hüschelrath & Müller, 2013). So, entering a market involves many decisions to be made by the airlines that would like to enter.

3.2.2 Competition effects

Table 6 Literature on competition

Competition type	Literature
Entry	Aydemir (2012); Brueckner et al. (2013); Goolsbee and Syverson (2008); Hüschelrath and Müller (2013); Morrison (2001); Valido et al. (2020)
Presence	Bendinelli et al. (2016); Bilotkach and Lakew (2014); Britto et al. (2012); Fu et al. (2006); Hofer et al. (2008); Kwoka et al. (2016); Wittman and Swelbar (2013)

Competition due to entry

Before an airline enters a market, the incumbent FSC airlines can choose to deter entry or accommodate entry to LCC's. Valido et al. (2020) did research to see till what degree the level of frequency should be increased in order to deter entry. Valido et al. (2020) showed that entry can be deterred when the FSC increase frequency or when the capacity at the airport is too low. On the other hand, when capacity is high enough, entry can be accommodated. Goolsbee and Syverson (2008) showed that the FSC's lowered the prices before the LCC Southwest enters the market and due to the lowered prices, the number of passengers has increased. In Aydemir (2012), the threat of entry of the LCC AirTran in a market where both LCC (Southwest) and six FSC's were present, was analysed and Aydemir (2012) showed that the airfares of the FSC's decreased and that of the LCC's increased. When AirTran actually flew, the FSC airfares decreased further and that of LCC's stayed approximately the same.

Evaluating the entry effect can be also be done on airport level besides on route level as was done by Dresner et al. (2017). When the LCC Southwest entered an airport, the yield (average price per mile) did not only decrease on the route it served, but also on competing routes. Brueckner et al. (2013) also showed that LCC competition both on routes and at adjacent airports has impacts on average fares. When lowering fares, this has enormous savings effects for both passengers and airlines (Morrison, 2001).

Most of the literature considering LCC entry, analyses the entry, or threat of entry of LCC's on routes and/or at airport level. Hüschelrath and Müller (2013) did research into the entry effect of FSC's besides entry of LCC's. Hüschelrath and Müller (2013) observed that also LCC's have recently entered long-haul markets and the results show that the entry of LCC's decreases market yield and the LCC's have higher survival rates compared to FSC's. Markets where FSC's enter, do not have much effect on market yield, but have much more effect when a FSC's enters a market where LCC's are present, and especially lower market yield is the result.

Competition due to presence

When LCC's are present, the airfares decrease, but when delays occur, the airfares increase (Britto et al., 2012). For consumers to benefit from the entry of LCC's, delays should be reduced as discussed by Bendinelli et al. (2016). Also Wittman and Swelbar (2013) did research into presence of low-cost airlines on the average fare and concluded that the presence of these airlines reduces the average one-way fare, but at the same time the number of passengers has increased. Kwoka et al. (2016) also did research into the pricing effect of LCC's on routes they serve. The results show that LCC's have a larger impact on fares than FSC's do, but when the LCC's become more dominant, the pricing-reducing effect diminishes. FSC's have a low effect on each other, but LCC's effects both the fares of FSC's and LCC's.

A factor influencing fares through competition or presence of LCC's is market power. When a firm has large market power, they can set the fares (Hofer et al., 2008). In this research the effect of market power on price markups has been analysed. LCC's do not include price markups. The results show that the LCC's market share increased and the number of passengers subjected to price markups decreased. Bilotkach and Lakew (2014) showed that dominance at airport is more important than at route to get an indication of market power. Furthermore Bilotkach and Lakew (2014) showed that fares on airport level depends on airport size and concentration on route level is an indicator for airport fares at large airports. Airports charge user charges and when these are increased, these have less effect on FSC's and more effect on LCC's output and thus profits (Fu et al., 2006).

3.3 Competition analysis references

In this section, literature on competition analysis techniques have been reviewed with a focus on econometric techniques. Besides this, the variables that these research have used, are mentioned in this section as well.

Table 7 Literature on methods and variables

Literature	Method	Independent variables	Dependent variables
Bachwich and Wittman (2017)	Two-way FE regression (time and individual)	Dummy variables on LCC and ULCC entry/exit and presence of incumbent airlines	Log of average fare
Goolsbee and Syverson (2008)	Controls regression	Dummy variables on LCC flying on route and at airport and FE	Log of mean fare
Daraban and Fournier (2008)	FE regression	Dummy variables on LCC entry/exit, FE's and control variables.	Log of average fare
Hüschelrath and Müller (2013)	Descriptive and FE regression	Dummy variables on presence of carrier, dummy variable on FSC/LCC presence only, FE and controls.	Log of yield, passengers, departures and seats
Salam and McMullen	FE regression	Dummy variable on	Log of passenger

(2013)		presence of LCC on current and adjacent route, FE	weighted average-fare
Wittman and Swelbar (2013)	Regression	Distance and dummy variables on LCC presence and vacation	Average fare

The aim of this research is to establish the relationship between price and the decision of a LCC entering a route on which another LCC and/or a FSC is present, with a focus on competition among LCC. The suitable method to tackle this problem is a regression method in which the decision variable entry of a LCC is considered. In table 7, all the literature have dummy variables indicating the entry or exit or presence of a LCC on the route or airport. Also, the variable on which the entry or exit of the LCC has influence is mostly fare as can be seen in table 7. The dummy variables in these different research have been defined differently ranging from capturing entry for a number of periods prior to entry and after entry. This means that different coefficient for the time periods is obtained prior and after entry. Several research also included dummy to indicate the exit of a carrier. Including both entry and exit dummy variable might give additional information on the effects on fare. In Daraban and Fournier (2008), they discussed how the airfare changes before and after entry of a LCC and before and after a LCC exits. Before the LCC enters, the fare already starts to drop and after entry the airfare continues to drop. When a LCC exits, the airfare increases. This is shown in figure 3, adjusted from the image shown in Daraban and Fournier (2008). The data that all the research in table 7 have used, is data that is available through the bureau of transportation statistics (BTS) namely ticket data and origin destination data.

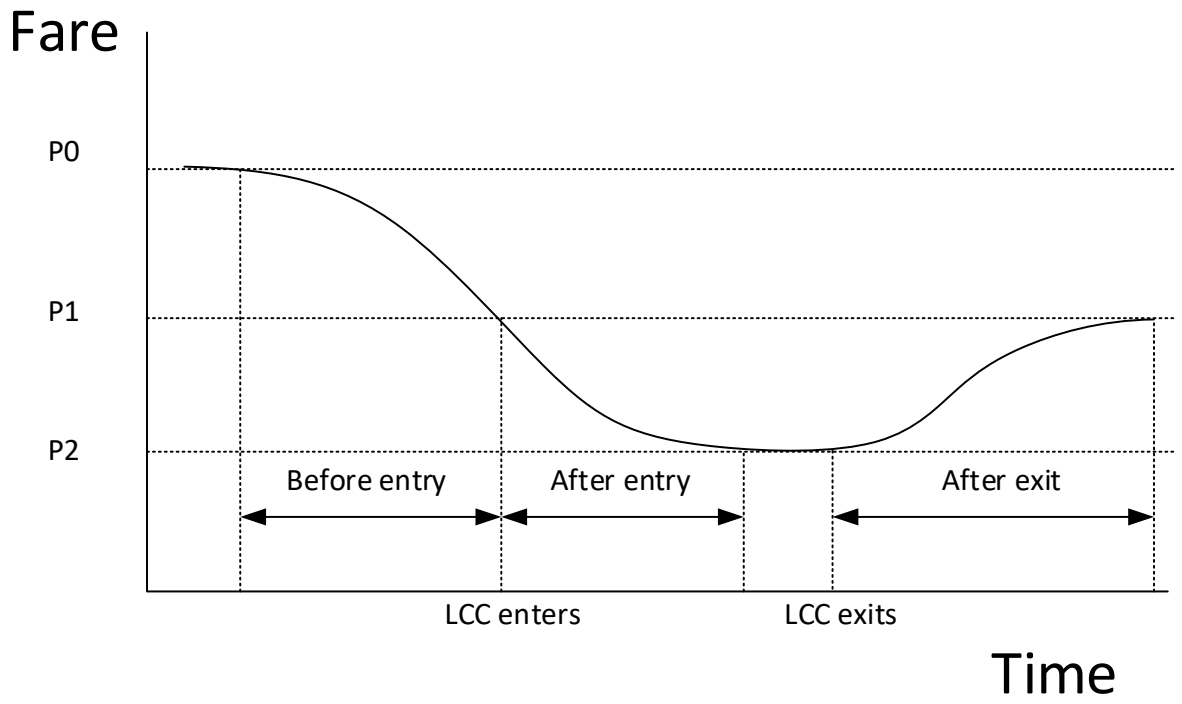

Figure 3 Influence of entry/exit decision of LCC on fare.

The interesting part is the fixed effects and controls that these different research have used.
Goolsbee and Syverson (2008) used route-carrier and carrier-quarter fixed effects. Which variables they exactly used as FE was not clear from the paper. Bachwich and Wittman (2017) used market FE's such as route distance and year specific time fixed effects. In Wittman and Swelbar (2013) a normal regression was carried out with market fixed effects. Salam and McMullen (2013) did a regression in which airline and year FE was used. Also control variables was used namely income and population. Besides these effects, also interaction effects was applied in the research of Salam and McMullen (2013), to see the effect of two dummy variables. Daraban and Fournier (2008) included many effects such as route specific effects, time fixed effects and control variables. The control variables used are income, population, market power, proportion of one-way tickets, proportion of non-stop tickets and other controls. The reason population for example is used is because otherwise it would be expected that routes originating in more densely areas. Hüschelrath and Müller (2013) also used controls for their model besides fixed effects to account for time varying market characteristics, which were the number of carriers serving the market, excluding the entered carrier, number of LCC's serving the market, average plane size, average unemployment rate and population size.

3.4 Conclusion and research gap

Conclusion
The literature on competition between different type of carriers is immense, especially literature on competition between LCC and FSC type of carrier is mostly available. To be more specific, the effect of competition on fare has been the interest of much research (Aydemir, 2012; Britto et al., 2012; Brueckner et al., 2013; Daraban & Fournier, 2008; Goolsbee & Syverson, 2008; Kwoka et al., 2016; Wittman & Swelbar, 2013). Also other aspect of which research has been carried out is available, but till less extent such as service (Alderighi et al., 2004; Hüschelrath & Müller, 2013; Valido et al., 2020), delay (Britto et al., 2012), market power (Bilotkach & Lakew, 2014; Hofer et al., 2008) and market yield (Alderighi et al., 2004; Dresner et al., 2017; Hüschelrath & Müller, 2013). Besides the dominant literature on competition between LCC and FSC, also literature on competition in which ULCC is involved is available but little. A research that considered the ULCC was Bachwich and Wittman (2017). The research on competition in which LCC are involved showed that when a LCC enters at an airport or a route or is present, the average fare decreases. To be more specific, the fares of the FSC's decreased, while that of LCC's increased or stayed the same. When the LCC exits the route, the fares increase.

Considering research methods, the dominant method was to apply regression techniques (Bachwich & Wittman, 2017; Daraban & Fournier, 2008; Goolsbee & Syverson, 2008; Hüschelrath & Müller, 2013; Salam & McMullen, 2013; Wittman & Swelbar, 2013). Before doing the actual analysis, most of the research first do a descriptive analysis, to explore the data, but Hüschelrath and Müller (2013) did a descriptive approach besides the econometric approach to explain their research purpose. All the research used the data available by the Bureau of transportation Statistics (BTS).

Research gap
As mentioned earlier the dominant competition type that was the interest of much research is that of between LCC's and FSC's and especially entry and presence of the LCC's. There was however no research that captured both entry and exit of LCC's on routes where only LCC's are present. Also no research on the effect of LCC's on routes where only LCC's operate was available. Pitfield (2008) mentioned some details on the competition between LCC's, but not explicitly on entry and exit of LCC's on a market where only LCC's operate. This same holds for Daraban and Fournier (2008). Further in this research, this gap has been tried to be filled.

4 Price competition analysis

In this chapter the regression analysis has been carried out. First, descriptive statistics has been provided of the processed dataset and then the econometric model has been defined after which the results of this model have been discussed in which the dataset as discussed in section 2 is the input.

4.1 Preparation of the data and descriptive statistics

As said earlier, the DB1BMarket dataset is suitable, since it has origin and destinations pairs included, but also the itinerary fare and number of passengers of each airline of the respective od-pair have been recorded in this dataset. There is a huge number of observations of around six million for each quarter. The dataset is available quarterly. For the analysis, data from the fourth quarter of 2015 till the fourth quarter of 2019 has been collected from the website of the bureau of transportation statistics (BTS). In total 17 quarters of data, each approximately 1.5 GB in size have been collected. Based on the data processing steps as described in section 2.2.2, the data has been processed and eventually the number of observations was N = 81280. The dataset 2015, quarter 4 has been used as base for computing entry and exit and this was then discarded for the analysis. Panel datasets can be balanced or unbalanced. In case of an OD-pair, balanced would mean that there are observations for each quarter of the OD-pair. Unbalanced would mean that some observations are not recorded or just missing. For this research only OD-pairs have been considered that are balanced.

In table 8, a summary of the variables that has been used for the analysis is shown. The average fare is 215.8, which is slightly different than the average reported fare of 385 by the BTS (Statistics, z.d.). From the used data in this research, there is a standard deviation of 90.3. The BTS has computed the average fare per quarter and with a filter of itineraries that have a fare above 50 dollars. That could describe the discrepancy. The distance starts at 11, which could indicate that this is a private flight with few passengers around 1. So, from this data, there might be correlation between distance and passengers. In figure 5, the fares density function has been plotted. From this it is clear that most of the OD-pairs have an average fare of around 200. The highest bin for example has a relative frequency of 0.5%, meaning that 0.5% of the OD-pairs have an average fare of around 200. It should also be noted that the right-hand side of the tail of the density function is very long and flat, meaning that there are a few OD-pairs that have a high average fare. The maximum number of airlines on a od-pair was 19 and minimum 1. Due to excluding observations that have no airlines, the minimum is 1. The maximum number of LCC's on an OD-pair was 5 and minimum 0, but the maximum number of FSC's on an OD-pair is 15, which is much higher than the maximum number of LCC's. The total number of LCC's from all the datasets together involved 8 LCC's, whereas the total number of airlines was 25. From all the OD-pairs, which are 5080, the total number of OD pairs on which only LCC operate are 1674, which is 33% of all OD-pairs.

Table 8 Summary of variables

VARIABLES	N	mean	sd	min	max
passengers	81,280	1,738	2,818	1	34,488
year	81,280	2,018	1.118	2,016	2,019
quarter	81,280	2.500	1.118	1	4
nrofairlines	81,280	3.762	2.679	1	19
nrlcc	81,280	0.973	0.829	0	5
nrfsc	81,280	2.790	2.467	0	15
lcc_entry	81,280	0.0835	0.277	0	1
lcc_exit	81,280	0.0900	0.286	0	1
lcc_only	81,280	0.282	0.450	0	1
pres_both	81,280	0.435	0.496	0	1
fare	81,280	213.0	80.51	26.63	966.1
comm	81,280	0.335	0.472	0	1
Total number of airlines	25	25	25	25	25
Total number of LCC's	8	8	8	8	8
Number of OD's	5,080	5,080	5,080	5,080	5,080
OD's with only LCC's	1674	1674	1674	1674	1674

Regarding the number of entry and exits of LCC's and FSC's as shown in figure 4, the number of entry and exits of FSC's are much higher compared to LCC's. The entry patterns of both LCC and FSC are similar, increasing towards the holiday seasons (Q4, Q2) and decreasing otherwise. However, the entry pattern of the LCC is much more stable compared to the entry pattern of the FSC. The exit patterns of both are not so straightforward. When the entry increases for the LCC, exit decreases for the LCC. This observation holds largely for the FSC as well. Note that the plotting is not based on the total number of entries of airlines on an OD-pair but is an observation if entry has happened on a route or not.

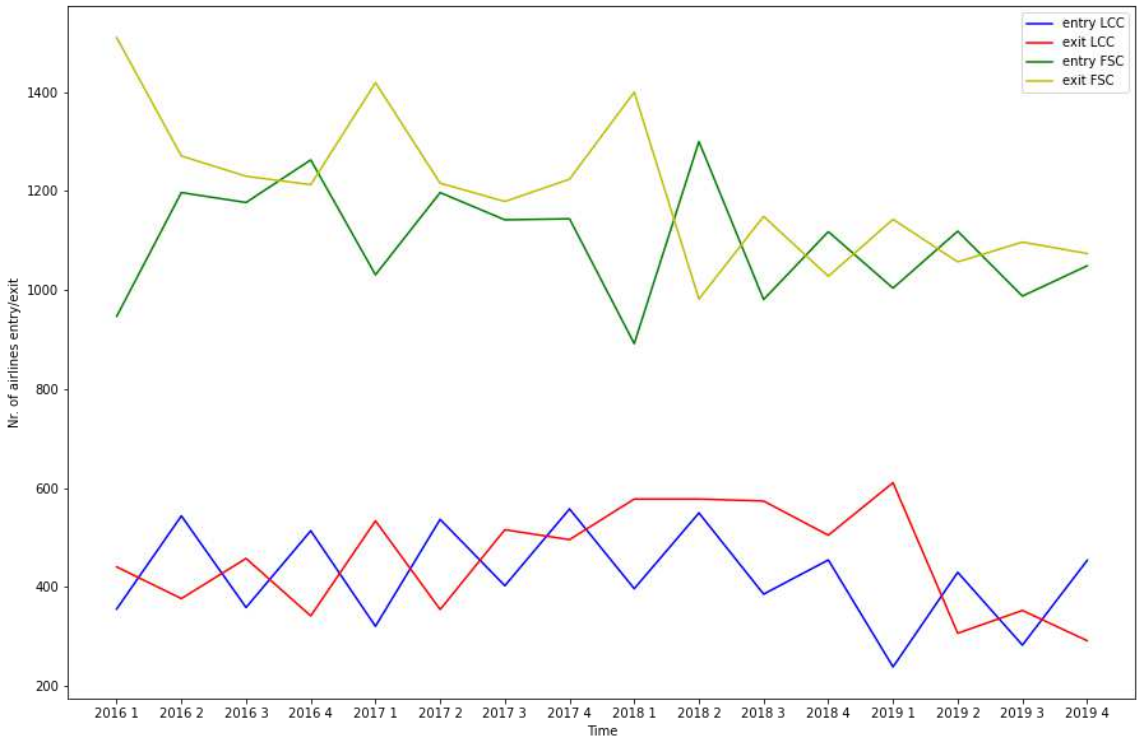

Figure 4 Number of entry and exits over the quarters of LCC and FSC's.

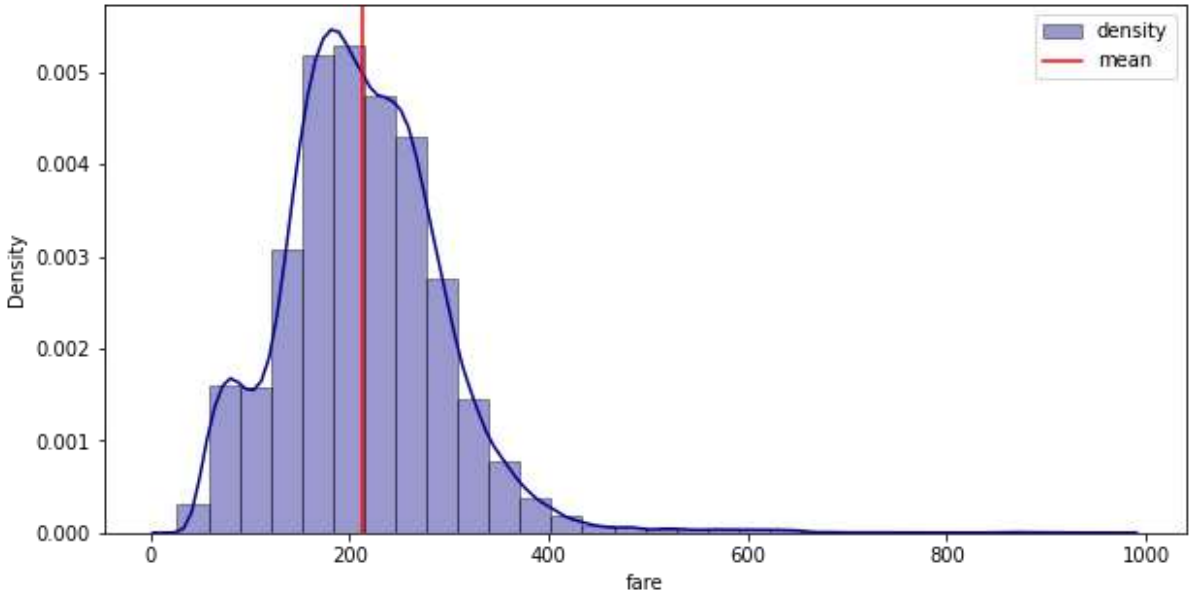

Figure 5 Fare density distribution

4.2 Regression results

In this section, the regression has been carried out and the results has been discussed including the description of the model.

4.2.1 Model description

Since the dataset has the form of a panel dataset, with several entities (OD pairs) from different time periods, the suitable model is the ordinary least squares model with fixed effects. Fixed effects can be added to account for bias that was possibly caused due to omitted variables.

In section 3.3, a literature review had been conducted on which method including which variables other research have used. In this sub-section, the variables, dependent, independent, FE and controls are mentioned. In section 4.2.2, these variables have been included in the different model specifications. The focus is on LCC entry and exit decisions, not on FSC's exit and entry decisions, although the presence of FSC's has been considered. Below, the variables used for the model have been discussed.

Dependent variable:

- fare, this is the average weighted fare of each OD-pair. Since the panel data consist of 10% of the ticket sales, the fare for the particular itinerary has been calculated as sum(passengers*marketfare)*10/ sum(passengers*10).

Used variables:

- LCC_entry: dummy variable indicating whether the low-cost carrier has entered (1) and otherwise (0). Entering occurs if the number of LCC's in the current quarter has increased compared to the previous quarter.
- LCC_only: dummy variable indicating whether the low-cost-carrier is the only type of carrier on the route (1) and otherwise (0).
- LCC_exit: dummy variable indicating whether a low-cost carrier has exited a route (1) and otherwise (0). Exit occurs if the number of LCC's in the current quarter has decreased compared to the previous quarter.
- pres_both: variable representing whether both airlines are present (1) and othwerwise (0).
- time: this variable represents each quarter of each year
- nrlcc: continuous variable which indicate the number of low-cost-carriers on a route
- nrfsc: continuous variable which indicate the number of full-service-carriers on a route
- comm: dummy variable for the comparison between nrlcc and nrfsc

Interaction effects:

- LCC_entry x LCC_only: to show what the effect is of the entry of a low-cost airline when only a LCC is present on the route.
- LCC_exit x LCC_only: to show what the effect is of the exit of a low-cost airline when only LCC's are present on the route

Fixed effects (FE): as said earlier, the fixed effects capture omitted variable bias. Based on literature, the FE's that will be used for the regression analysis are:

- time fixed effects ∂_t: is a time fixed effect accounting for the different quarters of the data. Each quarter represents a season, and the season characteristics can correlate with the outcome.
- route-fixed effects λ_i: the route-fixed fixed effect used for the analysis is passengers

Control variable: this is comm, stands for comparison and is a dummy variably which takes the value 1 if the number of LCC's is larger or equal to the number of FSC's in an OD-pair. This variable is needed to explain the interaction terms.

The econometric equation is:

$$fare = \alpha_0 + \beta_1 LCC_{entry_{it}} + \beta_2 * LCC_{only_{it}} + \beta_3 * LCC_{entry_{it}} * LCC_{only_{it}} + \beta_4 * LCC_{exit} + \beta_5 * LCC_{exit_{it}} * LCC_{only_{it}} + \beta_5 * pres_{both} + \beta_6 * comm + \partial_t + \lambda_i + u_{it}$$

The research goal is to see what the effect is of the entry of LCC's on the fare. Only regressing the LCC_entry dummy variable, would not give enough information. Interacting the variables with each other provides more information. A small trick to account for collinearity in the equation has been to define the variable LCC only to only account for whether only a low-cost carrier is present or not and pres_both is the dummy variable to indicate whether both types of carriers is available or not.

Software used

This model has been implemented through using the software STATA, version 18. For doing FE panel regression, the stata command xtreg is most known. Fixed effects can be added through using the keyword absorb. The code is shown below. With xtset the panel structure has been defined. With outreg2 the file has been exported. Most of the dummy variables had already been defined during the data processing with Python.

```
import delimited "C:\Users\bko200\Desktop\from_2016_balanced.csv

gen time = yq(year, quarter)
format time %tq
encode od_pairs, gen(od)
xtset od time

gen comm = .

replace comm = 1 if nrlcc >= nrfsc

replace comm = 0 if nrlcc < nrfsc

eret list

xtreg fare lcc_entry##lcc_only lcc_exit##lcc_only pres_both com, fe absorb(time passengers)

outreg2 using C:\Users\bko200\regression_results.doc, replace ctitle(Entry/Exit and Presence of LCC's) addtext(OD-pair FE, YES, Time FE, YES)
```

4.2.2 Regression results

In table 9, the regression results are shown of entry/exit and presence of the airline types. All the coefficient signs are as expected, and statistically significant. The constant term is also statistically significant at 1% level. This term indicates that if all the other terms are zero, that this is the intercept. In section 4.1, the average fare mentioned was 215 and the constant term of 219 does not deviate much from this.

The dummy variable lcc_entry and lcc_exit are the only variables that are significant at 10% and the rest is at 1% level. This could be due to omitted variables or the choice of fixed effects that have been used in this research. When using other FE, the results change. The estimated value of this dummy variable lcc_entry is -0.811 and is a relatively small effect on the average fare. This clearly needs additional analysis. Also, the dummy variable lcc_exit, which is -0.786, needs additional analysis. If a LCC enters a route regardless of the type of carrier operating on the route, it could be

FSC's or LCC's or both, the fare reduces by 0.8, which is a very small change. However, the core of this research was to see the effect of when a LCC enters a route on which only a LCC operates. The coefficient is -14.09 which means that when a LCC enters a route on which only LCC's operate, the average fare goes down by 14.09. This is a reduction of 6.4 % from the weighted average fare.

Also, when only LCC's operate on a route, represented by the variable lcc_only, the fare goes down by 9.9, which translates to a reduction of the average fare by 4.5 %. When both airlines operate on the same route, the average fare goes down by 3.4, a reduction of the average fare by 1.6%. So, the effect of only LCC's on a route has a much higher effect than when both airlines operate on the same route.

Regarding exit, this shows a decrease in average fare, but the magnitude differs. All have a small effect on the weighted average fare. When a LCC exits, regardless of the type of the carrier operating on the OD-pair, the average fare decreases by 0.79. It could be that only LCC's or only FSC's or both types operate on this OD-pair. The reduction by 0.79 monetary units needs additional analysis, since exiting a route on which only LCC or only FSC or both operates can have influence on the result. The highest effect is when a LCC exits a route and both type of airlines is present on the route. The reduction in weighted average fare is 5.5, translated to a reduction of 2.5% in weighted average fare.

The control variable comm, shows a statistically significant result. This control variable controls for whether there are more LCC's than FSC's on a route. The variable is 1 when the number of LCC's is higher or equal to the number of FSC's. When the number of LCC's is higher than the number of FSC's, the weighted average fare decreases by 3.8, a reduction of 1.7%. When the control variable comm is 0, meaning that the number of LCC's is smaller than the number of FSC's, the variable does not count towards the weighted average fare and thus there is an increase in fare. This could explain why the effect of a LCC exit has a much less effect on the weighted average fare.

When choosing time and passenger fixed effects, this resulted in the best results as shown in table 9. The R-squared did also improve, however the R-squared does not say much on the estimates. The estimates show statistically significant results, and this is more relevant in explaining the contribution of the variables towards the change in weighted average fare.

Table 9 Entry/exit of LCC and presence results

fare	Entry/Exit and presence
pres_both	-3.440***
	(0.488)
lcc_only	-9.934***
	(0.967)
lcc_entry	-0.811*
	(0.493)
lcc_entry#lcc_only	-14.09***
	(1.429)
lcc_exit	-0.786*
	(0.459)
lcc_exit#lcc_only	-5.527***
	(1.609)
comm	-3.828***
	(0.698)
Constant	218.9***
	(0.445)
Observations	81,280
Number of od	5,080
R-squared	0.191
OD-pair FE	YES
Time FE	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5 Conclusion

In this chapter, the main findings of this research are mentioned with the aim of answering the main research question as stated in chapter 1.

5.1 Main results

In section 3 and section 4, the sub-research questions were answered. From the literature review it became clear that the dominant competition type was on fare between LCC and FSC due to entry and presence. The competition on fare when a LCC enters and exits a route on which only LCC's operates could not be found in literature. This is the gap that this research has filled.

The result showed that when a LCC enters a route on which only LCC's operate, the weighted average fare decreases significantly by 6.4% and when a LCC exits a route on which both types of carriers operate, the weighted average fare decreases by 2.5%, but when a LCC exits a route on which only a LCC or a FSC operates, the reduction in weighted average fare is much less, namely 0.4%. This reduction is not very large when comparing to entry effects. The reason for this could be the number of LCC's serving a route compared to the number of FSC's serving a route. When there are more LCC's on a route than FSC's, the average fare is reduced by 1.7%.

With this being showed, the conclusion is that having only LCC's on a route or when LCC's enter a route on which only LCC's operate, can significantly reduce the average fare.

5.2 Limitations and further research

One of the limitations was that no distinction was made between fare of the different type of carriers. In this research the average fare was taken, whereas LCC's and FSC's have different fare settings. When having distinction in fare, the entry and effect due to LCC's on fares can be analysed in more detail.

From the analysis it was clear that additional analysis is necessary by optimizing the econometric model. This optimization can be achieved by accounting for omitted variable bias or by changing the specification of the econometric model. Applying an instrumental variable model could improve the results, but finding a suitable instrument might be challenging given the availability of the data.

This research can be further extended by focusing on LCC's. These carriers have shown to be very effective in competition on fares both in markets where only LCC's operates as is the result from this research as well in markets where both type of airlines operate as is the result from this research, as well from other research (Aydemir, 2012; Goolsbee & Syverson, 2008; Kwoka et al., 2016; Wittman & Swelbar, 2013).

In this research also no comparison was made when LCC enters a market where both types of airlines were operating, due to the focus on only LCC's. With making a comparison between entering an only-LCC market and entering a both-type airline market, a comparison in effect can be made, by also considering the entry and exit of FSC's in different type of markets. Previous research focused on competition between LCC's-FSC's, and this research has focused on competition between LCC's-LCC's. A follow-up research can do both and make comparisons on several attributes.

References

Alamdari, F., & Fagan, S. (2005). Impact of the adherence to the original low-cost model on the profitability of low-cost airlines. *Transport Reviews, 25*(3), 377-392.

Alderighi, M., Cento, A., Nijkamp, P., & Rietveld, P. (2004). The entry of low-cost airlines: price competition in the European airline market. *Tinbergen Institute Discussion Paper, No. TI 04-074/3*.

Aydemir, R. (2012). Threat of market entry and low cost carrier competition. *Journal of Air Transport Management, 23*, 59-62.

Bachwich, A. R., & Wittman, M. D. (2017). The emergence and effects of the ultra-low cost carrier (ULCC) business model in the US airline industry. *Journal of Air Transport Management, 62*, 155-164.

Bendinelli, W. E., Bettini, H. F., & Oliveira, A. V. (2016). Airline delays, congestion internalization and non-price spillover effects of low cost carrier entry. *Transportation Research Part A: Policy and Practice, 85*, 39-52.

Bilotkach, V., & Lakew, P. A. (2014). On sources of market power in the airline industry: Panel data evidence from the US airports. *Transportation Research Part A: Policy and Practice, 59*, 288-305.

Bitzan, J., & Peoples, J. (2016). A comparative analysis of cost change for low-cost, full-service, and other carriers in the US airline industry. *Research in Transportation Economics, 56*, 25-41.

Britto, R., Dresner, M., & Voltes, A. (2012). The impact of flight delays on passenger demand and societal welfare. *Transportation Research Part E: Logistics and Transportation Review, 48*(2), 460-469.

Brueckner, J. K., Lee, D., & Singer, E. S. (2013). Airline competition and domestic US airfares: A comprehensive reappraisal. *Economics of transportation, 2*(1), 1-17.

Camilleri, M. A. (2018). *Aircraft operating costs and profitability*. Springer.

Daraban, B., & Fournier, G. M. (2008). Incumbent responses to low-cost airline entry and exit: A spatial autoregressive panel data analysis. *Research in Transportation Economics, 24*(1), 15-24.

Dresner, M., Lin, J.-S. C., & Windle, R. (2017). The impact of low-cost carriers on airport and route competition. In *Low Cost Carriers* (1st edition ed., pp. 241-260). Routledge.

Fu, X., Lijesen, M., & Oum, T. H. (2006). An analysis of airport pricing and regulation in the presence of competition between full service airlines and low cost carriers. *Journal of Transport Economics and Policy (JTEP), 40*(3), 425-447.

Goolsbee, A., & Syverson, C. (2008). How do incumbents respond to the threat of entry? Evidence from the major airlines. *The Quarterly journal of economics, 123*(4), 1611-1633.

Hofer, C., Windle, R. J., & Dresner, M. E. (2008). Price premiums and low cost carrier competition. *Transportation Research Part E: Logistics and Transportation Review, 44*(5), 864-882.

Holloway, S. (2016). *Straight and level: Practical airline economics*. Routledge.

Hunter, L. (2006). Low cost airlines:: business model and employment relations. *European Management Journal, 24*(5), 315-321.

Hüschelrath, K., & Müller, K. (2013). Patterns and effects of entry in US airline markets. *Journal of Industry, Competition and Trade, 13*, 221-253.

Ison, S. (2017). *Low cost carriers: Emergence, expansion and evolution*. Routledge.

Kwoka, J., Hearle, K., & Alepin, P. (2016). From the fringe to the forefront: Low cost carriers and airline price determination. *Review of Industrial Organization, 48*, 247-268.

Morrison, S. (2001). Actual, Adjacent, and Potential Competition: Estimating the Full Effect of.

O'Connell, J. F., & Williams, G. (2005). Passengers' perceptions of low cost airlines and full service carriers: A case study involving Ryanair, Aer Lingus, Air Asia and Malaysia Airlines. *Journal of Air Transport Management, 11*(4), 259-272.

Pitfield, D. (2008). Some insights into competition between low-cost airlines. *Research in Transportation Economics, 24*(1), 5-14.

Salam, S. b., & McMullen, B. S. (2013). Is there still a southwest effect? *Transportation research record, 2325*(1), 1-8.

Statistics, B. o. T. (z.d.). *Average Domestic Airline Itinerary Fares*. https://www.transtats.bts.gov/averagefare/

Stock, J. H., & Watson, M. W. (2020). *Introduction to Econometrics* (Fourth Edition ed.). Pearson Education Limited.

Tsoukalas, G., Belobaba, P., & Swelbar, W. (2008). Cost convergence in the US airline industry: An analysis of unit costs 1995–2006. *Journal of Air Transport Management, 14*(4), 179-187.

Valido, J., Socorro, M. P., & Medda, F. (2020). Airport capacity and entry deterrence: Low cost versus full service airlines. *Economics of transportation, 22*, 100165.

Wittman, M. D., & Swelbar, W. S. (2013). *Evolving trends of US domestic airfares: the impacts of competition, consolidation, and low-cost carriers*.