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Note

Assessing fear of flying after a plane crash. The “Rainman” effect – Myth or reality?

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A B S T R A C T

This paper analyses the effects that the largest aviation accident in Spain in the last 25 years affected decisions by potential passengers. There evidence is of a long-lasting “Rainman effect”, with passengers penalising the airline involved with a 20% long-term reduction in traffic. There were also substitution effects towards other means of transport at Madrid-Barajas, where the accident happened, although these were limited in time. There have been no significant effects on other companies or on the total traffic at the aeroplane’s destination airport, Las Palmas de Gran Canaria (Canary Islands), where there are no comparable substitutes for air transport.

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1. Introduction

Air transport is an extremely safe means of transportation, but there are raw major accidents that result in major losses of life. While the actual numbers killed in air accidents, are small, their concentration in space and time gains then considerable public attention. A concern of airlines and the larger air transportation industry more generally is that, while statistically the risks of being involved in a major air crash are small, public perceptions after a major incident may affect traffic.

Here we examine the effects of a particular accident. On Wednesday 20th August, 2008, at 2:24pm local time, a McDonnell Douglas DC-9-82 aircraft on Spanair flight JKK5022 to Gran Canaria airport (Canary Islands) crashed on takeoff from Madrid-Barajas airport. One hundred and fifty-four of the 172 people on board died. The Government declared three days of official mourning and held a State funeral. One feature of the accident is that the airport that the aircraft was due to fly to, Gran Canaria Airport (LPA), is in the Canary Island Archipelago, a considerable distance from the Spanish mainland. It also involves a service to which there in no real travel alternative; the flight takes 2 h 45 min, the same trip by train and ferry would take two days. This study analyses the size of the impact of the accident, and its duration of the effect in terms of aversion of people to fly. A particular focus is placed on the light the incident sheds on the “Rainman” effect[1], namely do people who avoided flying with airlines that had had accidents?

2. The data

The data used to measure the effects of the plane crash on airports and airlines can be divided into three groups:

- *Endogenous variables.* These are the monthly air traffic at Madrid-Barajas Airport; at Las Palmas de Gran Canarias Airport; Spanair airline traffic; Spanair traffic at Madrid-Barajas airport; traffic at Madrid-Barajas airport not including Spanair and Spanair airline traffic at Las Palmas de Gran Canarias airport[2].
- *Exogenous variables are divided into*;
  Dummy 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 and their definitions are:
  a) EASTER: Air traffic around this holiday period is especially intense in Spain, where it is considered high season for tourists, amongst other reasons because of the numerous celebrations of the Passion of Christ. Accordingly, the

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[1] So-called because of the reluctance of Raymond Babbitt (played by Dutsin Hofman) in the film *Rain Man* to fly on any airline but Qantas because they the others had doubtful safety records.

[2] The time series spanning January 1999 to October 2010 are taken from the AENA database (http://www.aena-aeropuertos.es/csee/Satellite?Language=ES_ES&pagename=estadisticas).

Table 1
Results for univariate models with intervention variables.

	Madrid-Barajas (MAD)	Las Palmas de Gran Canaria (LPA)	Spanair (JKK)	Spanair Madrid (JKK at MAD)	Remainder Madrid (MAD without JKK)	Spanair Las Palmas (JKK at LPA)	Remainder Las Palmas (LPA without JKK)
EASTER	0.040***	0.045***	0.050***	0.029**	0.042***	0.106***	0.040***
TRADING		−0.006***		0.003***		−0.004***	−0.006***
LEAP	0.048**		0.035**	0.040**	0.047***		
YEAR	−0.045***				−0.041***		
9/11 Cycle	0.010**	0.005	0.024***	0.019**	0.010**	0.013	0.003
Accident (LS2008/09)	−0.056***	−0.003	−0.184***	−0.262***	−0.042	−0.255***	0.015
Denominator	0.913***						
AO00MAR	0.097***				0.093***		
AO00NOV				−0.124***			
AO03FEB			−0.095***	−0.083**			
AO04OCT			0.134***				
AO04NOV				−0.109***			
AO09JAN	−0.061***				−0.066***		
AO09FEB		−0.050***					−0.052**
AO09MAR		−0.093***					−0.089***
TC09MAY		−0.119***					−0.105***
Denominator		0.856***					0.831***
AO09NOV	−0.076***		−0.124***	−0.249***	−0.073***		
AO10APR		−0.110***	−0.172***	−0.189***			
MA (1)	−0.324**	−0.449***			−0.370***	−0.286***	−0.485***
MA (12)	−0.548***	−0.464***	−0.176*	−0.251**	−0.575***	−0.491***	−0.399***
$\sigma^2 \times 10^3$	0.617	0.904	2.522	3.627	0.661	5.683	0.928
Q (12)	16.196	10.193	10.272	15.141	18.202	7.354	10.968
Q (24)	27.074	21.450	22.173	24.287	30.984	19.594	23.119
Bera-Jarque	0.523 (0.770)	3.495 (0.174)	0.812 (0.666)	2.948 (0.229)	0.252 (0.881)	0.069 (0.966)	3.068 (0.216)

Note: * indicate significance at the 10% level, ** at the 5% level, and *** at the 1% levels. The number of months that the 9/11 effect lasted is given in parenthesis after the coefficient for the variable.

moveable feast of Easter variable is defined by weighting the different days during Easter Week according to the expected traffic density at Spanish airports (the weights must add up to one). Maximum weights are assigned to Wednesday, Thursday, Easter Sunday and Easter Monday. Weights of zero are assigned to the remaining days.

b) TRADING: The number of trading days in a month.
c) LEAP YEAR: For the leap year effect. The value is unity when February has 29 days, and zero, otherwise.
d) 9/11: The negative effect on air traffic resulting from the September 11, 2001 terrorist attacks 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 is been determined for each of the airports.
e) Other outliers related, for example, to bad weather conditions or strikes by air traffic controllers are included by selecting residuals outside four times standard deviation and including them as potential candidates in the models.

Economic activity. Fluctuations in economic activity are measured suing a Spanish Ministry of the Economy and Treasury synthetic economic activity index (http://serviciosweb.meh.es/apps/dgpe/default.aspx).

- Accident effect:

The specification is quite straightforward, since the effect is modelled as a dummy variable starting in September, 2008. Two specifications were systematically tested: as a permanent effect modelled by a sudden step and, as a transitory effect (an effect that disappears over time, TC below). Testing whether the effect started in August 2008 was also systematically included in all models, but was found not to be significant in any, basically because the accident took place very late in the month.

The time series models used in the analysis are in the class of discrete time linear Transfer Function models (Box et al., 1994). The general formulation may be expressed as in Equation (1) (see Castillo-Manzano et al. (2011) and Castillo-Manzano et al. (2010) for an analysis of the advantages of this methodology on transportation research studies).

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

where $y_{i,t}$ is air passenger data for each of the endogenous variables; $u_{i,j,t}$ is the inputs on which the output data depends (most are deterministic, with the sole exceptions of the economic cycle and part of the Spanair indirect effect, see the list above); $e_{i,t}$ is zero mean and constant variance Gaussian white noise; $\omega_{n_{i,j}}(B) = (\omega_{i,0} + \omega_{i,1}B + \ldots + \omega_{n_{i,j}}B^{n_{i,j}})$, $(j = 1,2,..h)$, are polynomials in the backshift operator (i.e. $B^k y_t = y_{i\text{-},t}$) that may have leading zero coefficients when a pure time delay is necessary; $\delta_{n_{i,j}}(B) = (1 + \delta_{i,1}B + \ldots + \delta_{n_{i,j}}B^{m_{i,j}})$ and, $(j = 1,2,..h)$,, are stationary or stable polynomials. The general representation of the noise model $N_i(B)e_{i,t}$ is an ARIMA standard model with monthly seasonality.

The identification of order models for the ARIMA part $N_i(B)$ $e_{i,t}$ was done by means of the simple and partial autocorrelation functions (ACF and PACF) (Box et al., 1994). The Transfer Function orders in Equation (1) were identified by selecting the models that minimised the Schwarz Information Criterion[3]. Estimation was carried out by Exact Maximum Likelihood in MATLAB using the ECOTOOL toolbox (Pedregal et al., 2010).

The treatment of outlier observations is important, and automatic detection algorithms were used. The outliers treated automatically were of the additive (AO), innovative (IO), level shift (LS), and transitory change (TC) types. Assuming that I_t is an impulse

[3] Estimation was carried out by exact maximum likelihood in MATLAB using the ECOTOOL toolbox (Pedregal et al., 2010).

Table 2
Significant effects of the Spanair accident.

	Madrid-Barajas (MAD)	Spanair (JKK)	Spanair Madrid (JKK at MAD)	Spanair Las Palmas (JKK at LPA)
Permanent effect		−20.20%	−29.95%	−29.05%
Transitory effect				
Initial shock	−5.76%			
% Monthly	−8.92%			

variable (zeros for all times except one single time observation), the dynamic models for each of these outliers are shown in Equation (2).

$$\left.\begin{array}{ll} \text{AO}: & wI_t \\ \text{IO}: & N(B)(e_t + wI_t) \\ \text{LS}: & \dfrac{w}{1-B}I_t \\ \text{TC}: & \dfrac{w}{1-\delta B}I_t \end{array}\right\} \quad (2)$$

In Equation (2), ω and δ are parameters to be estimated in each case ($0 < \delta < 1$). AO produces a sudden change (positive or negative) in one single observation; IO produces a sudden change that propagates into the future with the same dynamics as the ARIMA model; LS is a permanent change from a given starting point; TC produces a sudden change that tends to disappear gradually over time.[4]

3. Results

Six models have been estimated with the various explanatory variables. Table 1 shows the parameters estimates of the intervention variables for each equation in the seven models. Columns in Table 1 have models for each endogenous variable. The input variables in the first block are dummy variables for moveable feast days, the 9/11 effect and the economic cycle effect; the second block concentrates on the JKK5022 accident effect, divided correspondingly for each airport; 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); the fourth block corresponds to the parameters of the ARIMA part of the model; the final block includes additional tests of residuals in order to check the suitability of the model.

To make interpretation easier, Table 2 shows the exponential transformation of Table 1 coefficients that measure the effect of the accident. These coefficients enable the effects of the accident to be isolated from other determinants that might have affected the dependent variables during the period.

In short, the results in Tables 1 and 2 show that the accident had very significant effects at the 1% level both on the company and on Madrid-Barajas airport, i.e., on the main actors in the tragedy. However, while the effects on Spanair remained stable up to two years after the accident took place, at Madrid airport they have been transitory. The initial negative shock caused by the accident diminished at a rate of almost 9% a month, as a result of which at the end of the sample, October 2010, the effect was negligible with a 0.52% maximum value.

4. Conclusions

Our results indicate that there was no effect on the traffic at Las Palmas airport after flight JKK5022′s fatal accident. Although there was a permanent fall of 29% in the number of flights operated by Spanair at the airport, this coincided with a European wide economic crisis. There are both similarities and differences between Madrid-Barajas airport, where the accident took place, and Las Palmas airports. One feature the two airports have in common is that the whole effect of the accident focused on the airline involved; at Madrid-Barajas Spanair suffered almost identically to its activities at Las Palmas airport, with an almost 30% fall in traffic. The lack of flight coordination and the rescheduling effects on other companies following the accident were negligible at a major hub like Madrid-Barajas and, therefore, not statistically significant. A substitution effect from Spanair to other airlines was also found, although this did not happen quickly as it had at Las Palmas airport, but occurred slowly over a two year period. Consequently, the net effect over two years at Madrid airport was significant, with an initial shock approaching 6% in the month following the accident, but was inconsequential by the end of the period.

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[4] Two models are tested for the most important variable in the paper, i.e. the accident effect: as a permanent effect, implying that the fear for flying extends to the end of the sample, ii) as a transitory effect, implying that the effect disappears over time at a rate that depends on δ (a parameter closer to zero means a shorter period of time).