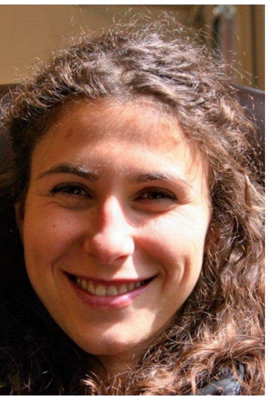


The 2010 Volcanic Ash Cloud and Its Financial Impact on the European Airline Industry

Mario Mazzocchi,
Francesca Hansstein and
Maddalena Ragona*

Introduction

Last April, European air traffic was heavily disrupted by the volcanic ash cloud generated by the eruption of the Icelandic volcano Eyjafjallajokull. Even though the explosion was of low intensity, it produced an enormous cloud of ash moving through the European skies. The fact that the ash was much finer than usual, moving quickly and possibly affecting aircraft engines, led the aviation authorities of the concerned countries to declare most of European skies as no-fly zones (NFZs). Based on the initially available information, there were claims of a huge economic impact on the air travel industry, even bigger than the direct impact of the US air traffic halt after the terrorist attacks on 11 September 2001 (European Commission 2010).

It is obviously difficult to obtain accurate estimates of the overall economic impact imputable to a natural disaster like this. Besides the unpredictable behaviour of nature – in this case not only the eruption but also weather conditions – one should consider the adaptive behaviour of people, whose complexity increases with the number of actors involved. For example, the threshold at which flying was admitted was raised by the relevant authorities after five days of air disruptions, a decision which is likely to have softened the potential impact.

Restrictive measures that caused the closure of the greatest part of European skies had been established on the basis of two previous accidents in the 1980s, when aircraft engines were compromised without any reported airplane crash, however. The interest of the mass media initiated by this type of event, together with the raised risk perception of travellers, may also alter economic behaviour. Thus, while flight operations rapidly go back to normality, it is likely that potential air passengers (for example, holiday makers) decide to cancel their trip or alter their plans (e.g. change the mode of transport or the destination country). When psychology comes into play, an accurate estimation of economic outcomes is even harder. Travelling with the worry that your flight schedule might be disrupted or – worse – that your aircraft engines might be damaged could by itself generate a welfare loss, even if the trip and aircraft are not affected. The literature on the response to risk information (see e.g. Becker and Rubenstein 2004) also shows that economic agents invest their money to take countermeasures, thereby generating profits for other economic agents. For example, air passengers may opt to take a train, rent a car or stay in a hotel, with different costs and economic outcomes, including (possibly) additional income for railways, car rental agencies and hotels.

A further reason why it is difficult to estimate the overall economic impact is the number of offsetting factors that need to be considered. Accountability is quite complicated for airplane and airport industries, due to the weight of offsetting effects as, for example, the tonnes of fuel saved or parking lots filled. The International Air Transport Association (IATA) has estimated that the airline industry uses around 4.3 million barrels of fuel per day. At the peak of the airspace closure, the demand for fuel is estimated to have fallen by 1.2 million kerosene barrels per day (about 110 million US dollars saved) (IATA 2010).

There are a few industries that could have benefitted from the volcano's eruption, at least in the short term, especially those linked to alternative modes of transport, like car rentals and railways. Eurostar reported that it carried 50,000 extra passengers on 15 April, and registered an increase of 33 percent on 17 April. P&O Ferries of France declared that their

* University of Bologna.

services between Britain, Spain, France and the Netherlands were fully booked and that they employed extra personnel to handle the huge volume of phone calls to their info centres.[1] On the other hand, other industries besides airlines have been negatively affected by the disruption: for example, courier services, air cargo businesses or industries that rely on air transport for trading perishable commodities. The European Commission has pointed out that air cargo traffic suffered a fall of 61 percent within the EU27 between the scheduled flights the week before and the 'ash days' (compared to a decrease of 64 percent in passenger traffic) (European Commission 2010).

A (partial) shortcut to the all but impossible task of estimating all those impacts is an analysis of financial markets. Assuming that investors make the best use of available information and base their purchasing or selling behaviour on their rational economic assessment (which rules out speculative behaviours), returns on equities may be seen as the 'thermometer' of the current and predicted performance of an individual industry. In this way one might be able to account for both the losses suffered by the air industry and the potential gains of other stakeholders. A comprehensive analysis is still impossible, at least in the short term. We cannot evaluate the welfare loss of stranded travellers or the productivity losses of all firms indirectly affected by the ash crisis. Another strong assumption is that the behaviour of listed securities is also representative of industries not listed on stock exchanges, such as small and medium-size enterprises. However, the analysis of stock returns seems the easiest and most reasonable way to explore the magnitude of such a complex event.

In this paper, we will provide a first basic estimate of some of the economic effects of the Eyjafjallajokull volcano's eruption, focusing on the airline industry, together with some evaluations of potential gainers, namely alternative transport industries. Toward this end we employ a basic event study analysis (MacKinlay 1997) with the most recent available data, in order to provide some estimates of financial losses that may be ascribed to the volcanic ash cloud. After giving an overview of initial attempts to estimate the economic consequences for the airline industry, we will briefly summarize the basic procedure for conducting an event study. In the final sections, the key results will be discussed and some conclusions drawn.

Economic impact on the airline industry

As it usually happens with crises of this scale, a number of attempts at quick – albeit rough – quantification of the magnitude of the economic impact have been produced. Right after the eruption, the majority of estimates were provided by the main airline association, the IATA and the European Commission. Table 1 reports some of these quantifications, all referring to the week following the first closure of airspace.

In terms of operations, on 17-18 April 2010, 17 EU Member States had a full airspace closure, 2 Member States had a partial closure and 6 non-EU States also decided on a full closure. On April 22, airspace was fully operational again, apart from a partial closure in southern Finland (European Commission 2010). In terms of passenger flows, the biggest domestic markets affected by the closure were Britain, France and Germany, while the biggest decline of airline revenues was due to the cancellation of US-UK flights.

In terms of economic impact, the revenue loss for airlines from scheduled services was estimated at 1.7 billion US dollars (this figure is considered 'conservative') during the period of 15-21 April 2010. The revenue loss per day varies according to the daily airspace closure, and reached 400 US dollars per day during the peak period (17-19 April). During the five days of disruption, British Airways reported a loss of 20 million British pounds per day as did Air-France KLM.[2]

The classical event study method

A rapid assessment of the financial impact of the volcanic ash cloud may be made with an event study analysis (MacKinlay 1997). The method basically ascribes to specific events significant deviations of individual returns on equities from the overall market trend, based on the 'ordinary' behaviour of share prices. For this purpose, one may benchmark ordinary behaviour using the market model, which assumes a linear relationship between returns on individual securities and the market return:

[1] From BBC News, www.bbc.co.uk.

[2] From The Economist, www.economist.com.

Table 1
Estimated effects of the volcanic ash cloud on the airline industry (15–23 April 2010)

Source	*Outcome*	
ACI Europe	313 airports	European airports totally disabled (75% of the European Airport Network)
IATA	100,000 flights 19,000 flights	Flights cancelled within the EU, to/from the EU and overflying the EU Peak of flights cancelled on 18 and 19 April
EUROCONTROL	10 million passengers 1.2 million passengers 24% (and 9% worldwide) passengers flow reduction	Estimated passengers unable to travel Average of scheduled passengers affected each day Reduction of the within-Europe and Europe-rest of the world passenger flows
Source	*Economic impact*	
IATA IATA	US$ 1.7 billion US$ 400 million	Revenue loss for airlines during the period 15-21 April Per day revenue lost for airlines over the peak period (17–19 April)
AEA	€ 850 million	Loss for airlines including profitability, assistance to passengers, costs for stranded crew, parking and positioning of aircraft and other cost issues (for the period 15–23 April)
ERAA	€ 110 million	Estimated loss for members of ERAA
ELFAA	€ 202 million	Estimated loss for members of ELFAA
IACA	€ 310 million	Estimated loss for members of IACA
ACI Europe	€ 250 million	Overall European airports losses
IAHA	€ 200 million	Direct financial loss for independent handlers pertaining to the IAHA
ANSPs	€ 25 million	Loss per day for Air Traffic Management (ATM)
EC	61%	Fall in air traffic cargo between the scheduled flight per week in the EU-27

Notes: ACI: Airport Council International; IATA: International Air Transport Association; AEA: Association of European Airlines; EUROCONTROL: European Organisation for the Safety of Air Navigation; ERA: European Regions Airline Association; ELFAA: European Low-Fare Airlines Association; IACA: International Air Carrier Association; IAHA: International Aviation Handlers Association; ANSPs: Air Navigation Server Providers and EC: European Commission.

Source: Websites of the sources indicated in the first column and listed above.

$$R_{it} = \alpha_i + \beta_i R_{Mt} + u_{it}. \quad (1)$$

where R_{it} is the return of a security at time t, R_{Mt} is the market return and u_{it} are independent normally-distributed residuals. The benchmark model is estimated on a sample prior to the event, which should not be affected by other major security-specific events. Then the ordinary behaviour is projected through a time window after the event occurs (the 'event window') and significant deviations from the ordinary behaviour are detected based on tests of the excess returns with the following null hypothesis:

$$H_0 : R_t = E(R_t | R_{Mt}) \qquad \text{with} \quad t \in \tau, \quad (2)$$

where τ is the event window set which covers the period following the occurrence of the event and $E(R_t|R_{Mt})$ is the 'normal' return, which is obtained by conditioning on the market return, and allows to predict the expected return had the event not occurred. Even if tests of individual securities and time periods are possible, these are less powerful compared to a test based on aggregations of time periods and/or securities. Once the parameters α and β are estimated, the normal returns may be predicted over the event window and are computed as:

$$E(R_{it} | R_{Mt}) = \hat{\alpha}_i + \hat{\beta}_i R_{Mt} \qquad \text{with} \quad t \in \tau. \quad (3)$$

So that excess returns correspond to the forecast error u_{it} and are computed over the event window as

$$u_{it} = R_{it} - \hat{\alpha}_i - \hat{\beta}_i R_{Mt} \qquad \text{with} \quad t \in \tau \quad (4)$$

Under the null hypothesis these results are normally distributed with the following standard error (Patell 1976):

$$\sigma_{u_{it}} = \sqrt{\sigma_i^2 \left(1 + \frac{1}{T} + \frac{(R_{Mt} - \bar{R}_M)^2}{\sum_{j=1}^{T} (R_{Mj} - \bar{R}_M)^2} \right)} = \sigma_i \sqrt{C_{it}} \qquad (5)$$

with $t \in \tau$

where σ_i is the regression standard error of the i-th security, $\bar{R}_M$ is the average market return over the estimation period, T is the number of observations in the estimation sample and C_{it} (i.e. the expression in brackets) is the variance inflation factor due to prediction outside the estimation period. A test for the null hypothesis for individual securities and individual time periods of the event window is provided by the Patell Standardised Residuals (PSRs):

$$z_{il} = \frac{u_{il}}{\sigma_{u_{il}} \sqrt{C_{il}}} \sim N(0,1) \quad \text{where } l \in \tau. \qquad (6)$$

For large T it is possible to obtain aggregated tests over the L time periods of the event window τ, across S securities of a given set ψ or across both τ and ψ, as follows:

$$z_{i0} = \frac{\sum_{l=1}^{L} u_{il}}{\sigma_i \sqrt{LC_{il}}} \sim N(0,1), \qquad (7)$$

$$z_{Sl} = \frac{\bar{u}_{Sl}}{SE(\bar{u}_S)\sqrt{C_{Sl}}} \sim N(0,1) \qquad (8)$$

and

$$z_{S0} = \frac{\sum_{l=1}^{L} \bar{u}_{Sl}}{SE(\bar{u}_S) \sum_{l=1}^{L} \sqrt{C_{Sl}}} \sim N(0,1), \qquad (9)$$

where

$$l \in \tau,\ \bar{u}_{Sl} = \frac{1}{S} \sum_{i \in \psi} u_{il},\ \bar{u}_S = \frac{1}{L} \sum_{l \in \tau} \bar{u}_{Sl},\ SE(\bar{u}_S) = \sqrt{\frac{1}{T-1} \sum_{t=1}^{T} (\bar{u}_{St} - \bar{u}_S)^2}\ .$$

Application and results

For this event study, we make use of Datastream daily data on share prices for selected securities on the London, Frankfurt, Paris and Stockholm stock exchanges. The estimation window is chosen to be relatively small (100 observations from 24 December 2009 to 14 April 2010) in order to minimize the risks of major structural changes associated with the economic crisis and to emphasize the short-run dynamics.[3] Nine airlines (7 flag carriers and 2 low-cost companies) were included, considering their listing on the most relevant stock exchange. We also selected six potential gainers: five car rental companies and Eurotunnel, the company which runs Eurostar trains and the Eurotunnel. Our assumption – partially confirmed by the results – is that these companies may have benefitted from a decrease in airplane transport by an increase in the demand for car rental and train services. The selected companies and the reference stock exchange are listed in Table 2.

The period affected by the ash cloud ran from 15 April to 20 May (day when European skies were declared 'ash-free'). A detailed timeline of events and effect on air operations is provided in Table 3. Based on the events listed in Table 3, several event windows (EW) were explored, as summarized in Table 4.

Despite using the basic event study approach, results were econometrically robust to choices on the size of estimation and event windows. Figure 1 shows the day-by-day Patell Standardised Residuals (PSRs) aggregated over the two groups of firms through the overall event window running from 15 April to 20 May, computed as indicated in equation (8). Significant abnormal returns at the 95 percent confidence level are those below or above the two horizontal lines. The aggregate value of the airlines (blue line) is below the zero line over most of the considered period, although it is only significant during the first peak period (17–19 April), on 28 April, over the second 'wave' of ash (5–7 May) and with the last occurrence of the ash cloud (around 17 May). On 21 April there is a positive significant return, a 'rebound' after the negative peaks of previous days. In contrast, in the aggregate, evidence on positive returns for potential gainers is quite weak, with positive values during the first few days (only significant on 15 April).

[3] However, estimation windows with 200, 300 or 400 observations produced similar results.

Table 2

Selected securities and reference market returns

Security	Reference market return (Stock Exchange)
	Airlines
Aerlingus	FTSE-All (London Stock Exchange)
Air France – KLM	CAC (Paris Stock Exchange)
British Airways	FTSE-All (London Stock Exchange)
Easyjet	FTSE-All (London Stock Exchange)
Finnair	DAX (Frankfurt Stock Exchange)
Iberia	DAX (Frankfurt Stock Exchange)
Lufthansa	DAX (Frankfurt Stock Exchange)
Ryanair	FTSE-All (London Stock Exchange)
SAS	OMX (Stockholm Stock Exchange)
	Potential gainers
Avis Europe	DAX (Frankfurt Stock Exchange)
Avis Budget Group	DAX (Frankfurt Stock Exchange)
Eurazeo	CAC (Paris Stock Exchange)
Eurotunnel	CAC (Paris Stock Exchange)
Hertz	DAX (Frankfurt Stock Exchange)
Sixt	DAX (Frankfurt Stock Exchange)

Source: Datastream.

Table 3

Timeline of events associated with the ash cloud and effects on flights

Date	Actual flights	Estimated flights in a normal day	EUROCONTROL's expectations declared each day (summary)
Wed 14 April	28,087	28,000	None
Thu 15 April	20,842	28,000	None
Fri 16 April	11,659	28,000	Airspace is not available for operation of civilian aircraft in the following countries/areas: Ireland, UK, Belgium, Netherlands, Denmark, Sweden, Norway, Finland, Estonia, northen France, parts of Germany, parts of Poland. Forecasts suggest that the cloud of volcanic ash is continuing to move east and south-east and that the impact will continue for at least the next 24 hours.
Sat 17 April	5,335	22,000	No landings and take-offs are possible for civilian aircraft across most of northern and central Europe: Austria, Belgium, Croatia, Czech Rep., Denmark, Estonia, Finland, northern France, most of Germany, Hungary, Ireland, northern Italy, Netherlands, southern Norway, Poland, Romania, Slovakia, Slovenia, Sweden, Switzerland and UK. Forecasts suggest that the cloud of volcanic ash will persist and that the impact will continue for at least the next 24 hours.
Sun 18 April	5,204	24,000	Air traffic control services are not being provided to civil aircraft in the major part of European airspace: Austria, Belgium, Croatia, Czech Rep., Denmark, Estonia, Finland, most of France, most of Germany, Hungary, Ireland, northern Italy, Netherlands, Norway, Poland, Romania, Serbia, Slovenia, Slovakia, northern Spain, Sweden, Switzerland, Ukraine and UK.
Mon 19 April	9,330	28,000	Air traffic control services are not being provided to civil aircraft in the major part of European airspace: Belgium, Czech Rep., Denmark, Estonia, Finland, parts of France, Germany, Hungary, Ireland, Netherlands, northern Italy, Poland, Romania, Slovenia, Switzerland, parts of Ukraine and UK.
Tue 20 April	13,101	28,000	The new procedures agreed yesterday have been in place since 6.00 UTC. Air traffic control services are not being provided to civil aircraft, or are being provided with significant restrictions, in the lower airspace in north-western Europe: Denmark, Estonia, Finland, northern France, northern Italy, Latvia, Slovenia, Slovakia and UK. In the upper airspace above 20,000 feet, all European airspace is available. In the evening almost 75% of the total continent area is free of any restrictions.
Wed 21 April	21,916	28,000	All European airspace is available above 20,000 feet. Below 20,000 feet, restrictions are still in force in a few areas (southern Sweden, part of Finland, parts of Scotland). It is anticipated that these restrictions will gradually be lifted throughout the day. It is anticipated that almost 100% of the air traffic will take place in Europe tomorrow.

Thu 22 April	27,284	28–29,000	A small number of cancellations can be expected due to some limited restrictions and the logistical problems of airlines. Almost all European airspace is available, with a few exceptions in parts of southern Finland, southern Norway, northern Scotland and western Sweden.
Fri 23 April		29,000	Almost all European airspace is available, with the exception of part of northern Scotland.
Wed 28 April	Normal	Normal	The Ash Concentration Charts produced by VAAC London show that there has been no area of high potential volcanic ash coverage within the CFMU area for several days now.
Tue 4 May		28,000	Airspace in Ireland, northern Ireland and small parts of western Scotland was closed between 8.00 and 14.00 CET (cancellation of some 150 flights). The latest Ash Concentration Charts show that the area where ash concentrations could exceed engine manufacturer tolerance levels has shrunk and is no longer affecting any substantial part of European airspace. This situation is expected to remain stable for the coming hours.
Wed 5 May	27,904	29,000	Several Irish airports will be closed for limited hours. Edinburgh is currently operating at reduced capacity and the western part of Scottish airspace is closed. The situation is not expected to improve in this area during the day. The whole of Ireland, western Scotland and north-western England could be affected. Greek airspace is also closed for all traffic as a result of industrial action.
Thu 6 May	30,202	28,500	No closures of airspace or airports within the Europe. The predicted area where ash concentration could exceed engine manufacturer tolerance levels lies to the west/north-west of Ireland. In the night of 5 to 6 May, renewed and more intensive ash eruptions took place.
Fri 7 May	30,342	28–29,000	Some airports were closed in western Ireland overnight. The main predicted area where ash concentration could exceed engine manufacturer tolerance levels lies to the western part of North-West Europe. Renewed and more intensive ash eruptions took place overnight, and the area of potential higher ash contamination is forecast to extend from Iceland as far south as the western edge of the Iberian Peninsula during the day. Transatlantic flights are being re-routed south of the affected area which could cause delays to these flights.
Sat 8 May	22,424	22,600	Ash eruptions are ongoing. Airports are closed or expected to close in northern Portugal, northern Spain and parts of southern France. Transatlantic flights are being re-routed around the affected area which is causing substantial delays to these flights.
Sun 9 May	23,491	25,000	Ash eruptions are still substantially affecting European airspace. Airports in northern and central Portugal, north-western Spain, northern and central Italy are unavailable, and are expected to open later. Transatlantic flights continue to be affected by the ash cloud (re-routings, delays).
Mon 10 May	29,155	29,000	Areas of high ash concentration have dispersed overnight over continental Europe. There is an area of ash cloud in the middle of the North Atlantic impacting transatlantic flights (re-routings, delays). No airports are closed in Europe. During the afternoon, areas of higher ash concentration could move in a north-easterly direction from the Atlantic into the Iberian Peninsula.
Tue 11 May	27,807	29,000	Airports on the Canary Islands, some in south-west Spain and some in Morocco are closed. At the same time, ongoing work by the UK Met Office and the UK CAA has confirmed the effectiveness of the model used to determine the areas where ash concentration could be above engine tolerance levels.
Wed 12 May	29,935	Normal	Areas of high ash concentration at lower altitudes, which are still causing some difficulties for trans-Atlantic flights, are currently found in the Mediterranean between the Spanish mainland and the Balearic Islands, and are moving north-east. All airports are available, however with the Balearic Islands airports operating at reduced capacity. The areas of higher ash concentration are expected to dissipate further during the day.
Thu 13 May	26,852	Normal	The areas of high ash concentration at high altitude have now dispersed. The areas of higher ash concentration are not expected to cause any disruption to air traffic during the next 24 hours.
Fri 14 May	Normal	Normal	The areas of ash concentration are mainly at low levels in the vicinity of Iceland, and are not expected to cause any disruption to air traffic during the next 24 hours.
Sun 16 May	25,088	25,000	None.

Mon 17 May		29,000	The areas of ash concentration are mainly at low levels. During the course of the day, the current cloud is expected to disperse somewhat. The cloud is expected to mainly affect northern Ireland, parts of Scotland and parts of south-western UK. On Sunday 16 May, the disruptions in Ireland and north-western UK resulted in a reduction in expected number of flights by about 400.
Note: Blanks in the actual flight number indicate that EUROCONTROL did not provide official information, which happened in days when air traffic was normal.			

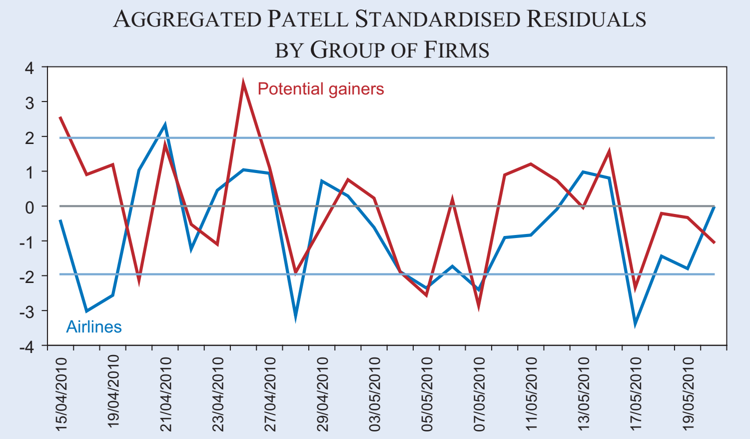
Source: EUROCONTROL News – Update on European Air Traffic Situation (www.eurocontrol.it).

Table 4

Event windows

Event window (EW)		Flights affected
EW1	15–19 April	Peak negative effect on most EU flights
EW2	15–23 April	Total period until return to normal flight operation (April)
EW3	3–7 May	Negative effects on UK, Ireland and southern European flights
EW4	17–19 May	Some disruption of flights to/from UK and northern Europe
EWTOT	15 April–20 May	Total period until return to normal flight operations (May)

Figure 1



Note: Continuous horizontal lines show 95% confidence level thresholds.

Source: Datastream; authors' calculation.

Table 5 clearly shows that a persistent negative impact on the selection of listed airlines may be observed throughout all event windows, with the exception of the second event window that ended on 23 April. This might be explained by the rebound observed on 21 April and presumably by the positive expectations driven by a return to normality and the debate about rising ash concentration thresholds to allow air traffic, which happened towards the end of the event window. The reoccurrence of the ash cloud in May resulted in new major negative effects, probably worsened by the expectation that the issue could be long-lasting. The overall effect over the longest event window is strongly negative, despite the fact that increasing the length of an event window usually reduces the power of tests because of forecast errors. Again, the evidence on potential gainers is mixed and confined to the short-term at the first occurrence of the crisis, while on the longest event window there is no detectable effect.

More powerful tests can be obtained by aggregating over time as well as over securities, according to equation (9). We consider the various event windows described in Table 5.

Finally, in Table 6, we provide an estimate of the overall effect of the crisis on the individual compa-

Table 5

Aggregate financial impact over various event windows (EW): Patell Standardised Residuals

	EW1	EW2	EW3	EW4	EWTOT
	15–19 April	15–23 April	3–7 May	17–19 May	15 April–20 May
Airlines	– 3.48*	– 1.29	– 4.04*	–3.80*	– 3.79*
Potential gainers	2.66*	0.98	– 3.13*	– 1.65	– 0.18
Note: * Significant abnormal returns at the 95% confidence level.					

Source: Datastream; authors' calculation.

Table 6

Impact by individual security (Patell Standardised Residuals and impact on firm market values)

	PSR	Firm value impact (million €)
Airlines		
Aerlingus	– 0.12	– 7
Air France - KLM	– 1.34	– 368
British Airways	– 1.43	– 365
Easyjet	– 2.20*	– 338
Finnair	– 1.91	– 83
Iberia	– 1.52	– 525
Lufthansa	– 2.20*	– 670
Ryanair	– 1.58	– 791
SAS	– 1.25	– 229
Potential gainers		
Avis	1.10	123
Budget	– 1.14	– 225
Eurazeo	0.56	110
Eurotunnel	– 1.02	– 201
Hertz	– 0.46	– 306
Sixt	– 0.56	– 76
Aggregate results		
Airlines	*– 3.79**	*– 3,374*
Potential gainers	*– 0.18*	*– 575*

Note: * Significant abnormal returns at the 95% confidence level.

Source: Datastream; authors' calculation.

nies, based on PSRs as computed in equation (7). We also give a rough estimate of the associated financial loss, based on the excess residuals on single days and the market value of firms.[4] Of course, these figures only refer to a small selection of companies and stock exchanges, but they may give an idea of the magnitude of the effect. Considering the period between 15 April and 20 May, the nine airlines considered for these studies experienced a loss of about 3.3 billion euros in terms of market value.

Concluding remarks

This study provides a timely exploration of the impact of the volcanic ash cloud, using financial data and a traditional event study approach. The volcanic ash cloud and its effect on air traffic represent a major example of the complexities that economists face in producing a rapid estimate of the monetary effects of a natural disaster. Although the event study approach is a dated instrument and was applied in its basic form, which consists in running a set of linear regressions and out-of-sample forecast tests, the procedure is still an efficient instrument for monitoring the patterns of these complex effects.

With respect to the ash cloud application, a few key results may be summarized. First, as experienced in other risk-related events, while the first occurrence of the crisis generated major negative impacts on airlines, the return to normal financial operations was quite rapid; one week after the first closure of European airspace and airports there was no major sign of significant losses. However, as the ash cloud returned to affect flight operations in May, despite the relatively low impact in terms of disrupted flights and grounded passengers, the financial reaction was quite strong. Reoccurring events raise the risk level for affected companies and may engender a structural impact on the economic performance of firms, at least in the short to medium term. Although our limited sample of securities does not allow for general conclusions, potential gains for economic agents who might benefit from the disruption of air travel seem to be short-lived, consistently with the adaptive behaviour of agents and the time needed for structural adjustments (e.g. increasing capacity for car rentals). Our overall estimate for 9 selected European flag carriers is a loss of about 3.3 billion euros over one month, a figure which is well above

[4] As a reference company market value we use Datastream estimates for May 2010.

the overall economic impact estimated in the aftermath of the event for all European airlines.

References

Becker, G. S. and Y. Rubinstein (2004), *Fear and the Response to Terrorism: An Economic Analysis,* Revised Version of February 2010, University of Chicago, http://www.econ.brown.edu/fac/yona_rubinstein/Research/Working%20Papers/BR_FEB2010.pdf.

European Commission (2010), *The Impact of the Volcanic Ash Cloud Crisis on the Air Transport Industry,* SEC(2010) 533, 27 April, Brussels.

International Air Transport Association (IATA, 2010), *IATA Economics Briefing: The Impact of Eyjafjallajokull's Volcanic Ash Plume,*
http://www.iata.org/whatwedo/Documents/economics/Volcanic-Ash-Plume-May2010.pdf.

MacKinlay, A. C. (1997), "Event Studies in Economics and Finance", *Journal of Economic Literature* 35, 13–39.

Patell, J. M. (1976), "Corporate Forecasts of Earning Per Share and Stock Price Behaviour: Empirical Tests", *Journal of Accounting Research* 14, 246–276.