The Role of e-Commerce in the Success of Low-cost Carriers

Marco Ginanneschi[*], Pietro Piu[**]

Abstract

This research aims to answer the question if e-commerce favoured in a special way the growth of low-cost carriers within the civil aviation market. After defining low-cost and traditional carriers' business models, data on transported passengers were collected for three countries (Italy, Germany and Spain) and confronted with the number of e-consumers. Despite a significant correlation in all the three markets, only in Italy our hypothesis has been supported by Granger causality, and the regression analysis allows to forecast a future characterized by a growing dominance of LCCs. Although the definition of an econometric model will require further studies, the distinctive features of the Italian market might represent a starting point for future research on the complex relationship between e-commerce and air transport.

Keywords: e-commerce; e-consumers; low-cost carrier; Ryanair; Granger-causality.

JEL classification: L10; L93; C53; C63.

1. INTRODUCTION

It has been observed that during the last decades few industries have undergone the same turmoil as the European airline industry (Cento, 2008). The pace and the intensity of this change depended on many factors. Institutional and political decisions displayed a fundamental role, with the establishment in 1997 of the "European single aviation market" which followed liberalization of the US market during the 1970s (Kassim and Stevens, 2010). But then, another very important push for change came from within the industry: in 1991 Ryanair converted into the first European low-cost carrier (LCC), following the example of South West Airlines in America. A new business model "no frills" definitively started just on time to intercept the booming demand for travel at a reasonable price which came along with globalization and widespread economic growth.

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[*] Finanza Futura Srl, Italy; e-mail: *ginanneschi.marco@alice.it* (corresponding author).
[**] Vismederi Srl, Italy; e-mail: *piu@vismederi.com*.

Many industry experts and academicians sincerely believed that LCCs operated inside a "new market segment", made of potential customers who could not afford to buy tickets from traditional companies (Dudas, 2010). In other words, the change introduced by LCC model would not disrupt traditional carriers (Full Service Network Carrier or FSNC). After all, there was not a single LCC model but many variants developed by a number of imitators, and according to the former IATA President Giovanni Bisignani, "every airline is now a lower-cost airline" (Smyth and Pearce, 2006), meaning that cost and tariff reductions were a common factor for the whole industry.

From 2000 onward, however, LCCs started to have a significant weight on the whole European passengers' traffic. Their share grew from 19% in 2007 to 30% in 2016 (Eurocontrol, 2017), evidently eroding market shares from traditional carriers. At this time the second wave of digital revolution took place, with internet connecting 3.48 billion of people[1] and e-commerce by individuals[2] in the EU (27 countries) passing from 26% to 55%.

The research question we want to address in this article regards the possible role of e-commerce in boosting especially LCCs' market share, giving the latter a competitive advantage towards traditional carriers.

In order to test this hypothesis, we will first summarize the distinctive characteristics of the two business models, as portrayed in academic literature. Subsequently we will define the perimeter of the research in terms of data and statistical methodology. Then we will present the result of the analysis conducted on three countries (Italy, Spain and Germany) for which a comparable set of data is available. Finally, we will try to draw some preliminary conclusions.

2. LITERATURE REVIEW

Until recently, scholars kept believing alternatively that: 1) among LCCs there may be successful companies but this does not imply their model to be successful (Button, 2012); 2) a "coexistence" of the two business models is still possible (Alderighi *et al.*, 2005; Acar and Karabulak, 2015); 3) the low-cost model is reaching anyway maturity, and a stop to market share increase is behind the corner (Bitzan and Peoples, 2016).

In any event, international authorities from ICAO to IATA and Eurocontrol started to collect and monitor statistics on LCCs' market share, drawing primary data from Member States, in the belief that "the identification of LCCs in ... statistics is gaining importance" and that the adoption of this business model is the discriminating factor for this identification (ICAO, 2009).

For the purpose of our research, it is important to recall the fundamental characteristics of LCCs compared to FSNCs and we will concentrate on these aspects to categorize airlines. We are not excluding the existence of hybrid models but at the same time we observe that LCCs are not hiding their nature, and on the contrary they advertise it.

We adopted the concept of business model as defined by Amit and Zott (2012)[3] and, drawing from a series of studies on the subject (Cento, 2008; Reichmuth, 2008; Diaconu, 2012b, 2012a; Eller and Moreira, 2014; Miranda *et al.*, 2016), we created a synthesis, technologically updated, of LCC and FSNC characteristics[4] (Table no. 1).

Table no. 1 – Major characteristics of LCC and FSNC

Characteristic	Low-cost carriers	Full Service Network Carriers
Aircraft utilization	high	Low utilization on short sectors
Aircraft	Single type	Multiple types
Sectors	Short, 500-1.000 km (continental)	From ultra-short to long (continental and intercontinental)
Network	Point to point	Hub and spoke (network connectivity)
Airports	Secondary or less congested	Focus on large airports
Classes	1	2-3
Catering	No meal or free drinks	In-flight catering
Turn around	20-30 minutes	1 hour on short sectors
Fares	Simple (minimum restrictions)	Complex (multiple restrictions)
Luggage	Hand luggage	Hold luggage up to 25kg
Distribution/sales/booking	Direct online, through website	travel agents, own ticket office, website
Ticketing	e-tickets or ticketless	Paper or electronic ticket
Check in	digitalized	At the desk

Even at first glance differences are such that the LCC model qualifies easily into Markides (2006) definition of <business model innovation> ("To qualify as an innovation, the new business model must enlarge the existing economic pie, either by attracting new customers into the market or by encouraging existing customers to consume more").

Experts agree that the LCCs' business model implies cost cutting in respect to traditional passengers' transport (Smyth and Pearce, 2006; Atiqur *et al.*, 2012; Huschelrath and Muller, 2012; Bitzan and Peoples, 2016; Miranda *et al.*, 2016), but are not unanimous in the identification of the most relevant economic advantages. Alderighi *et al.* (2005) and Eller and Moreira (2014) consider preponderant the choice of a network (point-to-point or hub-and-spoke) or the route structure. Riwo-Abudho *et al.* (2013) underline the influence of seven "Key Success Factors", among which technology plays a horizontal role. According to Campisi *et al.* (2010), the lower staff costs is the most relevant competitive advantage of LCCs' model although "sales and reservations" represent the second biggest cost difference (about 13%-18%) between the two models.

Cost leadership is not the only force behind competitive advantage. Correctly, Button (2012) has observed that "numerous large carriers that do not follow the low-cost path still survive". The last column of Table no. 1 helps identifying the advantage in terms of "differentiation" (Porter, 1985) behind the FSNCs' commercial offer. Using Porter's analytical framework (Porter, 1980), we could state, for example, that FSNCs can promise the travellers not just a lift to a remote destination but the assurance that they will get to the place they want (feature and technology), right in the middle of it (ease to use), under whatever conditions (network), in the most comfortable way and enjoying the experience of travelling (customer service).

The synthesis presented under Table no. 1 is not conclusive on which between the two business models will succeed in terms of market share[5]. Actions and reactions of the two groups of carriers are alternatively given by experts and academicians a chance of success for the future. In this panorama, the authors of this paper asked themselves why so little attention has been paid to the role of e-commerce. After all, this form of digitalized distribution, which reduces the distance between the company and the customer, interacts with almost all the characteristics of the air service (underlined in colour grey in the schema under Table no. 1).

We found two possible explanations for this lack of consideration. The first one is of general order. No one has made a final statement yet of which economic activity benefitted most and which suffered most the advent of e-commerce (Lieber and Syverson, 2012). The question is complex given that we are speaking of a relatively young technology (younger than the LCC model) with high impact on the number of companies (concentration) and the number of employees (automation) within an industry. The second explanation is peculiar to civil air transportation. In this sector it is commonly accepted that e-commerce represents a horizontal innovation with an impact on all industry segments (Harteveldt, 2012; Babic *et al.*, 2017). Even recent SWOT analysis of Ryanair strategic position (for example Geller *et al.*, 2013) do not mention among its strengths neither ICT nor e-commerce.

We speculated though that e-commerce could make a difference in the success of one of the two models. To measure this possible impact, in terms of competitive advantage, we decided to confront two series of data: the number of transported passengers respectively by LCCs and by FSNCs and the number of e-consumers over the longest possible span of time.

3. DATA AND METHODS

3.1 Research framework and data

Given the fact that the question of competitive advantage of one business model over the other one is a debated one, we decided to measure the influence of one specific factor, e-commerce alias online purchases, over the dynamic of air passengers. We are dealing with two recent phenomena, e-commerce and the new scenario for the air industry after the low-cost model introduction, and the lack of data has probably inhibited similar studies before.

Only one of the two variables has been surveyed through a harmonized system for a sufficient long and statistically relevant period of time at the European level. Among the existing Eurostat data collections, we took into consideration the evolution of the *number of e-consumers* (consumers who made at least one purchase online during the last 12 months).

No Eurostat data are available however on the historical trend of low-cost passengers (only total passengers transported and national passengers transported). Eurocontrol, an intergovernmental organisation with 41 Members committed to the building of the Single European Sky, keeps records of and makes forecast about air traffic and low-cost weight but only in terms of flight movements[6]. The number of passengers flying low-cost is of crucial importance for the purpose of our research and for its relative homogeneity and comparability to the number of persons who bought online. Missing the data of low-cost passengers at the European level, we searched at national level and found accessible or published data for Italy (source: ENAC) and Germany (source: DLR) while the analysis for Spain (source: AENA) has been limited to the number of passengers transported by Ryanair (the most important low cost on this market) and Iberia (the former flagship and legacy company).

Further limits to the research analysis are discussed and specified country by country in the Section Results.

Finally, only in one case (Italy), the Granger-causality test resulted in significant connection between the number of e-consumers and the number of LCC passengers. Accordingly, the formulation of a forecast by means of a three years lagged regression was appropriate only for Italy.

3.2 Statistical methods

We first associated the values of variable "number of passengers transported by low-cost companies" to the "number of e-consumers" along the period 2005-2016. Index numbers of both time series were built by taking the 2005 values as bases (= 100). The Pearson product-moment correlation was used to measure whether and to what extent the two variables were (linearly) associated. To address the issue whether the number of e-consumers could help forecast the number of passengers of LCCs, the time series underwent a Granger-causality test with a maximum number of lags equal to 3. The best model order was evaluated through the Bayesian information criterion (BIC). Magnitude and direction of the Granger-causality were calculated from the F-statistics (Seth, 2005). Accordingly, a simple linear regression was then calculated to predict the number of passengers based on the number of e-consumers. Robustness analysis of the parameter estimation was provided by a two-stage procedure. Firstly, the observed normalized time series were resampled one thousand times from a Gaussian-copula, such that the generated bivariate data preserved the correlation structure measured between the original time series. Subsequently, a cross-validation technique was applied over the resampled time series. Specifically, the holdout method was used to randomly assign data points to a training set (80 % of the copula-generated data points) or to a test set (20 % of the copula-generated data points). Each bivariate data series, both in the training set and in the test set, underwent a linear regression analysis. The mean of the root mean square (RMSE) values calculated from the errors in each regression was evaluated, along with its 95% confidence interval, as a measure of the performance of the regression model. The test set performance compared to the training set performance indicated the robustness of the hypothesized linear relationship between the two time series. Lastly, distributed lagged regression was implemented to estimate forward prediction of the number of passengers for a three-years period from 2017 to 2019 based on the e-consumers data observed in 2016. A comparison of the 2017 predictions with real data was also reported.

4. RESULTS

4.1 Overall outlook

The distribution by year and by country of the LCC and FSNC passengers along with their ratio over the total number of passengers are presented in Table no. 2. The overall variation measured the percentage of change between the data of 2016 and of 2005 for the total number of passengers, the LCC passengers, and the FSNC passengers. All the countries showed a positive overall increase in the total number of passengers and in the LCC passengers. Instead, the overall variation of FSNC was positive only in Germany. The data of passengers available for Spain are referred to the Ryan Air and Iberia numbers, which in the analysis were considered by extension as proxy of the LCC passengers and the FSNC passengers, respectively.

Table no. 2 – Distributions and year-on-year variations of LCC and FSNC passengers (2005-2016)

Country	Year	Total passengers	LCC Passengers*	% LCC Passengers	Year-on-year variation (%)	FSNC Passengers*	% FSNC Passenger	Year-on-year variation (%)
Germany	2005	164200000	31200000	19		133000000	81	
	2006	172900000	40300000	23,3	29,2	132600000	76,7	-0,3
	2007	183575690	48290432	26,3	19,8	135285300	73,7	2
	2008	189888350	53793481	28,3	11,4	136094900	71,7	0,6
	2009	180780489	52107581	28,9	-3,1	128672900	71,2	-5,5
	2010	190513700	65176600	34,2	25,1	125337100	65,8	-2,6
	2011	199711000	64058000	32,1	-1,7	135653000	67,9	8,2
	2012	201700000	64263000	31,9	0,3	137437000	68,1	1,3
	2013	203180000	65573000	32,3	2	137607000	67,7	0,1
	2014	209179000	66855000	32	2	142324000	68	3,4
	2015	217143000	68519000	31,6	2,5	148624000	68,4	4,4
	2016	224434000	75828000	33,8	10,7	148606000	66,2	0
	Overall variation (%)	36,7	143,0			11,7		
Spain	2005	178986878	6410938	3,6		43111524	24,1	
	2006	191476011	7382523	3,9	15,2	42568831	22,2	-1,3
	2007	209055003	11142132	5,3	50,9	40508364	19,4	-4,8
	2008	202695768	14871089	7,3	33,5	33647618	16,6	-16,9
	2009	186764003	19666616	10,5	32,2	30253630	16,2	-10,1
	2010	192045959	26616567	13,9	35,3	28850192	15	-4,6
	2011	203627283	34170177	16,8	28,4	24289628	11,9	-15,8
	2012	193449137	35565648	18,4	4,1	19816175	10,2	-18,4
	2013	186754594	32428398	17,4	-8,8	13243711	7,1	-33,2
	2014	195226852	31697207	16,2	-2,3	13348357	6,8	0,8
	2015	206865852	35155859	17	10,9	15020168	7,3	12,5
	2016	229649422	39850773	17,4	13,4	16588273	7,2	10,4
	Overall variation (%)	28,3	521,6			-61,5		
Italy	2005	112981108	20240940	17,9	208,9	92740168	82	-6,4
	2006	122970312	28405320	23,1	40,3	94564992	77	2
	2007	135308151	34870500	25,8	22,8	100437651	74	6,2
	2008	132952402	43393983	32,6	24,4	89558419	67	-10,8
	2009	129859539	46871169	36,1	8	82988370	64	-7,3
	2010	138909695	50803188	36,6	8,4	88106507	63	6,2
	2011	147946210	58123580	39,3	24	89822630	61	8,2
	2012	146000783	60293876	41,3	3,7	85706907	59	-4,6
	2013	143510334	57942340	40,4	-3,9	85567994	60	-0,2
	2014	150243142	68831494	45,8	18,8	81411648	54	-4,9
	2015	156965253	75943424	48,4	10,3	81021829	52	-0,5
	2016	164368109	81287723	49,5	7	83080386	51	2,5
	Overall variation (%)	45,5	301,6			-10,4		

Note: * The passengers' data for Spain are proxy of LCC and FSNC.

   Source: ENAC (Italy, www.enac.gov.it, Dati di traffico, 2005-2016); AENA (Spain, www.aena.es, Estadísticas de tráfico aéreo); DLR (Germany, www.dlr.de, Low Cost Monitor, 2006-2017).

Cross comparisons of the LCC passengers and of the FSNC passengers were enabled by their year-on-year variations. In all the countries, damping and almost always positive fluctuations characterized the time series of the LCC passengers. Instead, the variations in the FSNC passengers were on average lower. For Spain, the FSNC decrease was particularly dramatic, having suffered a loss in the absolute number of passengers of around 30 million units in the period considered (Figure no. 1).
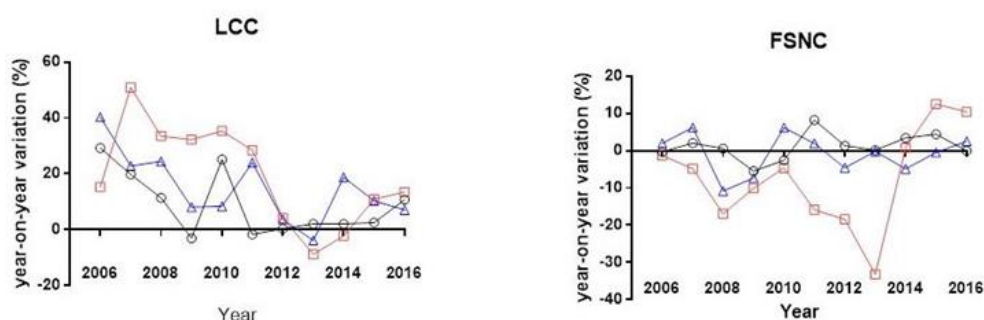
Note:. The panels show the year-on-year variation of the number of LCC and FSNC passengers over the period 2005-2016 for Germany (black circles), Spain (red squares), and Italy (blue triangles). The plots enable year-based comparisons among countries of the variations in the numbers of passengers and help discern possible trends.
Source: data on the plots from Table no. 2, columns "Year-on-year variation (%)".
**Figure no. 1 – Year-on-year variation of the number of LCC and FSNC passengers**

Steady growth of the number of e-consumers was observed in the three countries (Table no. 3). Specifically, the average growth rate of the e-consumers in the period 2005-2016 was around 4.8 % in Germany, 12.1 % in Spain, and 14.5 % in Italy. Different inclinations to online purchasing as well as infrastructural lacks or digital divide rates may explain the large differences in the e-consumers data.

Table no. 3 – Total number of e-consumers and their share over the population (2005-2016)

	Population			e-consumers			% e-consumers		
Year	Germany	Spain	Italy	Germany	Spain	Italy	Germany	Spain	Italy
2005	82500849	43296338	57874753	34650357	5195561	3472485	42	12	6
2006	82437995	44009971	58064214	40394618	6601496	5225779	49	15	9
2007	82314906	44784666	58223744	42803751	8061240	5822374	52	18	10
2008	82217837	45668939	58652875	43575454	8677098	6451816	53	19	11
2009	82002356	46239273	59000586	45921319	10172640	7080070	56	22	12
2010	81802257	46486619	59190143	49081354	11156790	8878521	60	24	15
2011	80222065	46667174	59364699	51342122	12600140	8904705	64	27	15
2012	80327900	46818219	59394207	52213135	14045470	10097015	65	30	17
2013	80523746	46727890	59685227	55561385	14952930	11937045	69	32	20
2014	80767463	46512199	60782668	56537224	17209510	13372187	70	37	22
2015	81197537	46449565	60795612	59274202	19508820	15806859	73	42	26
2016	82175684	46440099	60665551	60810006	20433640	17593010	74	44	29

Source: Eurostat (population; e-commerce statistics for individuals: at least one online purchase in the previous 12 months). Available at <https://ec.europa.eu/eurostat/data/database> [1 January 2018]

The three countries showed different patterns in the dynamics of the interaction between the increasing number of e-consumers and the variation in the number of LCC or FSNC passengers (Figure no. 2).
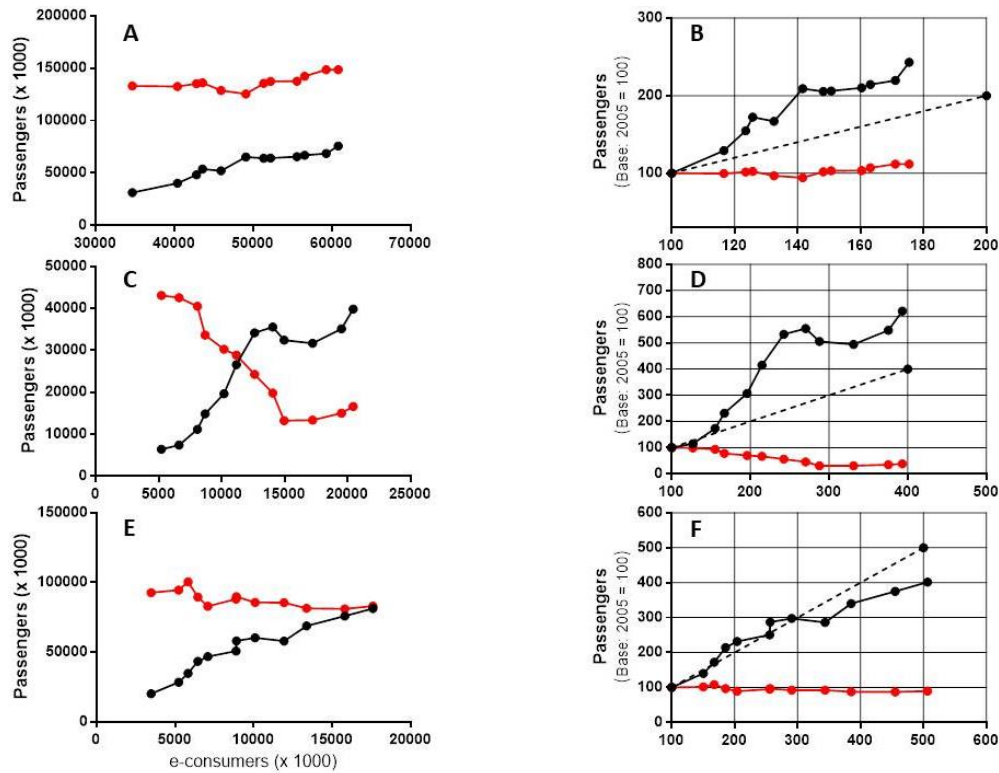
Note. Left column: scatter plots of the number (thousands) of e-consumers (abscissa) vs. the observed number (thousands) of passengers in the major LCC (black dots) and FSNC (red dots) carriers in Germany (panel A), Spain (panel C), and Italy (panel E). Right column: the panels display the scatter plots of the normalized values of e-consumers vs. the normalized values of passengers in the major LCC (black dots) and FSNC (red dots) carriers in Germany (panel B), Spain (panel D), and Italy (panel F). The two variables were rescaled by setting as base the year 2005 (= 100). The dashed lines represent how the passenger growth would evolve if it were proportional to the e-consumers growth rate. Deviations from those lines indicate unbalanced variation of the passengers.
Source: our elaboration from data reported in Tables no. 2 and no. 3.
Figure no. 2 – Passengers in LCC and FSNC vs. e-consumers: absolute and normalized data

Actually, the analysis of the absolute data revealed for Germany that both the distribution of LCC related to e-consumers and the distribution of FSNC related to e-consumers had positive trend. In addition, the curve of FSNC was always above the LCC curve (Figure 2A). In Spain the two curves gave rise to a chiasmus (Figure 2C), with an intersection point at year 2010 whence the number of LCC passengers began overcoming the number of FSNC passengers. Like in Spain, in Italy the number of FSNC passengers declined steadily with the increasing number of e-consumers, but at a slower pace than in

Spain. Other things being equal, the number of LCC passengers are expected to exceed the FSNC passengers by the year 2017 (Figure 2E). Data normalization gave further information about the relationship between the growth of e-consumers and the variation of passengers. With respect to the base value (2005 = 100), in all countries the variation of FSNC passengers compared to the variation of e-consumers was, on average, either barely above 100 like in Germany (102.7) (Figure 2B), or moderately below 100 like in Italy (94.6) (Figure 2F), or severely below 100 like in Spain (56.8) (Figure 2D). These findings evidenced the net loss of passengers for the FSNC in Spain and Italy over the period 2005-2016. On the contrary, the variation of LCC passengers outperformed the variation of e-consumers both in Germany and in Spain because their curves of the LCC were always above the bisection (dashed line), which is the locus of the points where the ratio of the variation of passengers over the variation of e-consumers equals 1. Instead, in Italy the LCC curve was above but quite close to the bisection up to 2012, and whereupon the growth has shifted below.

4.2 E-commerce and civil aviation in Italy

The time series[7] for the Italian passengers' market (Table no. 2) shows at glance a number of trends. First of all, we have to register an explosive growth of LCCs, which have increased their passengers by 301.6 % and total market share, passed from 17.9 % to 49.5%. Then we notice how the low-cost transport represents a driver for the growth of the total number of passengers (+45.5 % during the period). Finally, in a market in slow expansion, we take note that low-cost transport grew in part at the expenses of FSNCs, which lose 10.4 % of passengers during the 12 years period. Numbers show also that LCCs and FSNCs reacted differently to the 2008-2009 crises, with the first ones increasing their market share by 24% (2008) and by 8% (2009) and the second ones losing respectively the 10.8% and the 7.3% of passengers. The phenomenon can be explained with the drastic reduction of disposable income coupled with an accrued price sensitivity of the Italian consumers.

Traffic data relative to the first 10 air carriers in 2015-2016 are reported in Table no. 4:

Table no. 4 – Distribution of passengers (major air carriers in the Italian market, 2015-2016)

Ranking	Carrier	Country	Nr. transported passengers		Variation (%) 2016/2015	Market share (%) 2016
			2015	2016		
1	Ryanair	Ireland	29706675	32615348	9.8	19.8
2	Alitalia	Italy	22987134	23106354	0.5	14.1
3	Easyjet	UK	14363022	14335531	-0.2	8.7
4	Vueling Airlines	Spain	5304079	5901919	11.3	3.6
5	Lufthansa	Germany	4336318	4287095	-1.1	2.6
6	Wizz Air	Hungary	3168232	3517535	11	2.1
7	British Airways	UK	3036624	3109075	2.4	1.9
8	Meridiana Fly	Italy	2803712	2627654	-6.3	1.6
9	Air France	France	2790046	2598309	-6.9	1.6
10	Air Berlin	Germany	1750422	1873891	7.1	1.1

Source: our elaboration from ENAC, Dati di traffico 2015 and Dati di traffico 2016 (www.enac.gov.it).

Ryanair is market leader with more than 32 million passengers transported in 2016 (+9.8% over the previous year) and a share of 24.3% followed by the former flagship company Alitalia, a traditional carrier, with a share of 17.2% and a stagnant number of transported passengers since 1995 (Bergamini *et al.*, 2010). Moreover, we observe how the third and fourth most important carriers are LCCs and that 2016 has not been a favourable year for both Lufthansa and Air France.

In order to evaluate the role of e-commerce in the Italian civil aviation market we have reconstructed first the dynamic of online purchases made by Italians during the period. Eurostat data was available only for the period from 2005 to 2016 (Table no. 3).

The number of passengers in the low-cost companies was significantly correlated to the number of e-consumers, $r = 0.96^8$, $p < 0.0001$ (Figures 2E-F). Likewise, also the correlation between the number of FSNC passengers and e-consumers was significant, $r = -0.75$, $p = 0.005$. The results of the Granger-causality test indicated: a) that a model order of three lags was the most informative (BIC = 11.47) compared to the two lags order (BIC = 13.05), and b) that the variable number of e-consumers Granger-caused the variable number of passengers in the low-cost companies ($F = 24.5$, $p = 0.01$), while the inverse direction of causality was not significant ($F = 0.65$, $p = 0.63$).

Furthermore, a simple regression analysis was performed on the normalized data to predict of the number of passengers in the low-cost companies (NP) based on the number of e-consumers (E), which resulted in a significant regression equation, $F (10,1) = 129.1$, $p < 0.0001$. Precisely, the results of the regression (Table no. 5) indicated that $NP = 64.566 + 0.704 \times E$. Therefore, NP increased by some 0.7 units for each incremental unit of E over the period from 2005 to 2016. The predictor E also explained a significant portion of variance in NP ($R^2 = 0.93$).

Table no. 5 – Results of the linear model in observed normalized data

| Predictor	Coefficient	SE	95% CI low	95% CI up	t stat	p value
Intercept	64.566	18.602	23.118	106.013	3.47	0.006
E	0.704	0.062	0.566	0.842	11.36	< 0.0001

Linear regression analysis was then replicated 800 times on copula-generated bivariate data of size 12×2. In this training set the averaged results of the linear models (see Table no. 6) yielded $NP = 54.548 + 0.709 \times E$, which was consistent with the regression equation calculated for the original normalized data, and produced an average $R^2 = 0.97$ and RMSE equal to 0.069 with a 95% confidence interval from 0.068 to 0.07.

Table no. 6 – Results of the linear model in the training set

		Coefficient	SE	95% CI low	95% CI up	t stat	p value
Training	Intercept	54.548	13.483	24.506	84.590	4.046	0.002
	E	0.709	0.039	0.621	0.798	17.849	< 0.0001
Test	Intercept	54.649	13.237	25.155	84.143	4.128	0.002
	E	0.710	0.040	0.621	0.800	17.627	< 0.0001

The robustness of the linear relationship between NP and E was evaluated in an independent test set of 200 replications of copula-generated bivariate data of order 12×2, where the average RMSE was equal to 0.093 with a 95% confidence interval from 0.088 to 0.098. The regression equation of the test set was $NP = 54.649 + 0.710 \times E$. Overall, the cross-validation showed that the regression coefficients were both significant in training and test set. In addition, the results in validation were consistent with the estimates obtained from the regression between the observed normalized data.

Distributed lagged regressions enabled the predictions of the variation of the number of LCC passengers in the 3-years interval from 2017 to 2019 (Figure no. 3 and Table no. 7).
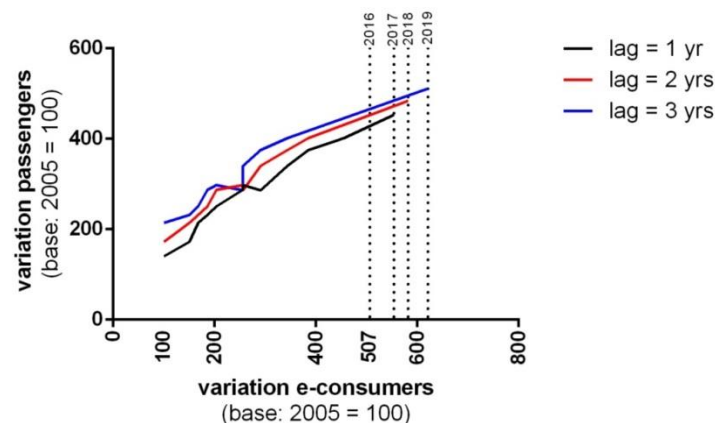
Note: Projections of the variation in the number of passengers of low-cost companies for years 2017, 2018, and 2019 based on variation in the number of e-consumers up to year 2016.

**Figure no. 3 – Distributed lagged regressions**

Table no. 7 – Expected LCC passengers in years 2017-2019 based on the number of e-consumers

		Observed		Projections		
		2016	2017	2017	2018	2019
E-consumers	Normalized value	507	558	554	582	621
	Absolute value	17593010	19388622	19242293	20214651	21570865
LCC Passengers	Normalized value	402	439	453	484	511
	Absolute value	81287723	88820337	91696943	98001328	103470916

Note: Normalized values refer to the 2005 basis (= 100).

By comparing the projections for the year 2017 with the real data, an almost exact prediction of the number of e-consumers was scored (- 0.75 %), while a slight overestimation in the number of LCC passengers was found (+ 3.24 %).

The year-on-year increase of the number of passengers (Δ NP) were expected to grow at a faster pace compared to the predicted year-on-year increases of the number of e-consumers (Δ E) across the period 2017-2018, where the measured incremental ratios, i.e., the marginal propensity Δ NP / Δ E, were estimated greater than 1.A relative minimum equal to 0.69 is expected in year 2019 (Figure no. 4).
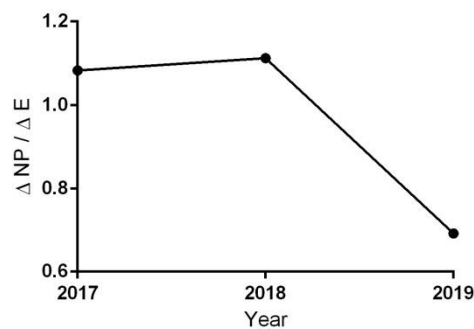
Note: The ratios of the year-on-year increase of the number of passengers (Δ NP) over the increase of the number of e-consumers (Δ E) across the period 2017-2019 indicated that the variations in the number of LCC passengers are expected to grow more than the expected variations in the number of e-consumers. Instead, a slight reduction of the ratio is also predicted for the year 2019.

Figure no. 4 – Ratio of the year-on-year increases in the period 2017-2019

4.3 E-commerce and civil aviation in Germany

For the German market we found that the number of passengers in the low-cost companies was significantly correlated to the number of e-consumers, $r = 0.96$, $p < 0.0001$. The number of e-consumers was significantly correlated with the number of FSNC passengers too, $r = 0.70$, $p < 0.012$. No significant causality was found between the e-consumers and the LCC passengers, in fact neither the number of e-consumers Granger-caused the number of LCC passengers ($F = 2.7$, $p = 0.22$), nor the inverse direction of causality was significant ($F = 0.35$, $p = 0.80$). This finding suggested that the regression analysis for the German data was not consistent.

On the contrary to what happened in Italy and in Spain (Table no. 2), in Germany FSNCs succeeded in increasing the number of transported passengers by 11.7% during the period 2005-2016 and in keeping LCCs' passengers down to 32% (+/- 1) between 2010 and 2016, while in the other two countries this percentage approached or surpassed 50%[9]. Why the German consumers, with the highest propensity to buy online (74% of the population against 29% of e-consumers among the Italian population), accorded so much preference to traditional carriers in relation to other countries can only be here object of speculation.

Per capita income could explain in part the different LCCs' market penetration levels in these countries (we already noticed how the LCC model at the start "created" a new demand for cheap travels). In fact, a low per capita income could increase the number of customers buying LCCs' offers. On the contrary, FNSCs can benefit from a high per capita income (Del Chiappa, 2013; Saleh, 2015)[10].

However, as far as the German market is concerned, the most impacting factors acting on the number of LCCs' passengers are probably not strictly income-related and stay all on the supply side of the market. From a literature review, we have identified the following:

a) market dominance (causing imperfect competition);

Imperfect competition can impair the functioning of the online market, for example by reducing the options available to consumers or by making options more expensive. Imperfect competition might result from excessive market power, such as dominance over

routes and airports, from market control through subsidiaries or from alliances reducing competition on hub to hub connections (ACI Europe, 2014; Ciliberto *et al.*, 2016). According to Domanico (2007), a common way incumbents can stop new entrants in the market is through the use of the so called "grandfather's rights" over slot allocation in congested airports. Exactly to prevent such a case, EU Commission opened an investigation on the Lufthansa – Air Berlin group projected acquisition of 2017 and accepted the deal only under condition that 50% of slots at Düsseldorf airport were held by Lufthansa's competitors (European Commission, 2017). In fact, new entrants (in this specific case, Ryanair) might find difficult to expand their clientele if the most valuable slots in the largest airports are not contestable (Fageda, 2014b). Under these conditions the e-commerce could not be able to improve competition and LCCs' offers may be artificially restricted.

b) a very efficient use of e-commerce by FSNCs;

This hypothesis is consistent with the wide diffusion of online purchases in Germany (higher than in Italy or Spain) but less consistent with the historical trend of travel distribution in this country (Ginanneschi, 2014). Doubts remain in particular on legacy airlines' website efficiency as e-commerce channels. A study on consumer perceptions (Powell, 2011) highlighted an average performance of the Lufthansa's website during 2001-2009 while Lufthansa Group's decision in 2015 to introduce a distribution cost charge for bookings made via GDSs (global distribution systems) is difficult to read in terms of strength/feebleness of the existing company website (Gnutzmann and Spiewanowski, 2016; Bingemer, 2018). Of course, this decision assumes a different meaning and economic weight in the context of Lufthansa's new big data strategy, based on the acquisition and anticipation of every possible customer need. Though already considered a school case ("Amazon in the Air"), this new IT and global strategy adopted in 2014 (Chen *et al.*, 2016) will eventually produce results in the future but does not change the track record of a distribution channel – the FSNC's web site - which is still today of secondary importance, despite all the efforts.

c) the power of brand;

Lufthansa Group, controlling also Austrian Airlines, Swiss International Airlines, Brussels Airlines, Eurowings and several Aviation Services companies, with total revenue EUR 31.66 billion and 109 million transported passengers in 2016 (half the size of the German passengers market) declared himself "the world's leading aviation group" (Lufthansa, 2016). Undoubtedly Lufthansa owns also one of the strongest brands among airlines in Europe and in the world. According to a recent study (Brand Finance, 2018), in financial terms the Lufthansa's brand is worth USD 2.9 billion. Calculating the share of brand-driven revenues for Lufthansa could be a useful tool to assess to what extent this brand increases the preference accorded by consumers to FSNCs. A commonly accepted definition of brand is "a promise made by the company to its consumers regarding its offer from a qualitative point of view" (Musetescu and Chira, 2015) and German nationals seem to especially appreciate the fulfilment of this promise. According to an EU Commission's survey, the highest level of consumer satisfaction with air traffic is in Germany (BDL, 2016). Germany scores very high also in the Country Brand Index (n° 3 in the world for 2012-2014)[11] and the company brand Lufthansa is consequently reinforced ("Country of

origin effect"). Finally, as far as German consumers are concerned, there is a certain evidence of "domestic country bias" to be considered (Evanschitzky *et al.*, 2008).

Without pretending this to be an exhaustive list of supply-related factors impacting the consumers' choice and probably reducing the number of LCC passengers in Germany, while waiting for more in-depth research on each item, we can though attempt an overall quality assessment (Dumbrava and Iacob, 2013) through a probability impact matrix (Table no. 8).

Table no. 8 – Supply related factors impacting the number LCC Passengers in Germany (probability impact matrix)

Factor	Impact	Probability	Significance
Market dominance	5	4	20
Efficient use of e-commerce	3	2	6
Brand power	2	4	8

Note: Rating 1-5 (Min.1, max 5).

In conclusion, if we cannot demonstrate via Granger-causality that in Germany the number of e-consumers is determining the number of passengers it is probably because supply-related factors contribute to keep lower the number of LCCs passengers compared to Italy (or Spain).

4.4 E-commerce and civil aviation in Spain

In the analysis of the Spanish data we considered the passengers of Ryanair as a proxy of LCC passengers, and the passengers of Iberia as a proxy of the FSNC passengers. This assumption, forced by the lack of aggregated data, reduces the possibility of generalizing the final result.

The number of e-consumers was significantly correlated both to the number of LCC passengers ($r = 0.92$, $p < 0.0001$) and to the number of FSNC passengers ($r = -0.93$, $p < 0.0001$). No significant connections were found between the e-consumers and the LCC passengers, in fact neither the number of e-consumers Granger-caused the number of LCC passengers ($F = 3.4$, $p = 0.10$), nor the inverse direction of causality was significant ($F = 0.89$, $p = 0.46$). This finding suggested that the regression analysis for the Spanish data was not consistent.

The case of Spain shows similarities with the Italian one but also differences. Among the former, it must be mentioned the competition moved by low-cost airlines to FSNCs at their operating bases/hubs, Madrid and Rome-FCO, and the consequent erosion of market shares undergone by the ex flag carriers (Fageda, 2014b).

Among the latter, we noticed Iberia's establishment in 2006 of a low-cost airline, Clickair, which in 2008 merged with the rival Vueling, ending up under Iberia's control. The larger Vueling intercepted the new consumption trends and some of the passengers traffic lost by Iberia. In 2016, with a share of 7% and 16.5 million transported passengers, Iberia was only third in the Spanish market, after Vueling with 14% and Ryanair with 17%[12].

Another difference lays on the size of the ex flag company. Iberia succeeded in merging with British Airways into IAG (International Airlines Group) in 2011. Both these operations, favouring concentration, could have resulted in new limits to perfect competition (Fageda, 2014a; Dobruszkes, 2009), therefore reducing the possible causality relationship between e-consumers and LCC's passengers.

4.5 Towards a synthesis

Considering only the supply-related factors, we tried to represent graphically the above described differences in a scheme showing market forces' influence over e-consumers (Figure no. 5).
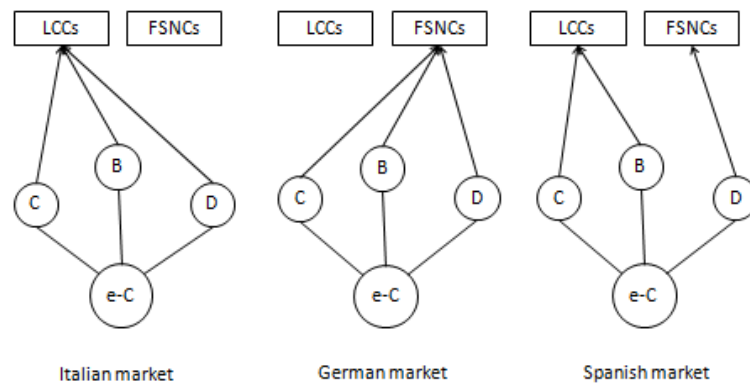
Note: C=Convenience; B=Brand Attractiveness; D=Market Dominance; e-C=e-consumers.
Figure no. 5 – Market forces' influence over e-consumers choices

To summarise, in Italy convenience of the commercial offer, market dominance and airline brand act all in favour of LCCs, in Germany the same factors support FSNCs while in Spain these forces operate in different directions.

5. CONCLUSIONS

Despite a significant correlation in all the three markets taken into consideration (Italy, Germany and Spain), no generalised and significant causality has been found between e-consumers and LCC passengers. Our hypothesis that the first variable could act independently in determining the value of the latter, with e-commerce giving a competitive advantage especially to LCCs, has not been supported by widespread evidence. In practice it is impossible to finalize a model without adding several other variables, which will require a supplementary research effort.

But in one market, Italy, the initial hypothesis has been supported by Granger causality and the regression analysis allows to forecast a future characterized by a growing dominance of LCCs, whose share of the civil aviation market will attain 60% in a few years. In Italy FSNCs could end up carrying out their activity in a niche.

Even when the Italian market were a class by itself, researchers could undertake new investigations on the role of e-commerce actually starting from what makes it special. At this stage we can suggest two distinctive features: 1) a large liberalized market; 2) no former flag company in a dominant position.

Moreover, the Italian and Spanish market dynamics show how crucial the e-distribution system can be for the leadership of cost. The number of passengers transported by Alitalia and Iberia presented low positive or negative correlation to the increase of online purchases.

Undeniably the e-commerce, through the comparison of prices and services made available to the consumer, reveals possible inefficiencies, privileges of position by a given carrier as well as badly communicated attempts to differentiate the offer. The case of Lufthansa in Germany is instead an example of product differentiation and of successful branding.

In conclusion, collected data do not allow asserting that LCCs, which adopted e-commerce as its only propagation medium, are always in the best position to exploit this technological innovation. However, if you are a traditional carrier operating in a perfectly competitive market, it is best if you take seriously this eventuality.

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Notes

[1] 2016, source: ITU. http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

[2] At least one online purchase in the previous 12 months. Source: Eurostat.

[3] "*a bundle of specific activities - an activity system - conducted to satisfy the perceived needs of the market*".

[4] We did not include among the characteristics the "ancillary services", which have an economic relevance in LCCs' balance sheet, because we considered them external to the core activity of passengers transport (here under consideration). We also excluded the "staff" component because its lower cost for LCCs is partly due to the business model, which implies a limited use of staff ("no service" or "no frills" model) and because some FSNCs (the ex "flag airlines") suffer from the "legacy" of high staff cost.

[5] However, Porter (1980) warned that differentiation "often requires a perception of exclusivity, which is incompatible with high market share".

[6] https://ext.eurocontrol.int/lexicon/index.php/Aircraft_movement. Also: https://www.eurocontrol.int/sites/default/files/article/attachments/eurocontrol-glossary-for-flight-statistics-and-forecasts.pdf

[7] Data on transported passengers reported yearly by ENAC (Ente Nazionale per l'Aviazione Civile), have two unique properties: 1) They are collected according to the same standard since 2004 (13 observations available); 2) They are divided in LCC and FSNC passengers. These data have two limits. The first one is inherent specifically to the Italian system of data collection. Conventionally passengers are considered the sum of national and international passengers. While the latter are

included in the figure if they arrived in an Italian airport or departed from an Italian airport, the first ones are counted twice, at departure and at arrival, because both airports are on Italian territory. Eurostat publishes only aggregated data (low cost detail unavailable) with no double counting. Being a standard and a number measured without variations since publication of official statistics by ENAC, this limit has been considered a minor one for the purpose of our research. A second limit is common to the whole European (and international) system of data collection. Passengers' data are not divided into residents and foreigner citizens (who could be especially numerous on international flights).

[8] In order to verify the possible influence on our analyses of the inclusion of foreigners in the number of transported passengers in Italy, we reconstructed from yearly publications by ENAC the number of the sole national passengers LCC transported 2009-2016 and measured again the correlation which resulted in a r= 0,928117019. We deducted a substantial solidity of our first measurement.

[9] In Spain LCC's overcame FSNC's passengers (as a % of international arrivals) in 2009. Source: Instituto de Estudios Turísticos, Informe Turismo, tráfico aéreo y compañías aéreas de bajo coste. 2009. http://estadisticas.tourspain.es/

[10] A partial correlation coefficient between number of passengers and e-consumers, controlling for the real GDP per capita show lower but still significant correlations for all the countries (Italy = 0.88, p= 0.0003; Germany = 0.71, p = 0.01; Spain = 0.90, p = 0.0001).

[11] The country's brand has been defined as "an umbrella identity that is incorporating and offering a meaning to brands orientated to specific objectives, such as promotion of direct foreign investment, tourism, exports and even as political influence" (Musetescu and Chira, 2015).

[12] Source: AENA (www.aena.es).

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