ANALYSIS OF AIR PASSENGER TRANSPORT IN EUROPE

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ABSTRACT

This article presents a set analysis of European airlines. The main results reveal that ARIMA models have better performance than the Holt-Winters method in time series of Revenue Passenger Kilometres in nineteen airlines members of the Association of European Airlines (AEA). Only seven airlines have been influenced by the September 11th terrorist attack, SARS and the ash crisis, while none of the analysed airlines has been influenced by the economic crisis that began in 2008. The results obtained might suggest, on the one hand that airlines can find the flexibility to meet demand, despite their difficulty to adjust capacity. On the other hand, given the heterogeneity of resources and flight destinations, the business environment does not affect the airlines in the same way or with the same intensity.

Keywords: ARIMA models, impact analysis, intervention

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1. INTRODUCTION

The air transport industry in general and in Europe in particular has been under significant pressure that has influenced the activity and the efficient management of resources. Major events that have happened since the late 1990s to the present year, period covered by this investigation, were as follows (Franke & John 2011):

i) September 11th 2001 terrorist attacks in the USA. The literature on the subject has taken two distinct views (Lai and Lu 2005). One view is that the effect of September 11th was severe, widespread and immediate with airlines and tourism industry being particularly badly affected. The other view is that before September 11th, passenger traffic was already showing a downward trend, price wars were accelerating, and new competitors were taking business from legacy hub-and-spoke carriers and thus the terrorist attack only exacerbated these problems;

ii) Two important events also took place in 2002 and 2003. The appearance of low cost airlines was for instance able to win around 22 million new passengers (at a time of a slight overall market decline) and the pandemic threat of SARS in 2003;

iii) The ash crisis, due to the Icelandic Eyjafjallajökull volcano eruption in April and May 2010, which left stranded more than 1.3 million and resulted in the airspace closure of Belgium, Ireland, United Kingdom, Denmark , Estonia, Finland, Hungary, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Romania, Sweden and Switzerland;

iv) The financial crisis that began in 2008.

As discussed by Hatty and Hollmeier (2003), when demand declines, capacity cannot be adjusted immediately due to the insufficient flexibility. Load factors decrease and therefore unit costs per revenue passenger increases. In their need to fill the empty seats, airlines start market share wars with significant cuts in tickets prices (and yields).

The aim of this paper is twofold. First, we propose a mechanism based on time series models, to monitor and control the behaviour of the series of revenue per passenger (RPK in million €) in 19 European airlines on a monthly basis during the period 1999-2011. To do this we made a comparison between ARIMA and Holt-Winters models. Second, an intervention analysis is performed to estimate the effect of the above events. For this purpose, a comparative study is conducted to assess whether the intervention analysis effectively accounts for the above mentioned effects (September 11th, SARS, Ash crisis and Economics crisis) in the behaviour of the series. These objectives are relevant, since the development of predictive models and the influence of exogenous variables in the airline industry could enable managers to take into consideration some aspects and to help them make strategic decisions in relation to managing resources and capabilities.

2. DATA AND METHODOLOGY

2.1 Data

To achieve the stated objectives, we use data from the monthly series of the Association of European Airlines (AEA) in terms of Revenue Passenger Kilometres, RPK) of AEA member airlines for the period 1999/01-2011/04. We analysed 19 of the 32 airlines[1] that make up the AEA. Table 1 shows some characteristics of the airlines studied. For example, 57.8% (11 carriers) are privately owned of which nine (i.e. AF, BA, FI, IB, JP, KLM, LH, OS, OU) are 100% private. 36.8% are owned partially or fully (as in the case of TAP) by their respective state.

Table 1: Main Features of the Sample Airlines

	Traffic			Investment (mil.€)		Fleet			Ownership	
Airlines	Employ	RPK Prog.	RPK (%)	Income	EBITDA	Airbus	Boeing	Others	Public	Private
AF – A.France[1]	106933	131657	2.3	23970	-129	194	74			100
AY - Finnair	8797	15567	-6.8	1838	-124	55	7	21	72	28
BA - British A.	39610	111995	-3.2	7994	-281	103	171			100
BD – bmi[1]	4300	10325	6.2	1040	-99.7	32	1	18	50	50
CY - Cyprus A.	1226	3082	-8.8	248.9	-5.7	11			69.57	30.43
FI - Icelandair	2182	3405	-11.11	80321	1483	0	18[3]	0	0	100
IB – Iberia[3]	20671	49556	-6.2	4409	-464	109	34	0	0	100
JP - Adria A.[1]	719	1003	16.2	207.2	1.2	6	1	12		100
KL - KLM	34032	73472	-5.2	20994	-1285	12	160	55	0	100
KM – A Malta	1429[1]	2305[1]	3.3[1]	273.7[2]	-8.3[2]	12[1]			98[1]	2[1]
LG - Luxair	2282	483	2.4	378.5	1	0	4	12	48.66	51.34
LH - Lufthansa	117521	123083	-2.5	22283	96	246	132	170	0	100
MA - Malev A.	1333	3528	-13.2	351.1	-46.4	0	19	10	95	5
OK - Czech A,	4172	5813	-2.3	1078.5	-278.9	19	18	12	91.51	8.49
OS – Austrian[2]	7914[1]	16458[1]	-5.6[1]	2530.6	-312.1	21	20	60		100
OU - Croatia A	1131	1151	-5.4	183	-23	12	6		0	100
SK - SAS Sca.	17153	23241	-16.7	44918	-1311	21	108	53	52.1	47.9
TK - Turkish A	12750	38974	19.7	6881	752	97	77	0	49.12	50.88
TP - TAP Port.	6986	21076	-3.8	2239.9	47.7	55	0	16	100	0

Source: AEA and own elaboration, Notes: (1) Date 2008, (2) Date of Income and EBITDA 2007, (3) Date Boeing fleet 2006.

Considering the size of firms by the number of employees, larger airlines are LH and AF with 117,521 and 106,933 employees, respectively, while the smaller ones are JP and OU with 719 and 1,131 employees, respectively.

[1] Other companies such as Alitalia, LOT, SWISS, Brussels, etc have information from 2008, 2001, 2002, or 2003 respectively. With a considered period of 148 months results are regarded as robust.

Figure 1 (a and b) shows the growth rates path of revenue per passenger for the airlines under consideration. 'Growth rates' refer to current month compared to the same month in previous year; "RPK_TO" stands for total scheduled, that is, the sum of total international and domestic traffic (continuous line); "RPK_ET" includes all cross border/ international routes originating and terminating within Europe (including Turkey and Russia up to 55ºE), Azores, Canary Islands, Madeira, Cyprus (dashed line); "RPK_DO" stands for domestic traffic, defined as traffic carried on routes originating and terminating within the boundaries of a State by an air carrier whose principal place of business is in that State, or on routes between the State and territories belonging to it, or in the case of multinational airlines owned by partner States, traffic within each partner State should be reported as domestic and all other traffic as international (dashed line).

Figure 1a: RPK (Global, European and Domestic) Growth Rate 1999-2011

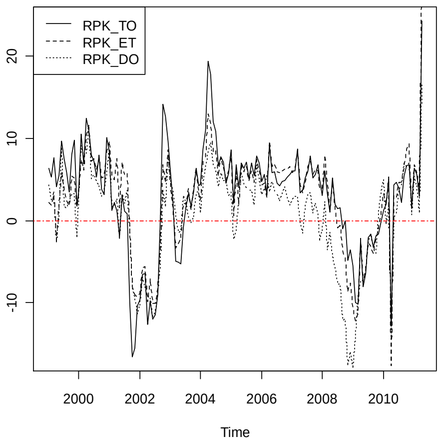
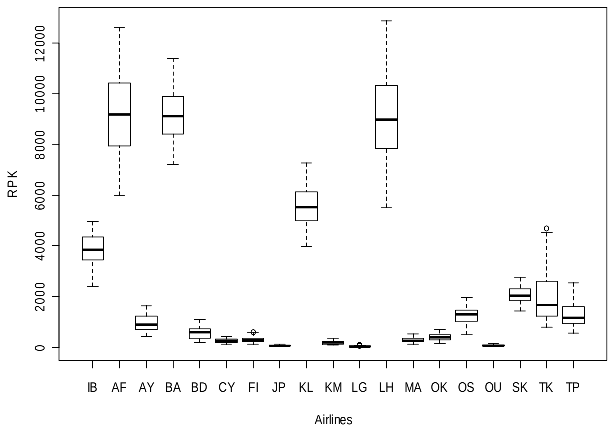


Figure 1b: RPK by Airlines boxplot



Source: AEA and own elaboration

2.2. Methodology

In this section we present the two models ARIMA forecasting and Holt-Winters (HW). As mentioned in Theodosiou (2011) ARIMA models are very popular in the literature for their robustness in modelling misspecification (Chen, 1997). For a review of time series models, see De Gooijer and Hyndman (2006). In the case of a non-seasonal *ARIMA (p,d,q),* the process is given by Athanasopoulos et al. (2011)

$$\O(B)(1-B^d)Y_t = c + \theta(B)\varepsilon_t \qquad [1]$$

Where $\{\varepsilon_t\}$ is a white noise process with mean zero and variance σ^2, B is the backshift operator, and $\emptyset(z)$ and $\theta(z)$ are polynomials of orders p and q respectively, d is the number of trend differences. Y_t is the observation at time t.

The seasonal ARIMA $(p,d,q)\ (P;D;Q)_m$ process is given by

$$\Phi(B^m)\emptyset(B)(1-B^m)^D(1-B)^d\, Y_t = c + \Theta(B^m)\,\theta(B)\varepsilon_t \qquad [2]$$

where $\Phi(z)$ and $\Theta\ (z)$ polynomials of orders P and Q respectively, each containing no roots inside the unit circle.

The main task in automatic ARIMA forecasting is selecting an appropriate model order; that is, the values of p, d, q, P ,D, Q and d. We use the automatic model selection algorithm that was proposed by Hyndman and Khandakar (2008).

A second alternative when analysing time series is called classical method of decomposition (HW). In this case it is usually considered that the series can be decomposed into some or all of the following components: a) strong, b) cyclical factor, c) seasonality d) irregular component. The statistical software used in this paper is the R language (R Development Core Team, 2010 and free to download from www.r-project.org). The forecast package (Hyndman, 2010) was used for implementation of the ARIMA and Holt-Winters methods.

The application of this method is based on a theoretical model that can be expressed as:

$$Y_t = (b_0+b_1)\ E_t + \mu_t \qquad [3]$$

where b_0 is the permanent component, b_1 the slope of the line and E_t is a multiplicative seasonal factor. The method raises three smoothing equations to estimate these components:

$$S_t = \alpha \frac{Y_t}{C_{t-L}} + (1-\alpha)\ (S_{t-1}+b_{1t-1}) \quad 0<\alpha<1 \qquad [4]$$

$$b_{1t} = \beta\ (S_t+S_{t-1}) + (1-\beta)\ b_{1t-1} \quad 0<\beta<1 \qquad [5]$$

$$C_t = \gamma \frac{Y_t}{S_t} + (1-\gamma)\ C_{t-L} \quad 0<\gamma<1 \qquad [6]$$

The predictions are made using the initial values and the constant values α, β and γ. The initial values required to start the recursive calculations are L+2, L corresponding to the previous year's seasonal factors, the first observation and the level and slope of period 0.

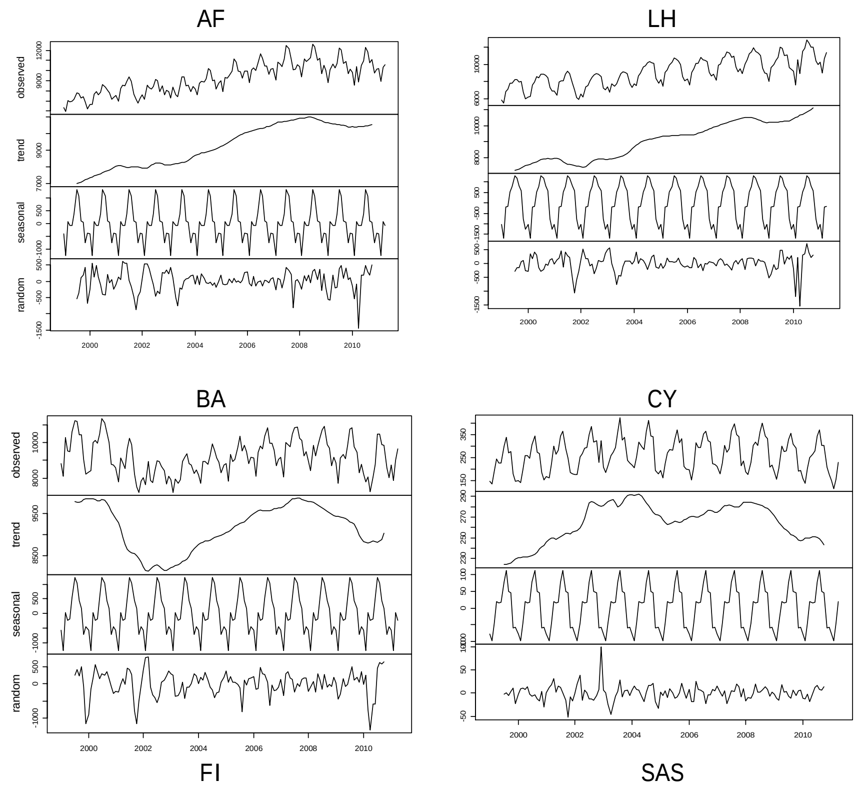
3. EMPIRICAL RESULTS

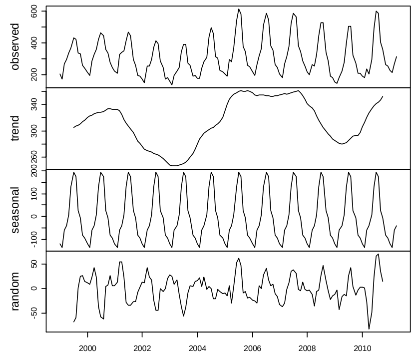
This section considers first ARIMA models for each airline; results will be compared with Holt-Winters decomposition. Second, we will analyse the influence of exogenous variables (e.g. September 11th effect, SARS, and economic crisis) in the time series. Finally, we made the predictions for year 1 from each of the series analysed.

3.1. ARIMA Models

Figure 2, shows the decomposition of eight series (the rest of the graphs are available upon request). These series have three different trend patterns. The time series of AF and LH airlines, show increasing trends (like the omitted series AY, IB, KL, OU, TK and TP). The time series of the airlines BA, CY, FI, OS and SK (like the omitted MA, OK, BD and JP) show different oscillatory trends. The time series of airline KM (like LG) shows a decreasing trend. Table 2 shows selected ARIMA models with the parameter estimates and statistical tests for each airline.

Figure 2: Results from Decomposition Procedure of the Eight Time Series





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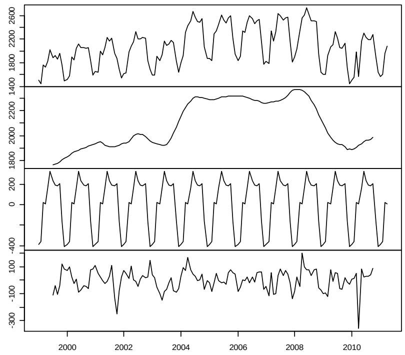
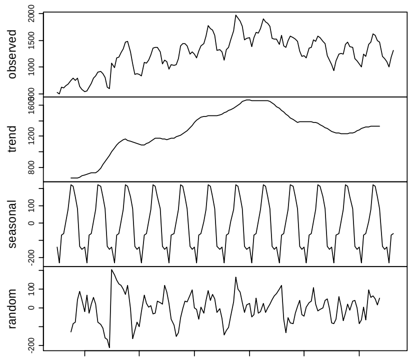
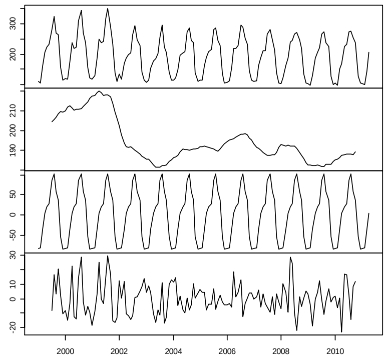


KM





Source: Own elaboration

Table 2: ARIMA Models

		Coefficients									Statistical test	
Airlines	ARIMA Model	Inter.	AR(1)	AR(2)	AR(3)	AR(4)	MA(1)	MA(2)	MA(3)	MA(4)	AIC	Log. Lik
AF	$(2,1,1)\ (1,1,1)_{12}$		-1.02	-0.33			0.789				2363.6	-1177.8
AY	$(0,1,1)\ (1,1,2)_{12}$						-0.192				1815.6	-905.8
BA	$(4,1,1)\ (2,1,0)_{12}$		0.576	0.007	0.174	-0.46	-0.852				2321.8	-1154.9
BD	$(4,1,1)\ (2,1,0)_{12}$		0.889	-0.04	-0.08	-0.29	-0.712				1574.6	-781.3
CY	$(1,1,1)\ (0,1,1)_{12}$		0.277				-0.213				1583.6	-788.8
FI	$(0,1,0)\ (0,1,1)_{12}$										1680.9	-839.3
IB	$(0,1,1)\ (0,1,1)_{12}$						-0.087				2077.2	-1036.3
JP	$(0,1,0)\ (0,1,1)_{12}$										1119.4	-558.7
KL	$(0,1,4)\ (0,1,1)_{12}$						-0.386	-0.06	0.134	-0.467	2174.3	-1082.1
KM	$(1,1,2)\ (2,1,0)_{12}$		0.331				0.047	0.086			1500.4	-746.2
LG	$(1,0,2)\ (2,0,2)_{12}$	289.0	0.702				0.335	0.264			1546.3	-768.1
LH	$(0,1,1)\ (0,1,1)_{12}$						-0.036				2382.9	-1189.5
MA	$(1,1,0)\ (1,1,1)_{12}$	286.3	0.835								1569.9	-782.0
OK	$(2,1,2)\ (1,1,1)_{12}$		1.726	-0.990			-1.804	1.000			1513.6	-751.5
OS	$(0,1,0)\ (2,1,1)_{12}$										1831.6	-914.8
OU	$(0,1,1)\ (1,1,2)_{12}$						0.536				1189.1	-592.5
SK	$(0,1,1)\ (0,1,2)_{12}$						0.133				1980.2	-988.1
TK	$(0,1,1)\ (0,1,1)_{12}$						0.115				2038.5	-1017.2
TP	$(0,1,1)\ (0,1,2)_{12}$						-0.048				1948.3	-972.1

Source: own elaboration

BA (British Airways) and bmi that show the same ARIMA model (4,1,1)(2,1,0); FI (Icelandair) and JP (Adria Airways) are consistent with model (0,1,0)(0,1,1) and IB (Iberia), LH(Lufthansa), TK(Turkish Airways) with model (0,1,1)(0,1,1). The remaining airlines exhibit different modelling behaviour.

Having determined the best fit ARIMA models for each airline, the table in the Appendix shows the comparison of ARIMA and Holt-Winters models, considering the MAPE and MASE measurement errors (Athanasopoulos et al. 2011) for each of the series studied[2]. A lower value of MAPE and MASE errors shows a better performance of ARIMA models.

As mentioned in the introduction, the airline industry in general and Europe in particular has been subjected to a number of different events, which may have exercised some influence on the series analyzed. According to Lai and Lu (2005), intervention analysis goes back to the 1970s (Box and Jenkins, 1976) and a general model form is:

$$z_t = \sum_{j=0}^{m} w_j \, I_t^{(h+j)} + w_k \, S_t^{(k)} + \Psi(B) a_t \qquad [7]$$

where $Y_t = \Psi(B)a_t$ is the RPK for each airline; $I_t^{(h)}$, $I_t^{(j)}$ and $S_t^{(k)}$ are the exogenous variables included in our model. For the events of the ash crisis $I_t^{(h)} = 0$ if $t \neq h$ y $I_t^{(h)} = 1$ if $t = h$ (April and Mai 2010). For the events of September 11th and SARS[3] $I_t^{(j)}$ equal to one $t=j$ (September 2001 to December 2003) and 0 otherwise. For the economic crisis event $S_t^{(k)} = 0$, if $t < k$ (t<2008) and $S_t^{(h)} = 1$, if $t \geq k$ (t ≥ 2008).

Table 3 shows the results of ARIMA and intervention model for seven of the nineteen companies that the events of the ash crisis; terrorist attacks and SARS were significant. The impact of these events was negative in six companies, with the exception of Austrian Airlines, whose impact was positive. In no case was the effect of the economic crisis significant.

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[2] Each time series was tested for outliers prior to the implementation of the ARIMA and Holt-Winters procedure. The detection of outliers was based on the equation: $\left|\frac{Y_t - \mu_t}{\sigma_t}\right| > 2$ where μ_t and σ_t denote the mean and standard deviation of the time series Y_t, respectively.

[3] A dummy variable was considered that jointly accounts for the events of the September 11th and SARS (September 2001 to December 2003). Also, we considered in isolation the effects, but there was no difference in the results. We have compared through the measurement errors MAPE and MASE using dummy variables together or independently. The lower values of the error measures indicate that the ideal model is presented in this work. The test results are available upon request.

Table 3: Summary of ARIMA and Intervention Model for Seven Airlines

	AY - Finnair (0,1,1) $(1,1,2)_{12}$		BA - British A. (4,1,1) $(2,1,0)_{12}$		BD - bmi (4,1,1) $(2,1,0)_{12}$		FI - Icelandair (0,1,0) $(0,1,1)_{12}$	
Economic crisis	54.74(0.06)		-232.72 (-0.52)		-39.76*(0.4)		-34(0.04)	
Ash crisis	-262.7(-3.91)	***	-971.89*(-1.87)	*	-69.07*(-3.04)	***	-114(-2.63)	***
Sep11 & SARS	-11.54(-0.03)		-744.05(-3.17)	***	-12.95(-0.17)		-4.5(-0.03)	
AR(1)	-		0.56(7.89)	***	0.88(8.16)	***	-	
AR(2)	-		0.01(0.17)		-0.02(-0.22)		-	
AR(3)	-		0.17(1.53)		-0.09(-0.91)		-	
AR(4)	-		-0.47(-5.47)	***	-0.28(-2.84)	***	-	
MA(1)	-0.176(-3.48)	***	-1.09*(-17.96)	***	-0.70(-8.34)	***	-	
MA(2)	-		-				-	
MA(3)	-		-				-	
MA(4)	-		-				-	
Chi2	27.52	***	702.61	***	523.17	***	6.92	***
Log Lik	-900.28		-1150.26		-778.29		-836.75	

	KL - KLM (0,1,4) $(0,1,1)_{12}$		OS - Austrian (0,1,0) $(2,1,1)_{12}$		SK - SAS (0,1,1) $(0,1,2)_{12}$	
Economic crisis	60.91(0.16)		-4.99(-0.03)		112.19(0.08)	
Ash crisis	-508(-2.01)	***	-11.64(-0.1)		-307.85(-2.63)	***
Sep11 & SARS	-225.99(-0.86)		265.27(8.1)	***	-31.27(-0.15)	
AR(1)	-		0.09(0.97)		0.15(1.79)	*
AR(2)	-		0.24(3.02)	***		
AR(3)	-		0.24(2.63)	***		
AR(4)	-		-0.23*(-2.9)	***		
MA(1)	-0.61(-5.99)	***				
MA(2)	-0.09(-0.93)					
MA(3)	0.11(1.09)					
MA(4)	-0.62(-6.45)	***				
Chi2	200.73	***	94.98	***	12.22	***
Log Lik	-1079.42		-896.22		-985.60	

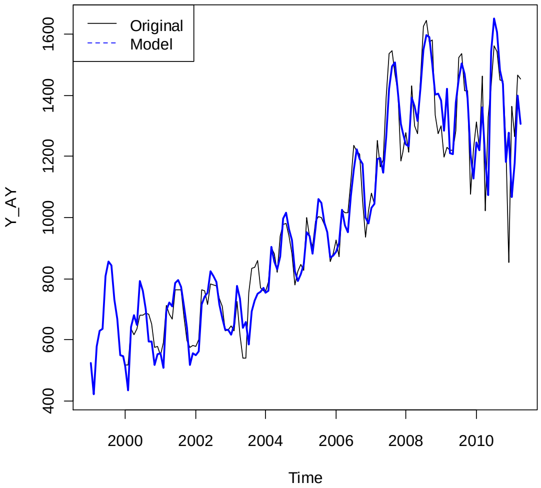
Source: own elaboration

*Significance level 0.05, **significance level 0.01, ***significance level 0.001

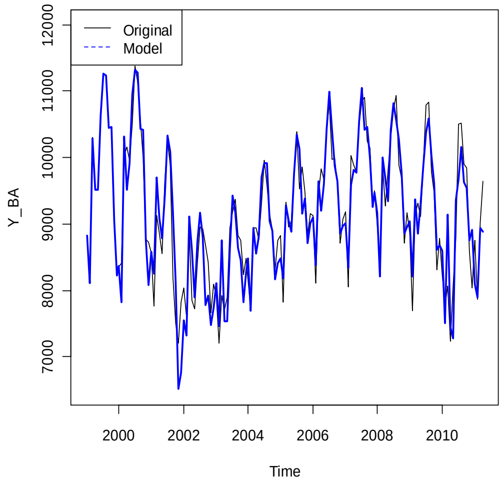
The time plot for AY (Finnair) and BA (British Airways) RPK reveal an upward and downward trend respectively along with seasonality patterns.

Figure 3: The Time Series AY and BA with original values and the intervention model

AY: Finnair



BA: British Airways

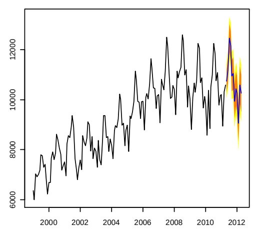


Source: own elaboration

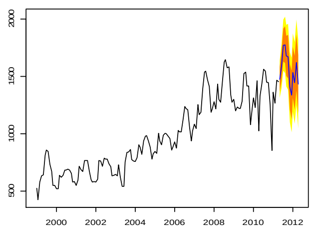
Finally, Figure 4 shows the predictions (omitted airlines bmi, JP and TK) with confidence intervals in red and yellow to 80 and 95 per cent respectively with a time horizon of one year (May 2011 - April 2012).

Figure 4: Prediction Models

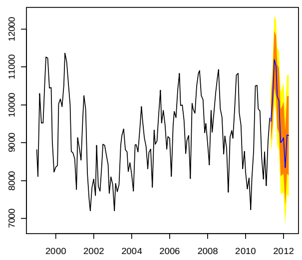
AF: ARIMA (2,1,1)(1,1,1)



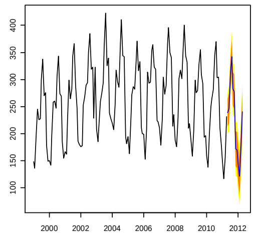
AY: ARIMA(0,1,1)(1,1,2)



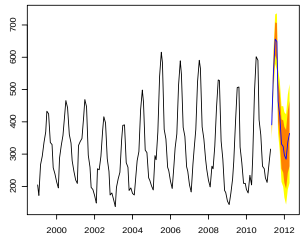
BA: ARIMA(4,1,1)(2,1,0)



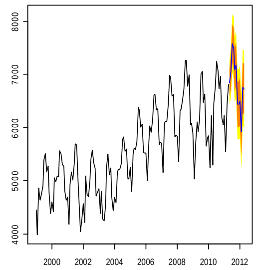
CY: ARIMA(1,1,1)(0,1,1)



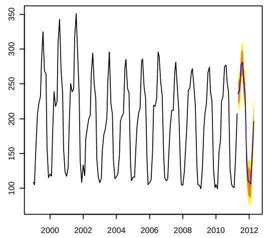
FI: ARIMA(0,1,0)(0,1,1)



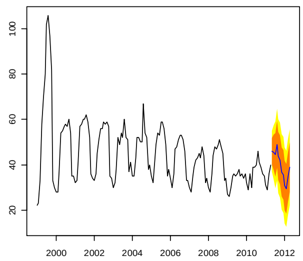
KL: ARIMA(0,1,4)(0,1,1)



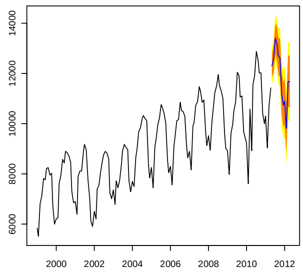
KM: ARIMA(1,1,2)(2,1,0)



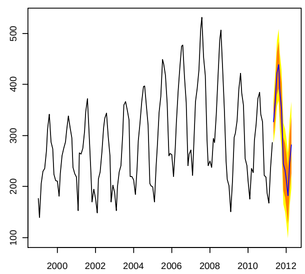
LG: ARIMA(1,0,2)(2,0,2)



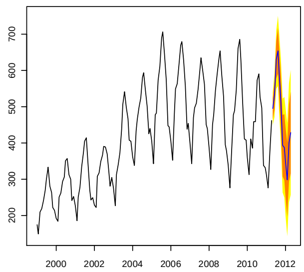
LH: ARIMA(0,1,1)(0,1,1)



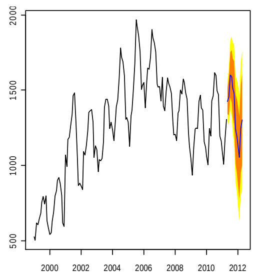
MA: ARIMA(1,1,0)(1,1,1)



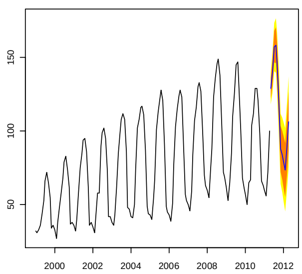
OK: ARIMA(2,1,2)(1,1,1)



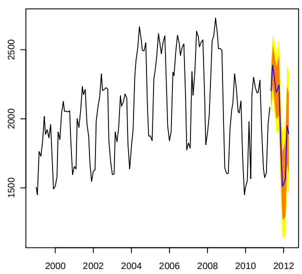
OS: ARIMA(0,1,0)(2,1,1)



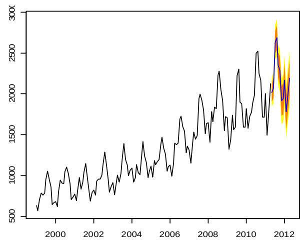
OU: ARIMA(0,1,1)(1,1,2)



SK: ARIMA(0,1,1)(0,1,2)



TP: ARIMA(0,1,1)(0,1,2)



Source: own elaboration

4. CONCLUSION

Understanding the evolution of demand, Revenue Passenger Kilometres is a strategic factor in the management of resources and capacity for decision-making. The time series analysis as performed in this paper can contribute to the scenario approach to carry out a proper strategic planning exercise. The main results reveal that ARIMA models have allowed us to a good performance of time series of Revenue Passenger Kilometres in nineteen airlines. The events occurred over the period analysed have not had the same impact on airlines. Only seven carriers have been influenced by the terrorist attack, SARS and the ash crisis, while none of the analysed airlines has been influenced by the economic crisis.

The results obtained might suggest, on one hand that airlines, despite their difficulty to adjust capacity, can find the flexibility to meet demand. This result is in line with Pearce (2012). On the other hand, given the heterogeneity of resources and flight destinations, the environmental events do not affect them the same way or with the same intensity. In this sense, authors like Ghobrial and Irvin (2004) mention that the events surrounding the aviation industry are dynamic and can indeed affect the different components of the industry. While the recent empirical literature focuses on the efficient management of the airlines, there are still many factors that need to be considered, which have recently been addressed in the 2010 Hamburg Aviation Conference (financial crisis, business strategies and risks, regulatory reform and innovation). Finally, it seems advisable to continue research into the effects of different events on European airlines, particularly those arising from the economic crisis.

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Appendix - Comparison of the ARIMA and Holt-Winters Models

Airlines	Model Type	MAPE	MASE
AF - Air France	Box-Jenkins	2.64	0.39
	HoltWinters	37.92	5.69
AY - Finnair	Box-Jenkins	5.47	0.67
	HoltWinters	39.28	4.92
BA - British Airways	Box-Jenkins	3.26	0.49
	HoltWinters	37.99	5.94
BD - bmi	Box-Jenkins	4.48	0.51
	HoltWinters	38.44	4.6
CY - Cyprus Airways	Box-Jenkins	5.2	0.27
	HoltWinters	46.17	2.6
FI - Icelandair	Box-Jenkins	5.2	0.27
	HoltWinters	46.17	2.6
IB - Iberia	Box-Jenkins	4.56	0.42
	HoltWinters	40.91	4.15
JP - Adria Airways	Box-Jenkins	5.98	0.46
	HoltWinters	42.58	3.38
KL - KLM	Box-Jenkins	2.43	0.4
	HoltWinters	37.71	6.3
KM - Air Malta	Box-Jenkins	3.94	0.22
	HoltWinters	46.15	2.69
LG - Luxair	Box-Jenkins	7.25	0.6
	HoltWinters	41.22	3.41
LH - Lufthansa	Box-Jenkins	2.58	0.39
	HoltWinters	38.14	5.86
MA - Malev Hunagrian A.	Box-Jenkins	5.64	0.38
	HoltWinters	44.73	3.09
OK - Czech Airlines	Box-Jenkins	3.85	0.34
	HoltWinters	41.68	3.63
OS - Austrian	Box-Jenkins	2.89	0.41
	HoltWinters	38.82	5.19
OU - Croatia Airlines	Box-Jenkins	5.03	0.28
	HoltWinters	45.95	2.73
SK - SAS Scandinavian A.	Box-Jenkins	3.07	0.41
	HoltWinters	38.7	5.34
TK - Turkish Airlines	Box-Jenkins	4.56	0.42
	HoltWinters	40.91	4.15
TP - TAP Portugal	Box-Jenkins	4.27	0.41
	HoltWinters	41.2	3.82

Source: Own elaboration