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The determinants of full-service carriers airfares in European hub-to-hub markets

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This paper explores the factors influencing the pricing behaviour of full-service carriers in European hub-to-hub markets. Drawing on a 2009 dataset containing route and airfare information, we establish an econometric model to estimate the impact of route structure, alliances, and market concentration on the pricing of European full-service carriers in these markets. The results suggest that alliances on routes connecting two primary hubs, airport concentration, market share inequality and competition from low-cost carriers influence average airfares of full-service carriers in the European hub-to-hub markets.

Keywords: *airfare pricing, alliances, European hub-to-hub network, full-service carriers, hub hierarchy.*

1. Introduction

Air transport deregulation in Europe has led to dramatic changes in the network configuration and business models of erstwhile national carriers. First, they have implemented or intensified the adoption of hub-and-spoke networks by concentrating traffic and flights around their hubs to accomplish network economies (Burghouwt and de Wit, 2005; Button, 2002; Caves et al., 1984; Janic and Reggiani, 2002). Second, sophisticated revenue management techniques have replaced the traditional regulated pricing mechanisms. Offering more differentiated products - such as in-flight entertainment, VIP waiting lounges, and other 'frills' - has gradually transformed national carriers into so-called 'full-service carriers' (FSCs) (Tretheway, 2011). Third, the industry has been consolidated via cross-border mergers to address the excess capacity caused by establishing too many airlines in the outdated flag-carrier system (Brueckner and Pels, 2005), as well as through establishing global alliances (Benacchio, 2008; Doganis, 1994). In addition, the emergence of low-cost carriers (LCCs) has been a competitive challenge for FSCs due to the former carriers' well-known cost advantages (Alderighi et al., 2012). These changes force FSCs in Europe to constantly (re)examine their pricing strategies in order to achieve profitability in what have become (relatively more) liberalized markets.

The literature examining the pricing strategies of FSCs in Europe is not as extensive as the one focused on the aviation market in the United States. Some of the exceptions include research on 1) flights from Nice Airport (France) to 9 European countries (Giaume and Guillou, 2004), 2) domestic routes and airport-pairs between the United Kingdom and 14 European countries (Piga and Bachis, 2007), and 3) city-pairs between Italy and the main destinations in the UK, Germany and the Netherlands (Alderighi et al., 2012). As a consequence, to the best of our knowledge there has been no research exclusively devoted to how carriers determine airfares in the emerging

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European hub-to-hub (HH) markets, where both origin and destination are to some degree dominated by a FSC.

An analysis of pricing in European HH markets is relevant for three reasons. First, hubs are typically located in Metropolitan Regions characterized by large populations, major levels of economic development, and an economic structure that is conducive to business travel (Dijkstra, 2009). Carriers operating HH routes can therefore not only expect to realize economies of density, but also capture more high-yield business travellers (Neal, 2011). Second, hubs assume different service levels in individual FSCs' networks, i.e. the so-called 'hub hierarchy' that is also emerging in the US (Burghouwt and de Wit, 2005; Burghouwt and Hakfoort, 2001; Dennis, 2005; Derudder and Witlox, 2009; Frenken et al., 2004; Malighetti et al., 2009; Thompson, 2002). Burghouwt (2007), for instance, clusters airports into 1st tier, 2nd tier and 3rd tier hubs based on the number of weighted indirect connections in a carrier's network, while Malighetti et al. (2009) distinguish between 'worldwide hubs', 'hubs' and 'secondary gates' based on traffic volume, destination of connections, connectivity and topology of service. The ensuing 'hub hierarchy' implies that the routes connecting different levels of hubs may vary in their pricing: routes involving more dominant hubs can in principle be related with higher airfares because of 'hub premiums' (Vowles, 2006; Zhang et al., 2013).

Third, strategic alliances have complicated the route structure of HH networks. European FSCs have over time joined one of the three global alliances, thus leading to the development of explicit and implicit multi-hub-and-spoke networks: carriers extend their reach by interlinking each other's networks (often via their hubs), so that the scope of their network grows without having to internally extend their own networks. Alliance carriers can, as a consequence, increase frequencies on their nonstop HH routes to facilitate customers, especially time-sensitive business travellers. Doganis (2006), for instance, found that the Lufthansa-SAS alliance increased daily departures between Frankfurt and Copenhagen for both carriers. As a consequence, carriers that do not ally on HH routes may lose competitive advantages comparing to allied carriers, so that the resulting market concentration can be expected to play an important role in explaining price discrimination (Borenstein, 1989; Piga and Bachis, 2007).

The emerging 'hub hierarchy', the growing importance of alliances and their combined impact (i.e., a route connected by two hubs with different levels of hubness may also be an allied route) gives rise to an inherently complex European HH network. This raises questions on the major factors influencing the pricing strategies of FSCs serving the hub markets. The objective of this paper, therefore, is to investigate to what extent the emerging hub hierarchy, strategic alliances and the ensuing landscapes of market concentration influence the price-setting of FSCs in the European HH markets. The remainder of this paper is organized as follows. Section 2 reviews previous studies on how alliances and market structure determine airfares and yield in the US and European airline industry. Section 3 defines the European HH network, and introduces our data and methods. Section 4 presents an analysis of the complex market structure of the European HH markets, and examines how route structure, alliances and market concentration influence the pricing strategies of FSCs. In section 5, we summarize the main implications of our analysis and outline some avenues for further research.

2. Literature Review

2.1 Hub dominance and airfares in HH markets

Hub-and-spoke networks are associated with the dominance of a hub airport by one or, occasionally, two carriers (Borenstein, 1992). If a carrier provides a large number of competitive indirect connections (Burghouwt and de Wit, 2005) or connects large volumes of transfer passengers (Lee and Luengo-Prado, 2005), then this carrier is said to 'dominate' its hub airport. The debate about the relationship between hub dominance and airfares rests on the question whether carriers can wield market power by charging higher airfares on routes from/to their hubs than on other routes. There is no consensus as to whether a carrier's pricing power at its hub airport can be conveyed to all routes involving the dominant airport, so that this relationship is discussed at both the airport and the route level to obtain unbiased estimations.

In US airline markets, researchers had found that the market power exercised by carriers has not been undermined since deregulation. Borenstein (1989) found that a carrier dominating at both the airport and the route level has the ability to charge higher fares, whereby the sources of this market power originate from 1) the dominant carriers' ability to deter the entry of potential competitors by controlling airport facilities, as well as 2) the marketing devices such as frequent flyer programs (FFP). However, Evans and Kessides (1993) found that dominance at the airport level, but not the route level, can confer substantial market power upon the carrier when unexplained inter-route heterogeneity is considered. Aircraft can be switched relatively easily and costlessly between different routes making these routes naturally contestable, whereas airport facilities, product differentiation barriers arising from FFPs and other impediments make these harder to contest. More recently, researchers have offered new evidence for US markets and found that a carrier dominating at the route level can also charge higher fares (Fischer and Kamerschen, 2003; Stavins, 2001).

Marín (1995) was the first to address the issue in the European context and found that, in contrast to the US situation, European carriers tended to compete in terms of prices by exploiting cost advantages after liberalization. Captain and Sickles (1997) further found that the reasons why some 'flag carriers' cannot exploit such cost advantages is due to technically inefficient use of inputs and high labour wages rather than wielding market power between 1976 and 1990. However, it is clear that these studies deal with the earlier stages of European aviation deregulation. As the European aviation sector has gone through dramatic changes in the last decades, the impact of market dominance on airfares has also been altered by factors such as the proliferation of low-cost carriers (LCCs). Piga and Bachis (2007) concluded that the impact of market dominance on fares in European airline market depends on the type of carriers (i.e. FSCs versus LCCs). FSCs' dominance at an airport plays a crucial role only for the fares associated with a particular set of booking days, i.e. the late booking dates, whereas LCCs' dominance at an airport is highly correlated with fares on any booking day before departure due to their ability to operate at lower costs. Dominance at the route level enables FSCs to exercise market power, but limits LCCs' ability to charge higher fares only for late booking fares. They also argue that the limited size of many 'natural monopoly' routes contribute to the route dominance enjoyed by European carriers.

2.2 *Alliances and airfares in HH markets*

An alliance can increase the market share and market power of alliance carriers at their hubs, and reduce or eliminate competition on specific routes. However, when alliances or mergers significantly reduce competition in the relevant markets, the European Commission has imposed conditions such as giving up airport slots or route licenses to encourage the entry of new carriers (Doganis, 2006).The vast majority of dense intra-European routes are short-haul routes with less than two-and-a-half hours of flying time, implying that alternatives via transfer routes are not very attractive. Joining in an alliance can therefore very effectively reduce competition on those routes by turning the previous duopoly into a de facto monopoly (Doganis, 2006). However, the degree to which alliance partners (ab)use their strengthened dominance to charge higher fares on their hub-to-hub routes remains unclear. Oum et al. (2000) study 22 international airlines for the 1986-95 period and find that partner airlines lowered prices by 1.3% after entering an alliance, and ascribe this result to the reduced cost because of efficiency or productivity gains. They particularly find that an airline with a longer average route length charged lower prices than that with a short average route length due to the competitive advantage of longer routes (e.g., reduced fuel consumption). At the same time, researchers have found that fares in markets served by an alliance were higher than those in non-alliance markets because of reduced competition, as in the SAS-Swissair alliance (Youssef and Hansen, 1994) and the Air France-KLM merger (Brueckner and Pels, 2005). Meanwhile, Wan et al. (2009) investigate the impact of airline alliances on airfares on transatlantic HH routes, and come to the conclusion that the net effect on airfares is uncertain as it depends on the ability of an alliance to coordinate fares.

2.3 Market concentration and airfares in HH markets

A carrier's pricing strategy is driven not only by the internal carrier-specific considerations but also by the structure of external markets. As a market (i.e., individual airport-pair market) is comprised of carriers, passengers, air travel products, and competing mass travel modes such as railway links, the external market structure in which the carriers are operating depends upon four aspects: 1) the number of carriers and passengers, 2) ease of market entry, adaptation, and exit, 3) the extent of product differentiation or distinctiveness, and 4) the availability and cost of information (Holloway, 2008).

The structure of the European airline markets can in practice be mainly categorized through three types, based on the number of carriers: monopoly (i.e., one carrier), duopoly (i.e., two carriers) and oligopoly (i.e., more than two carriers) (Alderighi et al., 2012). However, the number of carriers per se on a route is not the best measure of market structure and the competitive behaviour of carriers as it does not evaluate concentration (i.e., the market share distribution of carriers) (Giaume and Guillou, 2004; Shepherd, 1999). The concept of concentration has been extensively applied to represent market structure in research focused on the relationship between market structure and pricing. Aiming to reflect the entire market share distribution of carriers in a single indicator, researchers frequently use the Herfindahl-Hirschman Index (HHI) to quantify market concentration (Hannan, 1997).

The impact of route HHI on prices can be mixed and depends on the geographical areas. In the US airline markets, researchers have found that increases in route HHI raise prices to some degree as a few carriers in a concentrated market may collude more easily to charge higher prices (Borenstein, 1989; Chi and Koo, 2009; Evans and Kessides, 1993). However, a negative relationship between route HHI and prices also occurs when the dominant carrier enjoys technological advantages over its rivals and forces the other carriers to reduce prices to compete (Fischer and Kamerschen, 2003). In the European airline markets, Piga and Bachis (2007) found that prices were raised by FSCs and LCCs as route HHI increased, but only for the prices associated with late booking days. Giaume and Guillou (2004) observed a negative relationship between route HHI and prices in the European markets and attributed it to the high inequality of market share leading to strong price competition between carriers.

These findings suggest that the impact of changing market structure on fares for European markets will probably not be a copy of the US case, which calls for a systematic appraisal of its role in European aviation markets. Moreover, we also consider the impact of LCCs' presence at secondary airports and high-speed train (HST) competition on airfares, which to date are rarely incorporated in a pricing model related to European market.

3. Data collection and descriptive analysis

3.1 Data collection procedure

A first step is to define the geographical scope of our research. As there are no generally recognized boundaries of 'Europe', the scope of this study is confined to those Western/Central parts of Europe where the air transport industry is relatively more liberalized and developed. This paper considers the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

The second step is to define European FSCs and their established hubs as well as secondary airports close to these hubs. Researchers have long defined all 'flag carriers'[4] of the countries listed above as FSCs in Europe (Alderighi et al., 2012; Burghouwt et al., 2003). However, on-going deregulation has broadened the differences amongst these erstwhile flag carriers, as can be seen in the cases of Aer Lingus's (i.e., Ireland's flag carrier) transformation into a LCC (Barrett, 2006; O' Connell and Williams, 2005; Wallace et al., 2006) and the demise of Sabena (i.e., Belgium's former flag carrier) in 2001. Moreover, some flag carriers, such as Icelandair, Luxair and Olympic Airlines, did not join one of the major airline alliances. As per our research objective, FSCs are defined as the current flag carriers of countries locating in Western and Central Europe which run a complex business model by bundling a series of services, and have also joined one of the three global alliances (i.e., Star, Oneworld and SkyTeam) at the time of our research (column 2, table 1). Next, we identify these FSCs' hubs, thus establishing the hub-to-hub network in Europe. As the main purpose of a FSC's hub is to concentrate flights through synchronized waves and reroute passengers, our working definition of hubs in the European airline market focuses on the number of competitive indirect connections as presented by Burghouwt (2007). In his work, hubs are defined as airports with more than 200 indirect connections per day[5] and served by FSCs. A classification scheme based on the number of indirect connections is then applied to distinguish between 'primary hubs' (>2500) and 'secondary hubs' (200-2500). Table 1 presents an overview of the European FSCs' hubs and their adjacent secondary airports[6]. This provides the scope of our study as the HH market is taken to consist of all connections where both origin and destination are hubs (see Figure 1). As a result of the presence of this 'hub hierarchy', European HH network consists of three different types of routes, i.e., primary-primary (PP), primary-secondary (PS), and secondary-secondary (SS) routes.

Table 1. Categorization of hubs for European FSCs and list of secondary airports

Hub Airport	Carrier	Number of weighted indirect connections per day (2003[7])	Secondary Airport
Primary (8)			
Charles de Gaulle (CDG)	Air France	14005	Beauvais (BVA)
Frankfurt (FRA)	Lufthansa	13616	Frankfurt Hahn (HHN)
London Heathrow (LHR)	British Airways	9439	London Luton (LTN), London Stansted (STN)
Amsterdam (AMS)	KLM	8713	Rotterdam (RTM)
Madrid (MAD)	Iberia	6941	
Munich (MUC)	Lufthansa	4184	

[4] A flag carrier (also known as national carrier) is one that is substantially owned and effectively controlled by nationals of that state in the EU (Doganis, 2001; Barrett, 2006). However, waves of deregulation and privatization have changed the ownership of some flag carriers whereby they have become partially or even fully owned by the private sector. However, most of them are still considered to be flag carriers today as they are often interpreted as a sign of their home country's international presence (Smith, 1991).

[5] Burghouwt (2007) considered all the airports having indirect connections in an FSC's network as hubs or primary nodes. However, we set a minimum threshold as 200 indirect connections per day as this tends to select more important hubs through which airlines strive to establish a wave-system structure.

6 Secondary airports are defined as airports located less than 75 miles away from the hubs.

7 Burghouwt (2007)'s work to the best of our knowledge is the most detailed source on the hub-and-spoke practices of FSCs in Europe. Even though this classification was developed using pre-2005 data, it is still a valuable source because FSCs and their hubs tend to have longstanding, symbiotic relationships. Only in the cases of bankruptcy or the very drastic decision to fundamentally restructure their network, it would be possible for an FSC to either abandon a hub (Redondi et al., 2012) or establish a new one (Düdden, 2006). For the sake of data consistency, we investigated the network evolution of route maps of FSCs, and found that Alitalia was the only example here through its partially abandoning of Milan Malpensa (MXP) in 2008. However, excluding MXP from our dataset did not alter the results of our improved model. Taken together, then, Burghouwt's classification is still relevant for our research, in spite of it predating our own analytical framework.

Copenhagen (CPH)	SAS Scandinavian	2576	Malmo (MMX)
Vienna (VIE)	Austrian	2553	
Secondary (10)			
Rome Fiumicino (FCO)	Alitalia	2384	Ciampino (CIA)
Barcelona (BCN)	Iberia	2128	Girona (GRO)
Milan Malpensa (MXP)	Alitalia	1946	Linate (LIN), Bergamo (BGY)
Oslo (OSL)	SAS Scandinavian	1139	Torp (TRF)
London Gatwick (LGW)	British Airways	979	London Luton (LTN), London Stansted (STN)
Helsinki (HEL)	Finnair	957	
Lisbon (LIS)	TAP Air Portugal	792	
Paris Orly (ORY)	Air France	709	Beauvais (BVA)
Brussels (BRU)	Brussels[8]	452	Charleroi (CRL)
Dusseldorf (DUS)	Lufthansa	214	Kolon/Bonn (CGN)

Source: Burghouwt (2007)

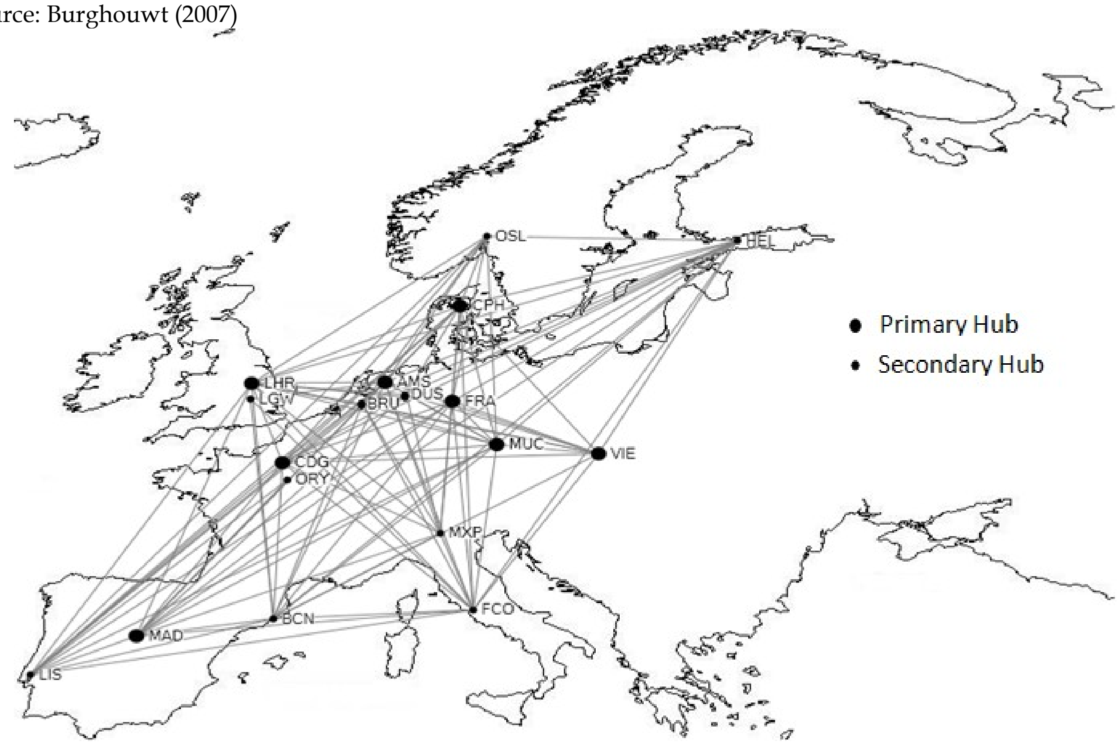

Figure 1. Non-stop connections between hubs of the European FSCs

We also identified types of carriers other than FSCs (e.g., LCCs and regional carriers) to examine the overall market structure. As not all the carriers registered in Europe can readily enter the European HH markets due to high entry barriers, we collected a list of carriers that actually served the HH markets (i.e., with a market share larger than 1%) in May 2009 from our database (see below). By comparing the combined lists of LCCs recently developed by Dobruszkes (2009) and Klophaus et al. (2012), we establish a list of LCCs for this study. All the other carriers are then defined as regional carriers (RECs)[9]. The overview of carriers is represented in table 2.

8 Brussels Airlines is the new flag carrier of Belgium. It started operations in 2007 after the merger between between SN Brussels Airlines (i.e., the former national carrier of Belgium, inherited from Sabena) and Virgin Express.

9 Even though some RECs are partial- or fully-owned subsidiaries of FSCs, we treat them separately as 1) their combined market shares would cause severe anti-competition issues due to monopolistic or duopolistic tendencies; 2) the integration may mask the roles played by RECs in reducing prices on routes with fierce competition from LCCs or those with unanticipated schedule disruptions (Forbes and Lederman, 2007).

Table 2. Overview of carriers and alliance for FSCs

Carrier Type	Carrier Name
FSCs	Air France (SkyTeam), Alitalia (SkyTeam), Austrian (Star), British Airways (OneWorld), Brussels (Star), Finnair (OneWorld), Iberia (OneWorld), KLM (SkyTeam), Lufthansa (Star), SAS Scandinavian (Star), TAP Air Portugal (Star)
LCCs	Aer Lingus, Air Europa Lineas Aereas, Air Berlin, EasyJet, Germanwings, Niki, Norwegian Air Shuttle, Spanair, Transavia.com, Vueling, Ryanair, Wind Jet
RECs	Adria Airways, Aigle Azur, Air Comet, Air Dolomiti, Blue1, BMI british midland, Brit Air, Cimber Sterling, Eurowings, Lufthansa Cityline, Regional, SAS Norge, Tyrolean Airways

Note: Alliance membership for FSCs is shown between parentheses.

The main dataset used in this paper is collected through a research cooperation with Sabre Airline Solutions, and contains information drawn from Airport Data Intelligence (ADI) on actual bookings for different carriers. The Sabre ADI has at least one major advantage when analysing pricing and scheduling in the airline industry: it seeks to establish a complete dataset by adjusting and calibrating data from 1) global distribution systems (GDS), 2) travel agencies, 3) direct bookings, low-cost carriers, charter operations and 4) other non-IATA distribution channels. Sabre's ADI database provides the required data for the proposed pricing analysis, including information at the route and carrier level of passenger numbers, revenue, cabin class and distance. It also indicates the intermediate stops when connecting services are available. The units of observation in our analysis are the non-stop connections between the 18 hubs in the overall network 'produced' by the 11 European FSCs given in Figure 1. An observed route is selected only if its monthly traffic volume is at least 100 passengers, and a carrier is considered to serve the route only if its market share is at least 1%. The data used in this paper is for May 2009. In addition, the population of the hub cities is obtained from www.World-Gazetteer.com. The data related to the presence of LCCs on competing routes whereby either endpoints are connected by secondary airports are collected from www.skyscanner.net[10]. Finally, HST data are collected from the official website of HST companies in Europe, such as TGV, ICE, Eurostar and other companies.

3.2 *Exploratory analysis of market structure*

Market concentration depends on the actual structure of individual hub airport-pair markets. Given the complex nature of market structure in the EU (partly because of the shorter distances between hubs and the alliance formation), we first perform a descriptive analysis of market structure before proceeding to the econometric analysis.

Market structure by route type

As competition has not been homogeneous at the route level in Europe (Giaume and Guillou, 2004), it is necessary to analyze the market structure for each HH route separately. Table 3 shows that European HH markets exhibit three types of market structure in terms of the number and type of carriers: monopoly (10% of routes), duopoly (49% of routes) and oligopoly (42% of routes)[11]. Previous research carried out by Alderighi et al. (2012) has shown that the entry of

[10] This data were not available for the year 2009 in our Sabre dataset. Skyscanner providing information about routes and carriers allows us to control for the impact of LCCs competition at secondary airports, even though the online data are about scheduled flights in 2014. Competing routes are assumed to be actually served by LCCs only if nonstop return services are provided every week in May, 2014. The website was accessed on 4th April, 2014.

[11] For instance, Barcelona-Frankfurt is a monopolistic route as Lufthansa is the only carrier serving this route at the time of data collection. Amsterdam-Charles de Gaulle is a duopolistic routes served by two carriers – Air France and KLM. The oligopoly markets have three or more carriers in services. Note that from an alliance perspective the CDG-AMS link will be monopolistic.

LCCs has increased the competition of the European aviation market. They particularly distinguish between symmetric duopoly (two FSCs) and asymmetric duopoly (one FSC and one LCC), and also between oligopolistic routes with or without the presence of LCCs. Drawing on their categorization method, we find that 11 duopolistic routes and 28 oligopolistic routes have been entered by LCCs. These fundamental statistics indicate that European HH markets are 1) served by few carriers and characterized by high concentration, and 2) penetrated by LCCs.

Table 3. An overview of market structure by route structure

	Monopolistic routes	Duopolistic routes			Oligopolistic routes				Total
		FSC	FSC&LCC	FSC&REC	FSC	FSC&LCC	FSC&REC	FSC&LCC&REC	
PP	2	11	0	2	1	2	4	4	26
PS	5	13	8	7	1	9	6	6	55
SS	3	2	3	3	1	6	1	1	20
Total	10	26	11	12	3	17	11	11	101

The presence of LCCs and RECs indicates the possible inequality of market shares among carriers. Route concentration measured by a regular HHI (i.e., the sum of squared market shares) may, therefore, be inadequate to represent concentration, as it does not separate the effects of the number of carriers and share inequality[12]. We thus use the decomposed HHI to measure the market concentration when both asymmetries of market shares and the number of competitors on a route should be accounted for. The decomposed HHI index is measured as:

$$\text{Decomposed HHI} = \text{H1} + \text{H2} = \text{CV}^2/\text{N} + 1/\text{N} \tag{1}$$

Where *CV* is the coefficient of variation of market shares, and *N* is the number of carriers on a route. The first part of this equation (*H1*) is of particular importance as it represents the market share inequality of carriers on a route, while the second part (*H2*) describes the value of *HHI* when all the carriers have equal market share (Laderman, 1995).

The impact of alliances on airfares

Alliances allow FSCs to form multi-hub-and-spoke networks and cooperate with carriers in the same alliance. 34 out of 101 routes in our study are connected by the same alliance's hubs in our study (table 4). We categorize six types of routes by considering both the degree of hubness and alliances: PP*Alliance (e.g., FRA-CPH), PP*NonAlliance (e.g., FRA-CDG), PS*Alliance (e.g., FRA-OLS), PS*NonAlliance (e.g., FRA-FCO), SS*Alliance (e.g., OLS-LIS) and SS*NonAlliance (e.g., FCO-OLS). For instance, as Lufthansa, SAS Scandinavian, Brussels and TAP Air Portugal all belong to the Star alliance, FRA-CPH is thus a PP*Alliance route whereby FRA and CPH are the primary hubs of Lufthansa and SAS Scandinavian, respectively. The same approach was applied to the other route types. Based on the disaggregated market share of the carriers in the same alliance, five allied routes are monopolistic and 21 are duopolistic. When the market shares of the alliance carriers are aggregated, about 90% of alliance routes are monopolistic or duopolistic.

[12] Our econometric analysis also proves that the regular HHI index does not have significant impact on fares. In addition, the different effects of number of carriers and market share inequality on fares also indicate that the decomposed HHI is more appropriate to represent market concentration in this study.

Table 4. The effects of alliances on market structure by route type

	Monopolistic routes	Duopolistic routes	Oligopolistic routes	Total
Before alliance				
PP*Alliance	2	4	2	8
PS*Alliance	2	13	5	20
SS*Alliance	1	4	1	6
Total	5	21	8	34
After alliance				
PP*Alliance	6	2	0	8
PS*Alliance	9	9	2	20
SS*Alliance	3	2	1	6
Total	18	13	3	34

We also carried out an exploratory analysis to examine whether allied carriers exercise pricing power when their joint market share increases. Table 5 shows that the alliance carriers charge significant higher fares only on PP routes, but not on the other types of routes. There are two possible reasons. First, the raised market concentration on the other types of routes is offset by the economies of density, resulting in statistically insignificant impact on airfares. Second, allied carriers coordinate their pricing decisions on the main PP routes, implying that they primarily wield market power on PP routes.

Table 5. The t-test results for average fares by route type

Average fares	N	Mean $	Std.dev.	Std.err.	t-value
PP route					
Same-alliance routes	8	188.75	25.16	8.89	3.964
Different-alliance routes	18	151.02	21.16	4.99	(0.001)
Difference		37.73		9.52	
PS route					
Same-alliance routes	20	170.70	58.33	13.04	1.22
Different-alliance routes	35	153.49	45.09	7.62	(0.227)
Difference		17.21		14.08	
SS route					
Same-alliance route	6	134.73	46.14	18.84	-0.737
Other routes	14	158.46	72.15	19.28	(0.471)
Difference		-23.73		32.19	

Note: H_0: mean (diff) = 0; H_a: mean (diff) > 0; the significance level is shown between parentheses.

The results in table 5 suggest that market concentration influences airfares, but previous research has shown that without taking mediating demand and cost variables into account such simple comparative approach can be misleading (Borenstein, 1989; Lee and Luengo-Prado, 2005). In the next section, we therefore establish an econometric model to assess the influence of hub hierarchies, alliances and concentration on airfares by controlling for these potentially intervening variables.

4. Econometric analysis

4.1 The empirical model

We establish an econometric model that explains the variability of earnings on non-stop HH routes in the intra-European air passenger markets. Earnings are measured through average one-way fares, which serve as the dependent variable in our model. The independent variables in the model combine demand, cost, route structure, and market structure variables. Continuous variables (i.e., population, business/economy traffic mix, distance and average fare) are transformed into their natural logarithms to reduce the impact of outlying observations and facilitate the interpretation of the coefficients as elasticities. The empirical pricing model for the HH network is specified as follows:

$$\begin{aligned}\mathrm{Ln(Avgfare)} = {} & \beta_0 + \beta_1 \mathrm{Ln(Population)} + \beta_2 \mathrm{RegionalEffects} + \beta_3 \mathrm{Ln(Business)} + \beta_4 \mathrm{Ln(Distance)} \\ & + \beta_5 \mathrm{PP} + \beta_6 \mathrm{PS} + \beta_7 \mathrm{AllianceRoutes} + \beta_8 (\mathrm{PP} * \mathrm{AllianceRoutes}) \\ & + \beta_9 (\mathrm{PS} * \mathrm{AllianceRoutes}) + \beta_{10} \mathrm{OneStop} + \beta_{11} \mathrm{Ln(AirportHHI)} + \beta_{12} \mathrm{H1} \\ & + \beta_{13} \mathrm{H2} + \beta_{14}\ \mathrm{LCCs} + \beta_{15} \mathrm{LCCSecondary} + \beta_{16}\ \mathrm{HST}\end{aligned} \quad (2)$$

Where: β_0 is the intercept and β_i are the estimated coefficients for the independent variables. *Avgfare* is the average one-way fares measured by the total revenues divided by the total number of passengers of all the European FSCs on a route.

Demand Variables
Population is the average population of cities where the hub airports locate, indicating the potential market size of a given route. The impact of *Population* on airfares can be mixed. On the one hand, larger population imply that more people will buy air tickets to travel, thereby increasing prices. On the other hand, higher population enables carriers to reduce prices by using larger and more cost efficient aircraft (Wan et al., 2009). The estimated influence of population cannot be predetermined.

The *RegionalEffects* variable is designed to control the unobserved regional effects in nature, for instance, warm weather (Morrison, 2001) or the coastal mass tourism belt in Southern Europe (Bramwell, 2004). Specifically, Wan et al. (2009) defined airports locating in "European countries on the Mediterranean Sea coast and Portugal" as vacation destinations. We, therefore, control routes whereby either of the two endpoints is located in Barcelona or Lisbon to account for regional effects. A negative relationship between regional effects and airfares is expected.

Business (i.e. a traffic mix continuous variable) is measured as the proportion of passengers travelling for business on a HH route[13]. We aggregated four types of tickets (i.e., first, business, discount business, and premium coach) together as 'business' passengers because carriers have largely blurred the distinction among these categories of premium tickets (Lee and Luengo-Prado, 2005). Morrison (2001) applied this variable to reflect the adoption of yield management techniques by airlines (i.e., charging business travelers higher fares than leisure travelers) and found that fares are 28 % higher on routes with 75% business travelers than comparable routes with 25% business travelers. The US Department of Transportation (2001) also concluded that high fares in hub markets can be explained by passenger mix when routes are lack of price competition. HH markets have a large proportion of demand coming from business travellers with a relatively high 'willingness-to-pay', making the demand curves for these markets steeper than is the case in respect of more price-elastic markets (Holloway, 2008). In other words, the price increase in HH markets may theoretically lead to a relatively small demand decline. The expected sign for business traffic indicator is thus positive.

Cost Variable
Distance is the non-stop distance (measured in miles) between two hubs. As distance increases, average fares can be expected to rise since carriers' operating costs with regard to fuel, in-flight service and wages will increase (Borenstein, 1989; Windle and Dresner, 1995; Vowles, 2006). The expected sign for *Distance* is positive.

[13] We use metropolitan-level data instead of airport-level data in 2008 (i.e., an earlier year) to measure 'BUSINESS' in order to guarantee its independence and exogeneity, which is similar to the setting of Morrison (2001).

Route Structure Variables
We include two variables *PP* and *PS* to account for the 'hub hierarchy' effects and one variable *AllianceRoutes* to consider the impact of alliances on fares[14]. The expected sign for those variables are difficult to predetermine as discussed in the literature review.

In order to study the interactive effect of alliances and route structure on airfares, we also establish two variables based on the exploratory analysis above. The $PP * AllianceRoutes$ dummy variable represents routes connected by two primary hubs served by carriers within the same alliance. As carriers operating on this type of routes may exercise certain pricing power[15], the expected sign of this variable is positive. *PS *AllianceRoutes* is a dummy variable detecting the effects of alliance carriers serving PS routes. As the pricing power may be offset by the increased traffic and economies of density on this type of routes, the expected signs cannot be predetermined.

The *OneStop* dummy variable represents routes whereby one-stop flights are also available. We consider a HH route with more than 1000 one-stop passengers on both directions in May, 2009 as a competitive one-stop alternative. The influence of providing indirect service on airfares can be complicated. On the one hand, it may reflect carriers' entry strategy into high-yield routes whereby both endpoints are dominated by incumbent carriers and have a positive relationship with airfares. This requires the entry carriers to develop strong and competitive hubs capable of diverting passengers. On the other hand, a central hub enables its dominant carriers to provide competitive indirect flights on long-haul HH routes with strong directionality (i.e., North-South or South-East), and thus reduce the prices. In addition, the narrower European market and reduced use of hub-and-spoke networks may make 'hubbing' insignificant on airfares (Giaume and Guillou, 2004). The expected sign of this variable is uncertain.

Market Structure Variables
AirportHHI is the simple average of Herfindahl indices at the two endpoints of a route. Researchers have found that concentration at the endpoint airports will lead to higher fares (Borenstein, 1989; Piga and Bachis, 2007). *AirportHHI* is expected to be positively associated with prices.

H1 and *H2* are the two components of the decomposed HHI index. As more than half of the European HH markets are routes where a large FSC competes with a small LCC or REC (table 3), the market share distribution of those carriers is highly unequal. The smaller carrier is likely to reduce the price to maintain its presence, leading to a strong price competition between carriers (Giaume and Guillou, 2004). The sign of *H1* is, therefore, expected to be negative. In a market characterized by perfect competition, higher market concentration due to a smaller number of carriers may increase the airfares on a route. Given that European HH markets appear to be imperfectly competitive, *H2* may have insignificant impact on airfares.

The *LCCs* dummy variable examines the impact of the presence of LCCs. *LCCs* are taken to be present in a market when they collectively have a market share larger than 1% of passengers in a market (Ito and Lee, 2003; Lee and Luengo-Prado, 2005; Windle and Dresner, 1995). The expected sign of this variable is negative.

The *LCCSecondary* dummy variable investigates the competitive influence of LCCs at secondary airports. Extensive literature has proved that this variable has significant negative impact on airfares in US airline industry (Brueckner et al., 2013; Morrison, 2001). However, its impact is rarely examined and uncertain in European market. Even though FSCs in Europe has perceived

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[14] In order to avoid the so-called dummy variable trap (Wooldridge, 2010), *SS* and *Non-Alliance Routes* are chosen to be the benchmark group for 'hub hierarchy' and 'Alliances', respectively, and thus not included in the model.
[15] We use dummy variables instead of market share of the leading carrier to define route dominance as it explicitly examines the relationship between route structure resulting from hub hierarchies and pricing.

the competitive pressure in prices from LCCs and are willing to adapt to these changes, their high cost structure and complex business model seems to hamper their swift transformation and response to the direct or adjacent competition from LCCs (Markus, 2004). The expected sign of this variable is uncertain.

HST is a variable examining the competition from high-speed train in Europe. We only consider the direct high-speed train connections including eight HST lines between cities where hubs locate (i.e., Paris to Brussels, Amsterdam, Dusseldorf and London; Madrid to Barcelona; London to Brussels; Munich to Dusseldorf and Frankfurt). Competition from HSTs may reduce FSCs' airfares due to shorter access time, the ability to hand large passenger volumes and better adaption to fluctuations in demand (Roman et al., 2007). However, Dobruszkes (2011) found that the ability of HSTs to compete with air transport was limited, particularly on routes with high flight frequency. The expected sign of this variable is, therefore, uncertain.

4.2 Summary statistics of variables

The summary statistics for all the variables are presented in table 6.

Table 6. Descriptive statistics of variables

	Minimum	Maximum	Mean	Std. Deviation
Avgfare ($)	53.70	371.95	158.83	48.96
Population (thousands)	581	5601	1985	1343
RegionalEffects	0.00	1.00	0.24	0.43
Business (%)	1.70	59.13	19.56	14.74
Distance (miles)	186	1834	683.53	341.94
PP	0.00	1.00	0.26	0.44
PS	0.00	1.00	0.54	0.50
AllianceRoutes	0.00	1.00	0.34	0.48
PP*AllianceRoutes	0.00	1.00	0.08	0.27
PS*AllianceRoutes	0.00	1.00	0.20	0.40
OneStop	0.00	1.00	0.12	0.33
AirportHHI	1000	4500	2200	600
H1	0.00	0.67	0.08	0.11
H2	0.17	1.00	0.47	0.20
LCCs	0.00	1.00	0.38	0.49
LCCSecondary	0.00	1.00	0.30	0.46
HST	0.00	1.00	0.08	0.27
# obs	101			

4.3 The econometric methodology

We perform a diagnostic test for multicollinearity, heteroskedasticity, and endogeneity to produce a robust and unbiased model. First, based on the variance inflation factor (VIF) for each independent variable (Baum, 2006), we do not find evidence of a multicollinearity problem. Second, as variables in our model are averaged, heteroskedasticity may occur in this situation (Baum, 2006), and we therefore report the robust standard errors for both OLS and 2SLS as developed by White (1980). Third, based on previous research (Borenstein, 1989; Piga and Bachis, 2007), we know that the *AirportHHI* variable may be endogenous, and we therefore apply a two-Stage Least Squares (2SLS) estimation method to correct this endogeneity problem. The instrument used in the 2SLS is the average airport HHIs in other markets, which is similar to the approach of Piga and Bachis (2007). It could be argued that other market structure variables may still confront potential endogeneity. However, it is difficult to find an instrument set to correct endogeneity in the airline industry given a large number of competition measures in the model, especially since the model already includes some route characteristics variables that might otherwise serve as instruments (Brueckner et al., 2013). As a result, we do not correct for the potential endogeneity bias of other variables.

5. Results and Discussion

Table 7 summarizes the regression results for the OLS and 2SLS models, whereby 9 out of 16 independent variables are found to be statistically significant, collectively explaining 55% of the price-setting of FSCs in the European HH markets. As the results for 2SLS with robust-standard errors are more reliable, we focus on these results.

Table 7. Coefficients for the regression model

	OLS	2SLS
Constant	3.449***(1.122)	3.309***(1.041)
Ln(Population)	-0.083*(0.046)	-0.082**(0.042)
RegionalEffects	-0.209***(0.061)	-0.207***(0.056)
Ln(Business)	0.094***(0.035)	0.095***(0.032)
Ln(Distance)	0.189***(0.070)	0.189***(0.064)
PP	-0.012(0.098)	-0.013(0.089)
PS	0.008(0.089)	0.007(0.081)
AllianceRoutes	-0.037(0.120)	-0.037(0.109)
PP*AllianceRoutes	0.276**(0.133)	0.278**(0.121)
PS*AllianceRoutes	0.091(0.140)	0.092(0.127)
OneStop	0.197**(0.081)	0.199***(0.074)
Ln(AirportHHI)	0.180**(0.087)	0.196**(0.087)
H1	-0.667*(0.381)	-0.681**(0.354)
H2	0.045(0.116)	0.037(0.107)
LCCs	-0.093*(0.056)	-0.093*(0.051)
LCCSecondary	-0.023(0.064)	-0.024(0.058)
HST	-0.091(0.106)	-0.091(0.096)
R Squared	0.55	0.55

Note: Robust standard errors are reported between parentheses.
*, **, *** Significance at the 10%, 5% and 1% level, respectively.

Demand Variables
The negative coefficient of *Population* indicates that carriers operating on the European HH routes can realize economies of scale by using larger and more cost efficient aircraft. As the average population increases 1% in the European HH markets, the prices are predicted to fall by 0.1%[16]. Routes centred on what are identified as predominant 'vacation destinations' are negatively related to airfares and are about 23% lower than the other routes. We also find that the 'traffic mix' is indeed a factor in the price setting of European FSCs in their HH markets. The estimates show that an increase of 10% in the proportion of business passengers leads to an increase of about 0.9% in fares charged by European FSCs. The relative small coefficient may reflect that business passengers may be becoming sensitive to fare (Gillen and Morrison, 2005). In the European airline markets, researchers have found that business travellers working for small

[16] When both independent and dependent variables are natural logarithmic transformed, back-transformation is compulsory to accurately interpret the results. The equation is $\left((1+1\%)^{\beta}-1\right)*100\%$. For all the dummy variables, the equation applied to interpret the results is $\left(e^{\beta}-1\right)*100\%$.

companies are more willing to trade in-flight service, frequency and FFP points for lower fares than those working for larger companies (Mason, 2001), suggesting a shift of pricing strategies for FSCs.

Cost Variable
Distance is positively related to the airfares as shorter routes are cheaper to run (in absolute terms) than longer ones. An increase of 1% in the route's length leads to an increase of about 0.2% in fares. The elasticity of less than one shows, however, that the airline's cost of carrying a passenger does decrease in relative terms with the distance of his/her trip.

Route Structure Variables
Prices are found to be about 32% higher on primary-primary routes operated by carriers within the same alliance than the other routes, indicating that alliance carriers wield some pricing power due to reduced market competition. The insignificant influence of the other types of alliance routes on airfares can be explained by the less intense use of hub-and-spoke network in intra-European airline markets compared to the US, corroborating the findings of Giaume and Guillou (2004). For instance, Paris Orly (ORY) and Brussels (BRU) are de facto specialized switching points for African markets rather than intra-European hubs (Burghouwt and de Wit, 2005). On the other hand, smaller airports have become more important in carrying intra-European traffic. Piga and Bachis (2007) found that lower fares are charged by LCCs on the routes from their hubs such as Stansted for Ryanair due to cost advantages.

In addition, the *OneStop* variable has a positive relationship with airfares, indicating that carriers choose high-yield routes to enter by providing one-stop flights[17]. Overall, prices on HH routes with the coexistence of nonstop and one-stop services are 22.1% higher than for the other routes. Lufthansa at Frankfurt and Swiss at Zurich contributed most to the transfer traffic on those routes due to their strong hub operations. As European FSCs gradually intensify the configuration of their hub-and-spoke network with less waiting time and lower routing factor, indirect connections can become more attractive and competitive in intra-European markets (Burghouwt and de Wit, 2005).

Market Structure Variables
As predicted, concentration at the endpoint airports is positively associated with airfares. The market concentration measured as the market share inequality (*H1*) has a negative impact on fares, which contrasts with the US experience in which concentration leads to higher airfares. Assuming that there are two routes (i.e., route 1 and route 2) whereby each of them is served by three carriers, the market shares of the carriers for route 1 are 0.5, 0.25 and 0.25, whereas those for route 2 are 0.4, 0.3 and 0.3, respectively. In other words, the distribution of market shares among carriers on route 1 is more unequal than that on route 2. Based on equation 1, the value of H1 for route 1 (i.e., 0.063) is higher than that for route 2 (i.e., 0.01) by 0.053, implying that the average fares charged by FSCs on route1 is 4% (i.e., 0.053 multiplied by the coefficient of H1 in table 7) lower than that on route 2. This finding also supports the exploratory analysis of the market structure of European HH markets whereby 61% of routes served by FSCs confront competition from at least one LCC or REC. The large difference of market share forces the only carrier to reduce its prices to compete with FSCs. This can be explained in two aspects. First, when the smaller carrier such as a LCC or a REC choose not to follow the general industry price set by the large carrier, the latter finds it difficult to execute market power to make its rival 'suffer' due to the small size of its MSH (Barla, 2000), while at the same time suffering losses by having to decrease its price on a large MSH. These effects diminish as MSHs converge, so that prices may

[17] The counterintuitive positive effect of *OneStop* variable found in this paper also occurred in Brueckner et al. (2013) and could be caused by endogeneity bias. When nonstop fares charged by FSCs are too high, other FSCs could provide more extensive onestop options for passengers.

decrease as the market share inequality rises. Second, at the same price levels, if passengers prefer the FSC with a larger capacity or a better service, cutting prices is likely to be the best strategy for the LCC or REC to increase its market share (Giaume and Guillou, 2004).

The presence of *LCCs* can largely influence FSCs' pricing decisions in the European HH markets. Their head-to-head competition with FSCs drives prices down by 9.7%. Finally, we do not find significant impact of competition from LCCs at secondary airports and HSTs on FSCs' fares.

6. Conclusion

The main purpose of this paper was to explore factors influencing the pricing of the European full-service carriers in the specific hub-to-hub markets. We find that five factors (i.e., route type, airport concentration, market share inequality, competition from low-cost carriers, and providing competitive one-stop alternative routings) contribute to explain the pricing in Europe's HH markets. As a consequence, we conclude that through strategic alliances, FSCs in Europe do charge higher fares on the routes connected by their primary hubs. However this finding only holds for connections between primary hubs, which may be related to the fact that – in contrast to the US market that has a longer history of deregulation and straddles a larger geographic area – an extensive multi-hub-and-spoke network does not yet exist (at least in terms of its potential pricing consequences).

Our finding that the market share inequality is negatively related with airfares corroborates the results obtained by Giaume and Guillou (2004). The specific characteristics of the European HH markets suggest that more new entries should be encouraged to compete with the incumbent FSCs. The low-cost carriers function as a main force for driving prices down in the HH markets, and will likely continue to influence the more extensive markets due to the enlargement of the European Union (i.e. the so-called 'new Europe, new low-cost air services' discussed by Dobruszkes, 2009).

Even though nonstop HH routes generally have high barriers to enter, we find that carriers, such as Lufthansa and Swiss, who have established strong hubs tend to enter some routes with high profitability by providing one-stop routings (i.e., the positive relationship between one-stop variable and prices). However, it is unclear how these carriers attract sufficient passengers to order these one-stop tickets along with sacrificing the longer travel time, given the short distances between airport-pairs in Europe. Future research may therefore focus on examining how FSCs in Europe set pricing strategies on one-stop connecting flights by considering factors such as, travel time, the competition from nonstop flights (Lijesen et al., 2004) and passengers' willingness to pay (Garrow et al., 2007).

Following Vowles (2006) and Zhang et al. (2013), this paper contributes to the literature in the field of examining pricing strategies in the hub-to-hub markets. Even though applying different geographical regions as empirical study, this paper confirms Zhang et al. (2013)'s finding that hub hierarchies characterizing route structure should be incorporated in a pricing model to better control inter-HH route heterogeneity. Furthermore, comparing the model and results of current paper with Zhang et al. (2013) also suggests that the determinants of FSCs' airfares seem to be different in the European and the US markets. First, the monopolistic effects on airfares diminishing as the hubs become less crucial in a carrier's network occur in the US case, but not in the Europe. This may reflect the fact that a multi-hub-and-spoke network configuration has been deeply established by the US FSCs, while the European FSCs are still on their way to construct such a network practice via alliances or mergers. Second, the extent that LCCs' direct presence reduces FSCs' prices is less in Europe than in the US (9.7% versus 49%). We also do not find a significant impact of the competition from LCCs at secondary airports on FSCs' fares in Europe, which contrasts the US case.

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