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A MODEL FOR AIR TRANSPORT MARKET COMPETITION ASSESSMENT: AIRLINE AND ALLIANCE PERSPECTIVE

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MODEL ZA OCENU KONKURENCIJE NA TRŽIŠTU VAZDUŠNOG SAOBRAĆAJA: AVIOKOMPANIJE I ALIJANSE

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A model for air transport market competition assessment: airline and alliance perspective

Abstract:

The thesis deals with several aspects of competition in long-haul market that is characterized by the presence of full-service network carriers that are typically members of large alliance groups and low-cost carrier that operates independently from any cooperation agreement. The thesis focuses on transatlantic market as one of the most lucrative airline market in the world characterized by the great number of full-service network carriers and recent influx of few low-cost carriers. In order to properly investigate the impact of low-cost carrier on full-service network carriers on competitive routes, three models were developed in the thesis. The first model presents the original econometric model designed to examine the impact of low-cost carrier on full-service network carrier's price and number of passengers in the predefined set of long-haul city-pair markets.

As airlines aim to obtain as larger portion of the market as possible, the second model in the thesis was developed to predict the airline market share on the routes characterized by the presence of low-cost carrier, as one of the competitor in long-haul city-pair markets. The model is based on the application of fuzzy logic. Taking into account the key factors that determine airline market share (price and frequency of service), the proposed market share model can provide satisfactory results without taking into consideration passengers' perceptions towards different aspects of airline service.

Measuring the airline efficiency becomes an inevitable step in assessing the airline competitive advantage. The fuzzy-based DEA CCR model is developed including the set of input and output variables carefully derived to reflect the current market outlook. The results show that major airlines which operate within alliances are generally more competitive than other mid-sized carriers, primarily due to the benefits derived from the economy of density.

Keywords: airline competition, low-cost carriers, full-service network carriers, low-cost long-haul business model, transatlantic market, econometric models, airline market share, airline efficiency, fuzzy logic, fuzzy-based DEA CCR model, sensitivity analysis

Scientific field: Transport and Traffic Engineering

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UDK:

Model za ocenu konkurencije na tržištu vazdušnog saobraćaja: aviokompanije i alijanse

Rezime:

Doktorska disertacija razmatra nekoliko aspekata konkurencije na tržištu dugolinijskog saobraćaja na kome su prisutne kako tradicionalne aviokompanije, koje su uglavnom i članice neke od vodećih alijansi, tako i niskotarifne aviokompanije, koje posluju nezavisno od bilo kakvog korporativnog udruživanja. Fokus disertacije je na severnoatlantskom tržištu koje se ubraja u najatraktivnija tržišta na svetu na kome je tradicionalno prisutan veliki broj tradicionalnih aviokompanija, ali od skoro, i neznatan broj niskotarifnih aviokompanija. U doktorskoj disertaciji su razvijena tri modela sa ciljem da se detaljno utvrdi uticaj koji niskotarifni prevozilac ima na svoje konkurente, tradicionalne prevozioce, na dugolinijskim rutama. Prvi model predstavlja originalno razvijeni ekonometrijski model koji za cilj ima utvrđivanje uticaja niskotarifnog prevozioca na cene karata i broj prevezenih putnika tradicionalnog prevozioca na unapred definisanom skupu dugolinijskih ruta koje povezuju određene parove gradova.

S obzirom na to da je jedan od osnovih ciljeva svake aviokompanije da ostvari što veći udeo na tržištu, u doktorskoj disertaciji je razvijen robusni model za predikciju učešća na tržištu aviokompanija koje obavljaju saobraćaj na dugolinijskim linijama na kojima postoji konkurencija od strane niskotarifnog prevozioca. Model je baziran na primeni fazi logike. Uzimajući u obzir ključne faktore koji određuju udeo na tržištu posmatrane aviokompanije, predloženi model daje zadovoljavajuće rezultate bez potrebe uzimanja u obzir preferencije putnika prema određenim aspektima usluge.

Merenje efikasnosti aviokompanija predstavlja neizostavni stepenik u oceni konkurentske prednosti posmatrane aviokompanije. Fazi DEA CCR model razvijen u ovoj disertaciji je baziran na pažljivo izabranom skupu ulaznih i izlaznih promenljivih kako bi što bolje opisalo trenutno stanje na evropskom tržištu. Rezultati ukazuju da su velike tradicionalne aviokompanije, koje ujedno predstvaljaju i stožere alijansi, konkurentnije od manjih tradicionalnih aviokomapanija, pre svega zbog benefita ostvarenih kroz efekat ekonomije obima.

Ključne reči: konkurencija, konkurentnost niskotarifne aviokompanije, tradicionalne aviokompanije, niskotarifni poslovni modeli u duolinijskom saobraćaju, severnoatlantsko tržište, ekonometrijski modeli, model za ocenu učešća na tržištu, efikasnost aviokompanija, fazi logika, fazi logički DEA CCR model, analiza osetljivosti

Naučna oblast: Saobraćajno inženjerstvo

Uža naučna oblast: Planiranje, organizacija i eksploatacija u vazdušnom saobraćaju

UDK:

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Introduction

The air transport market, probably more than any other, has undergone tremendous changes in the last four decades. In contrast to many other industries the evolution of which is primarily driven by the technological factors, changes in the airline industry highly depend on legal, institutional and cultural developments of the surrounding environment. Deregulation of airline industry that occurred in the United States in 1978 has served as a catalyst for the sector growth by providing favorable regulatory conditions that permanently altered the landscape of competition. Shortly after the reforms occurred in the U.S., the wave of regulatory changes was riding at phenomenal speed serving as an impetus to other regions, specifically Europe and Australia, to liberalize their markets across national borders. Over this period, a large number of formerly state-owned European airlines has been fully or partially privatized, whereas some of them went bankrupt as a result of their inability to accommodate their business models to the new market conditions. These events subsequently had a large impact on market structure. First, these flag carriers (hereinafter: full-service carriers – FSCs) started to develop international alliances that enabled them to exploit economies of scale and scope and to optimize their network operation and avoid to compete with each other. Secondly, with the network structure already reorganized as a hub-and-spoke system combined with the membership in some of international alliances, the FSCs in Europe have created the formation of multi-hub-and-spoke system.

However, one of the essential ideas behind these extensive processes is to create the arena where airlines can efficiently compete each other based on the free market and without government's involvement into economic and any other airline's decision. In light of these contextual settings, the airlines were forced to adopt a variety of abovementioned structural changes in order to reduce market pressure generated by competitors and sustain profitable growth as one of the primary goal. Generally, airlines established their competitive advantages through prices and/or quality of their services.

These services amount to a collection of features, such as amenities offered on board, the seating comfort, connectivity, or the loyalty scheme. One of the most important features of an airline's offer is certainly the flight frequency and timing, which are highly regarded by the passengers. Despite a set of strategic methods that can be applied by airlines to effectively combat their rivals, the price remains the most common countermeasure to challenge an actual or potential entrant.

The particular interest in the price impact of competition coincided with the emergence of low-cost carriers (LCCs), primarily Southwest in the U.S., exerting a great influence over the pricing of domestic U.S. market. LCCs have a substantial cost advantage over its FSC rivals achieved through adoption of a focused, simple operating model. In contrast to FSCs that developed hub-and-spoke network, LCCs rely on point-to-point network structure operated by uniform fleet (i.e. single aircraft type) mainly connecting secondary, less congested airports with charges significantly lower than at those at larger airports. LCCs have experienced substantial growth at onset of new millennium and were not severely affected by the consequences of September 11, 2001 since they could still attract a large portion of price-sensitive passengers, as opposed to FSCs that recorded substantial financial losses. For instance, the market share of LCCs has created a seismic shift in the European aviation landscape accounting for more than one third of the market capacity share in 2015. Nevertheless, all these facts shed the light on the importance of LCC competition that generated a dramatic downward pressure on FSCs' fares.

Despite the fierce competition induced by the penetration of LCCs in the market, it is worth mentioning that measuring competition between LCCs and FSCs remains a very controversial and challenging issue. A key element of LCC's route structure is operation from secondary airports that are very often located in broader metropolitan areas served by few other airports among which one of them mainly stands as a major hub for FSCs. Instead of direct competition between LCC and FSC that would assume offering the services at the same airport pairs, an LCC's fare impact in an airport-pair market often arises via service at "adjacent" airports. Although ignored in the past, this aspect of "adjacent" competition became particularly important in the era of LCC expansion, as it presents the substitutable service for the large portion of market segments. In addition to adjacent route competition, the entry of LCCs at a particular airport appears to generate a potential competition to other carriers on routes even in the case when there is no either direct or adjacent competition between them. This impact may exert a small, but still significant pressure on FSCs' fares particularly on the routes of the similar length as those operated by LCCs. This means that defining the appropriate spatial market level is a critical precondition for proper measurement of competition between LCCs and FSCs.

The competition between LCCs and FSCs has been focused exclusively on short to medium-haul markets for a long time (Dobruszkes, 2006; Alderighi et al, 2012). The launch of new aircraft generation entwined with further liberalization of intercontinental air transport market are among the major reasons explaining the recent attempts of many LCCs to extend their service into long-haul markets. Thus, the emergence of this new concept brought the paradigm change in the airline industry and its effect on competition becomes the particular motivation of this research. Although the existing academic literature is inconclusive about the sustainability of long-haul LCCs, presence of several successful carriers, particularly in Europe and the U.S., brings the renewed enthusiasm that such a business model could prevail more in the near future. Similar to short and medium-haul markets, the presence of LCCs in long-haul market could impose the competitive pressure on FSCs to reduce their fares in order to retain the market shares.

To fill this gap in the research, the objective of this thesis is to empirically examine the price effect of LCC competition on the well-established FSCs on the adjacent routes in transatlantic markets. Similar to previous studies that examine the FSC pricing behavior in response to LCC competition, this thesis aims to explain the variation in FSC's response to LCC competition over various city-pair routes. For this purpose, the thesis modifies/extends the existing econometric models to capture the characteristics of a specific market through careful selection of explanatory variables. The model allows variation of diverse measures of the market structure (particularly the route concentration level) in order to determine their impact on price behavior of an incumbent carrier. Additionally, the model examines to which extent the changing in capacity of the incumbent carrier could mitigate the impact of LCC competition in the adjacent long-haul market. The final goal of these strategies is to improve the position in the market (measured through the market shares) and maximize profit. It is very well known that airlines endeavor to obtain large portions of market, since it directly impacts the airline revenue side, and subsequently the sustainability in a particular market. Thus, the thesis proposes a robust model for evaluating airline market shares on long-haul routes faced with LCC competition. Finally, obtaining higher portion of market shares cannot ensure the positive outcome in the market if it is not founded on cost and product competitiveness. Thus, the third model proposes a methodological framework for evaluation of airline efficiency.

In the process of measuring competition, it is important to properly understand the concept of competition in general. Chapter 2 provides the necessary definition of competition as found in the relevant literature. In addition, the chapter summarizes the key indicators used to measure the level of competition intensity in the market. It places a special attention to competition in the airline industry along with thorough description of two distinct types of competition – price and service quality.

Chapter 3 provides an overview of the broader literature related to the impact of LCC competition on FSCs' fares in actual, adjacent and potential markets. A detailed review on the type of regression equations used in econometric models is given in the second part of this Chapter. It identifies the essential variables that are used in each of the three equations (i.e. price, demand and cost) that are commonly treated in the literature.

Chapter 4 provides brief information on the long haul low-cost business model, as a relatively novel concept in the airline industry. It also provides essential information on the carriers which adopted this business model in several regions across the world. The chapter also underlines the essential information on the new generation of aircraft types, widely used by the carriers in this sector. The last subsection of this chapter is dedicated to the description of the North Atlantic market structure which recently experienced substantial changes due to the penetration of a long haul low-cost carrier.

Chapter 5 investigates some important non-price aspect of competition between FSC and LCC in transatlantic market. In addition to brief description of the market (i.e. the routes investigated), the chapter provides comprehensive analysis of several important non-price aspects of competition such as schedule-based aspect of competition, comfort-based aspect of competition and airline image and reputation. The detailed analysis of traffic volume and market concentration of London – New York route is also provided.

Chapter 6 presents the developed econometric model used to estimate primarily the impact of LCC competition on FSC's prices in the long-haul market. The model is based on the system of two equations, and each of the equations contains a carefully selected set of variables which describe FSC's price and the number of passengers. The chapter also provides a sensitivity analysis performed to determine the impact of "capacity" expansion strategy adopted by FSCs as a part of counter-strategy measures in competitive markets.

The developed airline market share model on long-haul routes characterized by the presence of at least one low-cost carrier is introduced in Chapter 7. The robust market share model is built upon two input variables specially derived for the purpose of the thesis. The model is based on the application of fuzzy-logic as a universal approximator combined with the Bee Colony Optimization metaheuristic. Successful application of the model is demonstrated on a set of the transatlantic routes given in the last subsection.

Chapter 8 gives the methodological framework developed for the evaluation of airline efficiency based on the application of Data Envelopment Analysis (DEA) and fuzzy-logic theory. The chapter also addresses the importance of airline efficiency as an inevitable precondition for a competitive position of an airline in the market. It is worth emphasizing that airline efficiency does not necessarily lead to a competitive position of an airline in the market. On the other hand, airlines that are competitive in the market are likely to perform efficiently. A brief overview of the current market outlook with the special focus on European markets is also provided in this chapter.

Chapter 9 summarizes the concluding remarks based on the major findings obtained by the models proposed. It also outlines possible directions of further research.

Finally, the thesis contains 6 appendices that serve as supplementary materials and contribute to better understanding of the main content.

2. What is competition?

The concept of competition has been examined probably more than any other in all of economics, but it is still in the focus of ongoing debate and research among economic scholars and experts. At first glance, it seems that competition does not need any particular definition as it persists in the large number of activities and is intuitively easy to perceive. Novak Djoković, one of the best tennis players in the world, has claimed several times during his fruitful tennis career that “*Competition is something that makes me a better player and the constant pressure generated by my rivals forces me to give my best to sustain at the top of ATP”* (B92, 2015). This illustrative definition is very close to that provided by Begović and Pavić (2010) who defined the competition as “a market arena in which players compete each other” comparing the competition to “a pressure that such a contest creates to competitors”. In order to achieve the competitive advantage in a particular market segment or an overall market, the firms struggle to provide either higher quality products at the price equal to their competitor(s)’ or to provide the same level of product quality at lower prices. One may conceive that altruism towards consumers and their needs resides in the center of such behavior, although the ultimate goal of any firm activities in the market is highly related to gaining a larger portion of market share that will further enable higher profits. Thus, it is evident that competition imposes a burden of pressure upon each player, forcing them to be as efficient as possible in order to effectively compete their rivals on the market. In other words, competition assures that a firm produces the goods and services needed by consumers at optimal quantity (allocative efficiency) and to produce them at the lowest cost (productive efficiency). Moreover, the competition reinforces firms to invest into technological innovations and processes in order to enhance their products or services in the near future. Hereby, competition serves as a mechanism that successfully distinguishes the efficient firms from the inefficient ones, which eventually results in the increase of social welfare. Since establishing the vigorous competition in the market becomes an essential precondition for innovation and productivity growth (Begović and Popović, 2018), there are ample reasons to examine the degree of competition in specific markets.

2.1. General approaches to measuring competition intensity

Therefore, measuring the degree of competition in markets is of great importance for both decision makers in private industry (entry/exit decisions, differentiation/assimilation strategies, etc.) and regulatory bodies that aim at setting competition policies and making decisions about important aspects of the market (removing barriers to entry, imposing restrictions on firm behavior or strategies, etc.). Although Smith (1937) and the classical economists generally acknowledged that competition was more effective with a larger number than with a smaller number of competitors, the number of competitors does not always necessarily lead to more intense competition. The market of large commercial aircraft manufacturing contains only two leading manufacturers - Boeing and Airbus, but still serves as an example of the market with the most intense competition in the world (Begović and Pavić, 2010). The competitive pressure generated by these two manufacturers has created the abundance of innovation in areas of both aircraft design and management enabling them to ameliorate their supply and in some instances, to reduce purchase prices and lease costs for the carriers. In addition to the number of competing firms in a market that partially reflects the degree of competition, there are numerous methods that have been deployed to measure the degree of competition and concentration in markets (Table 2.1). However, the Hirschmann-Herfindahl index (HHI) is without doubt the most popular, due to its straightforward interpretation and light data requirements (Behrens and Lijesen, 2015). The HHI is constructed using the competing firms' market shares expressed in the various ways depending on the objectives of investigation (frequency share, passenger share, capacity share, revenue share, etc.). Among others, concentration ratios CR(n) have been widely used in different sectors, since they capture the market shares of the largest n firms to assess the extent to which a given market is oligopolistic. This index has, along with the similar C8, C20 and C50 indexes, been used for analysis and regulatory policy up to the 1980s (Lijesen et al., 2002). In addition, the price-cost margin (Lerner index) measures the mark-up in price over marginal cost, or relative profits encapsulating the change in competition.

Table 2.1. The most common competition indicators

Name	Abbreviation	Explanation
Number of competitors	n	Simply counting the competitors
Concentration ratios	CR(n)	The sum of market shares of the largest n firms, where the index n is predefined
Hirschmann-Herfindahl index	HHI	The sum of squared market shares of all firms in the market
Price-cost margin	Lerner index	It measures the mark-up in price over marginal cost, or relative profits encapsulating the change in competition

On the other hand, measuring the competition by employing the above mentioned indices is not without problems whatsoever. HHI index and other commonly used measures provide an indication of the expectation of competition, but do not provide any indication of the extent to which firms or products are rivalrous or the extent of competition in the market (Mantin et al., 2016). In other words, a duopoly with low prices resulted from intense competition and a duopoly with high prices due to the lack of competitors may have equal values of HHI, although they exert fundamentally different impacts on the consumers. In order to overcome this issue, there have been substantial attempts to refine the HHI index to by accounting for heterogeneity of products via estimations of cross-price elasticities (Hausman et al., 1992, 1994), which gives a natural measure for "closeness" for competitive purposes. This measure highly relies on extensive cost data of firms competing in the market which are very often difficult or impossible to obtain. In line with these attempts, Mantin et al. (2016) deployed the Schedule Differentiation Measure (SDM) encompassing firms' market shares as well as the degree of overlap and substitution between their competing services. Finally, CR(n) index has a practical limitation due to arbitrary character of its cut-off point that takes different number of competitors for different markets. For instance, in some markets, the market shares of four largest companies appear to be a relevant level to measure market concentration, while in some others, two or even five companies will be more relevant.

Despite their limitation, the concentration measures, such as the HHI and market shares of the largest firms, are highly intuitive and have been very popular for decades among regulatory bodies in the U.S. such as the Federal Reserve Board (banking), the Federal Energy Regulatory Commission (electricity) and the Department of Transport (aviation). For the purpose of the aviation market, Lijesen (2004) developed a way to incorporate imperfect substitutes into the HHI suggesting that the imperfect substitute of a direct flight from A to B, which is a layover flight from A to B, should have a weight of little over sixty per cent in calculating the HHI index.

2.2. Measuring competition in airline industry

Deregulation of the airline industry that occurred in the U.S. in 1978 had a profound impact on the market structure and permanently altered the landscape of competition. The regulation of prices, capacities and in-flight services had been increasingly relaxed which progressively intensified the competition among airlines. The newly emerged market conditions imposed a burden of challenges to airlines since the opportunities for product differentiation had dramatically increased. The airlines started to invest substantial efforts into customer-oriented marketing strategy as a key tool to recognize the preferences of different market segments (Shaw, 2004). Understanding the requirements of potential segments of customers lies in the focus of airline product planning, as it has a direct impact on passenger demand and consequently, airline’s operating costs. The major objective of product planning is to tailor the strategy that will enable to attract and hold customers from the market segments that an airline is targeting and to do this profitably.

According to Doganis (1991), airlines generally compete in five key aspects of product features that are identified as crucial in the process of airline choice decision-making by potential customers. These are: fare and fare conditions, schedule-based features, comfort-based features, convenience features and the role of CRS and eventually, overall airline image and reputation. Table 2.2 provides a detailed classification of each of these five aspects of product feature.

As in any other industry, airlines may focus their competition into two major fronts: price and non-price competition. To a large degree, the competitive battle has been fought using price as the primary weapon (Ostrowski et al., 1993). The competition in prices (i.e. fares) become of critical importance in the aftermath of deregulation processes, initially settled in the United States, and shortly after the spread over Europe and Australia. Under the umbrella of the newly arisen regulatory environment, a number of completely new carriers entered the market, which intensified the competition and eventually led to the reduction in airfares. Among the newcomers to the market, the emergence of low-cost carriers during 1990s, initially led by Southwest in the U.S., exerted a dramatic downward pressure on fares (e.g., Dresner et al. 1996; Morrison, 2001). In Europe, the market experienced a substantial penetration by low-cost carriers that have created a tectonic shift in the aviation landscape – in 2005, they held 16.5% in terms of seat capacity, and only within a decade, it had more than doubled to 37% (Rodriguez and O'Connell, 2017). With their focused, simple business model that highly relies on point-to-point network operated from secondary, less congested airports, LCCs succeeded to offer significantly lower fares compared to their full-service competitors in the overlapping markets. In order to efficiently adapt to the new market conditions and reduce the competitive pressure, full-service airlines in Europe started to restructure their business models by introducing low-cost subsidiaries which will enable them to participate in the markets that their core operations could not access with their currently high cost structure (Cento, 2009). By investigating the pricing response of full-service carriers when LCC enter the market, Alderighi et al. (2012) find that competition with low-cost carriers reduces both business and leisure fares of full-service carriers quite uniformly, with an emphasis on the mid-segment fares. However, the battle based on price alone is very often an inadequate strategy since its long-lasting persistence may lead to a market with only few survivors.

Table 2.2. Different aspects of airline product features (according to Doganis (1991))

Product feature	Description
Fare	• Fare level • Fare conditions
Schedule-based	• Frequency • Convenient schedule (departure and arrival times) • Direct flight/Flight with stopover • Punctuality • Aircraft type

Comfort-based	• Interior layout and aircraft configuration
	  ◦ Space for legs and belongings
	  ◦ Number of separate classes of cabin and service
	  ◦ Number of toilets
	  ◦ Seat type installed
	• In-flight service and catering standards
	  ◦ Quality of food and beverage
	  ◦ Number of cabin staff
	  ◦ Availability of newspapers and magazines
	  ◦ In-flight entertainments
	  ◦ Give-aways for first- and business-class passengers
	• Ground service
	  ◦ Own check-in and handling staff
	  ◦ Waiting time for check-in
	  ◦ Ground facilities for first- and business-class passengers (special lounges, office services, car parking valets, etc.)

Convenience and role of CRS	• Ease of customer access to airline reservation and ticketing services
	• Quality of airline reservation and ticketing services
	  ◦ Number, location and nature of sales outlets
	  ◦ Availability of open lines to the telephone reservation system
	  ◦ Helpfulness of counter or telephone staff
	• Distribution methods (Internet, telephone reservation etc.)

Airline image and reputation	• Nature of airline's advertising and promotions
	  ◦ Airline's logo
	  ◦ Color schemes
	  ◦ Design of aircraft interior, sale offices and airport lounges
	• Quality of services provided by airline's staff in the air/ground

In addition to competition in prices, airlines try to differentiate themselves through other, non-price related aspect of the services offered to their customers, as listed in Table 2.2. This is particularly apparent in the situation where competitors have comparable fares and the carrier with a better perceived product design will divert passengers from other carriers. Like in many other industries, flight frequency and schedules very often play a decisive role in a competitive environment faced by airlines. It is well known that different market segments will have different requirements towards schedule. If an airline competes to retain the segment of business passengers in a short-haul market, it will generally try to offer at least a morning and an early evening flight in each direction on weekdays, whereas the weekend flight will be more convenient for leisure segment of passengers. Richard (2003) finds that consumers value highly the convenience of a flight schedule with multiple departure times, because they are then more able to find a flight that is closer to their desired departure time. Peeters et al. (2005) claim that flight frequency is particularly important for high-yield passengers who are willing to pay in order to reduce the schedule delay. Martin et al. (2008) employed the stated preference model to examine passengers’ willingness-to-pay (WTP) for food, comfort, reliability, ticket flexibility and flight frequency. The results revealed that WTP for additional flight is €3 for leisure passengers and €15 for business passengers. On the other hand, larger aircraft enable airlines to exploit the benefits through economies of density and energy savings, but may generate schedule delay. Pitfield et al. (2010) find that an increase in number of passengers would result in a larger increase in frequency than in aircraft size. An airline has to be very cautious in decision making since a trade-off between frequency and aircraft size may have a direct implication on the airline’s financial performance and position on the market. Finally, hub-and-spoke network that have been extensively used by FSCs have significantly higher frequencies than point-to-point networks exploited by LCCs. Moreover, Wei and Hansen (2006) show that airlines can attract more connecting passengers in a hub-and-spoke structure by increasing service frequency than by increasing aircraft size.

Although less important in the process of competition among airlines in a short-haul market, the comfort-based product features, particularly seating comfort and in-flight entertainment, become of significant importance for long-haul market segments. Although proper schedule-related characteristics of products seem to be crucial competitive advantage, airlines are not able to adjust rapidly due to a large number of constraints (i.e. bilateral air service agreements, absence of available runway slots, etc.). On the contrary, the focus of airline product improvement in often placed on comfort-based characteristics, since these can be easily changed and adapted. The comfort-based product features can be broadly split into three distinctive groups easily perceived by the customers. The first group refers to interior layout and configuration of aircraft which directly affect seating density. On the other hand, seating density has tremendous impact on unit costs as a larger number of seats necessarily leads to lower operating costs per seat. The second aspect of comfort-based product features encompasses in-flight services and catering standards. The enhanced quality of meal served onboard will certainly not determine the choice of an airline for a journey, but it still contributes to the overall airline image and is important in marketing terms. Finally, the third aspect refers to a set of services offered to the customers on the ground such as own check-in and ground facilities specialized in the service of first-and business-class passengers (lounges, car parking valets etc.). In the era of fierce competition, airlines are constantly under the pressure to respond to product enhancement introduced by their competitors and even greater pressure to be the first to introduce innovation in product design.

The key aspect of airline's marketing is how to address potential customers in order to distribute and sell its products. The airline's major concern is to provide the ease of customer access to airline reservation and ticketing service. Thus, decision on the location and the number of its own shops and sales outlets become of utmost importance in airline marketing. Additionally, the airline has to take into consideration the proximity of its shops from the independent travel agencies that can also sell tickets for its flights. The importance of raised issues was particularly diminished in the era of extensive usage of

Internet booking and reservation system. In recent years, LCCs made revolutionary changes in the communication with potential customers by developing own Internet platforms where customers can purchase their tickets. Full-service carriers started to follow this innovative approach in ticket selling, although a large number of them still retains traditional channels of ticket selling. In the U.S., airline websites became a growing mechanism for selling airline tickets, capturing 58% of sales in 2005 (Ruiz-Mafé et al., 2009). According to Xperience Consulting (2007), users largely value website safety and ease of use when buying online and 35% of users state that they abandon the purchase due to information overload (Ruiz-Mafé et al., 2009). Thus, airline managers involved in ticket selling need to ensure two things: first, that the airline's Internet site is a well-secured and reliable environment for ticket purchasing; secondly, the Internet side has to be designed to easily guide the potential customer throughout the process of Internet purchasing requiring the verification barriers at each stage to avoid adverse actions.

As markets become more and more competitive, a vast number of airlines embrace the concept of "branding" in order to differentiate their products from the products of other airlines selling at the same or similar prices. The airline will design its logo, color schemes, the interior of its cabin, cabin crew's uniforms, the outlook of the Internet site and many other things with an attempt to do it better than its competitors. In this way, the airline creates a preferable corporate image both among its customers and among the public at large. For example, the advertising campaign of Singapore Airlines during the 1980s created a public image of a company with helpful and attentive cabin staff, emphasizing the aspect of 'special care' for each of its passenger. The advertising appeared to play a key role in maintaining surprisingly high load factor during this period. Thus, positive corporate images can add value to a firm in many ways. On the other hand, negative images might destroy a firm's reputation and alienate their customer (Liou and Chuang, 2009).

As already mentioned, airlines vigorously compete in fares and schedule-based characteristics of their products. These two product components are explicitly and precisely expressed: one can easily compare the fare offered by one airline with the fare offered by its competitor(s) for a specific flight, or a total journey time of a direct flight opposed to the flight with one or more stopovers. On the contrary, the assessment of seat comfort, quality of an airline's in-flight service or its Internet site is subjective. The passenger perception of the product characteristics will vary for each flight and between different passengers on the same flight. Thus, the next subsection thoroughly examines the quality of service, as an intangible aspect of the airline's product perceived by the passengers who already had some experiences with the given airline.

2.3. Quality of service in airline industry

With its distinct service, the carrier tries to persuade potential customers that its product is exactly what they need. Only the service that matches or even exceeds customers' expectation is perceived as a good service. Customer satisfaction can further result in customer loyalty which subsequently secure market shares. In other words, service quality conditions influence a firm's competitive advantage by retaining customer patronage, and with this comes the market share, and ultimately the profitability (Morash and Ozment, 1994).

Thus, in a highly competitive environment a delivery of high quality service became an imperative for many full-service network carriers. In essence, the quality of service can be regarded as a composite of various attributes that determine customer satisfaction. Table 2.3 provides the categorization of airline service according to four authors investigating this topic in the early to mid-stage of airline deregulation (from 1988 to 1994).

Gourdin (1988) finds the there is a lack of consensus among users and providers on the issue of airline service quality, but they generally agree that in addition to price, safety and on-time performance are the most critical aspect of airline service. Elliot and Roach (1993) identified on-time performance, baggage handling, food and beverage (F&B) quality, seat and legroom, check-in service and in-flight service as six key aspects of airline service.

Ostrowski et al. (1993) examined the relation between the service quality and customer loyalty.

Table 2.3. Airline quality of service according to different authors

Authors	Attribute
Gourdin (1988)	• Price • Safety • On-time performance
Elliott and Roach (1993)	• On-time performance • Baggage handling • Food & Beverage quality • Seat comfort • Check-in service • In-flight service
Ostrowski, O'Brien and Gordon (1993)	• Helpfulness • Ticket counter line wait • Boarding gate line wait • Amount of personal space when seated • Seating comfort • Food quality • Amount of food served • Overall service of flight attendants • Promptness of baggage delivery • Reservation service • Arm and shoulder room • Legroom • Condition of aircraft • On-time performance
Truitt and Haynes (1994)	• Check-in process • Convenience of transit • Process of luggage • On-time performance • Cleanness of seats • F&B quality • Customer complaints

Among the 15 specific service elements evaluated, the authors found that on-time performance, F&B quality and seat comfort were the essential attributes that reflected the quality of service. Truitt and Haynes (1994) distinguished the check-in process, the convenience of transit, the process of luggage, the cleanness of seat, the F&B quality and customer complaint handling as a standard for measuring quality of service.

Table 2.4. Framework for evaluation airline service quality (Tsaur et al., 2002)

Objective	Attribute
Tangibility	• Comfort and cleanness of seat • Food • On-board entertainment • Appearance of the crew
Reliability	• Professional skill of the crew • Timeliness • Safety
Responsiveness	• Courtesy of crew • Responsiveness of crew
Assurance	• Actively provided service • Convenient departure and arrival times • Language skills of the crew
Empathy	• Convenient ticketing process • Customer complaint handing • Extended travel service

In order to bridge the gap between specific characteristics and the abstract concept of quality, there have been attempts in the relevant literature to design a conceptual framework that will facilitate the evaluation of quality of service. Parasuraman et al. (1988) proposed a conceptual framework that identified five-aspect representation of service quality that linked specific service characteristics to consumer expectations of quality. The five aspects comprise tangibility, reliability, responsiveness, assurance and empathy. Further, an instrument for measuring service quality (i.e. SERVQUAL) has been developed on the basis of the above five dimensions. Based on the structure of the five aspects as a skeleton, Tsaur et al. (2002) deployed a similar framework to evaluate airline service quality by including 15 service quality criteria (Table 2.4). Gilbert and Wong (2003) combined the SERVQUAL instrument with Key Purchase Criteria formulated by Mason (1995) and identified 26 airline service quality items. Following similar SERVQUAL methodology and insights gained from interviews with airline managers, Park et al. (2004)

proposed a list that accounts for 22 airline service quality measurement items. Chen and Chang (2005) examined airline service quality from a process perspective and made a clear distinction between passengers' expectation during round and in-flight service stages. Using SERVQUAL framework, the authors identified 17 measurement items for ground process stage and 15 for in-flight stage.

3. Literature review

Deregulation and liberalization of the market brought a vast number of regulatory changes that undoubtedly spurred the competition among airlines. First, liberalization allowed the airlines to independently decide on important aspects of its operation such as pricing, route entry, service capacity and alliance membership. As the number of competitors or potential competitors on different routes has increased (Cento, 2009), the pressure on the players are becoming more intense. Thus, achieving a sustainable competitiveness becomes a crucial challenge for the airline industry. An airline is forced to perform more effectively against its competitors by using its resources in the most efficient manner, which further allows for reduction of prices and increase in services quality (flight frequency, FFP etc.). Second, liberalization enabled airlines to optimize their networks, as demonstrated by the deployment of hub-and-spoke network, implementation of which allowed carriers to consolidate their traffic in hub airport linking it with small markets (supported by feeder flights). In this way, airlines succeeded to increase the average load factor and improve overall efficiency which eventually led to substantial reduction in average costs.

However, the emergence of the low-cost business model stemmed as the most outstanding advent of liberalization processes which permanently alter the landscape of competition. Initially invented by U.S. carrier, Southwest Airlines, in the early 70s, it took more than 15 years in the U.S. and 20 years in Europe before major network carriers began to take the challenge of this new business model seriously (Franke, 2004). The lean business model adopted by LCCs offered the compelling alternative for passengers who wanted to avoid the higher prices of FSC demanded to maintain their complex hub-and-spoke system (Franke, 2004).

Although competition among airlines is typically measured at the route market level (Borenstein, 1989), there are a vast number of papers where competition extends beyond the airport-to-airport level to include adjacent competition in multi-airport cities which is particularly the case with the large metropolitan areas in the U.S. The impact of LCCs on average air fare on the route across different world regions has been well documented and will be presented in the chronological order in the next subsection. The second subsection will thoroughly discuss the methodology employed to determine the effect of LCC on market competition.

3.1. The impact of LCC competition on the market

Since the deregulation of aviation market first occurred in the U.S., accompanied with the emergence of LCCs, a bundle of literature investigated the structural changes particularly in this market. Whinston and Collins (1992) were among the first who examined the reactions of incumbent airlines' stock prices to announcement of entry by the low-cost start-up carrier, People Express. The authors provide a comprehensive market outlook in terms of the price, sales quantity and schedule changes that occurred in response to People Express's entry. In order to capture the predefined changes, the authors investigated 24 new domestic (non-slot-constrained) nonstop markets in which People Express started to offer its services. The results of an event study show that the incumbents suffered significant value reductions on routes entered by People Express. In particular, the average incumbent on these routes lost roughly $3 million to $6 million in value when entry was announced. As expected, the entry by People Express resulted in a drop of 34% in the average prices of incumbents on the entered route, while a smaller price reduction of 15% occurred on the routes between other airports in the same city-pair.

However, the most prominent work from this field examined the effect of Southwest airline, as one of the fastest growing and most profitable LCC in the U.S., on the fares of well-established FSCs. U.S. DOT (1993) report, prepared by Bennet and Craun, provides an extensive analysis of Southwest expansion in U.S. market. The authors reported that Southwest airline was highly focused on very dense, short-haul markets where it could provide frequent service and with unit costs one-half to two-thirds of its network carrier competitors. The authors thoroughly described the effect of Southwest impact into the largest domestic market, the California Corridor that connected San Francisco to Los Angeles. These two cities are served by eight airport pairs, of which Southwest operate three routes connecting Oakland to Los Angeles International, Los Angeles Ontario and Los Angeles Burbank. In less than four years of operation, Southwest became the largest carrier in the Corridor with 42% market share, despite the fact that it did not serve San Francisco International Airport, which was the dominant corridor airport in early 1989. The analysis shows that average fare (across all airlines) on the Oakland-Ontario route has dropped by 60% and the traffic tripled at the same time. Additionally, Oakland-Los Angeles Burbank experienced the reduction in fares by 55%, whereas the traffic increased six-fold due to United Airlines expansion in capacity after Southwest entered the market. In addition to the routes that were directly served by Southwest, the reduction in fares was also observed on parallel, competing routes in which Southwest did not offer its service, such as San Francisco-Los Angeles. Eight airlines ceased their operation in one or more airport pairs due to intense competition imposed by Southwest, while the ones that survived were quickly moving back towards their old fare levels. Thus, the authors raised serious concerns that such rapid expansion of Southwest could lead to the monopoly in many markets and underlined the importance of government in encouraging other LCCs to enter the market.

Windle and Dresner (1995) examined the impact of LCCs' entry on fares and traffic on a route and tried to determine whether the impact differed from entry by a network carrier. They also tried to address longer-term consumer benefits from new entry by examining whether the fares and traffic effects of both low-cost and other carriers, were sustained past the initial promotional period after the carriers entered the market. Based on the data encompassing the four quarters before and after entry, the authors found that route fares (averaged over all routes with entry) declined by 12% immediately after the entry by a network carrier, and one year later, the fares increased to reach the fare-level that was 5% below the pre-entry level. Traffic increased by 17% one year after entry. On the other hand, the impact of Southwest entry exerted stronger influence on the market with the average fare being reduced by impressive 48% that remained at almost the same level in the following four quarters. Significant drop in fares generated additional demand that resulted in the increase in traffic by 200% one year after the entry. Finally, the entry of other carriers had less impact on fares and traffic compared to Southwest, but still larger than the impact of network carriers: fares declined by 20%, whereas traffic increased by 50% one year after entry.

Dresner et al. (1996) have further examined the competitive impact of fares resulting from the entry of an LCC. The authors examined not only the impact of LCC on fares on the routes entered, but also the impact of LCC entry on other routes at the airport where entry occurred and on parallel routes from nearby airports. The authors particularly examined the effect of Southwest on the routes operating from Baltimore/Washington (BWI) airport to Cleveland and Chicago Midway. It is worth mentioning that BWI is among three airports, besides National (DCA) and Dulles (IAD) that serve Washington-Baltimore area. The authors found that fares on the routes where Southwest directly competes with other carriers at BWI are reduced by 60-75%, while the fares on other routes that are not operated by Southwest at the same airport dropped by 18-40%. The effect of fare reduction was particularly pronounced on the routes that are similar in length as those operated by Southwest. The reduction of fares at nearby Washington Dulles and National airport on the routes to Ohio and Chicago was also observed, although the reduction was significantly lower compared to the reduction at BWI.

In order to determine the impact of various factors on yield on the route, the authors extended the research using a sample of 200 routes from across the U.S. and expanding the list of low-cost carriers to include a number of airlines other than Southwest. The focus of the econometric model was to reveal to what extent the presence of a low-cost carrier on a given route (for example, Los Angeles-Oakland) depresses yields on competitive routes (for example, Los Angeles-San Francisco). The model consists of simultaneous equation system that was used to explain yields and passenger traffic encompassing the period from 1991 (third quarter) to 1994 (second quarter). The results of the first version of the model that classified only Southwest as a low-cost carrier, reveal that presence of this carrier reduced the average route yield by 53%. The second version of the model that takes into account other LCCs showed that average route yield were reduced by 38%. The model also showed that entry of an LCC at an airport had impact on the reduction of average yields by 41% on the routes not served by the LCC, with reductions in yields being larger as the number of routes operated by LCCs increase. Finally, the authors concluded that the presence of a low-cost carrier on a route has a spillover impact onto other competitive routes as well as on the other routes at the given airport.

Morrison (2001) specified the effect that Southwest may have on a route's fare in an original disaggregated way, which includes the effect of various form of actual, adjacent and potential competition from Southwest. For this purpose, the authors proposed a regression model by taking into account several independent variables, such as the number of carriers on the route, other market factors and dummies (indicating whether Southwest operated on the route, on a competing route or from the same airport) to determine their effect on a dependent variable, the average fare. Based on data from 1998, the results revealed that Southwest's presence as an actual competition on a route reduced fares by an average of 46% and that Southwest's presence on a competing parallel route as an adjacent competitor reduced average fares by between 15% and 26%, depending on route characteristics. Potential competition induced by Southwest is most effective in the case when it serves both endpoints of a route but not the route itself (lowering the fares by 33%) and least effective when it serves only one airport placed in the vicinity of the given airport, in which case fares are reduced by 6%. The author also included a dummy variable that indicated whether either endpoints is dominated by the carrier that accounts for more than 60% of enplanements, and found that airport concentration increased fare by 4%. Compared to the previous researches, Morrison

(2001) examined also the social benefit generated by the penetration of Southwest and calculating it at $12 billion.

Vowles (2001) was particularly interested in examining the effect of Southwest entry on fares and traffic on the competing adjacent routes. The authors selected four multi-airport regions: Miami (served by Miami, Fort Lauderdale and West Palm Beach), Washington (served by Washington International, Washington National and Baltimore), Chicago (served by Chicago O'Hare and Chicago Midway) and Houston (served by Houston Intercontinental and Houston Hobby). In order to capture the changes in the markets observed, the data were collected for the quarter prior to Southwest entry in a market as well as a year later. For example, the author observed the changes in fares for Washington National – Chicago Midway before and after Southwest entered Baltimore – Chicago Midway. The analysis has showed that Southwest not only lowers the fares in the market they serve, but also in the adjacent competing markets that include multi-airport regions. The analysis examined 47 routes, out of which 36 markets recorded a reduction in fares once Southwest began serving an airport in the region. The author also found that, generally, the airports that reduced their fares did not experience any increase in traffic. The reduction in fares at these airports rather serves as a counter-measure to maintain or avoid further loss of traffic due to competition from Southwest.

Ito and Lee (2003) analyze the price and capacity responses of incumbent hub-and-spoke carriers to LCC entry in the U.S. domestic airline industry in the period between 1991 and 2002. Using a relatively large sample of LCC entry events, the authors investigate how responses by incumbent carriers are actually aggressive and how they impact the probability of exit for a new entrant LCC using a probit exit model. A predatory incumbent response could reflect the situation in which the incumbent lowers its price below its costs, thus forcing the entrant to endure financial losses and eventually exit the market. The incumbent carrier may be able to sustain itself longer in a battle as it has bigger reserves and can get better terms of borrowing than the newcomer to the market. The incumbent's financial losses generated in this way will be compensated by higher profits once the entrant(s) exits the market. In addition to sharp reduction of fares, the incumbent airlines very often employ aggressive capacity expansion as an efficient, still controversial strategy, to reduce the probability of LCC market survival. Despite the well-established anecdotal evidence of mentioned strategies, the empirical analysis shows that highly aggressive incumbent reactions are more the exception rather than the rule. Based on the analysis that covers 370 market entry events, the results show that the incumbent generally aligns its price to that of entrant, but it rarely undercuts the entrant's average fares. Contrary to common perception that incumbents extensively expand their capacity as a response to LCC's market entry, the results provide no clear evidence that incumbents try to exceed the entrant's capacity choice. Moreover, the analysis provides no evidence that either incumbent's counter-strategy (capacity expansion or reduction in prices) following LCC's entry has negative impact on the probability that the LCC exit a market. The sustainability of LCC in a particular market is rather driven by the several other factors, among which the entrant's capacity choice, pre-existing market density and the LCC's pre-entry presence at the either of the endpoints in a market seems to play a key role.

Hofer et al. (2008) examine the effect of price premiums. Hofer et al. (2008) defined the price premiums as "the phenomenon that can be defined as price markups due to dominant position and market concentration at the airport and route market levels". The authors particularly examined the effect of LCC's competition on the level and the composition of price premiums, since the significance of price premiums may have changed over time due to rapid LCC expansion. The size and the composition of price premiums were observed for three years, 1992, 1997 and 2002 comprising 1000 U.S. domestic origin and destination route market. The authors derived two regression equations, the passenger equation and the fare equation, both containing the set of independent variable that influence them. The authors found that the largest components of price premiums were those from airport market share and airport concentration. Moreover, LCCs do not earn price premiums suggesting that LCCs do not consider airport or route dominance/concentration when making decision about prices. As a result of overall growth in market share of LCCs over the three years observed, the share of U.S. air passengers influenced by price premiums has substantially decreased. For instance, Hofer et al. (2008) found that "the percentage of passengers flying on a high cost carrier route without some LCC competition dropped from 65.2% in 1992 to 28.2% in 2002".

Goolsbee and Syverson (2008) examine "how major airlines (i.e. incumbent airlines) respond to the threat of entry by competitors (as distinct from how they respond to actual entry)". In contrast to the majority of the previous work that deals with market behavior after a competitor's entry occurs, the paper focuses on strategic entry deterrence and accommodation as a part of preemptive action. The authors particularly examine how incumbents react in the situation where Southwest begins or announces the operations in the second endpoint airport of a route (having already established operations out of the first endpoint), but before it starts flying the route itself. For this purpose, the data on fares and passengers were collected from the first quarter of 1993 through the last quarter of 2004 for the sample encompassing the routes between the 59 airports that Southwest ever flies any flights to. The baseline regression model is proposed to measure the impact of Southwest establishing a presence in both endpoints of a route by looking at the periods before, during, and after this event, while including other variables. The authors observed that Southwest threatening entry into 704 routes over the sample period, 533 of which Southwest had actually entered with direct flights by the final quarter of 2004. Goolsbee and Syverson found that "incumbents do indeed react preemptively to Southwest's entry threat and reduce their fares on threatened routes relative to their fares on other routes from the same airports". In this way, the incumbents stimulate passenger traffic growth on the threatened routes. However, the incumbents are likely to employ the strategy of entry deterrence on the threatened routes, though at the same time the possibility of accommodation cannot be rejected.

Aydemir (2012) broaden the previous research by examining how U.S. legacy carriers and a low cost incumbent, in this case, Southwest Airlines, have responded to the threat and actual entry by another low-cost carrier, AirTran Airways. The study investigates six legacy carriers (i.e. American, Continental, Delta, Northwest, United, and US Airways), as well as the two largest low-cost carriers in the U.S., Southwest and AirTran, encompassing the period from the first quarter of 1998 to the last quarter of 2007. Similar to the rationale behind the work of Goolsbee and Syverson (2008), AirTran's entrance in the new airport generate the threat that it will enter routes connecting that airport with others in its network. The author followed the methodology proposed in Goolsbee and Syverson (2008) and employed the fare regression model to quantify the effects of the LCC threat and actual entry on incumbent fares (both Southwest and US legacy carriers). Unlike Goolsbee and Syverson (2008) who analyzed a 25-quarter window, the author uses only a 13-quarter window to examine the effect of entry threat. The results indicate that the pricing behavior of a low-cost incumbent is quite different from incumbent legacy carriers in response to both actual and potential competition induced by an LCC entrant. Finally, Aydemir (2012) concluded: "legacy carriers' ex post fares are on average lower in response to AirTran's entry, consistent with earlier findings. On the other hand, the fares of Southwest are on average higher in response to AirTran's entry." Based on these findings one can derive conclusion that Southwest will continue to attract its loyal customers, while AirTran could count to divert a non-loyal portion of Southwest passengers.

Cho et al. (2012) extended the previous works by providing further insight into how various forms of direct and adjacent competition affect demand and prices in particular market. The empirical model includes the measures that control for various factors that have been shown to impact air fares in previous researches. These variables can generally be divided into three categories: route characteristics (i.e. length of route, number of passengers on the route, indication for tourist routes), airport characteristics (i.e. distance from the traveler's point of origin, the distance to the final destination, congestion at the airport, the degree of airport's passenger enplanements and the number of airports in the area) and carrier characteristics (i.e. operating costs of the carrier, carrier's financial condition and indication for low-cost carrier). The model contains two regression equations that have been estimated simultaneously. The analysis contains 37 airports within 14 metropolitan areas, with more than half of the airport pair included in a sample set have at least one alternative airport-to-airport route. Cho et al. (2012) concluded "an additional potential competitor at an end-point airport can result in a decrease in fares by $2.46 in single airport-to-airport market and $3.65 in airport-to-airport markets with competing airport-to-airport routes. Generally, the analysis reveals that initial LCC on a route leads to a $14.20 fare reduction, while adding a second LCC leads to additional fare decrease of $10.14. The results also show that in the case when Southwest is the first LCC that enters the market, it will result in additional $9.43 fare reduction for a total of $23.63. "

Brueckner et al. (2013) extended the previous researches by examining the fare impact of the low-cost carriers, including competition at adjacent airport in order to provide a broader picture of the competitive effects of both legacy carriers and low-cost carriers. The analysis measures the impact of direct (i.e. airport-pair) competition and adjacent competition for both types of carriers, while also taking into consideration the impact of potential competition generated from low-cost carriers. By using this comprehensive approach, the authors treated two markets separately, direct and connecting, which present an improvements in comparison to most previous studies. The analysis relies on the sample that covers four quarters (from the third quarter of 2007 to the second quarter of 2008), and thus capturing the effect of potential LCCs on fares before and after the entry is not possible. However, regression model employed in this research uses a substantially larger number of competition measures (in both direct and connecting regression models) compared to the previous researches. The regression results for the "base" model that investigates the competition in direct markets reveal that the effects of legacy competition in direct markets are not significantly different from zero. On the other hand, the presence of Southwest in a market connected by direct flights reduces the fares by 26%, the finding that goes in line with previous researches (Dresner et al. 1996;

Morrison, 2001; Goolsbee and Syverson, 2008), while the competition from other LCCs in the same market has a smaller effect of 12%. Concerning the adjacent competition, Brueckner et al. (2013) find: “model shows that adjacent legacy nonstop competition has no fare effect, while adjacent nonstop competition from Southwest reduces fares by 11%, which is consistent with the prior work. Adjacent competition on direct routes from other LCCs appears to be smaller in magnitude, on average 4%. The potential competition of Southwest has positive effect on the market by reducing fares by 8%, regardless of whether it is direct or adjacent market. In contrast, the other LCCs’ potential competition has no fare effect. Concerning the connecting market, the model shows that competition of legacy carriers has a small counterintuitive positive effect (probably caused by model bias), while connecting competition from Southwest and other LCCs reduces fares by 4% in each case. The paper generally finds that the competition in the market has been significantly altered in comparison to competition outlook that prevailed prior to the begging of new millennium, when the impact of legacy carriers had much larger magnitude.

In addition to the rapid expansion of LCCs in the U.S., the air travel market has experienced the influx of competition induced by Gulf carriers that are creating an increasingly dense global network in last decade. Dresner et al. (2015) examined the effect of Gulf carrier competition on U.S. carriers’ passenger volume and fares in international route markets. In methodological terms, this study bears similarity to studies on the effect of low-cost carrier competition in the U.S. airline industry. The data were retrieved for the period from the first quarter of 2003 (one year prior to the entry of the first Gulf carrier in the U.S.) to the third quarter of 2011. The empirical model consists of two simultaneous equations, with fares and passengers being the variables of interest (i.e., dependent variables). Dresner et al. (2015) provide “ample evidence that greater competition by Gulf carriers exert small, but still statistically significant fare reduction of U.S. carriers in both direct and adjacent markets that connects the U.S. with Africa, Asia, Australia and Europe.”

Besides the U.S. market, the effects of LCCs on market competition have been investigated for other regions such as Australia, Europe, South America and Asia (particularly China).

Forsyth (2003) was among the first who examined the impact of low-cost carriers on fares, costs and profitability in the Australian market. The authors investigated also the incumbents' response to a new LCC's entry. In order to provide more comprehensive market outlook, the authors identified two phases of entry, the early 1990s and the year 2000s. Similar to the North America and European markets, the incumbents have to make decisions about how they will response to new entrants – whether they should accommodate or they want to fight. In the first entry period, the incumbents adopted an aggressive strategy which means that they had to sustain the period of loss making. In this way, they reduced their prices to the level which were not likely to be sustainable for the new entrant in the long term. The response of the incumbents in the second entry phase in 2000s was more measured. Forsyth (2003) finds "The incumbents still endeavored to match the fares of the entrants, but the fares were not as low relative to costs as it was the case in the earlier entry phase."

Alderighi et al. (2012) investigate the behavior of full-service network carrier in terms of price setting in response to LCC's entry in European aviation market. The authors proposed eight regression models of airline competition which described various market structures, some of which include the competition induced by low-cost carriers. Data were collected for the city-pairs route between Italy and main destinations in the UK, Germany and the Netherlands, for the period from April 2001 to July 2003 (on a monthly basis). The dataset contains 41 routes where one, two or more carriers offer direct services. The model was estimated separately for economy and business classes in the case of monopolistic market (one FSC), symmetric duopoly (two FSCs), asymmetric duopoly (one FSC and at least one LCC) and asymmetric oligopoly (two FSCs and at least one LCC) with fares being the dependent variable. The results found by Alderighi et al. (2012) "reveal that competition among FSCs reduces the price levels of the business and leisure segments with a significantly stronger effect on the business fares. The entry of LCCs appears to have a more uniform impact on all fares, with an emphasis on the mid-segment fares. The results show that in the case of symmetric duopoly, an average FSC fare reduction accounts for around €32 for economy classes (with respect to monopoly case), while in the case of asymmetric duopoly it is about triple (on average €91). In the case of business classes, the competition from another FSC induces an average fare reduction of around €167, while in the case of LCC competition the reduction in fares is on average €80. Finally, in the case of asymmetric oligopoly, the average fare decreases in the economy and business classes are around €113 and €232 respectively (with respect to monopoly case)."

Fu et al. (2015) examined the evolution of the largest low-cost carrier in China, Spring Airlines, that recorded an increase in traffic volume, revenue and profitability since it commenced its operation in 2005. Despite Spring's strong growth over the years, it is evident that overall LCC development in China is still highly constrained by government regulation. Spring has limited entry at major hubs and on dense routes, and thus its beneficial effects on passengers cannot be fully realized as it was the case with major LCCs in North America and Europe. The authors followed the econometric model similar to that proposed by Morrison and Winston (1995) to determine the impact of Spring on average yield of the four largest carriers, among which three-state owned constitute the "Big Three" (Air China, China Eastern and China Southern) and the fourth largest carrier, Hainan airlines. The monthly panel data are compiled, encompassing 514 city-pair routes in the domestic market, with a time period from August 2008 to July 2012. The authors proposed five regression equations with dependent variable being the average yield of each of the four carriers separately, and one regression equations with the average yield of all FSCs. The results of the regression models reveal that Spring has moderate impact on FSCs competitors, reducing the average fare of Air China by 5.1%, the fare of China Eastern by 3.4% and the fare of Hainan Airlines by 6.2%. In addition to the econometric models, the authors also applied a discrete choice model to identify factors influencing

Spring's route entry decision. The results of the probit model indicate that Spring's entry decision is not significantly affected by competition, either from FSCs or high-speed rails. However, the further development of the network could be anticipated once the domestic market is fully liberalized.

Oliveira and Oliveira (2018) have recently examined the drivers of effective competition in the airline industry. The authors were particularly interested in market concentration since it is a commonly used metric for assessing competition. The paper develops a baseline regression model of market concentration that contains several variables, among which LCC entry at primary and secondary airports are also considered as explanatory variables. The dataset consists of a panel of domestic routes in Brazil for the period from January 2002 to December 2013. In the period observed, the Brazilian airline industry has experienced a rapid demand growth and two events of LCC entry. Gol was the first low-cost in the Brazilian market that commenced its operation in January 2001. Azul airlines is a low-cost carrier with the rapid growth which entered the market in December 2008 and based its operation at Sao Paulo/Campinas (VCP) airport that experienced the exponential growth in only three years (from 0.66 million movements in 2009 to 3.61 million in 2012). The main differences between the business model of Gol and Azul is that the former extensively uses the primary airports in Brazil, whereas the latter highly relies on secondary airports in its operations. The regression estimates for LCC variables show that the entry of an LCC at primary airports (Gol airlines in the early 2000s) had a statistically significant negative effect on market concentration. In contrast, the estimate for variable that indicates the LCC entry at secondary airports appears to have no significant statistical impact. Table 3.1 provides brief information on all relevant studies mentioned above.

As it can be observed, the FSCs extensively employed the strategy of "lower prices" to challenge a new LCC entrant despite theory's insistence that the price is a weak and inefficient strategic weapon (Kwoka and Batkeyev, 2018). Even in the case when FSC could respond to LCCs by offering comparably low prices, it would be very difficult to sustain these prices since their cost base is significantly higher than their LCC rivals', leaving a scarce space for maneuvering in this field. With the unit cost significantly lower than their FSC rivals', LCC managed to offer lower fares that enable them to exponentially increase the market share on continental routes. It is very well known that gaining a larger market share based on cost competitiveness and product competitiveness is the primary rather the ultimate goal of airlines to withstand global competition (Heshmati and Kim, 2016). In addition to the loss in market share of FSC in many markets, the most challenging effect of intensified LCC competition is certainly the rapidly declining yield level that posed a serious threat to FSC in a long term perspective. For instance, Dresner et al. (1996) found that entry by an LCC onto a route reduced average route yield by 38% or even 53% in the case when Southwest Airlines is an LCC opponent on the route. Similar effects were generated by Ryanair in one of the largest markets in Europe, London-Dublin with the demand being quadrupled in the period from 1986 to 2000, mostly enerated by the lower fares offered by Ryanair, while the yield level declined to one-fourth (Franke, 2004)

The adoption of such a focused, simple operating business model encompassing direct flights to and from high-density markets allowed the LCCs to achieve substantial cost competitiveness over their FSCs rivals. Doganis (2001) found that LCC business model can ensure the 51% cost advantage in relation to FSC. The further decomposition of cost structure reveals that 27% of cost advantage stems from explicit network structure and airport choices, another 12% of cost savings come from product/service characteristics (outsourced handling, no free in-flight catering), and a small portion of 9% comes from extensive use of distribution system and commercial agreements. Figure 3.1 depicts the differences in operating costs between FSC and LCC in Europe and the U.S. respectively. Concerning the U.S. territory, it is evident that Southwest had a very stable cost base, with a cost gap in 2004 that was virtually the same as in 1996. As observed, two other U.S. LCCs, AitTran and JetBlue, with slight fluctuations in CASK have also managed to sustain significant cost gap with the FSC over the period between 2001 and 2004. On the other hand, the cost differences between the leading European low-cost carrier, Ryanair, and FSCs tend to increase from 52% to 64% over the period between 1997 and 2004.

Nevertheless, it is evident that the European FSCs succeeded to reduce their unit costs since 2001, especially in the area of sales and distributions (IATA, 2006).

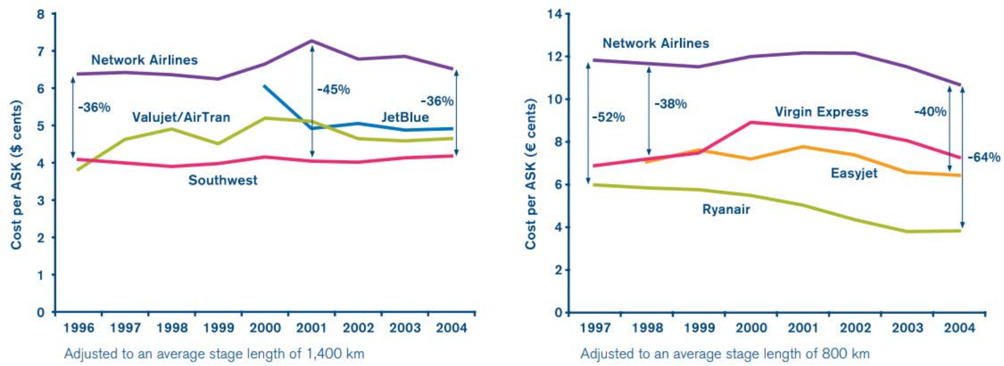


Figure 3.1. Adjusted cost per ASK for US airlines (1996-2004) and European airlines (1997-2004) (*Source: IATA, 2006*)

Despite the significant drop in CASK of FSC observed in both Europe and the U.S., overall, the post-2000 period ("LCC Growth and 'Legacy' Decline") has been very difficult to survive as a large number of U.S. legacy carriers were on the edge of bankruptcy or even termination of service. In contrast, major LCCs in Europe and the U.S. were profitable during this period, while other low-cost carriers were not as badly affected as FSCs. This is not surprising, bearing in mind that the new millennium has begun with the economic downturn that coincided with terrorist attacks, SARS epidemics, trade globalization and skyrocketing oil prices bringing a burden of challenges to the airline industry. The series of these events, often referred as "perfect storm", caused the loss of US airline industry of nearly $35 billion from 2001 to 2005 (US Air Transport Association, 2006). Airline profitability was further damaged in the aftermath of the world financial crisis of 2008 thus bringing a vast number of carriers to the edge of bankruptcy.

All abovementioned facts raised a serious concern among FSC whether their business model that proved to be very successful during the 1980s and 1990s was still sustainable in the era of continuous and extensive structural changes. It is evident that competition of LCCs forced FSCs to improve their strategies and move towards a new level of efficiency that highly affects their competitiveness in the global market. As discussed in economic theory (Porter, 1986), to achieve competitive success, any firm must process a competitive advantage in the form of either lower costs or differentiated products that command premium prices. Thus, FSCs were forced to increase their overall efficiency (by minimizing the cost for the given level of output or to maximize their output for the given set of input) since it may highly affect their competitiveness in the global market. In other words, airlines that can perform more efficiently are likely to be more competitive in a highly fluctuating environment. As reported in Fethi et al. (2000), airlines' efficiency has been significantly improved as a result of EU liberalization. Based on the abovementioned facts, it can be concluded that measuring the airline efficiency becomes an inevitable step in assessing the airline competitive advantage over its rivals.

Table 3.1. Studies that examined the impact of LCCs on air transport market

Author/Year	Scope of study	Region/ Route	Methodology	Data time horizon	Type of competition	Findings
Whinston and Collins (1992)	• Reactions of incumbent airlines' stock prices to announcements of entry by People Express	US/24 new domestic (non-slot-constrained) nonstop markets	• Event study	1984 vs. 1985	• Direct	• Entry by People Express resulted in a drop of 34% in the average prices of incumbents on the entered route • A smaller price reduction of 15% occurred on the routes between other airports in the same city-pair
U.S. DOT (1993), prepared by Bennet and Craun	• Southwest impact on average fare and passenger volume on the California corridor (San Francisco-Los Angeles)	U.S./San Francisco-Los Angeles route	• Time series analysis	1989 (Q3) – 1992 (Q3)	• Direct • Adjacent	• Avg. fare (across all airlines) on direct routes declined by 60% • Avg. fare on parallel routes (not served by Southwest) also declined
Windle and Dresner (1995)	• Differences between the effects of LCC and other carriers' entry on the route • Sustainability of	U.S./200 domestic O-D pairs	• Time series analysis • Econometric model (fare regression model)	1991 (Q3) – 1994 (Q2)		• Avg. route fares declined by 12% immediately upon the entry by a FSC and, one year later, increased to reach a fare-level that was 5% below the pre-entry level.

	price and traffic offered by new entrants after initial promotional period					• Entry by Southwest reduced the average route-fare by 48% and remained close to that level over the ensuing four quarters. • Entry of other non-network carriers reduced fare by 20%
Dresner, Lin and Windle (1996)	• Impact of LCC entry on carriers operating on other routes at the airport where entry occurred • Impact of LCC entry on carriers operating at competitive airports in close proximity to the airport where the entry occurred	U.S./200 domestic O-D city pairs	• Time series analysis • Econometric model (simultaneous equation system – yield and passenger regression equations)	1991 (Q3) – 1994 (Q2)	• Adjacent (parallel) • Potential	• Entry by an LCC onto a route reduced avg. route yields by 38% • If the LCC was Southwest, avg. yields had been reduced by 53% • Entry of an LCC at an airport reduced yields by 41% on routes not served by the LCC

Morrison (2001)	• Impact of LCC entry, specifically Southwest, on other routes from the same airport and on competing parallel routes from nearby airports. • Savings of passengers induced by the presence of Southwest as a competitor	U.S./1000 the most dense domestic route	• Econometric model (fare regression model)	1998 (quarterly data)	• Actual • Adjacent • Potential	• Southwest's presence as potential competition on a route reduced fares by an average of 46% • Southwest's presence on a competing parallel route as an adjacent competitor reduced avg. fares by between 15% and 26% • Southwest was estimated to induce $12.9 billion in savings to travellers per annum, $9.6 billion of which was due to actual and adjacent competition and $3.3 billion due to potential competition.
Vowles (2001)	• Impact of Southwest's (SW) entry into an airport on fares on competing routes at other nearby airports with no SW service.	U.S./47 domestic routes	• Time series analysis (descriptive statistics)	Not specified (quarter prior to entry-year after entry)	• Adjacent • Potential	• Generally, airports near an airport that Southwest enters also experience a decline in avg. air fares • Lowered fares at nearby airports were required to maintain or to avoid a significant reduction in traffic levels due to competition from SW

Ito and Lee (2003)	• Incumbents' reactions to LCC entry into routes to and from their hubs • Probability of the LCC's exit from a route	U.S./370 hub markets	• Probit model	1991-2002	• Direct • Adjacent	• LCC entered a route with a fare 50% less than the incumbent's pre-entry fare and provided about one third the capacity of the incumbent • Response of the incumbent was modest - capacity was increased by 3-4%, on average, and fares declined by 15% • Pre-existing market density, entrant's initial capacity choice and LCC's pre-entry presence at the market endpoints of a route, were more likely to impact their entry and exit decisions.
Hofer, Windle, Dresner (2008)	• Do LCCs affect the network carrier's ability to capitalize on market concentration and power • Do LCCs earn hub premiums	US/1000 domestic O-D route markets	• Econometric model (fare and passenger regression models)	All quarters of 1992, 1997 and 2002	• Direct • Adjacent	• Market concentration and airport market power are positively correlated with average fares, • Presence of an LCC reduces fares in a market • LCC presence consistently lowers hub premiums

						• LCCs appear to earn little or no hub premium at airports where they are the dominant carrier.
Goolsbee and Syverson (2008)	• How incumbent airlines respond to the threat of entry by competitors (as distinct from how they respond to an actual entry), particularly the threat of Southwest.	U.S./704 routes	Econometric model (fare, passenger and cost regression models)	Q1 1993-Q4 2004	• Actual • Adjacent • Potential	• Incumbents' fares drop on threatened routes relative to their fares on other routes from the same airports. • Incumbents' fare declines appear to stimulate an increase in passenger traffic on the incumbents' threatened routes. • No significant evidence in favor of strategic investment in excess capacity is found
Aydemir (2012)	• How U.S. legacy carriers and a LCC incumbent (Southwest) responded to the threat and actual entry by another LCC, (AirTran Airways)	U.S./338 O-D domestic routes	Econometric model (fare regression model)	Q1 1998 –Q4 2007.	• Actual	• Legacy carriers' ex post fares are on average lower in response to AirTran's entry • Southwest' fares are on average higher in response to AirTran's entry.

Cho, Windle and Hofer (2012)	• How various forms of direct and adjacent competition affect market outcomes in terms of demand and fares	US/2000 largest domestic airport-to-airport routes	Econometric model (simultaneous equation system – yield and passenger demand regression equations)	2003 (Q1) – 2006 (Q4)	• Actual (direct) • Adjacent • Potential	• An additional potential competitor at an end-point airport can result in a decrease in fares by $2.46 in single airport-to-airport market and $3.65 in airport-to-airport markets with competing airport-to-airport routes. • Initial LCC on a route leads to a $14.20 fare reduction, while adding a second LCC leads to additional fare decrease of $10.14. • In the case when Southwest is the first LCC that enters the market, it will result in additional $9.43 fare reduction for a total of $23.63
Brueckner, Lee and Signer (2013)	• Impact of in-market (i.e., airport-pair) competition and adjacent competition for both types of carriers (LCCs	U.S./Not specified	Econometric model (various forms of fare regression model)	2007 (Q3) – 2008 (Q2)	• Adjacent • Potential	• Most forms of legacy-carrier competition have weak effects on average fares • Southwest in nonstop market reduces the fares by 26%, while nonstop competition from other

	and FSCs), while also capturing the impact of potential competition from LCCs • Separate application of comprehensive approach to two different types of markets, nonstop and connecting					LCCs has a smaller effect of 12%. • Adjacent legacy nonstop competition has no fare effect, while adjacent nonstop competition from Southwest reduces fares by 11%. Adjacent nonstop competition from other LCCs has a smaller 4% effect • LCC potential competition from Southwest reduces fares by 8%, whereas potential competition from other LCCs has no fare effect.
Dresner (2015)	• Impact of Gulf carriers' competition on U.S. carriers' passenger volume and fares in international route markets	International market that connect U.S. with with Africa, Asia, Australia and Europe.	Econometric model (simultaneous equation system – fare and passenger regression equations	2003 (Q1) – 2011 (Q3)	• Actual • Adjacent	• Greater competition by Gulf carriers exerts small, but still statistically significant fare reduction of U.S. carriers in both direct and adjacent markets that connects the U.S. with Africa, Asia, Australia and Europe.

Forsyth (2003)	• Competitive response of incumbents to LCC entry.	Australia/not available	Descriptive analysis	Two periods - the early 1990s and 2000	• Direct • Adjacent • Potential	• In the first entry period, incumbents lowered their prices to the levels which were unlikely to be sustainable for the new entrant in the long term • In the second entry period, incumbents still endeavored to match the fares of the entrants, but the fares were not as low relative to costs
Alderighi, Cento, Nijkamp, Rietveld (2012)	• Price-setting behavior of FSCs in the European aviation market when LCC enter the market	Europe/41 O-D routes connecting Italy to the UK, Germany and the Netherlands	Eight fare regression equations	April 2001to July, 2003 (monthly basis)	• Direct • Adjacent	• Competition among FSCs reduces the price levels of the business and leisure segments with a significantly stronger effect on the business fares. • Entry of LCCs appears to have a more uniform impact on all fares, with an emphasis on the mid-segment fares.
Fu, Lei, Wang, Yan (2015)	• Impact of the largest LCC in China, Spring Airlines, on average yield of	China/514 city-pair routes in the domestic market	Five yield regression equations	August 2008 – July 2012 (monthly basis)	• Direct	• Spring has moderate impact on FSC competitors, reducing the average fare of Air China by 5.1%, the fare of China

	four largest FSCs in China					Eastern by 3.4% and the fare of Hainan Airlines by 6.2%.
Oliveira and Oliveira (2018)	• Drivers of effective competition in the airline industry, among which market concentration is of particular interest	Brazilian/routes that involve 26 state capitals and country's capitals	Regression model of market concentration	January 2002 – December 2013 (monthly basis)	• Direct • Adjacent	• LCC variables show that entry of an LCC at primary airports had a statistical significant downward effect on market concentration. • In contrast, the estimate for variable that indicates LCC entry at secondary airports appears to have no significant statistical impact

3.2. Review on the methodology employed to measure effect of LCCs on market competition

As discussed in the previous subsection, the emergence of LCCs and their effect on market competition was extensively investigated in the literature in the last three decades. In order to empirically determine the effect of LCCs on different aspects of competition (including both price and non-price competition), authors employed different econometric methods. The selection of methods is mainly driven by the objective of a particular study, as well as by the availability of the data necessary to conduct statistical analysis. Early studies from this field mainly examine the impact of LCC on the U.S. market, mainly because of two reasons. First, the Bureau of Transportation Statistics provides free access to the large dataset that contains a variety of information on capacity, passengers and fares of the U.S. carriers, which represent a substantial base for extensive researches. Second, the concept of LCC firstly appeared in the U.S. with the emergence of Southwest Airlines at the beginning of the 1970s. With its operating model enabling substantial savings, the airline exerted revolutionary changes on the competition in the U.S. market. Besides Southwest, a number of carriers that followed similar business models persisted at the onset of regulatory reforms, but Southwest certainly had the most profound influence on competition.

As it can be observed from the previous subsection, the methodology applied to examine the impact of LCC competition can generally be split into two major categories. The first group of papers employs a simple descriptive statistical analysis, mainly conducted for a particular year or a comparison of specific items across two or more years. The second group of studies extensively applies the econometric models that are based on the regression analysis. The regression analysis serves as an appropriate statistical method to statistically determine LCC effects on various aspects of competition. In this second group of studies, one may distinguish between the studies that estimate a single regression equation and the studies that simultaneously estimate more than one regression equation. Concerning the single regression equation, the variable of interest (i.e.

dependent variable) is mainly given throughout the different form of fare, described by the set of explanatory variables. In the system of more equations, the fare equation is simultaneously estimated with the passenger demand function, as there is a high interdependency among them.

Table 3.2 shows four most relevant papers that use the single regression equation. In the mid-1990s and early 2000s, a number of studies (Windle and Dresner (1995); Morrison and Winston (1995) and Morrison (2001)) investigated the changes in average one-way fare on a particular set of routes in the U.S. by employing the reduced form of fare regression. This group of studies examined the impact of Southwest on direct and adjacent routes by incorporating the dummy variables that indicate the presence of Southwest on the particular market.

The fare regression is generally the function of the variables that describe the passenger demand, costs and market structure (Richards, 1996). Although the selection of the explanatory variables in the observed studies is highly influenced by the concrete objective, they still have some variables in common that appeared to be of utmost importance in any fare regression equation. For instance, they all include the variable route distance since the increase of route length is associated with higher air fares due to the higher costs generated. In addition to distance, they also capture the impact of market concentration at the route or airport level mostly incorporated through an HHI index. All studies include the dummy variable that indicate whether the route is featured as touristic or not, since it is very well-known that tourist passengers are highly sensitive to price and consequently the carrier’s yield is expected to be lower on these routes. Similarly, the dummy variable that indicates the presence of LCC(s) on the route is important since the route served by LCC, particularly Southwest (in the U.S. market), are generally featured by lower prices

Table 3.2. Selection of variables in fare regression model

Morrison and Winston (1995)	Windle and Dresner (1995)	Morrison (2001)	Fu, Lei, Wang (2015)
Dependent variable	***Dependent variable***	***Dependent variable***	***Dependent variable***
Average one-way fare	Average one-way fare	Average one-way fare	Average FSC's yield
Independent variable	***Independent variable***	***Independent variable***	***Independent variable***
Non-dummy variable	***Non-dummy variable***	***Non-dummy variable***	***Non-dummy variable***
Number of route competitors	HHI	Number of LCCs (other than SWA	HHI
Number of airport competitors	Distance	Number of major carriers (other than SWA)	Distance
Total number of passengers	Total number of passengers	Other carriers	FSC's market share
Distance	***Dummy variables***	Distance	Airports' total seats
Dummy variables	Slot-controlled airport	Business passenger percentage	***Dummy variable***
Carrier specific	Vacation route	***Dummy variable***	Tourist destination
	Intra-Hawaiian route	Southwest's presence on the routes (8 variables)	High-speed rail service presence
	Carrier specific	Slot-controlled airport	Spring Airlines' presence
	Quarterly effects	Density (9 variables)	Major FSC's presence
		Concentrated hubs	Yearly effects
		Regional effects	Quarterly effects
		Quarterly effects	

The studies that specifically investigate the U.S. market include the dummy variable that reflects the existence of slot-controlled policy at the either endpoints of the route as this policy can deteriorate the possible entrance of new players in the market. Additionally, it is worth mentioning that Fu et al. (2015) chose the yield as the dependent variable (expressed as revenue per km) rather than the average one-way fare. Nevertheless, the methodology behind is very similar as in the case of other studies.

Table 3.3 provides the most prominent studies that simultaneously examined the yield and the passenger demand. There are two fundamental factors that underlie the need for examining passenger and fare equations simultaneously. First, it is well known that there are interrelations between passenger demand and price in the market. In other words, passenger demand may clearly influence the price on the route, but on the other hand, the lower price may serve as an impetus for stimulating passenger demand. Second, these two variables have to be treated jointly in order to avoid the model misspecification and potential bias that occurred as a result of independent estimation.

The early studies dated back to 1996 (Dresner et al. (1996); Richards (1996)) used yield (as a proxy for price) as a dependent variable expressed as either average price per mile (Dresner et al. (1996)) or average passenger revenue per mile (Richards (1996)). It can be generally observed that earlier studies include a lower number of explanatory variables in both yield and passenger regression. In the yield equation, the variable Distance, Route HHI and the number of passengers appear to be common variables for all five studies observed. Compared to other studies from Table 3.3, the study of Cho et al. (2012) provides more a detailed selection of explanatory variables in yield regression by including those that reflect route characteristics, airport characteristics and carrier characteristics. Although very similar in terms of methodology used and the selection of the variables in the yield equation, a recent study of Dresner et al. (2015) examines the effects of the Gulf carriers on the U.S. carriers' passenger numbers and fares, rather than the impact of LCCs as in all other studies.

Concerning the passenger equation, it is evident that the variables Population and Income represents the most important predictor of passenger demand (Dresner et al. (1996); Richards (1996); Hofer et al. (2008) and Cho et al. (2012)). All studies (except Hofer et al. (2008)) also include the variable Yield (i.e. price) as an explanatory variable in passenger equation. In addition to these major variables, there are several others that are deemed as significant contributor to passenger demand. For instance, Dresner et al. (2015) found that the trade flows between origin and destination countries of the given international route markets can additionally boost the passenger demand. Hofer et al. (2008) include the measure of convenience expressed through circuit ratio (the ratio between the distance actually flown and non-stop miles between airport) and load factor as an important variable that can highly affect passenger demand. Concerning the dummy variables, all studies (except Dresner et al. (2015)) include the binary variable to indicate a vacation route, while most of them include the time variable indicator (Dresner et al. (1996); Hofer et al. (2008) and Dresner et al. (2015)) that capture changes in passengers over time and a slot-controlled airport dummy (Hofer et al. (2008); Cho et al. (2012)) to measure the impact of this regime on passenger demand.

Table 3.3. Selection of variables in the simultaneous equation system (fare regression and passenger demand equation)

		Dresner et al. (1996)	*Richards (1996)*	*Hofer et al. (2008)*	*Cho et al. (2012)*	*Dresner et al. (2015)*
Yield equation[1]	Non-dummy	Total passengers	Total passengers	Total passengers	Total passengers	Total passengers
		Distance	Distance	Distance	Distance	Distance
		Route HHI	Route HHI	Route HHI	Route HHI (single airport)	Route HHI (sum by regions)
				Airport HHI	Route HHI (multiple airport)	Fuel
				Route share	Route HHI (city-to city)	Total Gulf passengers
				Airport share (max.)	Airport HHI (single)	
				Circuit ratio	Airport HHI (multiple)	
				Financial score	Airport HHI (city level)	
				Load factor	Distance to city center	
				Airline cost	Number of LCCs	
					LCC adjacent routes per number of LCCs	
					Operating Expenses per Passenger Mile	
					Avg. arrival delay (multiple airport pair)	
	Dummy	Slot-controlled airport	Slot-controlled airport	Slot-controlled airport	Slot-controlled airport	Quarterly effects
		Vacation route	Vacation route	Vacation route	Vacation route	
		LCC's presence	Hub airport	LCC Compete HCC	Southwest's presence	
		LCC presence at adjacent route		LCC Compete other LCC		
		Quarterly effects				

Passenger equation[1]	Non-dummy	Population	Population	Population	Population	Trade
		Income	Income	Income	Income	Total Gulf passengers
		Yield	Yield	Load factor	Yield	Price
		Distance		Distance	Distance	
				Airline cost	Avg. arrival delay (multiple airport pair)	
				Circuit ratio	Distance to city center	
				Financial score		
	Dummy	Vacation route	Vacation route	Vacation route	Vacation route	Quarterly effects
		Quarterly effects	Substitute mode	Slot-controlled airport	Slot-controlled airport	
				LCCCompForHCC	Non-stop flight	
				LCCCompForLCC		
				AltRouteLCC1M		
				Carrier specific		
				Time specific		

[1] The yield equation is expressed in several ways in the studies observed: average price per mile (Dresner et al. (1996), passenger weighted average fare per great circle distance (Cho et al. (2012)), one –way fare (Hofer et al. (2008) and average passenger revenue per mile (Richards (1996)).

4. Long-haul low-cost business model

The long-haul low cost business model is relatively novel in the airline industry, although there had been some attempts in the late 70s. As stated in Wensveen and Leick (2009), the concept of low-cost long haul flying dated back to 1977 when Skytrain, the company founded by Freddie Laker, operated between New York and London offering airfares substantially lower than its legacy competitors. Skytrain ultimately failed in February 1982 with debts of £270 million (Francis et al., 2007) and very few airlines have emerged in this sector since that period. In the recent few years, there has been abundance of literature that investigated the viability of such a concept that requires radical enhancement in order to be profitable. Bearing in mind that a large number of airlines in the world adhered to this model in the recent past, the investigation of cost and revenue aspects of their business model becomes an essential factor for their sustainability on the dynamic competitive market. The low cost business model has been reserved for short and medium-haul routes for years with 50-60% cost savings compared to FSCs (Fu et al., 2015; Oliveira and Huse, 2009; Morrell, 2008), the advantage that is impossible to achieve on long-haul routes.

The viability of the low cost business concept into long-haul service has raised a fierce debate among scholars and airline experts who broadly investigated the financial aspects of such a model. Francis et al. (2007) were among the first who evaluated the applicability of the LCC model into long haul service. They highly stressed the importance of connecting passengers and high yield premium passengers that significantly reduced the economic viability of long-haul flights. Similar to previous findings, Morrell (2008) took a rather pessimistic approach and questioned the problem of generating demand (due to the lack of connecting passengers) to support the existence of hub by-pass service. The author also claimed that lowering long-haul fares significantly from current fares is not feasible for LCCs. On the other hand, Douglas (2010) supported the assumption of long-haul economic viability through the concept of an effective "dual model integration" in which a FSC founds a LCC long-haul subsidiary. The concept underlines the integration of premium economy classes which allows the carriers the access to higher yield leisure traffic and to price-sensitive corporate travel on congested routes. Daft and Albers (2012) were among the first who examined the profitability of long haul LCC flights by taking into consideration both revenue and costs sides of held optimistic side emphasizing the importance of revenue consideration as a key factor of feasible existence of LCC long-haul service. Opposed to Morrell (2008) who emphasize the importance of connecting passengers, Daft and Albers (2012) suggest that there are markets that offer significant point-to-point demand without dedicated feeder traffic. The authors found that ancillary revenues can significantly contribute to airline's profitability. A recent study conducted by De Poret et al. (2015), who performed a detailed financial assessment of low-cost operation on the transatlantic market leads to similar conclusions. Namely, the authors revealed that higher seating densities, higher cargo revenues and additional ancillary revenues can ensure the economic viability of long-haul LCC operation. A recent study conducted by Wilken et al. (2016) attempts to identify potential intercontinental routes for new low-cost service. Although there are a greater number of routes that can be derived, the authors still emphasize the existence of some kind of "hubbing" to be an important requirement for long-haul LCC.

Despite previous work that focused on revenue side of long-haul low cost model, Soyk et al. (2017) focused solely on the evaluation of cost differences between 37 airlines that operate transatlantic routes, among which there are those that adopt low-cost business model (such as Norwegian Air Shuttle). With the cost per ASK accounting for 5.27 US$ cents (Figure 4.1), the third cluster derived (consists of only one carrier Norwegian Air Shuttle) achieved the 33% lower unit costs (i.e. 2.50 US$ cents) compared to legacy hub carriers from the first cluster (7.91 US$ cents), of which 24 percentage points were considered as sustainable. Within this 24% sustainable cost advantage, 11% is driven by lower staff costs, choice of airports with lower charges and lower costs of sales and distribution (i.e. distinctive business model), while the remaining 13% is directly derived from higher seating densities.

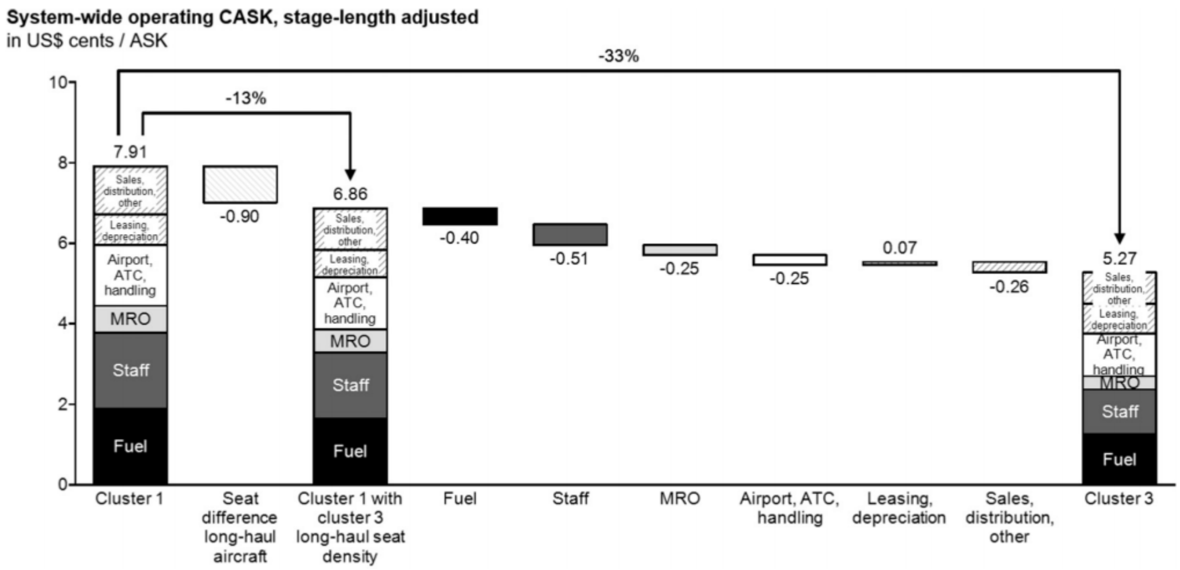


Figure 4.1. Differences in operating costs between airlines from two derived clusters by cost items (*Source: Soyk et al. (2017)*)

As seen from Figure 4.1., fuel cost is substantially lower for Norwegian Air Shuttle than other legacy carriers from the first cluster as a result of exploit of modern fuel efficient airplanes. However, this cost advantage is not sustainable over time as it requires that long-haul low cost airlines extensively reinvest in fleet modernization significantly earlier than their legacy hub rivals. Finally, in contrast to previous researches, Soyk et al. (2018) find that the emerging North Atlantic long-haul LCCs do not have a revenue disadvantage compared to FSCs, particularly on dense routes approved by the application of the new metric proposed.

In addition to already well-established European long-haul carriers, one can anticipate that prominent LCCs, such as Ryanair, could pave the way for successful acquiring of long-haul operation in the future, the idea which is thoroughly investigated in Van den Hoek (2017). Having in mind that there is a potential of between 20 and 113 out of 442 routes of up to 12,000 km that do not have non-stop flight to and from Europe (Wilken et al.,

2016) combined with the tendency of LCCs to enter the charter airline long-haul territory (Rodríguez and O'Connell, 2017), the development of future network of LCC long-haul carriers will be a challenging task.

4.1. The evolution of low cost business model in the world

As mentioned above, after the demise of UK-based Skytrain in 1983, the U.S. based low-cost carrier, People Express, commenced its ambitious plan by offering the service on transatlantic route from New York to London, and subsequently to Brussels, and the continental route from New York to Montreal. Despite its initial success to easily adopt the simple business model, the airline faced a serious management problem in addition to over-capacity issue and finally, ceased its operation in 1987 (Moreira et al., 2011). Since the failure of these two carriers, it took several decades for the long haul low-cost concept to become well established in the airline industry (Table 4.1).

The current iteration of the long haul low cost model has been around for a decade, with Australian-based Jetstar (2006) and Kuala Lumpur-based AirAsia X (2007) being the pioneers (CAPA, 2017). These two long-haul low cost carriers operate in a dual business model environment, as they are both founded by their parent companies, Quantas and Air Asia respectively. These airlines can benefit from the parent carrier's feed traffic, alliance arrangements and financial stability to provide significant competitive advantages (Boeing, 2018). With regard to Europe, Norwegian Airlines stands as a new start-up and was the pioneering company that launched its first long haul flight in 2013 between Oslo and New York and, shortly after, between Stockholm and New York. In addition to these transatlantic flights from Scandinavia (including Copenhagen), the carrier introduced long-haul links from three large European cities: London (2014), Paris (2016) and Barcelona (2017).

It is evident that most recent introduction of long haul low-cost model in different parts of the world has brought radical changes in global network structures with apparent tendency to permanently alter the landscape of competition in the future.

Table 4.1. Overview of long-haul LCC operations in the world

Name	Continent	Operations started	Status
Laker Airways' Skytrain	Europe	1977	ceased in 1982
People Express	North America	1983	ceased in 1987
Zoom Airlines	North America	2002	ceased in 2008
Oasis Airlines	Asia	2006	ceased in 2008
Jet Star	Australia	2006	In service
Air Asia X	Asia	2007	In service
Scoot	Asia	2012	In service
Norwegian Air Shuttle	Europe	2013	In service
Eurowings	Europe	2015	In service
Westjet	North America	2015	In service
Wow Air	Europe	2015	In service
Level	Europe	2017	In service

Source: Daft and Albers (2012); Soyk et al. (2018)

However, some markets tend to be more mature compared to others in terms of emerging low-cost service on the distances over 4,000 km. The most prominent among them is certainly Australian international air travel market characterized by the existence of a long haul low-cost option (i.e. Jetstar) for some years. Although the steady growth in available international seats has been recorded in the period between September 2014 and September 2017 (Figure 4.2), it seems that low cost share remained fairly static in this market – 15.9% in September 2014, 14.1% in September 2015 and 15.5% in 2016 (OAG, 2017). The mentioned market shares are split between four low-cost carriers, of which Jetstar and AirAsiaX hold the majority of capacity with the shares of 47% and 39% respectively, while the remaining shares are divided between Scoot (11% of capacity) and Cebu (4% of capacity).

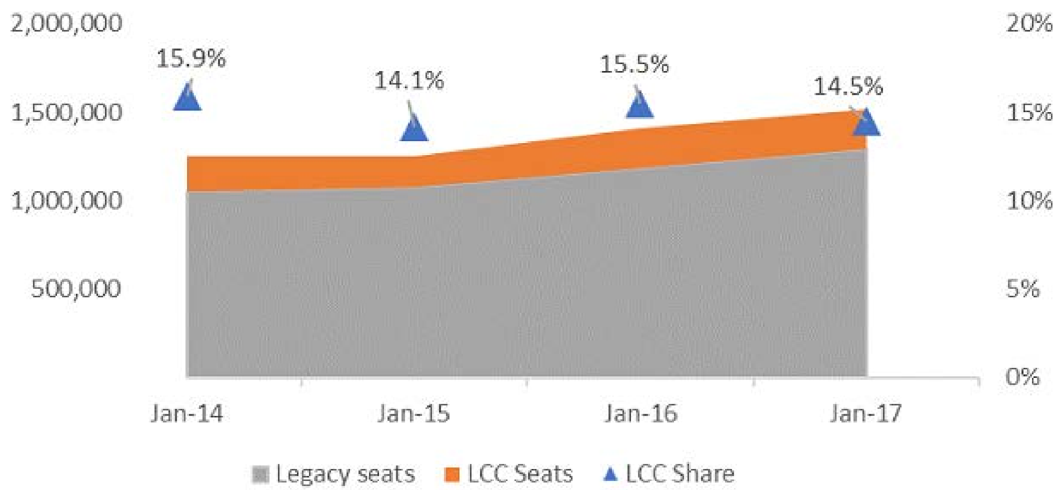


Figure 4.2. Long-haul low-cost growth and market to/from Australia (*Source: OAG, 2017*)

As opposed to the Australian market, LCCs account for only 2% of capacity in Asia-Europe market, with five long-haul LCCs competing in the market, compared to only two in 2015. As reported by CAPA (2018a), despite the anticipated expansion of the low-cost service in this sector in next few years, the projected capacity share for this particular market will not exceed 5%. The market will be dominated by three low-cost carriers: Icelandic Wow Air which will connect the capital Reykjavik with Delhi at the end of 2018, Malaysian Air Asia X that plans to launches the service to Eastern Europe in 2019 and Thai Lion Air that aims at launching service to Western Europe in 2020.

The airline sector witnessed the emergence of FSC's low-cost subsidiaries in the recent few years, mainly stemming from the effort to create a counter-strategy against their pure low-cost rivals. International Airlines Group (IAG) was among the first FSCs in Europe to launch a long haul low-cost carrier Level at the beginning of 2018. The airline commenced its operation from Barcelona Airport in June 2017 by offering transatlantic flights to Oakland (3 flights per week) and Los Angeles (2 flights per week) and flights to leisure destinations in Latin America – Buenos Aires (3 flights per week) and Punta Cana (2 flights per week) (Routes Online, 2017). Similar to its European counterparts, Japan Airlines has an ambitious plan to launch its new long haul low-cost carrier by 2020. In contrast to IAG that uses the existing aircraft from its numerous fleet (i.e. A330-200) for its long haul low-cost service, Japan Airlines considers to acquire additional Boeing new generation aircraft for its long haul subsidiary (CAPA, 2018b).

Nevertheless, irrespective of the core business strategy adopted by the airlines, the entire concept of long-haul low cost service is the highly adhered the strategy to exploit a fuel-efficient next generation aircrafts manufactured by either Boeing or Airbus. The next subsection provides a comprehensive overview of aircraft with their key operational characteristics that enable airlines to sustain lower fares on longer distances.

4.2. Technological development of next generation aircraft

Boeing and Airbus, the leading airplane manufacturers nowadays, have always had a fundamentally different perspective of future market development. In Boeing's (2005) "Current Market Outlook", the company states that "the single-aisle airplanes will dominate future deliveries", and "the share of 747 and larger airplanes will fall from 6% to 4%" at the end of 2024, whereas Airbus's (2005) "Global Market Forecast" emphasizes that "twin-aisle and large aircraft will take a bigger role" in the future. In other words, Airbus envisages the strong dominance of hub-to-hub network structure which will be supported by the employment of large wide body jets, such as A380, while Boeing foresees the development of the "hub bypass" network structure consisting of new long haul city pairs directly connected by using its next generation aircraft B787. As stated in Morrell and Lu (2007), the economic rationale that supports Boeing's vision (i.e., the transition from hub-to-hub operations towards hub by-pass) can be found in growing congestions at the hubs and improved economics for hub by-pass.

The major hub airports within Europe and the U.S become more and more congested, while some of them have reached the saturation level which does not allow further expansion in terms of available capacity. Moreover, most of them have faced the internalization of external environmental costs (both noise and emissions) that could favor the development of hub by-pass network in order to avoid additional environmental penalties. Morrell and Lu (2007) analyzed the difference in environmental costs for two patterns of service: hub-to-hub and hub by-pass. They found that the noise and emissions social cost impact of the hub by-pass networks was significantly lower than the hub-to-hub in all five long-haul markets investigated. The key characteristic of the routes considered, however, is that the long-haul sector includes at least one non-hub city (e.g. Glasgow and Hamburg) and the other city is a pure hub. Further analysis could be done on routes where both cities are non-hubs, but it would then be less likely that the route would have sufficient traffic potential.

The second important driver for introduction of point-to-point hub by-pass flights could come from a new long-haul aircraft type (e.g. the B787 and A350) or from the application of LCC techniques to these sectors. Considering that "LCC capacity on flights of more than 3000 nautical miles grew to more than 5% in 2017 compared to less than 1% in 2007" (Boeing, 2018), acquiring the advanced fuel-efficient next-generation aircraft will serve as a backbone for LCC sustainable business model strategy that continues growing around the world.

In spite of manufacturers' opposite perception of future aircraft size, both manufacturers invested substantial resources in developing a new generation of long range single-aisle airplanes with technical specification largely exceeding their ancestor in many aspects. The usage of composite material inbuilt in the structure of these airplanes has allowed the reduction in weight and consequently led to less fuel consumption that still constitutes a significant portion in airline operating cost. Qatar Airways has undoubtedly triggered a new era of a revolutionary changes in the airline industry when launching the first flight from Doha to Frankfurt with new single-aisle long haul Airbus A350 at the end of 2014 (Routes Online, 2016). With a smaller number of seats and very long-range capabilities, these types of airplanes provide airlines the unprecedented flexibility in network design regardless of their core business (low-cost or full-service) model. Although the purchase of new airplanes requires intense financial resources, fleet modernization is an essential strategic undertaking that allows airline's reoptimization, reduction in operating costs and competitive position on the market. Thus, the introduction of new airplane's type should be subject to comprehensive investigation and market analysis due to its long-lasting impact on airline's business performance.

In the last few years, several airlines in Europe, as well as in the other parts of the world, invested large financial resources in acquiring new types of airplanes. These advents permanently altered the global market outlook enabling connections of a great number of distant points in a cost-efficient manner. Introduction of new types of airplane has recently become particularly appealing to low-cost carriers in serving long-haul markets. As above mentioned, there are still long haul low-cost airlines, particularly those founded by parent companies that have not succeeded to acquire the next generation aircraft types, as their fleet relies on the availability of specific aircraft type in their parent companies However, Norwegian Airlines is certainly the leader in this challenging task and its capacity is strongly supported by the Europe biggest ever order of 222 single-aisle aircraft worth $21billion (Routes Online, 2018). At the end of 2017, the airline comprised 146 Boeing aircraft, of which 22 were B787 Dreamliners, 118 were B737-800s and 6 were B737 MAX.

4.2.1. The Boeing family

The passenger seat configuration for different series of the Boeing's 787 family is presented in Table 4.2. As it can be seen from Table 4.2, the seat capacity for standard 2-class configuration ranges from 242 seats (for B787-8) to 330 seats (for B787-10), while the maximum range varies from 13.6 thousand kilometers (for B787-8) to the revolutionary 14.1 thousand kilometers (for B787-9).

Table 4.2. Characteristics of different Boeing B787 airplane series

	Passengers (2-Class configuration)	**Range (km/nmi)**
B787-8	242	13 620/7 355
B787-9	290	14 140/7 635
B787-10	330	11 910/6 430

Source: (Boeing, 2017)

According to Boeing (2017), fuel efficiency and range flexibility of the 787 family help airlines optimize their fleets and networks while opening new non-stop routes. Additionally, Boeing B787 airplanes is designed to produce significantly lower emission of carbon dioxide (CO_2) and other green houses gasses (GHG) including methane and nitrous oxide (NO_x), as well as noise level. Both lower production of nitrous oxide and noise level may directly affect the level of airport charges, as many of the airports worldwide introduced these two types of charges as a tool to stimulate airlines to acquire new generation of aircraft.

Table 4.3. Production of NOx and noise categorization for three types of Boeing's engines

	Engine type	**NOx total mass (kg per engine)**	**Number of engine**	**Noise category**
B747-400	RB211-524H	24,5	4	Chapter 4 High
B777-300ER	GE90-110B1	34,88	2	Chapter 14 High
B787-900	Trent 1000-CE3	20,94	2	Chapter 14 Low

Table 4.3 provides the comparison of the amount of nitrous oxide and noise level produced by specific engine type installed in three different Boeing's aircraft types used in long-haul operations. The data for the production of nitrous oxide are obtained from ICAO Aircraft Engine Emission Databank officially published on EASA (2019a), whereas the data on noise level is obtained from EASA database of certification noise levels containing all approved aircraft configurations (EASA, 2019b). As observed form Table 4.3, the NOx emission and noise level of new B787 are significantly reduced in comparison to B777 and B747 as a result of intense technological improvements. The airlines that exploit this type of aircraft can make substantial saving in airport charges as it will be lately discussed in Section 5.2.

Moreover, an aircraft seat capacity of between 340 and 450 passengers is seen as suitable for average long-haul routes by offering a reasonable tradeoff between capacity and low variable operating costs over a heterogeneous route structure. Figure 4.3 depicts the market coverage by B787 that enabled opening more than 100 non-stop direct routes across the globe. With such kind of airplanes, the future global network is likely to experience tremendous changes as it allows connection of a large set of distant cities with non-stop service. Such connections were not viable in the past due to the limited range of airplanes used or due to the absence of bilateral agreements.

Figure 4.3. New potential markets with the introduction of B787 into service (*Source: Boeing, 2017*)

4.2.2. The Airbus's family

As the Boeing's major rival, Airbus promptly introduced its new A350 model to compete with Boeing's next generation 787 Dreamliner. As observed from Table 4.3, Airbus actually developed three versions of the A350 with the 350-900 being the most ordered by airlines across the globe. Essentially, the A350 is the Airbus successor to its long-haul A330 and A340, significantly outperforming its aluminum long-haul range competitors in terms of fuel consumption (up to 25% more fuel-efficient). In absence of available sources that provide information on aircraft's specific CASK, a recent presentation of Brian Pierce (IATA, 2012) illustrates the energy intensity (expresses as MJ per passenger kilometer) produced by different aircraft types which can serve as a good approximation of overall efficiency, particularly fuel efficiency. As observed in Figure 4.4, the Airbus A350 lies on the bottom in terms of energy intensity produced, significantly outperforming other aircraft types of the similar range.

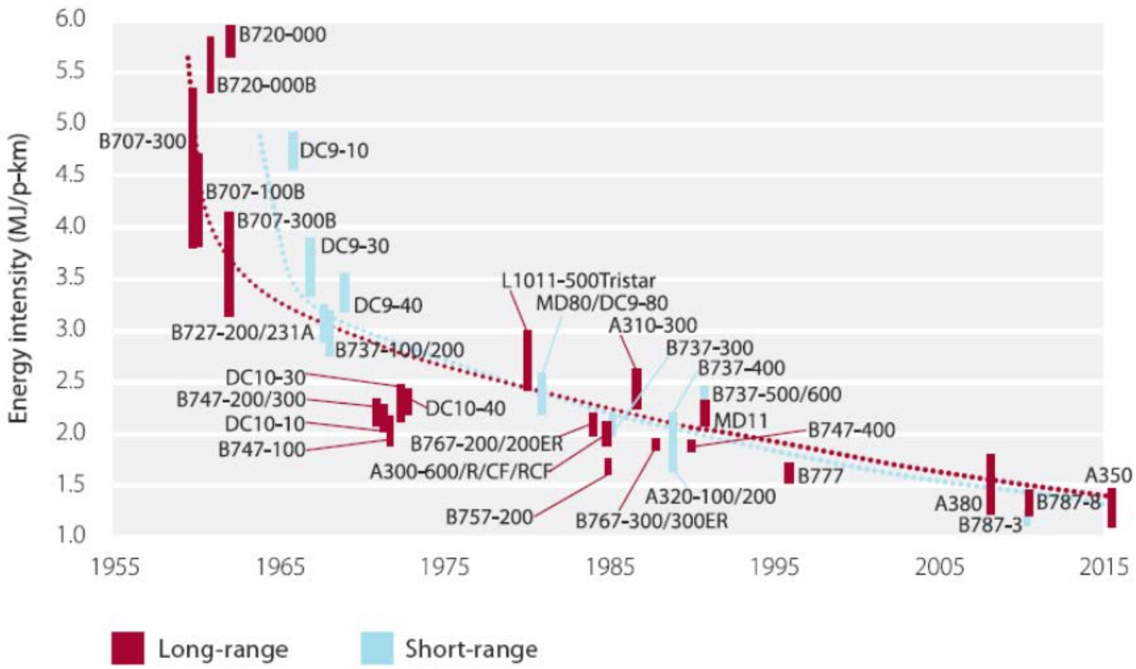


Figure 4.4. Energy intensity produced by different aircraft types (*Source: IATA, 2012*)

Some important specification of A350 series are given in Table 4.4.

Table 4.4. Characteristics of different Airbus A350 airplane series

	Typical seating	Max payload (tones)	Range (km/nmi)
A350-800	280	12.95	15 200/8 207
A350-900	325	16	15 000/8099
A350-1000	366	20.89	14800/7991

Source: (Airbus, 2017)

In addition to its efficient fuel consumption, the A350 significantly enhanced the interior of its new airplanes. Airbus (2016) claims that the total number of orders for these three types accounts for 777 airplanes from 41 customers, with A350-900 (580 order) certainly being the most ordered by airlines across the globe. It is worth emphasizing that among the large number of A350's customers nowadays, Singapore Airlines announced the usage of A350-900ULR (ultra-long range) on the world's longest non-stop flight from Singapore to New York (Points Guy, 2015). The range of A350-900ULR is 10 thousand miles and it exceeds the 9,500 mile flight from Singapore to New York. With its also advantageous geographical position, on the shortest way between many points between the East and the West, it seems that Singapore Airlines could gain substantial benefit from acquiring this type of airplanes.

4.3. North Atlantic market in the light of low-cost competition

Prior to market liberalization, the airlines in the North Atlantic[2] market have always struggled to achieve the rationalization of schedules through various forms of alliances that are primarily based on code share agreements and coordinated frequent flyer programs. The ratification of the Open Sky agreements between the European Union and the United States came into force in March 2008 and superseded the individual EU country Open Sky Agreements that many EU countries had with the U.S., commencing with the Netherlands in 1992 (Pitfield, 2009). Shortly after, the European Union and Canada agreed on establishing the Open Sky agreement in 2009 in addition to "comprehensive economic partnership agreement" stipulated in 2008 with the aim to facilitate trade between two regions. In other words, the Open Skies agreements allow any EU, US or CA airlines to operate commercial point-to-point flights between the relevant regions without any restrictions. In line with these institutional and regulatory changes, the composition of the alliances has gradually evolved to the stage where all the major air carriers belong to one of the three global strategic alliances (the Star Alliance, One World and Sky Team). These events served as an additional stimulus for several new North Atlantic long haul carriers (i.e. Norwegian, Eurowings, Westjet and Wowair) to commence their operation in this well-established market.

According to Soyk et al. (2017) four groups of carriers can be distinguished on the North Atlantic market: airlines that are part of a joint venture (JV), airlines that are part of an alliance but not part of a JV, leisure carriers, and those mentioned newly emerging LCCs.

In addition to partnership in alliance that does not necessarily assume the financial collaboration between the members, some airlines establish the extensive collaboration

[2] In this thesis, the terms "North Atlantic" and "transatlantic" will be used interchangeably.

through joint ventures that involve financial implications either through revenue-sharing or a profit-sharing mechanism. The most successful joint venture agreements are formed between the groups of airlines in each of three global strategic alliances: the first joint venture was formed between Star Alliance members Air Canada, United Airlines and the Lufthansa Group carriers Austrian Airlines, Brussels Airlines, Lufthansa and Swiss. The second joint venture was established between the Sky Team members Air France, Alitalia, Delta Airlines and KLM. The third joint venture was created between One World members American Airlines, British Airways (including Paris-based carrier Open Skies), Finnair and Iberia.

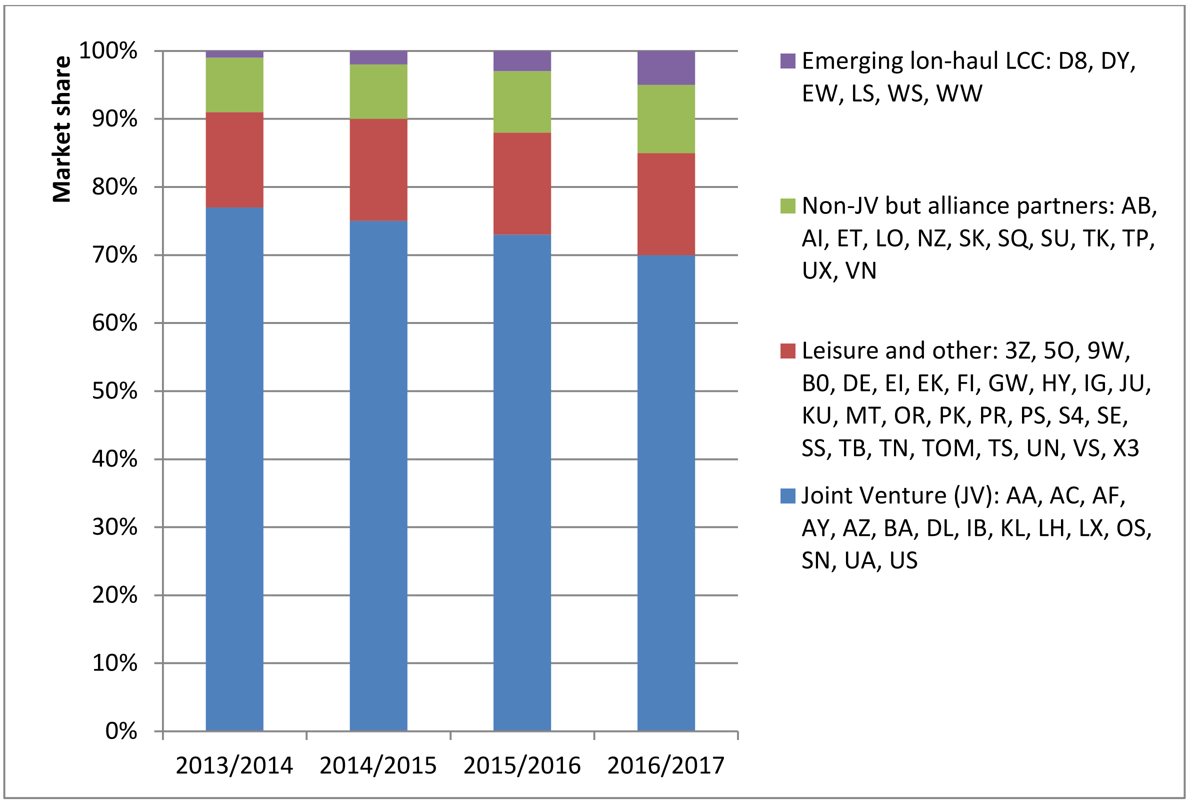


Figure 4.5. North Atlantic seating capacity share split by carrier type (*Source: Soyk et al. (2017))*

As observed from Figure 4.5, the joint venture carriers demonstrate significant dominance in the North Atlantic market with the market share of 77% in the combined summer and winter flight plan periods 2013/2014, although this share gradually shrank to 70% in

2016/2017. Still, TAP and Air Berlin[3], although members of Star Alliance and Oneworld respectively, are not involved in any North Atlantic joint ventures. However, these carriers rather cooperate through less intensive arrangements mainly relying on code-share agreements between partners. Their market share is pretty stable over the observed period, fluctuating around 8% to 10%. Likewise their non-joint venture counterparts, the leisure carriers (often referred to as charter carriers) keep the constant market share of around 15% in the period observed. The leisure carriers are normally owned by tour operators that combine two or more travel services (e.g. transport, accommodation, catering, etc.) and sell them either through travel agencies or directly to final consumers (Rodríguez and O'Connell, 2017). Among leisure carriers that operate across Atlantic, Thomson Airways, as a subsidiary of TUIfly, and a large UK charter, Thomas Cook, offer flights to some of the preferred long-haul leisure destinations in Latin America (e.g. Mexico), and several destinations placed in the Caribbean region[4] (e.g. Dominican Republic, Cuba and Jamaica), but with substantial lower frequencies than their counterparts.

Finally, the North Atlantic market became particularly appealing to relatively new low-cost carriers, as they recognized the potential of remaining profit pool that was previously split among three large joint venture carriers. In addition, the Open Sky agreement broke the regulatory barriers and motivated several European-based long haul LCCs, such as Eurowings and Norwegian, to penetrate the market. Meanwhile, two relatively new long haul LCCs increased their presence on the North Atlantic, including Icelandair's WOW air that based its hub at Reykjavik, and Canada's Westjet, which now serves six Canadian destinations to London Gatwick where its aim to capture some of the 3.1 million passengers who travel between Canada and the United Kingdom each year.

[3] Air Berlin ceased operations on October, 2017.

[4] Soyk et al. (2017) include some leisure destinations placed in the Caribbean region and Latin America as a part of North Atlantic market, although in the rest of the thesis this term "North Atlantic" market refers to destinations mainly placed on the territory of the U.S. and Canada.

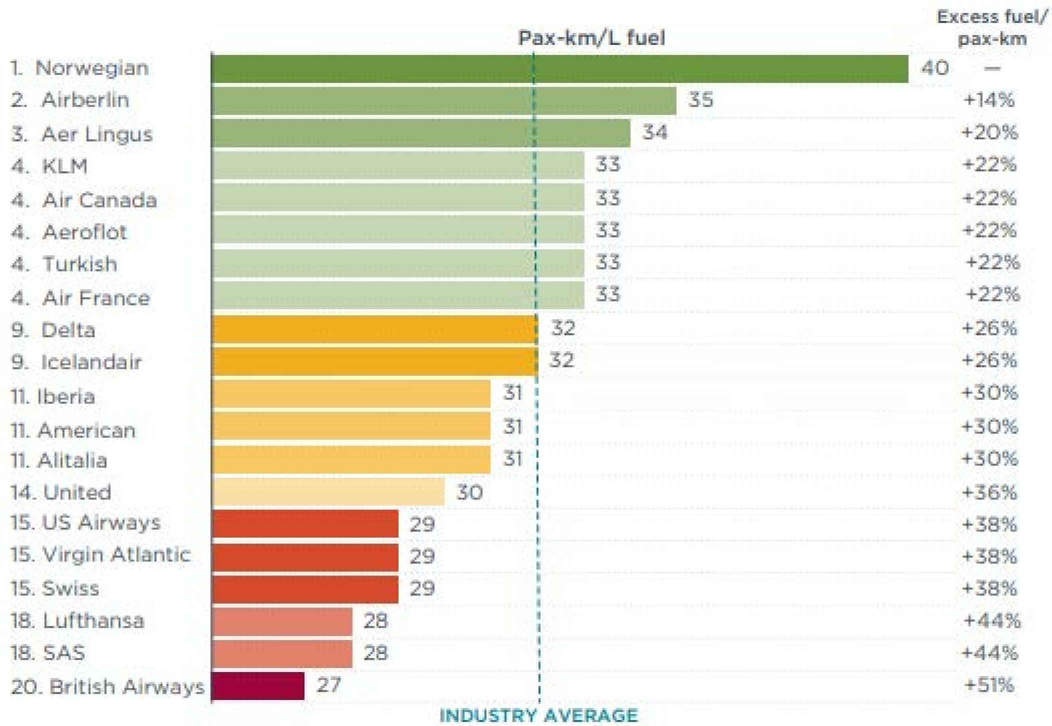


Figure 4.6. Fuel efficiency of the top 20 airlines on transatlantic routes in 2014 (*Source ICCT, 2015*)

It is worth mentioning that Norwegian Air Shuttle was the most efficient airline in transatlantic market in 2014, on average providing 40 passenger kilometers per liter (pax-km/L) of fuel on its predominately Boeing 787-8 fleet (ICCT, 2015). As shown in Figure 4.6, the large European legacy carriers Lufthansa, SAS and British Airways that jointly held 20% of total ASK in transatlantic market in 2014, was the least efficient with approximately 44% more fuel burnt per passenger kilometer compared to Norwegian. Consequently, Norwegian was also the most efficient airline in terms of CO_2 emission producing 720 kg CO_2 per passenger round trip on its most prominent route from Oslo to New York John Kennedy, whereas Lufthansa and British Airways produced significantly more, 1 200 and 1 100 kg CO_2 on their round trip from Frankfurt to New York and London to New York, respectively.

5. Non-price aspects of competition between FSCs and LCCs in long-haul sector: A case study of transatlantic market

The purpose of the first analysis in this thesis is to reveal some major aspects of non-price competition between FSC and LCC in transatlantic market based on panel dataset. The methodology on the different aspects of competition explained in Chapter 2 (according to methodological framework proposed by Doganis (1991)) will serve as a guideline to investigate potential differences and similarities between British Airways and Norwegian Air Shuttle's service that operate several competing transatlantic routes. The part of the analysis presented in this Chapter is published in Kuljanin et al. (2018a).

Table 5.1. Long haul low cost operations ranked by weekly seat capacity (2nd -8th October 2017)

Rank	Airline	Weekly seats	Number of routes
1.	AirAsiaX	133458	21
2.	Norwegian	87337	48
3.	Scoot	69144	18
4.	Jetstar Airways	46900	14
5.	Air Canada rouge	37923	20
6.	Thai AirAsia X	31668	4
7.	NekScoot	24070	6
8.	Cebu Pacific	13080	5
9.	Azul	12466	4
10.	Eurowings	11780	12

Source: CAPA (2017)

As it was previously mentioned, Norwegian Air Shuttle was the pioneering company in long haul low cost sector in Europe that launched its first long haul flight in 2013 between Oslo and New York and shortly after between Stockholm and New York. In addition to these transatlantic flights from Scandinavia (including Copenhagen), the carrier introduced long-haul links from three large European metropolises: London (2014), Paris (2016) and Barcelona (2017). By the end of October 2017, the airline's long haul network encompassed 26 destinations and 48 routes (Table 5.1) that place it as the largest long haul low cost operator in terms of network size and in the second place in terms of weekly seats (CAPA, 2017).

The carrier captured 81.3% of seat capacity in the European long haul low-cost sector, becoming the first big player in the global marketplace in 2016 (O'Connell and Rodriguez, 2017). Additionally, the low cost operations in the transatlantic market have experienced a substantial growth with approximately 6% of the total market share in terms of total seat capacity in 2017 compared to around 3% in 2016, the success that is partially driven by the rapid expansion of Norwegian Air Shuttle in this market (CAPA, 2017).

5.1. Outlook of competing segment of transatlantic market

This section aims to identify the set of routes in the transatlantic market that connects London with different cities in the U.S. where British Airways (BA) and Norwegian Air Shuttle (DY) competes each other. Additionally, the section provides essential characteristics of their service in this particular market segment that further allows better insight into the level of competition. With its eleven transatlantic routes (by September, 2018), Norwegian became the major competitor to British Airways, the major legacy carrier that has been operating these routes for many years. It is worth mentioning that many of these routes British Airways operated with American Airlines through the joint-venture agreement that came into effect since November 2010. The comparison between fares in 2008 and 2012[5] has statistically shown that the joint-venture agreement had particular effects on the reduction of British Airways' economy fares, while in the case of American Airlines the effect was observed in business airfares (Ustaömer et al., 2015). Table 4.2 outlines the characteristics of six competing routes between Norwegian and British Airways (the routes to Seattle, Denver, Austin, Chicago and Tampa were not introduced into the service at the time of investigation, thus they remained out of scope of the analysis) in terms of the airport operated, frequency of flying and schedule in winter timetable 2017/2018. The main sources of information were the Internet sites of

[5] These two dates represent the time period which covers two years before and two years after the joint venture formation.

both carriers (www.britishairways.com and www.norwegian.com). For the selected routes, from both sites one can easily retrieve the information on airport operated, weekly frequency of flying, time of departure and arrival, total duration of flights, fares for different tariffs, aircraft operated and code-share partner (in the case of British Airways).

5.2. Schedule-based aspect of competition

As discussed in the Section 2, the schedule-based aspect of services, in addition to prices, plays a key role in the decision-making process by the potential customer when he/she opts between different carriers on the market. The airline will devote particular efforts to design a convenient schedule (i.e. frequency operated, their departure and arrival times, routings taken and in particular whether flights are direct or involve one or more stopovers) in order to target the potential segment of passengers that are in the focus of their strategic planning. Thus, each item of the schedule-based feature will be separately examined to determine the level of competition between carriers. As it can be observed, Norwegian operates all its transatlantic flights from London Gatwick (LGW) which provides more flexibility in terms of airport charges (Figure 5.1) as well as slot allocations compared to the major London Heathrow (LHR) airport that has been operating at the level of traffic saturation in last several years. On the other hand, British Airways flights are mainly concentrated at LHR, although it directly competes with Norwegian on New York, San Francisco, Orlando and Fort Lauderdale routes from LGW.

However, not all routes presented in Table 5.2 are characterized by the same level of competition between these two airlines in terms of different aspects of schedule-based features. It is evident that competition will be intensified when there are overlapping characteristics of the service offered. However, the market share on specific routes will be highly affected by passenger’s personal preferential towards a specific aspect of services. The competition will be certainly intensified when both carriers offer their flights with similar schedule (the same day and broadly similar departure times), as is the case with New York and Los Angeles routes that are generally featured as high-density routes. It is notable that BA operates its flights to New York (JFK) and Los Angeles (LAX) with significantly higher frequencies that accounts for thirteen and five daily flight for JFK and LAX respectively, in comparison to DY that mainly operates two daily flights in the case of New York and one daily flight in the case of LAX.

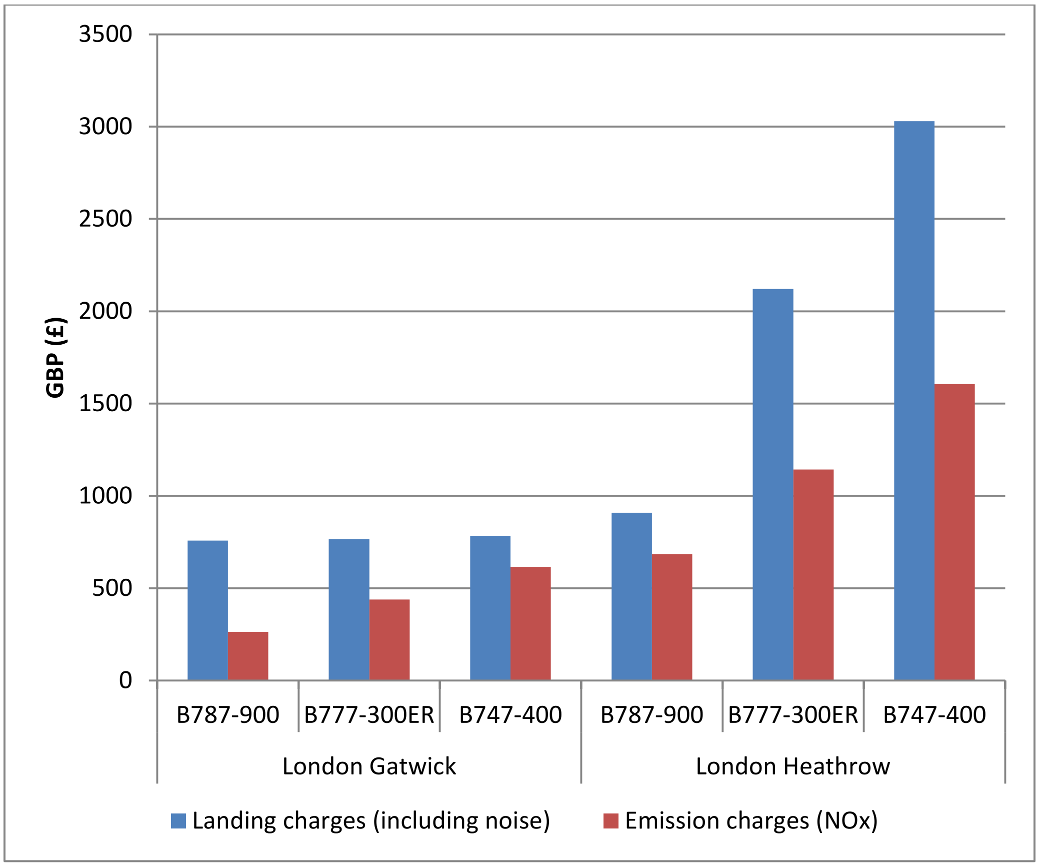


Figure 5.1. Airport charges for different aircraft types at LGW and LHR

In addition to these touristic destinations, BA and DY firmly compete on the route from London to Boston, where BA offers its flight only from LHR on daily basis with four departures evenly spread across the day, whereas DY offer five flights per week. On the other hand, Norwegian operates the Miami route four times a week by connecting LGW with Fort-Lauderdale (FLL), the secondary airport placed in the vicinity of Miami. The same route (i.e. LGW-FLL) is operated by BA three times per week, while the carrier also operates this route from LHR (i.e. route LHR-FLL) with one stopover at Dallas Airport in the code share with its partner American Airlines[6] every day with high frequency accounting up to ten daily flights. It is worth mentioning that in addition to its flights to FLL from LGW and LHR, BA also operates direct flight to Miami International Airport (MIA) on a daily basis with the frequency of four flights per day.

Bearing in mind the variety of airport-pairs that connects these two cities offered by these two carriers, one can consider the competition occurred in the adjacent airport-pair market in order to create the comprehensive outlook of the competing market. In the case of Florida Orlando (ORL) and San Francisco Oakland (OAK), similar service offered by these two carriers will certainly lead to fierce battle among the rivals. It is apparent that in the case of LGW-OAK, the carriers offer their service on different days in the week with different times of departure, but still with a comparable number of departures on a weekly basis. In the case of LGW-MCO route, the carriers operate this route three days per week (although on different days), but BA operates it with double frequencies in comparison to DY. However, one must bear in mind that competition between BA and DY on the LGW-OAK route is not straightforward since BA also operates the flights in the adjacent market by connecting LHR with the major airport in San Francisco metropolitan area (i.e. San Francisco International Airport –SFO).

Based on the schedule given in Table 5.2, it can be concluded that DY concentrates the departure times of its flights in the early to mid-afternoon, whereas BA tends to operate its flight in the morning or early afternoon. However, BA generally operates all the observed routes with the higher frequencies that place the carrier in a more favorable position over its LCC rival. In other words, multiple departures across the day allow potential passengers to find a flight that is a closer to their desired time of departure reducing the schedule delay in this way.

[6] In 2010, there was no schedule coordination between American Airlines and British Airways and they were departing at similar times that created 3 hour gap in the schedule from LHR to JFK. However, the joint venture enabled carriers to expand their flights more equally across the schedule (Ustaömer et al., 2015)

Table 5.2. Characteristics of competing transatlantic routes between Norwegian Air Shuttle (DY) and British Airways (BA) in 2017/2018 winter timetable

Destination airport	Origin airport	Days of operation	Frequency	Schedule departure
New York (JFK Airport)				
DY	London Gatwick	1234567	2 daily flights	06:00; 17:10
BA	London Heathrow	1234567	13 daily flights	From 08:25 to 19:50
BA	London Gatwick	1234567	1 daily flight	16:45
Los Angeles (LAX Airport)				
DY	London Gatwick	1234567	1 daily flight	12:50
BA	London Heathrow	1234567	5 daily flights	From 10:35 to 15:30
Boston (BOS Airport)				
DY	London Gatwick	1234567	1 daily flight	16:00 (4, 7); 16:20 (1,3); 16:50 (5)
BA	London Heathrow	1234567	4 daily flights	From 11:15 to 19:10
Fort Lauderdale-Miami (FLL Airport)				
DY	London Gatwick	1234567	1 daily flight	16:20 (1); 14:55 (3,5); 14:50 (7)
BA	London Gatwick	1234567	1 daily flight	09:05 (1, 4); 09:10 (6)
Florida Orlando (MCO Airport)				
DY	London Gatwick	1234567	1 daily flight	14:05
BA	London Gatwick	1234567 1234567	1 daily flight 2 daily flights	11:35 (1,2,3); 11:00 (7) 11:35; 13:20
San Francisco – Oakland (OAK Airport)				
DY	London Gatwick	1234567	1 daily flight	12:55 (2, 6); 12:45 (4); 14:20 (7)
BA	London Gatwick	1234567	1 daily flight	08:45 (1); 10:10 (3); 11:00 (6)

Source: constructed based on the information from airlines' official websites

Thus, BA will certainly have a competitive advantage over DY for the segment of passengers who highly regard convenient take-off and landing time over the price. For instance, BA offers thirteen daily flights spread across entire day at LHR compared to one daily flight offered by DY. With its well-established flights to New York, BA can capture the portion of passengers who highly regards early departure times. With its late afternoon flight, DY could count on the price sensitive segment of passengers who are willing to arrive late afternoon in New York and it is likely that certain portion of these passengers previously used the legacy carrier's flight. Afternoon departure times are generally characteristic of all DYs' transatlantic flights from London Gatwick, as it is probably seen as a good strategy that provides the balance between different passenger segments' requirements.

The aircraft operated by the carrier is one of the items which has to be considered within schedule-based feature of the service. DY exploits a uniform fleet that contains B787-900 with 294 seats onboard for all routes considered. On the other hand, the British Airways fleet is rather heterogeneous, consisting of different types of aircrafts of the same manufacturer, but also the aircraft from different manufacturers. As observed from Table 5.3, the majority of its transatlantic routes BA operates with either its B747 or B777 aircraft. The carrier does not provide the exact configuration of its airplanes on specific routes at its official Internet site on the page that provides additional information on the flight in question.

Table 5.3. Aircraft types operated on transatlantic routes by British Airways and American Airlines from LHR and LGW in 2017/2018 winter timetable

Destination (Airports)	British Airway Fleet (frequency)	American Airlines Fleet (frequency)
New York (JFK)	B747 (5), B777 (3)	B777 (4)
Los Angeles (LAX)	B747 (1), B787 (1), A380 (1)	B777 (2)
Boston (BOS)	B777 (3), B747 (1)	-
Miami (FLL)	B777 (1)	-
Orlando (MCO)	B777 (1)	-
San Francisco (OAK)	B777 (1)	

Source: constructed based on the information from airlines' official websites

In addition to airline's timetable and frequency, the on-time performance becomes of overwhelming importance to a large number of passengers as they require a punctual and convenient service. As investigated in Suzuki (2000), the passengers who experienced the flight delay with particular airline in the past are likely to switch that airline for their subsequent flights. The author also found that such inconvenience may adversely affect an airline's market share induced through the passenger' experience. DY records poor on-time performance on its flight from London Gatwick to New York John Kennedy with only 66.1% of flights being on-time (average delay of 30 minutes) in January 2017 reported by CAA (2018). However, such poor on-time performance could jeopardize the overall airline image particularly in the light of competition, bearing in mind that its major rival, BA, has better on-time performance at London Gatwick with 80.7% of flights being on time with an average delay of 20 minutes in the same period.

5.3. Comfort-based aspect of competition

It is very well-known that schedule-based characteristics of the service are on top of priorities for short or medium-haul flights. On the contrary, comfort-based features of the service, particularly the seating comfort and the quality of in-flight service, increase in relative importance when it comes to the long-haul sector (Doganis, 1992). The interior layout and configuration of the aircraft highly influence the passenger's perception of the airline service. As it was discussed in Section 2, space appears to be among the most important comfort variables perceived by the passengers as they are keen to have more legroom and space for their personal belongings. On the other hand, airlines try to make a trade-off between seating density and unit costs since more seats installed in the cabin leads to lower operating costs per seats. Thus, the airline has to be very cautious in making the decision about this issue. In addition to the decision on the seating density, an airline has to decide on the number of separate classes within the cabin since this will have a direct implication onto the structure of passengers on a particular flight, and consequently affect the airline's yield. However, bearing in mind that long-haul flights are tedious, passengers are also interested in in-flight entertainments and the nature and quality of the food and beverages provided during the long hours spent in the airplane.

As already discussed in the previous sub-section, BA operates its transatlantic routes with various aircraft types and various aircraft configurations which highly affect the capacity offered. As observed from Table 5.3, B777 is very often used by both British Airways (and its code-share partner American Airlines) on all considered transatlantic routes, except Los Angeles route. As it can be found on the Internet site Seat Guru (www.seatguru.com), British Airways owns two types of B777, series 200 and series 300, each of which has a variety of configurations (versions). The B777-200 has two versions (V1 and V2) with three class and four class configurations respectively (Table 5.4), while B777-300 has only a four class configuration. The three classes of B777-200 is a more common configuration accounting for 275 seats onboard split into 203 standard seats, 24 recliner seats and 48 flat-bed seats. The second, less common version, with four classes has 224 seats which are divided as follows: 122 standard seats, 40 recliner seats, 48 flat-bed seats and 14 open suits. The total number of seats at B777-300 version encompasses 299 seats.

Table 5.4. British Airways B777 and B747 configurations

	B777			**B747**		
	B777-200 (V1)	B777-200 (V2)	B777-300	B747-400 (V1)	B747-400 (V2)	B747-400 (V3)
Standard seats	203	122	185	243	185	145
Recliner seats	24	40	44	36	30	30
Flat bed seats	48	48	56	52	70	86
Open suites	-	14	14	14	14	14
Total	**275**	**224**	**299**	**345**	**299**	**275**

Source: www.seatguru.com

Additionally, the B747 is a larger airplane that can accommodate more passengers onboard ranging from 275 seats to maximum 345 seats in the four-class configuration. As previously mentioned, this difference of 70 seats between these two configurations could lead to false calculation of capacity on daily, weekly and annually basis (either underestimation or overestimation). Thus, additional effort should be made to reveal the exact configuration of the aircraft used on a specific flight in order to minimize potential miscalculations.

The seat pitch and seat width in the corresponding aircraft types are given in inches and shown in Table 5.5. As it can be observed, the dimensions of seats are standardized over different types of aircraft as well as over different series of the same aircraft type. The slight variation from standard seat pitch is observed in "flat bed" and "open suites" seats in the third version of B747-400 with seat pitch accounting for 73 and 79 inches respectively.

Table 5.5. Dimension of seats in British Airways travel classes

	B777-200,-300; B747-400 (V1, V2)		B747-400 (V3)	
	Seat pitch	Seat width	Seat pitch	Seat width
Standard seat	31	17.5	31	17.5
Recliner seat	38	18.5	38	18.5
Flat-bed seat	72	20	73	20
Open suites	78	22-	79	22

Source: www.seatguru.com

As already discussed, each of the four different types of seats from Table 5.4 coincides with different travel classes offered by BA on its transatlantic flights. British Airways offers four classes labeled as follows: "Economy", "Premium economy", "Business" and "First class". Table 5.6 provides the specifications of the each of four classes with detailed information on the availabilities offered to passengers including baggage allowances, food and beverage, seat dimensions, access to luxury lounges, fast track security, etc. As observed from Table 5.6, there is no sharp differentiation among the product components between economy and premium economy class, except in baggage allowances and seat pitch. BA permits passengers to carry two bags of 23kg in Premium Economy instead of one bag of 23kg allowed in the economy class. Seats installed in Premium Economy provides more room for legs and personal belonging as the seat pitch is slightly extended (by 8 inches) in comparison to economy classes. On the other hand, the product features significantly differ between the economy class (including premium economy) and the business class (including first class). In comparison to service components offered to passengers in economy classes, the product feature is significantly enhanced in business and first classes especially in the area of food and beverage structure and ground service (i.e. access to lounges, dedicated check-in areas and fast track security).

Table 5.6. British Airways classes' specifications/availabilities (*Source:* www.britishairways.com)

	Economy	Premium Economy	Business class	First class
Personal in-flight entertainment on demand	Included	Included	Included	Included
Headphones	Complimentary	Noise-reducing	Noise-cancelling	Noise-cancelling
Complimentary baggage allowance	1 x 23 kg (exception on economy Basic)	2 x 23 kg	2 x 32 kg	3 x 32 kg
Handbag/laptop bag plus an additional cabin bag (1 piece)	Included	Included	Included	Included
Seat pitch	31 inches	38 inches	6 ft fully flat bed	6 ft 6'' fully flat bed
Food and bar	Food, refreshments and bar service on board	Food, refreshments and bar service on board	Complimentary 4 course meal with fine wines and champagne	Dine from our à la carte menu when you want and enjoy flexible dining options
Dedicated check-in area	-	-	Included	Included
Personal in seat power socket	-	-	Included	Included
Access to British Airways lounges where available	-	-	Included	Included
Club Kitchen, our self service snack and refreshment area	-	-	Included	Flexible dining option
Washbag with amenity products	-	-	Included	Included
Fast Track security	-	-	Included	Included
Elemis Travel Spa and Skin Therapies at LHR Terminal 5, Terminal 3 and JFK Terminal 7	-	-	-	Included
Quintessentially, an exclusive complimentary concierge service	-	-	-	Included
Turndown Service whenever you decide to sleep	-	-	-	Included

Additionally, BA created a high quality customer-oriented service in the first class by providing exclusive concierge service and spa treatment at its base LHR. With the product characteristics significantly outperforming the service characteristics of its competitors, BA strongly competes with other carriers (especially with DY) for the segment of passengers who are willing to pay for advanced service. Based on the components of service in each of the classes offered, it is evident that BA aims to attract and hold a wide range of segments of customers encompassing those who are highly sensitive to price, but also addressing those who regard other aspects of service than price.

On the other hand, DY has a uniform long-haul fleet consisting of only one aircraft type Dreamliner (i.e. B787) with two series – B787-800 and B787-900. As observed from Table 5.7, the configuration of B787-800 accounts for 290 seats, while the series 900 can accommodate either 344 or 350 passengers. The passenger cabin on all DY's aircraft is physically divided into two passenger classes – economy and premium. The seat pitch in the economy class ranges between 31 and 32 inches with seat width accounting for 17.2 inches, whereas the seat width is in the premium class is more comfortable accounting for 19 inches with seat pitch of 46 inches.

Table 5.7. Norwegian Air Shuttle's B787 configurations

	B787-800	B787-900		
	B787-800 (V1)	B787-900 (V1)	B787-900 (V2)	B787-900 (V3)
Standard seats	259	288	309	315
Recliner seats	32	56	35	35
Total	291	344	344	350

Source: www.seatguru.com

As already mentioned, Norwegian's aircraft have a configuration with two separate classes: economy and premium. Each of these two classes has different tariffs that reflect the level of service offered to potential customers. Within the economy class, DY offers three tariffs labeled as "Lowfare", "Lowfare+" and "Flex", the prices of which are substantially lower than those in the "premium economy" cabin ("Premium" and "PremiumFlex").

Table 5.8. Norwegian's classes'-specifications/availabilities

	Economy cabin			Premium cabin	
	Lowfare	**Lowfare +**	**Flex**	**Premium**	**PremiumFlex**
Hand baggage	Free 1 x 10 kg	Free 1 x 10 kg	Free 1 x 10 kg	Free 1 x 10 kg	Free 1 x 10 kg
Checked baggage	$	Free 1 x 20 kg	Free 2 x 20 kg	Free 2 x 20 kg	Free 2 x 20 kg
Seat reservation	$	Free	Free	Free	Free
Fast track	$	$	Free	Free	Free
Meal	$	Free	Free	Free v	Free
Lounge	-	-	-	Free	Free
Changes	$	$	Free	$	Free
Refundable	-	-	Free	-	Free

Source: www.norwegian.com

As observed from Table 5.8, the concept of "Lowfare" is very similar to the lean product offered by pure low-cost carriers that primarily charge passengers for transportation service. By purchasing the ticket in the "Lowfare" tariff, passengers are allowed to take only one piece of hand luggage, with the possibilities to add one or more items listed in Table 5.8 with some restrictions imposed on using lounges at airports and possibilities to refund the ticket. However, DY allows significantly lower weights of hand and checked baggage compared to BA, the competitive disadvantage that can play a decisive role in passenger's decision making process. The upper tariffs provide the additional components of service that are gradually upgraded to "PremiumFlex", as the ultimate tariff that encompasses all passengers' availabilities. However, in addition to comparing the product features offered by BA and DY, it can be concluded that DY "PremiumFlex" is the most similar to BA "Premium economy". Although there is a slight portion of overlapping market between BA and DY encompassing the segment of passengers who are willing to pay more for a higher level of service, BA promotes the high quality standard of its business and first classes that cannot be compared to any of the DY classes. Thus, the very high-yield passengers remain exclusively in the focus of BA, whereas the fierce battle among carriers is expected for more price sensitive segments of passengers. It is evident that Norwegian's lower-price based strategy aims at diverting the portion of those price sensitive passengers away from incumbent carriers, and to secure some portion of business segment that is sensitive to prices in order to increase its yield.

5.4. Airline's image and reputation

BA is one of the oldest airline in Europe and one of the leaders in the creation of its corporate brand among European carriers. The airline brought a number of extensive innovative approaches to transform the image of a "bloody awful" airline that prevailed before privatization among people in Britain to "the world's favorite airline" in the early 1990s. Despite the considerable improvements in the marketing strategy with the focus on customer-oriented service, BA faced a number of challenges as a result of a rapidly globalized marketplace. Namely, the airline's customer base was shifting as the portion of British was falling and the number of other nationalities flying with the airline was rising (Hatch and Schultz, 2003). In order to derive the potentials of its global market more efficiently, BA decided to change some aspects of its visual identity by decorating the tail fins of airplanes with folk art patterns created by a large number of artists across different nations engaged by BA. Whereas the new design was perceived as a dominance of formidable colonial power by those who reside outside Britain, the anger and hostility was the major reactions at home, among British conservatives, many of whom constitutes BA's business class passengers (Hatch and Schultz, 2003). Additionally, replacing the British flag as the British mark on the planes with a contemporary stylish symbol was considered as undermining to British confidence. Despite the apparent difficulties in finding the optimal corporate branding that should have narrowed the gap between traditionalism and the globalization-driven requirements, the new millennium started with the top management's initiative to position BA as a "premium airline" with a primary focus on long-haul routes and business passengers. However, the airline also invested substantial efforts to position itself as an airline of choice for the segment of leisure passengers looking for a cheaper fare. The airline launched its "WorldOffers" sub-brand that aims at addressing the leisure segment of passengers separated from advertising and brand-building aimed at the status-conscious business travelers (Shaw, 2004). With the brand positioning that encompasses both segments, BA is perhaps among very few that successfully dealt with contradictory tasks.

On the other hand, Norwegian Air Shuttle is a rather young company founded in 1993 that began operating as a low-cost carrier in 2002. The airline owns one of the world's youngest and greenest fleet with 160 aircraft with an average age of 3.7 years. The airline is awarded as the most fuel-efficient airline on transatlantic routes and world's best long haul low-cost airline in 2018 (Norwegian, 2019). DY positions itself as an airline that primarily offers a core low-cost product that can be easily transformed into a more comprehensive package for passengers that require improved service. In this way, the airline offers service that can be an appealing choice for the price-sensitive segment of passengers, but also for the segment of passengers who are not willing to pay for a luxury service, but still have additional requirements towards different aspect of airline service. DY puts substantial efforts in designing its aircraft that are very often referred to as "Red Nose", because the front is painted red. In addition to the painted nose, DY depicts some of the most famous persons who "pushed the boundaries" and contributed to the world with some distinctive ideas and activities on the tail fins of its aircraft. At the beginning, the tail fins were depicted with the persons originating from Scandinavian countries, while afterwards DY added famous person from the countries they operate including the U.S., Argentina, France and many others. By placing the famous people who challenged the world on tail fins, DY endeavors to create an analogy between the activities of these people who brought revolutionary changes with its aim to break the well-established monopoly of its competitors in several markets.

With its strong corporate brand based on an innovative approach, Norwegian succeeded to position itself as a leading low-cost airline in the long-haul sector in Europe. Norwegian is today the largest foreign airline to fly between New York and Europe in terms of passenger numbers. However, Norwegian recorded poor on-time performance from the UK airports which seriously threatens to diminish its brand reputation within the broader audience[1]. In the last two years, DY faced serious financial problems emerging as a result of ballooning jet fuel costs and new competition from incumbent carriers (Forbes, 2018). The next section provides the comprehensive assessment of different aspects of competition that exists or has existed in high-density markets such as these that connect two metropolitan cities London and New York. The influence of Norwegian on legacy carriers, specifically British Airways as a dominant player in the London-New York market, will be thoroughly discussed through traffic and capacity statistics.

5.5. Some aspects of competition on the London – New York route

The London-New York route has always been one of the high density routes in the world. The two metropolises have historically had important links that catalyze the mobility of people, trade and services. Moreover, London stands out as an important gateway that consolidates a large portion of traffic from different parts of Europe, Africa and Asia that terminates in the New York area. Both London and New York are served by multiple airport systems, which allow a large number of possible connections between the two cities. Table 5.9 provides a list of airports that serves these two metropolitan cities along with their respective numbers of passengers.

For example, London is served by five airports among which London Heathrow is the largest one and serves as a hub of the full-service carrier British Airways. Additionally,

[1] The poor on-time performance of Norwegian's flights might stem from the similar issue already reported by Ryanair. Namely, Ryanair (2018) submitted the formal complaint to the European Commission and the UK CAA about NATS (with British Airways being one of the shareholders) discrimination on London Stansted against Ryanair. In the first quarter of 2018, 52% of all NATS delay took place in London Stansted, while 10% occurred in London Gatwick which had direct impact the dominant carriers in these two airports, Ryanair and Norwegian Air Shuttle.

London Gatwick is the second largest airport and is extensively used by the long-haul low cost airline Norwegian Air Shuttle. On the other hand, the New York metropolitan area is served by three airports, among which John F. Kennedy (JFK) is the largest and the most important one from which a large number of intercontinental flights are performed. In other words, the same city pair (i.e. London-New York) can be realized throughout different airport pairs enabling potential passengers to select between different airports, as well as between different airlines (Table 5.9).

Table 5.9. Airports serving the metropolitan areas of London and New York

City	Airports	IATA code	Number of passengers in 2015 (mil.)
London Airport System	London Heathrow	LHR	74.9
	London Gatwick	LGW	40.3
	London Stansted	STN	22.5
	London Luton	LTN	12.3
	London City	LCY	4.3
New York metropolitan area	John F. Kennedy International	JFK	56.8
	Newark Liberty International	EWR	37.5
	LaGuardia Airport	LGA	28.4

Source: Port Authority (2015)

5.5.1. Number of passengers and airlines' market share

In order to gain a better insight into the different degree of competition, Table 5.10 outlines the characteristics of the three routes (airport pairs) that served these two metropolitan areas in 2016. The data on the number of passengers have been retrieved from U.S. DoT's T-100 database provided by the Bureau of Transportation Statistics that allows free access.

As seen from Table 5.10, London – New York route was operated by two European carriers (BA and DY), four American carriers (VS, AA, UA, DL), one Middle Eastern carrier (KU) and one Asian carrier (AI). The high density route among these three airport pair options is certainly one that connects two major airports (LHR and JFK). This route encompassed the market share of 69.9% in terms of passenger numbers. BA is a dominant carrier on this route accounting for 45.4% of all passengers transported and followed by three American carriers – VS, AA and DL, the market shares of which account for 28.3%, 16.6% and 9.4% respectively. With slightly less than half a million of passengers transported, Virgin Atlantic holds a substantial market share of nearly 30%, which places it second, after BA. It is worth mentioning that among the American carriers, American Airlines is the member of the same global alliance, OneWorld, as British Airways which assumes a tight coordination in flight schedule between them. Additionally, these two airlines also cooperate through code-share agreements and thus, they cannot be considered as real competitors.

Table 5.10. Some characteristics of the London –New York route in 2016

Airport pairs	Airlines operated	Number of passengers	Total number of passengers (% of all pax)	Market share per route per airline
LHR-JFK	British Airways (BA)	651 397	1 434 051 (69.9%)	45.4%
	Virgin Atlantic (VS)	406 229		28.3%
	American Airlines (AA)	238 756		16.6%
	Delta Air Lines (DL)	135 282		9.4%
	Kuwait Airways (KU)	2 387		0.2%
LGW-JFK	Norwegian Air Shuttle (DY)	112 469	168 480 (8.2%)	66.8%
	British Airways (BA)	56 011		33.2%
LHR-EWR	United Airlines (UA)	232 118	449 963 (21.9%)	51.6%
	British Airways (BA)	134 599		29.9%
	Virgin Atlantic (VS)	74 050		16.5%
	Air India (AI)	9 176		2.0%

Source: Calculation based on US DOT data source of Bureau of Transportation Statistics (2018)

The second dense route is the one that connects LHR with EWR, the second largest airport in the New York area, with a market share of almost 22%. Contrary to LHR-JFK route in which BA holds the largest market share, this route is operated by the American carrier, United Airlines, as a dominant player with a market share exceeding 50%. BA is also present at this airport pair market with a market share reaching almost 30%. Virgin

Atlantic holds a smaller share in total passenger compared to the share in the LHR-JFK route, but still accounts for 16.5%. The flag carrier of India, Air India, has a very minor share of only 2% of total passenger transported in this airport pair. Finally, the route that connects the second largest airport (LGW) and the major airport in New York (JFK) is characterized by the presence of a low-cost carrier DY that started its operation in the third quarter of 2014. In order to reduce the competitive pressure induced by low fares offered by DY, BA has recently announced its flights to JFK from LGW. However, the market share of BA is significantly lower compared to DY that holds almost 70% share and transported more than hundred thousand passengers in 2016.

Figure 5.2 shows the historical trends in terms of the number of passengers on the London-New York route including traffic on all three possible airport pairs. It was felt that 2010 was an appropriate year to start, because this period coincides with the beginning of recovery of the airline industry after the severe world economic crisis in 2008.

As observed from Figure 5.2, the number of passengers from London Heathrow to New York JFK had seen a steady growth in the period from 2010 to 2013. Afterwards, the number of passengers fluctuated around 1.45 million reaching its peak in 2015 when almost 1.5 million people were transported between these two points. Among five airlines operating these routes, it is evident that BA has the highest market share. BA is currently the most dominant carrier on this route with market share encompassing approximately 45% of total passengers carried, followed by three American carriers: VA, AA and DA. However, not all of them have been the real competitors. For example, AA offers some portion of its flight in cooperation with BA through code-share agreements, while the other portion it operates independently.

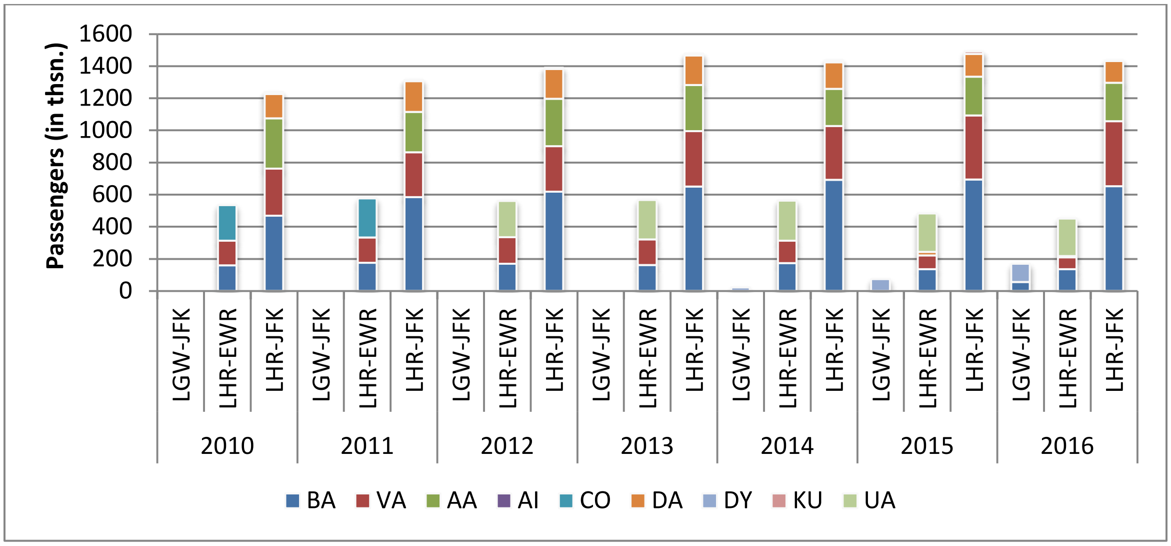


Figure 5.2. Number of passengers at the three routes connecting London and New York

Over the time horizon, VA has substantially increased its market share from 23.7% in 2010 to 28.3% in 2016, whereas AA reduced its share from 25.2% in 2010 to 16.6% in 2016. Finally, Kuwait Airways has been present on this route during the observed period, but its market share is not significant (less than 1%). On the other hand, the number of passengers at LHR-EWR was stable during the period from 2010 to 2014 accounting for around half a million passengers with a slight decrease in 2015 and 2016. Continental Airlines (CO) was present at this route with a significant market share in the past, but it withdrew from the market in 2012. Finally, the flights to New York have been introduced from LGW for the first time in 2014 when DY offered its service by affordable prices. Since then, this carrier records a rapid expansion with number of passengers exceeding one hundred thousand in 2016.

5.5.2. Market concentration of the London – New York route

The Herfindahl–Hirschman index (HHI) is defined as the sum of squared market shares of airlines in a market and thereby provides an easily interpretable measure of concentration (Lijesen, 2004). The HHI for a specific route can slightly vary depending on the measure used to express the market share and thus it can be calculated by either capacity offered or number of passengers transported. The HHI ranges from the value close to zero, indicating nearly perfect competition to ten thousand, indicating a monopoly. For the purpose of the thesis, the value of HHI is based on the market share expressed through number of seats (i.e. capacity of aircraft) offered by a specific airline. It is worth mentioning that depending on the configuration of the aircraft operated, the values of HHI can slightly differ. As a carrier with the most passengers carried, BA's configuration of two most dominant aircraft type B777 (two version – V1 and V2) and B747 (three versions – V1, V2 and V3) (Table 5.4), can have an impact on the value of HHI.

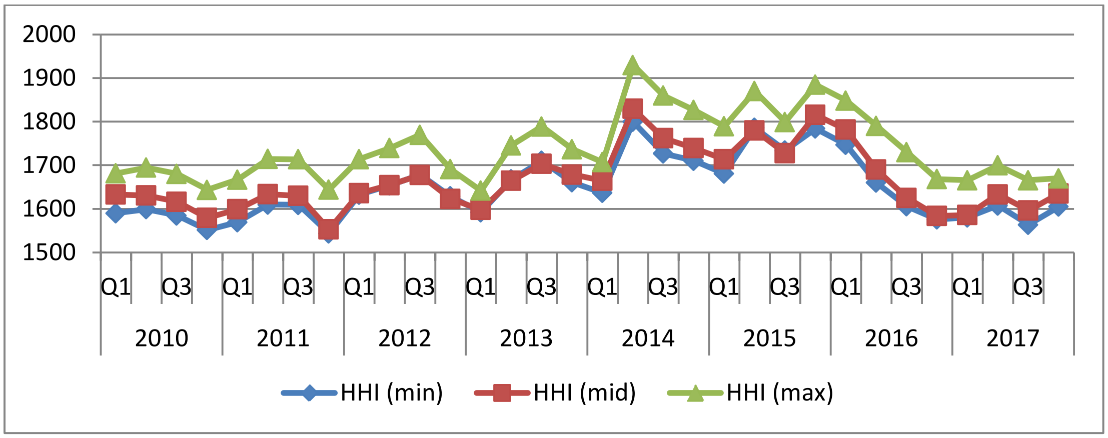


Figure 5.3. HHI index for different aircraft configurations for the London New York route

Figure 5.3 shows the different value of HHI based on maximum, medium and minimum configuration of aircraft operated on this route. The U.S. Department of Justice considers a market with an HHI of less than 1,500 to be a competitive marketplace, an HHI of 1,500 to 2,500 to be a moderately concentrated marketplace, and an HHI of 2,500 or greater to be a highly concentrated marketplace (U.S. Department of Justice, 2018). As observed from Figure 5.3, the market concentration index ranges from less than 1,600 in 2010 to more than 1,800 in the case of moderate capacity. Thus, the London–New York route can be characterized as a route with medium level competition, which might provide a benefit for potential passengers perceived through lower fares and higher level of service.

6. An econometric model of LCC competition effects on FSC's fares and passenger volume in transatlantic markets

The econometric model that aims to explain the effect on LCC competition on FSC’s price and number of passengers on long-haul routes is developed and presented in this chapter. The model shares the similarities with the models that investigate the similar topic to some extent, but it also bears the distinctive characteristics resulted from the careful selection of factors that serve as independent variables in two equations proposed. As shown in the previous section, the penetration of LCC on the transatlantic market boosted the new era of competition in long-haul transatlantic markets. The growth of LCC may further affect not only traffic volume on transatlantic routes, but also generate a fierce battle on prices among carriers. The model developed in this Chapter will examine how newly emerged LCC competition, measured in terms of particular LCC passenger volume, affects major FSN (the member of large alliance group) prices and traffic volume in several routes that connect London and selected U.S. cities. The initial research related to the application of above mentioned econometric model in transatlantic market is partially published in Kuljanin et al. (2018b).

6.1. Model specification

While the major purpose of this thesis is to examine the impact of LCC competition on prices charged by dominant FSC in the transatlantic market, the empirical model contains various measures that have been shown in the previous research efforts to affect the prices. The econometric model bears similarities to that proposed by Dresner et al. (2015) who examined the effects of Gulf carrier competition on U.S. airlines’ fares. However, slight modification in the selection of explanatory variables was necessary to conduct in order to capture the driving factors that affect passenger demands across different routes for the particular market. In other words, the econometric model is estimated to determine to what extent the entrance of a low-cost carrier affects the average fares offered by a well-established (dominant carrier) FSC on particular transatlantic long-haul route markets. The price on a route is assumed to be the function of the number of passenger variable, specific fuel cost variables, competition variables and route characteristic variables. According to economic theory, number of passenger (i.e. passenger demand) is highly influenced by the prices and as such, has to be treated also as an endogenous variable. The model consists of two simultaneous equations with fares ($Price_{FSC}$) and number of passenger (Pax_{FSC}) treated as dependent variables, while all others variables mentioned above are used as explanatory (i.e. independent) variables. The simultaneous equation system for all routes of interest is specified as follows:

$$lnPrice_{FSC_{r,t}} = \alpha_0 + \alpha_1 lnPax_{FSC_{r,t}} + \alpha_2 lnHHI_{r,t} + \alpha_3 Fuel_{r,t} + \alpha_4 Pax_{LCC_{r,t}} + \sum \alpha\, Time_t + \varepsilon_{r,t}$$

$$lnPax_{FSC_{r,t}} = \beta_0 + \beta_1 lnPrice_{FSC_{r,t}} + \beta_2 Trade_t + \beta_3 lnPax_{LCCr,t} + \beta_4 lnTourists_t + \sum \beta Time_t + \varepsilon_{r,t}$$

Where:

$Price_{FSC_{r,t}}$-	Dominant FSC's average one-way fare in city-pair route market r in time t;
$Pax_{FSC_{r,t}}$-	Total number of one-way FSC's passenger;
$HHI_{r,t}$ -	Herfindahl-Hirschman Index for city-pair route market r in time t, computed based on airlines' capacity (i.e. seats) on the city-pair route market;
$Fuel_{r,t}$ -	FSC's fuel costs for all flights on the city-pair route market r in time t;
$Trade_t$ -	Total imports and exports of goods and services between origin and destination countries of a given city-pair market in time t measured in U.S. dollars;
$Tourists_t$ -	Total number of tourists between origin and destination countries of a given city-pair market in time t;
$Time_t$ - time;	Binary variable that explains the changes in the passenger number over
$\varepsilon_{r,t}$ -	Random error term that varies across carrier-routes and across time.

The next subsection provides the detailed information on the variables used in the research, followed by the results of descriptive statistics.

6.2. Variable description and measurements

6.2.1. Dependent Variables

Average FSC fare

There are two dependent variables in this study: FSC' fares and number of passengers. The first dependent variable $Price_{FSC}$ represents a FSC passenger-weighted average one-way fare in a given city pair market in a given quarter and is measured in EUR. Having in mind that a specific city pair can be served by multiple airport pairs, the weight assigned to each airport pair is derived to calculate the total average fare on the city level. The corresponding weights are computed as a ratio between the number of passengers transported on a specific airport-to-airport route that connects the observed city pair market by the total number of passengers on that particular city pair market. The variable $Price_{FSC}$ for the given city pair is calculated as follows:

$$Price_{FSC} = \sum_j w_j Price_{FSC_j}$$

where j denotes the airport-to-airport pair within observed city pair market.

FSC passenger number

The variable number of passengers (Pax_{FSNC}) accounts for the FSC's total quarterly passenger volume in the observed city pair market.

6.2.2. Independent Variables

Number of passengers carried by LCC competitor(s)

The independent variable is the total number of passengers transported by long haul low-cost carriers in a given quarter on a specific transatlantic route (PAX_{LCC}). This variable serves as a proxy to capture the degree of LCC competition in the market that connects city pairs. As widely discussed in the Section 5, the LCC focus its service from less congested airports that are located in the vicinity of major hubs from which FSC operate their flights. In particular routes, the FSC and LCC have overlapping services since they operate the same airport pairs.

Market concentration (HHI index)

In addition to the number of passengers transported by the LCC, there are several additional variables that apparently have a substantial impact on FSC's fares and passenger volume. The level of competition in a market has been traditionally perceived as a major factor that influences ticket prices. As stated in Borenstein (1989), the dominance of the major airport by one or two carriers appears to result in higher fares for consumers. Moreover, the study of Cho et al. (2012) shows that the impact of adding competition at competing airport pairs is not as large as the impact of adding competition on the primary airport pair, it does significantly reduce fares. In the case of this study, this means that Norwegian Air Shuttle's service on the route between London Gatwick and New York John Kennedy directly competes with British Airways' service from London Gatwick to New York JFK, but also has a certain impact on the British Airways' service from London Heathrow. Thus, the Herfindahl-Hirschman Index (HHI) has been employed as an appropriate structural index to evaluate the competitiveness of air travel market on the city pair levels. The HHI can range from 0 to 10,000 with 0 representing a perfectly competitive route with an infinite number of competitors and 10,000 representing a monopoly route (Dresner et al., 1996). For the purpose of this research, the list of the competing airports within the area of the several observed metropoles is defined in Section 5. Finally, the city-to-city HHI index between the city i and city j for each carrier k in the quarter t is calculated as the sum of squared market shares in the total capacity (i.e. number of seats offered) of all airlines operating in that particular market and is given as follows:

$$HHI = \sum_{k=1}^{n} \left(\frac{\sum Capacity_{tk}}{\sum Capacity_{t}}\right)^2 \qquad (1)$$

As previously mentioned, the total capacity offered by an airline is calculated based on the capacity of its aircraft operated on a specific route. As already discussed in the previous section, it is evident that a different seat configuration of the aircraft used by the airline on a specific route may lead to a slight variation in the HHI measurements.

The calculation of capacity for Norwegian is simplified due to their uniform fleet that contains B787-900 with 294 seats onboard for all routes considered. On the other hand, the British Airways fleet is rather heterogeneous consisting of different types of aircraft of the same manufacturer, but also the aircrafts from different manufacturers. As it can be seen from Table 9, the majority of its transatlantic routes British Airways operates with either its B747 or B777 aircraft. The carrier does not provide the exact configuration of its aircraft on specific routes at its official Internet site on the page that lists the fares of inbound and outbound flights.

Fuel costs per route

The airline industry has always been highly sensitive to jet fuel prices. Jet fuel price is characterized by the volatility and its fluctuations on the stock could have tremendous impact on the airline operating costs structure. For example, Gillen (2009) found that the 10% increase in fuel prices has a moderate impact on the international air travel reducing the air travel demand by 3%. As shown in Table 6.1, between 2007 and 2017 the fuel bill of FSC reached its peak of \$230 billion in 2013 which was more than 30% of total operating costs.

Thus, fuel price in the market together with the distance between a route market's origin and destination directly affects a carrier's total fuel costs and therefore, are included as proxy variables in the estimation of air fares. These two variables are combined in order to derive the new variable $Fuel$ for specific route market specified as follows:

$$Fuel\ cost\ [\$] = \sum_i Fuel\ flow\ [kg/min]\ x\ Flight\ duration\ [min]\ x\ Fuel\ price\ [\$/kg] x Number\ of\ departures$$

Where i denotes the various aircraft types in the FSC's fleet operated in transatlantic routes in given quarter t.

Table 6.1. Fuel impact on FSCs' operating costs

Year	% of Operating Costs	Average Price per Barrel of Crude (US$)	Break-even Price per Barrel (US$)	Total Fuel Cost (billion US$)
2004	17.2%	38.3	34.7	65
2005	22.0%	54.5	52.0	91
2006	27.2%	65.1	68.1	127
2007	28.6%	73.0	81.7	146
2008	35.7%	99.0	83.3	203
2009	28.2%	62.0	59.1	134
2010	26.9%	79.4	89.8	151
2011	29.8%	111.2	116.1	191
2012	32.3%	111.8	117.1	228
2013	32.0%	108.8	114.8	230
2014	29.2%	99.9	107.4	224
2015	24.1%	53.9	72.6	174
2016	19.1%	44.6	61.5	135
2017	19.8%	54.9	72.6	149
2018F	22.5%	70.0	85.1	188

Source: (IATA, 2018)

For the sake of comparison, Table 6.2 presents the share of fuel cost in total operating costs for two European LCCs, Ryanair and Norwegian Air Shuttle. Overall, the share of fuel cost in Norwegian's total operating costs tend to be higher than in the case of FSC (Table 6.1) with the average share of 40% in the years 2013 and 2014, while these shares gradually declined in recent few years to around 30%. On the other hand, the share of fuel cost in Ryanair's cost structure is even higher accounting for around 45% in the period between 2013 and 2015, while in recent few years the share shrank to around 35%. The higher share of fuel cost in total operating costs of LCCs is expected since these carriers succeeded to significantly reduce other operating costs by employing its lean business model.

Table 6.2. Fuel cost's impact on Ryanair and Norwegian total operating costs (calculation based on airlines' annual reports)

Year	% of Operating Costs	Total Fuel Cost (million €)
	Ryanair	
2013	45.25%	1885.6
2014	46.03%	2013.1
2015	43.19%	1992.1
2016	40.83%	2071.4
2017	37.42%	1913.4
2018	34.69%	1902.8
	Norwegian Air Shuttle	
2013	41.39%	490.6
2014	41.15%	658.9
2015	32.73%	540.4
2016	28.03%	526.7
2017	30.55%	765.1

Trade

The growth in trade has always had a great impact on air travel demand. This is particularly true for the business market, and one could anticipate that the number of trips between a specific pair of countries is tightly related to their mutual economic activities. According to the results obtained by Gillen (2009), the amount of trade in merchandise and service has a positive impact on international air travel demand with the estimated elasticity of 0.83 (i.e. the increase in trade of 10% leads to 8.3% increase of international air travel). Dargay and Hanly (2001) have empirically tested several major determinants of air travel demand between UK and 20 OECD countries. The results showed that the growth in trade had the greatest impact on air travel demand, and particularly for business market with long-run elasticity greater than one. The $Trade$ variable is measured as the sum of total imports and export between origin and destination countries of an observed intercontinental route market and serves as a proxy variable in the demand Pax_{FSNC} equation.

Number of tourists

Tourism has always been in a tight correlation to air transport development. The existence of long-haul air service between specific country pairs will certainly booster tourist flow and as stated in Graham (2008) it will further contribute to the economic and political stabilization of a tourism-based country. In 2012, over half of the 1.18 billion international tourists travelled by air – 53% of whom travelled for leisure, recreation and vacation (UNWTO, 2016). However, once the long-haul air service is established between specific markets, it is reasonable to expect that the relation between air transport development and touristic growth takes the opposite direction. In other words, the growth in tourism activity can provide the additional impetus to airlines to expand their service by adding additional frequencies into particular markets. The historical trend in the number of tourists is seen as a proxy variable for air travel demand in leisure markets. The variable $Tourists$ is calculated as the number of tourists between origin and destination countries of intercontinental route market and it is employed to capture the increased percentage of tourist passengers who fly on these routes. Some routes are featured exclusively as a leisure market, and thus the historical number of tourists is an inevitable factor that can serve as an important predictor of the tourist flow in the future. Although the growth of leisure market is highly related to economic and social conditions (such as income and leisure time), Graham (2000) claimed that lower cost of air service may fundamentally change the way consumers view air travel and the priority which they give to it. For the purpose of this research, several routes have been characterized as predominantly leisure routes such as those with one of its points in either New York or Los Angeles (California).

6.3. Data

The U.S. DoT's T-100 database provides the international market data reported by both U.S and foreign carriers when at least one point of service is in the United States or one at its territories. The data on the number of passengers for carriers of interest was obtained from the database for the period from 2010 to 2017 on a monthly level. The data are aggregated on the quarterly level to derive the number of passengers for both Norwegian Air Shuttle and British Airways on the transatlantic routes originating from the corresponding airports in London. The resulting dataset includes 84 observations at the carrier-route-quarter level, where the route market is defined at a city-pair level.

The associated air fares are provided by Zurich University of Applied Sciences based on Sabre Air Vision Market Intelligence containing four different types of databases. For the purpose of this study, the specific database Market Intelligence GDD was employed since this specific database contains the reliable information collected from over 40 different data sources including Sabre, Amadeus & Travelport, DOT, Sabre Fare Data, Innovata Schedule and Capacity Data and many other industry data sources. The database provides the information on base fare and total fare (which includes taxes & surcharge information that an airline collects from the passenger). For the purpose of the models proposed, the data on total air fares offered by the dominant incumbent carrier at different airport pairs were used. The given total air fares for different airport pairs that serve the same city pair were further aggregated to derive the average fare on particular city pair market.

The fuel consumption (i.e. fuel flow) for various aircraft types is obtained from Eurocontrol's Base of Aircraft Data (BADA) that provides information on true air speed, rate of climb/descent and fuel flow for conditions of climb, cruise and descent at various flight levels assuming a priori different aircraft load factor. The FSC's load factor of 80% is assumed which correspond to the data reported in Mott MacDonald (2016). The actual flight levels for the observed routes was retrieved from *Flight Radar*, an Internet site that monitors the world traffic in real time by providing the information on the type of aircraft operated, actual flight level, ground speed and duration of the flight. Thus, both information on the flight level and duration of the flight obtained in such a way were served as an input to define the fuel flow in BADA. Finally, the data on the variable *Fuel price* is based on IATA Jet Fuel Price Monitor (2017) that provides the data on fuel price on monthly level and for the purpose of the model these values are aggregated on a quarterly level.

The data on export and import between the countries (the sum of which reflects the total trade) was derived from the United Nation's Comtrade database. The data are provided on the monthly level, and further aggregated to the quarterly level.

Finally, the monthly data on the total number of tourists between the United States and the United Kingdom has been obtained from National Travel and Tourism Office (NTTO, 2018). Likewise the data on trade, the number of tourists were also given on the monthly basis and further aggregated to the quarterly level.

6.4. Empirical estimation method

Bearing in mind the existence of simultaneity between $lnPrice_{FSC}$ and $lnPax_{FSC}$, the estimation of these equations requires a special statistical treatment. In such a situation, the application of common statistical estimation techniques (such as Ordinary Least Square –OLS) could lead to the effect of simultaneity bias in the model. Alternative estimation techniques, such as two-stage least squares (2SLS) and three-stage least squares (3SLS), are deemed a powerful statistical tool to address the endogenous relation between dependent variables. Unlike the 2SLS technique that estimates the coefficients of each structural equation separately with taking into account any restrictions placed on that equation without considering the restrictions on the other equations in the system, the 3SLS estimates all coefficients simultaneously by taking into account all restrictions on such equations (Pitfield et al., 2010). While 3SLS can lead to an inconsistent estimation of the coefficients in the case of model misspecification, it is generally proved to be more asymptotically efficient compared to sequential 2SLS procedure (Kennedy, 2003), that fails to fully deal with simultaneity between $lnPrice_{FSC}$ and $lnPax_{FSC}$. Thus, the estimation of the model will be conducted using 3SLS procedure in the software package *R*. This procedure is an iterative estimation technique that combines a 2SLS procedure with the seemingly unrelated regressions procedure (Zellner and Theil, 1962).

The model as a whole will be applied on three transatlantic routes in order to capture the effect of LCC entrance on FSC's prices in the transatlantic market. Among six competing routes already discussed in Chapter 5, the model includes the routes originating at London to New York, Los Angeles and Boston, perceived as the high density routes. These routes were among the first that Norwegian introduced from the London airport system. The total number of observations accounts for 96 city-pair quarters that encompasses the time period of eight years starting from the first quarter of 2010 until the fourth quarter of 2017. 2010 is taken as a starting year since it coincides with the period of conclusion of the joint venture agreement between British Airways and American Airlines that enable the carriers to enhance their level of coordination and a significant reduction in operating costs.

6.5. Descriptive statistics

Table 6.3 and 6.4 provide descriptive statistics and bivariate correlation matrix among the selected variables for all three routes considered.

Table 6.3. Descriptive statistics (pooled sample)

VARIABLES (unit)	Mean	Std. Dev.	Min	Max
$Price_{FSC}$ (U.S. $)	1 567	256	1 075	2 161
Pax_{FSC}	111 394	64 700	43 447	249 606
HHI	2 305	1 170	1 553	5 254
Pax_{LCC}	17 200	8 735	989	33 800
Fuel (million U.S. $)	23.6	15.9	5.7	63.5
Trade (billion U.S. $)	29.2	2.8	22.5	34.8
Tourists (million)	1.06	0.20	0.70	1.53

As observed from Table 6.3, the average British Airways' one-way fare for the routes between London and the three selected cities was $1,567.The average HHI value for the given routes was 2 305. The average number of passengers carried by the low-cost competitor, Norwegian Air Shuttle, was around 17 thousands. Total average trade between the UK and the U.S. accounted for $29.2 million. Finally, fuel expenses for the given routes were approximately $41.8 million.

Table 6.4. Correlation matrix

		1	2	3	4	5	6	7
1	**$Price_{FSC}$**	1						
2	**Pax_{FSC}**	0.52	1					
3	**HHI**	0.66	0.48	1				
4	**Pax_{LCC}**	-0.43	-0.12	-0.64	1			
5	**Fuel**	-0.27	0.25	0.08	-0.61	1		
6	**Trade**	0.51	0.51	0.54	-0.54	0.24	1	
7	**Tourist**	0.62	0.78	0.34	0.16	-0.19	0.24	1

The results of correlation matrix shown in Table 6.4 are in line with prior expectations. Positive correlation is observed between two dependent variables $Price_{FSC}$ and Pax_{FSC}. Not surprisingly, the variable that reflects the average fare of British Airways $Price_{FSC}$ is in negative correlation with the number of passengers of the low-cost carrier Norwegian Air Shuttle. On the other hand, positive correlation is found between the number of passengers Pax_{FSC} and variables $Trade$ and $Tourists$.This finding supports the claim that trade between any two countries may significantly boost mutual activities and mobility of their inhabitants and is likely to follow the similar pattern. For the purpose of the model, all the variables are log-transformed except $Fuel$, $Trade$ and $Tourists$ which are originally normally distributed.

6.6. Model results

6.6.1. Regression estimates (pooled model)

Table 6.5 provides the estimation results for both regression equations (output from R is given in Appendix 1). The first column in Table 6.5 shows the coefficient estimates for the price equation, whereas the second column provides estimates for the price equation.

Bearing in mind that the variables in the model are previously log-transformed (except $Fuel$, $Trade$ and $Tourists$), the estimated coefficients must be interpreted as elasticities rather than slope-coefficient. The R-squared statistics for price and passenger equations is 0.58 and 0.91 respectively, suggesting a satisfactory model fit.

Table 6.5. 3SLS coefficient estimates corresponding to minimum cabin seating density

	$lnPrice_{FSC}$	$lnPax_{FSC}$
$Constant$	4.079*** (1.002)	21.01*** (4.08)
$lnPrice_{FSC}$		-1.464** (0.608)
$lnPax_{FSC}$	0.380*** (0.097)	
$lnPax_{LCC}$	-0.086*** (0.030)	-0.087* (0.047)
$Fuel$	-0.006*** (0.002)	
HHI	0.153 (0.092)	
$Trade$		0.029*** (0.010)
$Tourist$		0.922*** (0.118)
$Time$	0.868*** (0.280)	0.903* (0.484)
$Dummy\_NYC$		
$Dummy\_LAX$	0.430*** (0.104))	-0.857*** (0.093)
$Dummy\_BOS$	0.255* (0.143)	-1.240*** (0.071)
	$R^2 = 0.581$	$R^2 = 0.913$

The coefficients of the dummy variables should be interpreted relative to the reference route (LON–NY)

Notes: Standard errors are given in parenthesis

*,**,*** indicate the difference from zero at the 90%, 95% and 99% level

Taking into consideration the model as a whole, it is evident that the results of the model are in line with prior researches (Dresner et al., 1996; Dresner et al., 2015) and a priori expectations. The results of the price equation reveal that passenger demand and market concentration have a mathematically positive impact on air fares offered by British Airways, although the coefficient of market concentration appears to be statistically insignificant. As observed, the variable passenger number appears to be the major determinants of fares. A 10% increase in passenger demand results in an increase in fares of, an average, 3.8%. In other words, greater passenger demand will enable the carrier to raise its air fares to some extent, while more concentrated market (indicated as a higher value of HHI index) are generally less contestable, which may provide maneuvering space for a potential increase in air fares. At first glance, the coefficient for the variable fuel price may seem surprising due to its negative impact on air fares. After careful inspection of the correlation matrix, it is determined that variables fare and fuel price was positively correlated before LCC's entrance in the market. After the entrance of LCC, the variable fuel price started to be negatively correlated with fare. This finding implies that BA offered lower fares despite the apparent growth in fuel costs in order to efficiently combat the competitive pressure induced by Norwegian. Such behavior distorts the sign of the variable fuel price in price equation. However, although significant, its magnitude is minor in absolute value. Finally, Norwegian Air Shuttle competition ($lnPax_{LCC}$), the variable of the utmost importance in the research, has statistically significant and negative impact on the average British Airways fares. The coefficient estimate provides ample evidence that 10% increase in the number of passengers of Norwegian Air Shuttle results in a reduction of British Airways average fares by approximately 1% in the case of the pooled model. Despite the fact that Norwegian Air Shuttle operates its flights from the alternative airport, London Gatwick, it seems that its presence on the city pair market has a substantial impact on British Airways and such an impact cannot be ignored in the future.

In the passenger-demand model, both number of tourists and the level of trade between two countries are positively related to the number of passengers of British Airways. The coefficient of both the number of tourists and the level of trade between two countries are positively related to the number of passengers of British Airways. The coefficients of both variables are highly significant indicating that touristic and trade activities are likely to intensify the passenger flow between two cities. The model shows that 10% increase in the trade flow will contribute to, on average, 0.3% increase in passenger demand, while the number of tourists proved to be a significant contributor, as the model showed that 10% in touristic activity are likely to increase the passenger demand by approximately 9%. Such an impressive growth in passenger demand induced by tourist activity is reasonable, bearing in mind that New York is one of the most prominent touristic destinations in the world. According to NYC&Company (2018), the United Kingdom stands out as the first producing country for international tourists to this destination with the number of tourists exceeding one million passengers over the years. However, Los Angeles, as the second most populous city in the United States, after New York, is an appealing touristic destination. The empirical results show that higher fares adversely affect passenger numbers with the elasticity of -1.46 at the 5 per cent level (i.e. 10 % increase in air ticket cause the reduction in passenger numbers by around 15%). Similar to the price equation, the estimated coefficient for the number of passengers of the low-cost competitor Norwegian Air Shuttle ($lnPax_{LCC}$) has a negative impact on British Airways passenger counts as expected, exerting the elasticity of -0.09.

Based on the results obtained, it is evident that the presence of the low-cost carrier Norwegian Air Shuttle at London Gatwick has a substantial impact on British Airways average fare from both London Heathrow and London Gatwick. These findings are similar to those obtained by Cho et al. (2012), who claimed that adding competition at competing airport pairs could still significantly reduced the fares at the city pair market. Bearing in mind the well-known feedback economic mechanism between fares and passenger numbers, there is no doubt that British Airways's lower ticket prices (initially reduced as a result of the penetration of Norwegian Air Shuttle on the market) will have a favorable effect on passenger demand in the future. Furthermore, greater passenger demand will enable British Airways to increase the ticket prices according to the economic theory. Following the methodology proposed in Dresner et al. (2015), the similar mathematical interdependency between fares and passenger demand will be derived to determine the effect of competition induced by Norwegian Air Shuttle on British Airways's ticket price and passenger demand on the transatlantic market. The mathematical formulation given in Eq. 1 and 2 can be simplified as follows:

$$\Delta Price_{FSC} = \alpha_1 \Delta Pax_{FSC} + \alpha_4 \Delta Pax_{LCC} \quad (3)$$

$$\Delta Pax_{FSC} = \beta_1 \Delta Price_{FSC} + \beta_3 \Delta Pax_{LCC} \quad (4)$$

After mathematical transformation which assumes substituting (4) in (3) and (3) in (4), the following expression is derived:

$$\Delta Price_{FSC} = \Delta Pax_{LCC}(\frac{\alpha_1\beta_3+\alpha_4}{1-\alpha_1\beta_1}) \quad (5)$$

$$\Delta Pax_{FSC} = \Delta Pax_{LCC}(\frac{\alpha_4\beta_1+\beta_3}{1-\alpha_1\beta_1}) \quad (6)$$

The parameters in parentheses of Eq. 5 and 6 are calculated for minimum cabin seating density. The empirical results for Eq. 5 show that increase in Norwegian Air Shuttle's passengers by 10% will result in a British Airways's price drop by around 0.765 per cent. Similarly, the 10% increase in Norwegian Air Shuttle's traffic will reduce British Airways' traffic by 0.249 per cent. Based on the results obtained in Eq. 5 and 6, one can conclude that an increase in Norwegian Air Shuttle's traffic will, on average, have a higher influence on British Airways' prices rather than its traffic volume. This finding is expected since the capacity offered by British Airways on the observed transatlantic routes is significantly larger compared to the capacity offered by Norwegian Air Shuttle. Not surprisingly, Norwegian will divert some portion of British Airways' passengers by offering lower prices, but its influence will be still more pronounced in the price battle field.

6.6.2. Regression estimates for different HHI specification (London-New York route)

Overall, the results suggest that British Airways was likely reacting to the presence of Norwegian Air Shuttle competition by employing a counter-strategy that will diminish the effect of its LCC rival. British Airways' response to the actual entry can be based on the trade-off between capacity and price. The capacity expansion on the airport pair market is the most common strategy analyzed. This strategy aims at adding more frequency, switching to larger capacity aircraft or changing the aircraft configuration to add more capacity on the market. The latter two actions (i.e. switching to larger capacity aircraft or changing the aircraft configuration) could potentially lead to a reduction in unit cost of an incumbent carrier. Extension of capacity is very often applied as a part of "deterrence entry" action where the incumbent tries to add more capacity in an attempt to discourage the potential rival to enter the particular market rather than to maximize its own profits. A well-established incumbent is even willing to sustain financial loss for some period of time that a new entrant, who has limited available financial resources, cannot afford. In this way, the new entrant cannot sustain the competitive pressure and eventually exits the market. Surprisingly, British Airways employed extension of the capacity after Norwegian already started its transatlantic operation from London Gatwick, by adding flights from the same airport and by offering services at prices similar to its competitor. Thus, this section will thoroughly examine to which extent the capacity changes of British Airways could mitigate the impact of Norwegian Air Shuttle competition.

An econometric model is estimated to determine to what extent the operation of a low-cost carrier Norwegian Air Shuttle depresses British Airways' fares offered on one of the densest route in the world, the London-New York route. As observed from Table 6.6, three versions of the model were deployed to examine the influence of airlines' capacity on prices. As already mentioned, British Airways, as the dominant carrier with the majority share in capacity on the London-New York route directly affects the level of market concentration expressed through the HHI index. Modification of cabin seating configuration may serve as a strategic tool to mitigate the competitive pressure as it allows the airline to manage its capacity and on the other hand, does not impose substantial financial investments. Thus, each of the three versions of the model take into account a different cabin seating configuration ranging from the minimum number of seats to the maximum number of seats (as it was already discussed in Chapter 5) embedded in the HHI specification. In order to determine how the subtle changes in capacities may affect the price, the disaggregated model that takes into account only the London-New York route will be considered.

For each of the three versions of the model, the first column shows the results with $lnPrice_{FSC}$ as the dependent variable, while the second column provides the estimation results for $lnPax_{FSC}$ as the dependent variable. The R-squared statistics for all three versions of the model (0.69 and 0.65; 0.66 and 0.60; 0.64 and 0.58 respectively) suggest a satisfactory model fit. The results of all three versions lead to very similar results compared to the pooled model, while they are still slight differences among them.

Taking into consideration the model as a whole, it is evident that the results of the model are in line with the pooled model, as expected. The results of the price equation indicates that passenger demand and market concentration have statistically significant and positive impact on air fares offered by British Airways. Compared to the pooled model in which the coefficient of HHI was statistically insignificant (although positive), the coefficient in the disaggregated model appears to have statistically significant influence on the prices with the elasticity ranges from 0.858 to 0.566 in respect to the seating density configuration. The estimation coefficient of Norwegian Air Shuttle competition ($lnPax_{LCC}$) exerts even more pronounced negative impact on British Airways' price than in the case of the pooled model. The results show that 10% increase in the number of passengers of Norwegian Air Shuttle contributes to a reduction of British Airways' average price by more than 1% in the case of all three versions of the model. However, as observed, the most tremendous impact of Norwegian Air Shuttle's passenger numbers on British Airways's price is present in the third specification of the model with maximum seating capacity with the elasticity reaching almost 1.3.

In the passenger equation model, the British Airways' average price appears to be the most notable variable that affects the passenger number with the elasticities ranges between -0.98 to -1.22. In addition to prices, the number of tourists has statistically positive impact on passenger demand with the elasticity ranges from 0.858 in the case of the first model to 0.920 in the case of the third model. Although minor in its magnitude in comparison to tourists, the trade between two countries also has positive impact on passenger demand. The coefficient of Norwegian's passenger number is negative and significant in the pooled model, yet it is not statistically significant in the disaggregated model implying that Norwegian's passenger number has a positive effect only when all routes are considered at the same time.

However, the models show some differences in the effect of seating configuration layouts expressed through the HHI index, which is worth further discussion and explanation. Namely, it is reasonable to expect that capacity expansion may generate different effects on the price and the magnitude of these effects in highly driven by the incumbent's readiness to promptly react to new market conditions (i.e. LCC entry). Thus, the next subsection will thoroughly examine the effects of capacity extension implementation on the reduction of British Airways' prices.

Table 6.6. 3SLS regression estimates for the London-New York route

	Minimum cabin seating density		***Medium cabin seating density***		***Maximum cabin seating density***	
	$lnPrice_{FSC}$	$lnPax_{FSC}$	$lnPrice_{FSC}$	$lnPax_{FSC}$	$lnPrice_{FSC}$	$lnPax_{FSC}$
$Constant$	-4.18e+00 (2.30e+00*)	1.75e+01 (3.09e+00***)	-3.24e+00 (2.48e+00)	1.87e+01 (3.32e+00***)	-2.35e+00 (2.46e+00)	1.92e+01 (3.50e+00***)
$lnPrice_{FSC}$		-9.80e-01 (4.56e-01**)		-1.14e+00 (4.90e-01**)		-1.22e+00 (5.17e-01**)
$lnPax_{FSC}$	4.46e-01 (1.41e-01***)		4.89e-01 (1.46e-01***)		4.71e-01 (1.56e-01***)	
$lnPax_{LCC}$	-1.12e-01 (5.71e-02*)	-1.03e-01 (8.29e-02)	-1.24e-01 (6.09e-02**)	-1.18e-01 (8.68e-02)	-1.29e-01 (6.35e-02**)	-1.27e-01 (8.90e-02)
$lnHHI_{min}$	8.58e-01 (3.44e-01**)					
$lnHHI_{mid}$			6.60e-01 (3.60e-01*)			
$lnHHI_{max}$					5.66e-01 (3.86e-01)	
$Fuel$	-5.83e-03 (1.93e-03***)		-5.96e-03 (2.05e-03***)		-5.98e-03 (2.08e-03***)	
$Trade$		3.16e-02 (9.06e-03***)		3.22e-02 (9.52e-03***)		3.22e-02 (9.78e-03***)
$Tourist$		8.58e-01 (1.54e-01***)		9.00e-01 (1.63e-01***)		9.20e-01 (1.70e-01***)
$Time$	1.04e+00 (5.45e-01*)	1.02e+00 (8.37e-01)	1.16e+00 (5.82e-01*)	1.18e+00 (8.77e-01)	1.20e+00 (6.07e-01*)	1.27e+00 (8.99e-01)
	R^2=0.69	R^2=0.65	R^2=0.65	R^2=0.60	R^2=0.64	R^2=0.58

*,**,*** indicate the difference from zero at the 90%, 95% and 99% level

6.6.3. A micro analysis of HHI specification (time response component)

As observed from Table 6.6, the results of the regression models slightly vary with respect to the HHI specification which highly depends on the cabin layout. The models show that Norwegian Air Shuttle exerts lower influence at greater values of HHI index, which coincides with higher seating density. On the contrary, the market concentration (i.e. HHI index) seems to have a greater influence on British Airways's average fare at minimum cabin seating density. Since there is a general consensus in the relevant literature that fares are expected to be higher in more concentrated route markets, these findings may seem controversial at first glance. Essentially, they reflect the hypothetical assumption inherited in the model and are subject to debate. It was necessary to see if the proposed model(s) could be modified to better reflect the real conditions on the market.

It is very well known that different seating layouts in the cabin of a single aircraft can accommodate different numbers of passengers. The lower seating density of British Airways is very often related to cabin layout with maximum number of classes, whereas high seating density involved the introduction of additional seating mostly in economy classes and consequently the reduction of seats in higher classes. Concerning the characteristics of a particular market or its market segments, an airline may struggle to increase the high-yield passengers by offering more seats in higher classes (i.e. First class and Premium class) at the expense of reduction seats in the economy class. This strategy is particularly implied when the competitive pressure of other airlines is small or an airline is dominant on the market. On the contrary, in the case when an airline serves predominately leisure market, the higher seating density which is necessarily related to greater number of seats in the economy class, will be an inevitable tool to meet passenger demand.

In the case of the London – New York route, it is reasonable to assume that British Airways operated flights with a greater number of seats in the higher classes (i.e. lower number of seats in economy classes) prior to Norwegian Air Shuttle entrance in the market. As a counter-measure to the lower fares offered by the low-cost competitor, British Airways may react by maximizing the number of seats in the economy classes on its flights. The strategy could enable the carrier to retain the price-sensitive segment of customers by offering them more seats at affordable prices and consequently to avoid the deterioration of its revenue. This hypothesis is proved by the statement of Willie Walsh, chief executive of British Airways's parent company IAG, who claimed that adding the 52 extra seats to airline's long-haul backbone B777 became the core strategy to lower the average cost per seat, charge a lower price and stimulate demand (Independent, 2016).

Thus, the hypothesis 1: The dominant carrier, British Airways, operated its flights on the long-haul transatlantic route between London and New York with aircraft configuration containing minimum number of seats (maximum number of classes). Shortly after the entrance of the low-cost competitor Norwegian Air Shuttle, British Airways promptly reacted by acquiring the strategy of "shrinking seat space to squeeze in more passengers" in the economy class. The strategy aims at reducing the competitive pressure induced by the lower fares offered by Norwegian Air Shuttle.

As it was previously explained, Norwegian Air Shuttle commenced its operation from London Gatwick on the London-New York route in the third quarter of 2014. British Airways could implement the above-mentioned strategy at any point of time following this event. In order to develop a better understanding of how the particular strategy will mitigate the competitive pressure on British Airways's fares, it was necessary to conduct some modifications in the price equation model. Thus, the sensitivity analysis is examined to determine how the changes in the time response (response rate) needed to implement the "squeezing more passengers" strategy could reduce the direct negative effect of Norwegian Air Shuttle.

Table 6.7. Empirical results for price equation sensitivity analysis

	2014 Q3	2014 Q4	2015 Q1	2015 Q2	2015 Q3
$Constant$	-4.31e+00 (2.35e+00*)	-3.50e+00 (2.25e+00)	-4.21e+00 (2.09e+00*)	-4.09e+00 (2.07e+00*)	-3.97e+00 (2.22e+00*)
$lnPax_{FSC}$	3.70e-01 (1.14e-01***)	3.75e-01 (1.17e-01***)	3.59e-01 (1.10e-01***)	3.58e-01 (1.10e-01***)	3.66e-01 (1.14e-01***)
$Fuel$	-5.05e-03 (1.71e-03***)	-4.57e-03 (1.77e-03**)	-4.42e-03 (1.67e-03**)	-4.72e-03 (1.66e-03***)	-4.77e-03 (1.71e-03***)
$lnHHI$	9.95e-01 (3.48e-01***)	8.74e-01 (3.32e-01**)	9.95e-01 (3.03e-01***)	9.83e-01 (3.01e-01***)	9.55e-01 (3.27e-01***)
$lnPax_{LCC}$	**-8.61e-02 (5.54e-02)**	**-1.06e-01 (5.39e-02*)**	**-1.19e-01 (4.88e-02**)**	**-1.43e-01 (4.75e-02**)**	**-1.49e-01 (4.88e-02***)**
$Dummy$	7.44e-01 (5.45e-01)	9.68e-01 (5.24e-01*)	1.10e+00 (4.72e-01**)	1.34e+00 (4.57e-01***)	1.40e+00 (4.69e-01***)
	$R^2 = 0.69$	$R^2 = 0.68$	$R^2 = 0.71$	$R^2 = 0.71$	$R^2 = 0.69$

Table 6.7 reports the estimated coefficient for the price equation model. The five scenarios are proposed in order to capture the effect of British Airways's time response to adjust the cabin layouts and offer more capacity on the London - New York market. There is empirical evidence that Norwegian Air Shuttle's impact on British Airways's fares significantly varied depending on British Airways's ability to adopt the strategy in a reasonable timeframe. In the case of "most rapid (or prompt) response" scenario (the third quarter of 2014) in which British Airways immediately adopts a denser seating configuration on its B777 flights, the impact of Norwegian Air Shuttle on fares would be negligible and statistically insignificant (see Figure 6.1).

On the contrary, in the case that British Airways postpones the implementation of the strategy for only one quarter (the fourth quarter of 2014), the estimate coefficient which reflects the effect of Norwegian Air Shuttle appears to become larger in magnitude, but still statistically insignificant at the 5 per cent confidence level. Finally, the estimates in the "latest response" scenario demonstrate the strong influence of Norwegian Air Shuttle on British Airways fares with elasticity of almost 0.15 (statistically significant at the 5 per cent level).

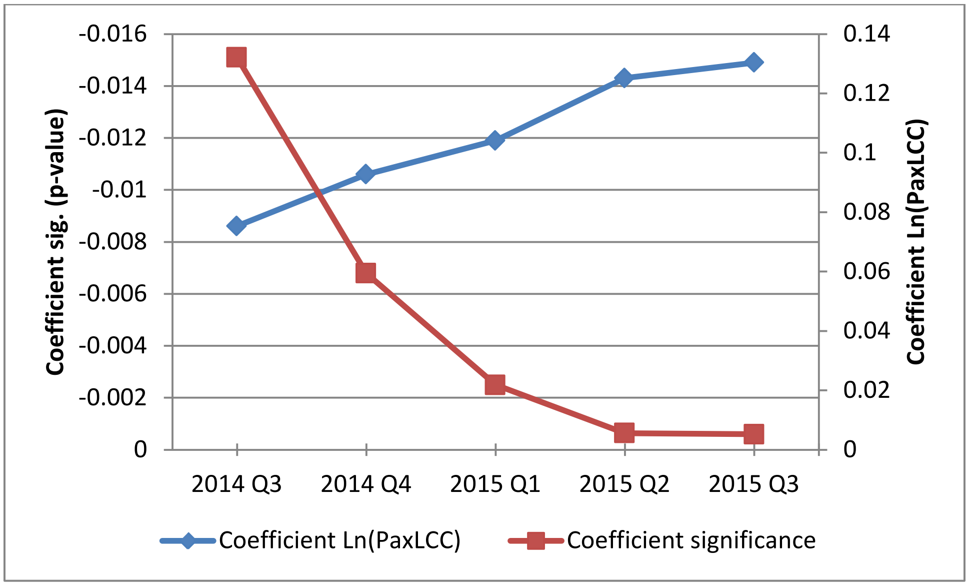


Figure 6.1. The impact of Norwegian Air Shuttle on British Airways' fares

Not surprisingly, as the time period required to adopt the strategy rises, Norwegian's effect on British Airways' fares will become larger in magnitude, in line with its statistical significances which exponentially converge towards zero. Thus, maximizing the seats in the economy class appears to be of the utmost priorities in British Airways' agenda, as it represents an inevitable tool to diminish the competitive pressure induced by Norwegian. As stated in Douglas (2010), entering the London – New York required "mooning the giant" of the global industry in their core home markets in which Norwegian Air Shuttle seems to be a serious threat to the well-established FSC. Overall, the findings of the sensitivity analysis reinforce the urgency of strategy implementation.

7. Airline market share model in long-haul markets based on Fuzzy logic and Bee Colony Optimization metaheuristic

This Chapter addresses the issue of airline market shares on long-haul routes that are characterized by the competition between FSC (mainly member of one of major alliance groups) and LCC. For this purpose, a robust airline market share model is developed based on the application of fuzzy logic and Bee Colony Optimization (BCO) metaheuristic. Namely, the initial results of airline market shares obtained by the application of fuzzy logic are improved by employing the Bee Colony Optimization (BCO) algorithm, specially accommodated to the given problem.

7.1. Statement of the problem

Prediction of market shares appears to be an important issue in airline planning, as airlines are generally keen to attract as larger portion of passengers as possible. An airline's ability to gain higher portions of the market could directly affect its revenue side, and subsequently have tremendous impact on its profit. As already discussed, an airline may compete against its rivals in numerous ways including pricing, frequency and many other aspects, which eventually results in the distribution of the market share across airlines in the particular market. Additionally, an airline's market share in the particular market will also highly depend on the performance of the airline's competitors. An airline that can perform more aggressively against its competitors will certainly increase its market share. On the other hand, the higher market share could assure the favorable position for the airline since its dominance may deter a potential entrant to penetrate the market. Namely, an airline with high market share can derive an immense potential through the economy of density, which further allows reduction in prices (as one of the preemptive actions), and thus produce the adverse effect onto a potential competitor.

An airline may opt between different strategies that aim to increase the market share which highly depends on the airline's management decision to make balance between customers' requirements towards different aspects of airline service and profitable growth (Babić, Kuljanin and Kalić., 2016). Thus, the relation between passenger demand and service quality is a critical issue for carriers, since it enables airline managers to make decisions on the level of service quality and related investments required to achieve the market share targets (Suzuki et al., 2001). There are abundant researches employing the logit model which incorporates customer evaluation of carrier's service attributes to study airline's demand and subsequently to determine an airline market share. For example, Hansen (1990) defined the passenger's utility function within logit model by including variables such as frequency, fare and flight distance. An empirical study based on logit model by Nako (1992) has shown that among many factors, frequent flyer program substantially affect the passenger's airline choice and can serve as an important tool in airline strategy to increase its market share. Proussaloglou and Koppelman (1995) applied multinominal logit approach with the utility function built from three components, each of them containing the variables that reflect carrier-specific, trip-specific, and traveler-specific characteristics (with the total number of 14 variables). The authors also emphasize the role of passenger loyalty reflected through the membership in frequent flyer program on the carrier's market share. However, both studies omitted the aircraft size and type as variables that may influence the passenger's decision regarding airline choice. Coldren et al. (2003) also applied the aggregate multinominal logit model by extending the list of variables that encompasses fares, time of day, carrier market presence, itinerary level-of-service (non-stop, direct, single-connect, or double-connect) and connecting quality to design an itinerary level market share. In a recent study, Wei and Hansen (2005) emphasized the role of aircraft size, service frequency, seat availability and price as the most significant determinants of an airline's market share. By applying the nested logit model, the authors found that airlines could gain higher returns in market shares by increasing frequency rather than increasing aircraft size (i.e. using airplanes with more seats). In contrast to these traditional models (i.e. logit models) that assume the smooth (differentiable) curves between airline product characteristics and passenger demand, Suzuki et al. (2001) proposed a novel approach by using non-smooth functions to describe the relationships. In other words, the service quality may have different implications on airline's market share depending on whether it is above or below the market reference point (i.e. median service quality of service quality in the specific period). The authors use service quality (encompassing on-time performance, mishandled baggage, overbooking ratio and in-flight food quality), price, frequency, number of airports served, average flight distance and safety records to formulate an additive carrier attractiveness function. In addition to the studies in the relevant literature, the airlines operated in the U.S. often use the methodology based on Quality of Service Index (QSI) to predict weekly market share taking into consideration the schedule of all airlines operating in the given market. The total QSI score for each carrier in the market is calculated as the weighted metric of QSI scores for each individual attribute of airline service. Finally, the market share of the given carrier is determined as the carrier's total QSI score relative to the QSI scores of all service available at particular market.

As discussed, the majority of the models is based on the evaluation of passenger perceptions of different airline attributes, and thus require extensive market surveys which are often costly and time consuming. On the other hand, mathematical specification of the relation between passenger demand and the evaluation of carriers' characteristics may pose a challenging task for an analyst. Unlike statistical methods, fuzzy systems do not require the functional specification between output and input data, and thus it is very often referred as "the model without a model". The main objective of this thesis is to develop the market share model (in terms of passenger transported) in the long-haul market based on the fuzzy logic technique that produces high quality predictions. As long-haul markets (particularly the transatlantic market) have recently experienced structural changes due to penetration of low-cost carriers, the redistribution of passengers across competing carriers is an inevitable process. Thus, the primary task is to design the model that should be able to accurately predict the market share in the long-haul markets with changing environment. The model results could also have practical implications not only on airlines involved in the market, but also to policy makers who monitor market evolution. Finally, as other models based on fuzzy logic which belong to the concept of the "intelligent system", the model developed should be able to generalize, adapt and learn based on the new information available (Kalić and Teodorović, 2003).

7.2. Proposed solution to the problem

A robust market share model that applies fuzzy logic and a Bee Colony Optimization is proposed. The model consists of two parts. In the first part, the fuzzy rule base was generated in order to determine the airline market share on the transatlantic routes. The estimated value of airline market share obtained in this way has a certain deviation from the actual value. The aim of the second part was to modify the initial fuzzy rule base in order to increase the model fitness between estimated and actual values of airline market share by applying the meta-heuristic BCO.

7.2.1. Fuzzy Logic in Market Share modeling

The fuzzy logic finds its broad application in solving various type of traffic and transportation problem. Teodorović (1994a, 1999) provides the most extensive overview of analysis and results obtained by fuzzy logic in modeling complex traffic and transportation processes. Teodorović, Kalić and Pavković (1994b) particularly examined the potential for using fuzzy set theory in airline netwrok design, while Teodorović and Kalić (1995) developed a fuzzy route choice model for air transportation networks. Kalić and Teodorvić (1999) also proposed the application of fuzzy logic in modal split modelling. The fuzzy logic theory found its broad application in air travel demand modelling (Kalić and Tošić, 2000), with special consideration of trip generation and trip distribution (Kalić, Kuljanin and Dožić (2014a); Kalić, Dožić and Kuljanin (2014b)). As already mentioned, Babić, Kuljanin and Kalić (2015) combined a regression analysis and fuzzy logic for modeling market shares of incumbent carriers located in the Central and South East Europe at their respective hubs.

Based on the very well elaborated studies, it can be concluded that the list that encompasses factors affecting an airline's market share is large and non-exhaustive. On the other hand, including a large number of factors in the model is often very costly and it could impose difficulties in model interpretation. Additionally, the existence of multicollinearity among various factors could lead to spurious results. The set of potential factors initially selected to describe an airline's market share included ten variables. In an attempt to create a robust market share model, the set of factors were shortlisted after a careful consideration. It can rationally be assumed that an airline's market share on intercontinental routes is highly driven by the airline's frequency and its ability to offer affordable fares. Thus, the first variable labeled "frequency share" is derived as the portion of flights performed by a specific airline in total frequency on a given intercontinental city pair market, while the variable fare is expressed as the ratio between the lowest possible fare and the specific airline's fare on a given intercontinental route. The first variable frequency share reflects the aspect of airline supply on a particular market, while the second one incorporates the dimension of price competition through comparison to the lowest rival's fare. As in the case of the model presented in Chapter 6, the model developed is also focused on city-pair market, and encompasses all routes where there is competition of one LCC. After determining the input variables, the fuzzy logic was applied by using the following type of rules:

IF FREQUENCY SHARE OF AN AIRLINE ON A GIVEN INTERCONTINENTAL ROUTE is **large**,

And THE AIRLINE FARE IN RESPECT TO THE LOWEST FARE ON THE ROUTE is **small**,

then AIRLINE MARKET SHARE is **high**.

Thus, general description of the market share (presented in Figure 7.1) model is as follows: according to the airline frequency share on a given intercontinental route o, and the ratio between the lowest fare and the specific airline fare on the route p, by applying the fuzzy logic as a universal approximator, the airline market share on a given route, l, is determined. The inputs and the output of the model were a priori normalized in order to create the universal market share model on intercontinental routes.

Fuzzy rule bases from the numerical example were generated by applying the procedure proposed by Wang and Mendel (1992). Thus, the fuzzy sets for all the antecedents and the consequences were established.

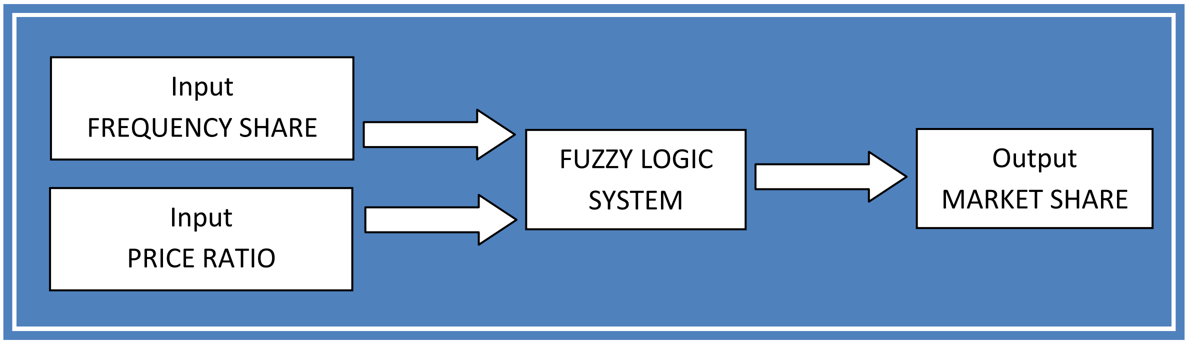


Figure 7.1. Fuzzy logic model of market share on intercontinental routes

The domain interval of each variable is divided into the predefined number of overlapping regions, which is not necessarily the same among variables. The length of the overlapping regions is very often the same for the given variable, but it could also vary. After labeling the overlapping regions, the membership function has been assigned to each of them. Different variables can take different types of membership functions. According to the previously defined notations for inputs and the output, let us assumes that there is the following set of input output data pairs

$$\left(o^{(1)}, p^{(1)}, l^{(1)}\right), \left(o^{(2)}, p^{(2)}, l^{(2)}\right), \ldots, \left(o^{(n)}, p^{(n)}, l^{(n)}\right)$$

Values o, p and l belong to the corresponding intervals $[o_{min}, o_{max}]$, $[p_{min}, p_{max}]$, $[l_{min}, l_{max}]$. Each of the intervals is divided into subintervals within which the membership functions of fuzzy sets are defined (Figure 7.2). Although there are large numbers of possible shapes of membership function of fuzzy sets, the triangular shapes are employed for all three variables.

After defining the corresponding fuzzy sets, the next step is to generate fuzzy rules. For the sake of simplicity, the generation of fuzzy rules will be shown on the first input output pair of data $\left(o^{(1)}, p^{(1)}, l^{(1)}\right) \Longrightarrow (59.6, 34.4, 60.6)$. For the given value $o^{(1)}$, one can detect the fuzzy set O_5 in which it has the largest membership degree accounting for 0.650. The same procedure should be conducted for $p^{(1)}$ and $l^{(1)}$. In this way, O_5, P_4, L_5 have been identified as the fuzzy sets in which the given values achieve the largest degree of membership.

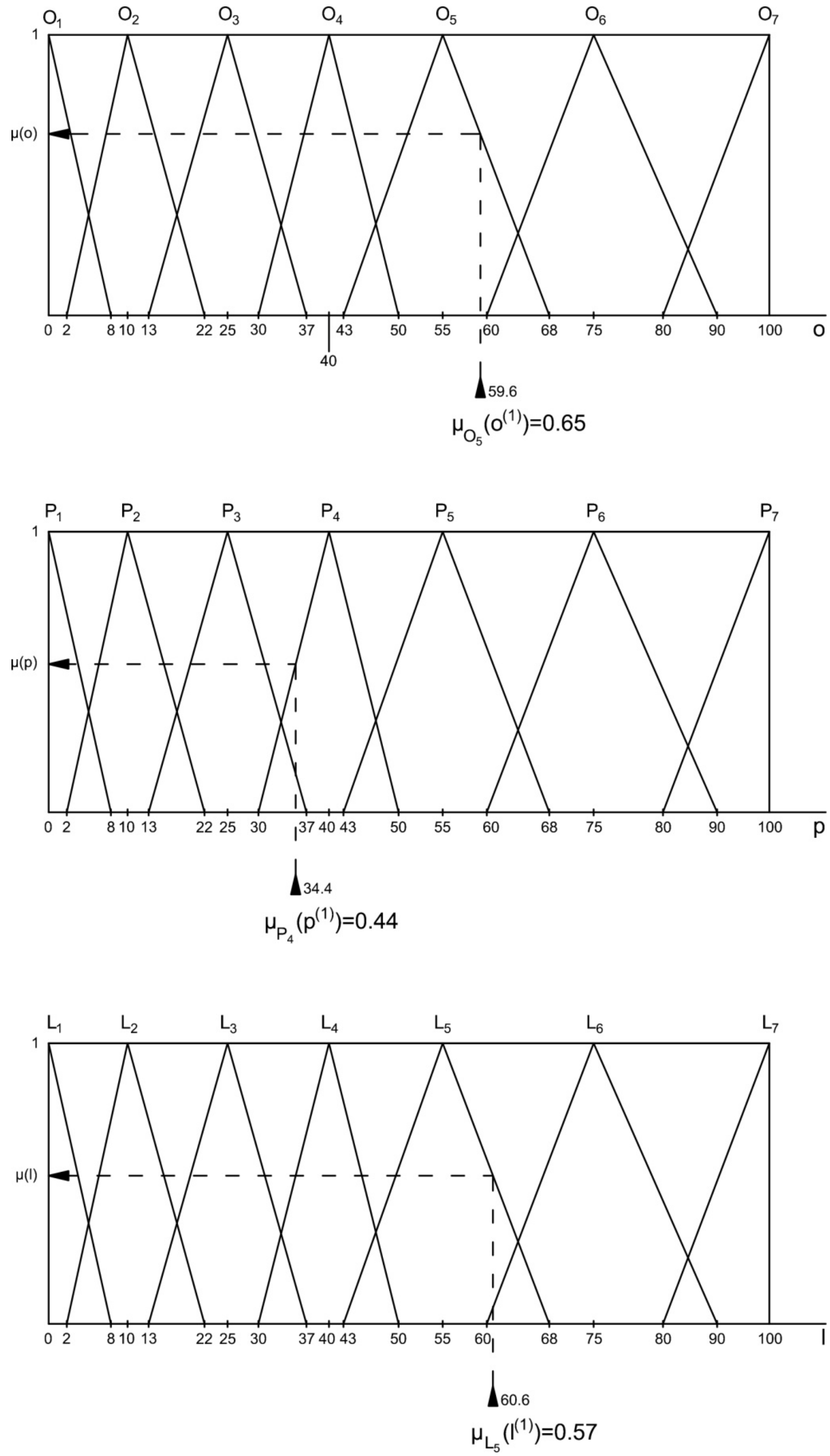


Figure 7.2. Membership function of fuzzy sets

Based on the fuzzy sets and corresponding membership functions (obtained as illustrated in Figure 7.2), for the first pair of data $\left(o^{(1)}, p^{(1)}, l^{(1)}\right) \Longrightarrow$ ($o^{(1)}$ belongs to set O_5 with $\mu_{O_5} = 0.65$, $p^{(1)}$ belongs to set P_4 with $\mu_{P_4} = 0.44$, $l^{(1)}$ belongs to set L_5 with $\mu_{L_5} = 0.57$). Rule 1 is derived as follows:

$$\text{If } o = O_5 \text{ and } p = P_4 \text{ then } l = L_5$$

The above explained procedure should be performed for all data pairs. During this procedure, the conflict rule may emerge, the state in which the same premise leads to a different consequence. In order to overcome the issue, the degree of rules should be computed. The degree of rule is defined as a product of membership degree of o, p, l in corresponding fuzzy sets.

$$D(\text{Rule}) = \mu_O(o) \cdot \mu_P(p) \cdot \mu_L(l)$$

The degree of rule 1 is calculated as follows:

$$D(\text{Rule1}) = \mu_{O_5}(o^1) \cdot \mu_{P_4}\left(p^{(1)}\right) \cdot \mu_{L_5}\left(l^{(1)}\right) = 0.65 \cdot 0.44 \cdot 0.57 = 0.16$$

After calculating the degree of conflicting rules, the rule with the greatest degree should be retained, whereas the ones with smaller degrees should be discarded. After a problem of conflicting rules is resolved, a set of fuzzy rules is obtained. However, the set is frequently incomplete and requires an additional effort to be completed. In the case of fuzzy system with two premises, the remaining fields can be handled by analyst who properly understands the logic of the given matrix. Thus, the complete fuzzy rule base is obtained and displayed in Figure 7.3.

Once the fuzzy rule base is formed (see Appendix 2), the next step assumes the application of inference method (i.e. reasoning technique). The output of fuzzy logic can be either a fuzzy set or a "crisp" value. If the output is required in the form of "crisp" value, the proper defuzzification method should be employed. The model applies the centre of gravity, as one of the most common defuzzification method. To conclude, the fuzzy system proposed in this thesis is based on singleton fuzzification, triangular shape of membership function of input and output variables, MAX-MIN fuzzy reasoning and the centre of gravity as a defuzzification method.

	P_1	P_2	P_3	P_4	P_5	P_6	P_7
O_1				L_1	L_1	L_1	L_1
O_2			L_2	L_2	L_3	L_2	L_2
O_3			L_3	L_3	L_3	L_3	L_4
O_4				L_4	L_4	L_4	L_4
O_5			L_5	L_5		L_5	L_5
O_6				L_6	L_6	L_6	L_6
O_7				L_6	L_7	L_7	L_7

(a)

	P_1	P_2	P_3	P_4	P_5	P_6	P_7
O_1	L_1	L_1	L_1	L_1	L_1	L_1	L_1
O_2	L_1	L_1	L_2	L_2	L_2	L_2	L_2
O_3	L_2	L_3	L_3	L_3	L_3	L_3	L_4
O_4	L_3	L_3	L_3	L_4	L_4	L_4	L_4
O_5	L_4	L_4	L_5	L_5	L_5	L_5	L_5
O_6	L_5	L_5	L_6	L_6	L_6	L_6	L_6
O_7	L_6	L_6	L_6	L_6	L_7	L_7	L_7

(b)

Figure 7.3. Fuzzy rule bases: (a) incomplete and (b) complete

7.2.2. Bee Colony Optimization algorithm for modifying membership functions

The overall performance of fuzzy system rises as estimated values are closer to actual values of the output. Consequently, the fuzzy set domain fine tuning plays an important role as the fitness between estimated and actual values can be significantly improved in this way. The problem of determining the domain of fuzzy sets for all variables of interest is solved by using a Bee Colony Optimization (BCO).

BCO was developed by analogy with bee's behavior in the nature during the foraging process. Lučić and Teodorović (2001, 2003) were among the first who achieved the most significant results by using the principle of collective bee intelligence in solving combinatorial optimization problems. As in the case of other metaheuristics, the BCO algorithm should be modified for a specific problem. BCO belongs to the group of population-based algorithms in which population of artificial bees search for an optimal solution. The BCO algorithm consists of two distinctive phases: forward pass and backward pass. In each forward pass, every artificial bee is exploring the search space by applying a predefined number of moves. Each move constructs or/and improves the solution yielding to a new solution. Having obtained new partial solutions, the bees go back to the nest when the second phase starts (i.e. backward pass). During this phase, all artificial bees share the information about their current solutions among each other. At the same time, every bee decides with a certain probability whether to abandon the created partial solution and again become an uncommitted follower or to recruit other bees from the nest before returning to the created partial solution. The algorithm is designed so that the bees with higher objective function values (in the case of maximization oriented problems) have greater chances to continue their own exploration (Teodorović and Šelmić, 2012). On the other hand, every bee follower chooses a new solution from the recruiters applying the roulette wheel so that the recruiters with greater objective function have a higher possibility of being chosen for exploration. The two phases of the algorithm, forward and backward pass, are performed iteratively until a prespecified stopping condition is satisfied (such as maximal total number of backward/forward passes, the desired value of objective function, maximum CPU time allowed etc.) (Teodorović, 2009). The final solution of the problem is the best solution generated during the search.

As previously mentioned, the fuzzy logic system proposed consists of two input variables and one output variable. Each variable is defined by the seven fuzzy sets represented by the triangular membership functions as depicted in Figure 7.4. As already discussed, the domain of each membership function for the given variable was initially defined by the author based on the careful observation of dataset. The minimum and maximum values of the domain for each fuzzy membership function represent the parameters that will be improved by applying the BCO approach. The initial values of parameters are shown in Figure 7.2. The fitness function represents the sum of the square deviation of real from estimated value of the market share obtained by fuzzy logic (Eq.1).

$$\sum_{i=1}^{N}(Y_i - Y_f)^2 \tag{1}$$

in which:

Y_i – real value of market share;

Y_f – estimated value of market share obtained by fuzzy logic;

N – number of observations.

The objective of the algorithm is to minimize the given fitness function. The four sets of bees are formed in the hive. The first set of bees is allowed to change the parameters of membership functions for all input and output variables. The second set of bees can modify the parameters of membership functions for the first variable (i.e. frequency share) only. The third set of bees can modify the parameters for the second input variable (i.e. price ratio), while the fourth set of bees will only modify the membership functions of the output variable (i.e. market share). Each of the four sets of bees will perform the forward and backward passes. The values of the BCO algorithm parameters that need to be set prior to the algorithm execution are as follows:

B1 – number of bees in the first set;

B2 – number of bees in the second set;

B3 – number of bees in the third set;

B4 – number of bees in the fourth set;

NC1 – maximum number of parameters that can be modified during one forward pass by the first set of bees;

NC2 – maximum number of parameters that can be modified during one forward pass by the second group of bees;

NC3 – maximum number of parameters that can be modified during one forward pass by the third set of bees;

NC4 – maximum number of parameters that can be modified during one forward pass by the fourth set of bees;

NM –number of constructive moves that improve solution during one iteration,

IT – number of iterations;

LB_i – minimal value of each membership function;

UB_i– maximal value of each membership function.

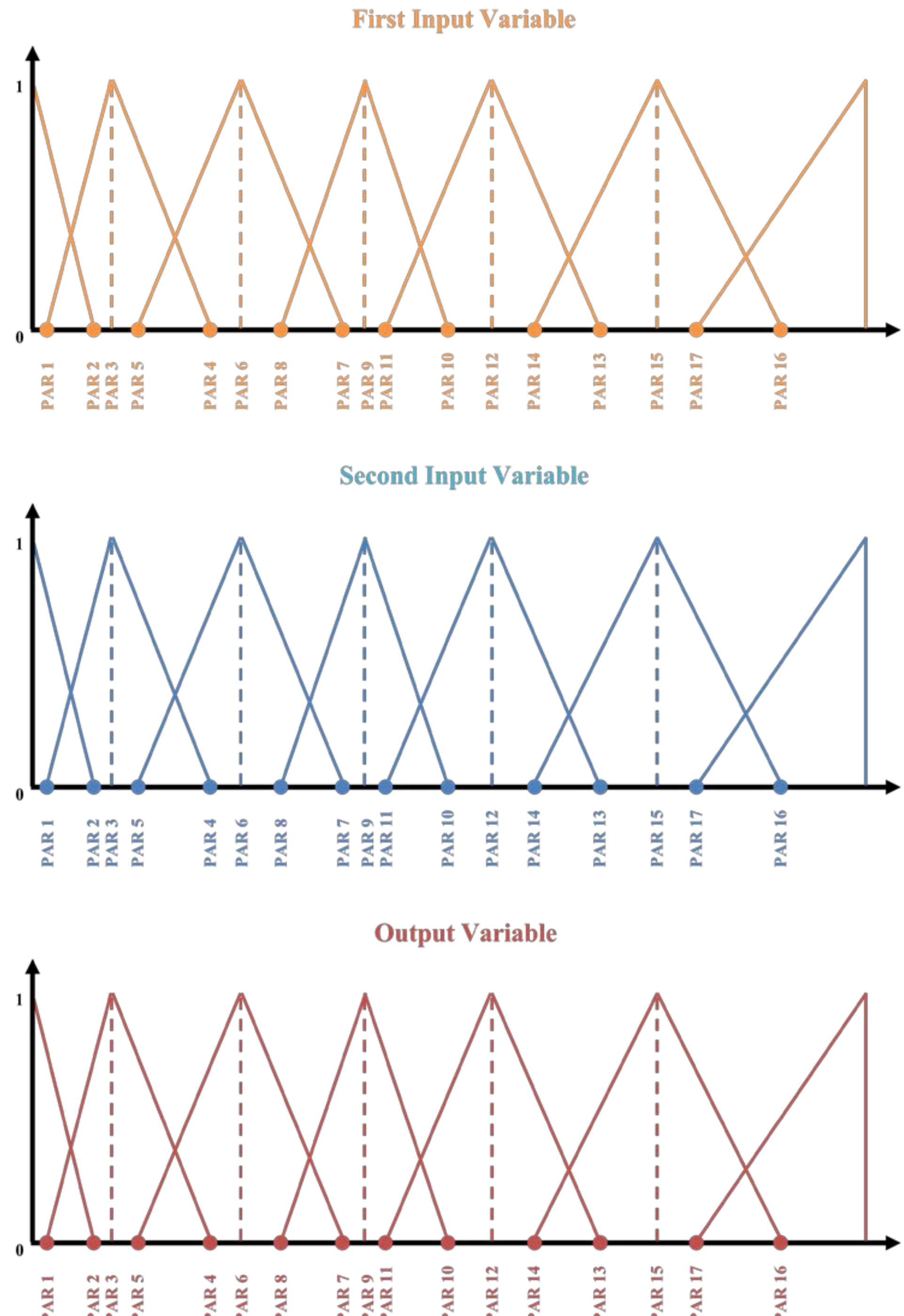


Figure 7.4. Parameters of the fuzzy logic system

The pseudo code of the BCO algorithm is given in Appendix 3. Before the algorithm starts, the initial solution is determined and assigned to each bee. The solution is randomly generated on the interval between the minimum and maximum values of each membership function for the given variable. The solution has to meet the condition that the membership functions are overlapped. In the case when the condition is not satisfied, the solution is regenerated until the condition is met. In this way, the total number of B solutions are generated. The best solution among these B generated solutions will be assigned as an initial solution to all bees in the nest. The artificial bee modifies the assigned solution during the backward pass. At the beginning of new iteration, the best solution found in the previous iteration will be assigned to all bees in each of the four sets.

The number of parameters to be modified will be determined randomly, as well as whether the parameter will increase or decrease. In case of the parameter increases (Eq. 2), the new value will be calculated in the following way:

$$x_i = x_i + random\ (0, 0{,}1) * (UP_i - \ LB_i) \tag{2}$$

In case the parameter increases (Eq. 3), the new value will be calculated in the following way:

$$x_i = x_i - random\ (0, 0{,}1) * (UP_i - LB_i) \tag{3}$$

In order to meet the condition of membership function overlapping, the set of rules for each membership function is generated. Rules for membership functions are given in Appendix 4. Rules for the membership functions of the two remaining variables follow the similar logic with the parameters enumerated accordingly.

The bees return to the hives with their respective modified solutions. All modified solutions are then evaluated by all bees in the hives. During the backward pass, every bee decides with a certain probability whether to abandon the created partial solution and become the uncommitted follower or recruit other bees before returning to the created partial solution. The probability that the bee is loyal to the previously generated solution is calculated as follows:

$$p_b^{u+1} = e^{-(O_{max}-O_b)}, b = 1,2, \dots, B, \tag{4}$$

where:

O_b – normalized value of the fitness function generated by the *b*th bee;

O_{max} – maximum value of the fitness function generated by all bees;

U – ordinary number of forward pass.

As already discussed, by using the probability given in relation (4) and a random number generator, every bee decides to become the uncommitted follower or to remain loyal to the previously generated solution and continues its exploration in the next forward pass. In the case in which the randomly generated number is less than the probability obtained from relation (4), the bee is loyal to its previously generated solution, otherwise the bee chooses to become the uncommitted follower (Teodorović and Šelmić, 2012).

In the case that the bee chooses to abandon the previously generated solution, the bee will have to decide which "recruiter" to follow. The probability that the recruiter b's solution will be chosen by any uncommitted bee equals:

$$p_b = \frac{O_b}{\sum_{k=1}^{R} O_k} \tag{5}$$

where:

O_b – objective function value of the *k*th recruiter;

R– number of recruiters;

By using the probability value obtained in this way (i.e. relation (4)) and a random number generator, every uncommitted follower joins one recruiter. Thus, in the next forward pass recruiters and their respective recruited mates start to exploit the solution space from the solution previously discovered by the recruiter (Nikolić and Teodorović, 2013).

7.3. Numerical example

7.3.1. Data description

The model proposed predicts the market share of a given airline on a transatlantic route in which at least one low-cost carrier operates the flights. The model is illustrated on the real data collected for 2017 on all Norwegian transatlantic flights from Europe to North America. Bearing in mind that Norwegian started to operate its transatlantic flights in 2013, the period of four years is seen as reasonably large for the carrier to accommodate in long-haul business sector and adequately position itself against its rivals. Thus, 2017 is selected as a suitable year for the investigation and the data were collected on the quarterly basis. The data set initially covered 30 city-pair markets encompassing 47 airport-pair routes as presented in Table 7.1 (i.e. 324 input-output vectors).

These routes connect the cities located in six European countries (the United Kingdom, France, Spain, Denmark, Norway and Sweden) to six destinations spread across U.S. territory. The average number of carriers at city-pair market accounts for 2.63, whereas the average number of carriers per airport-pair is slightly less and accounts for 2.55 carriers per route.

This minor discrepancy in the average value is not surprising bearing in mind that there are 9 airport pairs on which Norwegian is the only carrier. These routes are mainly operated from large Scandinavian cities (i.e. Oslo, Stockholm, and Copenhagen) to leisure destination in the U.S. (i.e. Orlando, Oakland, Los Angeles and Miami). After careful consideration these routes are excluded from further investigation. Figure 7.5 displays the distribution of the number of city-pair routes across different number of carriers.

Table 7.1. Description of the routes initially selected

Origin county	City-pairs	Airport-pairs
United Kingdom	London – Boston	LHR – BOS; LGW – BOS
	London – Los Angeles	LHR – LAX; LGW - LAX
	London – Miami	LHR – MIA; LGW – FLL
	London – New York	LHR – JFK; LHR – EWR; LGW - JFK
	London – Oakland	LGW - OAK
	London – Orlando	LGW - MCO
France	Paris – Los Angeles	CDG - LAX
	Paris – Miami	CDG –MIA; CDG - FLL
	Paris – New York	CDG –JFK; CDG – EWR; ORY –JFK; ORY -EWR
	Paris – Orlando	CDG -MCO
Spain	Barcelona - Los Angeles	BCN – LAX
	Barcelona - Miami	BCN – MIA; BCN - FLL
	Barcelona-New York	BCN – JFK; BCN - EWR
	Barcelona-Oakland	BCN - OAK
Denmark	Copenhagen – Boston	CPH - BOS
	Copenhagen – Los Angeles	CPH - LAX
	Copenhagen – Miami	CPH – MIA; CPH - FLL
	Copenhagen – New York	CPH – JFK; CPH – JFK
	Copenhagen – Oakland	CPH - OAK
	Copenhagen – Orlando	CPH - MCO
Norway	Oslo – Boston	OSL - BOS
	Oslo – Los Angeles	OSL - LAX
	Oslo – Miami	OSL – MIA; OSL-FLL
	Oslo – New York	OSL – JFK; OSL - EWR
	Oslo – Oakland	OSL - OAK
	Oslo – Orlando	OSL - MCO
Sweden	Stockholm – Los Angeles	ARN - LAX
	Stockholm – Miami	ARN –MIA; ARN – FLL
	Stockholm – New York	ARN – JFK; ARN - EWR
	Stockholm – Oakland	ARN - OAK

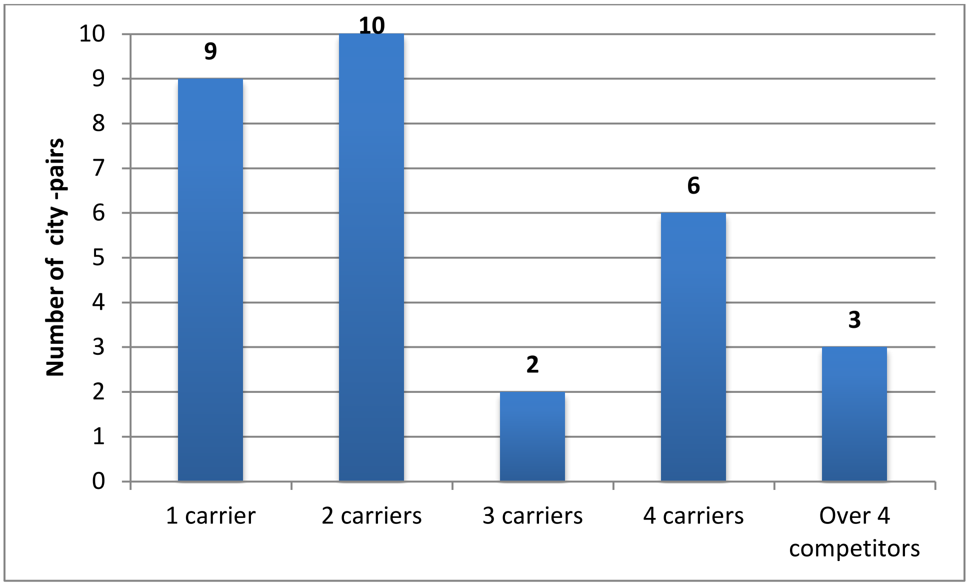


Figure 7.5. Distribution of the number of city-pair routes across number of carriers operated the route

As observed, majority of the city-pair routes are characterized by the presence of two carriers (i.e. one competitor), whereas the 9 city-pair routes are operated by only one carrier holding the monopoly. It is worth mentioning that on all 21 city-pair routes operated from six European countries, Norwegian competes with major incumbent carriers, such as British Airways (routes from London), Air France (routes from Paris), Iberia (routes from Barcelona) and SAS (routes from Copenhagen, Oslo and Stockholm). In addition to the presence of the major carriers on these routes, the competition on some routes is even intensified by the existence of code-share agreements between carriers within same airline alliance. For example, on the routes between London and New York and London and Los Angeles, British Airways tightly cooperate with American carrier, American Airlines, through code-share agreements and flight schedule coordination, which is also the case with Air France and Delta Air Lines on the route from Paris to New York. The final database consists of 285 input-output vectors covering the total number of 855 (i.e. 285x3) observations. The training set consists of 212 input-output vectors that represent the first three quarters, while the last quarter (encompassing 73 input-output vectors) is used as a testing set.

As already mentioned, the variables used in this study refer to the frequency share of the given airline in the total number of frequency offered on the transatlantic city-pair route, the ratio between the lowest fare and the given airline's fare and the given airline's market share on a particular route on the city level, denoted respectively by o, p, l. Based on the values of the given variables, membership functions of the fuzzy sets were subjectively defined. For the purpose of this study, only triangular membership function was applied for the fuzzy sets of all three variables. Finally, the incomplete fuzzy rule base shown in Figure 7.3 was obtained by applying the method of Wang and Mendel. So, the initial fuzzy rule base contained the total of 66 generated rules, which was further downsized to 36 rules, which means that some data vectors yielded equal rules, or some of the rules were conflicting. The remaining 19 fields depicted in Figure 7.3 were completed by the author following the elementary logic that an increase in the given airline's frequency share and the increase of the ratio between the lowest fare and given airline, the given airline's market share on the particular route also tends to increase.

7.3.2. Results

The market share of the given airline on individual transatlantic route was calculated based on the approximate reasoning algorithm. The procedure of designing the membership functions of the given input and output variables consist of two steps. First, the membership functions of the fuzzy sets were subjectively designed after the careful analysis of the data. Second, subjectively designed membership functions were improved by applying the BCO algorithm.

The first step will be described as follows. During the iterative procedure, the market shares values obtained by the fuzzy logic were several times compared to the real values in order to obtain the satisfactory correspondence between these values. After the first comparison, subtle modification of the membership function and the rules was performed, and the market share was further recalculated. Subsequently, another comparison of the obtained market share values and the real value has been carried out, followed by another modification of the membership functions and /or rules. The market share model was designed using free computer software R. The results were obtained in a very short time (C.P.U. time was less than one second – 0.45 seconds) which supported the iterative procedure and enabled the process of modifying membership functions and rules. The final outlook of the membership functions for two input and one output variables are already depicted in Figure 7.2.

Figure 7.6 gives a graphical representation of the comparison between the real values and the values obtained for the testing set (for the numerical values, see Table A5.1 provided in Appendix 5).

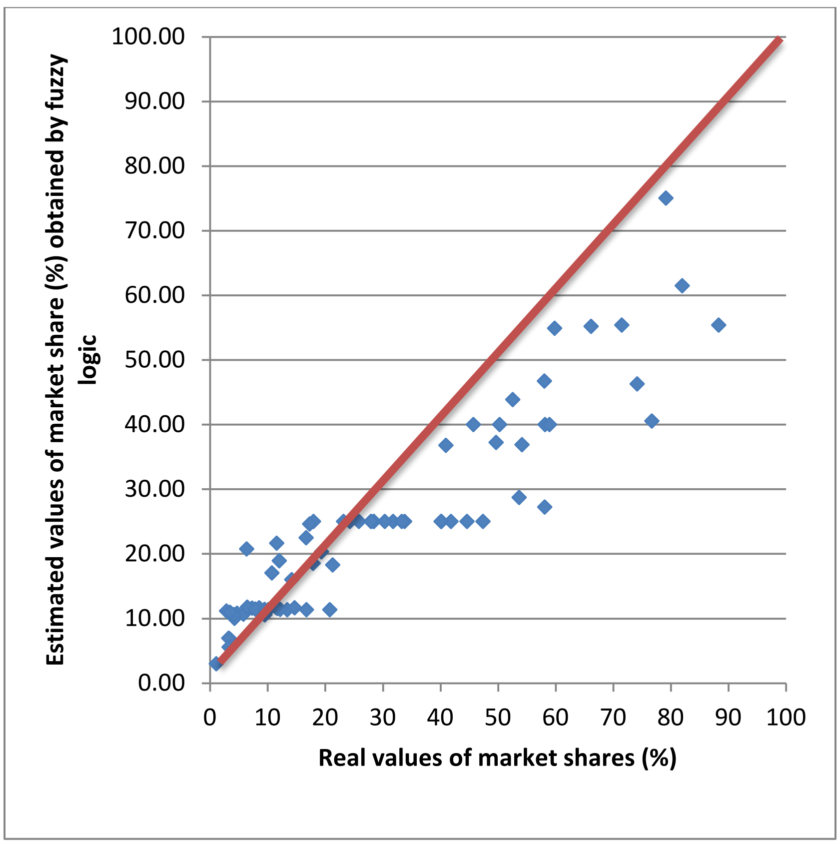


Figure 7.6. Comparison of real and estimated values of airline's market share in long-haul market (testing set)

In order to check the statistical performance of the model, absolute errors were calculated for both training and testing sets. The absolute errors for the training and testing sets account for 8.44% and 8.40% respectively, indicating satisfactory results. Overall, according to the results achieved, it can be concluded that good prediction of airline's market share on transatlantic city-pair market can be obtained.

However, the aim of the research was to modify the minimum and maximum value of each membership function for the given variable in order to improve the statistical performance of the model. The total number of iterations accounts for 400. The first set of bees encompasses 120 bees, while three other sets account for 20 bees. Bees from the first set can modify maximum three parameters during one forward pass, whereas bees from other sets are restricted to only one parameter. The number of moves during one iteration is predefined to 20 for each of the four sets of bees.

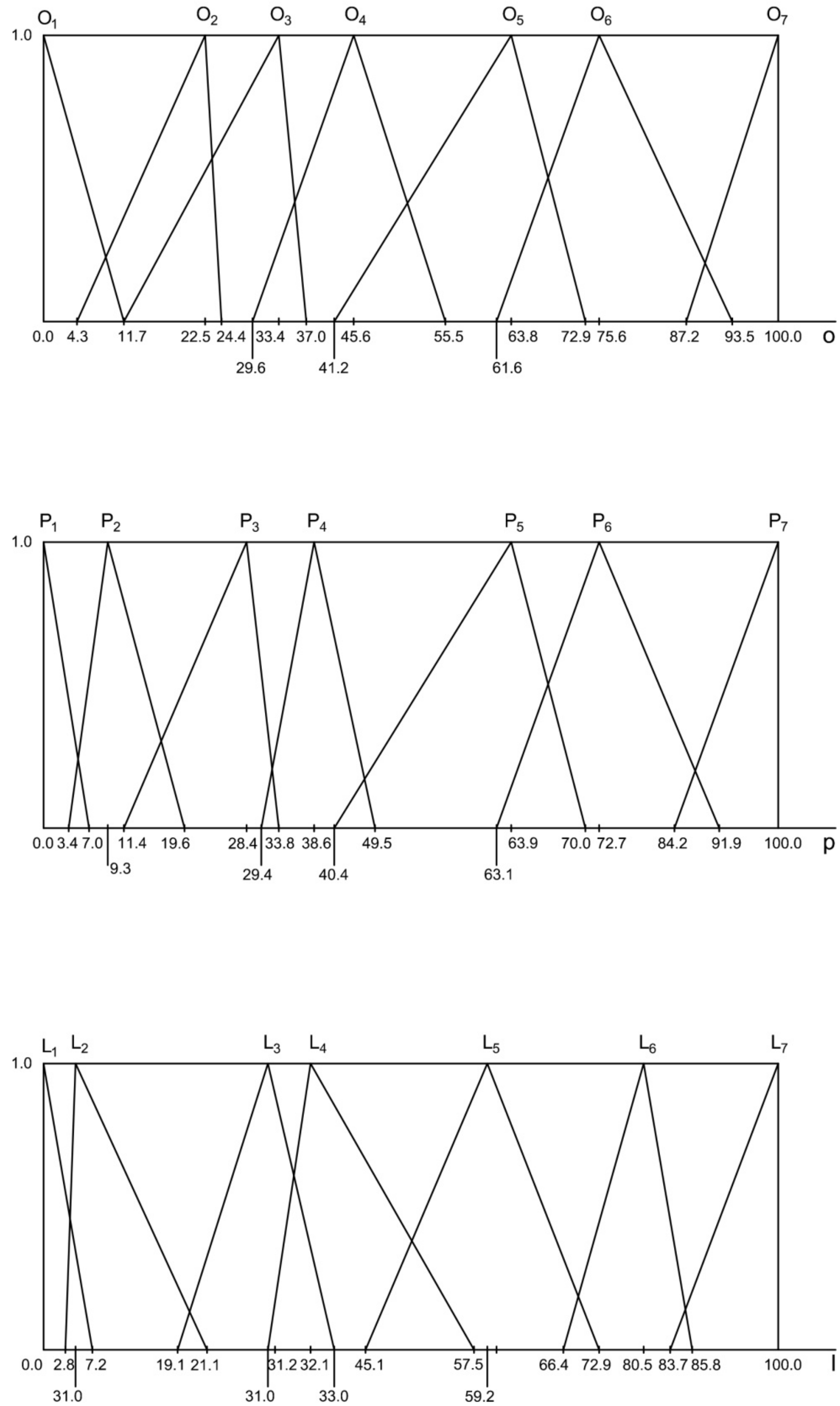


Figure 7.7. Membership functions for input and output variables obtained by BCO algorithm

As observed from Figure 7.8, the values of the fitness function gradually decreased as the number of iterations evolved. By applying the algorithm, new values of membership functions (see Figure 7.7) for each variable were obtained resulting from the optimization of the fitness function which represented the sum of the squared deviation of the real from the estimated value of the output variable (i.e. airline's market share).

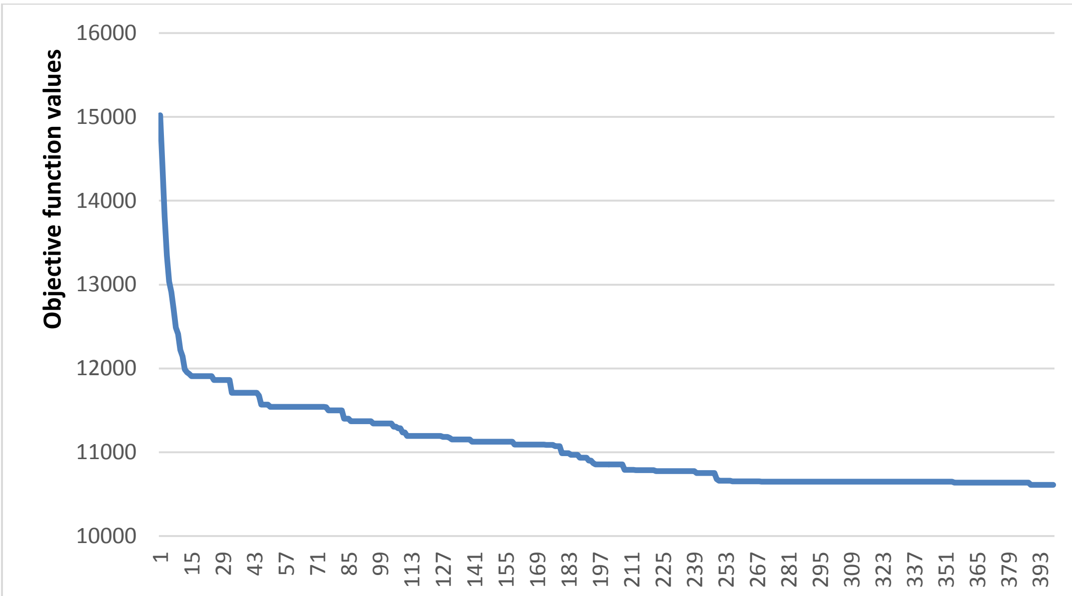


Figure 7.8. The values of objective function over iterations

Figure 7.9 provides graphical representation of the comparison between the real and the estimated value of the market share obtained by applying the BCO algorithm for testing set (see Table A5.2 in Appendix 5 for numerical values).With a simple visual inspection and according to the results achieved, it can be concluded that joint application of fuzzy logic and BCO optimization provide very good predictions of airline's market share on the transatlantic market. The application of the BCO substantially contributed to the reduction of absolute errors for both testing and training sets compared to the initial solution, for almost double. The absolute errors for the training and testing sets account for 4.37% and 4.48% respectively, indicating high quality results and thus, justifying the application of the BCO algorithm.

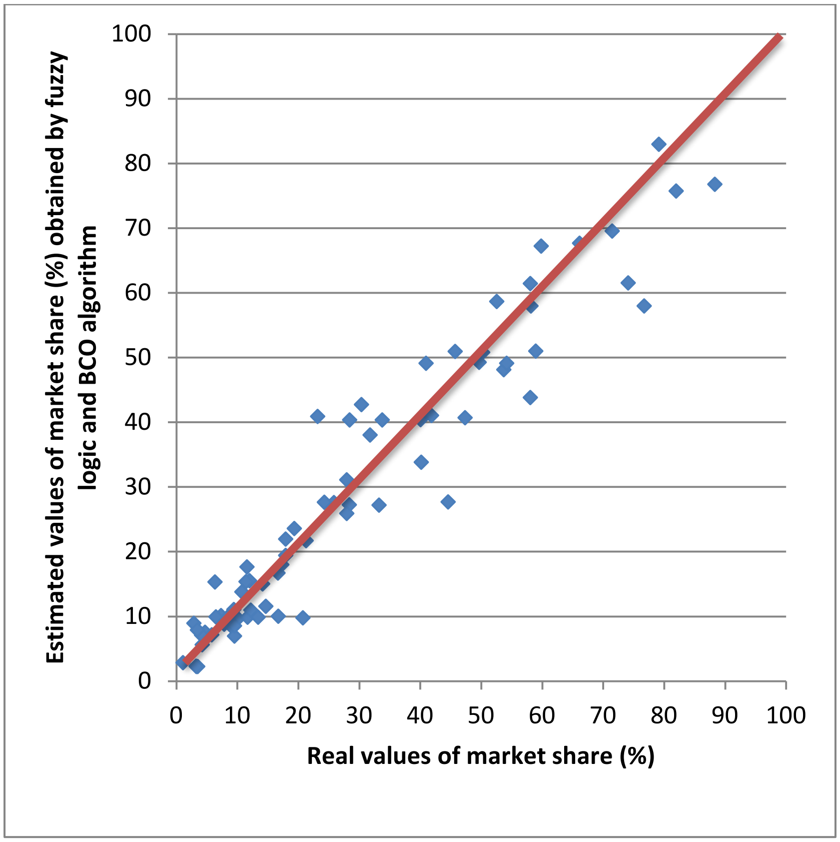


Figure 7.9. Comparison of real and estimated value of airline's market share in long-haul markets obtained by BCO algorithm (testing set)

Not surprisingly, it is evident that the frequency share plays a significant role when determining the market share, as already discussed in other studies that deals with similar issues. In other words, the strategy of increasing frequency remains most powerful among strategies that aim to increase market share, although the impact of price should not be neglected. However, with its ability to adapt to new information, the model proposed has the potential to be improved in the future by extending the current dataset with the data from other world regions as an attempt to design the universal model. Application of the model would be particularly interesting for the region of Australia and Oceania, since these regions have recently experienced an expansion in offered international seats in the markets over 4 000 km, which is an the immense potential for low-cost carriers.

8. Measuring the efficiency of airlines operated in Europe: an application of fuzzy-DEA analysis

The Chapter emphasizes the importance of measuring airline efficiency as an important contributor to airline competitive position on the market. As already mentioned, an airline that performs efficiently on the market is not necessarily competitive, but the airline that achieves the competitive advantage over its rivals are certainly efficient. This Chapter develops the methodological framework based on the application of Data Envelopment Analysis (DEA) and fuzzy logic for efficiency evaluation of the airlines operating across Europe in the new market context in the years 2008 and 2012. The efficiency measures are calculated by a non-parametric approach DEA which has particular applicability in the airline industry. Bearing in mind that some of the inputs/outputs in a DEA model can be subject to imprecise measurements, but still highly affect an airline's efficiency, a fuzzy-based DEA approach has been employed as an appropriate tool. Productivity is measured by the Malmquist index and defined as the ratio between efficiency, as calculated by the DEA, for the same set of airlines in two different time periods. The sample contains 17 airlines that operate in the European market. The initial research was published in Kuljanin et al. (2017), while the full version of the paper is available at Kuljanin et al. (2019). Before presenting the model, the next subsection briefly outlines the current market trend, with special focus on the competition among leading European carriers.

8.1. The current market trend outlook in Europe

The airline industry has faced a burden of challenges in the last decade with the landscape of competition evolving in a very unpredictable way. Although the primary goal of deregulation was to increase the number of competitors in the market, it seems that market evolution went in the opposite direction. In other words, the industry experienced substantial consolidation realized through a various forms of airline agreements in an attempt to reduce the costs. The effect of 2008 world financial crisis was so severe bringing a vast number of carriers to the edge of bankruptcy, especially those representing former national flag carriers. In order to survive the new market conditions, many international flag carriers across Europe chose to consolidate their operations and created economies of scale through mergers and acquisitions (Min and Joo, 2016). With the Air France/KLM merger occurred in 2004, the new chapter of the airline industry was opened as other larger carriers decided to follow similar examples. In response to the rival's move, Lufthansa initiated the process of acquisition by taking the majority stakes in Swiss International Airlines (2005), Eurowings (2005), SN Airholding/Brussels Airlines (2009), BMI (2009) and Austrian Airlines (2009). The third large airline group, named International Airline Group, was formed around British Airways that completed the process of merger with Iberia (which had already owned two low-cost carriers, Vueling and Clickair) in 2010. The group was further enlarged by purchasing BMI from Lufthansa in 2012 and by a merger with Air Lingus in 2015. The mergers and the acquisition were particularly plausible to major carriers to strengthen their market positions as they obtain access to smaller carriers' hubs with their previously well-established hub-and-spoke networks, which resulted in creation of a large integrated network. These three airline groups together with two largest low-cost carriers in Europe, Ryanair and EasyJet, jointly hold around 43% of the total market share in terms of capacity, whereas the top six airlines in North America hold 75% of the seating capacity as the result of mergers (CAPA, 2016b,c). Since consolidation is a global trend that will certainly continue in the future, it is evident that medium-sized European carriers (such as Finnair, LOT Polish Airline and SAS) could hardly be exempted from this process. On the other hand, selling these airlines to large foreign stakeholders might impose a burden of challenges due to national interests and difficulties in branding. Thus, they need to be well-prepared in order to gain as much benefit as possible through attracting more bidders that will offer fair merger conditions. However, further mergers and acquisition will certainly depend on the legal ability of foreign carriers outside Europe (particularly U.S. carriers and the Gulf carriers) to own and control the majority of stakes in European carriers.

In addition to the extensive consolidation process among major airlines, the remaining LCCs in Europe continue to record positive trends and exert a strong competitive pressure on FSCs. The market share of LCCs in terms of capacity in the European market dramatically rose from only 5% in 1998 to 48% in 2015 (CEPS, 2018). The battlefield among LCCs and FSCs is largely extended since LCC have gradually developed their networks by introducing flights from primary airports (Burghouwt and De Wit, 2015). For example, the largest European individual carriers by the passenger number (in contrast to other major carriers that operate in the group), Ryanair, has slightly changed its network strategy since 2014 by initiating service from primary European airports in addition to well-developed low-density routes from secondary airports. Thus, Ryanair has become a serious threat to not only FSCs, which primarily operate from large airports, but also to EasyJet which already focused its operation from primary airports. Despite the subtle change in network development, both Ryanair and EasyJet continue to record positive annual growth in terms of passenger numbers, which placed them among the first five European carriers (Figure 8.1).

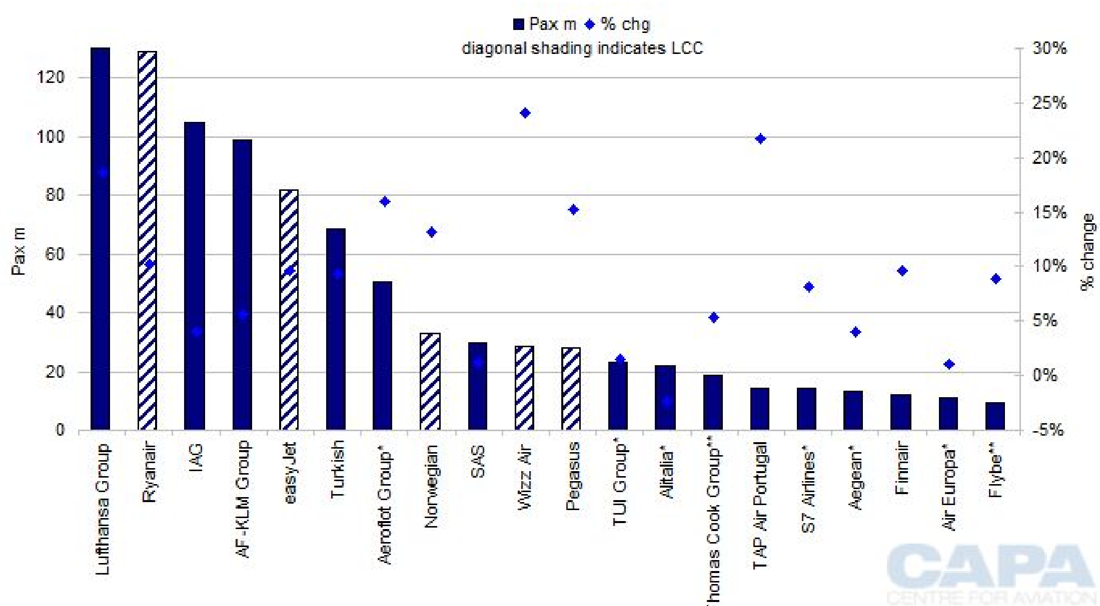


Figure 8.1. Europe's top 20 airline groups by passenger numbers: calendar 2017 (*Source: CAPA, 2018c*)

As observed from Figure 8.1, in addition to EasyJet and Ryanair, there are three more LCCs (Norwegian, Wizz Air and Pegasus) which belong to the top 20 European airlines in terms of passenger numbers (CAPA, 2018c). Among them, Wizz Air is the fastest-growing carrier in Europe with annual passenger growth rate of almost 25% in 2017 and the network mainly focusing on connecting Central and South East Europe airports to those located in the Western Europe. Turkish LCC, Pegasus, is very similar to Wizz Air in terms of passenger numbers, but with a significantly lower annual passenger growth accounting for around 15% in 2017. With capacity experiencing the steady growth in the last decade (from 23.9% in 2009 to 36.3% in 2018 – Anna Aero (2018)[8]), the LCCs also contributed to around 40% fall in average yields on the intra-European market in the same period.

In addition to LCCs' expansion, the former European flag carriers experienced significant competitive pressure by the influx of the rapidly expanding airlines from the Middle East region and Turkey, particularly in long-haul market to Asia and Australia. In only ten years, from 2005 to 2015, three main Gulf carriers (often referred as "the Big three"), Emirates, Etihad and Qatar Airways, tripled the number of inbound flights to the European market (from less than 14 000 to 51 500 – Figure 8.2), while the total capacity almost quadrupled due to the increased average aircraft size[9]. All three carriers concentrate their flights primarily in three European countries, the United Kingdom, Germany and France and thus, became a serious threat to major carriers in these countries (i.e. British Airways, Lufthansa and Air France/KLM respectively). The Gulf carriers improve their networks in two distinctive ways. The first one focuses on adding alternative routes (i.e. "edges") rather than incorporating more airports (i.e. "nodes"). Thus, the Gulf carriers directly compete with major European carriers by offering an alternative way to passengers (for example, London-Dubai-Sydney with Emirates, as opposed to London-Singapore-Sydney with British

[8] The calculation of market shares is based on the capacity including total European seats offered. Concerning the intra-European capacity, the LCCs' market shares accounted for 40% in 2017.

[9] In the period from 2005 to 2015, Emirates' average aircraft size on the European market increased from 281 to 399, as supported by employing large A380. Qatar Airways has increased its average aircraft size from 216 to 251 during the same period, while Etihad's average aircraft size accounted for 234 seats in 2005 to 274 seats in 2015 (Anna Aero, 2015)

Airways). The second improvement emerges from the reduction in the number of legs required to connect a certain set of O-D markets, which directly increases the passenger convenience through reduction of travel times (Manchester-Dubai-Sydney with Emirates, as opposed to Manchester-London-Singapore-Sydney with British Airways).

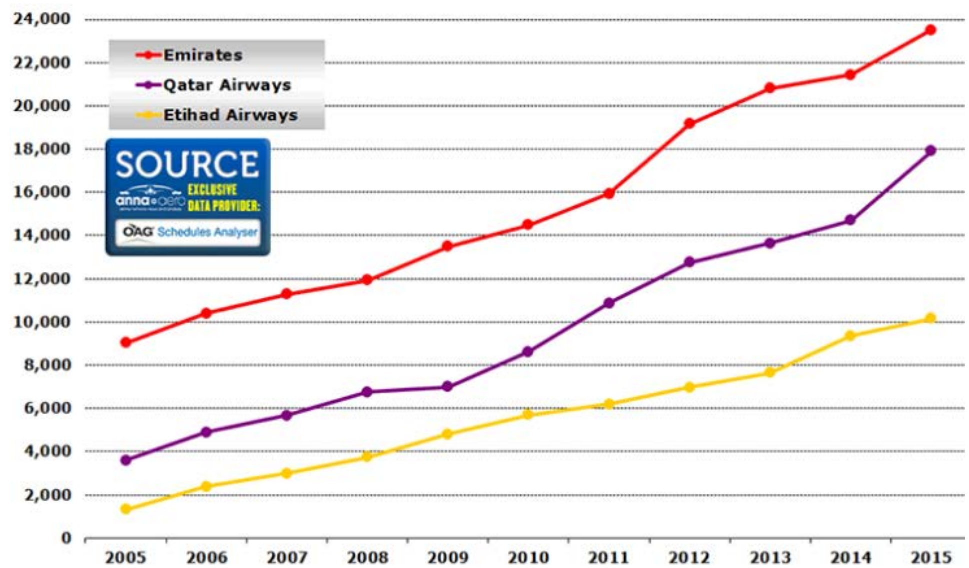


Figure 8.2. Gulf carriers' annual flights on routes to Europe (*Source: Anna Aero, 2015*)

With these network changes, "the Big three" succeeded to attract a large portion of connecting passengers from the European hinterlands to Asia and Australia over their geographically advantageously located hubs in Dubai, Abu Dhabi and Doha. The Middle East carriers have a favorable competitive position over their rivals on routes connecting Europe to the southern parts of Asia, whereas for the northern parts the incumbent players are well-positioned concerning both variety of destinations offered and total travelling time (Vispermann et al., 2008). As a result of fierce competition induced by "the Big three" on Europe-Asia market, the European major carriers' market share has gradually diminished from 30% in 2006 to around 20% (Figure 8.3), whereas the average yields have declined by 22% (McKinsey&Company, 2016).

Additionally, the research on fare differences between the Gulf carriers and large European carriers carried out by SEO Amsterdam Economics (2016) showed that the Gulf carriers tend to charge their indirect flights around 8% lower than direct flights of their major European rivals (for example, Amsterdam-Dubai-Singapore with Emirates as opposed to Amsterdam-Singapore with KLM). However, in the case of connecting markets where both the Gulf carriers and the European carriers offer indirect flights, the large European carriers appear to be more competitive in comparison to the Gulf carriers. On the other hand, the analysis showed that there is no statistical difference in the fares between the Gulf carriers and the major European carriers on direct flights (Amsterdam-Dubai with either KLM or Emirates). In addition to price, the Gulf carriers also compete in terms of service quality with the European carriers.

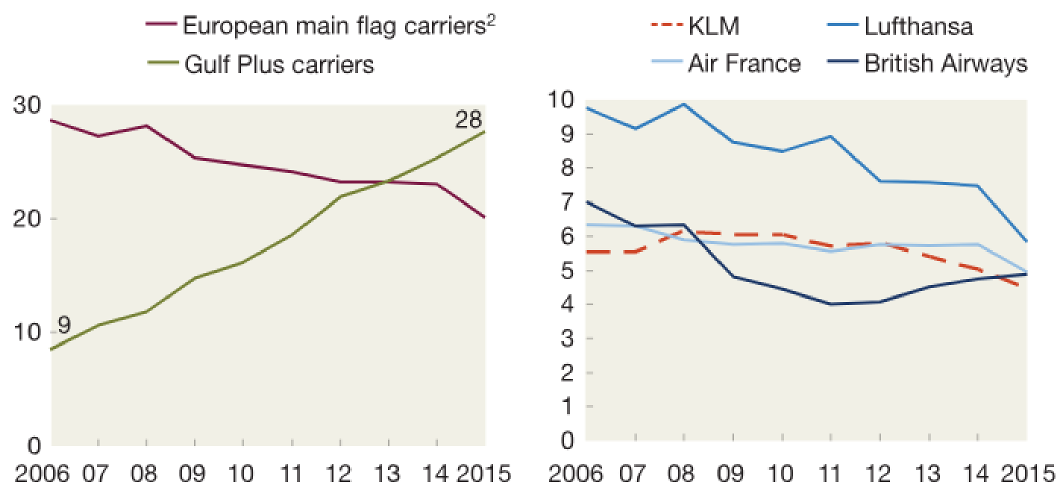


Figure 8.3. Market share in passenger transported on the European-Asia routes (*Source: McKinsey&Company, 2016*)[10]

In recent years, the emergence of long-haul low-cost carriers exerts additional pressure on the large European carriers on intercontinental markets. As discussed earlier, Norwegian Air Shuttle started to aggressively expand its network by adding transatlantic links from several European large metropolises such as London (2014), Paris (2016) and Barcelona (2017), facilitated by the strategy of exploiting new Boeing 787. Although this carrier still holds minority in seat capacity shares on many transatlantic routes operated from London

[10] The original data come from International Air Transport Association Market Intelligence

in comparison to British Airways, it threatens to sharply reshape the competition in the long-haul market. Finally, Norwegian's network expansion from Barcelona in 2017 probably served as an impetus to IAG to launch its own long haul low-cost subsidiary[11], Level. Before that advent, Lufthansa[12] also establish Eurowings at the end of 2015, a long haul low-cost subsidiary with its base in Cologne. Despite the rapid expansion in terms of network development and growth in passenger numbers, it seems that Norwegian experienced the debt payment issue which emerged as a result of high fuel price growth (Forbes, 2018). Consequently, IAG has acquired a 4.61% stake in Norwegian, with an ambitious plan of full acquisition in the near future. This is not surprising, since the full acquisition will extend IAG's leadership on the North Atlantic and accelerate its long haul low-cost ambition (CAPA, 2018d). On the other hand, if Norwegian overcomes the current issue, further operation could potentially evolve into development of a low cost hub-and-spoke system at London Gatwick, similar to the one already developed by Air Asia X[13] which operates the feeder flights to its parent Air Asia's connecting flights in Kuala Lumpur and Bangkok.

All abovementioned facts support the theory that FSCs' business model that proved to be very successful during the 1980s and 1990s, should be fundamentally revised in the era of diverse competition and extensive structural changes. Since the market liberalization in Europe initiated in 1990s, only a small number of airlines survived the emerging conditions, while the inefficient ones went bankrupt or were acquired[14]. It is evident that

[11] Vueling and Aer Lingus (which transformed itself into a low-cost company in 2006) were low-cost companies acquired by IAG group, while Level was the first airline created by the Group.

[12] Since 2012, there have been 15 launches of long haul low-cost companies across the world, among which five are established as subsidiaries or brands under full service airline groups: Air Canada, Hainan Airlines, Korean Air, Lufthansa, Qantas, SIA and IAG (CAPA, 2017).

[13] Air Asia X, the long haul low-cost company, enjoys the logistical and management support through fuel hedging and aircraft lease of its parent company Air Asia. Additionally, by applying the "judo" strategy in gaining market shares, the company entered the routes with little or no direct competition (Douglas, 2010).

[14] it can be concluded that airline industry is inherently oligopolistic and eventually control by the small number of carriers.

competition of LCCs and the Gulf carrier rivals with their lower unit costs[15] forced the FSCs to improve their strategies and move towards a new level of efficiency. As discussed in the economic theory (Porter, 1986), to achieve competitive success, any firm must process a competitive advantage in the form of either lower costs or differentiated products that command premium prices. However, the application of cost-cutting strategy seems to be inefficient enough without intensive business restructuring[16], particularly in the aspect of the costly FSCs' short-haul feeder system (Burghouwt and De Wit, 2015). Thus, the FSCs were forced to increase their overall efficiency (by minimizing the cost for the given level of output or to maximize their output for the given set of input) since it may highly affect their competitiveness in the global market. In other words, the airlines that can perform more efficiently are likely to be more competitive in the highly fluctuating environment. As reported in Fethi et al. (2000) the airlines' efficiency has been significantly improved as a result of EU liberalization. Based on the abovementioned facts, it can be concluded that measuring the airline efficiency becomes an inevitable step in assessing the airline's competitive advantage over its rival. In other words, the airline efficiency appears to be the first precondition of airline's competitive position.

The following subsection proposes a methodological framework to evaluate the efficiency of airlines that operate across Europe encompassing the airlines differing in terms of four core aspects such as their size (large legacy carriers vs. smaller legacy carriers), dominant business models (full service carriers vs. low-cost carriers), geographical location (European carriers vs. Middle Eastern carrier) and time adjustment to the new market conditions (carriers operate at early liberalized markets vs. carriers operate at lately liberalized market). The methodology enables one to derive and compare the airlines' efficiency scores for the years 2008 and 2012, the period that imposed a burden of

[15] According to chart given in SEO, Emirates's unit cost of less than 6 euro cents per ASK in 2016 was significantly lower than its major rival British Airways, Lufthansa and Air France-KLM with unit costs accounting for 8, 8.8 and 6.7 euro cent per ASK respectively.

[16] Long haul low cost becomes mainstream as FSCs gradually embrace new business models (CAPA, 2017).

challenge to the airline industry due to the severe global economic crisis occurred in 2008 and followed by the rapid recovery.

8.2. Measuring airline efficiency

Measuring airline efficiency has been extensively dealt with in the literature since the deregulation, but it never fades due to constantly changing conditions in the air travel markets that impose revision of airlines' strategies. It seems that, among many techniques that can be used to evaluate efficiency, the DEA method has gained much attention in airline performance benchmarking. Schefczyk (1993) is the pioneer in using DEA technique who analyzes and compares operational performance of 15 international airlines using non-financial data. Shortly after, Good et al. (1995) employ both DEA method and Cobbe-Douglas econometric model to examine the efficiency of eight largest European and eight largest American airlines during the period 1976-1986, which coincides with the process of deregulation and liberalization of the markets. In the following period, there have been a vast number of studies that used some modification of the standard DEA approach combined with the Total Factor Productivity index (Barbot et al., 2008), the Malmquist index (Chow, 2010), regression models (Greer, 2009; Barros and Peypoch, 2009), Tobit model (Fethi et al., 2000; Bhadra, 2009), the two-stage DEA approach, with partially bootstrapped random effects Tobit regressions in the second stage (Merkert and Hensher, 2011) and the B convex DEA model (Barros et al., 2013).

However, to the best of our knowledge, a fuzzy-based DEA has not been employed in evaluating airline efficiency. Bearing in mind that some of the inputs/outputs in a DEA model may be subject to imprecise measurements, but still highly affect airlines' efficiency, such modification of the standard DEA is very reasonable. Thus, our paper extends the current literature by employing this technique.

8.3. Methodology

8.3.1. Fuzzy DEA CCR input-oriented model

Data envelopment analysis is a non-parametric mathematical technique for measuring relative efficiency of Decision Making Units (DMUs) that does not require any functional relation between inputs and outputs. Initially proposed by Farrell (1957), it allows evaluation of efficiency based on multiple inputs and only one output. After two decades, Charnes et al. (1978) extended the Farrell's model by proposing the well-known CCR DEA (Charnes, Cooper & Rhodes DEA) model that allows multiple outputs but assumes the constant return to scale. Banker et al. (1984) propose the BCC model to deal with variable return to scale (VRS). Since then, various modifications of the standard DEA method have been applied in a large number of transportation fields.

The fuzzy DEA model employed in this paper basically relies on the standard input-oriented CCR model which can be expressed as a linear programming problem:

$$\max_{u,v} \sum_r u_r y_{r0} \tag{1}$$

Subject to

$\sum_i v_i x_{i0} = 1$
$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0$
$u_{r,} v_i \geq 0$
with $r = 1, \ldots, s$ and $i = 1, \ldots, m$; $\forall j = 1, \ldots, n$;

Where:

- n is the total number of DMUs;
- s is the total number of outputs;
- m is the total number of inputs;
- $y_{rj}$is an output r belonging to the DMU $j$assuming y_{rj} to be positive;
- x_{ij} is an input i belonging to the DMU j assuming x_{ij} to be positive;
- $y_{r0}$is an output r belonging to the DMU the efficiency of which is being assessed;
- x_{i0} is an input i belonging to the DMUthe efficiency of which is being assessed;

- u_r and v_i are the weights assigned to the output r and to the input i, respectively.

Weights u_r and v_i are the decision variables of the problem. The objective function expresses the efficiency score of the considered DMU (j = 0). DMUs with efficiency equal to 1 are considered efficient. Efficiency scores less than 1 denote some inefficiencies of the considered DMU. For more details on problem (1) see Cooper et al. (2007).

We extended the DEA model (1) by allowing the introduction of fuzzy-based inputs/outputs, as the available data used in the airline industry are sometimes imprecise, vague or apparently not available as a result of airlines' confidentiality policy. In fuzzy logic, a crisp number belongs to a set (fuzzy set) with a certain degree of membership, named also satisfaction h. The degree of membership is defined by a ''membership function'' (see Zimmermann, 1996). The simplest and most common membership function is the triangular one. If there is no specific information on the type of membership of an imprecise variable, it can then be expressed by a triangular fuzzy set with the shape shown in Fig. 8.4. This is the form of the membership functions we adopted for the uncertain variables of our problem. In Fig. 8.4, Δ represents a fuzzy input (x_{ij}) or a fuzzy output (y_{rj}) that we are considering. For example, if the variable Δ is flight delay, the value a represents the mean value of an airline flight delay (with the degree of membership equal to 1), whereas a^- and a^+ represent the minimum and the maximum delay respectively (degree of membership equal to 0).

If there are uncertain inputs or outputs in problem (1) and they belong to the fuzzy set of Figure 8.4, it is necessary to add other constraints. For example, the constraints to be added can be the following:

$$\Delta \leq a + (a^+ - a)(1 - h) \qquad (2)$$

$$\Delta \geq a - (a - a^-)(1 - h) \qquad (3)$$

A pair of inequalities (2)-(3) must be added to problem (1) for each uncertain input or output.

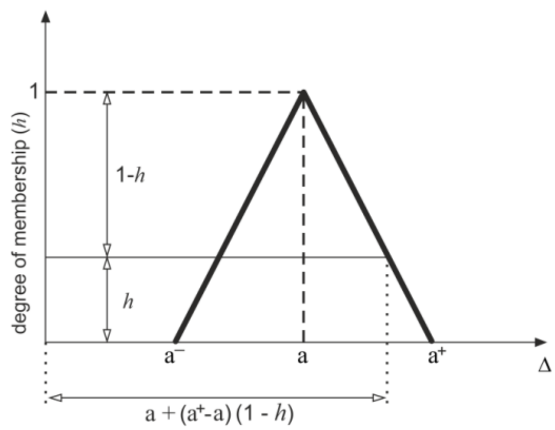


Figure 8.4. Triangular membership function of a fuzzy input or fuzzy output (*Source: Bray et al. (2015)*)

According to Teodorović and Vukadinović (1998), in a linear programming problem with fuzzy constraint coefficients, the objective function can also be expressed by a fuzzy set and it becomes a constraint. With the presence of uncertain inputs or outputs, problem (1) turns out to be transformed into this fuzzy programming input-oriented CCR model:

$$\max h \quad (4)$$

Subject to:

$$\sum_r u_r y_{r0} \geq h \quad (5)$$

$$\sum_i v_i x_{i0} = 1$$

$$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0$$

$$u_r, v_i \geq 0$$

$$y_{bj} \leq a_{bj} + \left(a_{bj}^{+} - a_{bj}\right)(1-h)$$

$$y_{bj} \geq a_{bj} - \left(a_{bj} - a_{bj}^{-}\right)(1-h)$$

$$x_{cj} \leq a_{cj} + \left(a_{cj}^{+} - a_{cj}\right)(1-h)$$

$$x_{cj} \geq a_{cj} - \left(a_{cj} - a_{cj}^{-}\right)(1-h)$$

with $r = 1, \dots, s$ and $i = 1, \dots, m$; $\forall\, j = 1, \dots, n$; $\forall\, b \in B; \forall\, c \in C$

Where:

- $h$is the satisfaction;
- B is the set of fuzzy outputs;
- $C$is the set of fuzzy inputs;
- a_{bj} is the mean value of a fuzzy output y_{bj};
- a_{bj}^{+} is the maximum value of a fuzzy output y_{bj};
- a_{bj}^{-} is the minimum value of a fuzzy output y_{bj};
- a_{cj} is the mean value of a fuzzy input x_{cj};
- a_{cj}^{+} is the maximum value of a fuzzy input x_{cj};
- a_{cj}^{-} is the minimum value of a fuzzy input x_{cj};

In this case, the decision variables of the problem are the weights u_r and v_i and the satisfaction$h$. The new objective is maximizing the satisfaction. The original objective (which continues to represent, also in this case, the efficiency score) has been transformed into a constraint of the type represented in Figure 8.5. This constraint (5) assumes the specific triangular shape of Figure 8.5, since the maximum value of the weighted sum of the outputs is equal to 1. In this way, maximising the satisfaction is equivalent to maximising the weighted sum of the outputs. For further details and other applications of this DEA extension, see, for example, Caggiani et al. (2014) and Bray et al. (2015).

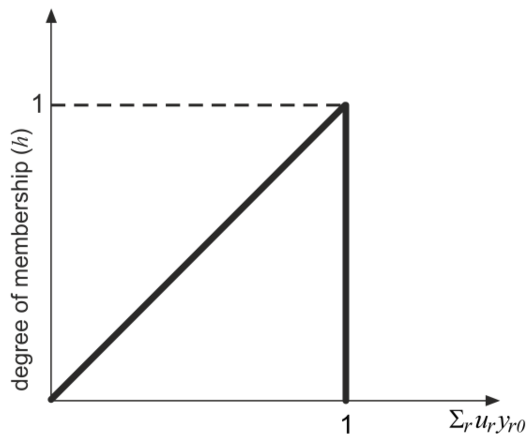


Figure 8.5. Fuzzy set representing the original objective function of problem (1)(*Source: Bray et al. (2015)*)

8.3.2. The Malmquist productivity index

We have applied the problem (4) to the airlines' data for the years 2008 and 2012 as it will be described better in the following chapters. In addition to efficiencies evaluations, for each airline, a comparison will also be made between the two yearsconsidered. Since the efficiency score of a DMU cannot be compared directly over time, the Malmquist productivity index (introduced by Caves et al., 1982) must also be calculated. This index enables comparison of efficiency over an observed period of time, measuring the productivity change. The Malmquist productivity index (MALM) can take values greater than 1 indicating productivity increase of a DMU over time, whereas values less than 1 refer to a decrease in productivity. The value of 1 indicates no changes in productivity. As proposed by Färe et al. (1992), MALM can be decomposed into efficiency (EFFCH) and technical change (TECHCH). Therefore, the mathematical formulation of MALM can be expressed as follows:

MALM = EFFCH x TECHCH

These two separate causes of productivity change are central for the definition of MALM (Greer, 2008). An improvement in efficiency can be derived by rational use of inputs, while an improvement in technical efficiency can occur when an airline acquires new technologies (new aircraft types and Internet-based reservation and ticketing system).

Likewise MALM, if EFFCH or TECHCH is greater than 1, productivity change is due respectively to technical efficiency improvements or technical change enhancement. On the contrary, if they turn out to be less than 1, it means that a deterioration of efficiency occurred. The value “1” indicates no changes. More details on the mathematical formulation of these indices can be found in Färe et al. (1992) and Álvarez et al., 2016.

8.4. Data and specification of inputs and outputs

The study involves 17 airlines that operated at European airports during 2008 and 2012 (see Table 8.1).

Table 8.1. Initial set of airlines selected (DMUs)

Airline/ ID	Lufthansa Group 1	AF-KLM 2	British Airways 3a	EasyJet 4
	SAS 5	Ryanair 6	Iberia 3b	Air Berlin 7
	Finnair 8	JAT Airways 9	Adria Airways 10	Croatia Airlines 11
	Czech Airlines 12	LOT Polish 13	Tarom 14	Norwegian 15
	Emirates Airlines 16			

Majority of all these airlines are registered in Europe, with Emirates standing as the only Middle-Eastern carrier with large dominance in Europe. In addition to the CE and SEE airlines that represent the focus of this paper (LOT Polish Airlines, Czech Airlines, Jat Airways, Croatia Airlines, Adria Airways and Tarom)(see Appendix 6 for more information), the set of airlines contains some of the mega airlines in Europe (Lufthansa Group, AF-KLM, IAG[17]), the most successful European LCCs (Ryanair and EasyJet) and other legacy carriers

[17]International Airlines Group was formed in January 2011 after a merger agreement by the absorption of British Airways into Iberia. Thus, these two companies were separate entities in 2008 (the year of observation).

smaller in scope and size (Finnair, SAS, Air Berlin and Norwegian).We derived the data used in this research primarily from the airlines' annual reports supplemented with the data from the European Commission reports, which were mainly used as the source of the data for the airlines operating in CE countries. Moreover, the reports published by the Association of European Airlines reports (AEA 2010, AEA 2013) were a valuable source to verify the consistency of the data obtained from different sources. Data from prominent aviation Internet sites such as CAPA and Anna Aero had eventually led to the last level of data verifications, especially for data concerning the airlines in SEE countries.

Given the data availability, we definedthe sets of inputs and outputs (see Table 8.2). The inputs can be divided into four subcategories: resources, costs, capacity and marketability index. The outputs encompass three sets of variables that capture three main aspects of performance: productivity, profitability and marketability. The selection of variables employed in the paper is very similar to Zhu (2011). Unlike Zhu (2011), who used various types of costs per ASK as input variables, we added the marketability aspect of airline services as well, expressed through the delay indicator and the capacity aspect expressed through ASK. In terms of output variables, the model follows the work of Zhu (2011), who selected RPK and number of passengers, but it also contributes by adding one additional variable, passenger per employee.

As it was mentioned above, the input variable "delay" is fuzzified. This variable has been easily converted from the "on-time performance" indicator for the sake of model specification since it was assumed as an input. This indicator goes hand in hand with efficient service and is calculated as the portion of all flights performed within 15 minutes after scheduled time of arrival/departure (FAA, 2012). This measure is seen as a very common parameter that reflects an airline's image and thus, airlines constantly aim at improving their values. Nowadays, airlines use buffer times to mitigate passenger-perceived delays against schedule that would, without buffers, arise from more complex network operations (Baumgarten et al., 2014).

Table 8.2. Inputs and outputs

Variable set	Items	ID
Input		
Resources	Number of employees	I1
	Number of aircraft in the fleet	I2
Costs	Cost per ASK	I3
	Employee cost per ASK	I4
Capacity	Available Seat Kilometre-ASK	I5
Marketability	Delay (1-on-time performance)	I6
Output		
Productivity	Aircraft per employee	O1
	Passenger per employee	O2
Profitability	Revenue Passenger Kilometre - RPK	O3
	Load factor	O4
	Number of passengers	O5
	Operating revenue	O6
Marketability	Number of destinations	O7

Inferior delay records might result in passengers switching to airlines with better on-time performance (Cook et al., 2012), and thus by buffering the schedule time, an airline can reduce passengers' anxiety about being late for the final destination. Therefore, the data on this parameter contains a level of uncertainty in airlines' reporting depending on the mechanism applied to incorporate buffer in the time schedule. Thus, applying a fuzzy number instead of using crisp values for this indicator is more than justified.

8.5. Empirical results

8.5.1. Exploratory analysis on the dataset

DEA is sensitive to outliers (Boyd et al., 2016). A comparison between large airline groups and small carriers could distort the results. For this reason, we carried out an exploratory analysis on the entire datasetavailable. To identify the main outliers, we adapted the procedure proposed by Adler and Raveh (2008) and by Mahlberg and Raveh (2012). Instead of using the Multi-Dimensional Scaling (MDS) Co-Plot, we applied the Robust Co-Plot (Atilgan, 2014; Atilgan and Atilgan, 2017). This kind of MDS works better than Co-Plot with datasets containing outliers since it is not affected by their presence (Atilgan, 2014).

Both Co-Plot and Robust Co-Plot allow to graphically show multivariate data by superimposing two graphs. One is a non-metric representation of the MDS through a set of points, each of them belonging to an observation (in our case, to a DMU). The distance between these points indicates the similarity between the observations. Goodness-of-fit of this representation is summarized by a single parameter. In Robust Co-Plot this parameter is the Kruskal stress value (Kruskal, 1964).The other graph is a representation of interrelations among the variables (which, in our case, are the inputs and the outputs) through vectors. Each variable has its own vector. The more the vectors have a similar direction, the more the variables are related to each other. In this case, we have goodness-of-fit for each variable. It expresses the goodness of the regression with respect to the observations and it is visualized by the magnitude of the vector (which is directly proportional to the value of the correlation).For more details, see Adler and Raveh (2008) and Bravata et al. (2008).

The procedure to identify outliers consists of repeating the Robust Co-Plot several times, removing, before each repetition, those DMUs whose representative points are positioned far from the center of gravity (the point where the vectors diverge) compared to the other points of the chart.

We first calculated the efficiency values by solving problem (4) and using all 17 DMUs for the years 2008 and 2012. In detail, for each year and for each DMU, 7 efficiency values were calculated, considering the 6 inputs and a different output at a time. Figure 8.6 and Figure 8.7 show, for example, the Robust Co-Plots obtained for outputs O1 and O6 in the first repetition.

The graphs of the other outputs have similar configurations with respect to those of outputs O1 and O6. The DMUs that have been found to be efficient are drawn with a red circle. The inefficient DMUs are instead represented with a black cross. The Kruskal stress value (σ) ranges from a minimum of 0.033 to a maximum of 0.048. According to Kruskal (1964), with these values, the goodness-of-fit turns out to be between good and excellent.

In all cases, given their position, it can be remarked that DMUs 1 and 2 (Lufthansa Group and AF-KLM) are the outliers.

The value of the correlations for all the vectors found (inputs and outputs) is on average high. After this first step, we deleted the DMUs 1 and 2 from the set of the considered airlines.

This entire procedure was repeated twice more, and British Airways (and consequently Iberia because in 2012 they became a single carrier), SAS and Emirates Airlines were also removed. In Figures 8.8 and 8.9, for example, the final Robust Co-Plot, with the remaining DMUs are shown. At the end, the goodness-of-fit of the MDS is on average improved compared to the first step (with a minimum of less than 0.025, considered "perfect" by Kruskal (1964)). The average correlation is quite high, and the inputs/outputs are well differentiated except in some cases where some input can be irrelevant.

With this methodology, we have thus identified the most evident outliers. They turn out to coincide with the largest airline groups among the 17 considered.

The following tables (Tables 8.3-8.6) show some descriptive statistics of the inputs and outputs used in this analysis. In each table the values related to the full dataset and to the selected DMUs are shown. We can see that in most cases the standard deviation and the maximum values of inputs and outputs of the remaining 11 DMUs are lower than those of the full dataset. This represents a further remark of the removal of outliers.

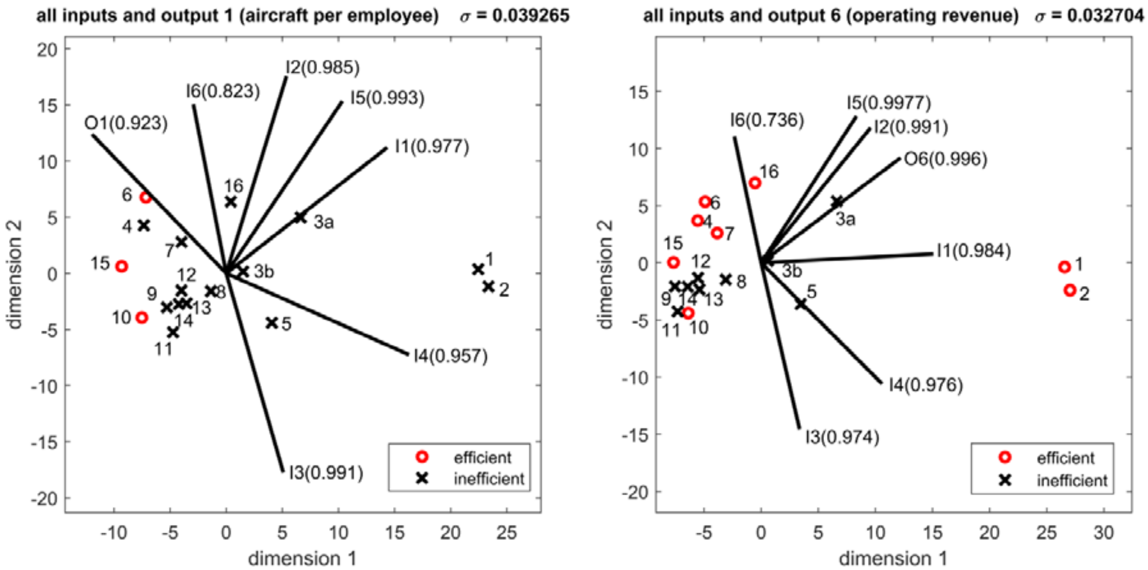


Figure 8.6. Robust Co-Plot analysis: 17 DMUs, all inputs/O1 and all inputs/O6 (2008 dataset)

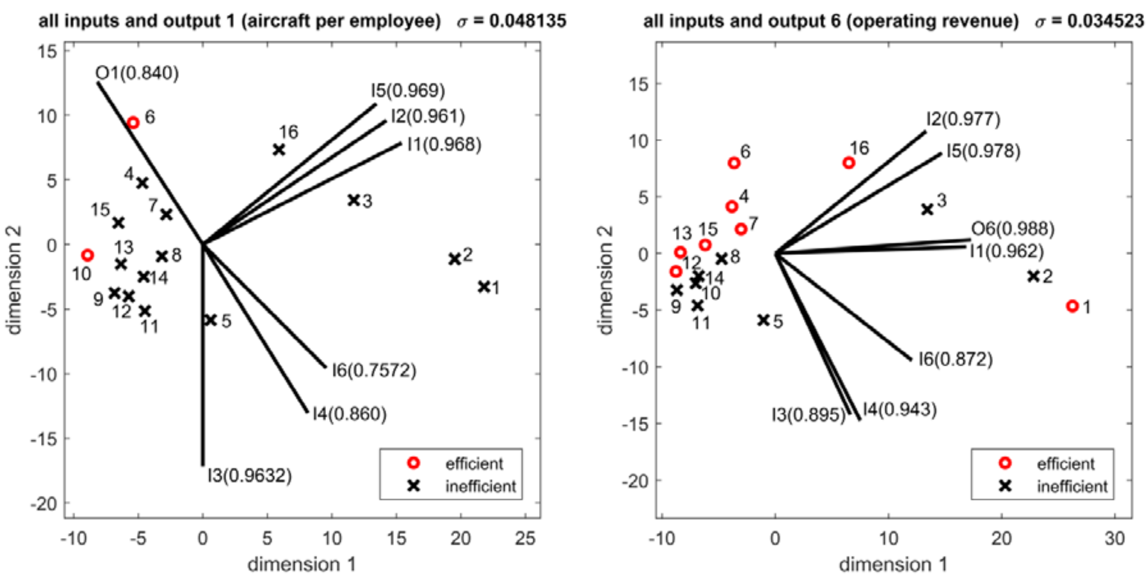


Figure 8.7. Robust Co-Plot analysis: 17 DMUs, all inputs/O1 and all inputs/O6 (2012 dataset)

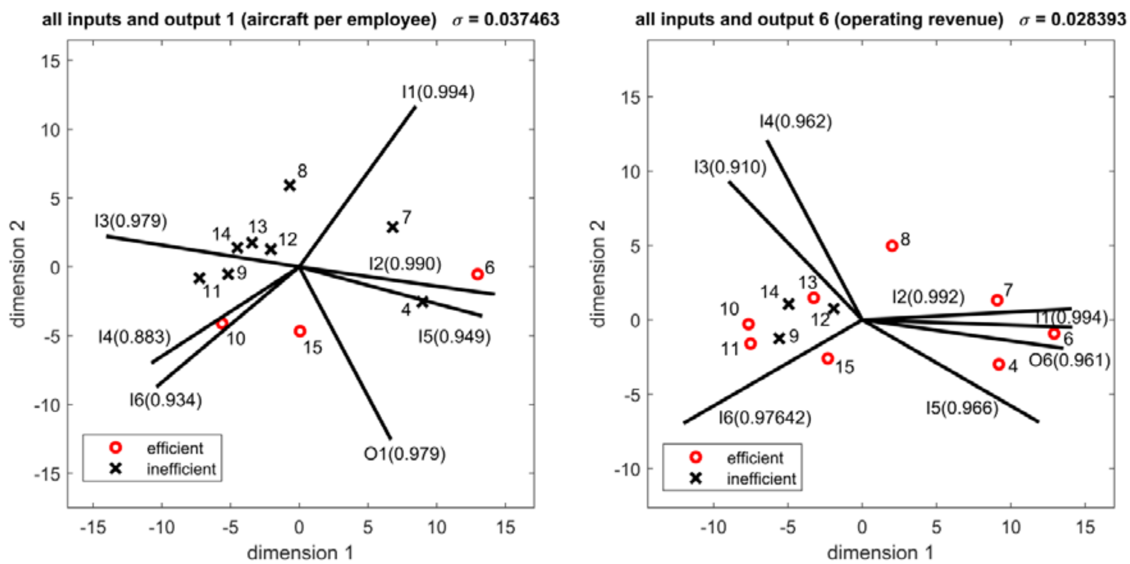


Figure 8.8. Robust Co-Plot analysis: 11 DMUs, all inputs/O1 and all inputs/O6 (2008 dataset)

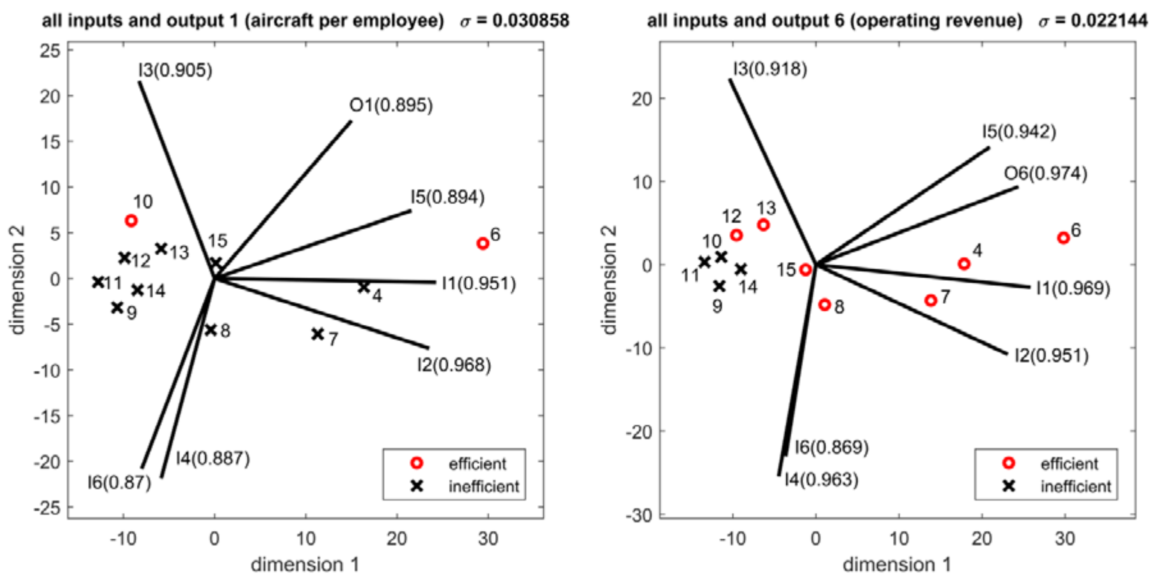


Figure 8.9. Robust Co-Plot analysis: 11 DMUs, all inputs/O1 and all inputs/O6 (2012 dataset)

Table 8.3. Descriptive statistics of inputs - year 2008

	Full dataset (17 DMUs)					
	I1	I2	I3	I4	I5	I6
Mean	21881	144	8.16	0.017	60915	0.208
Median	6375	109	8.05	0.015	45764	0.190
Minimum	726	10	4.05	0.004	2056	0.110
Maximum	107800	543	12.45	0.036	200797	0.350
Std. dev.	34165	162	2.48	0.009	66853	0.074

	Selected Decision Making Units (11 DMUs)					
	I1	I2	I3	I4	I5	I6
Mean	4230	66	7.54	0.013	23604	0.208
Median	3730	40	7.91	0.014	11530	0.200
Minimum	726	10	4.05	0.004	2056	0.120
Maximum	9595	181	10.90	0.020	75805	0.310
Std. dev.	3069	61	2.08	0.005	26717	0.071

Table 8.4. Descriptive statistics of outputs - year 2008

	Full dataset (17 DMUs)						
	O1	O2	O3	O4	O5	O6	O7
Mean	0.012	2350	48429	0.75	23904	5419	102
Median	0.009	1205	33097	0.78	21229	2942	87
Minimum	0.005	543	1349	0.62	1302	149	24
Maximum	0.029	9195	162658	0.86	70545	25720	252
Std. dev.	0.008	2626	53785	0.07	22800	7843	68

	Selected Decision Making Units (11 DMUs)						
	O1	O2	O3	O4	O5	O6	O7
Mean	0.016	3124	18820	0.72	14993	1349	70
Median	0.011	1679	7841	0.73	5626	789	61
Minimum	0.007	758	1349	0.62	1302	149	24
Maximum	0.029	9195	63090	0.86	58566	3416	140
Std. dev.	0.008	3017	22354	0.08	19804	1283	39

Table 8.5. Descriptive statistics of inputs - year 2012

	Full dataset (16 DMUs)					
	I1	I2	I3	I4	I5	I6
Mean	23661	175	8.76	0.015	82126	0.166
Median	7495	107	8.64	0.012	34386	0.155
Minimum	413	13	3.64	0.004	1565	0.080
Maximum	116957	627	12.65	0.035	269299	0.280
Std. dev.	37037	199	2.42	0.009	98489	0.062

	Selected Decision Making Units (11 DMUs)					
	I1	I2	I3	I4	I5	I6
Mean	4075	83	8.43	0.011	29710	0.154
Median	2189	26	8.24	0.012	9340	0.150
Minimum	413	13	3.64	0.004	1565	0.080
Maximum	9284	305	12.65	0.016	114489	0.280
Std. dev.	3484	97	2.56	0.004	37398	0.060

Table 8.6. Descriptive statistics of outputs - year 2012

	Full dataset (16 DMUs)						
	O1	O2	O3	O4	O5	O6	O7
Mean	0.015	2672	66516	0.77	31788	7178	119
Median	0.011	1675	26092	0.78	22950	3327	122
Minimum	0.004	775	1059	0.67	988	119	32
Maximum	0.034	8749	223034	0.90	102776	31831	253
Std. dev.	0.010	2530	79753	0.06	33221	9941	73

	Selected Decision Making Units (11 DMUs)						
	O1	O2	O3	O4	O5	O6	O7
Mean	0.018	3408	24662	0.76	19241	1881	86
Median	0.014	2392	7297	0.78	4972	838	68
Minimum	0.009	949	1059	0.67	988	119	32
Maximum	0.034	8749	96345	0.90	79256	4884	174
Std. dev.	0.009	2758	32041	0.07	26769	1988	52

To obtain sufficient differentiation between the DMUs efficiency scores, it is preferable that the DMUs number be not too small compared to the number of inputs and outputs. In the literature, there is no theoretical treatment that gives unique suggestion on this issue, but there are different rules of thumb. For example, Dyson et al. (2001) suggest that the number of DMUs should be greater than or equal to twice the product between the number of inputs and that of outputs. With 6 inputs and 1 output, the number of DMUs should be greater or equal to 12 but our remaining DMUs are 11. Given that he vectors of input I4 and input I6 assume often a similar direction, we have decided to delete input I4 (employee cost per ASK) from the dataset.

The values of the efficiencies obtained starting from the remaining DMUs and one output will be presented and discussed in the next chapter.

8.5.2. DEA and Malmquist index results

Tables 8.7, 8.8 and 8.9 show the results of the DEA frontier for 2008 and 2012 and the Malmquist index estimation with respect to three single outputs (Operating Revenue, RPK and Number of passengers). As it was mentioned above, DEA scores reveal the position of the airlines in relation to the frontier for each year. However, the DEA scores do not provide any information on relative position improvements and deterioration of airline productivity between the two observed years and thus, the Malmquist is employed as an appropriate tool.

A number of conclusions stem from the present study. First, there are significant differences in the DEA scores between the airlinesobserved. Second, the DEA scores confirmed the hypothesis that CE and SEE airlines tend to be less efficient than their counterparts in the rest of Europe. Third, the efficiency scores varied among the airlines, with the LCCs significantly outperforming their counterparts from the set across both observed years.

As it can be observed from Table 8.7, according to the DEA scores for 2008 from the entire set only three airlines from CE and SEE were inefficient. Serbian carrier Jat Airways had the worst record among them, with the score of only 0.68, followed by Tarom with a slightly better performance and the score of 0.86. The efficiency score for CSA Czech Airlines almost reached the maximum value of 1 (i.e. 0.99). Similar results were obtained for 2012, but with additional carriers Adria Airways and LOT Polish being inefficient with the scores of 0.92and 0.97 respectively. Poor performance of Jat Airways in both years is not surprising, since this period overlapped with significant replacement of the management board, reduction in the number of destinations and closing of representative offices across Europe (EX-Yu Aviation News, 2014). Romanian national carrier Tarom was in the same position as its Serbian counterpart, and this carrier has been permanently recording significant profit loss since 2008 (ZfCompanii, 2017) as a result of combined effects of the financial crisis and the airline's inability to adjust to the new market conditions.

Table 8.7. DEA Score and Malmquist index for single output (Operating Revenue)

Airlines	DEA Score 2008	DEA score 2012	EFFCH	TECHCH	Malmquist
Easyjet	1.00	1.00	1.00	1.22	1.22
Ryanair	1.00	1.00	1.00	1.86	1.86
Air Berlin	1.00	1.00	1.00	1.08	1.08
Finnair	1.00	1.00	1.00	1.04	1.04
Jat Airways	0.68	0.53	0.78	1.21	0.95
Adria Airways	1.00	0.92	0.92	1.08	1.00
Croatia Airlines	1.00	0.89	0.89	1.12	1.00
Czech Airlines	0.99	1.00	1.01	1.00	1.01
LOT Polish	1.00	0.97	0.97	1.03	1.00
Tarom	0.86	0.59	0.69	1.34	0.93
Norwegian	1.00	1.00	1.00	1.00	1.00

Nevertheless, based on the results provided by the Malmquist index, the efficiency of LOT Polish and CSA Czech Airlinesremained stable over the observed period of time. However, one can observe that CSA Czech Airlines experienced slight improvement in efficiency mainly through the gain in pure efficiency primarily by implementing "cutting-employee" strategy as one of the radical measure to decrease operational costs. As seen from (see Appendix 6 - Fig. A6.1), CSA Czech Airlines reduced its number of employees by double in only four years, from 2008 to 2012.

As previously mentioned, these two carriers, recovered, to some extent, from the crisis and outlined ambitious plans to sustain their market positions. Moreover, they both received aid through financial loans from their Governments (EU COM, 2012; EU COM, 2014), which certainly had positive impacts on their overall performance.

Since the EFFCH scores tend to be less than TECHCH, one can conclude that the improvement in productivity resulted more from the adoption of new technologies than fromefficiency improvements. This is a particularly apparent finding for the major low-cost carrier in Europe, Ryanair, which invested substantial sources in customer-focused technology that aims at enhancing customer experience within the airline. In the case of the inefficient carriers, it is evident that their deterioration is mainly derived from the decrease in pure efficiency since they could not easily cope with the increasing competitive threats induced by more efficient discount carriers during this period. On the other hand, TECHCH scores higher than 1 indicate that all airlines from CE and SEE countries (except CSA Czech Airlines the TECHCH of which remained unchanged) improved their technical efficiency. This finding is not surprising having in mind that a period of four to five years is sufficiently long to invest into new technologies, especially in acquiring new modernized aircraft.

Table 8.8. DEA Score and Malmquist index for single output (RPK)

Airlines	DEA Score 2008	DEA score 2012	EFFCH	TECHCH	Malmquist
Easyjet	1.00	1.00	1.00	1.00	1.00
Ryanair	1.00	1.00	1.00	1.71	1.71
Air Berlin	1.00	0.97	0.97	0.99	0.96
Finnair	0.95	1.00	1.05	0.97	1.02
Jat Airways	0.74	0.81	1.10	1.06	1.16
Adria Airways	0.77	0.75	0.98	1.06	1.03
Croatia Airlines	0.76	0.76	1.00	1.06	1.06
Czech Airlines	0.78	0.78	0.99	1.06	1.05
LOT Polish	0.85	0.87	1.02	1.05	1.08
Tarom	0.72	0.74	1.02	1.06	1.08
Norwegian	0.92	0.93	1.01	1.00	1.01

A similar conclusion can be drawn from Table 8.8 in the case of RPK as an output. However, there is generally a smaller number of carriers on the efficiency frontier compared to the previous results from Table 8.7. All CE and SEE carriers in 2008 and 2012 were inefficient and their scores fluctuated around 0.75. Whilst acknowledging that RPK is an indicator highly related to both number of passengers and airline's network design, it is apparent that the airlines from CE and SEE could not find an optimal solution to efficiently manage their networks and demands compared to their Western European counterparts. Nevertheless, based on the Malmquist result, one can conclude that all carriers from the set, except Air Berlin, improved their total efficiency in 2012 compared to 2008.

Finally, Table 8.9 provides the results of efficiency scores for the output expressed through the variable Number of passengers. It is evident that efficiency gap between the efficient and the inefficient carriers is the largest in this case. Compared to the results obtained in Table 7.8, it can be seen that CE and SEE airlines tend to be even more distant from the efficiency frontier. Among these airlines, CE airlines LOT Polish and Czech Airlines performed worst, followed by SEE airlines Tarom, Jat Airways and Adria Airways, with efficiency scores of around 0.75. However, as in the case of the previous results, the total efficiency improved in 2012 compared to 2008 for airlines from CE and SEE Europe and this was mainly driven by technological improvements.

Table 8.9. DEA Score and Malmquist index for single output (Number of passengers)

Airlines	DEA Score 2008	DEA score 2012	EFFCH	TECHCH	Malmquist
Easyjet	1.00	1.00	1.00	1.00	1.00
Ryanair	1.00	1.00	1.00	1.52	1.52
Air Berlin	0.72	0.75	1.04	0.95	0.99
Finnair	0.39	0.44	1.12	0.92	1.03
Jat Airways	0.71	0.80	1.14	1.03	1.17
Adria Airways	0.75	0.74	0.99	1.03	1.02
Croatia Airlines	1.00	1.00	1.00	1.00	1.00
Czech Airlines	0.61	0.68	1.12	1.03	1.16
LOT Polish	0.56	0.66	1.20	1.02	1.22
Tarom	0.68	0.69	1.02	1.06	1.08
Norwegian	1.00	0.91	0.91	0.96	0.88

8.6. Remarks

The analysis offered a Fuzzy Theory-based DEA approach to evaluate efficiency of the airlines in the period shortly before and after the global economic crisis (2008 and 2012), the period that coincides with intense market volatility in the European Union. On-time performance (converted to delay index) emerged to be an important aspect of an airline's overall image perceived by its customers, and reporting is consequently very often subject to hidden and imprecise interpretation. The fuzzy number is seen as an appropriate mathematical tool to include this indicator into the model. The model has been shown with respect to several single outputs and predefined set of inputs that were carefully selected. The results of the fuzzy DEA analysis reveal that the efficiency scores could slightly vary in respect to different output(s) across the set of airlines. However, despite the selected output(s), the results show that two major European LCCs, Ryanair and EasyJet, undoubtedly perform more efficiently when compared with the airlines selected across all single outputs. Concerning the efficiency of the CE and SEE airlines, it can be observed that these airlines are less efficient than their counterparts from the rest of Europe. However, it is evident that the efficiency scores (except for the number of passengers) tend to be slightly higher for the CE airlines (LOT Polish and CSA Airlines) compared to those operating in SEE countries. This would seem to suggest that the policy of opening the market earlier forced them to enhance their business and to become more competitive. Finally, the Malmquist indexes calculated for the period observed reveal that improvements in the CE and SEE airlines' productivity were attained mainly through adoption of new technologies, rather than through improvements in pure airline efficiency. This finding is in line with the process of fleet modernisation that occurred in almost all CE and SEE airlines in the period observed.

However, since many of them changed their ownership structure in the recent years, it will be a challenging task for the future to undertake a similar analysis against the newly arisen circumstances. In addition to enlargement of time series, it would be very interesting to perform a sensitivity analysis of the model in terms of input and output selection as well as some improvements in the fuzzy-based DEA technique.

9. Conclusion

The competition among full-service and low-cost carriers was exclusively restricted to short- and medium-haul sector for a long time in the past. However, the emergence of new aircraft types featured by very long-range capabilities with efficient fuel consumption and smaller capacity stands out as a backbone for revolutionary changes in the airline industry, as it enables the penetration of the low-cost business model into the long-haul sector. Thus, the advances in aircraft technology have shifted the airline industry in the direction of greater competition since a number of long-haul markets that were previously dominated by major full-service carriers becomes disrupted by low-cost carriers. As one of the high density markets, the transatlantic market between Europe and North America has witnessed the expansion of low-cost capacity on a number of routes that connects the major airports located in the United Kingdom, France, Spain, Norway and Denmark with dozen of destination spread across the U.S.

The thesis deals with various aspects of competition in the long-haul market which is characterized by presence of a major full-service carrier, typically a member of a large alliance group and a low-cost carrier that operates independently from any collaborative agreements. The thesis proposes three separate models developed with the aim to shed light on the competition that prevails in the long-haul market with players having distinctive core business models. The first model proposed in this thesis emphasizes the aspect of price competition between the major full-service carrier and the low-cost carrier, as price often plays the most important and decisive role in airline choice. The thesis proposes an original econometric model consisting of two simultaneous equations designed to capture the impact of the low-cost carrier (expressed through the number of passengers) on the dominant full-service carrier's price in long-haul city-pair markets. In addition to the effect of low-cost carrier, the model also reveals the influence of other factors that are perceived as very important in determining the full-service carrier's price such as market concentration, level of trade, tourism activity, fuel price, etc. Moreover, the three versions of the model were deployed to examine the influence of the major full-service carrier' capacity on prices embedded through the modification of the HHI index that directly depends on the aircraft seating density configuration (i.e. the seating density ranges from the maximum to the minimal number of seats installed in the cabin). The sensitivity analysis is performed to determine how the changes in the full-service carrier's time response (i.e. time of reaction) needed to implement the "capacity expansion" strategy could reduce the direct negative effect of the low-cost carrier. The results support the assumption that the model accurately reflects the reality on the market, as supported by the recent implementation of the "squeezing more passengers" strategy adopted by British Airways on its flight from London airports. At the same time, the model incorporates all key variables that are seen as crucial in the issue of price competition.

The second model in the thesis was developed to predict the airline market share on the route where at least one low-cost carrier competes with other full-service carrier(s) in long-haul markets. In an attempt to offer a robust market share model that will avoid the evaluation of passenger perceptions and market diversities, two input variables were identified as key factors that determine airline market shares in long-haul market. The first variable reflects the frequency share of the given airline in the total number of flights offered in the observed city-pair market, while the second variable presents the ratio of the ticket price of the given airline and the lowest ticket price offered in the route (typically offered by low-cost carrier). The model is based on the application of fuzzy logic employed as a universal approximator. The fine tuning of the membership functions for input and output variables is achieved by employing the Bee Colony Optimization method. The results of the model suggest that good prediction of the market share can be achieved, which is of crucial importance to airline planners in making the strategic decision. However, the model reveals that the strategy of increasing frequency in long-haul markets remains the very powerful one among these that aim to increase the market share, although the impact of price should not be neglected.

The third model proposed in the thesis is developed to evaluate airline efficiency based on careful selection of the sets of input and output variables. Bearing in mind that airline efficiency is the major precondition for gaining competitive advantage in a particular market, such models represents an inevitable part of any market research. The fuzzy DEA CCR input-oriented model was originally designed to deal with uncertainties and fuzziness inherited in the input variable. In addition to fuzzy DEA approach, the model also applies the Malmquist index that allows the comparison on airline efficiency over the observed time period.

Based on the abovementioned overview of the three models proposed, the following theoretical and practical contributions could be potentially drawn:

- The first model is designed to particularly capture the effect of low-cost competition on full-service carrier's price in the long-haul sector, the issue that was not empirically studied in relevant literature in the past; (the first model)
- The model is calibrated on the real data for transatlantic markets encompassing three routes that connects London with several destinations in the U.S. All three versions of the model are also calibrated on the data for the London –New York route, since the route is characterized as one of the densest routes in the world with a great number of competitors. (the first model)
- The sensitivity analysis proposed within the first model enable the full-service airline's managers to empirically consider the potential effects of different decisions regarding the "capacity expansion" strategy on mitigating the competitive pressure induced by the low-cost carrier; (the first model)
- The output of the first model can be of crucial importance to civil aviation authorities who monitor the shift in the competition in long-haul market and subsequently, to tailor the corresponding regulatory measures. (the first model)
- The second model is originally designed and it could serve as a decision making tool for a potential new entrant who is keen to assess the market share in the long-

haul market based on the anticipated flight frequency and price; Additionally, the logic beneath the model is intuitively clear for the analyst who can easily operate with two input variables and be aware of their impact on the market share (<u>the second model</u>).

- The second model is based on the real data encompassing all transatlantic routes operated by currently the largest European low-cost carrier, Norwegian Airlines, in which the airline has at least one full-service competitor; (<u>the second model</u>).
- The third model is originally built by using the set of variables carefully selected and can be used for efficiency evaluation for any other set of decision making units (i.e. airlines); (<u>the third model</u>)
- The application of the third model is shown on the example of large set of airlines operating in Europe in 2008 and 2012. (<u>third model</u>)
- Although these models are developed separately from one another, they can be jointly applied in market researches that require comprehensive analyses of competition between airlines.

Overall, all three models reveal that major airlines which operate within alliances are generally more competitive than other mid-sized carriers, primarily due to the benefits derived from the economy of density. However, the emergence of a low-cost carrier in long-haul sector poses a significant threat to full-service carriers to preserve market shares, although it seems that low-cost carriers are far from gaining a larger portion of market shares (as shown in the market share model, primarily due to small frequency). As observed from the first model, the major full-service carrier promptly reacted in order to reduce the competitive pressure of newcomers by applying the capacity extensions in the transatlantic market, as well as by introduction of new long haul narrow-body aircraft in its fleets. More recently, the major full-service airline groups, particularly in Europe (IAG, Air-France and KLM) and Asia (Singapore Airlines and AirAsia), provided an important strategic response to their pure LCC rivals in the long-haul sector by establishing their own low-cost subsidiaries. The IAG launched the long haul low-cost brand, Level, with an aim to adapt to the changing environment and reduce the pressure generated by independent carriers[18]. Thus, the competition between pure low-cost carriers and full-service network carriers would present a challenging task for future investigation. In addition, bearing in mind the distinctive characteristics of each competing route in the long-haul market, the price competition model could be improved by applying the disaggregate approach which would allow the introduction of additional variables that describe the competition on the route in more a subtle way. Regarding the market share model, the model can be extended in two possible directions. First, one can assume the introduction of additional variable such as number of carriers per route since it is observed that different routes experienced different level of concentration. Moreover, the cluster analysis based on the number of competitors could be performed to derive the market shares of airlines experiencing different level of competition. Second, with its ability to adapt to new information, the model proposed has the potential to be improved in the future by extending the current dataset with data from other world regions, as an attempt to design the universal model. Application of the model would be particularly interesting for the region of Australia and Oceania, since these regions have recently experienced the expansion in offered international seats in the markets over 4 000 km, which is an immense potential for low-cost carriers.

Finally, the fuel cost remains the critical component of sustainable development of any airline operating in the long-haul low cost sector. For example, Norwegian currently faces substantial financial losses, partially resulting from high fuel cost induced by inadequate fuel hedging strategy. Thus, the last model could be improved by including an input variable that treats only airline's fuel cost in addition to the very common CASK measure. It would also be interesting to compare the efficiency of airlines that operate in the long-haul low cost sector based on the model proposed with slight modification in the selection of input and output variables.

[18] IAG announced to launch Level few months after Norwegian decided to open its long haul base at Barcelona airport.

References

Adria Airways, 2017. History. Available at: https://www.adria.si/en/about-us/the-company/history/ (accessed 07.04.17).

Adler, N., Raveh, A., 2008. Presenting DEA graphically. Omega 36, 715–729.

Airbus, 2005. Global Market Forecast 2004–2023.

Akbar, Y., Németh, A., Niemeier, H-M., 2014. Here we go again: the Permanently Failing Organization: An application to the airline industry in Eastern Europe. Journal of Air Transport Management 35, 1–11.

Alderighi, M., Cento, A., Nijkamp, P., Rietveld, P., 2012. Competition in the European aviation market: the entry of low-cost airlines. Journal of Transport Geography 24, 223-233.

Álvarez, I.C., Barbero, J., Zofío, J.L., 2016. A Data Envelopment Analysis Toolbox for MATLAB. Working Papers in Economic Theory 2016/3, Department of Economics, Universidad Autónoma de Madrid, Spain. Available at: https://ideas.repec.org/p/uam/wpaper/201603.html (accessed 03.05.2018).

Anna Aero, 2010. Adria Airways grew 50% between '05 and '08; network designed to feed Star Alliance; Belgrade route returns soon. Available at: http://www.anna.aero/2010/02/16/adria-airways-grew-almost-50-between-2005-and-2008/(accessed 05.02.17).

Anna Aero, 2015. MEB3 in Europe +360% since 2005: Emirates, Etihad Airways, Qatar Airways now serve 48 airports in 28 countries. Available at: https://www.anna.aero/2015/11/18/emirates-etihad-airways-and-qatar-airways-in-europe-analysed/ (accessed 21.01.2019).

Anna Aero, 2016a. TAROM quickly losing market share in fast-growing Romania as Blue Air, Ryanair and Wizz Air all expand rapidly. Available at:

http://www.anna.aero/2016/10/07/tarom-now-has-just-20-percent-of-the-romanian-market/ (accessed 11.04.17).

Anna Aero, 2016b. LOT Polish Airlines capacity up 20% in 2016 but still behind Ryanair in Poland; US routes key to growth in 2017 as fleet will reach 50 aircraft. Available at: http://www.anna.aero/2016/10/19/lot-polish-airlines-capacity-up-20-percent-in-2016/ (accessed 05.02.17).

Anna Aero, 2018. LCC capacity in Europe set for half a billion seats in 2018; nine nations already at 50% market share; European share forecast for 50% in 2027. Available at: https://www.anna.aero/2018/07/18/lcc-capacity-in-europe-set-for-half-a-billion-seats-in-2018/ (accessed on 22.01.2019).

Association of European Airlines (AEA), 2007. Yearbook 06. Brussels, Belgium

Association of European Airlines (AEA), 2010. Yearbook 09. Brussels, Belgium

Association of European Airlines (AEA), 2013. Yearbook 12. Brussels, Belgium

Atilgan, Y.K., 2014. Robust Coplot Analysis.Communication in Statistics – Simulation and Computation 45 (5), 1763–1775.

Atilgan, Y.K., Atilgan, E.L., 2017. RobCoP: A Matlab Package for Robust CoPlot Analysis. Open Journal of Statistics 7, 23–35.

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

B92, 2015. Novak: Endi, Rafa i Rodžer žele broj 1, to me motiviše. Available at: http://www.b92.net/sport/usopen2015/komentari.php?nav_id=1035311 (accessed 02.07.2017).

Babić, D., Kuljanin, J., Kalić, M., 2014. Market share modelling in airline industry: an emerging market economies application. Transportation Research Procedia 3, 384-392.

Balkan Insight, 2012. Croatia Airlines Gets Government Aid. Available at: http://www.balkaninsight.com/en/article/croatia-airlines-gets-government-aid (accessed 04.05.2017).

Banker, R.D., Charnes, A., Cooper, W.W., 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science 30 (9), 1078–1092.

Barbot, C., Costa, A., Sochirca, E., 2008. Airlines performance in the new market context: a comparative productivity and efficiency analysis. Journal of Air Transport Management 14 (5), 270-274.

Barros, C.P., Peypoch, N., 2009. An evaluation of European Airlines' operational performance. International Journal of Production Economics 122 (2), 525–533.

Barros, C. P., Liang, Q. B., Peypoch, N., 2013. The technical efficiency of US Airlines. Transportation Research Part A: Policy and Practice 50, 139–148.

Baumgarten, P., Malina, R., Lange, A., 2014. The impact of hubbing concentration on flight delays within airline networks: An empirical analysis of the US domestic market. Transportation Research Part E-Logistisc and Transportation Review 66, 103–114.

Begović, B., Pavić, V., 2010. Šta je to konkurencija i kako se štiti?. Centar za liberalno-demokratske studije, Beograd, Srbija (in Serbian language).

Begović, B., Popović, V. D., (eds.). 2018. Competition Authorities in South Eastern Europe: Building Institutions in Emerging Markets. Springer.

Behrens, C. L., Lijesen, M. G., 2015. Measuring Competition Intensity; An Application to Air/HSR Transport Markets. (TI Discussion Paper; No. 15-075/VIII). Amsterdam: Tinbergen Institute.

Bhadra, D., 2009. Race to the bottom or swimming upstream: Performance analysis of US airlines. Journal of Air Transport Management 15 (5), 227–235.

Boeing, 2005. Boeing Commercial Airplanes Current Market Outlook 2005.

Boeing, 2017. Boeing 787 Dreamliner. Available at: https://www.boeing.com/commercial/787/ (accessed 02.03.2017).

Boeing, 2018. Commercial market outlook 2018-2037.

Borenstein, S. 1989. Hubs and High Fares: Dominance and Market Power in the US Airline Industry. Rand Journal of Economics 20 (3), 344–365.

Bray, S., Caggiani, L., Ottomanelli, M., 2015. Measuring transport systems efficiency under uncertainty by fuzzy sets theory based Data Envelopment Analysis: theoretical and practical comparison with traditional DEA model. Transportation Research Procedia 5, 186–200.

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

Boyd, T., Docken, G., Ruggiero, J., 2016. Outliers in data envelopment analysis. Journal of Centrum Cathedra 9 (2), 168–183.

Bravata, D.M., Shojania, K.G., Olkin, I., Raveh, A., 2008. CoPlot: A tool for visualizing multivariate data in medicine. Statistics in Medicine 27, 2234–2247.

Burghouwt, G., de Wit, G. J., 2015. In the wake of liberalization: long-term developments in the EU air transport market. Transport Policy 43, 104-113.

Caggiani, L., Ottomanelli, M., Dell'Orco, M., 2014. Handling uncertainty in Multi Regional Input-Output models by entropy maximisation and fuzzy programming. Transportation Research Part E-Logistisc and Transportation Review 71, 159–172.

CAA – Civil Aviation Authority 2018. Available at: https://www.caa.co.uk/uploadedFiles/CAA/Content/Standard_Content/Data_and_analysis/Datasets/Punctuality_stats/2018/201801_Punctuality_Statistics_Monthly.pdf (accessed 05.02.2019).

CAPA– Centre for Aviation, 2009. Air France-KLM up as it withdraws from Czech Airlines privatization. Available at: https://centreforaviation.com/insights/analysis/air-france-klm-up-as-it-withdraws-from-czech-airlines-privatisation-9648 (accessed 03.02.17).

CAPA– Centre for Aviation, 2012. Poland's LOT and Turkish Airlines highlight Eastern European flag carriers investor/seller. Available at: https://centreforaviation.com/insights/analysis/polands-lot-and-turkish-airlines-epitomise-eastern-european-flag-carriers-investorbuyer-shortfall-66878 (accessed 03.02.17).

CAPA– Centre for Aviation, 2013. Croatia Airlines: loss-making, high-cost and in need of capital. Any takers?. Available at: https://centreforaviation.com/insights/analysis/croatia-airlines-loss-making-high-cost-and-in-need-of-capital-any-takers-126540 (accessed 06.03.17).

CAPA– Centre for Aviation, 2014. LOT Polish Airlines starts to look beyond restructuring to improve its lot. Available at: https://centreforaviation.com/insights/analysis/lot-polish-airlines-starts-to-look-beyond-restructuring-to-improve-its-lot-174497 (accessed 06.04.17).

CAPA – Centre for Aviation, 2016a. European Airline Consolidation and Profitability Part 1: Top 5 Airline Groups Have Only 43% Share. Available at: https://centreforaviation.com/analysis/european-airline-consolidation-and-profitability-part-1-top-5-airlinegroups-have-only-43-share-275322 (accessed 05.02.2018).

CAPA – Centre for Aviation, 2016b. European airline consolidation and profitability Part 1: top 5 airline groups have only 43% share. Available at: https://centreforaviation.com/analysis/reports/european-airline-consolidation-and-profitability-part-1-top-5-airline-groups-have-only-43-share-275322 (accessed 21.01.2019).

CAPA – Centre for Aviation, 2016c. European airline consolidation Part 2: M and A potential of major groups; benefits and hurdles. Available at: https://centreforaviation.com/analysis/reports/european-airline-consolidation-part-2-m-and-a-potential-of-major-groups-benefits-and-hurdles-275377 (accessed 21.01.2019).

CAPA - Center for Aviation. 2017. Long haul low cost becomes mainstream as full service airlines gradually embrace new business models. Available at: https://centreforaviation.com/insights/analysis/long-haul-low-cost-becomes-mainstream-as-full-service-airlines-gradually-embrace-new-business-models-348105 (accessed on 21.03.2018).

CAPA – Centre for Aviation, 2018a. Long haul low cost airlines slowly start to grow in Asia-Europe market. Available at: https://centreforaviation.com/analysis/reports/long-haul-low-cost-airlines-slowly-start-to-grow-in-asia-europe-market-426864 (accessed 04.05.2018).

CAPA – Centre for Aviation, 2018b. Japan Airlines to decide on 787 aircraft for long haul LCC. Available at: https://centreforaviation.com/analysis/reports/japan-airlines-to-decide-on-787-aircraft-for-long-haul-lcc-428536 (accessed 04.05.2018).

CAPA – Centre for Aviation, 2018c. Europe's Top 20 airline groups by passengers 2017; Lufthansa wrests top spot from Ryanair. Available at: https://centreforaviation.com/analysis/reports/europes-top-20-airline-groups-by-passengers-2017-lufthansa-wrests-top-spot-from-ryanair-394211 (accessed 22.01.2019).

CAPA – Centre for Aviation, 2018d. IAG and Norwegian Air begin to tango. Available at: https://centreforaviation.com/analysis/reports/iag-and-norwegian-air-begin-to-tango-411857 (accessed 21.01.2019).

Caves, D.W., Christensen, L.R., Diewert, W.E., 1982. The economic theory of index numbers and the measurement of input, output, and productivity. Econometrica 50 (6), 1393–1414.

Cento, A., 2009. The airline industry: Challenges in the 21st century. Physica-Verlag, Heidelberg.

CEPS – Centre for European Policy Studies, 2018. Low-Cost Airlines: Bringing the EU closer together. (prepared by Akgüç, M., Beblavy, M., Simonelli, F.) Available at: https://www.ceps.eu/publications/low-cost-airlines-bringing-eu-closer-together (accessed 22.01.2019).

Charnes, A., Cooper, W.W., Rhodes, E.L., 1978. Measuring the efficiency of decision making units. European Journal of Operational Research 2 (6), 429–444.

Chen, F-Y., Chang, Y-H. 2005. Examining airline service quality from a process perspective. Journal of Air Transport Management 11 (2), 79–87.

Cho, W., Windle, J. R., Hofer, C., 2012. Route competition in multi-airport cities: an analysis of US air fares. Transportation Journal 51 (3), 265-288.

Chow, C. K. W., 2010. Measuring the productivity changes of Chinese airlines: the impact of the entries of non-state-owned carriers. Journal of Air Transport Management 16 (6), 320–324.

Coldren, G.M., Koppelman, F., Kasturirangan, K., Mukherjee, A., 2003. Air travel itinerary share prediction: Logit Model Development at Major US Airline. In: Transportation Research Board annual meeting CD ROM.

Cook, A., Graham, T., Lawes, A., 2012. The Hidden Cost of Airline Unpunctuality. Journal of Transport Economics and Policy 46 (2), 157–173.

Cooper, W.W., Seiford, L.M., Tone, K., 2007. Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software, second ed. Springer US, New York.

Croatia Airlines Annual Report 2012, 2013. Available at: https://www.croatiaairlines.com/About-us/Financial-information/Financial-reports (accessed 05.03.17).

Daft, J., Albers, S. 2012. A profitability analysis of low-cost long-haul flight operations. Journal of Air Transport Management 19, 49-54.

Dargay, J., Hanly, M., 2001. The Determinants of the Demand for International Air Travel to and from the UK . 9th World Conference on Transport Research Society, Soeul, Korea.

Dixit, A., 1979. A Model of Duopoly Suggesting a Theory of Entry Barriers. Bell Journal of Economics 10, 20–32.

De Poret, M., O'Connell, J. F., Warnock-Smith, D., 2015. The economic viability of long-haul low cost operations: Evidence from the transatlantic market. Journal of Air Transport Management 42, 272-281.

Dobruszkes, F., 2009. New Europe, new low-cost air services. Journal of Transport Geography 17 (6), 423–432.

Doganis, R., 2001. The airline business in the 21st Century. Routledge, London.

Doganis, R., 1991. Flying off course: The Economics of International Airlines. (2nd eds.) Routledge, London.

Douglas, I., 2010. Long-haul market entry by value-based airlines: dual business models support product innovation. World Review of Intermodal Transportation Research 3, 202-214.

Dresner, M., Lin, S-J. C., Windle, R. J., 1996. The Impact of Low-Cost Carriers on Airport and Route Competition. Journal of Transport Economics and Policy 30 (3), 309-328.

Dresner, M., Eroglu, C., Hofer, C., Mendez, F., Tan, K., 2015. The impact of Gulf carrier competition on U.S. airlines. Transportation Research Part A: Policy and Practice 79, 31-41.

Dyson, R., Allen, R., Camanho, A., Podinovski, V., Sarrico, C., Shale, E., 2001. Pitfalls and protocols in DEA. European Journal of Operational Research 132 (2), 245–259.

EASA – European Union Aviation Safety Agency, 2019a. ICAO Aircraft Engine Emissions Databank. Available at: https://www.easa.europa.eu/easa-and-you/environment/icao-aircraft-engine-emissions-databank (accessed 09.04.2019).

EASA – European Union Aviation Safety Agency, 2019b. EASA certification noise levels. Available at: https://www.easa.europa.eu/easa-and-you/environment/easa-certification-noise-levels (accessed 09.04.2019).

EU COM, 2012. State aid: Commission approves restructuring aid for Czech Airlines. IP/12/981. European Commission, Brussels.

EU COM, 2014. State aid: Commission approves restructuring aid for LOT Polish Airlines. IP/14/883 European Commission, Brussels.

EU COM, 2015. Commission decision on the measures SA.32715 (2012/C) (ex 2012/NN) (ex 2011/CP) implemented by Slovenia for Adria Airways d.d.). Official Journal of European Union L78/18.

European Commission - World Bank, 2007. The European Common Aviation Area and the Western Balkans: Domestic Reforms and Regional Integration in Air Transport. Available at: http://documents.worldbank.org/curated/en/390621468255858328/The-European-Common-Aviation-Area-and-the-Western-Balkans-domestic-reforms-and-regional-integration-in-air-transport(accessed 25.04.17)

Ex-Yu Aviation News, 2014. Available at: http://www.exyuaviation.com/2014/07/ (accessed 05.04.17).

Farrell, M.J., 1957. The measurement of productive efficiency. Journal of the Royal Statistical Society – Statistics in Society Series A 120 (3), 253–281.

Färe, R., Grosskopf, S., Lindgren, B., Roos, P., 1992. Productivity change in Swedish pharmacies 1980–1989: a nonparametric Malmquist approach. Journal of Productivity Analysis 3, 85–102.

Federal Aviation Administration (FAA), 2012. FAA Aerospace Forecast – Fiscal Years 2012–2032. US Department of Transportation, Washington DC.

Fethi, M. D., Jackson, P. M., Wayman-Jones, T. G., 2000. Measuring efficiency of European airlines: an application of DEA and Tobit analysis. Discussion paper, Efficiency and Productivity Research Unit, University of Leicester, UK.

Francis, G., Dennis, N., Ison, S., Humphreys, I., 2007. The transferability of the low-cost model to long-haul airline operations. Tourism Management 28, 391-398.

Franke, M., 2004. Competition between network carriers andlow-cost carriers—retreat battle or breakthrough to a new level of efficiency?. Journal of Air Transport Management 10, 15-21.

Forbes, 2018. Discount Carrier Norwegian Air Faces Financial Pressure As Year Ends. Available at: https://www.forbes.com/sites/grantmartin/2018/12/22/discount-carrier-norwegian-air-faces-collapse-by-years-end/#2555b0ef4e9b (accessed 02.01.2019).

Forsyth, P., 2003. Low-cost carriers in Australia: experiences and impacts. Journal of Air Transport Management 9 (5), 277-284.

Fu, X., Lei, Z., Wang, K., Yan, W. K., 2015. Low cost carrier competition and route entry in an emerging but regulated aviation market – The case of China. Transportation Research Part A: Policy and Practice 79, 3-16.

Geroski, P.A., 1983. Some reflections on the theory and application of concentration indices. International Journal of Industrial Organization 1, 79–94.

Gilbert, D., Wong, K.C. R., 2003. Passenger expectations and airline services: a Hong Kong based study. Tourism Management 24, 519–532.

Gillen, D., 2009. International Air Passenger Transport in the Future. 18th International Transport Research Symposium, discussion paper no. 2009-15, Madrid.

Goetz, A. R., Vowles, T. M., 2009. The good, the bad, and the ugly: 30 years of US airline regulation. Journal of Transport Geography 17, 251-263.

Good, D. H., Röller, L-H., Sickles, R. C., 1995. Airline efficiency differences between Europe and the US: Implications for the pace of EC integration and domestic regulation. European Journal of Operational Research 80 (3), 508–518.

Goolsbee, A., Syverson, C., 2008. How Do Incumbents Respond to the Treath of Entry? Evidence from the Major Airlines .The Quartely Journal of Economics 123 (4), 1611-1633.

Gourdin, K. (1988). Bringing quality back to commercial travel. Transportation Journal 27 (3), 23–29.

Graham, A., 2000. Demand for leisure air travel and limits to growth. Journal of Air Transport Management 6, 109-118.

Graham, A., 2008. Trends and characteristics of leisure travel demand. In: Graham, A., Papatheodorou, A., Forsyth, P. (eds), Aviation and Tourism: Implications for Leisure Travel. Ashgate Publishing, 21-23.

Greer, M.R. 2008. Nothing focuses the mind on productivity quite like the fear of liquidation: Changes in airline productivity in the United States, 2000–2004. Transportation Research Part A: Policy and Practice 42 (2), 411–426.

Greer, M.R., 2009. Is it the labor unions' fault? Dissecting the causes of the impaired technical efficiencies of the legacy carriers in the United States. Transportation Research Part A: Policy and Practice 43, 779–789.

Hansen, M., 1990. Airline competition in a hub-dominated environment: An application of noncooperative game theory. Transportation Research 24 (1), 27-43.

Hatch, M. J., Schultz, M., 2003. Bringing the corporation into corporate branding. European Journal of Marketing 37 (7/8), 1041-1064.

Hausman, J., Leonard, G., Zona, J. D. 1992. A Proposed Method for Analyzing Competition among Differentiated Products. Antitrust Law Journal 60, 889-900.

Hausman, J., Leonard, G., Zona, J. D. 1994. Competitive analysis with differentiated products. Annales d'Economie et de Statistique, 159-180.

Heshmati, A., Kim, J., 2016. Efficiency and competitivness of international airlines. Springer, Singapore.

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

IATA – International Air Transport Association, 2006. Airline cost performance: Economics Briefing No 5, Mark Smyth, Brian Pearce.

IATA – International Air Transport Association, 2012. Economic profit and loss in the aviation value chain, Presentation at European Aviation Conference 2012, Brian Pearce.

IATA Jet Fuel Price Monitor, 2017. Available at: https://www.iata.org/publications/economics/fuel-monitor/Pages/index.aspx (accessed 27.01.2018).

IATA – International Air Transport Association, 2018. IATA Fact Sheet – Fuel. Available at: https://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/fact-sheet-fuel.pdf (accessed 30.11.2018).

ICCT – International Council of Clean Transportation, 2015. Transatlantic airline fuel efficiency ranking, 2014. Irene Kwan and Daniel Rutherford. Available at: https://www.theicct.org/sites/default/files/publications/ICCT_transatlantic-airline-ranking-2014.pdf (accessed 10.04.2019).

Independent, 2016. British Airways to shrink seat space to squeeze more passengers on to flights. Available at: https://www.independent.co.uk/travel/news-and-advice/british-airways-ba-cuts-space-economy-passengers-toilets-seats-a7398251.html (accessed 22.12.2017).

Ito, H., Lee, D., 2003. Incumbent Responses to Lower Cost Entry: Evidence from the U.S. Airline Industry (December 11, 2003). Brown University Department of Economics Paper No. 2003-22. Available at: http://dx.doi.org/10.2139/ssrn.724161 (accessed 27.10.2018).

Jankiewicz, J., Huderek-Glapska, S., 2016. The air transport market in Central and Eastern Europe after a decade of liberalisation – Different paths of growth. Journal of Air Transport Management 50, 45–56.

Kalić, M., Teodorović, D., 1999. Modal Split Modeling Using Fuzzy Logic. In: Proceedings of the Conference "Modelling and Management in Transportation", Poznan-Cracow, Poland, 91-96.

Kalić, M., Tošić, V., 2000. Soft Demand Analysis: Belgrade Case Study. In: Proceedings of the 8th Meeting of the Euro Working Group Transportation (EWGT) and Workshop IFPR on Management of Industrial Logistic Systems "Rome Jubilee 2000 Conference", Rome, Italy, 271-275.

Kalić, M., Teodorović, D., 2003. Trip distribution modeling using fuzzy logic and a genetic algorithm. Transportation Planning and Technology 26 (3), 213-238.

Kalić, M., Kuljanin, J., Dožić, S., 2014a. Air Travel Demand Fuzzy Modelling: Trip Generation and Trip Distribution. Soft Computing in Industrial Applications, Springer, Proceedings of the 17th Online World Conference on Soft Computing in Industrial Applications, Series: Advances in Intelligent Systems and Computing, Vol. 223, XIV, 279-291.

Kalić M., Dožić, S., Kuljanin, J., 2014b. The Fuzzy System Sensitivity Analysis: An Example of Air Travel Demand Models, Computer-based Modelling and Optimization in Transportation, Springer, Advances in Intelligent Systems and Computing Volume 262, pp 361-373.

Kennedy, P., 2003. A Guide to Econometrics, (fifth ed.) MIT Press, Cambridge, MA.

Kruskal, J., 1964. Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. Psychometrika 29, 1–27.

Kuljanin, J., Kalić, M., 2015. Exploring characteristics of passengers using traditional and low-cost airlines: A case study of Belgrade Airport. Journal of Air Transport Management 46, 12–18.

Kuljanin, J., Kalić, M., Caggiani, L., Ottomanelli, M., 2017. Airline efficiency performance in the turbulent period before and after economic crisis. Tehnika-Saobraćaj 72 (5), 725-732.

Kuljanin, J., Kalić, M., Renold, M., 2018a. The impact of low cost carrier on competition in long haul market: London – New York route. In: Proceedings of XVI International symposium SYMORG 2018: "Doing business in the digital age: challenges, approaches and solutions", Zlatibor, Serbia, 252-259.

Kuljanin, K., Kalić, M., Mijović, N., Renold, M., 2018b. The impact of low-cost carrier on traditional airline' fares on intercontinental routes. Tehnika-Saobraćaj 73, 117-123. (in Serbian language).

Kuljanin, J., Paskota, M., Kalić, M., 2018c. Methodological framework for the investigation on the rapidly growing air travel market – An application of multivariate statistical analysis. Journal of Air Transport Management 72, 86-91.

Kuljanin, J., Kalić, M., Caggiani, L., Ottomanelli, M., 2019. A comparative efficiency and productivity analysis: Implication to airlines located in Central and South-East Europe. Journal of Air Transport Management, doi: https://doi.org/10.1016/j.jairtraman.2019.01.009.

Kwoka, J., Batkeyev, B., 2018. Strategic responses to competitive threats: airlines in action. Review of Industrial Organization, 1-27.

Liou, J. J., Chuang, M-L., 2009. Evaluating corporate image and reputation using fuzzy MCDM approach in airline market. Springer, Quality & Quantity 44 (6), 1079–1091.

Lijesen, M. G., Nijkamp, P., Rietveld, P., 2002. Measuring competition in civil aviation. Journal of Air Transport Management 8, 189-197.

Lijesen, M. G., 2004. Adjusting the Herfindahl index for close substitutes: an application to pricing in civil aviation. Transportation Research Part E: Logistics and Transportation Review 40 (2), 123-134.

Lučić, P., Teodorović, D., 2001. Bee system: modeling combinatorial optimization transportation engineering problems by swarm intelligence. In: Preprints of the TRISTAN IV Triennial Symposium on Transportation Analysis. Sao Miguel, Azores Island, Portugal, 441–445.

Lučić, P., Teodorović, D., 2003. Computing with Bees: Attacking Complex Transportation Engineering Problems. International Journal on Artificial Intelligence Tools 12 (3), 375–394.

Mahlberg, B., Raveh, A., 2012. Co-plot: a useful tool to detect outliers in DEA. Available at: http://dx.doi.org/10.2139/ssrn.1999370 (accessed 03.05.2018).

Maldutis, J., 1997. Concentration of market power is reaching excess levels. Spotlight on finance, Vol. 2 (3). Available at: http//www.awgnews.com/SOF SEPT97/airlines.html (accessed 02.04.2018).

Mantin, B., Gillen, D., Delibasi, T. T., 2016. Measuring competition intensity and product differentiation: evidence from the airline industry (draft version). Available at: http://www3.grips.ac.jp/~econseminar/seminar2016/BDT_draft_2016-06-27_BM_Japan (accessed 29.03.2018).

Martín, J. C., C. Román and R. Espino. 2008. Willingness to Pay for Airline Service Quality, Transport Reviews 28 (2), 199-217.

Mason, K.J., 1995. A stakeholder approach to the segmentation of the short haul business air travel market. Unpublished Ph.D. thesis, Faculty of Science, University of Plymouth.

McKinsey&Company, 2016. Winter is coming: The future of European aviation and how to survive it. Available at: https://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/winter-is-coming-the-future-of-european-aviation-and-how-to-survive-it. (accessed 21.01.2019)

Merkert, R., Hensher, D.A., 2011. The impact of strategic management and fleet planning on airline efficiency: a random effects Tobit model based on DEA efficiency scores. Transportation Research Part A: Policy Practice 45 (7), 686–695.

Min, H., Joo, S-J., 2016. A comparative performance analysis of airline strategic alliances using data envelopment analysis. Journal of Air Transport Management 52, 99–110.

Mijović, N., 2018. Ocena greške modela neto profitnih ciklusa primenom fazi logičkog sistema i optimizacija funkcija pripadnosti primenom optimizacije kolonijom pčela. Seminarski rad na predmetu Fazi sistemi sa primenama u saobraćaju i transportu. Saobraćajni fakultet.

Morash, E.A., Ozment, J., 1994. Toward management of transportation service quality. Logistics and Transportation Review 30, 115–140.

Moreira, M.E., O'Connell, J.F., Williams, G., 2011. The viability of Long-haul, Low Cost Business Models. Journal of Air Transport Studies 2 (1), 69–91.

Morrell, P., Lu, C., 2007. The environmental cost implication of hub-hub versus hub by-pass flight networks. Transportation Research Part D 12, 143-157.

Morrell, P., 2008. Can long-haul low-cost airlines be successful?. Research in Transportation Economics 24 (1), 61-67.

Morrison, S. A., Winston, C., 1995. The Evolution of the Airline Industry. The Brooking Institution, Washington, DC.

Morrison, S. A., 2001. Actual, Adjacent, and Potential Competition: Estimating the Full Effect of Southwest Airlines. Journal of Transport Economics and Policy 35 (2), 239–256.

Mott MacDonald, 2016. Annual Analyses of the EU Air Transport Market 2015. European Commission.

Nako, S.M., 1992. Frequent flyer programs and business travelers: an empirical investigation. The Logistics and Transportation Review 28 (4), 395-414.

Németh, A., 2011. Strategies for Eastern European airlines: the case of Malév Hungarian airline. In: CRNI Conference Working Paper. Available at: http://www.crninet.com/2011/c12c.pdf (accessed 17.03.17)

Nikolić, M., Teodorović, D., 2013. Transit network design by Bee Colony Optimization. Expert Systems with Applications 40 (15), 5945–5955.

Norwegian Air Shuttle ASA, 2015. Annual report 2014. Available at: https://www.norwegian.com/globalassets/ip/documents/about-us/company/investor-relations/reports-and-presentations/annual-reports/norwegian-annual-report-2014-printer-friendly.pdf (accessed 08.04.2019).

Norwegian Air Shuttle ASA, 2017. Annual report 2016. Available at: https://www.norwegian.com/globalassets/documents/annual-report/nas_annualreport_2016.pdf (accessed 08.04.2019).

Norwegian Air Shuttle ASA, 2018. Annual report 2017. Available at: https://www.norwegian.com/globalassets/ip/documents/investor-relations/annual-report-2017-interactive.pdf (accessed 08.04.2019).

Norwegian Air Shuttle ASA, 2019. Our Awards and Recognition. Available at: https://www.norwegian.com/uk/about/our-story/awards-and-recognitions/ (accessed 07.04.2019).

NTTO – National Travel and Tourism Office, 2018. Available at: https://travel.trade.gov/ (accessed 02.07.2018)

NYC&Company, 2018. Available at https://business.nycgo.com/research/ (accessed 02.07.2018).

OAG, 2017. Australia Long-Haul Low-Cost and Lessons for North Atlantic. Available at: https://www.oag.com/blog/australia-long-haul-low-cost-lessons-for-north atlantic?utm_source=hs_email&utm_medium=email&utm_content=58368759&_hsenc=p2ANqtz-_1AHmJg4OtmQOJAl7UWLaeL4cEdhIgyc_BJBveEyivTfD_IBgQ5u2sKaaHEui4ccACKI5aPsUqICYKfFuTkCQvithNSA&_hsmi=58368759 (accessed 02.05.2018).

Oliveira, V.M. A., Huse, C., 2009. Localized competitive advantage and price reactions to entry: Full-service vs. low-cost airlines in recently liberalized emerging markets. Transportation Research Part E: Logistics and Transportation Review 45 (2), 307–320.

Oliveira, V. R. M., Oliveira, V.M. A., 2018. What drives effective competition in the airline industry? An empirical model of city-pair market concetration. Transport Policy 63, 165-175.

Ostrowski, P. L., O’Brien, T. V., Gordon, G. L., 1993. Service quality and customer loyalty in the commercial airline industry. Journal of Travel Research 32 (2), 16–24.

Parasuraman, A., Zeithaml, V.A., Berry, L.L., 1988. SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality, Journal of Retailing 64 (1), 12-40.

Park, J-W., Robertson, R., Wu, C-L. 2004. The effect of airline service quality on passengers' behavioural intentions: a Korean case study. Journal of Air Transport Management 10 (6), 435–439.

Peeters, P., P. Rietveld, and Y. Schipper. 2005. Deregulation in Europe aviation and the evolution of hub-and-spoke networks: impacts on the environment. In: Regions, Land Consumption and Sustainable Growth: Assessing the impact of the Public and Private Sectors Atzema, O., Rietveld, P., Shefer, D. (eds.).

Pitfield, D. E., 2009. The assessment of the EU–US Open Skies Agreement: The counterfactual and other difficulties. Journal of Air Transport Management 15, 308-314.

Pitfield., D. E., Caves, R. E., Quddus, M. A., 2010. Airline strategies for aircraft size and airline frequency with changing demand and competition: A simultaneous-equations approach for traffic on the north Atlantic. Jornal of Air Transport Management 16, 151-158.

Points Guy, 2015. Singapore to Resume World's Longest Flights from New York and LA. Available at: https://thepointsguy.com/2015/10/singapore-worlds-longest-flight/ (accessed 24.05.2017).

Port Authority of NY & NJ. (2016). 2015 Airport Traffic Report. Retrieved from https://www.panynj.gov/airports/pdf-traffic/ATR_2015.pdf (22.03.2018)

Porter, M. E., 1986. Competition in global industries. Harvard Business Press, Boston.

Proussaloglou, K., Koppelman, F.S., 1995. Air carrier demand: an analysis of market share determinants. Transportation 22 (4), 371-388.

Ryanair – Annual Report 2014. 2015. Available at: https://investor.ryanair.com/wp-content/uploads/2015/04/2014-Annual-Reports-Annual-Report.pdf (accessed 09.04.2019).

Ryanair – Annual Report 2016. 2016. Available at: https://investor.ryanair.com/wp-content/uploads/2016/07/Ryanair-Annual-Report-FY16.pdf (accessed 09.04.2019).

Ryanair – Annual Report 2017. 2017. Available at: https://investor.ryanair.com/wp-content/uploads/2017/07/Ryanair-FY2017-Annual-Report.pdf (accessed 09.04.2019).

Ryanair, 2018. Airline Owned UK ATC Provider NATS Discriminates Against Ryanair & Other Stansted Airlines. Available at: https://corporate.ryanair.com/news/airline-owned-uk-atc-provider-nats-discriminates-against-ryanair-other-stansted-airlines/ (accessed 07.04.2018).

Richards, K., 1996. The effect of Southwest airlines on U.S. Airline market. Research in Transportation Economics 4, 33-47.

Richard, O., 2003. Flight frequency and mergers in airline markets. International Journal of Industrial Organization 21 (6), 907-922.

Rodriguez, A. M., O'Connell, J. F. 2017. Can low-cost long-haul carriers replace Charter airlines in the long-haul market? A European perspective. Tourism Economics, 1-15.

Routes Online, 2016. The A350-1000 takes flight, but where does the A350 currently fly?, Available at: https://www.routesonline.com/news/29/breaking-news/270071/the-a350-1000-takes-flight-but-where-does-the-a350-currently-fly-/ (accessed 17.06.2018).

Routes Online, 2017. IAG plans new LEVEL of evolution for low-cost long-haul model. Available at: https://www.routesonline.com/news/29/breaking-news/271892/iag-plans-new-level-of-evolution-for-low-cost-long-haul-model/?utm_medium=email&utm_source=the-hub&utm_campaign=the-hub-EU&utm_content=the-hub-20170324 (accessed 06.08.2017).

Routes Online, 2018. How Norwegian became a disruptive force. Available at: https://www.routesonline.com/news/29/breaking-news/279533/how-norwegian-became-a-disruptive-force/ (accessed 07.08.2018)

Ruiz-Mafé, C., Sanz-Blas, S., Aldas-Manzano, J., 2009. Drivers and barriers to online airline ticket purchasing. Journal of Air Transport Management 15, 294–298.

Schefczyk, M. 1993. Operational performance of airlines: an extension of traditional measurement paradigms. Strategic Management Journal 14, 301–317.

SEO Amsterdam Economics, 2016. Fare differences between Gulf carriers and incumbents. Available at: http://www.seo.nl/uploads/media/DP_87_Fare_differences_between_Gulf_carriers_and_incumbents.pdf (accessed 23.01.2019).

Shaw, S., 2004. Airline marketing and management. Ashgate (fifth ed.), Burlington, USA.

Smith, A., 1937. The Wealth of Nations, The Modern Library, New York.

Soyk, C., Ringbeck, J., Spinler, S., 2017. Long-haul low cost airlines: Characteristics of the business model and sustainability of its cost advantages. Transportation Research Part A: Policy and Practice 106, 215-234.

Suzuki, Y., 2000. The relationship between on-time performance and airline market share: a new approach. Transportation Research Part E: Logistics and Transportation Review 36 (2), 139–154.

Suzuki, Y., Tyworth, J. E., & Novack, R. A. 2001. Airline market share and customer service quality: a reference-dependent model. Transportation Research Part A: Policy and Practice 35 (9), 773–788.

Telegraph. 2016. British Airways 'to squeeze extra 52 seats onto Boeing 777 economy flights'. Available at: https://www.telegraph.co.uk/news/2016/11/07/british-airways-to-squeeze-extra-52-seats-onto-boeing-777-econom/ (accessed on 08.03.2018).

Teodorović, D., 1994a. Invited review: fuzzy sets theory applications in traffic and transportation. European Journal of Operational Research 74 (3), 379–390.

Teodorović, D., Kalić, M., Pavković, G., 1994b. The potential for using fuzzy set theory in airline network design. Transportation Research Part B: Methodological 28 (2), 103 121.

Teodorović, D., Vukadinović, K., 1998. A Fuzzy Mathematical Programming Approach to Transportation, in: Traffic Control and Transport Planning. International Series in Intelligent Technologies. Springer, Dordrecht, pp. 185–234.

Teodorović, D., 1999. Fuzzy logic systems for transportation engineering: the state of the art. Transportation Research Part: Policy and Practice 33 (5), 337–364.

Teodorović D. 2009. Bee colony optimization (BCO). In: Lim CP, Jain LC, Dehuri S, editors. Innovations in swarm intelligence. Berlin, Heidelberg: Springer-Verlag, 39–60.

Teodorović, D., Šelmić, M., 2012. Računarska inteligencija u saobraćaju, Univerzitet u Beogradu – Saobraćajni fakultet.

Truitt, J. L., Haynes, R., 1994. Evaluating Service Quality and Productivity in the Regional Airline Industry. Transportation Journal 33 (4), 21-32.

Tsaur, S-H., Chang, T-Y, Yen, C-H., 2002. The evaluation of airline service quality by fuzzy MCDM. Tourism Management 23, 107–115.

UNWTO - United Nations World Tourism Organization, 2016. Tourism Highlights, 2016 Edition. Available at: http://mkt.unwto.org/publication/unwto-tourism-highlights-2016-edition (accessed 22.07.2018).

U.S. Air Transport Association (ATA), 2006. Annual Revenue and Earnings, US Airlines-all Services. ATA, Washington, DC.

U.S. Department of Justice, 2018. Herfindahl-Hirschman index. Available at: https://www.justice.gov/atr/herfindahl-hirschman-index (accessed31.09.2018)

U.S. Department of Transportation (U.S. DOT), 1993. The airline deregulation evolution continues: The Southwest continues. Available at: http://www.dtic.mil/dtic/tr/fulltext/u2/a299083.pdf (accessed 10.10.2018).

Ustaömer, T. C., Durmaz, V., Lei, Z., 2015. The Effect of Joint Ventures on Airline Competition: The Case of American Airlines, British Airways and Iberia Joint Business. Procedia – Social and Behavioral Sciences 210, 430-439.

Van den Hoek, M. (2017). A Competitive Analysis of Ryanair in the Long-Haul Airline Industry. Master thesis at Seoul National University. Available at: http://s-space.snu.ac.kr/bitstream/10371/129130/1/000000141295.pdf (accessed on 28.05.2018).

Vespermann, J., Wald, A., Gleich, R., 2008. Aviation growth in the Middle East – impacts on incumbent players and potential strategic reactions. Journal of Transport Geography 16, 388-394.

Vowles, M. T., 2001. The "Southwest Effect" in multi-airport regions. Journal of Air Transport Management 7, 251-258.

Wang, L. X., Mendel, J. M., 1992. Generating fuzzy rules by learning from examples. IEEE Transactions on Systems, Man and Cybernetics 22, 1414–1427.

Wei, W., Hansen, M., 2005. Impact of aircraft size and seat availability on airlines' demand and market share in duopoly markets. Transportation Research Part E: Logistics and Transportation Review 41 (4), 315-327.

Wei, W., Hansen, M., 2006. An aggregate demand model for air passenger traffic in the huband-spoke network. Transportation Research Part A 40 (10), 841–851.

Wensveen, J. G., Leick, R., 2009. The long-haul low-cost carrier: A unique business model. Journal of Air Transport Management 15 (3), 127–133.

Whinston, M. D., Collins, C. S., 1992. Entry and Competitive Structure in Deregulated Airline Markets: An Event Study Analysis of People Express. The RAND Journal of Economics 23 (4), 445-462.

Wilken, D., Berster, P., Gelhausen, M. C., 2016. Analysis of demand structures on intercontinental routes to and from Europe with a view to identifying potential for new low-cost services. Journal of Air Transport Management 56 (Part B), 79-90.

Windle, R., Dresner, M., 1995. The Short and Long Run Effect of Entry on U.S. Domestic Air Routes. Transportation Journal 35 (2), 14-25.

Zacks Equity Research, 2011. Airline Industry Outlook – Jan. 2011. Available at: https://www.zacks.com/stock/news/46361/airline-industry-outlook-jan-2011 (accessed 04.03.17).

Zellner, A., Theil, H., 1962. Three-stage Least Squares: Simultaneous Estimation of Simultaneous Equations. Econometrica 30 (1), 54–78.

ZfCompanii, 2017. Tarombifează al patrulea an de pierderi: 2011 a adus o gaură de 58,6 mil. €, iarprognozelepânăîn 2014 aratătotpierderi. Available at: http://www.zf.ro/companii/tarom-bifeaza-al-patrulea-an-de-pierderi-2011-a-adus-o-gaura-de-58-6-mil-iar-prognozele-pana-in-2014-arata-tot-pierderi-9187249/poze/ (accessed 24.03.17)

Zhu, J., 2011. Airlines Performance via Two-Stage Network DEA Approach. Journal of Centrum Cathedra 4 (2), 260–269.

Zimmermann, H.J., 1996. Fuzzy Set Theory and Its Applications. Kluwer Academic Publisher, Dordrecht.

Appendices

Appendix 1 – Output from statistical software R for the first model (effect of LCC competition on FSC's price and number of passengers (pooled model)

```
eq2 96 88 2.36819 0.026911 0.164047 0.913367 0.906476

The covariance matrix of the residuals used for estimation
           eq1        eq2
eq1 0.01128393 0.00675154
eq2 0.00675154 0.02190241

The covariance matrix of the residuals
          eq1       eq2
eq1 0.0119558 0.0102832
eq2 0.0102832 0.0269113

The correlations of the residuals
         eq1      eq2
eq1 1.000000 0.573288
eq2 0.573288 1.000000


3SLS estimates for 'eq1' (equation 1)
Model Formula: Fare ~ BAW + HHI + NAX + Fuel + Dummy + Dummy_LAX + Dummy_BOS
Instruments: ~Fuel + Trade + Fuel + HHI + NAX + Tourists + Dummy + Dummy_LAX +
    Dummy_BOS

                Estimate  Std. Error  t value   Pr(>|t|)
(Intercept)  4.07902e+00 1.00238e+00  4.06935 0.00010260 ***
BAW          3.79628e-01 9.76566e-02  3.88738 0.00019612 ***
HHI          1.52736e-01 9.38967e-02 -1.62664 0.10739028
NAX         -8.64782e-02 2.97696e-02 -2.90492 0.00464485 **
Fuel        -5.81692e-03 1.90448e-03 -3.05433 0.00298433 **
Dummy        8.67660e-01 2.80031e-01  3.09845 0.00261156 **
Dummy_LAX    4.29571e-01 1.04079e-01  4.12734 8.3154e-05 ***
Dummy_BOS    2.54666e-01 1.42728e-01  1.78428 0.07782473 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


Number of observations: 96
SSR: 1.052112 MSE: 0.011956 Root MSE: 0.109343
Multiple R-Squared: 0.581058 Adjusted R-Squared: 0.547733


3SLS estimates for 'eq2' (equation 2)
Model Formula: BAW ~ Fare + Tourists + Trade + NAX + Dummy + Dummy_LAX + Dummy_BOS
Instruments: ~Fuel + Trade + Fuel + HHI + NAX + Tourists + Dummy + Dummy_LAX +
    Dummy_BOS

                Estimate  Std. Error   t value   Pr(>|t|)
(Intercept)  2.10908e+01 4.08888e+00   5.15809 1.5240e-06 ***
Fare        -1.46371e+00 6.07657e-01  -2.40878  0.0180914 *
Tourists     9.22313e-01 1.18539e-01   7.78068 1.2968e-11 ***
Trade        2.89417e-02 1.03745e-02   2.78971  0.0064666 **
NAX         -8.76402e-02 4.68698e-02  -1.86987  0.0648274 .
Dummy        9.03891e-01 4.84514e-01   1.86556  0.0654343 .
Dummy_LAX   -8.57106e-01 9.34076e-02  -9.17598 1.7764e-14 ***
Dummy_BOS   -1.24047e+00 7.10716e-02 -17.45382 < 2.22e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Number of observations: 96
SSR: 2.36819 MSE: 0.026911 Root MSE: 0.164047
Multiple R-Squared: 0.913367 Adjusted R-Squared: 0.906476
```

Appendix 2 – Linguistic interpretation of fuzzy rule base

1. If (*frequency share is very-low*) and (*price ratio is very-low*) then (*market share is very-low*)

2. If (*frequency share is very-low*) and (*price ratio is low*) then (*market share is very-low*)

3. If (*frequency share is very-low*) and (*price ratio is low-mid*) then (*market share is very-low*)

4. If (*frequency share is very-low*) and (*price ratio is mid*) then (*market share is very-low*)

5. If (*frequency share is very-low*) and (*price ratio is mid-high*) then (*market share is very-low*)

6. If (*frequency share is very-low*) and (*price ratio is high*) then (*market share is very-low*)

7. If (*frequency share is very-low*) and (*price ratio is very high*) then (*market share is very-low*)

8. If (*frequency share is low*) and (*price ratio is very-low*) then (*market share is very-low*)

9. If (*frequency share is low*) and (*price ratio is low*) then (*market share is very-low*)

10. If (*frequency share is low*) and (*price ratio is low-mid*) then (*market share is low*)

11. If (*frequency share is low*) and (*price ratio is mid*) then (*market share is low*)

12. If (*frequency share is low*) and (*price ratio is mid-high*) then (*market share is low*)

13. If (*frequency share is low*) and (*price ratio is high*) then (*market share is low*)

14. If (*frequency share is low*) and (*price ratio is very high*) then (*market share is low*)

15. If (*frequency share is low-mid*) and (*price ratio is very-low*) then (*market share is low*)

16. If (*frequency share is low-mid*) and (*price ratio is low*) then (*market share is low-mid*)

17. If (*frequency share is low-mid*) and (*price ratio is low-mid*) then (*market share is low-mid*)

18. If (*frequency share is low-mid*) and (*price ratio is mid*) then (*market share is low-mid*)

19. If (*frequency share is low-mid*) and (*price ratio is mid-high*) then (*market share is low-mid*)

20. If (*frequency share is low-mid*) and (*price ratio is high*) then (*market share is low-mid*)

21. If (*frequency share is low-mid*) and (*price ratio is very high*) then (*market share is mid*)

22. If (*frequency share is mid*) and (*price ratio is very-low*) then (*market share is low-mid*)

23. If (*frequency share is mid*) and (*price ratio is low*) then (*market share is low-mid*)

24. If (*frequency share is mid*) and (*price ratio is low-mid*) then (*market share is low-mid*)

25. If (*frequency share is mid*) and (*price ratio is mid*) then (*market share is mid*)

26. If (*frequency share is mid*) and (*price ratio is mid-high*) then (*market share is mid*)

27. If (*frequency share is mid*) and (*price ratio is high*) then (*market share is mid*)

28. If (*frequency share is mid*) and (*price ratio is very high*) then (*market share is mid*)

29. If (*frequency share is mid-high*) and (*price ratio is very-low*) then (*market share is mid*)

30. If (*frequency share is mid-high*) and (*price ratio is low*) then (*market share is mid*)

31. If (*frequency share is mid-high*) and (*price ratio is low-mid*) then (*market share is mid-high*)

32. If (*frequency share is mid-high*) and (*price ratio is mid*) then (*market share is mid-high*)

33. If (*frequency share is mid-high*) and (*price ratio is mid-high*) then (*market share is mid-high*)

34. If (*frequency share is mid-high*) and (*price ratio is high*) then (*market share is mid-high*)

35. If (*frequency share is mid-high*) and (*price ratio is very high*) then (*market share is mid-high*)

36. If (*frequency share is high*) and (*price ratio is very-low*) then (*market share is mid-high*)

37. If (*frequency share is high*) and (*price ratio is low*) then (*market share is mid-high*)

38. If (*frequency share is high*) and (*price ratio is low-mid*) then (*market share is mid-high*)

39. If (*frequency share is high*) and (*price ratio is mid*) then (*market share is high*)

40. If (*frequency share is high*) and (*price ratio is mid-high*) then (*market share is high*)

41. If (*frequency share is high*) and (*price ratio is high*) then (*market share is high*)

42. If (*frequency share is high*) and (*price ratio is very high*) then (*market share is high*)

43. If (*frequency share is very high*) and (*price ratio is very-low*) then (*market share is high*)

44. If (*frequency share is very high*) and (*price ratio is low*) then (*market share is high*)

45. If (*frequency share is very high*) and (*price ratio is low-mid*) then (*market share is high*)

46. If (*frequency share is very high*) and (*price ratio is mid*) then (*market share is high*)

47. If (*frequency share is very high*) and (*price ratio is mid-high*) then (*market share is very high*)

48. If (*frequency share is very high*) and (*price ratio is high*) then (*market share is very high*)

49. If (*frequency share is very high*) and (*price ratio is very high*) then (*market share is very high*)

Appendix 3 – Pseudo code for BCO algorithm

```
For (b1=0; b<B1; b++)
The randomly generated solution is initially determined and assigned to each bee.
Ensure that membership functions are mutually overlapped and calculate the
fitness function for each bee.
Evaluate all solutions and keep the best solution only.
For (it=1; it ≤ IT; it ++) {
Assign the obtained best solution to each bee.
#First set of bees
For (nm=1; nm ≤ NM; nm++) {
nc1=random(1, NC1)
For (ncc1=1; ncc1<nc1; ncc1++){
For (b1=0; b<B1; b1++){
The new solutions are generated for all membership function parameters that were
previously randomly defined.
For each solution obtained, ensure that membership functions are mutually
overlapped.
}
Evaluation of the fitness function.
}
Za (b1=0; b<B1; b1++){
Calculate the fitness function for each bee from the first set.
}
Za (b1=0; b<B1; b1++){
Make the decision on loyalty for each bee from the first set.
}
For (b1=0; b<B1; b1++){
For each bee follower, choose the solution of one of the loyal bee that will be
followed.
}
}
#Second set of bees
Za (nm=1; nm ≤ NM; nm++) {
nc2=random(1, NC2)
Za (ncc2=1; ncc2<nc2; ncc2++){
Za (b2=0; b<B2; b2++){
```

```
The new solution is generated for parameter of membership function for the first input variable that was previously randomly defined. For each solution obtained, ensure that membership functions are mutually overlapped.
}
Evaluation of the fitness function.
}
For (b2=0; b<B2; b2++){
Calculate the fitness function for each bee from the second set.
}
For (b2=0; b<B2; b2++){
Make the decision on loyalty for each bee from the second set.
}
For (b2=0; b<B2; b2++){
For each bee follower, choose the solution of one of the loyal bee that will be followed.
}
}
#Third set of bee
For (nm=1; nm ≤ NM; nm++) {
nc3=random(1, NC3)
For (ncc3=1; ncc3<nc3; ncc3++){
For (b3=0; b<B3; b3++){
The new solution is generated for parameter of membership function for the second input variable that was previously randomly defined. For each solution obtained, ensure that membership functions are mutually overlapped.
}
Evaluation of the fitness function.
}
For (b3=0; b<B3; b3++){
Calculate the fitness function for each bee from the third set.
}
For (b3=0; b<B3; b3++){
Make the decision on loyalty for each bee from the third set.
}
For (b3=0; b<B3; b3++){
```

```
For each bee follower, choose the solution of one of the loyal bee that will be
followed.
}
}
#Fourth set of bee
For (nm=1; nm ≤ NM; nm++) {
nc4=random(1, NC4)
For (ncc4=1; ncc4<nc4; ncc4++){
For (b4=0; b<B4; b4++){
The new solution is generated for parameter of membership function for the output
variable that was previously randomly defined. For each solution obtained, ensure
that membership functions are mutually overlapped.
}
Evaluation of the fitness function.
}
For (b4=0; b<B4; b4++){
Calculate the fitness function for each bee from the fourth set.
}
For (b4=0; b<B4; b4++){
Make the decision on loyalty for each bee from the fourth set.
}
For (b4=0; b<B4; b4++){
For each bee follower, choose the solution of one of the loyal bee that will be
followed.
}
}
Evaluate the obtained solutions and assign the best solution to all bees.
}
```

Appendix 4 – Membership function overlapping condition

The code is inspired by the seminar paper of Mijović (2018)

IF PAR equal to (2 OR 19 OR 36) and
(less than LOWER BOUND or more than (PAR -1) – BUFFER) then
PAR equal to RANDOM_BETWEEN (LOWER BOUND and (PAR -1))

IF PAR equal to (3 OR 6 OR 9 OR 12 OR 15 OR 20 OR 23 OR 26 OR 29 OR 32 OR 37 OR 40 OR 43 OR 46 OR 49) and
(less than (PAR -1) + BUFFER AND more than (PAR +1) - BUFFER)
PAR equal to RANDOM_BETWEEN ((PAR -1) + BUFFER and (PAR +1) - BUFFER)

IF PAR equal to (4 OR 7 OR 10 OR 13 OR 21 OR 24 OR 27 OR 30 OR 38 OR 41 OR 44 OR 47 OR 1 OR 18 OR 35) and
(less than (PAR +2) AND more than (PAR +1) + BUFFER)
PAR equal to RANDOM_BETWEEN ((PAR + 1) + BUFFER and (PAR +2))

IF PAR equal to (5 OR 8 OR 11 OR 14 OR 22 OR 25 OR 28 OR 31 OR 39 OR 42 OR 45 OR 48 OR 17 OR 34 OR 51) and
(less than (PAR - 2) AND more than (PAR -1) - BUFFER)
PAR equal to RANDOM_BETWEEN ((PAR - 2) and (PAR - 1) - BUFFER)

IF PAR equal to (16 OR 33 OR 50) and
(more than UPPER BOUND or less than (PAR + 1) + BUFFER) then
PAR equal to RANDOM_BETWEEN ((PAR + 1) + BUFFER AND UPPER BOUND)

Appendix 5 – Real and estimated values in market share model (testing set)

Table A5.1. Real and estimated values for airline's market share obtained by fuzzy logic (testing set)

Obs.	Route	ADEP	ADES	Airline	Real market share	Market share obtained by Fuzzy
1	LONDON-BOSTON	EGLL	KBOS	British Airways	58.19	40.00
2	LONDON-BOSTON	EGLL	KBOS	Virgin Atlantic Airways	14.22	15.99
3	LONDON-BOSTON	EGLL	KBOS	Delta Air Lines	10.81	17.01
4	LONDON-BOSTON	EGKK	KBOS	Norwegian Air Shuttle	16.78	11.35
5	LONDON-MIAMI	EGLL	KMIA	British Airways	40.20	25.00
6	LONDON-MIAMI	EGLL	KMIA	Virgin Atlantic Airways	17.98	25.00
7	LONDON-MIAMI	EGLL	KMIA	American Airlines	28.00	25.00
8	LONDON-MIAMI	EGKK	KFLL	Norwegian Air Shuttle	9.06	11.18
9	LONDON-MIAMI	EGKK	KFLL	British Airways	4.76	10.79
10	BARLONA-NEW YORK	LEBL	KJFK	American Airlines	28.44	25.00
11	BARLONA-NEW YORK	LEBL	KJFK	Delta Air Lines	25.90	25.00
12	BARLONA-NEW YORK	LEBL	KEWR	United Air Lines	24.34	25.00
13	BARLONA-NEW YORK	LEBL	KEWR	Norwegian Air Shuttle	21.32	18.24
14	COPENHAGEN-NEW YORK	EKCH	KJFK	Norwegian Air Shuttle	33.83	25.00
15	COPENHAGEN-NEW YORK	EKCH	KEWR	Scandinavian Airlines Sys.	66.17	55.16
16	BARCELONA-LOS ANGELES	LEBL	KLAX	Iberia	17.96	18.51
17	BARCELONA-LOS ANGELES	LEBL	KLAX	Norwegian Air Shuttle	82.04	61.43
18	BARCELONA-OAKLAND	LEBL	KOAK	Iberia	49.70	37.22
19	BARCELONA-OAKLAND	LEBL	KOAK	Norwegian Air Shuttle	50.30	40.00
20	LONDON-OAKLAND	EGKK	KOAK	British Airways	23.25	25.00
21	LONDON-OAKLAND	EGKK	KOAK	Norwegian Air Shuttle	76.75	40.55
22	LONDON-ORLANDO	EGKK	KMCO	British Airways	31.81	25.00
23	LONDON-ORLANDO	EGKK	KMCO	Virgin Atlantic Airways	53.73	28.72
24	LONDON-ORLANDO	EGKK	KMCO	Norwegian Air Shuttle	10.16	11.34
25	LONDON-ORLANDO	EGKK	KMCO	Thomas Cook Airlines	4.31	9.98
26	LONDON-LOS ANGELES	EGLL	KLAX	British Airways Plc	33.32	25.00
27	LONDON-LOS ANGELES	EGLL	KLAX	American Airlines	16.74	22.47
28	LONDON-LOS ANGELES	EGLL	KLAX	United Air Lines	7.37	11.60
29	LONDON-LOS ANGELES	EGLL	KLAX	Virgin Atlantic Airways	17.37	24.57
30	LONDON-LOS ANGELES	EGLL	KLAX	Air New Zealand	11.75	11.53

31	LONDON-LOS ANGELES	EGKK	KLAX	Norwegian Air Shuttle	13.46	11.34
32	PARIS-LOS ANGELES	LFPG	KLAX	Air France	74.17	46.28
33	PARIS-LOS ANGELES	LFPG	KLAX	Norwegian Air Shuttle	19.42	20.29
34	PARIS-LOS ANGELES	LFPG	KLAX	Air Tahiti Nui	6.41	20.73
35	OSLO-MIAMI	ENGM	KMIA	Scandinavian Airlines Sys.	40.99	36.77
36	OSLO-MIAMI	ENGM	KFLL	Norwegian Air Shuttle	59.01	40.00
37	COPENHAGEN-MIAMI	EKCH	KMIA	Scandinavian Airlines Sys.	45.77	40.00
38	COPENHAGEN-MIAMI	EKCH	KFLL	Norwegian Air Shuttle	54.23	36.87
39	STOCKHOLM-MIAMI	ESSA	KFLL	Norwegian Air Shuttle	88.37	55.36
40	STOCKHOLM-MIAMI	ESSA	KMIA	Scandinavian Airlines Sys.	11.63	21.63
41	BARCELONA-MIAMI	LEBL	KMIA	American Airlines Inc.	71.52	55.38
42	BARCELONA-MIAMI	LEBL	KFLL	Norwegian Air Shuttle	28.48	25.00
43	LONDON -NEW YORK	EGLL	KJFK	British Airways	28.02	25.00
44	LONDON -NEW YORK	EGLL	KJFK	American Airlines	12.25	11.38
45	LONDON -NEW YORK	EGLL	KJFK	Delta Air Lines	9.51	11.38
46	LONDON -NEW YORK	EGLL	KJFK	Virgin Atlantic Airways	14.72	11.64
47	LONDON -NEW YORK	EGKK	KJFK	British Airways	3.54	6.78
48	LONDON -NEW YORK	EGKK	KJFK	Norwegian Air Shuttle	9.58	10.54
49	LONDON -NEW YORK	EGLL	KEWR	British Airways	5.86	10.62
50	LONDON -NEW YORK	EGLL	KEWR	Virgin Atlantic Airways	3.29	6.95
51	LONDON -NEW YORK	EGLL	KEWR	Air India	1.14	2.99
52	LONDON -NEW YORK	EGLL	KEWR	United Air Lines	12.08	18.91
53	OSLO-NEW YORK	ENGM	KJFK	Norwegian Air Shuttle	47.42	25.00
54	OSLO-NEW YORK	ENGM	KEWR	Scandinavian Airlines Sys.	52.58	43.83
55	STOCKHOLM-NEW YORK	ESSA	KJFK	Norwegian Air Shuttle	41.89	25.00
56	STOCKHOLM-NEW YORK	ESSA	KEWR	Scandinavian Airlines Sys.	58.11	46.70
57	PARIS-MIAMI	LFPG	KMIA	American Airlines Inc.	30.40	25.00
58	PARIS-MIAMI	LFPG	KMIA	Air France	58.12	27.20
59	PARIS-MIAMI	LFPG	KFLL	Norwegian Air Shuttle	11.48	11.71
60	PARIS-NEW YORK	LFPG	KJFK	Delta Air Lines	8.77	11.41
61	PARIS-NEW YORK	LFPG	KJFK	American Airlines	6.53	11.72
62	PARIS-NEW YORK	LFPG	KJFK	XL Airways France	3.37	5.56
63	PARIS-NEW YORK	LFPG	KJFK	Air France	44.64	25.00
64	PARIS-NEW YORK	LFPG	KEWR	Delta Air Lines	4.18	10.58
65	PARIS-NEW YORK	LFPG	KEWR	United Air Lines	8.57	11.61
66	PARIS-NEW YORK	LFPO	KJFK	Air France	7.91	11.42
67	PARIS-NEW YORK	LFPO	KJFK	Openskies	2.92	11.14
68	PARIS-NEW YORK	LFPG	KJFK	Norwegian Air Shuttle	9.60	11.28

69	PARIS-NEW YORK	LFPO	KEWR	Openskies	3.51	10.94
70	COPENHAGEN-BOSTON	EKCH	KBOS	Scandinavian Airlines Sys.	79.18	75.00
71	COPENHAGEN-BOSTON	EKCH	KBOS	Norwegian Air Shuttle	20.82	11.33
72	STOCKHOLM-LOS ANGELES	ESSA	KLAX	Scandinavian Airlines Sys.	59.86	54.88
73	STOCKHOLM-LOS ANGELES	ESSA	KLAX	Norwegian Air Shuttle	40.14	25.00

Table A5.2. Real and estimated values for airline's market share obtained by fuzzy logic and BCO (testing set)

Obs.	Route	ADEP	ADES	Airline	Real market share	Market share obtained by Fuzzy and BCO
1	LONDON-BOSTON	EGLL	KBOS	British Airways	58.19	57.93
2	LONDON-BOSTON	EGLL	KBOS	Virgin Atlantic Airways	14.22	15.01
3	LONDON-BOSTON	EGLL	KBOS	Delta Air Lines	10.81	13.75
4	LONDON-BOSTON	EGKK	KBOS	Norwegian Air Shuttle	16.78	9.99
5	LONDON-MIAMI	EGLL	KMIA	British Airways	40.20	33.80
6	LONDON-MIAMI	EGLL	KMIA	Virgin Atlantic Airways	17.98	19.41
7	LONDON-MIAMI	EGLL	KMIA	American Airlines	28.00	31.09
8	LONDON-MIAMI	EGKK	KFLL	Norwegian Air Shuttle	9.06	8.46
9	LONDON-MIAMI	EGKK	KFLL	British Airways	4.76	7.52
10	BARLONA-NEW YORK	LEBL	KJFK	American Airlines	28.44	27.20
11	BARLONA-NEW YORK	LEBL	KJFK	Delta Air Lines	25.90	27.56
12	BARLONA-NEW YORK	LEBL	KEWR	United Air Lines	24.34	27.61
13	BARLONA-NEW YORK	LEBL	KEWR	Norwegian Air Shuttle	21.32	21.68
14	COPENHAGEN-NEW YORK	EKCH	KJFK	Norwegian Air Shuttle	33.83	40.35
15	COPENHAGEN-NEW YORK	EKCH	KEWR	Scandinavian Airlines Sys.	66.17	67.66
16	BARCELONA-LOS ANGELES	LEBL	KLAX	Iberia	17.96	21.92
17	BARCELONA-LOS ANGELES	LEBL	KLAX	Norwegian Air Shuttle	82.04	75.69
18	BARCELONA-OAKLAND	LEBL	KOAK	Iberia	49.70	49.22
19	BARCELONA-OAKLAND	LEBL	KOAK	Norwegian Air Shuttle	50.30	50.79
20	LONDON-OAKLAND	EGKK	KOAK	British Airways	23.25	40.88
21	LONDON-OAKLAND	EGKK	KOAK	Norwegian Air Shuttle	76.75	57.93
22	LONDON-ORLANDO	EGKK	KMCO	British Airways	31.81	37.99
23	LONDON-ORLANDO	EGKK	KMCO	Virgin Atlantic Airways	53.73	48.10
24	LONDON-ORLANDO	EGKK	KMCO	Norwegian Air Shuttle	10.16	9.63
25	LONDON-ORLANDO	EGKK	KMCO	Thomas Cook Airlines	4.31	5.60

26	LONDON-LOS ANGELES	EGLL	KLAX	British Airways	33.32	27.19
27	LONDON-LOS ANGELES	EGLL	KLAX	American Airlines	16.74	16.70
28	LONDON-LOS ANGELES	EGLL	KLAX	United Air Lines	7.37	10.08
29	LONDON-LOS ANGELES	EGLL	KLAX	Virgin Atlantic Airways	17.37	17.98
30	LONDON-LOS ANGELES	EGLL	KLAX	Air New Zealand	11.75	9.85
31	LONDON-LOS ANGELES	EGKK	KLAX	Norwegian Air Shuttle	13.46	9.88
32	PARIS-LOS ANGELES	LFPG	KLAX	Air France	74.17	61.49
33	PARIS-LOS ANGELES	LFPG	KLAX	Norwegian Air Shuttle	19.42	23.54
34	PARIS-LOS ANGELES	LFPG	KLAX	Air Tahiti Nui	6.41	15.27
35	OSLO-MIAMI	ENGM	KMIA	Scandinavian Airlines Sys.	40.99	49.07
36	OSLO-MIAMI	ENGM	KFLL	Norwegian Air Shuttle	59.01	50.94
37	COPENHAGEN-MIAMI	EKCH	KMIA	Scandinavian Airlines Sys.	45.77	50.91
38	COPENHAGEN-MIAMI	EKCH	KFLL	Norwegian Air Shuttle	54.23	49.10
39	STOCKHOLM-MIAMI	ESSA	KFLL	Norwegian Air Shuttle	88.37	76.73
40	STOCKHOLM-MIAMI	ESSA	KMIA	Scandinavian Airlines Sys.	11.63	17.63
41	BARCELONA-MIAMI	LEBL	KMIA	American Airlines	71.52	69.53
42	BARCELONA-MIAMI	LEBL	KFLL	Norwegian Air Shuttle	28.48	40.33
43	LONDON -NEW YORK	EGLL	KJFK	British Airways	28.02	25.86
44	LONDON -NEW YORK	EGLL	KJFK	American Airlines	12.25	10.95
45	LONDON -NEW YORK	EGLL	KJFK	Delta Air Lines	9.51	11.04
46	LONDON -NEW YORK	EGLL	KJFK	Virgin Atlantic Airways	14.72	11.54
47	LONDON -NEW YORK	EGKK	KJFK	British Airways	3.54	2,26
48	LONDON -NEW YORK	EGKK	KJFK	Norwegian Air Shuttle	9.58	6.92
49	LONDON -NEW YORK	EGLL	KEWR	British Airways	5.86	7.12
50	LONDON -NEW YORK	EGLL	KEWR	Virgin Atlantic Airways	3.29	2.29
51	LONDON -NEW YORK	EGLL	KEWR	Air India	1.14	2.83
52	LONDON -NEW YORK	EGLL	KEWR	United Air Lines	12.08	15.50
53	OSLO-NEW YORK	ENGM	KJFK	Norwegian Air Shuttle	47.42	40.70
54	OSLO-NEW YORK	ENGM	KEWR	Scandinavian Airlines Sys.	52.58	58.62
55	STOCKHOLM-NEW YORK	ESSA	KJFK	Norwegian Air Shuttle	41.89	41.01
56	STOCKHOLM-NEW YORK	ESSA	KEWR	Scandinavian Airlines Sys.	58.11	61.42
57	PARIS-MIAMI	LFPG	KMIA	American Airlines Inc.	30.40	42.70
58	PARIS-MIAMI	LFPG	KMIA	Air France	58.12	43.78
59	PARIS-MIAMI	LFPG	KFLL	Norwegian Air Shuttle	11.48	15.34
60	PARIS-NEW YORK	LFPG	KJFK	Delta Air Lines	8.77	9.16
61	PARIS-NEW YORK	LFPG	KJFK	American Airlines	6.53	9.89
62	PARIS-NEW YORK	LFPG	KJFK	XL Airways France	3.37	2.23
63	PARIS-NEW YORK	LFPG	KJFK	Air France	44.64	27.65

64	PARIS-NEW YORK	LFPG	KEWR	Delta Air Lines	4.18	7.06
65	PARIS-NEW YORK	LFPG	KEWR	United Air Lines	8.57	9.93
66	PARIS-NEW YORK	LFPO	KJFK	Air France	7.91	8.76
67	PARIS-NEW YORK	LFPO	KJFK	Openskies	2.92	8.89
68	PARIS-NEW YORK	LFPG	KJFK	Norwegian Air Shuttle	9.60	8.53
69	PARIS-NEW YORK	LFPO	KEWR	Openskies	3.51	7.88
70	COPENHAGEN-BOSTON	EKCH	KBOS	Scandinavian Airlines Sys.	79.18	82.94
71	COPENHAGEN-BOSTON	EKCH	KBOS	Norwegian Air Shuttle	20.82	9.77
72	STOCKHOLM-LOS ANGELES	ESSA	KLAX	Scandinavian Airlines Sys.	59.86	67.19
73	STOCKHOLM-LOS ANGELES	ESSA	KLAX	Norwegian Air Shuttle	40.14	40.38

Appendix 6 – Historical overview of air transport market development in CE and SEE countries

The period of transition of CE and SEE countries that started in 1989 has paved the way for a significant transformation not only in the economy and politics, but also in the aviation sector. The former period of centrally planned economy governed by authorities along with the limited trade of goods and services with other countries has left very scarce space for development of air travel market (Jankiewicz and Huderek-Glapska, 2016). The liberalization of the air transport market coincided with the period of the accession of CE and SEE countries into the European Union(EU) followed by the adoption of abundant regulatory and environmental changes stipulated as the European standards.

The first enlargement of the EU occurred during 2004, when the countries located in Central and Eastern Europe joined the European Union (Poland, Slovakia, the Czech Republic, Hungary, Slovenia, Estonia, Latvia, Lithuania), while the second enlargement occurred in 2007, when the countries in SEE, Bulgaria and Romania, became members. The latest country from SEE to join the EU was Croatia in 2012.In regard to the aviation sector, these enlargements have meant an expansion of the single market as well as of the liberalized European space (Dobruszkes, 2009).The entering of low-cost carriers has intensified the competition by breaking the monopoly previously established by national flag carriers. As a result of intensified competition and inability to promptly adjust to the new market conditions, the national flag carriers of CE countries (the largest were: LOT Airlines in Poland, CSA Airlines in the Czech Republic and Malev in Hungary) persistently faced bad operational performance and loss in market shares (Németh, 2011). In the case of Malev all these circumstances resulted in a serious financial loss, pushing the carrier to bankruptcy.

Despite the fact thata few countries located in SEE are not members of the EU, all of themhave signed the agreement on the establishment of a European Common Aviation Area (ECAA) in 2006. This event triggered a rapid traffic growth, encouraged foreign investments in the sector and acted as an important catalyst for broader regional integration (European Commission - World Bank, 2007). With less than 3 million passengers in 2005, the combined air traffic of the Western Balkans (Albania, Bosnia and Herzegovina, Macedonia and Serbia) remained below that of a small EU country. Although very small compared to their counterparts in CE in terms of passengers carried, the Serbian national carrier,Jat Airways, and the Croatian carrier, Croatia Airlines, remained the two dominant carriers in the Balkan region in the period after the liberalization.

In order to enable a better insight into the characteristics of major airlines (i.e. national flag carriers) located in CE and SEE, the next two subsections briefly describe their performance in the period from 2006 to 2012.

An overview of airlines in CE countries

In the group of countries of CE, Poland and the Czech Republic certainly stand out as the countries with the highest volume of air passenger traffic. The Czech national carrier, CSA Czech Airlines (CSA), and the Polish national carrier, LOT Polish Airlines (LOT), are considered some of the oldest in Europe, both of them were founded before the Second World War. After the new package of the Single European Sky came into effect in April 2004, the carriers lost the privileged position on the market and faced the new competition mainly induced by the penetration of low-cost carriers. As stated in Akbar et al. (2014), LOT lost half of its market share mainly to Wizzair and Ryanair in the first four years of the common air transport market, while low-cost carriers (LCCs) were also dominant in the Czech Republic with 22.3 percent market share in seat capacity by the end of 2011.

CSA Czech Airline

CSA Airlines had struggled to find a strategic partner since early 90s. Selling minority shares to Air France in 1992 was a real failure leading to a withdrawal of the French airline and bringing back the airline into the state's hands again (Akbar et al., 2014). Despite the business fiasco, these two companies continued their tight cooperation through the activities that emerged after CSA Airlines joined Sky Team alliance in 2001. The airline announced a second privatisation bid envisioning Air France-KLM as a major potential partner in 2009. Aeroflot was interested as well, but only Unimex Travel Service made an offer that was rejected by the state due to its small bid of €40 million (Németh, 2011).

In response to the global financial crisis, the CSA Airlines management board successfully implemented the 2009 Action Plan involving drastic downsizing and restructuring measures, which also included personnel measures that were seen as essential for surviving the effects of 2008 economic crisis (CAPA, 2009). As it can be seen from Fig. 1,CSA Airlines has substantially downsized the number of employees from more than 4.5 thousand in 2008 to less than 2 thousand in 2012.

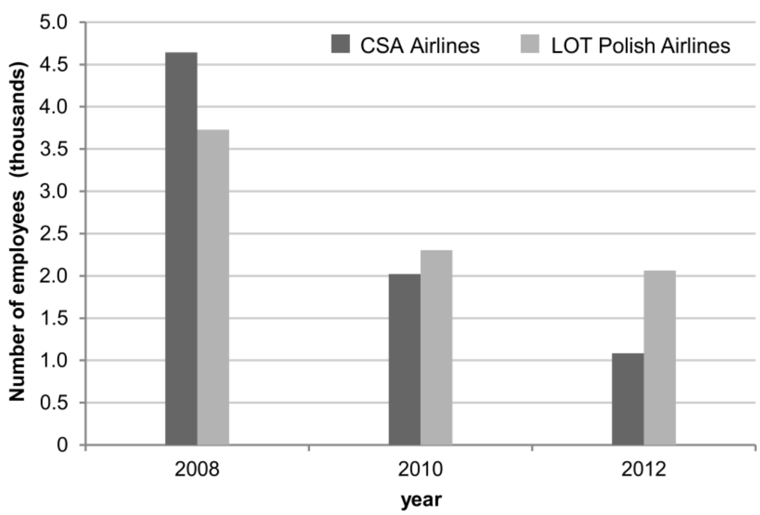


Figure A6.1. Number of employees of CSA Airlines and LOT Polish Airlines (Source: Compiled by the authors based on the information from the airlines' annual reports and relevant airlines' websites)

The company has received a debt-to-equity swap of a CZK 2.5 billion (€100 million) loan in 2010 from a state-owned company Osinek which should have helped the airline become viable within a five year period (EU COM, 2012). Despite such radical measures and the state intervention, CSA Airlines continued to report financial losses in the upcoming years

(Figure A2.2).As observed from Figure A2.2, the company's net profit recorded positive trends from 2005 to 2008, with 2007 and 2008 being the years with positive business results. However, external factors such as the global economic crisis, market liberalization and rising competition from LCCs combined with the company's internal factors (such as inadequate business model, organizational latency, etc.) deteriorated the airline's financial performance with negative net profits recorded since 2009.

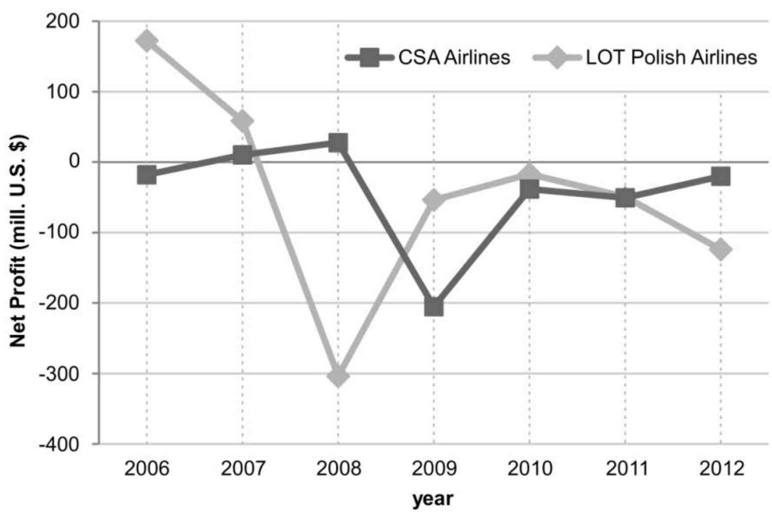
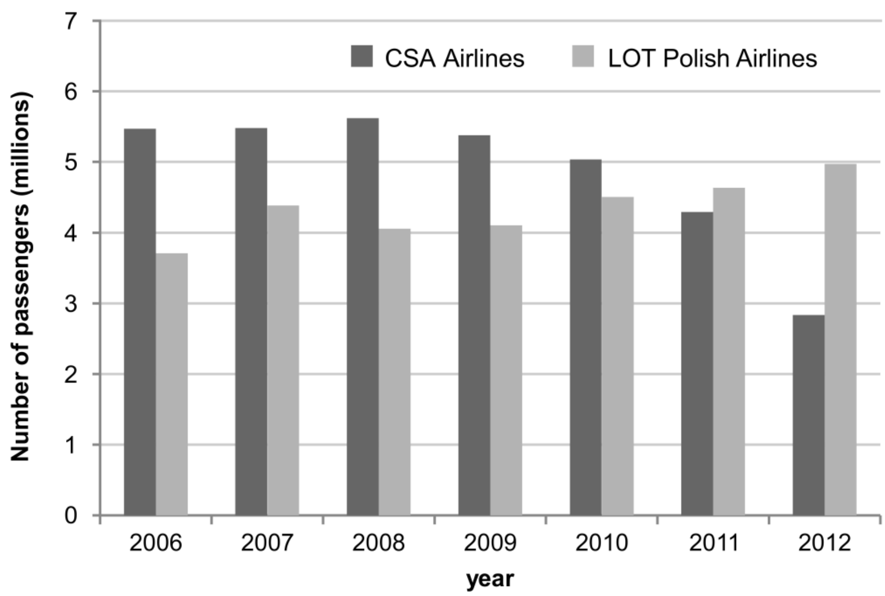


Figure A6.2. Net profit results in the period from 2006 to 2012 (Source: Compiled by the authors based on the information from the airlines' annual reports and relevant airlines' websites)

LOT Polish Airlines

As a neighboring counterpart to CSA Airlines, LOT Polish aimed at finding partnership in the early stage of restructuring its business model. Swissair was the first strategic partner that acquired 10% of LOT Polish in 1999, and further expanded its ownership up to 37.6% (Akbar et al., 2014). Swissair withdrew from the company due to its financial problems, and in 2002 it became state owned again. Shortly after, in 2003 the company became a member of Sky Alliance which certainly helped the airline to overcome the problem of LCC competition to some extent. In 2012, Turkish Airlines had an ambitious plan to acquire a part of LOT Polish (CAPA, 2012), but the companies never reached an agreement mainly due to the differences in their size, network and performances.

As it can be observed from Figure A2.3, the growth in the number of passengers was slow, but constant over the observed period (2006 to 2012). The company saw 2012 as a record year in the number of passengers transported, with almost 5 million throughout its network. Despite the evident growth in the number of passengers (as observed in Figure A2.3), LOT Airlines had difficulty in generating profits (Figure A2.2).



A6.3. Number of passengers for the two airlines in the period from 2006 to 2012 (Source: Compiled by the authors based on the information from the airlines' annual reports and relevant airlines' websites)

As many traditional carriers in Europe, LOT established its own LCC subsidiary Centralwings as a competitor to new LCCs on the Polish market, mainly Wizzair and Ryanair. In 2006, LOT accounted for almost 40% of all seats at Polish airports, with its Centralwings adding a further 6% (Anna Aero, 2016b). Centralwings went bankrupt in 2009, while the total market share of LOT gradually reduced over the years to 31.6% in

2012 (Anna Aero, 2016b). The company was severely hit by the meteoric rise of these new competitors and was not able to sustain profitably on the market (CAPA, 2014).

An overview of airlines in SEE countries

Although the region of SEE encompasses a large territory, the paper focuses on the performance of airlines from the region of the Balkans. Airlines from four selected countries in this region have been investigated: Serbian Jat Airways, Croatian Croatia Airlines, Slovenian Adria Airways and Romanian Tarom. For the sake of simplicity in interpretation, the performance of the first three airlines (Jat Airways, Croatia Airlines and Adria Airways) will be illustrated together since their states were constituted after the break-up of Yugoslavia in the 1990s. Finally, Tarom stands out as the national carrier of Romania that experienced a turbulent economic crisis in the 1990s but with the economic recovery slightly different from ex-Yugoslav countries. Thus, its performance will be shown separately.

The region of the Balkans has passed through a turbulent period in the last two decades. The breakup of Yugoslavia in 1991, followed by the ethnic war eventually led to the constitution of five independent republics, Serbia and Montenegro, Croatia, Bosnia and Herzegovina, Slovenia, and Macedonia (Kuljanin and Kalić, 2015; Kuljanin, Paskota and Kalić, 2018c). Each of the five countries constituted their own national flag carrier as a symbol of state's sovereignty, with Serbia's JAT emerging as the successor of Yugoslav Airlines. All national carriers were state-owned and carried a very small number of passengers in comparison with the major European airlines.

The air transport market in the Balkan region had a similar path of development as the market in CE, triggered when countries of this region signed the agreement on the establishment of a European Common Aviation Area (ECAA) in 2006. This event paved the way to healthier competition on the market, but also induced the erosion of market shares of the flag carriers at their base airports.

Croatia Airlines

Croatia Airlines is a joint stock-company with the state holding the largest share of 97.78% (Croatia Airlines Annual Report 2012, 2013). As seen from Figure A2.4, the airline has significantly outperformed its counterparts in terms of passengers (at its peak of 1.95 million in 2012) primarily due to attractive tourist market and a coherent regional strategy (short to medium-distance routes throughout Europe, while counting on its partners for long-distance and intercontinental connections). Despite its professional management and very-well developed network, the airline is loss-making since 2008, with a high-cost CASK structure and liable to need fresh equity capital (CAPA, 2013).

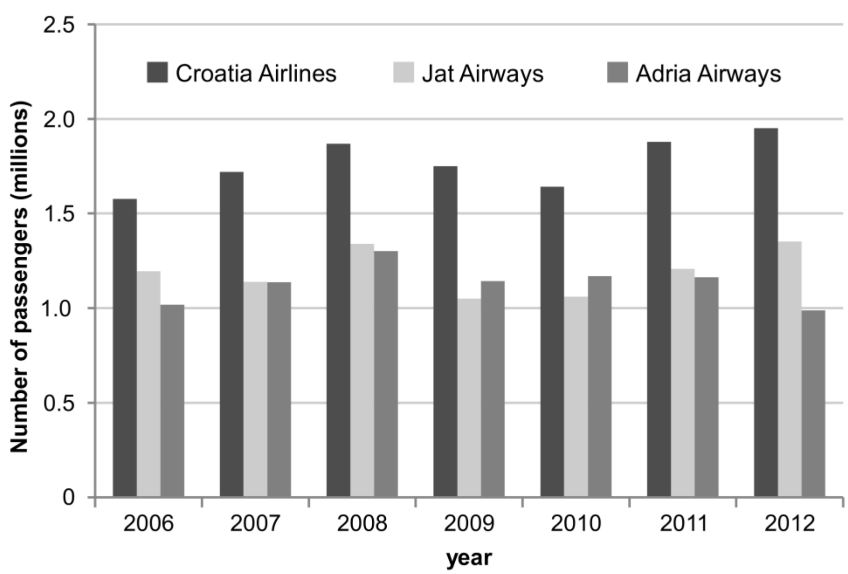


Figure A6.4. Number of passengers for the period 2006-2012 for the carriers from SEE (Source: Compiled by the authors based on the information from the airlines' annual reports and relevant airlines' websites)

In order to help its carrier become a profitable company, the Croatian Government approved injection of funds, several months ahead of Croatia's anticipated EU accession as a means to avoid strict EU competition regulations (Balkan Insight, 2012). The financial aid aimed at covering the airline's debt of€82.6 million, and remaining €19.8 million were invested in making the carrier more competitive.

Jat Airways

In comparison to Croatia Airlines that started its business from the scratch, Jat Airways continued its operation as a successor of the large airline, Yugoslav Air Transport, that persisted in a country with approximately 20 million inhabitants. As a national carrier of Serbia, a country with 7 million people, the carrier suffered from the lack of demand that occurred as a result of severe economic conditions with high portion of inhabitants living in poverty in the period shortly after the 90's turmoil (Kuljanin and Kalić, 2015).Likewise the other carriers from the "former communist bloc", JAT experienced a huge problem with its aging and inefficient fleet as opposed to the carriers in Western Europe that had already largely invested in their fleet modernization.

After the liberalization of the Serbian air transport market and the expansion of low-cost carriers in 2006, Jat Airways market share gradually declined. In the first four years of the liberalized market,Jat Airways market share at its base, Belgrade Airport, dropped down from 54.7% in 2006 to 36.5% in 2010 mainly due to Wizzair[19]. The company also suffered poor performance of load factor accounting for around 57.1% in 2006, being the lowest as opposed to the two other neighboring carriers (Croatia Airlines with almost 62% and Adria Airways with the load factor of 66.4%) (AEA, 2007). Total number of passengers carried was fluctuating around one million (Figure A2.4) between 2008 and 2012. 2008 was particularly difficult for the airline and a significant amount of losses (€82 million) was accumulated during that time (Ex-Yu Aviation News, 2014).

Adria Airways

After the break-up of Yugoslavia, Adria Airways had to reorganize its operations from mainly charter-oriented to a scheduled operator since the majority of charter destinations from Western Europe to the Adriatic coast had become inaccessible as they were now

[19] The calculation is based on the Fig. 2 in Kuljanin and Kalić (2015)

situated on the territory of other countries (Adria Airways, 2017). The fleet became excessively large for the new market conditions that forced the airline to lease their planes across the globe. The number of passengers has been fluctuating around one million, which categorizes the company as very small, but efficient in terms of labour productivity as it had the highest ratio among passengers carried and number of employees (Figure A2.5).

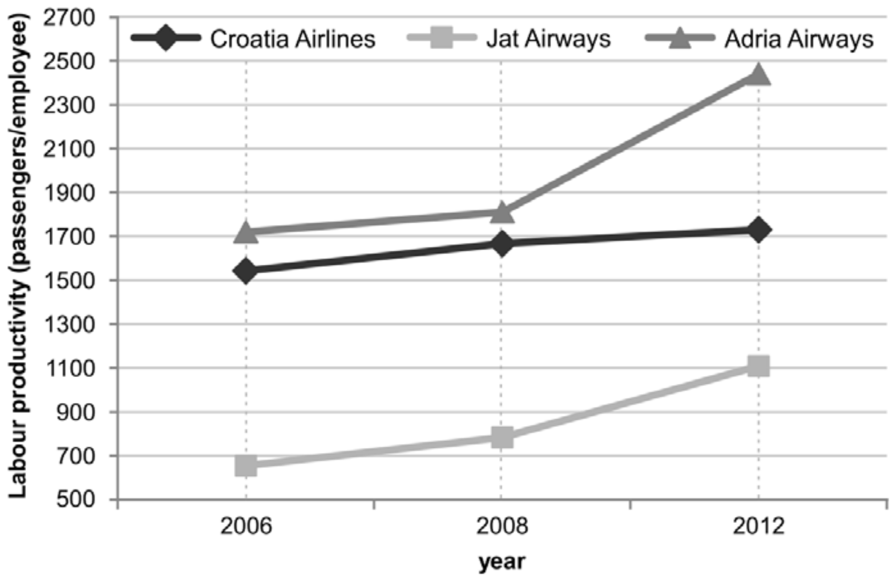


Figure A6.5. Labour productivity for the airlines from SEE (Source: Compiled by the authors based on the information from the airlines' annual reports and relevant airlines' websites)

In the period after 2000s, the airline started to connect Balkan cities (Sarajevo, Skopje, Ohrid, Tirana, Pristina) with Western Europe (Scandinavia, the UK, Germany, France). Slovenia's entry to the European Union in 2004 did not give an immediate boost to Adria's passenger numbers, but load factors did, however, start to rise in 2005 (Anna Aero, 2010).Likewiseits counterparts, Adria Airways entered the new decade with substantial financial losses despite the reduction in the number of employees, modernisation of its fleet and Government intervention to loan-to-equity swap of €19.7 million (EU COM, 2015).

Tarom

Tarom is a state-owned company of Romania, which underwenta turbulent period after the collapse of the communist regime in 1989, like other carriers from this region. The high cost models were being aggressively challenged by competition from the region's low-cost operators (Wizzair entered the market in 2006) and the airline was seeking for a strategic investor for a long time. The market share of Tarom reduced from 33.6% in 2006 to 28.1% in 2012 at Romanian airports, whereas Wizzair had a phenomenal expansion from 4.9% of market share in 2007 to 23.1% in 2012 (Anna Aero, 2016a).In order to decrease its costs and adjust the supply to the new market conditions, the company started with fleet modernisation in 2006 and acquired Airbus A318, Boeing 737-800 and ATR 72-500. In addition to the fleet enlargement, the airline joined Sky Team in 2010.

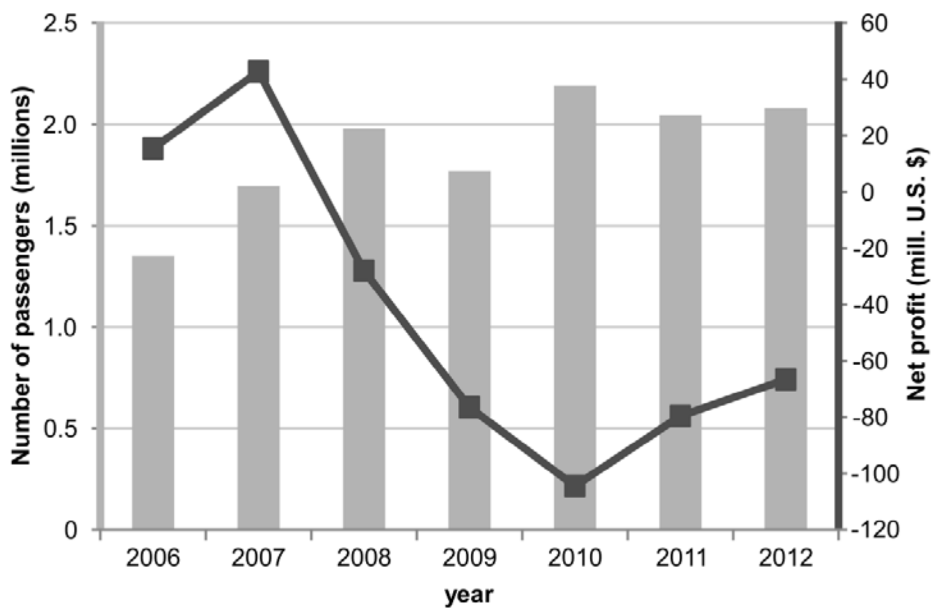


Figure A6.6. Tarom’s number of passengers and net profit from 2006 to 2012 (Source: Compiled by the authors based on the information from the airlines’ annual reports and relevant airlines’ websites)

As other SEE carriers that survived, Tarom experienced a slight increase in the number of passengers (Figure A2.6) over the period observed. On the other hand, the company has faced financial losses since 2008 (Figure A2.6), although they have been gradually reduced in the recent years as a result of private leadership. Namely, starting from November 2012, in accordance with the Romanian state-company legislation, Tarom was led by a private manager, Belgium's Christian Heinzmann.

Biography

Jovana Kuljanin was born in Smederevo, 12.10.1985. She finished primary and secondary school in Smederevo. She enrolled in the Faculty of Transport and Traffic Engineering in 2004. Graduated in May 2010, with the graduation thesis titled "Market segmentation at Nikola Tesla airport in Belgrade", mentor Prof. Milica Kalić, with top marks (10) for her thesis, and an average mark of 9.13 during her studies.

She has interned at two airports: Tivat Airport, Montenegro (one month) and Zurich Airport, Switzerland (2011/2012). During her six month internship at the Forecasting and Simulation Department at Zurich Airport, she accomplished the project titled "Air travel demand forecast at Zurich Airport" mentored by Professor Manuel Renold.

She enrolled in postgraduate studies at the Faculty of Transport and Traffic Engineering in 2012/2013. She completed coursework and passed the exams prescribed by the curriculum (with an average mark of 10) and obtained ECTS 93 credits. The research proposal within doctoral dissertation for her PhD was accepted by the University of Belgrade in February 2018.

From October 2012 through March 2014 she was employed by the Division of Aircraft Operations and Air Transport Planning and Management as Junior Teaching Assistant. During this period, she was engaged in labs for two undergraduate courses: Transportation Networks and Computer Technical Drawing. Since April 2014 she has been employed by the Ministry of Education, Science and Technological Development of the Republic of Serbia within the Project TR36033 (2011-2019) – *"A Support to Sustainable Development of the Republic of Serbia's Air Transport System".*

During her PhD studies, she spent three month period at study visit at Polytechnic University of Bari as a part of ERASMUS plus programe.

She has taken part in 4 science and professional projects. She is the author or coauthor of 24 published and/or presented papers (of which 3 papers published in SCi journal with impact factor, 2 papers published as chapters in international Springer monograph, 14 papers published in international conferences and one paper presented at international conference).

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