



## The short-term impact of 9/11 on European airlines demand

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### Abstract

*This paper assesses the short-term impact of the US September 11<sup>th</sup> terrorist attacks and its after-effects on European Airline Demand. Using monthly data for ten time series from the Association of European Airlines (AEA), different univariate methods are estimated in order to evaluate the airlines traffic in terms of revenue passenger kilometres by comparing the fitted values resulting from the univariate methods employed for one year against the actuals. The results suggest that September 11<sup>th</sup> impacted all of the European airline routes under study to a varying degree. The effects of the terrorism attack did not fully dissipate in most of the time series understudy by the end of October 2002.*

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### Introduction

The global travel industry has endured many shocks throughout the past decade, such as economic oscillations, diseases and terrorist attacks making it a rather fragile industry. Both the demand and supply sides of the industry are extremely vulnerable to these occurrences. However, tourism officials generally plan the development of their country's tourism sectors without allowing for these shocks, either foreseen or unforeseen. Within the past decade, terrorism has played a more influential role than the past in skewing visitors' arrival patterns. Terrorism, as qualified by Ganor (1998), is the intentional

use of, or threat to use, violence against civilians or against civilian targets in order to attain political aims. Arguably September 11<sup>th</sup> (9/11) has been called the worst terrorism attack that the tourism industry has suffered to date even though it only took place on United States of America soil. As the world watched on that fateful day the events unfold, no one could have foreseen at that exact moment the full extent of this planned attack on the global tourism industry.

Although this event did not occur in Europe the effects were felt in the region and worldwide especially in terms of international

arrivals. This horrific event marked dramatic dips in international tourist arrivals for individual countries including those in Europe, with each country encountering a different experience. Europe itself has been the victim of domestic terrorism incidents such as the London underground bombings of 2005 which had a negative effect on the safety and security of the country.

Terrorism can not only dampen tourist arrivals to a particular country or region by discouraging potential tourists from visiting, but may have longer implications on the economy (Sloboda, 2003). Indirect costs of terrorism such as increased expenditures to pull tourists to the country, the reconstruction of tourist facilities and the heightened security measures to prevent the attacks can occur. Moreover, its effects can reach other key economic variables, such as Foreign Direct Investment, savings and consumption, investment, the urban economy, stock market and overall economic development (Frey et al. 2007).

Aviation has always been one form of transportation highly susceptible to terrorism (Economic Analytical Unit, 2003). With its complex systems which span airports, airlines and other logistical players, the vulnerability of infiltration may be great. Perhaps the hardest hit segment from this attack of the European travel industry is that of airline industry. It responded immediately to the attack by temporarily suspending all flights and then eventually reducing capacity to match the fall off in demand. Globally, early estimates for 2001 by the International Air Transport Association (IATA) estimated a direct loss from the impact between US\$10 billion and US\$12 billion (UNWTO, 2001). Even after the initial panic subsided, the hassles that the new security measures, long delays and other inconveniences served to further stifle demand for regional air transport. Further, since tourism is a significant component of the international air travel it is safe to say that this tragic event not only affected airline arrivals to the European region but also affected its tourist trade.

Little is known as to the exact extent of the impact of the event on Europe as most of the literature which concerns this topic is based on US airlines. Therefore, this study seeks to answer how can time series models help us quantify the short-term impact of 9/11 on airline passenger arrivals to Europe on national carriers and, of these source markets under study affected, which had the highest deficit in air arrivals and why.

The paper proceeds into five sections. Section 2 will serve as a review of the literature surrounding terrorism and tourism including a closer look at September 11<sup>th</sup> and the airline industry. Section 3 highlights the methodologies/analytical framework used for the paper while section 4 explains the data, models and results. For validation of the results, the different estimations are compared. The proceeding section will hold the discussion and concludes the paper.

### **Literature Review**

There is an extensive amount of literature which scrutinizes the various effects of terrorist events. There is also a growing amount which observes terrorism and more specifically, the outcome of individual attacks and the shocks which follow on tourism flows.

Blake et al. (2003) use a Computable General Equilibrium (CGE) model to recreate shocks mirroring that of 9/11 for a simulated US economy on variables such as employment, GDP and welfare; and to gauge the effects of proper policy on the economy. They found that the resulting fall in tourism expenditures from this terrorism attack reduces Gross Domestic Product (GDP) by almost \$30 billion; and as an additional consequence in a loss of over half a million jobs most of which are located in the airline and accommodation sectors.

Due to the accessibility of long time series, economists and other researchers have been able to use time series approaches to study the effects of terrorism on various indicators of tourism. One of the earlier analyses presented by Enders et al. (1991) uses monthly data from 1970 to 1988 and employs

a Vector Autoregressive model (VAR) to find that one terrorist attack reduces the amount of visitors to Spain by approximately 140,000. A later piece of work by Enders et al. (1992) employ estimated ARIMA models for data spanning from 1970 to 1990 to determine the correlation between the reduction in tourism arrivals and that of terrorist incidents for Austria, Greece and Italy. By doing so they estimated the immense effect of the incidents on revenue for the respective tourism industries. More specifically, Austria lost \$4.5 billion in tourism expenditure, Italy \$1.1 billion and Greece \$0.8 billion during 1974 to 1988. Overall, Europe incurred a loss of 16.1 billion of visitor expenditure from the aftermath of the terrorism incidents. They also noted that the outcomes of the events could last for a relatively long time, even until six to nine months after the event. In most cases, the events would have a delayed impact on tourism to the country by up to three months.

Coshall (2005) found similar results when utilizing intervention analysis within an ARIMA model to examine the impact of, among other events, terrorism on the expenditure of tourists visiting the UK and that of the UK citizens abroad. He found that spending overseas only declined within September and December 2001 and showed signs of improvement from January 2002 with steady rises. He noted that the recovery of the overseas spending of the UK tourists in terms of quantity and time span was less than that of international tourists' expenditure within that country. This would thereby worsen the balance of payments within UK's tourism industry.

These findings were somewhat supported by Sloboda (2003) who through an autoregressive moving average with explanatory variables (ARMAX) model concludes that a terrorism incident could have longer but still temporary effects on tourism flows. The author analyzes annual time series which encases a number of terror attacks on US interests and US tourism receipts for 1988-2001. The data also includes the effect of the Gulf War in 1991 and the resulting increase in anti-American attacks on tourism

revenues. He concluded that in 1991 with a doubling of incidents on US interests, the ensuing shock had a temporary negative impact on the tourism industry, lasting until 2000. The author calculated that the total losses in revenue from the initial shock to the industry were approximately \$57 billion.

More specific to the airline industry, there are some works which examine the impact of this catastrophic event. Ito et al. (2005) sought to assess through simple linear models the impact of 9/11 and its effects on air travel demand in the USA taking into account the institution of new, tighter security measures. Through this reduced form of the model of demand for air services and a monthly time series dating as far back as 1986, they were able to model the post-September 11 period as a shock process which was comprised of a transitory and on-going component. Subsequent to controlling for cyclical, seasonal and other unique events which affected the industry such as the unemployment rate, they derived estimates of the initial demand shock of more than thirty percent using the objective airline demand indicators, revenue passenger miles (RPMs).

A similar approach was taken by Guzhva et al. (2004) who used a VAR model to isolate and evaluate the effect of September 11<sup>th</sup> on the performance of the US airlines from that of the general economic climate. They also utilize RPMs and further incorporated real GDP as their main macroeconomic indicator into the VAR model. Additionally, Ito et al. (2005) found a decline in yields of a little over seven percent (7.3%). The authors also noted an ongoing downward shift in demand of 7.4% measured by RPMs and a 10% decline measured by yield. It was observed that the decline in demand was more accentuated in the short-haul market where the number of substitutes is greater. Finally, they conclude that the terror attacks and the corresponding heightened security measures accounted for an approximate decrease of 94% in RPMs from their peak. However Guzhva et al. (2004) results showed that although the event did have a significant economic and statistical effect in that respect,

not all airlines were affected in the same way as some airlines were able to increase their performance even after the tragic event.

These reasons of the event and the increased security measures were also given by Inglada et al. (2004) for the explanation behind the adverse impact of the event on airline arrivals to Spain especially that of the international arrivals. Using an Autoregressive Moving Average model estimated with exact likelihood (AREMA) they also posited that the impact although not as pronounced as in the US, was of a long-term nature thereby contradicting Enders et al. (1992) and Coshall (2005).

Bonham et al. (2006), by means of vector error correction models and ARIMA modelling, generated dynamic visitor forecasts to assess whether tourism in Hawaii and the US was recovered fully from 9/11 and other such catastrophic events through quantifications and analysis of the effects. They also posited that there has been a decline in US international outbound traffic which could be attributed to an increase in domestic outbound traffic, Hawaii being the main beneficiary. The authors believed that Hawaii is a relatively safe destination in the eyes of travellers; and thereby seconding the conclusions of Sönmez et al. (1998) who postulated that people substitute riskier, more terrorism-prone international travel for domestic travel. They concluded that the US arrivals had not recovered at the time of writing the paper but Hawaii airline arrivals did mostly due to the increase in domestic inbound travel.

Generally, there is a miniscule amount of research of the impact of 9/11 within Europe and especially the impact on airline arrivals. In this paper, we will venture to bridge this gap in research by analyzing the impact of this event on Europe's national carriers in terms of airline arrivals. By evaluating data of monthly revenues for passengers by kilometres (RPK) data for all European carriers to Europe we will be able to establish trends to further our investigation. The RPK figures are used for all European carriers'

passengers to Europe by source market and spans from January 1991 to October 2002 as retrieved from the Association of European Airlines (AEA).

### **Methodology**

Time series models are the most commonly used quantitative methods in tourism demand forecasting and modelling for over four decades with the most autoregressive integrated moving average models (ARIMA) modelling being the dominant one (Burger et al., 2001; Cho, 2003; Coshall, 2005; Song et al., 2008;). Time series models pay specific attention to historic trends and patterns like seasonality of the time series under study, and forecasting the future of the series given the trends and patterns identified in the model.

Univariate time-series methods are non-causal techniques and assume that a variable can be forecasted without reference to the factors which could have determined the level of variable (Witt et al., 1992). ARIMA, naïve 1 and exponential smoothing techniques are forms of this method of time series analysis.

An alternative method of causal methodology or multivariate methods using explanatory variables could have been used for this analysis. This method was not pursued for several reasons. The complexity of the causal structure and the unavailability of relevant data of possible causal variables to explain the change in RPKs would have been a severe obstacle (Kim et al., 2001). With multivariate methods we are frequently asked to predict both dependent and independent variables. Herein lays the problem. There would be great difficulties in this case to obtain accurate forecasts of variables (such as income) which influence air travel and thus RPKs (Witt et al., 1992). This is because it is probable that September 11<sup>th</sup> may have directly or indirectly led to lower levels of macroeconomic activity in the European economy, (Ito et al., 2005); the effects on macroeconomic variables are unclear therefore complicating the process of accurately forecasting a variable such as income assuming the event had not occurred.

Thus, even though time series extrapolation models are considered to be unsophisticated in that they do not take into account the impacts of the forces that determine the behaviour of time series like multivariate models, they often predict relatively well especially with relatively short-term forecasts (Uysal et al., 1985; DeLurgio, 1998; Yorucu, 2003). Therefore, their use is preferred in this study.

In addition, previous literature has highlighted the superiority of the univariate models over multivariate ones when producing forecasting. Among them, Goh et al. (2003) suggest that the performance of the univariate models studied was above that of all the other forecasting methods including multivariate models. Additionally, du Preez et al. (2003) concluded that the short-term forecasting ability of the univariate methods exceeded that of the multivariate ones. Kim et al. (2001) find that univariate models generate better forecasts than the opposing methods when modelling time series for airline passengers among three major Australian cities. They found that multivariate methods forecasts suffered from over-parameterization.

For the purpose of our analysis, we present three methods of univariate models: naïve 1, Holt-Winters exponential smoothing and ARIMA. The observations from January 1991 to August 2001 are used, first, to establish whether an additive or multiplicative process should be applied to the data and, secondly to develop appropriate difference filters for the ARIMA model. By capturing the dynamics in the data until August 2001, we use the reserved data from October 2001 to October 2002 for forecasting purposes, to effectively isolate the short-term effects of 9/11.

More specifically, dynamic ex-post forecasts are developed for each RPK time series within the model namely for Domestic, Cross-border Europe, North Africa, Middle East, North Atlantic, Mid Atlantic, South Atlantic, Sub-Saharan Africa, Far East Australasia and the total. Ex-post forecasts are derived when the model is estimated using data for the period  $t_0$  to  $t_2$  that is up to the present time or

end of sample which is October 2002 (Witt et al., 1992). In this instance, the sample is set until August 2001. The estimated model is then used to make out-of-sample forecasts for RPKs assuming that 9/11 and other subsequent shocks had not occurred for the period October 2001 to October 2002.

The predicted path results are then compared against the actual path of RPKs in the post-9/11 period; the difference between the two would then be attributed to the effects of the shocks. This will thereby provide an indication of the extent of the short-term effect that September 11<sup>th</sup> had on airlines demand within Europe while allowing the identification of the routes which recorded the highest levels of losses in RPKs.

Then, the Naïve 1 could be classified as time series models (Coshall, 2005). As our data is seasonal, as is the case with most tourism related time series, we employ the use of the seasonal naïve 1 model. It postulates that the next period's value is equal to the value of the same period in the previous year (Frechtling, 2001). Naïve 1 models have also been noted to outperform other forecasting models in some cases (Martin et al., 1989; Turner et al., 2001a). Additionally, this method is often used as a yardstick against which other forecasting methods are measured (Witt et al., 1992).

Exponential smoothing is a method of forecasting that aims to separate the trends or seasonality from irregular variation. Generally, it has been noted to be more effective when the components which determine the time series are slowly changing over time. A new estimate is determined using a combination of the present time period estimate in addition to a part of the random error which is generated within the present time period. The nature of monthly data with a high level of seasonality suggests the employment of the multiplicative Holt-Winters model as the amplitude of the seasonal pattern changes over time. The smoothed series  $\hat{y}_t$  is given by:

$$\hat{y}_t + \kappa = (\alpha + \beta k)\chi\tau + \kappa$$

where  $\alpha$  is the permanent component (intercept),  $\beta$  the trend and  $\chi\tau$  the multiplicative seasonal factor. These parameters are supposed to control how rapidly the model reacts to changes in the process that generates the time series. Smoothing models are quite useful in forecasting tourism demand as they can react rapidly to the changes in economic conditions as recent observations are assigned larger weights within the forecasting process (Coshall, 2008).

Finally ARIMA is a univariate regression built on a methodology developed by Box-Jenkins in 1970 and like other time series models, is modelled on the basis of its past values and random disturbance term. The term which stands for autoregressive integrated moving average combines three forms of processes: autoregression (AR), differencing to remove the integration (I) of the series and moving averages (MA). Authors have deemed this method to be rather accurate in forecasting (DeLurgio, 1998; Kulendran et al., 2001; Lim et al., 2002).

Unlike univariate smoothing models the ARIMA approach requires that a tourism time series has to be stationary for estimation and forecasting to occur (Lim et al., 2002). To achieve stationarity and avoid spurious regression problems which frequently occur with monthly data series, 12-order differences of the natural logarithm of the dependent variables were employed. This serves to stabilize their variances and means thereby making the model better equipped to produce reliable forecasts (Lim et al., 2002). Acting on the assumption of stationarity, the ARIMA function takes on the traditional form from which the within-sample predicted values are calculated:

$$Y_t = \phi_1 Y_{t-1} + \dots + \phi_p Y_{t-p} - \theta_1 \alpha_{t-1} - \dots - \theta_q \alpha_{t-q} + e_t$$

Where  $Y_t$  is the number of RPKs by routes (as listed previously),  $\alpha_t$  is the innovation or

moving average term,  $\theta_t$  and  $\phi_t$  are the parameters to be estimated for the moving average and autoregressive parts of the model respectively and  $e_t$  the error term. The error terms are generally assumed to be independently, identically distributed variables sampled from a normal distribution with a mean of zero.

## Data and Results

### Data

The air transport flows set consists of the Revenue Passenger-Kilometres Flown (RPK) that are calculated by the product of the total number of revenue passengers on all of the routes under consideration and of the corresponding stage distances. A RPK may be defined as one paying passenger travelling one kilometre. Although there are possibly other measures of airline demand, this is considered a good proxy and is an objective performance indicator by combining financial and operational information of airlines (Guzhva et al. 2004; Ito et al., 2005). The considered routes, their relative importance and the relationship between them are shown in Figure 1 and Table 1. Data for the air traffic were taken from the Association of European Airlines (AEA), a non profit-making association that is made up of 33 European carriers, carrying 346 million passengers each year, operating 2,540 aircrafts, serving 605 destinations in 161 countries with 11,030 flights a day. A complete description of the data and its sources is summarized in Appendix 1.

As is visible from Figure 1, the North Atlantic market represents the highest portion of RPKs followed by Cross border Europe and then Far East Australasia. Collectively, these markets are almost seventy percent of the total RPKs. The smallest market according to the data is North Africa which only accounts for about one percent of the total.

Figure 2 shows the monthly data of all of the routes under study unadjusted RPKs from Europe from January 1991. However, only the data until October 2002 was used in our analysis. Even though the data was clearly

available for a longer series, a truncated end period is preferred to control for other possible outliers or shocks to the data such as the Madrid bombings in 2004, the outbreak of SARS in 2003 and the London bombings in 2005 thereby delivering more reliable results in the quantification process. In addition, this abbreviated time period is used to more effectively examine the short-term effects of the terrorist attacks of September 11<sup>th</sup> on European airlines' passenger demand. Figure 2 also makes several features of the data apparent. Firstly, it is evident that there is a

seasonal component to airline demand. This arises from the highly seasonal nature of the airline industry where the summer and holiday seasons generally mark higher periods of demand, whereas winter indicates the lower ones. Seasonality within the data is also apparent from the repetitive peaks and troughs from year to year. Within our model seasonality in the data and thus seasonal unit roots which negatively influence the forecasting ability of the model are controlled for by differencing the data which removes its seasonal component.

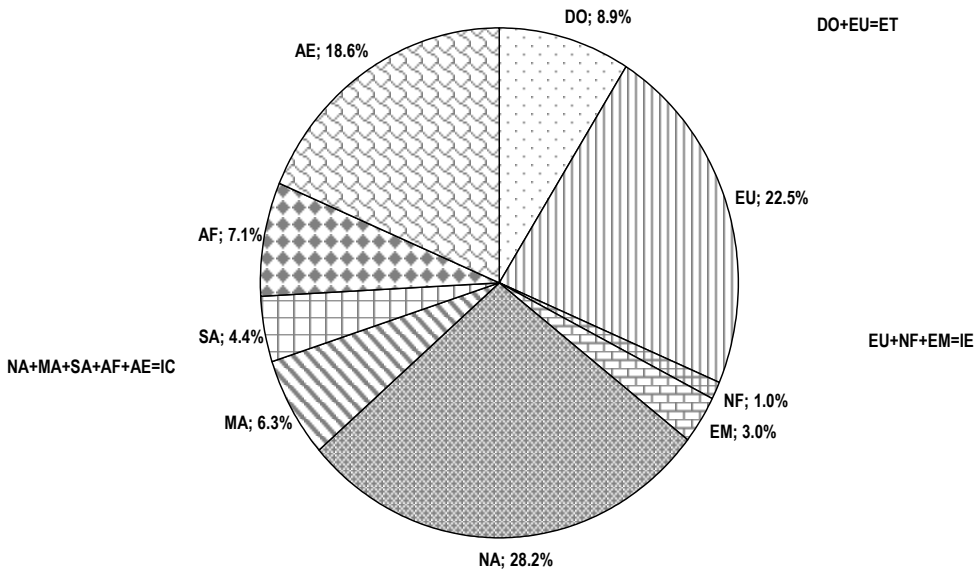
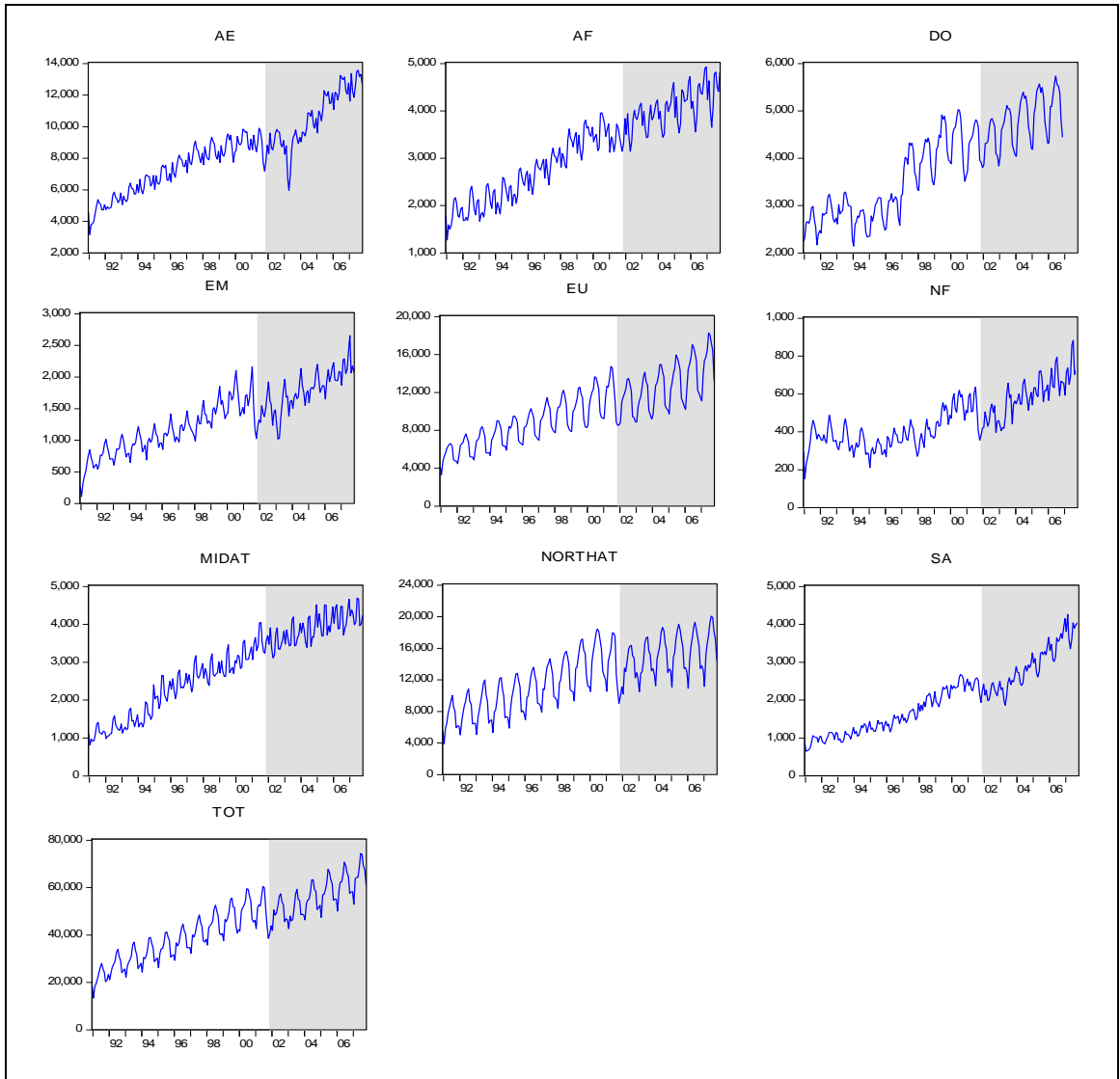


Figure 1: Relative importance and composition of the RPK time series

Table1: Aggregation correspondence of the RPK time series

ET - Europe Total	DO – Domestic	IE - International Short/Medium Haul	TO - Total Scheduled
	EU - Cross-border Europe		
NF - North Africa			
EM - Middle East			
NA - North Atlantic			
MA - Mid Atlantic			
SA - South Atlantic			
AF - Sub Saharan Africa			
AE- Far East Australasia			
	IC - Total Long haul		



**Figure 2: Monthly European RPK time series for all routes**

Also, one may notice the cyclical nature of airline demand and trend within the data. It can be seen that before September 2001, the industry's demand was taking an upward trend. This could have perhaps been due to economic growth and declining real airfares in Europe. However after that month, there is a decided downward turn in the trend which

seems to have impacted until the end of 2002. This prolonged effect may be due to the severe repercussions of the attack in terms of stricter security measures and increased fear of flying as stated earlier.



**Table 2: Estimated coefficients: Dependent variable:  $\ln(\ ) - \ln(\ )$**

Variable	SS Africa	FE Australasia	Domestic	Middle East	CB Europe	North Africa	Mid-Atlantic	North Atlantic	South Atlantic	Total
Constant	4.58***	4.89***	5.54***	26.96***	29.85***	1.47*	5.17***	18.94***	24.35***	8.86***
AR(1)	5.12***	8.79***	19.02***	8.07***	4.41***	-	-3.63***	6.62***	10.48***	7.17***
AR(2)	-	3.03**	-	4.17***	-	8.90***	8.94***	-	-	5.16***
AR(3)	5.88***	-	-	-	-	-	7.89***	2.16**	-	-
AR(12)	-1.90*	-	-	-	-	-1.69*	-3.51***	-	-	-
MA(1)	-	-	-	-	-	21.87***	302.58***	-	-	-
MA(2)	-	-5.65***	-	-1.76*	-	-	-	-2.27**	-	10.18***
MA(3)	-	-	-	-	-	-	108.91***	-	-	-
MA(4)	-	-	-	-	-	-	-	-3.14***	-	-
MA(12)	-	-14.49***	-35.83***	-8.24***	-	4.71***	-	-6.36***	56.34***	6.24***
R <sup>2</sup>	0.5	0.7	0.83	0.81	0.65	0.77	0.7	0.41	0.73	0.81
Adjusted R <sup>2</sup>	0.49	0.69	0.82	0.8	0.64	0.76	0.69	0.39	0.73	0.8
S.E. of regression	0.03	0.03	0.05	0.04	0.02	0.07	0.05	0.03	0.04	0.02
Sum squared resid	0.11	0.08	0.25	0.22	0.05	0.46	0.28	0.12	0.2	0.05

Note: \*\*\*, \*\* and \* indicates significance at the 1%, 5% and 10 % levels respectively

*Estimation results*

Using the data and the methodologies developed earlier, we model the European RPKs of the ten monthly time series to determine the extent of the disruption in travel following the September 11<sup>th</sup> occurrence. Natural logarithms were integrated to the order of 12 to achieve stationarity (i.e. I(12)) thereby producing the following estimated coefficients and further results for the ARIMA models (Table 2).

All of the constant terms above are statistically significant from 0 at the 1% level, except North Africa. There are no similar results in the estimated coefficients as each of the markets is somewhat distinct from each other. Therefore they are drawing from different sources, or in this case, pools of tourists as reflected in their RPKs (Enders et al., 1992). All the variables, save Europe's smallest market - North Africa, have an autoregressive term at lag 1.

The above table also relates the fit of the predictive models results versus that of the actual RPKs through the R<sup>2</sup> and the adjusted R<sup>2</sup>. The predictive models fit very well with the actuals except in the case of Sub-Sahara

Africa and North Atlantic. However, an author notes that these measures of percent variations in dependent variable may be low in ARIMA models in some instances due to the differencing in the data (Wang et al., 2003). However, the standard error of the regression for all the time series that takes into account the residuals of the regression is low. These indicators attest to the validity of the models and thus their predictive capabilities.

*The Impact of 9/11 on European Airlines Demand*

The proceeding tables (tables 3, 4 and 5) highlight the differences between the predictive results given that 9/11 had not occurred and what actually transpired in the markets using the three univariate methodologies under study: naïve, Holt-Winters exponential smoothing and ARIMA. The estimated percentage changes in RPKs were derived from first taking the difference between the actuals and forecasted estimates and then calculating this difference as a percentage of the predicted values. A similar approach was used in Bonham et al. (2006) for estimating the effects of September 11<sup>th</sup> on tourist arrivals to Hawaii and the US. From

the tables we can ascertain many observations which are related forthwith.

studies have shown. The markets most affected by the terrorist attacks were the international markets, a result given by all three models under study.

The seasonal naïve model results displayed in table 5 would suggest that the total effect of 9/11 was not as pronounced as previous

**Table 3: Estimated Percentage Changes in RPKs using Seasonal Naïve Methodology, October 2001- October 2002**

Month	SS Africa	FE Australasia	Domestic	Middle East	CB Europe	North Africa	Mid-Atlantic	North Atlantic	South Atlantic	Total Markets
2001M10	-11.5%	-20.4%	-8.1%	-28.4%	-9.5%	-32.3%	6.6%	-33.4%	-15.3%	-18.6%
2001M11	-9.1%	-17.4%	-9.3%	-26.0%	-10.3%	-32.3%	5.2%	-31.5%	-13.1%	-17.2%
2001M12	-9.0%	-8.6%	-11.3%	-15.7%	-8.7%	-18.6%	9.4%	-20.8%	-7.8%	-11.2%
2002M01	3.1%	-4.4%	-7.5%	-13.2%	-7.4%	-18.7%	8.8%	-7.8%	-5.3%	-5.0%
2002M02	12.1%	-2.9%	-4.0%	-10.0%	-4.6%	-15.6%	13.4%	-3.1%	-10.5%	-1.9%
2002M03	14.3%	1.4%	-4.9%	-9.2%	-3.9%	-14.3%	11.4%	-6.2%	-8.9%	-1.9%
2002M04	2.6%	-1.2%	-5.4%	-17.0%	-9.3%	-22.9%	-7.6%	-13.0%	-12.7%	-8.3%
2002M05	0.1%	1.3%	-5.0%	-11.2%	-5.4%	-15.0%	-5.8%	-8.6%	-11.1%	-5.5%
2002M06	0.7%	-0.5%	-7.0%	-8.8%	-8.7%	-11.8%	-7.4%	-11.4%	-10.5%	-7.6%
2002M07	2.6%	-3.5%	-6.3%	-10.4%	-9.2%	-14.5%	-7.0%	-9.3%	-5.8%	-7.1%
2002M08	10.1%	1.1%	-3.9%	-11.2%	-7.7%	-14.1%	-3.5%	-6.5%	-5.1%	-4.3%
2002M09	11.2%	6.5%	-1.1%	4.6%	-1.2%	-3.3%	-5.0%	18.7%	-9.2%	5.4%
2002M10	15.7%	25.2%	7.4%	33.3%	8.8%	33.1%	1.9%	39.9%	1.0%	19.5%
<b>Total</b>	<b>3.1%</b>	<b>-2.1%</b>	<b>-5.0%</b>	<b>-10.3%</b>	<b>-6.0%</b>	<b>-15.0%</b>	<b>1.1%</b>	<b>-8.5%</b>	<b>-8.8%</b>	<b>-5.2%</b>

**Table 4: Estimated Percentage Changes in RPKs using Holt-Winters methodology, October 2001 - October 2002**

Month	SS Africa	FE Australasia	Domestic	Middle East	CB Europe	North Africa	Mid-Atlantic	North Atlantic	South Atlantic	Total Markets
2001M10	0.6%	-19.1%	2.9%	-32.6%	-16.6%	-28.5%	-0.3%	-28.7%	-14.6%	-18.6%
2001M11	0.2%	-18.4%	-2.0%	-32.2%	-16.1%	-27.8%	1.4%	-19.8%	-13.0%	-15.4%
2001M12	-3.5%	-10.2%	0.4%	-22.1%	-16.0%	-21.8%	6.6%	-11.1%	-8.8%	-11.1%
2002M01	8.8%	-5.8%	-2.7%	-12.0%	-14.4%	-13.9%	-2.0%	0.5%	-11.3%	-6.8%
2002M02	19.5%	-0.6%	-0.7%	0.1%	-7.2%	-1.5%	7.6%	10.6%	-9.3%	0.4%
2002M03	21.1%	1.2%	-4.7%	-8.0%	-8.9%	-2.2%	11.0%	3.2%	-6.2%	-1.4%
2002M04	10.7%	-2.5%	-5.3%	-21.6%	-12.0%	-14.5%	-0.3%	-6.1%	-11.2%	-7.4%
2002M05	6.8%	-3.0%	-6.1%	-21.8%	-11.6%	-15.2%	-0.5%	-7.9%	-15.4%	-8.6%
2002M06	5.6%	-1.9%	-1.4%	-18.0%	-11.9%	-11.2%	-2.1%	-7.3%	-13.5%	-8.3%
2002M07	-0.5%	-6.2%	-4.1%	-19.9%	-12.5%	-15.9%	-11.3%	-11.8%	-15.5%	-11.6%
2002M08	2.1%	-6.5%	-3.8%	-17.4%	-13.9%	-18.2%	-10.1%	-13.2%	-11.0%	-11.8%
2002M09	4.2%	-4.2%	-3.7%	-20.3%	-13.5%	-18.7%	-5.8%	-11.6%	-18.4%	-10.7%
2002M10	9.6%	-4.1%	-1.2%	-16.5%	-13.9%	-8.8%	-4.8%	-6.3%	-19.4%	-8.5%
<b>Total</b>	<b>6.3%</b>	<b>-6.2%</b>	<b>-2.6%</b>	<b>-19.0%</b>	<b>-13.0%</b>	<b>-15.5%</b>	<b>-1.2%</b>	<b>-9.2%</b>	<b>-13.0%</b>	<b>-9.4%</b>

**Table 5: Estimated Percentage Changes in RPKs using ARIMA methodology, October 2001-October 2002**

Month	SS Africa	FE Australasia	Domestic	Middle East	CB Europe	North Africa	Mid-Atlantic	North Atlantic	South Atlantic	Total Markets
2001M10	-5.1%	-20.3%	1.3%	-33.9%	-16.3%	-33.5%	-13.0%	-39.0%	-21.8%	-22.2%
2001M11	-4.5%	-20.2%	-2.9%	-32.0%	-16.1%	-33.9%	-11.2%	-29.9%	-21.0%	-17.1%
2001M12	-13.4%	-13.2%	-1.2%	-23.7%	-15.8%	-29.6%	-2.2%	-25.3%	-18.2%	-14.4%
2002M01	-0.2%	-9.1%	-5.2%	-19.2%	-14.4%	-21.1%	-10.1%	-15.2%	-17.4%	-14.4%
2002M02	11.3%	-4.8%	-5.1%	-8.1%	-9.8%	-13.9%	7.1%	-4.4%	-17.1%	-6.9%
2002M03	20.5%	1.1%	-8.8%	-11.4%	-9.6%	-0.7%	13.9%	-7.0%	-14.9%	-2.2%
2002M04	2.9%	-4.3%	-10.0%	-27.3%	-13.5%	-14.7%	-7.4%	-15.9%	-20.2%	-10.3%
2002M05	-2.7%	-6.7%	-10.4%	-26.9%	-12.8%	-18.7%	-13.5%	-23.8%	-22.3%	-15.9%
2002M06	-6.0%	-6.6%	-6.6%	-26.7%	-14.1%	-11.9%	-17.2%	-21.4%	-22.2%	-17.0%
2002M07	-15.4%	-9.6%	-9.1%	-28.3%	-14.0%	-20.6%	-24.7%	-26.8%	-22.6%	-19.1%
2002M08	-13.6%	-11.0%	-9.9%	-25.0%	-14.6%	-27.6%	-27.0%	-31.4%	-20.0%	-20.7%
2002M09	-9.8%	-7.6%	-8.9%	-26.9%	-15.0%	-29.6%	-26.4%	-26.1%	-27.4%	-17.7%
2002M10	2.6%	-5.2%	-4.6%	-19.8%	-15.3%	-15.7%	-21.6%	-21.1%	-29.3%	-13.4%
<b>Total</b>	<b>-3.5%</b>	<b>-9.0%</b>	<b>-6.5%</b>	<b>-24.2%</b>	<b>-14.0%</b>	<b>-21.5%</b>	<b>-13.3%</b>	<b>-23.2%</b>	<b>-21.3%</b>	<b>-15.2%</b>

This finding was seconded by Inglada et al. (2004) who found when studying the effect of 9/11 on Spain, that the international market was more affected than the domestic. The most afflicted international markets as highlighted by the naïve model are namely: North Africa, Middle East and South Atlantic with North Atlantic closely following. The significant 15.0 % percentage loss within the Europe-North Africa route could be attributed to the volatile economic and political situation of this particular area which may have then had dire implications on the consistency of demand and supply of airline arrivals. However, further analysis beyond the boundaries of this paper would be needed to determine the exact reasoning for this result.

The model predicts that there was no decline overall in two of the markets under study: Sub-Sahara Africa and Mid-Atlantic. These results show that within the time frame, the effect of the terrorist attacks was negated and moreover, in both cases a small increase within that year occurred. Perhaps the most surprising result of the model is that North Atlantic's results were not more dramatic. Using the conclusions of this model, one may

say that the September 11th's total negative impact on European Airlines Demand was an estimated 5%.

The Holt-Winters model produced the results displayed in Table 4 which is believed to be more in line than the naïve model with previous literature and market studies. All markets except for Sub-Sahara Africa recorded a loss as expected with some variations in results between markets. Firstly, let us examine the results considering the market.

The markets which had the lowest actual RPKs than the predicted number in October 2002 were Middle East, North Africa, South Atlantic, cross-border Europe and North Atlantic in that order with cross-border Europe and South Atlantic recording the same level of losses. These results save that of North Africa were expected within the model.

The Middle East was looked upon at that time as an unsafe area due to the terrorists involved in the attack origins and the ensuing war which worsened both the economic and political stability of these countries. Thus it is not unanticipated that this market would be

among the hardest hit routes. In the South Atlantic, AEA believes that the noted decline could have been more due to the financial crisis in Argentina rather than the 9/11 effect (AEA Yearbook, 2003).

Cross-border Europe results are not surprising as within this market as well as the domestic market there are generally other modes of transport with which air transport is highly substitutable. Another point to note is that during this time of uncertainty, Europe was looked upon as the next terrorist target (Ito et al., 2005). This would have affected both the domestic market and the cross-border Europe market and may have also encouraged use of alternative forms of transport as well.

A noteworthy observation is that North Atlantic losses were not as great as anticipated. By October 2002, North Atlantic actual RPKs were only 9% lower than the predicted amount. This result is questionable as the North Atlantic is a long-haul route which involves travel to the USA and its territories. This route especially was subjected to the most stringent of heightened security clearances and checks; coupled with the increased check-in time where passengers were asked to check-in for these flights more than 2 and 3 hours before the flight departure time; all producing a significant hassle factor. In addition, there was a noted shift in demand to taking trips closer to home, to familiar destinations, often with private transport during this period as European travellers were more risk adverse (Kester, 2002).

The three markets which recorded the lowest levels of decline were Sub-Sahara Africa, Domestic, and Mid-Atlantic routes. Sub-Sahara Africa was the only route at the end of October 2002 to have RPKs which were 6.3% higher than the forecasted level. The AEA does note that this route was the least affected but does not purport explanations as to this minimal effect. It would be also anticipated that the domestic RPKs would be amongst the markets which would be lowest

hit because of the perceived safety that flying domestically may produce.

Totally, the impact of the event is noted to be the highest in the months directly following September 2001. Then the figures improve in the early months of 2002 only to worsen later on. Overall, we can say that the estimated percentage loss in RPKs for all of the markets; and the total effect of September 11th, 2001 on European Airlines Passenger Demand, using Holt-Winters methodology, was approximately a 9% decline.

Out of the three models under study, the ARIMA methodology perhaps produces the results which are most in line with what is expected. Here the markets which recorded the highest percentage losses (excluding North Africa, the smallest market) were Middle East, North and South Atlantic in that order. By October 2002, the actual RPKs for these routes were 24%, 22% and 21% respectively, lower than the forecasted values. Between the Holt-Winters estimate and the ARIMA estimate for the North Atlantic there is a significant differential of 14 percentage points presumably due to the differences in estimation procedures. The AEA states that the downturn spurred by the events in September set the growth trend back for that route back two years and that substantial declines continued in 2002. By the end of 2001, this route had a decrease of over 10% over the previous year.

Cross-border Europe ranks fourth in the decline in demand under ARIMA methodology; and the three least affected markets changes slightly to replace Mid-Atlantic route as found under the Holt-Winters methodology with Far East Australasia. AEA does note that there were minimal effects on Far East Australasia route. Along with Sub-Sahara Africa, these two routes were the least affected with the fastest recovery rates. Although a possible explanation can not be ventured forth for Sub-Sahara Africa; but it is probable that the latter route was not as affected due to the high rates of economic growth that were recorded for this geographic area during this time. This route is comprised

of some of the world's emerging economies which were then registering rapid rates of growth.

Totally, the figures follow the same pattern as that of the Holt-Winters models as the impact of the event is highest in the months directly following September 2001; they improve in the earlier months of 2002 and then deteriorate again. Overall, we can say that the estimated percentage loss in RPKs for all of the markets; and the total negative effect of September 11th, 2001 on European Airlines Passenger Demand, using ARIMA models, was approximately 15%. Therefore, it can be said that the effect that September 11<sup>th</sup> created on airline demand had not dissipated by the October 2002. This finding contradicts Lai et al. (2005) who found that the results of the event on airline demand were more temporary.

**Table 6: Estimated Changes in RPKs Summary Table**

Markets	ARIMA	HW	Naïve
SS Africa	-3.5%	6.3%	3.1%
FE Australasia	-9.0%	-6.2%	-2.1%
Domestic	-6.5%	-2.6%	-5.0%
Middle East	-24.2%	-19.0%	-10.3%
CB Europe	-14.0%	-13.0%	-6.0%
North Africa	-21.5%	-15.5%	-15.0%
Mid-Atlantic	-13.3%	-1.2%	1.1%
North Atlantic	-23.2%	-9.2%	-8.5%
South Atlantic	-21.3%	-13.0%	-8.8%
<b>Total Markets</b>	<b>-15.2%</b>	<b>-9.4%</b>	<b>-5.2%</b>

Note: From October 2001 to October 2002

**Discussion and Conclusions**

The global travel and tourism industry has shown much resilience to the impacts of many exogenous factors which threaten its performance. This paper examines the extent of the short-term impact of September 11<sup>th</sup> on European Airlines Demand measured in RPKs. It seeks to provide estimates for the change in RPKs attributed to the large-scale terrorism attack of 9/11. Currently, the existing literature does not detail this impact

on Europe as a whole especially while investigating the airline routes which were affected by the attacks.

Using three univariate methodologies ARIMA, Holt-Winters and naïve models intended to approximate the magnitude of the effect it becomes clear that the event did impact the demand for European airlines. To determine to exactly what extent, the time series models were developed to construct a predictive path that the RPKs would have taken if 9/11 had not taken place. Using the data from January 1991 to August 2001 (pre-9/11 data) we extrapolate dynamic forecasts (ex-post) of air travel for all ten time series under study for the post-9/11 period until October 2002. These data are then compared to the actual levels of RPKs to evaluate the short-term impact and percentage differences in the RPKs.

Our analysis finds that there are variations in months and the magnitude of the impact on routes. Middle East, North and South Atlantic and cross-border Europe markets were the most affected collectively of all the time series. This is mostly attributed to the political instability in the Middle East; the increased hassle factor and risk in the North Atlantic routes; the economic uncertainty in the South Atlantic; and the availability of transport substitutes in Europe. The markets which were least affected were that of Sub-Sahara Africa, domestic and Far East Australasia. It is not known exactly why the differential between the actual and predicted one was minimal for Sub-Sahara Africa. However possible reasons why the other two routes exhibited such meagre rates of impact could have been accredited to the domestic market being perceived as a low-risk route and the presence of emerging economies in Far East Australasia.

This study purports that the total short-term impact of 9/11 on European Airlines Demand was between 5% and 15% with the ARIMA models producing the upper boundary results; and the seasonal naïve model the lower boundary. Ito et al. (2005) in a study examining the impact of the terrorist attack on

European airlines demand until November 2003 deduced that domestic demand reduced up to 17% while the international routes had a 33% decline. Particularly, as to the North Atlantic routes, the magnitude of the effect was 31%, the highest of all the routes. This is greater than the impact of another study by the same authors which reports that the impact to the US airline demand was only 7.9%. The differences may have been due to the increased risk aversion of the Europeans and the shoe-bombing incident which occurred in the end of 2001 highlighting the deficiencies in European airport security.

Through the methodologies employed, it can be seen that the dramatic effects of September 11<sup>th</sup> were not limited to only the US aviation industry but in fact had far-reaching implications to the global aviation industry. The aviation industry by its very nature creates cross-linkages between countries that when one major component is affected, the ripple effects can be felt universally. September 11<sup>th</sup> was therefore the instigator of a significant transmutation in the global aviation industry.

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## Appendix One:

Aggregated RPK data for Europe is from the Association of European Airlines' (AEA) historical database of passenger traffic and includes data for the following carriers: Air France, Finnair, Alitalia, British Airways, bmi, Cyprus Airways, Aer Lingus, Icelandair, Iberia, Meridiana, Spanair, Adria Airways, Yugoslav Airlines, KLM, Air Malta, Luxair, Lufthansa, LOT Polish Airlines, Swiss International Airlines, Balkan, Malev, Olympic Airways, CSA, Austrian Airlines, Croatia Airlines, Tarom, SAS, SN Brussels Airlines, Sabena, Swissair, Turkish Airlines, and TAP Air Portugal.

The routes are as follows:

**EU Cross-Border Europe:** Includes all cross-border/international routes originating and terminating within the Europe (including Turkey and Russia up to 55° East), Azores, Canary Islands, Madeira, and Cyprus.

**NF Europe – North Africa:** Services between Europe and Algeria, Egypt, Libya, Morocco, Sudan and Tunisia.

**EM Europe – Middle East:** Terminating services between Europe and Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Saudi Arabia, Syria, United Arab Emirates, Yemen and the Democratic Republic of Yemen.

**NA North Atlantic:** Any scheduled service between Europe and North, Central or South America via gateways in continental USA (including Alaska and Hawaii) and Canada.

**AE Europe-Far East Australasia:** Services between Europe and points east of the Middle East region, including Trans-Polar and Trans-Siberian flights. All traffic on such services is reported, including local traffic in Europe and Middle East region.

**AF Europe-Sub Saharan Africa:** Routes between Europe and Africa, excluding Algeria, Egypt, Libya, Morocco, Sudan and Tunisia.

**SA South Atlantic:** Any scheduled service between Europe and North, Central or South America via gateways in, or South of Brazil (i.e. Argentina including the Falkland Islands, Brazil, Chile, Paraguay and Uruguay).

**MA Mid Atlantic:** Any scheduled service between Europe and North, Central and South America via gateways in the Caribbean, Central America or the South American mainland North of Brazil (i.e. Bolivia, Colombia including the San Andres Islands, Ecuador, French Guinea, Guyana, Peru, Suriname and Venezuela).

**DO Domestic:** Data available from 1992 Domestic traffic is 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 between two such territories even though a state may cross international waters or over the territory of another State

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and carry international traffic on intermediate stages.

TO Total Scheduled: The sum of all individual routes.