



Innovative Applications of O.R.

The impact of the internet on the pricing strategies of the European low cost airlines

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ABSTRACT

This study seeks to analyse the price determination of low cost airlines in Europe and the effect that Internet has on this strategy. The outcomes obtained reveal that both users and companies benefit from the use of ICTs in the purchase and sale of airline tickets: the Internet allows consumers to increase their bargaining power comparing different airlines and choosing the most competitive flight, while companies can easily check the behaviour of users to adapt their pricing strategies using internal information.

More than 2500 flights of the largest European low cost airlines have been used to carry out the study. The study revealed that the most significant variables for understanding pricing strategies were the number of rivals, the behaviour of the demand and the associated costs. The results indicated that consumers should buy their tickets before 25 days prior to departure.

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1. Introduction

In recent years, the analysis of prices in the air transport sector has focused on the dispersion of fares and optimal pricing in line with the developments made in yield management. This analysis has evolved from the first articles by Smith, Leimkulher, and Darrow (1992) or Botimer (1996), related to strategies to address last-minute demand or overbooking to the recent studies by Aydin and Morefield (2010) or Ater and Orlov (2010), in which optimal pricing strategies are considered as being structural and inherent in industries with high semi-fixed costs.

The literature published in the last decade has referred to a wide range of elements that intervene in the yield maximisation of airlines, such as the number of seats sold, the geographical location, the distance or the behaviour of demand. Despite these studies, there is no reliable model for predicting the optimal purchase timing by consumers (Button & Vega, 2007), although certain repeated patterns depending on the market type have been observed, as we shall see in this paper.

One of the variables affecting both optimal pricing strategies and optimal purchase timing is related to the inclusion of ICTs in the airline market. The appearance of the Internet has changed how demand and supply are communicating, with the creation of

platforms where users and buyers interact (Rochet & Tirole, 2003). As Ramón-Rodríguez, Moreno-Izquierdo and Perles-Ribes (2011) pointed out, the Internet effect has been observed from two different perspectives in the air transport industry: first, it provides a higher volume of information for sellers than ever before, creating new possibilities for price adjustment and dispersion thanks to an abundance of real-time user data (Dana & Orlov, 2009); second, according to Ackerman (2006), the Internet allows consumers to compare different airline fares and airport combinations in a matter of seconds, which implies an increase in the bargaining power of users, forcing airlines to be more competitive. However there are asymmetries of information that benefit companies. Airlines obtain a wealth of data from consumer behaviour to establish pricing, but on the other hand users do not know relevant information as how many seats have been sold or when companies are going to change their fares.

This paper studies this double effect of the ICTs on price configuration seeking a real approximation of how the Internet is affecting airlines pricing. To do this, the study has been based on a general price determination model which includes more than twenty variables, most of which are described in the literature review in Section 2 of this paper, including three Internet related variables. Section 3 defines the empirical model for a sample from 2011 representing low cost tourist flights in Europe (Section 4). Finally, in Section 5, the results are presented and conclusions are drawn, with the aim of responding to two questions: how does the Internet affect purchases and sales in the air transport sector? May this model be used to improve benefits for other industries?

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2. Current research

In recent years there has been a growing interest in price determination in the air transport industry and other perishable products distributed by the Internet, with the analysis focusing particularly on price dispersion and revenue maximization (Anjos, Russell, Cheng & Currie, 2005; Otero & Akhavan-Tabatabaei, 2015). On the whole, this is explained by a structure of very high fixed and semi-fixed costs, which obliges companies to optimise each fare sold in order to make flights profitable (Bilotkatch, 2005; Aydin & Morefield, 2010). In addition, there is a considerable influence from external variables and macro variables such as GDP, population, exchange rate or oil prices (Dresner, Lin & Windle, 1996; Verlinda & Lane, 2004).

Price dispersion in the industry became more acute with the emergence of the low cost companies, generating a decrease in average prices and consumer welfare gains, according to Schipper, Nijkamp and Rietveld (2007). These companies still set the trend in the air transport industry, particularly in Europe.

2.1. Dynamic pricing and low cost airlines strategies

Dynamic pricing, or yield management, allows companies to increase profits –especially when a product expires at a point time-basing on the demand information. Then the Internet and the ability to collect detailed information about customers' behaviour are crucial in order to understand dynamic pricing and companies' benefits (Elmaghraby & Keskinocak, 2003). Dynamic price competition has been deeply studied in Industrial Economics (see Tirole, 1988), and some theories from Industrial Organization, as the fat cat effect (Fudenberg & Tirole, 1984) has been used to explain the competitive behaviour of airline market.

According to Malighetti, Palaria and Redondi (2010), the price dispersion of low cost airlines can be explained, on the whole by the number of days before departure when ticket purchases are made. However, this is not the only determining factor. In fact, the evolution of fares of companies such as Ryan Air or EasyJet is not usually linear, but follows an irregular “U” curve. According to previous research, such as Alderighi, Cento, Nijkamp and Rietveld (2012) for Europe, or McAfee and te Velde (2006) in the case of the United States, middle bookers are those who obtain the cheapest rates. According to Piga and Bachis (2007) this strategy may lead to situations where the fares of low cost companies are even higher than those of scheduled airlines during the last few days before departure. These authors explain the price dispersion of low cost airlines as the adjustment between the real load factor and the predictions made, particularly during the last two weeks before the flight.

For many authors, price discrimination is related to market concentration, although no clear conclusions have been drawn. Studies carried out prior to the expansion of the low cost model found a positive relationship between market concentration and price dispersion (see Borenstein, 1989; Hayes & Ross, 1998; Stavins, 2001, among others), although in European markets this relationship was found to be negative (see Giaume & Guillou, 2004; Gerardi & Saphiro, 2007; Gaggero & Piga, 2011). According to Giaume & Guillou (2004), this difference could be due to the fact that the European routes are usually operated by several companies with a lower concentration of market power than in the American routes, in which traditional, charter and low cost companies with a low capacity are competing against each other.

It could be said, therefore that the competition between low cost airlines in Europe generates a reduction in prices that is higher than that generated by the rivalry between traditional airlines (Alderighi, Cento, Nijkamp & Rietveld, 2011), which, in turn, leads to a greater dispersion of prices.

Contrary to the traditional airlines, the low cost companies do not use third degree price discrimination formulas beyond charging

more to passengers who wish to board the aircraft first or choose a seat. Therefore, airlines such as Ryan Air or EasyJet must segment the market depending on the type of route or flight. Different authors have observed that holidays (Malighetti, et al., 2010), the day of the week or the month of purchase (Salanti, Malighetti & Redondi, 2012), or even the number of days that the passenger is to stay in the destination (Alderighi, et al., 2011) are used by airlines to differentiate between business passengers and tourists. The results of the study of EasyJet conducted by Salanti, et al. (2012) reveal that tourist routes exhibit lower dispersion and lower average fares than business routes, and other variables such as GDP, the population volume or predominant economic activity in the regions of origin and destination could be behind the different strategies implemented by the airlines (see Table 1).

Another factor that is fundamental to understanding price dispersion in the air transport industry is the emergence of the Internet, as pointed out by Bachis and Piga (2011) based on their study of different European low cost airlines. The effect of the Internet has been particularly significant in domestic markets, as indicated by Orlov (2011), where the average price of fares reduces as the possibilities of price variation increase without being penalised by the demand. This effect has awakened greater interest in the evolution of prices in the short term, with almost daily monitoring. In previous studies, such as Keeler (1972), Butler and Huston (1988), Morrison and Winston (1990) or Evans and Kessides (1993) among many others, the timeframe used is much longer than one year. However, the more recent studies analysing price dispersion use timeframes of months (such as Alderighi, et al., 2011 or Salanti, et al., 2012) or even days. For example, Escobari and Jindapon (2008) use a sample of eighty-two days; Stavins (2001) thirty-five days; and Giaume and Guillou (2004) twenty-two days, with almost daily observations of the fares.

2.2. Measuring the impact of the internet on air fares

According to many authors, e-commerce generates a greater efficiency of markets in terms of prices and elasticity (see Smith, Günther, Rao, & Ratliff, 2001; Gillen & Lall, 2004; and Verlinda & Lane, 2004). In general terms, Ernst (2003) points out that the Internet promotes the direct interaction between companies and users which implies that, despite the distances involved, it is close to achieve markets of perfect competition. This adjustment leads to a decrease in prices and a greater dispersion according to Sengupta and Wiggins (2006), Brunger (2010) or Piga and Filippi (2002) among others. At the same time, according to Dana and Orlov, (2009) these effects lead to a higher average load factor in regions with a larger number of Internet users, which reinforces the effect of the ITCs on the supply of the sector².

In the case of the demand for air transport, the Internet provides users with more information about the market. According to the study carried out by Baye, Morgan and Scholten (2004), there are three types of different users in online sales: those who search and find the most economic fares; those who directly search a brand due to recognition and expected quality; and finally, those who want to obtain the lowest prices but are not familiar with the tools that they need to use in order to find them. As highlighted by Brunger (2010), over time, the first group is becoming consolidated, generating a reduction in fares.

The penetration of the Internet in a society is directly related to the access of information by users, as mentioned by Garín-Muñoz and Pérez-Amaral (2011). This effect has also been observed in the air transport sector by Orlov (2011), who found an inverse relationship

² It is true that in some articles, such as Clemons, Hann and Hitt (2002) or Lehman (2003) price changes generated by the effect of the Internet have not been observed although Brunger (2010) puts this down to the collection of data at a very early stage when the Internet had still not become consolidated as a rival for travel agencies.

Table 1
Effects on prices observed in previous studies.

	Period	Area	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Graham, Kaplan and Sibley (1983)	1980	US	(+)	(+)					(-)								(-)		
Bailey, Graham and Kaplan (1985)	1976–1981	US	(+)						(-)			(-)					(+)		
Olson and Trapani, 1981	1971–1977	US	(-)	(+)				(-)									(-)		
Morrison and Winston (1987)	1976–1981	US		(+)					(-)										
Borenstein (1989)	1987	US	(-)	(+)				(-)	(-)	(+)		(-)					(+)		
Morrison and Winston (1990)	1987–1988	US	(+)	(+)													(+)		
Strassmann (1990)	1980	US	(+)														(-)		
Brueckner, Dyer and Spiller (1992)	1985	US					(+)					(-)					(+)		
Marin (1995)	1982 and 1989	EU		(+)	(+)							(+)		(+)			(+)		
Dresner, et al. (1996)	1991–1994	US	(+)	(-)	(+)	(+)	(+)		(-)								(-)		
Oum, Park and Zhang (1996)	1982–1992	TR		(-)	(+)												(+)		
Richards (1996)	1995	US	(+)		(+)												(-) ^a		
Windle and Dresner (1999)	1993–1996	US		(+)				(0)	(-)								(-)		
Brueckner and Whalen (2000)	1997	US					(+)					(+)		(+)			(+)		
Park and Zhang (2000)	2000	US–EU		(-)								(-)					(-)		
Stavins (2001)	1995	US		(+)			(+)	(+)	(-)									(-)	(-)
Piga and Fiippi (2002)	2000	UE							(-)						(-)				
Rietveld, Schipper and Nijkamp (2002)	1988–1992	UE		(+)		(+)				(+)							(-)		
Giaume and Guillou (2004)	2002	EU		(-)			(0)		(-)								(+)	(-)	
Pels and Rietveld (2004)	2002	EU																(-)	
Verlinda and Lane (2004)	1998–2002	US				(+)	(-)							(-)	(-)		(+)		
Sengupta and Wiggins (2006)	2004	US						(+)	(-)						(-)			(-)	(-)
Manuela (2007)	1982–2003	AS		(-)	(+)	(+)											(-)		
Pigas and Bachis (2007)	2002–2004	EU														(+)			
Hofer, Windle and Dresner (2008)	1992, 2002, 2007	US	(+)	(+)	(-)			(-)	(-)								(+)		
Oliveira and Huse (2009)	2001	BR	(-)	(-)								(-)					(+)		
Malighetti, Paleari and Redondi (2009)	2005–2006	EU		(+)	(+)	(-)	(+)			(+)							(+)		
Brunger (2010)	1998–2006	US													(-)				
Malighetti, et al. (2010)	2006–2007	EU			(+)	(-)				(-)				(+)			(+)	(+)	
Mantin and Koo (2010)	2008	WW																	(+)
Alderighi, et al. (2011)	2001–2003	EU		(-)														(-)	
Bachis and Piga (2011)	2002–2004	EU	(+)																(+)
Orlov (2011)	1997–2003	US	(+)	(-)													(-)		
Salanti, et al. (2012)	2012	EU			(-)	(-)							(-)	(-)			(-)		

* US = USA; EU = Europe; AS = Asia; TR = Transoceanic; BR = Brazil; WW = Worldwide

1. Airport concentration; 2. Route concentration; 3. Airport charges/size; 4. Gross domestic product; 5. Population; 6. Load factor; 7. Tourism effect; 8. Frequency of flights; 9. Government/subsidiaries effect; 10. Number of seats per flight; 11. Exchange rate; 12. Oil Prices; 13. Internet effect on Demand; 14. Internet effect on supply; 15. Distance; 16. Period between purchase and departure; 17. Weekend.

^a Refers to the average distance per user, as routes with connections are considered

between Internet access and flight fares. Previous studies, such as Piga and Filippi (2002) or Segunpta and Wiggins (2006) already found individually that those users who purchased their tickets through the Internet obtained significant discounts on their fares.

On the other hand, air transport supply has also benefitted from the opportunities generated by the Internet. For example, the change in tourism trends observed by Mills and Law (2004) and Trettheway (2004) among others, which has a more digital profile, has given low cost airlines an advantage above traditional airlines. Furthermore, the reduction in costs inherent in e-commerce derived from the elimination of intermediaries (Barrett, 2004) can also be used to improve the service. In more specific terms, Albers, Koch and Ruff (2005) indicate that new technologies render the primary activities of an airline's value chain more competitive: internal logistics, operations, external logistics, marketing and sales³, and services.

On the other hand, the companies use the information about the users collected in order to optimise the prices of their products. Mantin and Koo (2010) describe how the airlines study the moments when to vary their prices according to access to the registered websites so as to optimise yields. In the same way, Bachis and Piga (2011) have analysed how low cost airlines exploit the ease with which prices can be modified on the Internet in order to seek the maximum yield possible, which has even led to breaches of the European law of one price.

3. Empirical model

A model for estimating low cost airline prices has been established based on the variables identified in the previous literature for both low cost and traditional airlines. They have been summarised in Table 1. According to Button and Vega (2007), there are elements that are very difficult to calculate, so a total of 26 multicolinearly independent variables have been included. A detailed description of how to obtain each variable of the model may be found in the Appendix.

$$\begin{aligned} \log P_{it} = & \alpha + \beta_1 AIC_{it} + \beta_2 ROC_{it} + \beta_3 AIRP_{it} + \beta_4 GDP_{it} + \beta_5 POP_{it} \\ & + \beta_6 LOAD_{F_i} + \beta_7 TUR_1 + \beta_8 TUR_{2it} + \beta_9 TUR_{3it} \\ & + \beta_{10} FREQ_{it} + \beta_{11} GOV_{it} + \beta_{12} SEATS_{it} + \beta_{13} X_RATE_{it} \\ & + \beta_{14} OIL_{it} + \beta_{15} INT_{1it} + \beta_{16} INT_{2it} + \beta_{17} INT_{D_{it}} \\ & + \beta_{18} DIST_{it} + \beta_{19} ANT_{1it} + \beta_{20} ANT_{5it} + \beta_{21} ANT_{10it} \\ & + \beta_{22} ANT_{15it} + \beta_{23} ANT_{20it} + \beta_{24} ANT_{25it} \\ & + \beta_{25} ANT_{30it} + \beta_{26} VSD_{it} + v_{it}, \end{aligned} \quad (1)$$

where $i=1, \dots, N$ (single indicator of the airline and route)
 $t=1, \dots, T$ (days of flight observed in the sample).

In the model, P_{it} is the previously explained dependent variable Price. Authors of previous studies, such as Bachis and Piga (2011), Stavins (2001) or Orlov (2011), have used absolute prices as this paper does, although it is common to find some variation of it such as Mantin and Koo (2010), who used "average fares", or Schipper, et al. (2007) and Manuela (2007) who used "average fares per kilometre".

In this study *Price* is presented as a logarithm due to the difference in units of measure between the many variables selected, simplifying the analysis and understanding. In addition we have opted for a log-level model in order to mitigate heterokedasticity problems. In this semi-log model the coefficients are interpreted as the semi-elasticity of the response variable with respect to the regressor.

The model seeks to collect data regarding a series of effects which have been identified by different authors as having the capacity to define the pricing strategies of airlines (Table 1). These variables include

first, the effects of airport concentration (AIC_{it}) and route concentration (ROC_{ij}). Then variables related to airline costs are described such as airport charges ($AIRP_{it}$), the price of fuel (OIL_{it}) or the distance of the route in kilometres ($DIST_{it}$). In the case of airport charges, the volume of passengers from passenger origin and destination has been used as, according to Bel and Fageda, (2010), it is a good estimator of airport costs.

The variables that measure the frequency of flights ($FREQ_{it}$) and the number of seats for sale ($SEATS_{it}$) are variables that can be understood as *barriers to entry* according to the definition offered by Levine (1987).

This model also includes the load factor of each route ($LOAD_{F_i}$), one of the most important elements for determining the price strategies of airlines. Despite its importance, the load factor has not been used directly in many studies mainly due to a lack of data. In this case, this variable will be determined by using the Eurostats database on a monthly basis which will give us an estimation of the behaviour of demand on the route, not the flight. In order to compensate the effects that may be lost by measuring the load factor each month instead of each day, the number of days between the purchase date and the departure date ($ANT_{X_{it}}$) is included, which hypothetically shows the volume of demand for seats; as the departure date approaches, the price rises.

It is also important to consider demand characteristics in the determination of airline prices. The model has contemplated two types of effects: first, the general characteristics of demand, taking into account the purchasing power (GDP_{it}) and the population volume (POP_{it}). The effect of "tourist" routes (TUR) has also been considered, which previous articles have identified as having a high impact on fares. The variables used indicate the hotel capacity (TUR_{1it}), the percentage of international tourism (TUR_{2it}) and the average hotel occupancy (TUR_{3it}) of a region. In this way both the effect that tourism has on prices and the variation within the tourist routes is measured. There is also a possible segmentation between business and leisure flights depending on when the trip is made. The VSD_{it} variable (week-end flights) is also related to the tourism effect, according to Mantin and Koo (2010) and Salanti, et al. (2012), as flying at weekends is closely related to the tourism market.

The effect of governmental decisions has also been included in this model. For the first time data has been collected regarding the subsidies received by the airlines in Spanish airports (GOV_{it}). The existence of subsidies in the European air transport market has been condemned in Barrett (2004), Tinard (2004) or Bel and Fageda, (2010) among others, although data have never been used to observe their effect on final prices.

It is also worth mentioning the effect of the exchange rate (X_RATE_{it}). The effects of this variable were revealed in Bachis and Piga (2011), which shows how the pound/euro exchange rate affected the final consumer. According to the authors, the airlines take advantage of the exchange rate to generate differences in prices and a greater dispersion in the European low cost market. This form of discrimination could be relevant taking into account that there are routes between Spain and the United Kingdom in the sample.

Finally, the effect that the *Internet* has on prices has been taken into account from two points of view:

- INT_{1it} and INT_{2it} describe the effect of using the Internet from the demand side. Due to the volume of data, no direct surveys of users are available. Therefore the model uses variables that measure the penetration of the Internet in the origin and destination of a route through the number of citizens connected to the Internet (1) and the number of citizens who shop through the Internet (2). Previous studies by Brunger (2010), Piga and Filippi (2002) and particularly Orlov (2011) confirm the close relationship between *digital communities* and the reduction in fares and price dispersion due to a higher access to information.

³ Regarding the importance of e-commerce, its development and impact on the air transport sector, much was written during the first decade of the twenty-first century. The following reading is recommended Jarach (2001), Buhalis and Licata (2002), Buhalis (2003), de Pablo Redondo (2006) or Valls (2008) among others.

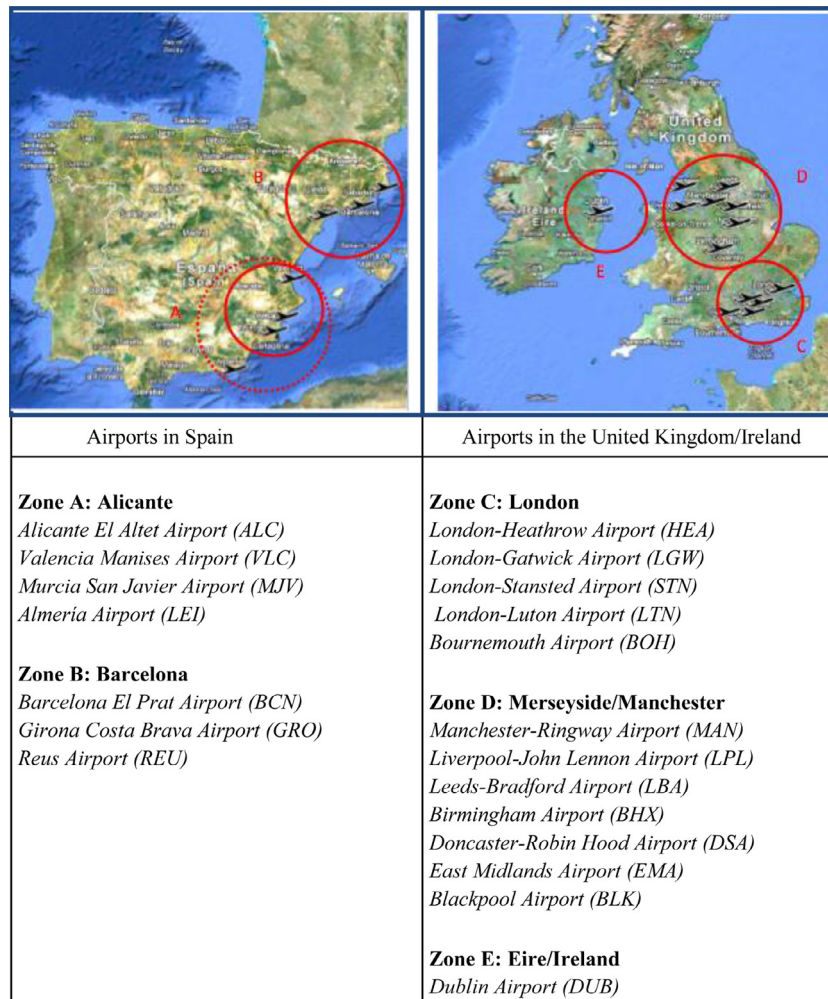


Fig. 1. Airports included in the sample.

- $INT_{D_{it}}$ seeks to explain how the airlines use the ICTs to change their pricing strategies. It is probably the most important variable with respect to the effect of the Internet on pricing strategies as it is completely new. This variable has been obtained from data collected with the tool *Google Insight*, which allows us to observe the search trends of Internet users in specific places during a time period.

4. Data

In order to carry out the analysis it is decided to select a series of tourist routes in Europe, using a sample of more than 2600 direct international flights from the Mediterranean region of Spain (zones A–B) to England or Ireland (zones B–C–E) and vice-versa between June and September 2011 (see Fig. 1). Only those low cost companies (LCCs) that operated flights for the whole period were included in order to carry out a panel data analysis: *Ryanair (FR)*, *EasyJet (U2)*, *Jet2 (LS)*, *BMI Baby (WW)* and *Monarch Airlines (ZB)*. A total of 17,664 observations were finally included in the analysis. Table 2 provides the mean, standard deviation, minimum and maximum values for the variables included in the model.

The timeframe used for the study was a total of four months, in line with the current trend of studies that analyse price dispersion whose samples rarely exceed twelve months, as in Alderighi, et al. (2011), Salanti, et al. (2012), Escobari and Jindapon (2008) or Giaume and Guillou (2004), to name some examples.

In this sample, the data were observed for each flight 60, 30, 25, 20, 15, 10, 5 and 1 day before the departure date. The information

was collected from data provided by websites that integrate flights (principally *trabber.com*, *kayak.com* and *liligo.com*). These types of websites are used by other authors such as McAfee and te Velde (2006), Puller and Taylor (2012), Domínguez-Mencheró, Rivera and Torres-Manzanera (2014) or Law et al (2011) to obtain their respective samples, as they provide fast and reliable information. Other authors, such Pels and Rietveld (2004), Piga and Bachi (2007), Maliguetti et al. (2009) or Alderighi, et al. (2012), use the airlines' own websites, although this is only recommended when only one airline is being analysed.

5. Results and discussions

For this study it is carried out a series of seven analyses of longitudinal panel data (Table 3), method 1: ordinary least squares (OLS); method 2: random effects (RE); method 3: fixed effects (FE); method 4: fixed effects with first order autoregressive error term (AR1); method 5: feasible generalised least squares (FGLS); method 6: panel-corrected standard errors (PCSE) –correcting heteroskedasticity; and method 7: panel-corrected standard errors (PCSE) – correcting heteroskedasticity and autocorrelation.

The seventh estimation method best adapted to this case, in order to perform it a succession of statistical tests had to be carried out. First, the Breusch–Pagan test, also known as the *Lagrangian multiplier test for random effects*, was conducted so as not to forget the *principal of parsimony*. After rejecting the null hypothesis, it was found that estimation methods 2 and 3 – grouped models – were more suitable

Table 2
Descriptive statistics – weighted means ($N = 17,664$)

Variable	Mean	S.D	Minimum	Maximum
Price	94.596	53.967	12.50	436.99
Airport concentration (HHI)	0.209	0.141	0.049	0.764
Route concentration (%)	28.90	19.45	2.51	87.07
Airport size (route pass.)	2994.04	1752.65	1875	66983
GDP per capita PPP	27521.28	5250.58	22686.86	46643.89
Population	4,065,228	18,97,984	9,17,992	105,89,824
Load factor (%)	90.01	4.01	67.03	97.93
Hotel supply	53.009	51.219	1.833	336.433
International tourism (%)	36.63	11.64	14.33	53.34
Hotel occupancy	73.748	11.989	46.025	92.240
Frequency of flights	2.05	1.27	1	6
Government subsidies	0.901	0.041	0.670	0.979
Aircraft capacity	177.95	21.60	122	361
Exchange rate	1.135	0.011	1.109	1.151
Price of oil	93.765	6.502	80.33	113.77
Internet access (%)	67.87	5.37	56.95	83.12
Internet purchases (%)	41.53	8.43	23.45	62.87
Google insights (%)	62.192	18.016	10	100
Distance (Kilometre)	1449.86	192.82	1047	1789
No. days purchased before flight	0.125	0.330	0	1
Weekend flights	1.349	0.476	1	2

for this case than OLS. This result was expected as OLS estimates are not able to capture time effects. Subsequently, the Hausman test determined that the Fixed effects method is the more appropriate of the two grouped models (FE and RE), although it omitted relevant variables that generate significant changes in the results if it compares them with the rest of the methods.

Estimation methods 4, 5 and 6 (AR1, FGLS and PSCE) address the need to correct autocorrelation and heteroskedasticity problems in the sample. Wooldridge tests were conducted to test for the existence of autocorrelation. The modified Walt test confirmed the heteroskedasticity in the model.

The fourth method (AR1) corrected the autocorrelation however it was necessary to model the functional form of heteroskedasticity in order to obtain more efficient estimates of the parameters (Cameron and Trivedi, 2009). To do this, methods 5 and 6, the FGLS and PSCE estimators, proved to be highly effective. Finally, in the last method the PSCE method was corrected using the Prais–Winsten technique with more precise standard errors than the previous methods. This method provided the best results with an explanatory power of R^2 which was much higher than the others. Furthermore, it was found that in models 1, 2, 5, 6 and 7, the results obtained in the value corresponding to each of the variables were very similar to one another, which illustrates the robustness of the analysis carried out.

Unfortunately, the panel could not be corrected for contemporary correlation as it is a highly unbalanced panel. Neither the Breusch Pagan LM test nor the Pesaran CD was successful either.

The results obtained in the last method of the analysis give the acceptable log-linear model ($R^2 = 0.7180$) a greater explanatory capacity than in the previous models thanks to a higher number of explanatory variables, the logarithmic transformation of the dependent variable and the use of PCSEs⁴. It can be observed that practically all of the results were highly significant which confirms that the variables used in previous models also affect the routes selected for this study.

Some obvious results already contemplated in the previous literature can be confirmed in the model tested, such as the positive impact

and high significance of airport concentration and route concentration on prices (AICit, ROCit), as found for example in Stavins (2001), which uses a similar methodology to ours although the effect found in the study is somewhat greater. Similarly, the variables related to barriers to entry (SEATSit and FREQit) have a negative relationship with price fixing, particularly the latter. An increase in the number of flights per day represents an important saving for the user as already detected by Manuela (2007) and Maligetti et al. (2009).

The positive behaviour of the volume of passengers per user (AIR-Pit), is also noteworthy, and also confirms in this case the relationship between the size of the airport and charges. For this sample, a difference of 100,000 passengers between airports can result in an increase of the final price of up to 13%. This effect, however, can be partly corrected with governmental subsidies (GOV_{it}), which, as shown by the model, are significant and have a negative impact. Although their effect is not very high (around 1% discount for each euro/user subsidised), it should be taken into account that these data refer only to Spanish airports and not to airlines, which undoubtedly dilutes the real effect of governmental subsidies.

It can also be highlighted the role of the tourism sector as a complementary element. Although business routes have not been contemplated for comparison, within the tourist routes it can be observed that the prices of the more traditional routes usually increase during periods of maximum hotel occupancy (TUR_3), which reveals the relationship between air transport and tourism. This effect is also observed in Salanti, et al. (2012). We should also refer to the variable VSD (Fridays, Saturdays and Sundays), which, although on business routes could be good days to travel, on tourist routes it is observed that this is the worst option for the user. This finding is consistent with those of Malighetti, et al. (2010) and Salanti, et al. (2012).

The rest of the variables (TUR_{1it} ; TUR_{2it} ; $PIB_{PPA_{it}}$) show that even within the tourist routes, those which have a more diversified production have higher prices which reflects the business effect. This result is consistent with those of the authors in Table 1 who pointed out that the *Tourism routes* have a negative effect over air transport fares.

Finally, and before addressing the variables related to technology, it will be commented on the effects observed for distance ($DIST_{it}$) and the price of fuel (OIL_{it}). In the first case, the results show that distance has a negative impact on final prices as the greater the mileage the lower the average costs. Some previous authors, such as Salanti, et al. (2012), Manuela (2007) or Rietveld, et al. (2002) observed the same negative effect because of the “economies of distance”: In longer

⁴ In the case of Salanti, et al. (2012) the explanatory capacity of their model is 35% for the case of European tourism markets; Piga and Filippi (2012) -25%- and Malighetti, et al. (2010) -56%- also obtain lower R^2 in fairly similar exercises as those carried out here. However, these results are very similar to those obtained in or models before using the PCSEs. Perhaps the most striking case is that of Manuela (2007) for international flights with a R^2 of over 0.9.

Table 3
Empirical results

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
AIC	.20225*** [.04257]	.17017*** [.05654]	−1.7342 [.51089]	−.78464 [.61526]	.23910*** [.01898]	.20218*** [.04442]	.15436*** [.04622]
ROC	.09980** [.01795]	.11145*** [.02253]	−.07463 [.05810]	−.22338** [.06018]	.11268*** [.00668]	.09191*** [.01945]	.09567*** [.01951]
AIRP	.00014*** [.00000]	.00014*** [.00000]	.00020*** [.00001]	.00014*** [.00002]	.00013*** [.00000]	.00014*** [.00000]	.00013*** [.00000]
PIB_PPA	.00000* [.00000]	.00000* [.00000]	.00000 [.00000]	−.00001 [.00001]	.00000* [.00000]	.00000* [.00000]	.00000* [.00000]
POB	−.00000* [.00000]	.00000* [.00000]			−.00000* [.00000]	−.00000** [.00000]	−.00000* [.00000]
LOAD_F	4.2551*** [.07667]	4.6659*** [.07586]	4.8808*** [.08468]	5.0139*** [.09976]	4.3842*** [.03685]	4.2551*** [.08895]	4.1062*** [.09072]
TUR_1	−.00034* [.00008]	−.00027** [.00011]			−.00002 [.00004]	−.00016* [.00008]	−.00016* [.00009]
TUR_2	−.00281*** [.00048]	−.00179** [.00069]			−.00329*** [.00023]	−.00284*** [.00052]	−.00214*** [.00056]
TUR_3	.00419*** [.00002]	.00396*** [.00026]	.00287*** [.00031]	.00202*** [.00037]	.00456*** [.00013]	.00419*** [.00027]	.00363*** [.00026]
FREQ	−.04291*** [.00392]	−.03878*** [.00499]	.00612 [.00936]	.01774* [.01036]	−.03571*** [.00159]	−.03734*** [.00403]	−.04063** [.00384]
GOV	−.04192* [.01113]	−.04020* [.01520]	−.03926* [.07757]	.16948 [.08540]	−.04557* [.00645]	−.05692* [.01152]	−.03845* [.01238]
SEATS	−.00143*** [.00016]	−.00137*** [.00021]	.00118* [.00050]	.00203** [.00058]	−.00133*** [.00000]	−.00143*** [.00016]	−.00152*** [.00017]
X_RATE	.032430 [.02740]	−.01320*** [.02447]	−.03222 [.02520]	−.04490 [.29984]	.02378** [.01145]	.03964 [.02760]	.01937 [.02732]
OIL	.00537* [.00148]	.00481** [.00201]	.00451* [.00271]	.001106 [.00167]	.00410* [.00238]	.00537** [.00136]	.00518* [.00180]
INT_D	.00380*** [.00038]	.00335*** [.00036]	.00317*** [.00040]	.00046*** [.00384]	.00387*** [.00016]	.00411*** [.00039]	.00368*** [.00045]
INT_1	−.00043 [.00207]	−.00045 [.00227]			−.00148* [.00089]	−.00070 [.00215]	−.00043 [.00225]
INT_2	−.00572** [.00103]	−.00473* [.00113]			−.00411** [.00046]	−.00572* [.00114]	−.00234** [.00058]
DIST	−.00022*** [.00003]	−.00023*** [.00004]			−.00023*** [.00001]	−.00026*** [.00004]	−.00024*** [.00004]
ANT_1	.71063*** [.01309]	.72378*** [.01741]			.71396*** [.00539]	.71063*** [.01299]	.71458*** [.01403]
ANT_5	.44627*** [.01292]	.45923*** [.01728]			.44481*** [.00530]	.44627*** [.01315]	.44940** [.014209]
ANT_10	.27820*** [.01295]	.17979*** [.01731]			.28328*** [.00477]	.27820*** [.01308]	.28069** [.014157]
ANT_15	.16668*** [.01236]	.17979*** [.01711]			.17477*** [.00544]	.16668*** [.01287]	.16840*** [.01395]
ANT_20	.07782*** [.01254]	.08745*** [.0170]			.09279*** [.00551]	.07782*** [.01298]	.08042*** [.01399]
ANT_25	.01840* [.01267]	.02776 [.01697]			.03015*** [.00583]	.01840 [.01281]	.020543 [.01395]
ANT_30	.02067** [.01245]	.02488** [.01694]			.02606*** [.00469]	.02067** [.01295]	.020507** [.01406]
VSD	.08069*** [.00636]	.06978*** [.00626]	.06597*** [.00687]	.06489*** [.00769]	.07541*** [.00312]	.08094*** [.00662]	.06596*** [.00617]
_cons	.11372 [.34564]	2.0512 [.35197]	−.50452 [.00000]	−.56324** [.22486]	−.07113 [.15861]	.11322 [.34021]	.60643** [.34480]
Observations	17664	17664	17664	13686	17664	17664	17664
R-squared	0.5025	0.5014	0.2076	0.1964		0.5032	0.7180

Standard errors in brackets

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level

routes airlines have lower costs per kilometre because they can distribute their fixed costs over a longer distance. On the contrary, it is observed that the variation in oil prices has a positive relationship. Throughout the sample, the variations in oil prices – between 80 and 113 euros – were responsible for an increase in fares of up to 16.5%.

5.1. The effect of technology on the price fixing strategies of air transport

With respect to the variables related to technology, the results obtained enable us to respond to two fundamental questions: can airlines anticipate how demand will behave?; and how do users benefit from a greater access to information?

First, the variable *INT_D* shows a positive and highly significant relationship with respect to price. By using the tool *Google Insights* (which measures the popularity of a term using a scale of 0–100) it is possible to establish whether the airlines respond to user indications – Internet searches would be reflection of accesses to the websites of the companies – to modify their prices. Until a few years ago, the information that they used to adjust prices (*yield management*) was based on historical series: today they have access to data in real time. In the case of this sample, there are differences of up to €45 per ticket depending solely on expected demand, which is a large amount for low cost flights.

This effect is reflected in the discrimination that occurs almost every day and which has been reflected in studies of both American and

European markets. Although there is a clearly positive relationship as the date of the departure approaches, there is no case of a specific day when it can be confirmed that prices will be lower. For example, for the case of Europe, Pels and Rietveld (2004) indicate that the best option is to purchase the ticket 20 days before the day of departure, while McAfee and te Velde (2006) in the case of the United States, indicate that the best day is between 21 and 28 days before the flight. Domínguez-Menchero, et al. (2014), using an isotonic model for four different routes including both long and short haul, observed that the users can buy their tickets until 18 days prior to departure without any significant penalty with respect to the best purchase day.

In this sample, tickets bought 25 days prior to departure implied a minor percentage increase over the final price (1.84%) compared to those bought 30 days prior to departure (2.06%). As the sample data has been compiled every 5 days we cannot determine exactly which is the cheapest day to buy. So buyers should be recommended to buy their tickets up to 25 days prior to departure if they do not want to pay a higher fare. Beyond this date, and up to 60 days before departure, there is no penalty on prices.

In this case, and depending on the company, the results indicate that the point of inflection can be found between 25 and 30 days before departure. The effect of the period between the purchase date and departure date is highly important for the consumer of cheap flights. According to the analysis, a flight purchased one day before departure is 50% more expensive than a flight purchased ten days before.

The result obtained for the variable *INT_2* is consistent with the studies carried out by Verlinda and Lane (2004) and Orlov (2011), which use similar variables to observe the Internet effect with respect to prices. According to the results, the population segments which are most familiar with using the Internet usually obtain a better final price. This impact can be seen principally in Brunger (2010) for the case of the United States and in Piga and Filippi (2002) for the different European routes. Therefore, the greater the penetration of the Internet in a territory, the greater the reduction in fares. This is the result of the higher level of competition on the Internet and the greater volume of information that reaches the consumer.

6. Conclusions

This study seeks to analyse the price fixing strategy of low cost airlines in Europe and the effect that the Internet has on both supply and demand. In view of the results observed, there is no doubt that the concept of *yield management* has changed indefinitely. It has transformed from a discrimination process based on experience to strategies capable of responding to information in real time.

The most significant results obtained are the following:

1. The results revealed an opposite effect to the economies of density that were used to deregulate the industry (a greater concentration of the product tends to reduce prices), and the power of the monopoly increases the final price of the product.
2. The Internet effect has been proven for the sample, both from the supply point of view and the demand perspective. The regions with greater access to the Internet find lower prices thanks to a higher level of competitiveness derived from the access to information; while the airlines have the possibility of using the information that is available to them to modify prices in real time. These types of connotations have opened a new panorama in e-commerce which has given rise to the exploitation of big data in every industry.
3. The LCCs observed seem to define their strategies according to different elements, although the most significant are the number of rivals, the behaviour of demand, the associated costs and the subsidies received. The ICTs are responsible for periodic price alterations which do not affect demand.

In summary, the results obtained in this study are consistent with those found by authors such as Malighetti, et al. (2009), Bachis and Piga (2011) or Salanti, et al. (2012). The incorporation of new variables can be considered as a further step in the research of the low cost airline segment which should continue to analyse how complementary product, governments and particularly new technologies condition the access by the demand and the strategies of the airlines.

APPENDIX. Variables included in the study

Airport concentration (AIC): Concentration in origin and destination airports (X_i) measured through the total number of seats offered per airline (x_{ij}), using the Herfindhal index:

$$AIC = [\sum (x_{ij\text{ORI}} + x_{ij\text{DEST}}) / (X_{\text{ORI}} + X_{\text{DEST}})^2]$$

Source of information: OAG.

Route concentration (ROC): relative weight of the number of seats offered by an airline in a day (x_{ij}) regarding the total number of seats offered by all airlines:

$$ROC_D = (x_{ij\text{ORI}} + x_{ij\text{DEST}}) / (X_{\text{ORI}} + X_{\text{DEST}})$$

Source of information: OAG.

Airport Taxes proxy (AIRP): Total number of users in the airports integrated in the route per month:

$$AIRP_X = \text{Users}_i\text{ORI} + \text{Users}_i\text{DEST}$$

Source of information: OAG.

Origin and destination's wealth (GDP): Gross domestic product per capita PPA, measured basing on the origin and destination cities

$$GDPPPA = [(GDPPPA_i + GDPPPA_j) / (\text{Pop}_i + \text{Pop}_j)]$$

Source of information: Eurostat

Population (POP): population residing in the cities included in the route:

$$POP = \text{Population}_i + \text{Population}_j$$

Source of information: Eurostat

Load factor (LF): Monthly load factor of each route

$$LF_i = x_{ij} / n_{ij}$$

x_{ij} : total number of passengers taking a route i.

n_{ij} : total number of seats offered in a route i.

Source of information: Eurostat

Tourism effect on routes (TUR_i):

TUR₁: Number of hotel beds per 1,000 inhabitants (sum of the origin and destination populations)

$$(\text{HotelBeds}_{\text{ORI}} + \text{HotelBeds}_{\text{DEST}}) / [(\text{Pop}_{\text{ORI}} / 1.000) + (\text{Pop}_{\text{DEST}} / 1.000)]$$

Source of information: Eurostat

TUR₂: Percentage of foreign tourists in the route.

$$[(\text{TURExtr}_{\text{ORI}} + \text{TURExtr}_{\text{DEST}}) / (\text{TURNa}_{\text{ORI}} + \text{TURNa}_{\text{DEST}})] * 100$$

Source of information: Eurostat

TUR₃: Hotel occupancy in Spanish cities referred to in the sample.

Source of information: IET – Tourspain.

Frequency of flights (FREQ): Number of flights offered by a company during one day for a specific route.

Source of information: OAG

Government grants to airline industry (GOV): Annual state grant (2011) received by operating airlines in the different Spanish airports. Measured as an average per annual passenger volume.

Source of information: CNC

Number of seats per flight (SEATS): Total number of seats offered for a flight per airline.

Source of information: OAG

X_RATE: Euro/pound Exchange rate on the day when the ticket price is observed.

Source of information: www.forexpros.es

Oil prices (OIL): Brent's barrel price on the date the price of the flight is observed.

Source of information: www.forexpros.es

Internet effect on Demand (INT_i):

INT_1: Percentage of the population shopping online in the origin and destination regions integrated in the study using Eurostat database.

Source of information: Eurostat

INT_2: Number of households with Internet access in the origin and destination regions integrated in the study using Eurostat database.

Source of information: Eurostat

Internet effect on Supply (INT_D): number of searches for the terms regarding the destinations integrated in the route. Measured in index numbers, base 100.

Source of information: Google insights.

Distance (DIST): Distance in kilometres between different origin and destination airports in a route.

Source of information: innatia.com

ANT_X: Number of days before the date of the departure of the flight when the data is taken.

VSD: Dichotomous variable which indicates whether a flight is programmed to depart on Friday, Saturday or Sunday (theoretically the most expensive days):

1 = Weekend flight. 0 = Not weekend flight.

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