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How Can the Effects of the Introduction of a New Airline on a National Airline Network be Measured?

A Time Series Approach for the Ryanair Case in Spain

José I. Castillo-Manzano, Lourdes López-Valpuesta, and Diego J. Pedregal

Address for correspondence: José I. Castillo-Manzano, Facultad de Ciencias Económicas y Empresariales, University of Seville, Avda. Ramón y Cajal, 1, 41018 Seville, Spain (jignacio@us.es). Lourdes López-Valpuesta is at Facultad de Ciencias Económicas y Empresariales, University of Seville (Spain) (lolopez@us.es). Diego J. Pedregal is at Ingenium Research Group and IMACI, University of Castilla-La Mancha (Spain) (diego.pedregal@uclm.es).

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Abstract

This paper quantifies the Ryanair Effect on the Spanish airline network. It proposes new methodology based on an advanced time series approach that allows both the direct and indirect effects of the incorporation of a new airline to be measured and that can be easily extrapolated to other airport systems. The findings show the mean indirect effect on other airlines, in absolute value, is 8.6 per cent of the total airport traffic, peaking at a maximum of almost 29 per cent. Also, surprisingly, there is found to be a negative indirect effect at only four of the ten airports analysed.

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1.0 Introduction

There is a wealth of literature illustrating the international development of the low-cost model and its expansion into different geographical areas (see Francis *et al*., 2006, for an overview of this development). To be specific, in Europe, the early mid-1980s' liberalisation between Ireland and the UK created the conditions that allowed the first low-cost airline to appear in Europe, Ryanair (see Francis *et al*., 2006, for the reasons that favoured the creation of Low Cost Carriers (LCCs) in these two countries). This airline has developed into the main low-cost European airline and the most successful LCC in the world in terms of profitability (Oliveira, 2008).

Ryanair followed in the footsteps of the Southwest Airlines company (see Guillen and Lall, 2004, on the main differences between Ryanair and Southwest), although time has shown that Ryanair has remained more faithful to the features of the original low-cost model than its precursor, Southwest (Alamdari and Fagan, 2005). It has also created a model that can be easily replicated (Guillen and Lall, 2004).

One of the salient features of the Ryanair management model for our analysis is the use of underutilised secondary airports, often far from main city airports, and regional airports. This is what differentiates the airline from other major LCCs like easyJet or Southwest (Dobruszkes, 2006; Francis *et al*., 2006; Graham, 2009). Ryanair usually avoids using primary airports, except when a secondary airport is not available in the region (Graham, 2009), as the latter are less expensive in terms of landing charges; they are less congested than the major hub airports; shorter turnarounds are possible and, therefore, more journeys per day per plane can be achieved (Barrett, 2004).

Ryanair plays the dominant role in many of these secondary or regional airports and in some, such as Charleroi and Girona (Barbot, 2006), almost exercises a monopoly. This power influences its price strategy, as Ryanair seems to set lower fares when flights depart from or arrive at dominated airports (Barbot, 2006; Malighetti *et al*., 2009). This is, in turn, influenced by the fact that operating at airports of this type allows Ryanair always to be in a position to negotiate airport fees (Fröidh, 2008; Oliveira, 2008). In this way Ryanair has shown that secondary airports are not only able to charge less (see Castillo-Manzano, 2010) but also offer subsidies to attract airlines (Papatheodorou and Lei, 2006), often with the aid of local or regional public authorities (see Castillo-Manzano and López-Valpuesta, 2010).

Secondary airport managers where LCCs are found should be aware that they are facing high volatility in their traffic, due both to the greater likelihood of bankruptcy or merging of these kinds of airlines and to their dependence on the aid and subsidies that they apply for. There is even higher volatility when the airport has a dominant single LCC (Guillen and Lall, 2004; Barbot, 2006; Bel, 2009), as is the case of Ryanair at many of the secondary airports where it operates.

In this context, the objective of this article is an analysis of what has been dubbed, according to Guillen and Lall (2004), the Ryanair Effect on the Spanish airline network. Following Vowles (2001) and Pitfield (2008) on the Southwest Effect, the Ryanair Effect would be the effect on average airfares, traffic volumes, and market shares experienced in the markets into which Ryanair enters. The prior academic literature has studied the impact of the arrival of a new LCC at the airports which accept them, mainly analysing the effect that this arrival has on airfares and the spillover effects on nearby airports

(Morrison, 2001; Vowles, 2001; Daraban and Fournier, 2008). With respect to the effects on traffic, most of the studies (Donzelli, 2010; Graham and Dennis, 2010) analyse the impact of the arrival of an LCC by computing the overall growth in passenger numbers without analysing any possible collateral effects on the traffic of other companies.

This paper seeks to quantify the overall effect on commercial traffic by responding to the following question: given the evident increase that the arrival of Ryanair means for an airport's traffic which has been highlighted in the literature (Barrett, 2004; Francis *et al.*, 2004; York Aviation, 2007; Bel, 2009), how much of this growth can be directly attributed to Ryanair's own traffic, and what proportion can be attributed to the reaction of the other airlines at the airport to the arrival of said low-cost airline? For the other companies, the arrival of this low-cost company can have either a competitive or a catalyst effect — that is, be a stimulus that increases their volume of traffic — or it can have no effect whatsoever, or it can lead to a reduction in their traffic due to the substitution effect.

As described previously, the first effect, the competitive or catalyst effect, would be attributable to Ryanair having become a leading company in the European aviation sector. In some countries, like Spain, it is even the leading airline in passenger traffic. It should therefore be anticipated that when a leading company breaks into new markets/airports, it could raise the competitiveness of the other companies/airlines operating there and, especially, point the way (pull or knock-on effect) for others that were not operating in this market (generally, a regional or previously underutilised secondary airport) to follow them. With respect to increased competitiveness, this has been documented by Southwest. To be specific, according to Vowles (2001), the entry of Southwest can in some cases lead to other carriers lowering their fares to remain competitive, which stimulates more traffic. Gillen and Lall (2004) also state that fares fall prior to the arrival of Southwest at a new destination and this generates tremendous demand which also benefits other carriers. With regard to the possible pull effect, according to York Aviation (2007), Ryanair acted as a catalyst to further growth at Eindhoven airport by proving that low-fare services were sustainable, thus attracting new airlines. Generally, this competitive effect, in any of its forms, could also be supported by the increase in the appeal of the airport from the perspective of transfers on the back of Ryanair's new destinations.

With regard to the above-described substitution effect, this can in turn be one of two types: First, the arrival of Ryanair with connections to the main European cities, like London and Paris, can have an effect on the connections that already exist between the Spanish airports and destinations such as these which had previously been in the hands of the network carriers (NCs). Second, the introduction of new point-to-point destinations, especially in the case of regional airports, will reduce the number of flights to hubs like Madrid and Barcelona, which were previously an obligatory stopover point when travelling to the new destinations. This possible negative point, namely the fall in NCs traffic, has been condemned by Spanish travel agency associations protesting about non-returnable subsidies and other economic aid being granted to Ryanair and other LCCs by the public authorities (see Castillo-Manzano and López-Valpuesta, 2010). According to these associations, these substitution effects are especially detrimental to conference tourism (see Castillo-Manzano *et al.*, 2011).

Both the total direct and indirect effects of Ryanair need to be measured from the point of view of transport policy for local and regional public administrations to assess the increasingly frequent and higher economic compensation that the company demands to operate in regional airports both in Spain (see Castillo-Manzano *et al.*, 2011) and in the rest of Europe.

Methodologically, this study uses an econometric model to estimate the net quantitative impact of the arrival of this airline on the main traffic at Spanish airports in line with other studies (Pitfield, 2007, 2008).

The major advantage of the proposed methodological approach is that it can be easily extrapolated to other airport systems to measure the effects that the arrival of any new airline, be it an LCC or an NC, would have on the other airlines at the various airports.

The article is organised as follows. Section 2 lays out the data and presents the methodological approach. Section 3 presents the empirical results, while Section 4 includes the discussion of these findings and, finally, Section 5 presents the conclusions of the study.

2.0 Data and Methods

The Spanish airports analysed in this study were chosen for having achieved Ryanair traffic figures of over 400,000 passengers in 2008. Four of the ten airports in the sample were in the list of the top fifty busiest airports in Europe in 2008, specifically Madrid-Barajas (fourth), Palma de Majorca (thirteenth), Málaga (thirty-second), and Alicante (forty-first). When we add the case of Barcelona (ninth), where Ryanair started operating in the autumn of 2010, to these airports, it can be seen that, unlike in other countries, Ryaniar operates at the major hubs in Spain, not only at secondary or regional airports. This is due both to Spanish airport charges being low and to the fact that there are no great differences between these charges at the various airports, whatever their size.[1]

The total effect of Ryanair's arrival on the above-mentioned airports to December 2008 will be split into a direct effect and an indirect effect:

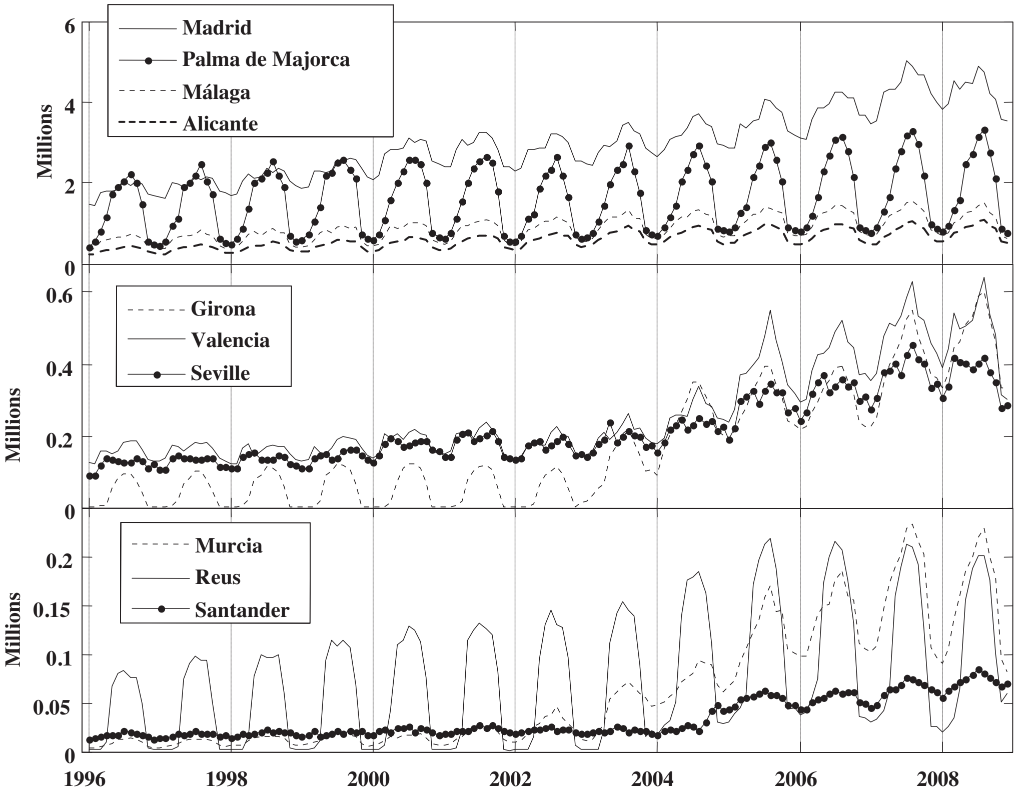
1 The direct effect is the effect that the literature has traditionally measured — that is, the percentage represented by Ryanair traffic out of the total traffic at the airport (see equation (1)). $TR_{i,t}$ = Ryanair traffic at airport i during month t and $TT_{i,t}$ = total traffic at airport i in month t (see Figure 1). Finally, l is the month that Ryanair began to operate at airport i and N is the number of observations:

$$DE_i = \frac{\sum_{t=l}^{N} TR_{i,t}}{\sum_{t=l}^{N} TT_{i,t}} 100. \tag{1}$$

[1]For example, the airport charge for domestic and European Union flights at Barcelona airport's spectacular new terminal was €6.12 per tonne (10–100 tonne aircraft), while at Barcelona's secondary and most distant airports, Reus and Girona, the charge stood at €5.55 — that is, only 10 per cent less. Nevertheless, new charges have come into force in 2011 with greater discrimination according to airport size.

Figure 1

Millions of Air Passengers (Per Month) at the Ten Spanish Airports Considered



2 The indirect effect, often ignored by previous studies, will comprise two entries, which will be aggregated for their estimation. These entries are the competitive or catalyst effect on other airlines, with a positive sign, and the substitution effect on other airlines — NCs in the main — with a negative sign. The substitution effect can be caused both by Ryanair offering connections which had previously been offered by other airlines and also by the company's new destinations, which reduce traffic to national hubs like Madrid and Barcelona. The data used to measure the indirect effects of Ryanair on airport *i* can be divided into three groups:

(A) The endogenous variables will be the monthly air traffic, without considering Ryanair traffic, at the ten Spanish airports included in the study; this is residual traffic. The available time series spans from January 1996 to December 2008 are taken from AENA yearbooks (source: www.aena.es).

(B) The exogenous variables, separated into two groups, are as follows:

(B.1) **Dummy exogenous variables:** a wide range of variables are included in models to estimate a number of intervention variables and outlier effects seen in the data. The most important, with their definitions, are as follows:

(B.1.1) **Easter:** Air traffic around this holiday period is especially intense in Spain. Indeed, it is considered to be high season for tourists, among other reasons due to the numerous celebrations of the passion of Christ. Accordingly, the moveable feast of Easter variable is defined by assigning different weights to the days in question depending on the expected traffic density at Spanish airports (these weights have to add up to one). Maximum weights are assigned to Wednesday, Thursday, Easter Sunday, and Monday. Weights of zero are assigned to the rest of the days.

(B.1.2) **Business:** Monthly time series that are totals of daily activities can be influenced by each calendar month's weekday and weekend composition. This variable is introduced to take into account the differences among months regarding the proportion of weekdays with respect to weekends. It is constructed as the number of business or trading days with respect to weekend days and holidays in each individual month — that is, the number of business or trading days minus the number of Saturdays and Sundays multiplied by 5/2. Extra holidays in each month are subtracted from the business days.

(B.1.3) **Leap:** Addresses the leap year effect. The value is 1 when February contains 29 days, and 0 otherwise.

(B.1.4) **9/11:** The negative effect on air traffic that resulted from the 9/11 terrorist attacks which, as found in earlier studies (Inglada and Rey, 2004), also had a significant effect on the Spanish airport system. The duration of these effects in number of months has been determined empirically by estimating successively models in which this effect have increasing durations from one to six years and choosing the model with the best fit.

(B.1.5) There are other outliers, often related to bad weather conditions, covert strikes by air-traffic controllers, or even the opening of new air terminals like Terminal T4 at Madrid-Barajas airport (LST4). These have all been detected by statistical tools. The procedure to search for such outliers consists of selecting the residuals outside four times standard deviation and including them as potential candidates in the models under different specifications (see the methodological section below). The outliers are included in final models with the specification that provides the best fit when they are statistically significant.

(B.2) **Economic activity:** The literature argues that economic activity is closely linked to air traffic as a result of which it is generally included as an indicator when modelling air traffic (see Inglada and Rey, 2004). In this article, economic activity is represented using a Spanish Ministry of the Economy and Treasury synthetic economic activity index (source: http://serviciosweb.meh.es/apps/dgpe/default.aspx).

(C) **The Ryanair indirect effect:** This effect has been split into two terms for testing: (i) one constant for the periods when Ryanair was operating at each airport, measuring the shock it produces (called 'Ryan Shock' afterwards); and (ii) mean corrected Ryanair traffic, measuring how the dynamics of Ryanair traffic affect the overall dynamics at a given airport and any possible lags for this variable ('Ryan Dynamic'). There were four cases (Girona, Reus, Murcia, and Santander) where the previous procedure had to be refined in order to find appropriate models. Ryanair has a dominant position at these four airports that would explain the structural changes that have been detected after Ryanair commenced operations, resulting in the need for special treatment in these cases (see details below).

The time series models employed in the analysis are in the class of discrete time linear Transfer Function models (see Castillo-Manzano *et al.*, 2010, for an analysis of the advantages of this methodology on transportation research studies). The general formulation may be expressed as in equation (2):

$$y_{i,t} = \sum_{j=1}^{h} \frac{\omega_{n_{i,j}}(B)}{\delta_{m_{i,j}}(B)} u_{i,j,t} + N_i(B) e_{i,t}, \tag{2}$$

where $y_{i,t}$ are the air passenger total data for the ith airport excluding the Ryanair passengers; $u_{i,j,t}$ are the inputs on which the output data depend (most of them deterministic, with the sole exceptions of the economic cycle and part of the Ryanair indirect effect, see the list above); $e_{i,t}$ is a zero mean and constant variance Gaussian white noise; $\omega_{n_{i,j}}(B) = (\omega_{i,0} + \omega_{i,1}B + \cdots + \omega_{n_{i,j}}B^{n_{i,j}})$ $(j = 1, \ldots, h)$ are polynomials in the backshift operator (that is, $B^k y_t = y_{t-k}$) that may have leading zero coefficients when a pure time delay is necessary; and $\delta_{m_{i,j}}(B) = (1 + \delta_{i,1}B + \cdots + \delta_{m_{i,j}}B^{m_{i,j}})$ $(j = 1, \ldots, h)$ are stationary or stable polynomials.

It is important to include a specific comment on the Ryanair input variables introduced in equation (2). Broadly speaking, the input variables linked to the Ryanair indirect effect are: (i) 'Ryan Shock': one step variables with zeros before Ryanair commenced operation, and ones after the company had commenced operation; and (ii) 'Ryan Dynamic': Ryanair traffic minus its mean level during the period of operation. However, although this would be the general way that the airports are treated, there are four airports that behave in a special way given the dominant role played by Ryanair in their traffic. These are the aforementioned cases of Girona, Reus, Murcia, and Santander. As such, the standard method used for handling the Ryanair indirect effect by dividing it into 'Ryan Shock' and 'Ryan Dynamic', as in the cases shown in Table 1, was inadequate for these four airports. By way of example, Figure 2 shows the special case of Girona and compares variable $y_{i,t}$ (that is, the total number of passengers excluding Ryanair) with Ryanair traffic at Girona airport (where Ryanair commenced operations in December 2002).

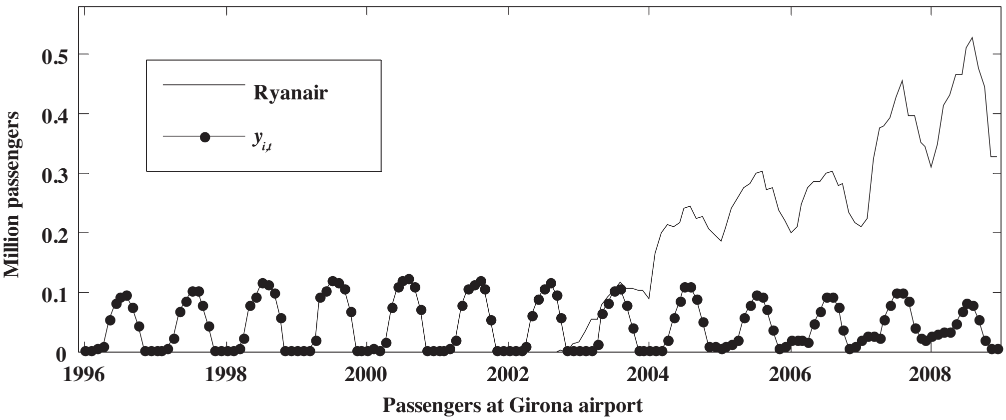
It is clear that the total effect of Ryanair is enormous in this case, since, to put it in simple terms, Ryanair traffic is greater than all the other flights together and is on the increase. The importance of Ryanair at Girona even affects the dynamics of the traffic there as, after Ryanair started to operate in Girona, the tendency that was seen was for numbers of non-Ryanair passengers to decrease during summer (peaks), while they tended to increase during winter (troughs). This suggests that Ryanair flights have different and opposing effects in winter and in summer (although it will be shown below

Table 1
Estimation Results for Univariate Models with Intervention Variables

	Madrid-Barajas	*Alicante*	*Valencia*	*Málaga*	*Palma de Majorca*	*Seville*
Easter	0.032***	0.035***		0.052***	0.088***	
Business		−0.003***		−0.007***	−0.005***	
Leap	0.021**	0.044***		0.035***		
9/11	−0.056***	−0.044***	−0.071***	−0.052***	−0.077***	−0.118***
	(20)	(13)	(20)	(19)	(14)	(28)
Cycle	1.845***	1.732***	1.966**B	1.168**	2.109**B	2.523***B^4
Ryan Shock	−0.158**	−0.035*	0.079**	0.048***–0.061***B	0.085***–0.087***B	0.077**B
Ryan Dynamic	0.119***		0.036*	−0.014***B^3		
AO97JUN		−0.044**				
AO97DEC				−0.063***		
AO98APR			0.165***			
AO98JUN						−0.061**
AO99NOV	0.062***					
AO99DEC		−0.044**		−0.037**		
AO00MAR	0.048***			0.065***		
LS03JAN		0.041**				
AO03MAY						0.172***
LST4	0.058***					
LS08NOV		−0.092***		−0.135***		
MA1	−0.202**	−0.666***	−0.240***	−0.559***	−0.568***	−0.152**
MA2						−0.192**
MA12	−0.474***	−0.392***	−0.312***			−0.463***
MA24			−0.294***			
σ^2	0.468	0.797	2.282	0.787	1.855	1.897
Q(12)	4.432	19.142	3.775	12.281	19.577	10.935
Q(24)	15.062	27.949	9.094	28.466	33.701	22.001
Bera-Jarque	5.805	0.428	1.277	0.3077	0.0042	0.332
	(0.054)	(0.807)	(0.528)	(0.857)	(0.997)	(0.847)

Note: Significant at *10 per cent, **5 per cent, and ***1 per cent levels, respectively. σ^2 stands for the innovations variance; Q(12) are the Ljung–Box Q statistics for 12, respectively; Bera-Jarque is a normality test (*P*-values in brackets); *H* is a variance ratio homoscedasticity test (*P*-values in brackets). The number of months that the 9/11 effect lasted is given in brackets after the coefficient for the variable.

Figure 2
Million Passengers (Per Month) at Girona Airport



that the summer effect is in fact insignificant, since it would seem that the summer declines had started before Ryanair commenced operations at the airport — see Table 2). For this reason, winter and summer are estimated as separate effects in the model (see new variables Sum## and Win## in Table 2, where '##' stands for the last two digits of the year).

Traffic at Reus airport was seen to follow a similar behaviour, perhaps due to the fact that before Ryanair arrived at these airports, both were only used during the summer season (mainly as operating bases for charter flights to the Catalonian coast).

Similarly, the regional airports in Murcia and Santander also have to address Ryanair's dominant position, as a result of which the Ryanair indirect effect has had to be adapted to the structural changes produced by the company after its arrival. Specifically, the Ryanair indirect effect at both of these airports was divided into several empirically identified steps (see Table 2, fourth column, third row). Specifically, for Murcia airport three different steps were found (February 2005 to February 2007, March 2007 to October 2007, and November 2007 onwards), while at Santander airport, only two steps were needed (March 2005 to February 2007 and March 2007 onwards).

To summarise, the Ryanair indirect effect ($H_{i,t}$) would be the addition of the Transfer Function terms in (2) that have links with the Ryanair variables. In most cases it will be just two terms, the shock and the dynamic effects ('Ryan Shock' and 'Ryan Dynamic' as defined above and shown in Table 1), that is:

$$H_{i,t} = \sum_{j \in \text{Ryanair}}^{n} \frac{\omega_{n_{i,j}}(B)}{\delta_{m_{i,j}}(B)} u_{i,j,t}. \qquad (3)$$

The general representation of the noise model $N_i(B)e_{i,t}$ in (2) is an $ARIMA(p_i, d_i, q_i) \times (P_i, D_i, Q_i)_{12}$ formulation shown in equation (4):

$$N_i(B)e_{i,t} = \frac{1}{(1-B)^{d_i}(1-B^{12})^{D_i}} \frac{\vartheta_{q_i}(B)}{\phi_{p_i}(B)} \frac{\Theta_{Q_i}(B^{12})}{\Phi_{P_i}(B^{12})} e_{i,t}. \qquad (4)$$

Table 2
Estimation Results for Univariate Models with Intervention Variables

	Girona	*Reus*		*Murcia*	*Santander*
Easter		0.511***	Easter	0.057***	
Business			Business	−0.006***	0.004***
Leap		−0.335***	Leap		
9/11	−2.047***/(1−0.651***B)	−0.349***	11S		−0.063*
		(6)			(25)
Cycle	1.874*	2.274***	Cycle	3.793**	2.382**B
Ryan Sum04		−0.473***	LS05FEB–07FEB	0.259**	
Ryan Sum05		−0.877***	LS07MAR–07OCT	0.410***	
Ryan Sum06		−1.257***	LS07NOV	0.362**	
Ryan Sum07		−1.416***			
Ryan Sum08		−1.334***	LS05MAR–07FEB		0.166**
Ryan Win03	−0.327*		LS07MAR		0.297***
Ryan Win04	−0.727***	0.942***			
Ryan Win05	0.772***	0.292**			
Ryan Win06	1.086***				
Ryan Win07	1.173***	−0.561***			
Ryan Win08	1.744***	−1.428***			
Ryan Win09	1.082**	−1.137***			
Ryan Dynamic		0.782***			
AO99NOV	−1.019***		AO99DEC	−0.191***	
AO00MAR		0.928***	AO02AUG	0.180***	
MA1			MA1	−0.509***	
MA12		−0.706***	MA12		−0.847***
AR1	−0.484***		AR1		0.471***
AR12	0.292***		AR12		0.334***
σ^2	87.41	52.428	σ^2	11.041	4.831
Q(12)	6.913	10.464	Q(12)	8.381	12.750
Q(24)	23.748	18.418	Q(24)	20.471	28.548
Bera-Jarque	2.867	6.112	Bera-Jarque	2.642	0.920
	(0.238)	(0.047)		(0.267)	(0.631)

Note: Significant at *10 per cent, **5 per cent, and ***1 per cent levels, respectively. σ^2 stands for the innovations variance; Q(12) are the Ljung–Box Q statistics for 12, respectively; Bera-Jarque is a normality test (*P*-values in brackets); *H* is a variance ratio homoscedasticity test (*P*-values in brackets). The number of months that the 9/11 effect lasted is given in brackets after the coefficient for the variable.

Here $(1-B)$ and $\left(1-B^{12}\right)$ are differencing operators necessary to reduce the time series to mean stationarity; $\phi_{p_i}(B)=\left(1+\phi_{i,1}B+\phi_{i,2}B^2+\cdots+\phi_{i,p_i}B^{p_i}\right)$ and $\Phi_{P_i}\left(B^{12}\right)=\left(1+\Phi_{i,1}B^{12}+\Phi_{i,2}B^{24}+\cdots+\Phi_{P_i}B^{12P_i}\right)$ are stationary polynomials in the backshift operator; $\vartheta_{q_i}(B)=\left(1+\vartheta_{i,1}B+\vartheta_{i,2}B^2+\cdots+\vartheta_{i,q_i}B^{q_i}\right)$ and $\Theta_{Q_i}\left(B^{12}\right)=\left(1+\Theta_{i,1}B^{12}+\Theta_{i,2}B^{24}+\cdots+\Theta_{Q_i}B^{12Q_i}\right)$ are invertible polynomials.

The identification of order models for the ARIMA part (3) was done by means of the Simple and Partial Autocorrelation Functions (ACF and PACF, see Box *et al.*, 1994). The Transfer Function orders in equation (2) were identified by selecting the models that minimised the Schwarz Information Criterion. Estimation was carried out by Exact Maximum Likelihood in MATLAB, with the help of the ECOTOOL toolbox (Pedregal *et al.*, 2012).

One important part of this study was the treatment of outlier observations. For this, automatic detection algorithms were used, also implemented in ECOTOOL (Pedregal *et al.*, 2012). The type of outliers that were detected on the endogenous variables in this paper are of two types: a sudden change positive or negative known as an Additive Outlier (coded later on as AO) and a sudden change that persists in time, known as a Level Shift (LS).

Finally, the total effect for airport *i* will be obtained by aggregating the direct and indirect effects at said airport according to the following expression:

$$TE_i = \frac{\sum_l^N (TR_{i,t} + H_{i,t})}{\sum_l^N TT_{i,t}} = \frac{\sum_l^N TR_{i,t}}{\sum_l^N TT_{i,t}} + \frac{\sum_l^N H_{i,t}}{\sum_l^N TT_{i,t}} = DE_i + IE_i\,, \tag{5}$$

where $H_{i,t}$ is the measurement of the indirect effect — that is, the effects caused by Ryanair on the traffic of the other airlines generally measured by the two types of variable described above, which in the standard form will be:

$$H_{i,t} = \sum_k \hat{\gamma}_k \varepsilon_{l+k-1}^{\text{from } l \text{ to } N} + \sum_{k+h} \hat{\gamma}_{k+h} TR_{l+h-1}. \tag{6}$$

To summarise, as $IE_{i,t}$ can be either positive or negative, the total effect can be greater or smaller than, or equal to, the direct effect. It will always be equal when the estimations of the coefficients that measure the Ryanair indirect effect are not significant. It will be greater (smaller) when the Ryanair competitive or catalyst effects are higher (lower) than the substitution effect on the NCs.

3.0 Results

Ten models have been estimated with the different explanatory variables. Tables 1 and 2 show the estimated parameters of the intervention variables for each equation in the ten models. Both tables have the same format:

(i) the input variables in the first block are dummy variables dealing with moveable festivals, the 9/11 effect and the economic cycle effect;
(ii) the second block concentrates on the Ryanair indirect effect, divided as corresponds for each airport;
(iii) the third block contains a set of dummy variables whose names indicate the type of outlier (two letters), the year (two digits), and the month (last three letters);
(iv) the fourth block corresponds to the parameters of the ARIMA part of the model; and
(v) the final block includes additional tests of residuals in order to check model appropriateness.

As was explained in the previous section, Table 1 shows the standard estimations for airports where Ryanair is not the dominant airline. Meanwhile, Table 2 gives individualised estimations at airports which had marginal traffic before the arrival of

Table 3
Total, Direct, and Indirect Effects of the Arrival of Ryanair on the Ten Airports Analysed

	Direct effect (%)	*Indirect effect (%)*	*Total effect (%)*
Madrid-Barajas	2.6	6.2	8.8
Alicante	9.8	−2.8	6.9
Valencia	15.2	11.5	26.7
Málaga	1.7	−1.5	0.2
Palma de Majorca	1.8	0.2	2.0
Seville	8.6	6.7	15.3
Girona	86.0	−3.1	82.9
Reus	43.1	−28.8	14.4
Murcia	43.7	15.1	58.8
Santander	46.1	10.5	56.6
Mean of absolute values	25.9	8.6	27.3
Standard deviation	27.9	8.5	28.6

Ryanair but where this company now has a dominant position, bordering on a monopoly in some.

Finally, Table 3 presents the different effects for each of the airports included in the study. These are the mean effects during the period analysed from the arrival of Ryanair to the end of 2008. Obviously, the intensity of these effects varies over time, depending on how traffic varies.

4.0 Discussion

When taken as a whole, the results presented in Tables 1, 2, and 3 provide a clear view of the effects caused by Ryanair on the Spanish airport system, both at international hubs (Madrid), regional hubs (Palma de Majorca, Málaga, and Alicante), secondary airports (Reus and Girona), and regional airports (Seville, Valencia, Murcia, and Santander). In general terms, the total effect can be seen to be significantly positive with the sole exception of Málaga, where it is insignificant. However, the different size of the total effect, from 0 per cent to 83 per cent, provides a set of relatively heterogeneous case studies.

With regard to the indirect effects, what is striking is the high mean value with an absolute value of 8.6 per cent. Moreover, they are positive at most of the airports, at six to be specific, which means that the competitive or catalyst effects of Ryanair predominate over other companies, primarily over those with a similar business model — that is, LCCs — rather than the substitution effects on NCs.

The case of Madrid merits special mention. It is one of the few international hubs at which Ryanair operates in continental Europe. Ryanair's arrival at the airport in November 2006, and its recent establishment in Barcelona, in September 2010, is due in the main part to the low airport fees charged compared to other European airports of a similar size, which makes these hubs compatible with the LCC management model. Said low charges could not be justified in these airports' accounts — both are currently running at a loss — so we may be talking of covert subsidies to air transportation which favour, among other things, one of the country's main strategic sectors, tourism (Spain is currently one of the premier tourism destinations in the world).[2]

What is true is that when presented with this new business opportunity of operating at intercontinental hubs, Ryanair has responded with an even more aggressive strategy, setting up multiple routes in a short space of time. In Madrid, for example, almost four years after beginning to operate there, the company operates forty-four routes, whereas in Barcelona, only one month after initiating operations, it has already programmed twenty-three different routes. The Madrid results show that this strategy is mutually beneficial; for the airport also as it gains an indirect effect which is almost two and a half times that of the direct effect, 6.2 per cent of all airport traffic, to be specific. This new commitment to LCCs therefore translates into a significant percentage of traffic in an adverse economic environment. Thus, if we compare the total traffic share for all LCCs at Madrid airport during the quarter prior to Ryanair's introduction with the same quarter two years later, an increase can be seen from 5.6 per cent to 10.2 per cent without Ryanair traffic being considered, rising to 13.5 per cent when Ryanair is considered. Specifically, the other LCCs experienced an 84.2 per cent increase in their traffic during those two years, while the NCs and charter airlines saw an average fall in traffic of 4 per cent.

One collateral effect of this new strategy of operating at hubs will be seen at the airports at Reus and Girona in the short term. To date these have played the role of secondary airports to Barcelona and, according to the findings of this study, can be seen to have an overwhelming dependence on Ryanair. Furthermore, the commitment to Ryanair, supported by not insubstantial subsidies (see Bel, 2009, for the case of Girona), seems to have resulted in incompatibilities with other airlines, and these airports are the two that present the highest negative indirect effects, which indicates the extent to which they have depleted their potential for growth with other airlines. Be that as it may, a distinction must be made between Reus' −28.8 per cent and Girona's −3.1 per cent. The lesser negative effect at the latter of the two airports may be due to the large number of new routes that Ryanair has set up in Girona, sixty-four compared to twenty-eight in Reus. This makes Girona much more attractive as an airport where stopovers can be made en route to other Spanish and European airports.

Even so, it does not seem possible to extrapolate the conclusions for Madrid airport to other regional hubs which specialise in sun-and-sand tourism, with their associated charter flights — that is, Málaga, Alicante, and Palma de Majorca (8.9 per cent, 11.3 per cent, and 20.6 per cent, respectively, of charter flight passengers on average in 2008). At these airports the indirect effect turns into a substitution effect, and not a multiplying effect, as is the case in Alicante and Málaga, or is simply insignificant, as is the case in Palma de Majorca. Therefore, the Ryanair total effect at best is limited to its own traffic (Palma de Majorca) or, in the worst case scenario — Málaga — is not significant.

Finally, in the last group, the regional airports, a distinction must be made between those that enjoyed a significant amount of traffic before the arrival of Ryanair, such as

[2]According to the UNWTO (2009), France is the first country considering the number of tourist arrivals, followed by the United States and Spain. According to international tourism revenues, the same three countries are in the first three places, but with the United States in first place, Spain in second, and France in third place.

Valencia and Seville, and those that were completely underutilised infrastructures, such as Murcia and Santander (Francis *et al.*, 2004, cite the existence of approximately 200 airports in Europe that can be classed as underutilised). In both categories the effects are entirely positive although the dependence is much greater in the second case, where Ryanair is responsible, either directly or indirectly, for a percentage of total traffic approaching 60 per cent.

In other respects, the proportionality that exists between the direct and indirect effects in Seville and Valencia is striking, specifically 78 per cent and 76 per cent, respectively. Furthermore, in both cases the indirect effect allows the corresponding direct effect to be multiplied, basically with the arrival of other low-cost airlines.

Thanks to the additional variables used, other results can be drawn that complement the findings of the study. For example, the effect of the 9/11 terrorist attacks was felt much more at urban airports like Madrid (twenty), Seville (twenty-eight), or Santander (twenty-five) than at sun-and-sand related airports with charter flights like Alicante (thirteen) and Reus (six).

5.0 Conclusions

The primary objective of this paper is to provide and test an advanced time series approach that allows both the direct and indirect effects of the incorporation of a new airline at an airport or in an airport system to be measured. This approach is sufficiently flexible for it to be adapted to any case as long as sufficiently broad time series are available, which is relatively easy in air transport.

This methodological proposal has been tested for a specific case, the incorporation of Ryanair into the Spanish airport system. The relevance of this case study is justified both by the significance of the airline itself, Ryanair, and by the transport policy debate that the company's arrival tends to bring with it. Specifically, an instrument is offered that uses the basis of results at similar airports to provide help to local and regional administrations in the hinterland of any given airport to take clear decisions on whether to submit to the airline's initial economic demands. Also, at a later date, it allows the effects on the airport itself to be estimated and so to judge whether maintaining these subsidies over time is profitable, as the airline also demands.

This debate needs to be clarified if the ever greater amounts in the form of subsidies demanded by the airline are taken into account. According to estimations by the Air France–KLM air group, cited in the French newspaper, *Le Figaro*,[3] Ryanair receives in all of Europe 660 million euros in subsidies annually, the equivalent of 11 euros per passenger (specifically at the Catalonian airports of Girona, Reus, and especially Lleida, Ryanair receives over 8.5 million euros per year from public and private subsidies).[4]

Compared to earlier studies that only stress the growth that has occurred in the overall traffic at an airport after the arrival of an LCC, the need for this more complex

[3]See www.lefigaro.fr/societes/2010/03/11/04015-20100311ARTFIG00389-air-france-veut-porter-plainte-contre-ryanair-.php.

[4]See www.elpais.com/articulo/cataluna/milagro/amenaza/elpepiespcat/20100823elpcat_7/Tes.

focus, which splits the growth into direct and indirect effects, is evident due to the size of the latter. Specifically, the mean indirect effect, in absolute value, is 8.6 per cent of the total airport traffic, peaking at a maximum of almost 29 per cent. The fact that the indirect effect is only negative at four of the ten airports analysed might also be an indication of a degree of overvaluation of the substitution effects that Ryanair, in theory, has on other airlines. So, although there is clear evidence that these effects might occur on occasion both at Spanish airports and in other countries (see, for example, Pitfield, 2007), this cannot be used as a general argument by Spanish travel agency associations against Ryanair (see Castillo-Manzano *et al.*, 2011). Conversely, at five of the airports analysed, clear competitive or catalyst effects seem to exist for the other airlines.

Two cases have been differentiated between the methodological proposal. First, for the majority of the airports where the arriving airline has a significant but not dominant (in our case, up to 15 per cent) mean weight (direct effect), the measurement of the indirect effects can be taken using a standard procedure based on two terms. Specifically, a constant from the incorporation of the new airline and another variable and its possible lags have been used (and could be used for other cases) that record the effects of the arriving airline's dynamic over other traffic.

The results of this, when applied to the Spanish airport system, show that the majority of the airports, especially in urban areas not specialised in sun-and-sand tourism charter flights,[5] have benefited from some positive effects of Ryanair beyond said company's own traffic, especially at airports that were greatly underutilised before the arrival of the airline.

Although a focus was chosen in which the results are measured with relative values as percentages of total traffic type, the different scales of the airports should not be forgotten. As such, the 6.2 per cent indirect effect at Madrid-Barajas, despite not being among the highest values and even somewhat under the average (8.6 per cent), is especially relevant. This 6.2 per cent implies that after the arrival of Ryanair, and during the following 14 months, said airline would be indirectly responsible for almost 7 million passengers. This result is clear empirical proof of the viability of the low-cost model at large intercontinental hubs as long as they have excess leisure capacity, as did Madrid-Barajas in this case, after the opening of terminal T4, and as long as the airport charges are not high.

Second, at airports where Ryanair is in a dominant position with a market share or direct effect of over 40 per cent, a more individualised focus that takes into account the profound changes that such huge dependence might have on the overall traffic structure at these airports was opted for. In this regard, estimations justified by a prior automatic outlier detection process have been made at Reus and Girona airports, which are used by Ryanair as secondary airports for Barcelona, of the differentiated effects that Ryanair has caused on the traffic during the winter and summer seasons since the airline's arrival there. Broadly speaking, the effects on the summers have been negative and on the winters, positive. This could be explained by the fact that before Ryanair's arrival, both airports were underutilised, and were basically used in summer as operational bases for

[5]The negative influence of Ryanair and of LCCs in general on the traditional charter markets has been studied in Williams *et al.* (2001) and Vera and Ivars (2009).

charter flights to the Catalonian coast (83.7 per cent of flights at Girona and 92.2 per cent at Reus were charter flights in 2002, before the arrival of Ryanair at Girona in December of that same year).

The large negative indirect effect at Reus of almost 29 per cent must be highlighted. This is a clear example of the incompatibility of the Ryanair model with other airlines which, therefore, increases the dependence of the receiving airport on said company. This result is especially relevant if it is taken into account that Ryanair has commenced operations at Barcelona, which raises serious questions about the future of traffic at Girona and Reus.[6]

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[6]At a press conference, Ryanair stated that in the wake of its commencing operations out of Barcelona airport, it will reduce flights at Girona by 36.8 per cent and at Reus by 15.2 per cent if AENA does not lower charges for airlines at smaller airports.

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