Do Markets React Rationally? An Event Study on the Effect of the 2010 Volcano Eruption on Airline Stock Returns

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Abstract: In April 2010, a volcano eruption in Iceland caused a temporary flight ban on most of European airspace resulting in a negative financial impact on European airlines in particular. By conducting an event study, we investigate if market participants reacted rationally to the effects of this event. Our results suggest that the capital market did not consider the effects of the flight ban as severe to individual airline companies. We find inconclusive results when testing if market participants differentiated between securities based on company characteristics. For the portfolio of European airlines, however, the exposure to the event has a certain explanatory power for abnormal returns. In addition, we find that on an industry level, investors were fairly good at quantifying the airlines' one-time loss. We conclude that the lack of significant results constrains us from drawing clear inferences on market rationality. However, despite the low significance of abnormal returns, we find that investors acted rationally to some extent by correctly assessing the magnitude of the financial impact.

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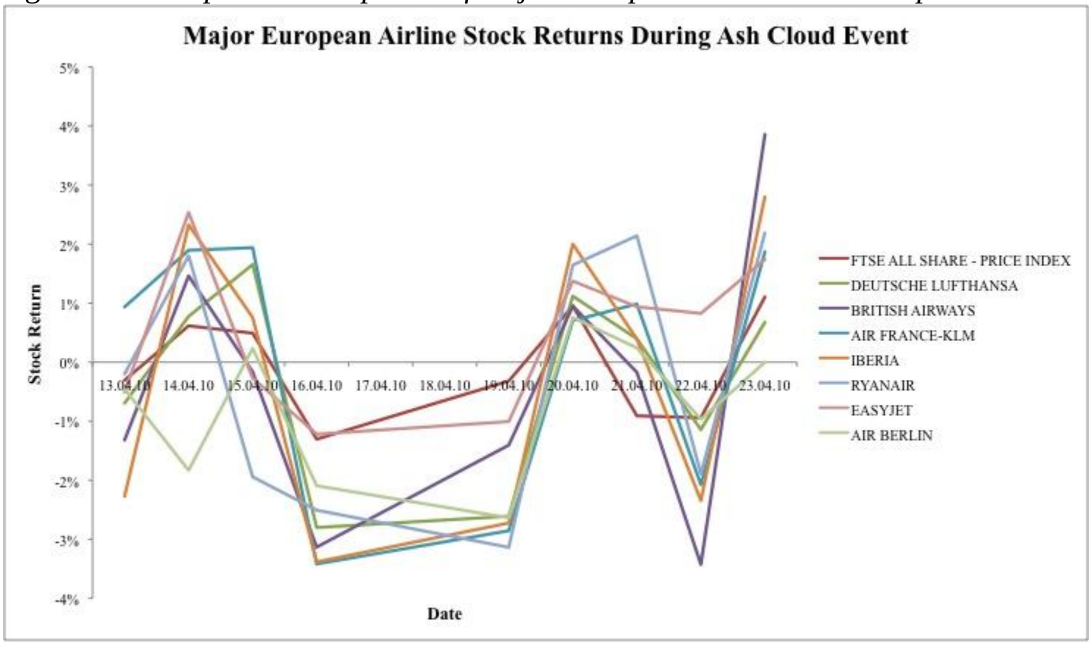
1. Introduction

1.1 The Ash Cloud Event and its Impact

The eruption of Icelandic volcano Eyjafjallajokull in April 2010 had severe consequences for European airlines. The dimension of the eruption and the volcanic ash thrown kilometers into the atmosphere caused European airspace to close for several days thus forcing airlines to ground their airplanes (IATA, 2010, A). The extensive media coverage underlined that this was an event of important economic impact that especially impacted passenger airlines through additional expenses such as accommodation, passenger compensation and aircraft re-routing. Despite the fact that it is hard to quantify the overall impact on the economy of the ash cloud event, it is estimated that the approximately 100,000 affected flights led to a direct negative financial impact of about $1.8 billion to all airlines (IATA, 2010, A). As European airlines were just recovering from the financial crisis in 2008, the volcano ash cloud plumped in and caused an 11.7% year-on-year drop in passenger traffic for European airlines in April 2010. As an example, Deutsche Lufthansa published an estimate of a loss of €25 million a day (Spiegel Online, 2010). Among airlines, it was feared that the financial burden resulting from the ash cloud could be worse than the negative impact of September 11th. Taken together, the six major European airlines (Easyjet, Ryanair, British Airways, Iberia, Air France-KLM and Lufthansa) were estimated to accumulate a loss of €140 million a day (Spiegel Online, 2010).

Figure 1: *Share price development of major European airlines in mid-April*

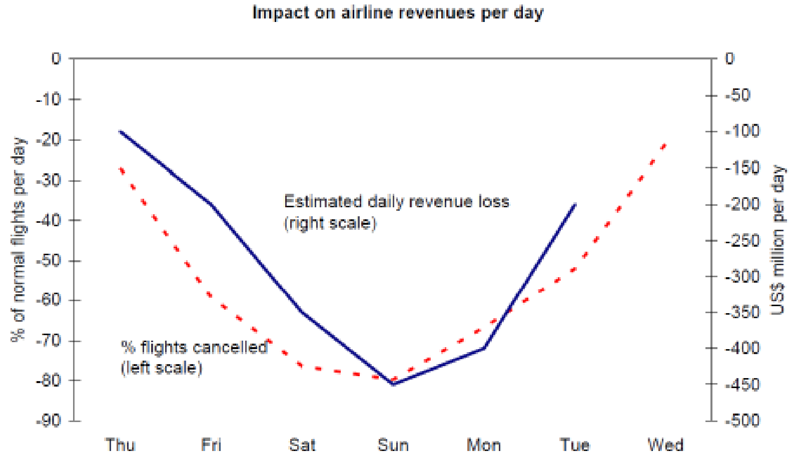


Source: Own Illustration, data from Datastream

The graph above illustrates the stock returns (share price compared to previous day) of selected European airlines from the 13th to the 23rd of April 2010. The FTSE All Shares Index is taken as a benchmark in this graph. It can be observed that all securities show negative returns on all days from the 15th of April to the 19th of April. On average, it can be seen that shares were down by about 2-3% on the trading days between the 15th and the 19th of April, while the benchmark index was down between 0-1% in the same period. We are aware of the fact that the volcanic eruption also had an effect in May, but since there were only 7,000 flights cancelled compared to 104,000 flights in April, no major cash losses were observed in May 2010 (Eurocontrol, 2010).

US carriers also suffered from the ash cloud due to flight cancellations to and from Europe, but with 1.9% year-on-year decline in April passenger traffic was not hit as severely as for European airlines (IATA, 2010, B). Airspace in Southern Europe remained partially opened throughout the ash cloud event. Figure 2 illustrates and summarizes the chronological order of flight cancellations and the approximate economic impact on European airlines during the volcanic eruption.

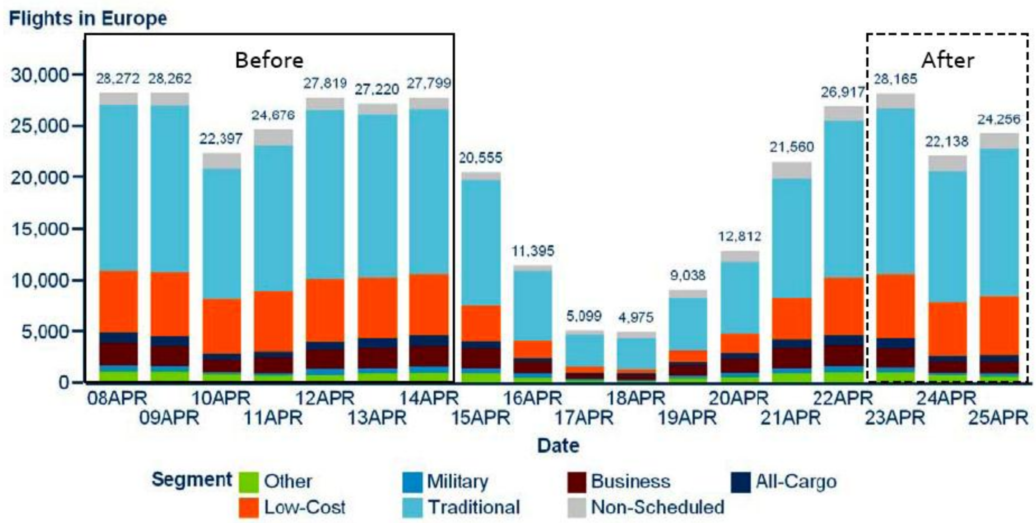
Figure 2: *Operational and financial impact of volcano ash cloud*



Source: IATA, C, The Impact of Eyjafjallajokull's Volcanic ash Plume, 2010

The graph above shows that the substantial financial burden occurred during the weekend from Friday, the 15th of April 2010, until Monday, the 19th of April 2010. Information was available on the 19th of April that most airspace would soon be open again (Agence France Press, 2010). In this context, it is important to state that we define the event window according to the point in time when new information was available to the capital market. Therefore, our event window comprises the days from the initial closing of the European airspace to the point where information was publicly available that airspace will gradually reopen.

Figure 3: *Flights in Europe in April 2010*



Source: Eurocontrol (2010)

As can be inferred from the figure above, however, it takes a few days to return to normal operations, since airlines operate a complex logistical network with many crews and airplanes out of position (The Telegraph, 2010). The graph shows that even though airspace was mainly re-opening on the 19th/20th of April (depending on region), it took the airlines about three days to reach normal operations again. The underlying assumption for our choice of event window is that investors on the 19th of April could assess what the overall losses would be.

Table 1: *Chronological order of announcements*

Date	Actual Flights	Estimated Flights on a normal day	Announcements by Eurocontrol
April 14th, 2010	28,087	28,000	No effects on European airspace during the day In the evening, small parts of airspace in Scotland, Norway, Sweden and Finland restricted
April 15th, 2010	20,842	28,000	Denmark & Ireland close airspace Regulations in Sweden and Norway France remains largely open
April 16th, 2010	11,659	28,000	German airspace, some eastern and southern European countries' airspace is closed
April 17th, 2010	5,335	22,000	No landings and take-offs are possible for civilian aircraft across most of northern and central Europe. Forecasts suggest that the cloud of volcanic ash will persist and that the impact will continue for at least the next 24 hours
April 18th, 2010	5,204	24,000	Northern Spain is regulated until 8 am Madrid, Bordeaux and Marseille regions cancel restrictions Spain, France, Austria, Switzerland, Poland as well as parts of Germany open airspace above certain flight level
April 19th, 2010	9,330	28,000	Large part of European airspace, such as Germany and France open above certain flight level
April 20th, 2010	13,101	28,000	Most of airspace reopened UK still closed until 20.00 CET German airspace also open below certain flight level In the evening almost 75% of the total

			continent area is free of any restrictions.
April 21th, 2010	21,916	28,000	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 on the 22nd.

Source: Adapted from Mazzocchi, Hansstein & Ragona (2010) and Eurocontrol (2010)

The table above gives an overview of the timeline during the ash cloud event in April 2010. It generally shows, in line with previous statements, that no major effect of the ash cloud was expected until the night between the 14th and 15th of April. The table also shows that countries in Northern Europe, such as the UK or Germany, were affected longer than countries in Southern Europe, such as Spain.

1.2 Research Hypotheses

This study addresses whether the stock market reacted rationally to the newly available information in connection to the airspace closure. Since the particular event of investigation constitutes a negative effect for the period's cash flows, negative returns are likely to be observed. Since it lowers cash flows of the current period, the airlines' market value should be affected (Sprecher & Pertl, 1983)

We will conduct an event study that focuses on the days from the announcement that a large part of European airspace will be closed until the announcement that reopening is likely to occur, i.e. 15th of April until the 19th of April. This time span constitutes three trading days on the stock markets.

According to the theory of efficient markets, which we will discuss later on, the capital market should absorb new information (Sprecher & Pertl, 1983). We therefore expect a stock price reaction as a result of the new information that was accessible to the market in the event window. Explicitly, we expect to find negative returns during the event window due to the adverse effect of the ash cloud. In addition, we expect differences in company characteristics (such as liquidity and degree of impact) to have an influence on the size of abnormal returns. Lastly, we also expect that there is a positive correlation between the disclosed loss in the company reports due to the ash cloud and the decrease in market value for each company during the event. In line with these hypotheses, we expect investors to have acted rationally to the event at hand.

1.3 Contribution

While market efficiency has been subject to much research, investigating the rationality of investor behavior in relation to a specific event has not received the same attention. This study aims to contribute to the previous research in this field. The majority of research has had US companies and events as targets, notably the event study of the airline industry reaction to September 11 made by Carter and Simkins (2002).

This study aims to contribute in three ways; first by contributing to the event study practice by applying MacKinlay's (1997) and Carter and Simkins' (2002) methodologies on a European cross-country event. Secondly, we contribute with our research through investigating to what extent the investor reaction in relation to the Icelandic ash cloud can be explained as a behavior guided by the same rational thinking that Carter and Simkins (2002) found in their study. By doing this we analyze, if our results are in line with Carter and Simkins' (2002) findings on market rationality. Thirdly, we carry the ambition to provide some new ideas on how investor behavior can be investigated and inferred through a methodology of multiple steps as they are outlined in the course of the investigation.

1.4 Course of the Investigation

In order to analyze the rationality of investors in relation to the event, three steps are undertaken in order to accumulate insight. Firstly, the significance of the stock reactions is investigated. Secondly, we analyze individual company and portfolio characteristics and their linear relation with the stock reactions. In the last step we investigate, if investors managed to correctly assess the magnitude of company losses by analyzing the relation between ex-post disclosed financial loss and investor behavior.

The first step in the outline of the study is to show the statistical significance of abnormal returns in the sample portfolio during the specified event window. This part also introduces the sample portfolio of European airlines as well as specifications of the event study, such as event and estimation window. This follows the usual event study methodology of rejecting the null hypothesis of non-significant abnormal returns, which lays the basis for being able to investigate the proposed event. An analysis of the statistical results will be given subsequently.

In the second step, we test if there was a differentiated assessment of the market due to the degree to which airlines were affected and due to firm-specific characteristics. We base this step on the methodology performed by Carter and Simkins (2002) who have investigated market rationality of airline stock returns after the September 11th tragedy. Using a multiple-regression model, we want to find out how firm characteristics affected stock price reaction. Following the hypotheses tests, we will analyze the implications of the statistical results. Furthermore, we will conduct a similar approach on different portfolios of airlines and compare our European sample portfolio to other regional portfolios of airlines that were not affected at all or only to a limited degree.

In addition and as a last third step, we further extend the proposed research approach by conducting an ex-post analysis. As the investigated event is about 11 months in the past at the time of writing and most airlines have until now been able to clearly quantify the losses related to the ash cloud, we will compare the actual losses disclosed by the airlines with the drop in market capitalization in the event window. By doing this, we expect to obtain an additional view of market rationality related to this event compared to traditional event study methods. By conducting a holistic approach, we will try to draw conclusions if the market acted rationally or if market under- or overreactions can be observed.

As an introduction to the subject and the study itself, we will introduce theoretical backgrounds on event study methodologies. In addition, a brief theoretical overview of market efficiency will be given and we will argue for the definition of market efficiency that we are using. Furthermore, we will present the basic concepts of fundamental valuation that the capital market uses in order to value securities and situate it into our context. This is necessary since our research question addresses market rationality, which builds on the above-mentioned theories.

1.5 Demarcation of the Topic

Firstly, when we refer to the “ash cloud”, the eruption that affect airlines from the 14th of April to the 21st of April is meant. Additional eruptions occurred shortly afterwards that affected Northern and Southern Europe. We will not take these eruptions into account. We are aware of the fact that this causes some inference problems when conducting the ex-post analysis of the event. However, as stated by Eurocontrol (2010), the cancellations in May were too small to have a relevant impact on the actual losses of airlines. The difference in magnitude is illustrated by the fact that a total of 7,000 flights were cancelled in May due to volcanic ash, while a total of 104,000 flights were cancelled in April (Eurocontrol, 2010).

Secondly, this event study is not a longitudinal study, but the effect the eruptions had on the security holders’ wealth in the short-term will be analyzed. This is done, since short-term event studies constitute a useful tool to test market efficiency and to draw conclusions about market rationality, which is the aim of this study (Kothari & Warner, 2006).

2. Previous Research

2.1 Introduction to Event Studies

In this section, we will give a theoretical background on the research that has been conducted on event studies. In order to do this, we draw on literature that proposes methods and statistical recommendations for event studies and on actual event studies that have been conducted. This is important, in order to understand the benefits and drawbacks of an event study approach to research.

An event study aims to investigate and relate a particular economic event with security prices (Thompson, 1985). The applications of event studies reach from mergers & acquisitions, earnings announcements, stock splits to the field of law and regulation that have potential impact on security prices in the short or in the long run. Event studies have received increased research attention over the last years. In this context, a large number of event studies have been conducted and a lot of research has been done on handling the different methodologies of event studies. With regard to the explanatory power of such studies, it can be said that the usefulness of event studies derives from the significant abnormal returns of a company's share around a corporate event (Kothari & Warner, 2006). If market efficiency is assumed, event studies represent a useful tool to analyze the effect of a specific event to the value of a company. However, a useful application of event studies is only ensured, if the results are interpreted correctly and if the following assumptions are fulfilled. Firstly, it has to be assumed that the event cannot be anticipated before the occurrence, which implies that insiders are not acting in the marketplace that leverage the advantage of possessing information that is not publicly available (insider information). Secondly, it has to be assumed that the consequences a certain event bears for a security is immediately absorbed by the company's share price (MacKinlay, 1997).

The conduct of an event study depends on the data that is available and in this context, Dyckman, Philbrick and Stephan (1984) study the dependence of identifying abnormal returns on several criteria. They find that it becomes less difficult to identify abnormal returns, if there is little confusion about the event date, the number of companies included in the portfolio is high and abnormal returns are large (Dyckman et al., 1984).

As already indicated, event studies can be divided into short-horizon and long-horizon studies. In general, short-horizon studies are lower in complexity, since issues such as risk adjustment, cross-correlation in returns, and changes in volatility during the event period do not have to be dealt with. From this, it can be inferred that results from long-horizon event studies have to be treated with caution, since reliability may to some extent be flawed. In addition, short-horizon event studies are simpler in their setup and an adequate tool to test market efficiency (Kothari & Warner, 2006). In addition, short-horizon event studies' usefulness is further enhanced by the fact that shareholders' wealth is affected immediately in contrast to an increase or decrease of operational figures, such as productivity, which only gradually impacts the value of a company (MacKinlay, 1997). In order to investigate the relationship between such operational ratios and their impact on value, a long-horizon event study would have to be conducted, which faces the above-mentioned challenges.

2.2 Overview of Related Research

2.2.1 Findings on Market Efficiency and Rationality

Since the initial publishing of the theory of market efficiency by Fama (1970) numerous counter-arguments have been presented, arguing that the market continuously under- and overreacts to information. Debondt and Thaler (1985) give an overview of previous findings within the field of how the market reacts to new information and cite Keynes (1936) to have made one of the earliest observations:"…day-to-day fluctuations in the profits of existing investments, which are obviously of an ephemeral and nonsignificant character, tend to have an altogether excessive, and even an absurd, influence on the market" (pp. 153-154). Debondt and Thaler (1985) discuss observations by Arrow (1982) referring to the excess volatility of security prices to recent information. Shiller (1979) suggests that the historical variations in stock prices cannot be seen as motivated by the variation in dividend payouts. Debondt and Thaler further comment on Kleidon's (1981) findings, arguing that the stock price movement of two consecutive periods are highly correlated, suggesting a prediction possibility. In their own study, Debondt and Thaler (1985) find similar results pointing at a strong reversal effect for both past looser and winner portfolios. Anomalies connected to specific events have also been observed, notably in relation to initial public offerings

(IPOs) and seasoned equity offerings (SEOs). Barberis, Shleifer and Vishny (1998) and Daniel, Hirshleifer, and Subrahmanyam (1997) have proposed such theories, which build on behavioral finance models and do show explanatory power to these reactions.

Fama (1997) argues that since under- and overreactions show similar frequencies, it does not necessarily contradict market efficiency and therefore does not prove the existence of market irrationality. A recurrent discussion topic is whether observed anomalies, of which we mention a few above, are due to badly specified models, notably the misspecification of expected return measures and the resulting estimation of abnormal returns. In this context, Ball (1978), among many others, emphasizes the impact that omitted risk factors in the models can have. He argues that if the risk measure is correctly specified and measured, the anomalies decrease to insignificance and can even completely disappear (Ball, 1978). This would be the case when a security's outperformance of the market is merely a justified compensation for the security's higher risk. In addition to the issue of correctly measured abnormal returns, the research target itself varies largely, from investigating the rational valuation of an entire stock market (or specific financial instruments) to focusing on the reaction of a sub-entity of stocks to an individual event.

The discussion of market rationality can be seen as taking market efficiency one step further as it not only addresses to what degree new information is incorporated but also puts additional constraints on the stock reaction in relation to the fundamental value of the underlying asset. Summers (1986) investigates whether the market rationally reflects fundamental values and also highlights the sensitivity of tests in relation to the model specification. He further argues that one of the most straightforward evidence within financial research is the aggregated stock market's seemingly instantaneous and correct adjustment to new information, proven by a vast number of studies (Summers, 1986). Whether this means that investors are rational or if it is attributable to a majority that through trading large quantities are correcting for irrational ones, is unclear and disputed.

Although the market may be efficient in incorporating new information, Bernstein (1985) argues for the presence of an investor bias towards recent news. He sees an explanation to this in the fact that risk-averse investors, in response to the inherent uncertainty related to estimating the present value of future cash flows, will overemphasize the immediately available and understandable information to other types of information of a more long-term nature.

2.2.2 Findings of Carter and Simkins

Carter and Simkins (2002) have approached the investigation of the effects of the September 11th tragedy on airline stock returns and argue that market rationality is given, if market participants differentiate between securities based on company characteristics (i.e. rational pricing). In their paper, they test for different independent variables that address size, liquidity, financial structure, profitability, and type of company (i.e. freight or passenger). They find statistical significance for their liquidity measure and type of company variable. Carter and Simkins (2002) therefore draw the conclusion that market participants acted rationally by basing their investment decision on short-term liquidity and differentiated between freight and passenger airlines. For all other independent variables, Carter and Simkins (2002) do not find statistical significance. We take these findings into account when setting up our cross-sectional regression equation and adjust it according to our event-specific characteristics, such as the degree of impact.

2.3 Theoretical Framework of the Study

As explained earlier, our study of investor rationality in relation to the Icelandic ash cloud contains several steps. The first step of this thesis, investigation of stock related abnormal returns, follows MacKinlay's (1997) method, whilst the second step, investor differentiation between stocks according to company characteristics, uses the method outlined in Carter and Simkins (2002) and the final third step relates the disclosed financial loss announcements to the stock returns during the event window, drawing from valuation theory. In this theoretical framework section we have chosen to present research in related fields as well as the method related to the first and second step. More precision for the three steps is presented in respective segments.

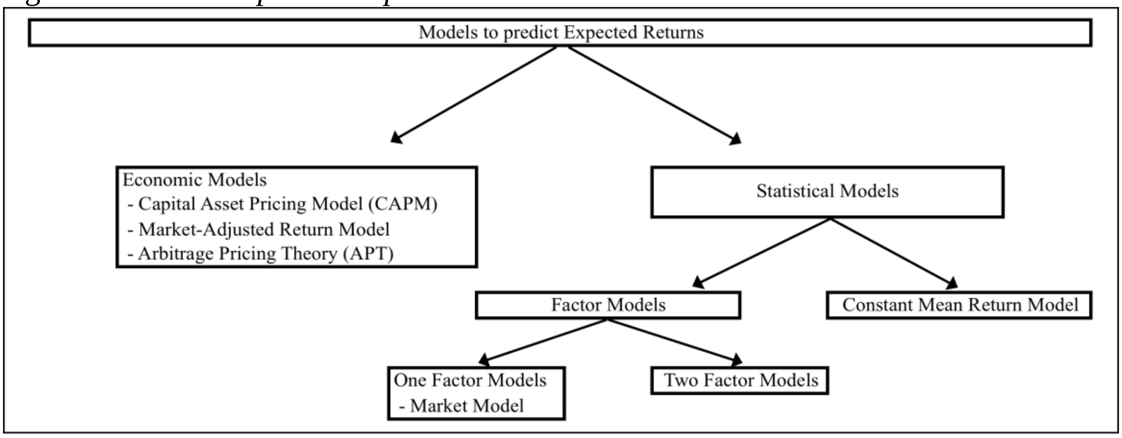
2.3.1 MacKinlay Event Study Methodology

MacKinlay (1997) examines several event study methods and gives an overview of the different methods to conduct an event study in his paper "Event Studies in Economics and Finance". His findings of structuring an event study can be split up into six major steps. Naturally, the first step is to define the event itself and the window that frames the event. In case the event window cannot be defined clearly, MacKinlay (1997) argues for setting the event window larger than the event itself, in order to study returns around the event. The second step includes extracting a portfolio of companies that the researcher would like to study. In this context, rationales for selecting the particular company portfolio should be outlined as well. The third step covers calculations for expected returns for the event window. The statistical properties and different models that can be used, in order to conduct the third step, are explained in detail later. The fourth step consists of defining the estimation window, in order to calculate the parameters necessary to calculate abnormal returns during the event window. Alternatively, parameters of the post-event window can be taken into consideration, if the pre-event window is marked by peculiarities. In a fifth step, a framework for testing the abnormal returns that were calculated is introduced. If the event window consists of several days, abnormal returns are aggregated to cumulated abnormal returns. In this step, a definition of the null hypothesis that will be tested for is also given. Alternative hypotheses can be set up depending on the issues the researcher wants to investigate. In the final sixth step, a thorough analysis of the results should be conducted. The aim is to interpret the results of steps three to five and put the findings into the right context. Concretely, this could mean that firms, which have a large impact on the findings, influence the sample (MacKinlay, 1997). Following the specification of expected returns, abnormal returns for the event window are calculated. The standard event study null hypothesis states that the mean abnormal return during the event window equals zero. The mean is preferred, in order to test for cross-sectional aggregation. In addition to cross-sectional aggregation, time-series aggregation can be investigated, in order to test if abnormal returns are observable in the pre- and post-event window, which would violate market efficiency and constitute a profitable trading strategy (Kothari and Warner, 2006).

2.3.2 Expected Return Models and Abnormal Returns

In order to analyze the abnormal returns that occur due to an event, it is crucial to correctly specify the models that should be used to calculate expected returns. As mentioned above, we now give a detailed explanation of the different models that exist to calculate expected returns, which relates to MacKinlay's (1997) third step of conducting an event study. After setting up the sample and deciding on the event and estimation window, one has to estimate the securities' expected or normal performance. These can be interpreted as the expected returns of the security that would have occurred, if the event had not taken place. Estimating normal performance can be executed by using different methods such as the capital asset pricing model, the market model or the constant expected returns model (Kothari and Warner, 2006). In general terms, the models can be grouped into economic and statistical models (MacKinlay, 1997). Noteworthy to mention is that economic models do not disregard statistical assumptions, but include economic restrictions. Despite the potential benefit of including economic restrictions, statistical models have been preferred in event studies in recent decades and relate the security's return to the return of a benchmark, most often an index.

Figure 4: *Models to predict expected returns*



Source: Own illustration based on MacKinlay (1997)

For a better understanding about what models exist and where they belong, figure 4 gives a graphical illustration of how the different models can be split up and grouped together. Within statistical models, we can differentiate between so-called factor models and constant mean return model. The constant mean return model is considered to be the simplest method of calculating expected returns and is in contrast to the market model a non-regression based technique (Cable & Holland, 1999). The benefit of the linearly defined market model constitutes that it tends to lower the variance of abnormal returns, since it can eliminate the part of variation in abnormal returns that is caused by the benchmarked market's return. Dyckman et al. (1984) find that the market model is a more powerful tool compared to the mean return model and the market-adjusted return model to identify abnormal returns. While the market model can be considered to be a one-factor model, multiple factor models exist with the aim of further lowering the abnormal return's variance. To conclude, multiple factor models present an improvement of the CAPM model by eliminating some of the biases of that model due to the economic restrictions. However, as MacKinlay (1997) argues, the statistical market model also satisfies this criterion and therefore dominates the other two models. Further evidence in favor of the market model is its high comparability value from widespread use amongst researchers, not least in studies encompassing several countries and markets (Campbell, Cowan & Salotti, 2009). Therefore, the model of choice in this study is the market model.

2.3.3 Market Efficiency

In contrast to the market efficiency section 2.2.1, this section focuses on the underlying assumptions and applications to our study rather than on the findings in that area. Market efficiency concerns to what extent stock prices incorporate available information. Fama (1997) also mentions that the focus on short event windows relies on the assumption that the price effect of new information is swift and short in period, thus identifiable within the event window.

The conventional definition by Fama (1970) divides the market into three schematic levels of efficiency and although extensive work in the field has been done since, this classification still serves as the main foundation in event studies.

The three levels of market efficiency, as defined by Fama (1970), are:

The weak form

The weak form is respected when stock prices incorporate all historical information. Abnormal returns from analyzing historical trading data cannot be earned.

The semi-strong form

The semi-strong form is respected when stock prices incorporate all available information and not only past one. New information is instantly incorporated in stock prices and abnormal returns are not possible to generate from any of the publicly available information. This form is generally assumed to be in place in developed stock market.

The strong form

The strong form hypothesis assumes that all information, public and private, is incorporated in the stock price. It has proven to be hard to establish evidence for the existence of this extreme form of market efficiency.

In line with previous event studies, we are building our research on the assumption that the semi-strong market efficiency theory is respected. This implies that all publicly available information at the beginning of the event, the closing of the airspace due to the Icelandic ash cloud, is fully incorporated in the respective stock price of each airline. Furthermore, this allows us to assume that if no other significant information was transmitted and the markets remained efficient during the event, the stock price reaction in the event window was a reaction to the event in question.

2.3.4 Fundamental Valuation

In the study, as mentioned earlier, we seek to investigate investor rationality by also observing the change in market valuation, the stock price, in relation to changes in fundamental value of the firm. This approach uses market value of equity as a benchmark and rests on the assumption of a certain level of market efficiency implying that stock prices absorb publicly available information in a rather instant way. When doing such value relevance studies the assumption is important, as Penman (1989) points out that the market value of equity is enough to determine the value of the firm.

In the situation where stock prices perfectly reflect the fundamental value of a firm, a change in expected cash flow should have a direct and corollary effect on stock price, reflecting the same decrease in value (Penman, 1989).

An overview, as well as more thorough discussion, of calculating the fundamental value with the discounted cash flow model (DCF) can be found in “Valuation: Measuring and Managing the Value of Companies” (Koller, Goedhart and Wessels, 2005). The conventional DCF consists of two steps: (1) Estimating annual Free Cash Flows and (2) discounting them with the weighted average cost of capital (R_{wacc}) for the corresponding amount of years (t). The Free Cash Flows are defined as the cash flows distributable to all claimants of the firm, both equity and debt holders. Deducting the market value of debt from the enterprise value yields the market value of equity.

DCF Valuation:

$$EV = \sum \frac{FCF_t}{(1+R_{wacc})^t} + \frac{FCF_T}{(1+R_{wacc})^T}$$

where

$$FCF = OperatingIncome \times (1-t) + depr/amort - Capex + /- \Delta WorkingCapital$$

$$FCF_T = \frac{FCF^{T-1} \times (1+g)}{R_{wacc} - g}$$

where the weighted average cost of capital (WACC):

$$R_{wacc} = \frac{MV_e}{MV_d + MV_e} \times R_e + \frac{MV_d}{MV_d + MV_e} \times R_d \times (1-t)$$

where the cost of equity is calculated using the capital asset pricing model (CAPM):

$$R_e = R_f + \beta(R_m - R_f)$$

$$\beta = \frac{Cov(R_i, R_p)}{Var(R_p)}$$

Source: Koller et al. (2005)

A logic consequence of the DCF formula is that the expected present enterprise value can change through three main scenarios; (1) a change in expected cash flows, (2) a change in the discounting factor, or (3) both. A change in R_{wacc} can be the result of a change in capital structure, corporate tax, cost of debt or cost of equity.

In our study, we define the change in market value of equity as a numerator effect by a decrease in expected cash flows due to loss of revenue and the additional operational costs for the airlines related to the ash cloud event. This means that the event is assumed to have had a non-significant impact on capital structure, cost of debt or cost of equity. The Beta's role in the CAPM is to adjust the risk premium for systematic risk, not company specific risk. As no shift in non-diversifiable risk can be observed in our case, the Beta should stay the same. The market risk premium is also considered to be non-affected throughout the event and as a result, cost of equity remains stable. It could be argued that the cost of debt should have shown an increase over a short period, however this peak is believed to fairly quickly revert to expected market rates.

2.3.5 Market Rationality

The ideal outcome of a public market is a situation where prices provide investors with accurate information for resource allocation and this is the case when market prices can be judged to fully reflect available information (Fama, 1970). In previous paragraphs the assumption is made that semi-strong efficiency is present. Summers (1986) argues that the natural consequence of the efficient market hypothesis is that market price reactions should represent rational assessments of fundamental values. In this study, we assume semi-strong market efficiency and together with Summers' (1986) reflection on its consequence for rational pricing, it seems reasonable to judge the investor rationality out of this framework. More precisely, in our third step we investigate to what extent the loss in market value, measured by the stock price, is in rational relation to the loss of fundamental value, measured by the decrease in expected cash flows.

3. Was the Ash Cloud Significant to the Stock Market?

3.1 Sample Firms, Event Window and Data

The aim of the study is to perform an event study with a sample of affected airlines as large as possible. However, since many regions, North America for example, were only affected to a very small extent, we are using a geographic cut-off point limiting the geographic focus to Europe, since this is the airspace that was mostly affected (IATA, C, 2010). For creating the sample, we use Orbis database, in order to search for listed airline companies in Europe. We narrow down the search by adding the criteria to search for passenger air transport companies. In line with our previous argument, we exclude freight companies for comparability reasons, since these companies did not incur additional compensation costs (Mazzocchi et al., 2010). To illustrate this fact, for easyjet about 47% of total costs incurred due to the ash cloud are attributed to additional expenses, while 53% are attributed to lower revenues (easyjet full year results, 2010).

The table below summarizes our additional sample criteria and shows, if the selected companies fulfill them.

Table 2: *Selection of sample companies*

Company Name	Abbreviation	Company ID	% of Revenues from Air Passenger Transportation	Actively Traded	IFRS Consolidated Disclosure
Deutsche Lufthansa	LH	1	79%	v	v
British Airways	BA	2	93%	v	v
Iberia	IB	3	71%	v	v
Air France/KLM	AFKLM	4	77%	v	v
Ryanair	FR	5	80%	v	v
Easyjet	EZY	6	81%	v	v
Air Berlin	AB	7	92%	v	v
Turkish Airlines	TK	8	90%	v	v
SAS	SAS	9	73%	v	v
Norwegian Air Shuttle	NO	10	87%	v	v
Aeroflot	SU	11	84%	v	v
Vueling Airlines	VLG	12	76%	v	x
Aer Lingus	EL	13	82%	v	v
Finnair	AY	14	75%	v	v
Aegean Airlines	AEG	15	83%	v	v
Icelandair	FI	16	58%	x	v
Jet2 (Dart Group)	DART	17	74%	v	v
Meridiana Fly	MER	18	99%	v	x
Cyprus Airways	CY	19	92%	x	v
Atlantic Airways	ATL	20	100%	x	v

As can be seen in the table above, we have set three additional relevant criteria. If a company does not fulfill any one of the three criteria, it is excluded from the sample.

Firstly, we acknowledge the fact that some of these companies, such as Deutsche Lufthansa or AirFrance/KLM, have substantial revenues from other activities like cargo or technical maintenance that are related to aviation but are not directly linked with passenger transportation. We adjust for this factor by implementing a criterion of a minimum percentage (50%) of revenues generated by passenger transportation. The rationale is essentially the same as excluding freight companies. The calculations are based on the disclosed information in the 2009 annual reports of the securities. If companies do not generate their main revenues by the air passenger transportation, they will financially not be hit as hard as other airlines. All companies generate at least 50% of their revenues through air passenger transportation and we therefore do not exclude any of the companies based on this criterion.

The second criterion that we implement relates to the active tradability of each security. Since market efficiency in the semi-strong form is an important assumption for the methodology of our study and to ensure comparability between sample securities, investigating the trading activity of the sample securities is important. In order to adjust for securities that are not actively traded, we create scatter plots with market returns in terms of the security's return. Securities in the sample that show distributed returns equal to zero for most of the trading days are further investigated. The related scatter plots of the respective securities can be found in the appendix. Through downloading trading volumes in Datastream, we observe that Cyprus Airways, Atlantic Airways and Icelandair fail this criterion due to their low trading volume.

The third criterion requires the companies to disclose consolidated accounts according to IFRS. This is important, in order to ensure comparability when we regress financial ratios (company characteristics) on each security's abnormal return in the fourth section. Vueling Airlines and Meridiana Fly are therefore excluded from the sample from the beginning, since these companies do not present consolidated accounts according to IFRS. In total, we exclude five securities and use a sample of 15 companies for investigating the ash cloud event.

Figure 5: *Timeline*

The figure above graphically illustrates our choice of estimation, event, and post-event window. The estimation window comprises 89 trading days and the event window three trading days (April 15th through April 19th). The estimation window length of 89 days is guided by the motivation to have a sufficiently large sample for the model estimations without encountering problems with structural breaks within the industry. We test different event windows (see appendix) and have found this window to represent the event in the best way, from initial information about the ash cloud and airspace closure until the information that the airspace would be reopened.

3.2 Empirical Methodology and Specification of Regression Models

In order to test for the significance of the event, which is the first regression of this study, we conduct the following steps. We use Datastream, in order to obtain the share prices of the sample portfolio for a 145-day period (December 10th, 2009 through June 30th, 2010). We use the Return Index (RI) instead of the Price (P), since the Return Index is adjusted for dividends. We use the market model, as suggested by MacKinlay (1997), in order to predict normal performance of all securities. As a market return basis, each individual securities home markets general stock index is used.

For each security individually, the estimation window is used to estimate the market model parameters and thereafter, daily abnormal returns are generated.

$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$, where

R_{it} is the return for security i on day t

α_i is the intercept of the linear model for security i

β_i is the slope coefficient of the market model for security i

R_{mt} is the local benchmark index' return on day t or S&P Europe 350 for the portfolio

ε_{it} is the residual term for security i on day t

Abnormal Returns are defined as:

$AR_{it} = R_{it} - \hat{\alpha}_i - \hat{\beta}_i R_{mt}$, where in addition to the definitions above

AR_{it} is the abnormal return of security i on day t

$\hat{\alpha}_i$ is the estimated alpha intercept for security i

$\hat{\beta}_i$ is the estimated beta parameter for security i

In the market model, the residuals (ε_{it}) equal the daily abnormal returns. Abnormal Returns are aggregated over the three-day event window for each security. The MacKinlay (1997) framework for calculating the standard deviation of the abnormal returns, as well as aggregation over time is used. Notably moving from a daily to a three-day standard deviation of the abnormal returns allows testing the significance of abnormal returns.

The standard deviation of the residuals of each security:

$$\hat{\sigma}^2_{\varepsilon_i} = \frac{1}{EstW - 2} \sum_{t=T_0+1}^{T_1} (R_{it} - \hat{\alpha}_i - \hat{\beta}_i R_{mt})^2$$

Under the Ordinary least square (OLS) assumptions the residuals have a zero mean with a variance equal to:

$$\sigma^2(AR_{it}) = \sigma^2_{\varepsilon_i} + \frac{1}{EstW}\left[1 + \frac{(R_{mt} - \hat{\mu}_m)^2}{\hat{\sigma}^2_m}\right]$$

The first component in this equation comes from the previous equation (standard deviation of residuals), whilst the second component is to adjust for sampling error in the market model coefficients. However, MacKinlay (1997) argues that a large estimation window (EstW) lowers the necessity for this adjustment and therefore EstW is often chosen to be large enough to assume the contribution of the second component to be zero. With an estimation window of 89 days, we consider this to be a realistic assumption for our study.

Assumption of normally distributed abnormal returns:

$AR_{it} \sim N(0, \sigma^2(AR_{it}))$

The assumption of normally distributed abnormal returns in the estimation window and no change during event window on mean or variance of the abnormal returns allows us to use the distributional properties of the estimates calculated under the estimation window on other periods.

Abnormal returns of the three-day event window are:

$$CAR_i(t_1,t_2) = \sum_{t=t_1}^{t_2} AR_{it}$$

With variance (for reasonable size of estimation window)

$$CAR_i(t_1,t_2) \sim N(0,\sigma_i^2(t_1,t_2))$$

The same methodology is applied to the European portfolio of our sample. Individual daily stock returns of the 15 securities are averaged, in order to obtain a daily return for the European portfolio. Then onwards, the portfolio is treated using the same methodology as the individual securities.

With these parameters, a significance test for each security of the event window's abnormal return is conducted. We further extend this step by looking at the impact of the ash-cloud on airline stocks on the European portfolio level as explained above. This serves to investigate the abnormal returns on an industry level and to get an additional view of the stock reactions without the noise that might occur due to market and on an individual security basis.

3.3 Tests of Assumptions under OLS and Additional Data Tests

Outliers (Grubb's tests)

We perform a visual inspection and the Grubb's test, in order to check for outliers in the estimation window. We find between zero and one outlier for the market return and between zero and four outliers for the securities' return (within the 89 days of the estimation window). We subsequently look up these outliers, using the factiva database, to see whether they are likely to be the result of a specific event or merely a normal fluctuation. We find them to be related to extraordinary events and therefore have estimated the market model of the individual stocks excluding these outliers.

Normality

We test the residuals for normality using the Jarque-Bera test. The normality assumption is rejected at a five percent level for four out of 15 individual stocks with the portfolio also showing normally distributed residuals. Considering the 89 observations of our estimation window, we assume normality of all residuals according to the central limit theorem, which allows us to use the distributional-based test for significance of abnormal returns.

Heteroscedasticity

In our use of the market model, we are interested in relating the stock return with a market return in order to calculate an expected return. In presence of heteroscedasticity, the coefficient of the regression remains unbiased and consistent meaning that as the sample size increases, it still holds the important characteristic of converging to its true value as a normal BLUE-estimator would. In fact, Gujarati (2003) concludes that the homoscedasticity plays no role in the unbiasedness property. This can be observed by performing a heteroscedastic and autocorrelation consistent regression (Newey-West) verifying that the coefficient stays the same. What differs though is that the standard deviation of the coefficient of the explanatory variable might be flawed, i.e. either over- or under-estimated and therefore might not allow for statistical inference on that coefficient. However, as we are interested in the prediction ability of the model and not the inference of the coefficient itself, this does not constitute a problem. Instead, the statistical inference that follows in this step of the study is based on the abnormal returns, the residual of the model, and their standard deviation.

Serial Correlation

As often the case with observations of stock price development over time, there is a risk of serial correlation of the observed errors of the regression that the error for day t is correlated with the error term for previous days. Although autocorrelation does not cause the coefficient to be biased, it might hinder a correct estimation of the standard deviation of the residuals. A correct estimation is important since the residuals are the estimation of abnormal returns when using of the market model, and a correct estimation of their standard deviation is important to enable statistical inference. We test for serial correlation of the residuals by using the Breusch-Godfrey LM test for autocorrelation with the defined lags 1, 2, 3, 4, 8, 12 days. We find that Finnair together with Norwegian Air Shuttle are the only companies in the sample to show autocorrelation of the residuals with the lags 1, 2, 3, 4 and 8 days at a 5% level for Finnair and 2-day lag at 5% level for Norwegian Air Shuttle. As previously stated, we are using the MacKinlay (1997) methodology for calculating a three-day standard deviation of abnormal returns. Using a sufficiently large sample, he argues that aggregation can be made despite the potential effects of autocorrelation of the residuals as the true parameters are independent through time and a larger estimation window will see them converge towards the true values (MacKinlay, 1997). We therefore choose to treat Finnair and Norwegian Air Shuttle in the same way as the other companies regarding the calculation of the standard deviation of the abnormal returns (see autocorrelation tables for the two concerned companies in the appendix).

Alternative indices – Expected Return Estimation

As suggested by McWilliams and Siegel (1997), we also run the market model using other indices. In the methodology of event studies, the abnormal return is calculated in comparison to an expected normal return. As explained earlier, we are using the market model together with the stock exchange of each security's main listing as the comparative index. However, since the airline industry is very important for the economic activity in general, there is a risk of understating the negative abnormal return of the airlines, as the market in general went down. To investigate whether this might be the case, we also calculate the expected returns of each company, via the market model, on two alternative indexes. We firstly use the S&P Europe 350, to potentially eliminate some extreme differences in market movements within Europe and secondly the MSCI world index, to check whether the high interdependence between the airlines and the European economy in general could cause a flawed estimation of abnormal returns.

Neither the S&P 350 nor the MSCI world index yields significantly different expected return estimations and the abnormal returns logically do not vary much either (see appendix).

Alternative Model Specification

As previously stated, the security and portfolio abnormal returns of the event window have been defined as the three-day cumulated return. In order to test the significance of these abnormal returns, we compute a three-day standard deviation of the abnormal returns in the estimation window, originating from a daily standard deviation. A similar approach would be to aggregate the abnormal returns over the estimation window and event window to directly reflect three-day abnormal returns, thus obtaining a standard deviation applicable to the three-day event window abnormal returns. We get similar results when taking three-day instead of daily returns and test with the related standard deviation (see appendix). We therefore chose not to alter the original approach.

3.4 Hypothesis Testing

A negative abnormal return for securities and the portfolio would be in line with theory, since this event constitutes newly available *negative* information for the sample portfolio. As presented in section 2, previous research also supports this view.

In order to test, if the ash cloud had a significant impact on airline stock returns, we set up the following hypotheses and test them according to Student's t-test. The test is one-tailed, as theory suggests the occurrence of negative abnormal returns and not positive returns:

H_0: $AR_i = 0$

The null hypothesis is tested on each security individually. We want to test this hypothesis to see, if the ash cloud event lead to a significant negative impact for each company on a stand-alone basis.

H_1: $AR_{portfolio} = 0$

This hypothesis covers the portfolio of our European sample. With this hypothesis, we test if there was a significant abnormal return for the entire portfolio of securities. We test this by calculating a daily average stock return across all sample securities, to get an average return of the sample portfolio. This is done on an equally weighted basis, without adjustment for company size (e.g. market capitalization), since we are at this time interested in the relative change of each security and not in the absolute drop in value.

The abnormal returns for both each individual company and the portfolio are used for further analysis in the next section, when we examine how certain characteristics of companies or portfolios explain their abnormal returns.

Table 3: *Statistical results for Company ID 1-8*

Name	LH	BA	IB	AFklm	Fryan	EZY	AB	TK
Comp ID	1	2	3	4	5	6	7	8
Adj Std. Deviation	0,0194	0,0317	0,0310	0,0310	0,0309	0,0235	0,0336	0,0255
AR	-0,0230	-0,0359	-0,0470	-0,0276	-0,0696	-0,0229	-0,0331	0,0411
p-Value	12,0%	13,1%	6,6%*	18,8%	1,4%**	16,6%	16,4%	5,5%

Table 4: *Statistical results for Company ID 9-21 (including portfolio)*

Name	SAS	NO	SU	EL	AY	AEG	DART	**Portf**
Comp ID	9	10	11	13	14	15	17	21
Adj Std. Deviation	0,0742	0,0460	0,0336	0,0516	0,0251	0,0370	0,0553	0,0123
AR	-0,0692	-0,1022	-0,0482	-0,0434	-0,0580	-0,0484	0,0284	-0,0389
p-Value	17,7%	1,5%**	7,7%*	20,1%	1,2%**	9,8%*	30,4%	0,1%***

*=10%
**=5%
***=1%
one-tailed significance

The tests show that we can reject H_0 for six securities at a 10% significance level out of the sample (Company IDs: 3, 5, 10, 14, 15). Turkish Airlines (Company ID: 8) is not significant, since we conduct a one-tailed test for significance. Out of these five securities, we can also reject the H_0 for three securities at a 5% significance level (Company IDs: 5, 10, 14). However, for nine securities, we cannot reject the null hypothesis, which means that the event did not cause significant abnormal returns for them on a stand-alone basis. The tests also permit the rejection of H_1 for the entire portfolio at a 1% significance level (Company ID: 21).

3.5 Analysis of Statistical Results

In this analysis, we will first focus on the securities individually and then consider the portfolio. It is important to mention, however, that the two are interrelated, since the portfolio is created out of the individual securities.

When looking at the result table, two main observations can be made. The first observation concerns the direction of abnormal returns. Out of the 15 sample companies, 13 companies show a negative abnormal return. Only Turkish Airlines and Dart Group (Company IDs: 8 and 17, respectively) have positive abnormal returns during the event window. In general, this confirms our reasoning that the ash cloud event affected companies' cash flows in a negative, and not in a positive way. The second observation concerns the difference in abnormal returns between the securities. It is striking to see the rather large difference in abnormal returns between the securities. The abnormal returns for the securities range from -10,86 % for Norwegian Air Shuttle (Company ID: 10) to +3,77 % for Turkish Airlines (Company ID: 8). This is a difference of about 14,5 percentage points between the security with the lowest and highest abnormal return. The range of 14,5 percentage points appears relatively large especially considering that all of the companies experienced a similar event. This leads to the hypothesis that the market differentiated between securities. These findings serve as the basis for the next section, when we try to analyze what characteristics market participants took into consideration when evaluating the effect of the event on each security.

The rather modest negative abnormal returns for most of the airlines show that market participants did not believe that companies would be severely troubled due to the event. In contrast to Carter and Simkins (2002), who observe a significantly higher negative stock reaction as a result of the 9/11 event, our results only suggest a limited effect of the event. In the retrospect, Carter and Simkins' (2002) findings can be validated, since all major US airlines (American Airlines, Delta Air Lines, United Airlines) filed for bankruptcy (Chapter 11) in the period following September 11th. In this light, it also seems logical for their study to compare passenger companies to freight companies, in order to illustrate the change in behavior. In our study, this is not necessary, since no change in travel behavior is expected.

For the portfolio, we can draw the conclusion that the flight ban represented statistically significant negative information for the investors. The high significance is partly due to the fact that 13 out of 15 sample securities have negative abnormal returns and that the standard deviation is much lower on a portfolio basis than on an individual security basis. The low standard deviation, leading to an increased significance, can be attributed to the fact that "noise" is removed when averaging the individual returns to a portfolio. The underlying logic is presumably that insignificantly correlated stock returns create a portfolio with less volatile daily returns. Taking an industry perspective through our European portfolio, we can conclude that investors acted on the airline companies' overall exposure. The result for the portfolio can be interpreted in such a way that market participants regarded the consequences of the event as value relevant for the airline industry.

For the following investigation, it has to be stated that the rather low significance for the individual securities may post a problem when looking for explanatory power. Therefore, since we only have significant abnormal returns for three out of 15 companies, we have decided to also investigate the portfolio, due to the rejection of its abnormal returns at a highly significant level (1%). For this purpose, we set up comparative portfolios, i.e. companies in the same industry, however in other geographic regions.

4. Did the Market Differentiate Between Companies or Portfolios?

After analyzing how big the impact was for each airline and for the European airline portfolio as a whole, we now go on by investigating if market participants differentiated between airlines or airline portfolios. Therefore, we split this section accordingly into two regressions. The first regression will focus on the differentiation between companies, based on the method used by Carter and Simkins (2002) in their study of the airspace closure following 9/11. As explained earlier, we investigate the relation between airline stock returns and specific company characteristics. The second part of this section focuses on the differentiation between geographic portfolios based on the different degrees they were economically affected by the ash cloud.

4.1 Sample Firms and Data

For the first regression equation, we use abnormal returns of the individual securities from section three. We delete Aeroflot (Company ID: 11) from the sample, since no information on the degree of impact (independent variable) could be gathered through the available information. In contrast to the Carter and Simkins (2002) study, where the entire US airspace was shut down, the ash cloud affected geographic regions to a different degree. Since European airlines have a different geographic spread of operations, this is consequently reflected in the economic impact they suffer. As the sample companies do not disclose the exact percentage of their disrupted flight operations, we estimate this percentage for every sample company by using a report published by the Eurocontrol (2010), in which we find how European countries were affected by the ash cloud. In order for this variable to better reflect operations of each company, an average degree of impact is calculated out of the geographic location of each company’s operational bases. For companies such as Ryanair, which has operational bases in eight different European countries, the average is therefore calculated as the average closure of these countries. We are aware of the fact that the underlying assumption is that the amount of operations is spread equally across the countries with operational bases, which is most certainly not the case. However, we think that this measure has a link to an airline's profit generation due to the complex logistical network these airlines operate, where one-day route often include passing through at least one of these operational bases. We therefore believe that it still gives a valid approximation of the degree of being affected by the event.

4.2 Empirical Methodology and Specification of Regression Models

Previous studies have shown explanatory power of models that try to investigate how company characteristics influence stock price behavior. In this context, Carter and Simkins (2002) argue that investors evaluate companies based on their characteristics, such as size, liquidity, financial structure and profitability as a basis for rational pricing. Taking these findings into account, we would like to investigate, if we can see a similar pattern for the event at hand.

Company Characteristics

Based on the study of Carter and Simkins (2002), we estimate the cross-sectional regression equation. Precise definitions of how the independent variables have been calculated can be found in the appendix:

$$AR_i = \alpha_0 + \ln \beta_1 SIZE_i + \beta_2 CASHTA_i + \beta_3 LEVERAGE_i + \beta_4 ROA_i + \beta_5 IMPACT_i + \varepsilon_i,$$

where

$SIZE_i$ is the natural logarithm of total assets for airline i,

$CASHTA_i$ is the ratio of cash and equivalents to total assets for airline *i* in last annual report prior to the event,

$LEVERAGE_i$ is a debt / equity measure of leverage for airline *i*,

ROA_i is the return on assets for the year prior to the event for airline *i*,

$IMPACT_i$ is an estimation of the affected flights for airline *i*,

ε_i is an error term for airline *i*.

The size variable serves to control for the size differences among the companies. We include a cash variable, in order to test if investors regarded it as important that companies were able to cover short-term obligations. The leverage variable accounts for the capital structure. The ROA variable investigates the importance of past profitability for investment decisions. The impact variable is specific to our study and accounts for the different exposure to the event. The table below illustrates the setup for the regression run on company characteristics.

Table 5: *Setup of independent variables, company characteristics*

	DEPENDENT VARIABLE	INDEPENDENT VARIABLES				
Company	**Abnormal Return**	**Ln Total Assets**	**Cash/Assets**	**Leverage (D/E)**	**ROA (09)**	**Estimated Impact (% of flights cancelled)**
Deutsche Lufthansa	-0,0230	17,1	17%	1,42	-0,4%	**76%**
Ryanair	-0,0696	15,8	37%	1,08	4,8%	**74%**
Air France/KLM	-0,0276	17,1	15%	2,42	-5,4%	**79%**
British Airways	-0,0359	16,3	16%	2,28	-4,2%	**93%**
Iberia	-0,0470	15,4	39%	0,72	-4,8%	**44%**
Easyjet	-0,0229	15,2	30%	0,84	2,0%	**71%**
Air Berlin	-0,0331	14,7	15%	1,56	-0,4%	**62%**
Turkish Airlines	0,0411	15,2	15%	1,02	7,0%	**37%**
SAS	-0,0692	15,2	10%	1,34	-6,4%	**83%**
Norwegian Air Shuttle	-0,1022	13,3	29%	0,70	16,4%	**81%**
Aer Lingus	-0,0434	14,4	38%	0,73	-6,2%	**89%**
Finnair	-0,0580	14,7	25%	0,88	-4,9%	**84%**
Aegean Airlines	-0,0484	13,0	47%	0,55	5,2%	**29%**
Dart Group PLC (Jet2)	0,0284	12,9	15%	0,21	5,6%	**93%**

We expect, in line with the reasoning of Carter and Simkins (2002) that company characteristics as outlined in the table above, can at least partly explain abnormal returns during the event window. As Carter and Simkins (2002) find statistical significance for the liquidity ratio of airlines, we expect to find similar results. The underlying logic is that companies with low cash to assets ratios should have more negative abnormal returns due to a higher danger of a liquidity squeeze. We also include the other independent variables of Carter and Simkins (2002) in our model in order to make it encompassing and take into account all relevant elements of previous research, but do not expect significant results for variables of total assets, leverage, and profitability.

The impact variable can be considered to be a company characteristic, since it explains the different degrees to which the airlines were exposed to the event. That is why we include it into the multiple-regression model of company characteristics. As outlined before, we argue that there should be a strong relation between the degree of exposure to the event and the abnormal return. We expect the impact variable to have significant explanatory power on abnormal returns of the companies due to the link between the degree of impact and the costs incurred during the event. Therefore, investors should be expected to act accordingly.

Portfolios

For the second regression, we use the sample portfolio of European airlines of section three to compare it to portfolios of different geographic regions, such as North America, Latin America, Asia-Pacific and Middle-East. Africa has been left out due to a lack of listed companies in that area. We run the regression under three scenarios: (1) with five portfolios including Asia-Pacific (2) with the Asia-Pacific portfolio, however excluding Chinese companies and (3) without the entire Asia-Pacific portfolio (i.e. with four portfolios). The reason for treating the Asia-Pacific portfolio in a special way is that changes in the macroeconomic environment during the event window, originating from the Chinese government, led to the fact that all major Asian stock markets dropped. Especially Real estate developers' and banks' shares were down due to the announcement of the Chinese government to restrain property prices (Kumar, Allen & Tan, 2010). As a result, the Shanghai Composite Index dropped by 4,8% on the 19th of April and took other Asian markets with him (Frangos, 2010). Furthermore, the increased uncertainty seems to also have had a particular impact on Chinese airline stocks.

Abnormal returns have been calculated the same way for each geographic portfolio as on the original European portfolio in section three, averaging the daily individual stock returns. The event window still remains from the 15th of April until the 19th of April 2010.

The purpose of the following regression is to find out whether investors considered how the different regions were impacted by the event. We therefore specify the second regression equation as follows:

$AR_p = \alpha_0 + \beta_1 IMPACT_p + \varepsilon_p$, where

$IMPACT_p$ is an estimation by IATA of the percentage of total available seat kilometers (ASK) being affected for portfolio *p*,

ε_p is an error term for portfolio *p*.

The question we would like to answer with this regression equation is if investors on the capital market took the impact the event had on European airlines into account or if they disregarded the fact that European airlines were hit the hardest. In line with Fama, French, Jensen, and Roll (1969), we are now interested in the average of different portfolios rather than in the individual company returns. From this logic, we expect that portfolios of other geographic regions should not have lost as much in market value, since they were not affected to the same extent. We therefore expect to find explanatory power by investigating how the impact variable influences abnormal returns of different geographical portfolios during the event window. The reasoning is essentially similar to the impact variable of the regression on company characteristics.

Table 6: *Input data for different geographic portfolios*

Geographic Area	Abnormal Return	Operational Impact
Middle-East	-0,0236	20%
Asia-Pacific	-0,0463	16%
Asia-Pacific (without China)	-0,0325	16%
Latin-America	-0,0195	15%
North America	-0,0190	14%
Europe	-0,0391	75%

The table above shows abnormal returns and the operational impact for the different geographic portfolios. The operational impact is an estimate by the IATA (C, 2010) and shows the cancelled percentage of available seat kilometres (ASKs) in the respective region.

For the model to be correctly specified, it is crucial to have enough observations. The minimum number of observations should at least be three times the explanatory variables. In our case, the ratio is five to one, as we have five portfolios and the impact variable (explanatory variable). Additionally, one can consider the threshold for near micronumerosity determined by Gujarati (2003). Near micronumerosity occurs when the number of observations barely exceeds the number of estimated parameters. As a consequence, having a relatively reduced sample, as we do, can cause extreme observations to have a large impact on the outcome of the regression. Having the impact of the European portfolio on the slope coefficient in mind is therefore important when analyzing the results of the regression-model on different geographic portfolios, which will be discussed later on.

4.3 Cross-Sectional Results

Company Characteristics

A natural first step when using multiple independent variables is to show the correlation between all independent and dependent variables. The table below therefore shows the correlations and p-values (referring to rejecting the H_0 of zero correlation) of all dependent and independent variables.

Table 7: *Correlation of dependent and independent variables*

		AR	LnSIZE	IMPACT	ROA	LEVERAGE	CASHTA
AR	Correlation P> |t| , Sig.	1					
LnSIZE	Correlation P> |t| , Sig.	0,047 0,873	1				
IMPACT	Correlation P> |t| , Sig.	-0,185 0,527	0,135 0,644	1			
ROA	Correlation P> |t| , Sig.	-0,041 0,989	-0,521 0,056	-0,231 0,427	1		
LEVERAGE	Correlation P> |t| , Sig.	-0,041 0,890	0.784* 0,001	0,233 0,423	-0,448 0,108	1	
CASHTA	Correlation P> |t| , Sig.	-0,386 0,173	-0,344 0,228	-0,408 0,148	0,164 0,575	-0,519 0,057	1
* Significant correlation at 5% level (Two-tailed)							

The table above illustrates that none of the explanatory variables is close to having a perfect linear relationship with the dependent variable (AR column). The liquidity measure (CASHTA) is closest to having a perfect linear relationship to abnormal returns yielding that companies with relatively high cash to assets ratios had a lower abnormal return. However, the correlation is not significant and neither can something be inferred about the causal relationship between the variables nor about the steepness of the slope.

There is one significant correlation between the independent variables, the relationship between leverage and size of the company. This tells us that large airline companies in the sample have a higher debt to equity ratio than smaller companies. In general, the correlations between the independent variables cannot be too strong, since this would constitute a multicollinearity problem (Gujarati, 2003). However, as will be shown in section 4.5 and as the correlation table hints at, multicollinearity is not an issue in this regression. This also indicates that each variable's coefficient in the regression is likely to be attributable to that specific variable and not to the relationship between the independent variables.

Table 8: *Statistical results of multiple-regression model on company characteristics*

	Intercept	LnSIZE	IMPACT	ROA	LEVERAGE	CASHTA
Coefficient	0,0187	0,0063	-0,0745	-0,0615	-0,0332	-0,2398
P> |value| , Sig.	0,9230	0,6370	0,2120	0,7470	0,2840	0,0610
Std Error	0,1869	0,0129	0,0549	0,1840	0,0289	0,1103

R^2	0,4011
R^2_{ADJ}	0,0268
Prob>F, Model Sig.	0,442
VIF_{MAX}	3,21
VIF_{MEAN}	2,09

The table above shows that none of the parameters used in the model show significance in explaining the abnormal returns of the securities. For the five independent, explanatory variables we get an adjusted R^2 of 2,68%. This shows, when adjusted for the number of independent variables, that the model does not have explanatory power. Turkish Airlines and Dart Group (Company IDs: 8 and 17 respectively) are responsible for the negative sign of the liquidity parameter (CASHTA), because they combine low cash/assets ratios with positive abnormal returns. This would mean, against our expectation, that high liquidity companies had a more negative abnormal return. However, the parameter is not significant, and, if we take out the two companies to show the sensitivity, the coefficient turns slightly positive. In total, the low value of the adjusted R^2 clearly shows that the data of the independent variables is not coherent in explaining the variations in abnormal returns.

Portfolios

Table 9: *Statistical results of regression on different portfolios*

Portfolio	Intercept	Impact	R^2_{ADJ}
All Regions			
Coefficient	-0,0237	-0,0207	0,0789
P> |value| , Sig.	0,078	0,462	
Std Error	0,0090	0,0246	
Without Chinese Carriers			
Coefficient	-0,0193	-0,0266	0,5173
P> |value| , Sig.	0,02	0,105	
Std Error	0,0042	0,0116	
Without Asia Pacific			
Coefficient	-0,0154	-0,0318	0,9741
P> |value| , Sig.	0,006	0,009	
Std Error	0,0012	0,0030	

In order to further investigate the impact variable's importance for investor behavior, we also consider portfolios of different geographic areas. Following our reasoning, these portfolios should show different abnormal returns since the impact was not as severe. For the portfolio, we run a regression with several dependent variables, the different abnormal returns of each portfolio and with one explanatory variable (the impact) that is different for each portfolio as specified in the table above. Doing this under the first scenario (all regions), we receive an adjusted R^2 of 7,89%. When taking out Chinese airlines from the sample, the adjusted R^2 increases from 7,89% to 51,73%. Under the third scenario (without Asia-Pacific), R^2 increases to 97,41%. This clearly indicates the sensitivity of the regression slope to extreme values, as observed by Gujarati (2003). For the same reason, the European portfolio mainly determines the slope of the regression line.

Despite the sensitivity to extreme values, the models specified under the second and third scenario of the portfolios have a certain explanatory power. Therefore, the impact variable in the second and especially in third scenario (1% significance) shows the ability to explain the variation in abnormal returns. It is, however, important to mention the few observations (five and four, respectively).

4.4 Analysis of Statistical Results

Company Characteristics

The results are inconclusive when trying to explain company abnormal returns with company characteristics. Against our expectations, neither the liquidity ratio nor the degree of impact can explain the variations of abnormal returns on a company level. This contradicts the economic intuition expected from investors as argued for by Carter and Simkins (2002). In addition, it contradicts our reasoning that companies with a relatively high exposure to the event should be punished to a greater extent by the capital markets.

There are three possible explanations, why the specified model does not explain abnormal returns of the different securities. The first reason relates to the available data. For the impact variable, for example, we rely on external data and try to approximate the impact through operations of each airline. The data could therefore be flawed due to the fact that it might not approximate well how the airlines were really affected. Other data, such as liquidity (cash/assets ratio) is taken from the companies' annual reports. Since this represents the liquidity at one point in time and not over a certain period, the data could be flawed by companies having an exceptionally high or low amount of cash at a specific point in time. Another factor relating to data that may cause non-explanatory power is a low variation in the dependent variable (abnormal return). If the variation in abnormal returns is not large enough, the observations will be very close together. In general, the first reason addresses the fact that the collected data does not represent the actual reality at the time of the event or that the variation in the data may be too low.

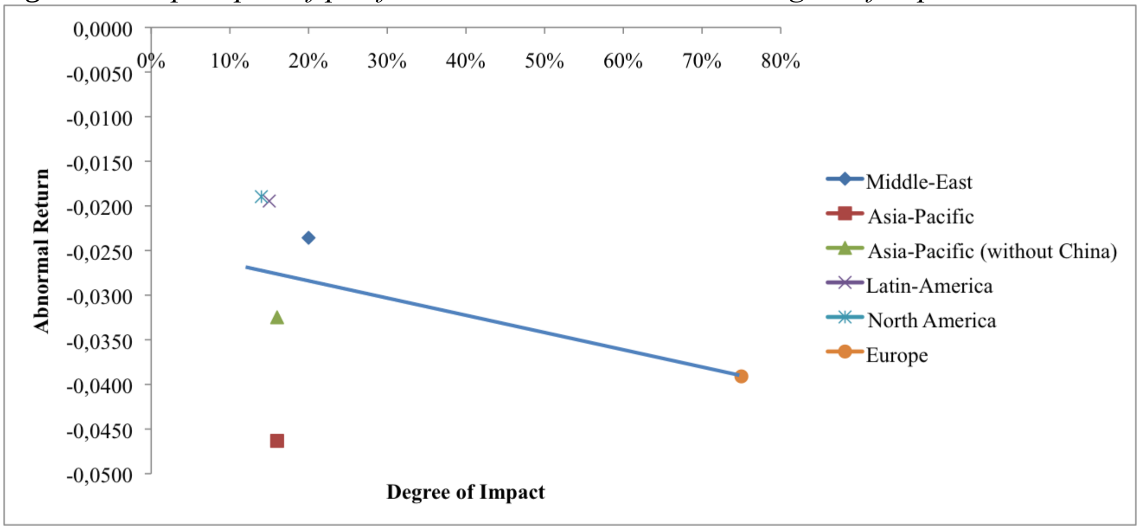
The second reason addresses the specified model. The model takes into account several independent variables that we think, based on previous research and own reasoning, should explain investors' behavior during the event. However, a reason for the non-explanatory power of the model could be that it is wrongly specified. This would mean that investors took company characteristics into account when estimating the effect of the event that we disregard in our model. In order to avoid this problem, we run a test for omitted variables. Since the test yields, as shown later, that no variables are omitted, we estimate the probability of the model being specified incorrectly to be rather low.

The third reason for the non-explanatory power of the model relates to the results of section 3, where we test the significance of abnormal returns for each company on an individual basis. Since the abnormal returns are only significant for three out of 15 companies (at a 5% significance level), the problem of low significance might be transferred to the multiple-regression model of company characteristics. Explanatory power of the impact variable for portfolio abnormal return can therefore be a sign that the low statistical significance on an individual company basis is the main problem for the non-explanatory power of the above-specified regression model.

Portfolios

For the impact variable of the portfolios, we get significant results when excluding the Asia-Pacific portfolio. It is however, important to mention that we only have a limited number of observations (five and four portfolios) and a lot of variation in the explanatory variable, degree of impact (from 15-75%). Within this variation, the European portfolio is responsible for the slope of the regression line (under scenario two), as the other portfolios are clustered on the opposite diagonal of the range, as shown in the figure below.

Figure 6: *Graphic plot of portfolios' abnormal returns and degree of impact*



Nevertheless, the results suggest that investors took the impact into account, since a large part of the portfolios' abnormal return can be explained by the extent to which each portfolio was impacted. We can infer that the "impact" characteristic can explain at least some of the reactions in the stock markets. In contrast to the model of company characteristics, the problem of low abnormal returns is not an issue for the regression model of portfolios, supporting our previous reasoning.

For rationality, this means that when only looking at company characteristics, we cannot draw conclusions if the market reacted to the event in a rational manner. Due to the lack of significance in both regressions (market model and multiple), we can make no inferences. Due to the fact that our results do not show any signs of investors differentiating between companies, we can state that this is contrary to the economic intuition that market participants usually follow. However, a contradiction to market rationality can only be inferred, if the results had shown significance. Since this is not the case, we cannot draw any conclusions about market rationality at this point. For portfolios, however, a hint towards market rationality guided by the degree of impact, with the above-mentioned restrictions, can therefore be assumed.

4.5 Tests of Assumptions under OLS and Additional Data Tests

Autocorrelation and Homoscedasticity

Since we are not conducting the multiple regression on a data set of time-series data, neither autocorrelation nor heteroscedasticity of the residuals is of concern in this step of the study.

Normality

We test the normality assumption with the Jarque-Bera normality test of the residuals. We conclude in favour of normally distributed residuals with a probability of wrongly rejecting the H_0 (normality assumption) being equal to 72.14%. The residuals further show a slight platycurtic distribution (kurtosis of 2.5530) indicating slightly less concentrated observations around the mean than the normal distribution and a slightly longer left tail (skewness of -0.4795). We also perform a visual inspection applying a kernel density estimate and comparing this to a normal distribution. The visual inspection allows us to conclude in line with the Jarque-Bera test in favour of normality of the residuals. Normally distributed residuals are necessary, in order to be able to make inferences on the results of the regression.

Collinearity

Collinearity, or multicollinearity as it also referred to, is tested for using the Variance Inflation Factor (VIF). An often used cut off point for when variables may merit further investigation of possible collinearity, is when a variable is showing a VIF in the region of 10 (Gujarati, 2003). Our variables have a mean VIF of 2.09 with leverage having the highest VIF of 3.21. This allows us to assume that no collinearity is present.

Assumption of Linear Relation of the Regression Model

Wrongfully assuming a linear relationship between the independent and dependent variables represents a major mistake in a regression model. In order to check for this, we first perform a visual inspection by pair-wise plotting each independent variable with the dependent variable with an added linear regression line. We secondly perform the same inspection between the residuals and each independent variable to see if any pattern can be observed. None of the visual inspections hints at the fact that another relationship than linear is plausible. This is also logic as previous studies, explaining the same dependent variable with similar independent variables, have proven a linear relation.

Omitted Variables

With the low explanatory power of our independent variables, it is of interest to check whether the model is lacking any explanatory variables. In addition to considering previous studies, we also perform the Ramsey test, which is a regression specification test to detect omitted variables. The test refits the model and verifies whether the creation of new variables improve the explanatory power. We conclude in favour of no omitted variables (H_0) with a probability of wrongfully rejecting this hypothesis of 70.54 %.

Alternative Models

Even though no immediate evidence can be found indicating that the model is not correctly specified, we choose to investigate whether increased explanatory power could be found in other models. Therefore, we test log-linear versions and log versions of the variables. We also consider other explanatory variables and additional control variables. These alternative models show increased multicollinearity between the variables, which together with our relatively small sample can cause an increase in adjusted R^2.

However, as we find no previous reason to question the correct specification of the model, we do not consider the minor increase in adjusted R^2 as significant enough or motivated by economic theory to change the model specification.

Risk of an Overspecified Model

As can be seen in the analysis, our model contains variables that, in contrast to theory, have low explanatory power of the dependent variable, the abnormal returns. Since we have tested with alternative model specifications, functional forms and checked for omitted variables, the next logical step to consider is the risk associated with including irrelevant explanatory variables in the model.

The inclusion of a potential irrelevant variable does not change the quality of the OLS estimators, which stay unbiased and consistent with correctly estimated error variance and relevant hypothesis tests of coefficients. On the other hand, adding a variable with high correlation to other variables will cause the estimated coefficients to become increasingly inefficient despite an increase in R^2. Gujarati (2003) makes the recommended conclusion clear: Once a model is formulated on the basis of the relevant theory, Carter and Simkins (2002) in our case, "one is ill-advised to drop a variable from such a model" (p. 513). Since we already have tested and concluded in favour of no correlation between explanatory variables, we follow the advice to not change the original model specification.

5. Is there a Relation Between Financial Reports' Disclosed Loss and the Change in Market Value?

This chapter rounds off our analysis with a discussion on the actual loss that the companies disclose in their financial reports relative to the change in market capitalization during the event window. Therefore, this chapter is the third step in our analysis that we present in the introduction. This third step of analysis differs from our previous steps in that we now take the point of view from approximately one year after the event and investigate the adverse effects of the ash cloud from an ex-post perspective. While the usual event study approach takes into consideration the information that is available at the time of the event, we now conduct an investigation ex-post, as the companies have disclosed the loss they attribute to the event.

The aim of this investigation is to estimate how well investors were able to assess the effects of the event thus constituting an additional angle of analyzing market rationality. As outlined in previous research, we define the value of a company as derived from the expected cash flows (section 2.3.4). The event at hand adversely affected every company's cash flow for the current period. The fundamental value of a company is therefore changed through lower cash flows (numerator of formula in section 2.3.4). In the following, we will first show the absolute impact of the event as disclosed in the annual or interim report of each company. Furthermore, we go on by converting the absolute into relative numbers, in order to also test the correlation between disclosed numbers in the company report and the decrease in market capitalization in the event window. In order to give additional input into the analysis, it is natural to use the same sample portfolio as we do in steps one and two. However, we exclude Turkish Airlines and Aeroflot (Company IDs: 8 and 11, respectively), since these two companies have not published the annual report for the year 2010 yet. Aegean Airlines (Company ID: 15) does not quantify the impact of the ash cloud and does not state anything about it under "important events" in its annual report. We therefore also exclude Aegean Airlines, since the data necessary to do the analysis is not available.

This alternative approach of analyzing the event not only gives an additional angle of analyzing whether investors differentiated between companies but also allows to investigate to what extent investors where able to correctly assess the magnitude of the negative financial impact. This method further allows us to draw inference on whether market participants under- or overreacted with respect to this event.

With regard to this, it is particularly important that we have chosen an event window that takes into consideration the information arrival that airspace would be closed, until the first information that it would be opened again. We have motivated our choice of event window in section 3.1. To know the length of the event (i.e. the length of airspace restrictions) is important, since otherwise it would be impossible for investors to quantify the final financial impact of the event. Again, we do not consider other factors influencing stock movements in this event window, but rather assume and analyze the data as if the ash cloud was the only news that affected share prices during the event window. Even though we know that there most certainly was other news as well, we have gone through databases, such as factiva, in order to make sure that there was no other major news that could affect airline securities in the event window.

As mentioned before, we do not consider the ash cloud event to have had an impact on the securities' systematic risk, but rather to have lowered cash flows for the current period. Naturally, we cannot expect the decrease in market value to exactly equal the disclosed loss, but expect the pattern to follow the above-mentioned reasoning. However, we expect a positive correlation between the two figures (market value loss vs. disclosed loss), meaning that companies with high losses due to the ash cloud should incur a high decrease in market capitalization and expect these movements to be relatively close. Before going into the actual analysis, we first outline some potential limitations of this method.

5.1 Limitations of the Method

If it is assumed that the ash cloud was not considered to be a potential source of risk for a company's cash flows prior the event, one could argue that investors have become aware of a new danger for future cash flows. Investors could further assess the ash cloud as being a recurring rather than a non-recurring event impacting the cash flow. Further, it may be assumed that investors were not aware of ash clouds constituting such a risk for airline companies. This would imply a more long-term effect on expected cash flows, something we disregard in our method of comparison. The reason is that we do not believe this to be plausible, and even if so, the benefits of including these long-term risk aspects are likely to be outweighed by the difficulties and imprecision associated with their consideration. In addition, the present value of these future losses represent minor changes in current enterprise value and are thus not considered as value relevant (DCF formula in section 2.3.4).

5.2 Analysis of Market Under- or Overreaction

As can be seen in the table below, 12 out of 15 companies make disclosures about the financial impact of the ash cloud. For three companies, as mentioned above, no reliable, quantitative information can be gathered through company interim or annual reports. For Deutsche Lufthansa (Company ID: 1), it is stated in the annual report that the ash cloud had a three-digit million negative impact on the company's result (Lufthansa Annual Report, 2010). However, Lufthansa's CEO is quoted that the financial impact was close to 200 million Euros, which we then take as a reliable estimate (McGroarty, 2010).

Table 10: *Change in market capitalization and disclosed loss in Euro*

Company	Comp ID	**Change in Market Value, in millions**	**Disclosed Loss, in millions**	**Under / Overreaction**
Deutsche Lufthansa	1	-224	-200	Overreaction
British Airways	2	-148	-123	Overreaction
Iberia	3	-131	-20	Overreaction
Air France/KLM	4	-165	-158	Overreaction
Ryanair	5	-445	-50	Overreaction
Easyjet	6	-59	-65	Underreaction
Air Berlin	7	-16	-40	Underreaction
Turkish Airlines	8	26	n/a	n/a
SAS	9	-112	-72	Overreaction
Norwegian Air Shuttle	10	-73	-13	Overreaction
Aeroflot	11	-126	n/a	n/a
Aer Lingus	13	-16	-20	Underreaction
Finnair	14	-36	-30	Overreaction
Aegean Airlines	15	-12	n/a	n/a
Jet2 (Dart Group)	17	2	-3	Underreaction
Sum (excl. Comp Ids 8, 11, 15)		**-1423**	**-794**	Overreaction
Correlation (excl. Comp Ids 8, 11, 15)				0,41

Source: Own Illustration based on Datastream and Companies' Interim/Annual Reports, currencies converted using Oanda

From the table, we can see that the financial impact between the companies differs. The financial losses are converted from local currency as disclosed by the company into Euros. In absolute terms, Lufthansa suffered the greatest financial burden due to the event of 200 million Euros. The last column illustrates, if the stock price movement reflected an under- or overreaction in relation to the disclosed loss by the companies.

We want to point out, however, that we do not expect the change in market value to exactly equal the loss. Our aim is to investigate, if there was a general pattern of a market under- or overreaction. The row “sum” shows all companies’ change in market value and all companies’ disclosed lost, both excluding Turkish Airlines, Aeroflot, and Aegean Airlines, since no information is available for them. From the table, we can infer that for eight companies the decrease in market value was higher than the actual loss from the event (market overreaction). For four companies, the actual loss exceeds the decrease in market value during the event window thus constituting market underreactions. In total, the decrease in market value of all companies (excluding Company IDs: 8, 11, 15) is almost twice as high as the actual loss all the companies accumulated due to the ash cloud. However, we observe that this is highly influenced by extreme losses in market value by Iberia, Ryanair, and Norwegian Air Shuttle.

The conclusions we can draw from this are the following. The fact that most of the companies do not show a large difference hints at the fact that investors were able to quantify the impact fairly well. It is striking that in general the change in market value and the disclosed loss are relatively close. For companies like Lufthansa, British Airways and Air France/KLM, for example, the difference between the two numbers is rather low. Our general impression of this analysis is therefore that investors were able to estimate the size of the impact fairly well. We can also observe a correlation of 0,41 between the two rows change in market value and disclosed loss. However, this correlation is to be treated with caution, since it is not yet a relative measure adjusted for size. In all the severe cases of incorrect assessment (Iberia, Ryanair, and Norwegian), the market overreacted. It is mainly due to these outliers that the accumulated decrease in market value clearly outweighs the accumulated disclosed losses on a portfolio level.

5.3 Analysis of Relative Disclosed Financial Impact on Sample

In general, there are two major factors influencing the *absolute* financial burden. Firstly, the geographic area the airline is operating in determines the exposure to the ash cloud event. Secondly, the size of the company determines the absolute loss in revenues and additional expenses. We can adjust for this second factor by putting the loss in relation to market capitalization of the company, which can be drawn from the table below. Following from step two in our analysis, when we compare the impact of different company characteristics, we can draw the conclusion that the size of the company does not imply a higher or lower exposure to the event in relative terms. That is why we can adjust for company size.

Table 11: *Relative change in market value and relative disclosed impact*

Company	Comp ID	**Relative Change in Market Value**	**Relative Disclosed Impact**
Deutsche Lufthansa	1	-3,77%	-3,36%
British Airways	2	-4,65%	-3,85%
Iberia	3	-5,30%	-0,80%
Air France/KLM	4	-4,35%	-4,17%
Ryanair	5	-7,40%	-0,83%
Easyjet	6	-2,47%	-2,74%
Air Berlin	7	-4,45%	-10,94%
SAS	9	-8,53%	-5,50%
Norwegian Air Shuttle	10	-10,83%	-1,86%
Aer Lingus	13	-4,00%	-4,99%
Finnair	14	-5,96%	-4,98%
Jet2 (Dart Group)	17	1,59%	-3,37%
Average		**-5,01%**	**-3,95%**
Correlation			**-0,13**

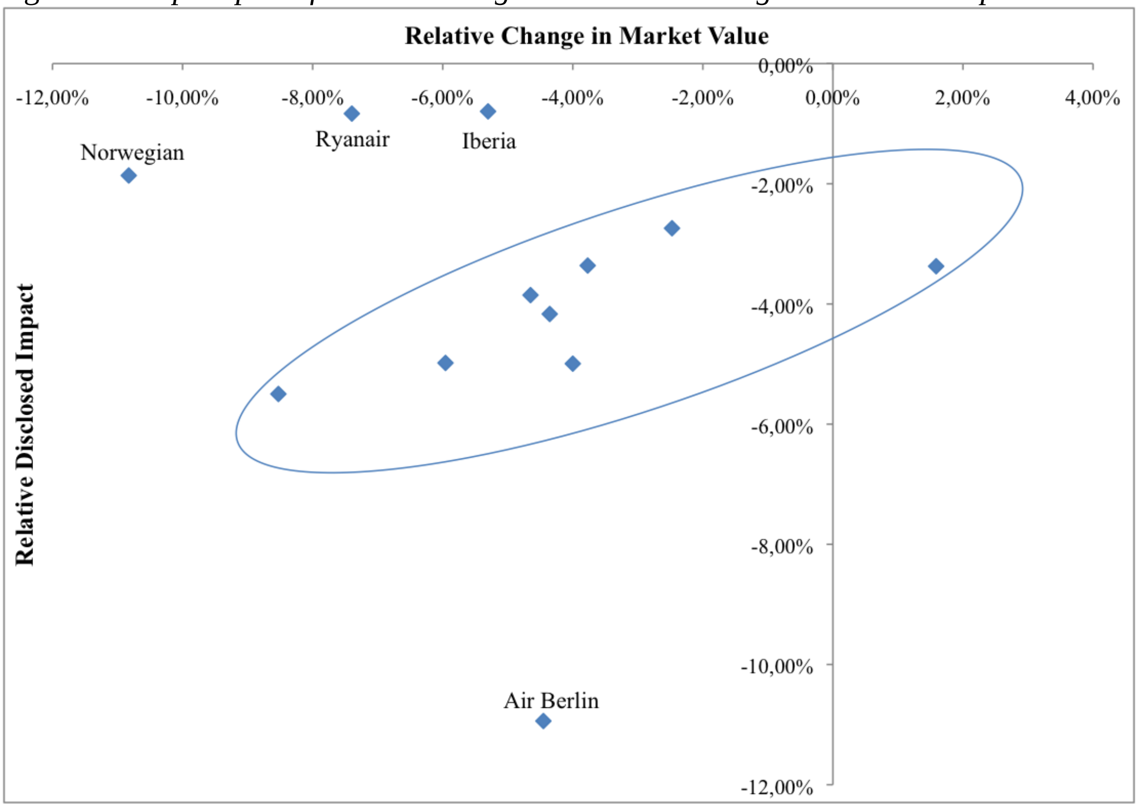
Source: Own Illustration

In the table, the relative change in market value (absolute loss in market value in relation to the market value on the 14th of April, 2010) is compared to the relative disclosed loss (absolute disclosed loss in relation to the market value on the 14th of April, 2010). As can be seen, the same denominator is used (market value), in order to make the two relative figures comparable. This is done, in order to present a relative measure of how each company was affected. The first measure addresses a capital-market view, while the disclosed impact represents a reported financial loss. Lufthansa, for example, lost 3,77% in market value during the event. In other words, after the event Lufthansa was worth 96,23% of the value before the event. Since accounting numbers, such as earnings announcements and losses, are relevant to investors, we also expect to see a correlation between the two relative measures in the table above (Sprecher & Pertl, 1983).

The relative figures give a more comprehensive picture of market under- or overreaction than absolute numbers. Since we have relative numbers now, we average the portfolio instead of summing it as done in the comparison of absolute numbers. The first observable issue is that the difference between the two averages of the relative measures (average row) is fairly close, -5,01% compared to -3,95%.

We also test the two rows for correlation. From a logical point of view, a larger relative impact should lead to a larger relative decrease in market value. That is why we expect the correlation to be positive. Surprisingly, the correlation turns out to be negative (-0,13). This is due to the outliers that exist. Due to the few observations, the outliers have a high weight in the calculation of the correlation coefficient. The graph below shows that a general pattern can be observed (within the oval), but also depicts the outliers.

Figure 7: *Graphic plot of relative change in market value against relative impact*



Source: Own Illustration

In the figure above, every dot represents a company. It is especially the four outliers (Iberia, Ryanair, Air Berlin, Norwegian Air Shuttle) that are responsible for the negative correlation coefficient. Since three of these companies (Iberia, Ryanair, Norwegian Air Shuttle) were hit hard by the capital market (-4,3%, -7,4%, -10,83%, respectively), but did not disclose a huge loss, they do not follow the logical pattern of the other companies. Air Berlin is one of the few companies, where the market underreacted. Even though the disclosed impact was at -10,94%, the decrease in market capitalization was at 4,45%. In order to show the high weight of these outliers and to illustrate the sensitivity of the correlation coefficient, we can take away the four outliers and the coefficent increases from -0,13 to 0,73. However, since we cannot argue to take out the four companies due to other noise in the event window, we leave them in the sample. Taking them out serves the purpose of showing how sensitive the correlation coefficient is towards the four companies with great differences in the figures. As can be seen, there is a linear relationship between the relative decrease in market value and the relative impact. However, as can be observed from the figure, several outliers exist.

To conclude, the signs of the correlation coefficients are not in line with our expectations, i.e. the correlation between the two ranks is negative instead of positive. Therefore, no clear inference can be made that a higher impact on the profit due to the ash cloud is positively correlated with a higher decrease in market value. Despite this fact, we see a linear relation when excluding extreme values. In addition to that, on an aggregated level, the drop in market value (-5,01%) indicates that investors rather accurately assessed the financial impact of the event (-3,95%). As a consequence, no major under- or overreactions can be inferred. Therefore, our findings hint at the fact that the market reacted rationally, but we cannot infer this with certainty.

6. Conclusion

6.1 Limitations to the Conducted Research

The conducted research also has limitations. Demarcations were presented in the first section in order to give limits to the research. The first limitation of the study refers to the data. We limit the thesis to the ash cloud event in April 2010. As it was stated, the ash cloud not only had consequences in April, but also affected airspace in May. Therefore, one limit to the research is the investigation of market rationality only in April 2010. In this context, future research can extend the event window to also include the effects of the May 2010 ash cloud.

The second limitation of the conducted research is the rather low significance of this event study. Due to the fact that only three out of 15 companies show significant negative abnormal returns in the event window (at a 5% significance level), inferences and conclusions about market rationality can only be made to a limited extent.

A third limitation to the research is the scope of the study. Since we study one particular event, statements about investor behavior can only be applied to the event at hand and cannot be generalized. In this light, this study is a complementary part in the larger research field on market rationality.

6.2 Concluding Remarks

The objective of this paper was to provide insights into the following research question: Did the stock market react rationally to the ash cloud event in April 2010? In order to investigate this research question, we split up the analysis into the following three questions: (1) Was the ash cloud event significant to the stock market? (2) Did the market differentiate between companies or portfolios? (3) Is there a relation between financial reports' disclosed loss and the change in market value?

In this conclusion, we will connect and summarize our research findings of the three steps as outlined in the introduction. Taking the findings jointly together, we will answer the research question, if the market reacted rationally during the ash cloud event.

The findings of the first step of the analysis suggest that the market perceived the ash cloud event to be significant for three out of 15 sample companies. For twelve companies, no significant stock price reaction could be observed. For the portfolio of European airline companies, a significant stock price decrease occurred during the event. In line with our expectations, the analysis yields that the stock market interpreted the event as negative information, since 13 out of 15 sample companies had negative abnormal returns in the event window. However, since no drastic stock price decreases occurred, the market did not give too much importance to the effect of the ash cloud.

The findings of the second step of the analysis suggest that company characteristics, including size, liquidity, financial structure, profitability and the exposure to the event, do not explain abnormal returns of the securities. The findings are mostly contradictory to our expectations, since we expected that the liquidity ratio and the exposure to the event would yield statistically significant explanations for the variation in abnormal returns. However, we conclude in favor of no model specification errors. Possible reasons for the non-explanatory power of the model were also outlined. In this context, we argue that the low significance of abnormal returns (only 3 out of 15 companies) is a source of the problem. The rather low abnormal returns from the first step of the analysis are transferred to the second step. Due to the lack of significance in the analysis of company characteristics, we cannot infer conclusions about rational market behavior. We further investigate portfolios of different geographic areas with the aim of testing if the degree of impact as the independent variable can explain the variation in abnormal returns. The findings suggest that the exposure to the event of the different portfolios can explain the abnormal returns to some extent. This is in line with our expectation that market participants should take the exposure to the event into account in the valuation. In general, however, we find inconclusive results from company characteristics trying to explain abnormal returns, while we see a hint towards some explanatory power of the impact variable on a much broader portfolio level. Nevertheless, the lack of significance and the few number of observations pose powerful restrictions to an inference and inhibit a clear interpretation of market rationality from the second step of our analysis.

The findings of the third step suggest that the market slightly overreacted at the time of the event. However, with the exception of three companies, the market was fairly good at quantifying the loss that airlines would incur. Considering that investors were in times of uncertainty, a market overreaction is in line with previous research

(Bernstein, 1985). After converting the change in market capitalization and disclosed financial impact into relative measures adjusted for size, we run a correlation on these two figures. Against our expectations, the correlation coefficient turns out to be negative, which would mean that companies with a higher relative decrease in market value had a lower relative disclosed financial impact. However, when we plot the results, a positive linear relationship can be observed for eight out of 12 companies (see figure 7). The large outliers pose a problem, because they obtain a lot of weight due to the limited number of observations and are therefore responsible for the negative sign of the correlation coefficient. In line with our reasoning from step one and two, we see that on a portfolio level, the market correctly estimated the negative financial impact. This can be observed from the fact that on a portfolio level, the difference between relative change in market value and relative disclosed impact is rather low.

The objective of the three-step analysis was to give a holistic view on how the market perceived and reacted to the ash cloud event. After having conducted the three steps, we have obtained an idea of how investors regarded the event. We conclude that the feared losses were not significant enough for the investors to be concerned about company characteristics, such as liquidity. This is due to the fact that investors did not change their fundamental view on companies due to the event, such as a lower ability to cover short-term obligations. Therefore, the event posed a one-time financial burden on the companies, but did not have a persisting effect on companies' cash-generating ability. Therefore, the main effort of the investors was to quantify this one-time loss, something we find evidence for in the third step of our analysis. This provides us with signs of investors having acted based on relevant rationales to the effects of the April 2010 volcano eruption. However, market rationality as defined by Carter and Simkins (2002) can still not be inferred from our study.

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Currency converted through Oanda, retrieved through
http://www.oanda.com/currency/converter/

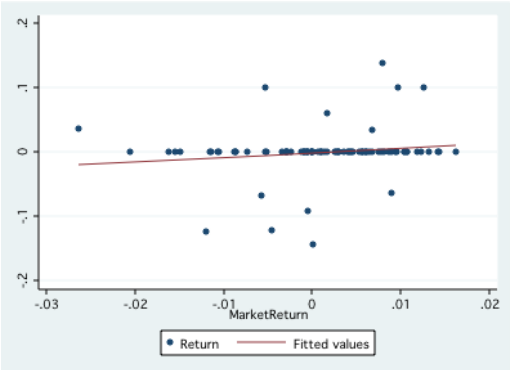
Databases used: Datastream, Factiva, Orbis

Programs used: Excel and Stata Version 11

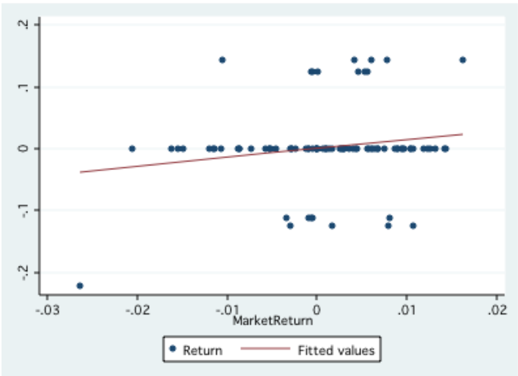
Appendix

Companies deleted from the sample due to low trading activity:

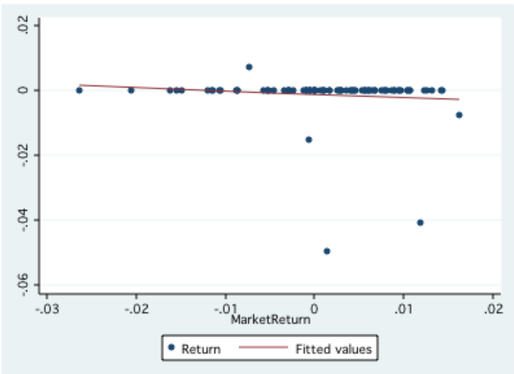
Icelandair (Company ID: 16)



Cyprus Airways (Company ID: 19)



Atlantic Airways (Company ID: 20)



Results of market model with event window 14th – 19th of April:

Name	LH	BA	IB	AFklm	Fryan	EZY	AB	TK	SAS	NO	SU	EL	AY	AEG	DART	**Portf**
Comp ID	1	2	3	4	5	6	7	8	9	10	11	13	14	15	17	21
CAR	-0,0190	-0,0271	-0,0283	-0,0132	-0,0609	-0,0070	-0,0555	0,0315	-0,0866	-0,1007	-0,0708	-0,0440	-0,0574	-0,0496	0,0594	-0,0351
T-Value	-0,8689	-0,7200	-0,7723	-0,3544	-1,5257	-0,2586	-1,4487	0,8764	-1,0035	-1,8098	-1,7284	-0,7386	-1,9765	-1,1533	0,9379	**-2,5931**
p-Value	38,7%	47,3%	44,2%	72,4%	13,1%	79,7%	15,1%	38,3%	31,8%	7,4%	8,7%	46,2%	5,1%	25,2%	35,1%	**1,1%**

Results of market model with event window14th – 20th of April:

Name	LH	BA	IB	AFklm	Fryan	EZY	AB	TK	SAS	NO	SU	EL	AY	AEG	DART	**Portf**
Comp ID	1	2	3	4	5	6	7	8	9	10	11	13	14	15	17	21
CAR	-0,0263	-0,0340	-0,0256	-0,0249	-0,0594	-0,0037	-0,0676	0,0078	-0,0456	-0,0537	-0,0601	-0,0852	-0,0727	-0,0347	-0,0352	-0,0399
T-Value	-1,0747	-0,8067	-0,6251	-0,5950	-1,3317	-0,1213	-1,5797	0,1941	-0,4728	-0,8631	-1,3131	-1,2788	-2,2421	-0,7218	-0,4977	**-2,6350**
p-Value	28,5%	42,2%	53,4%	55,3%	18,6%	90,4%	11,8%	84,7%	63,8%	39,0%	19,3%	20,4%	2,7%	47,2%	62,0%	**1,0%**

Results of market model with event Window 15th – 19th of April with 3-day returns:

Name	LH	BA	IB	AFklm	Fryan	EZY	AB	TK	SAS	NO	SU	EL	AY	AEG	DART	MER	**Portf**
Comp ID	1	2	3	4	5	6	7	8	9	10	11	13	14	15	17	18	21
CAR	-0,0155	-0,0355	-0,0450	-0,0282	-0,0636	-0,0283	-0,0337	0,0352	-0,0634	-0,1100	-0,0569	-0,0256	-0,0596	-0,0431	0,0165	-0,0445	-0,0376
T-Value	-0,8850	-1,1431	-1,6055	-0,7831	-1,9007	-1,1713	-1,4729	1,1679	-0,9399	-1,9347	-1,7621	-0,5687	-2,1551	-1,1374	0,3898	-1,2109	-3,1366
p-Value	37,9%	25,6%	11,2%	43,6%	6,1%	24,5%	14,4%	24,6%	35,0%	5,6%	8,2%	57,1%	3,4%	25,8%	69,8%	22,9%	**0,2%**

Results of market model using the MSCI world index:

Name	LH	BA	IB	AFklm	Fryan	EZY	AB	TK	SAS	NO	SU	EL	AY	AEG	DART	**Portf**
Comp ID	1	2	3	4	5	6	7	8	9	10	11	13	14	15	17	21
Adj Std. Deviation	0,0204	0,0328	0,0319	0,0334	0,0355	0,0238	0,0348	0,0327	0,0746	0,0469	0,0352	0,0515	0,0251	0,0373	0,0558	0,0133
AR	-0,0242	-0,0351	-0,0457	-0,0240	-0,0727	-0,0180	-0,0398	0,0346	-0,0736	-0,0967	-0,0632	-0,0393	-0,0627	-0,0445	0,0345	-0,0387
p-Value	11,9%	14,3%	7,8%	23,7%	2,2%	22,6%	12,8%	14,7%	16,3%	2,1%	3,8%	22,4%	0,7%	11,8%	26,9%	0,2%

Serial Correlation Finnair:

DAY						
	T	T-1	T-2	T-3	T-4	T-8
T	1					
T-1	0,1506	1				
T-2	0,0218	0,1336	1			
T-3	0,0639	0,0032	0,1296	1		
T-4	0,2262	0,0567	0,01	0,1565	1	
T-8	0,1414	0,014	-0,046	0,1646	0,2459	1

Breusch-Godfrey LM test of Autocorrelation			
Finnair, comp id:14			
Lags	F	DF	Prob>F
1	8,789	(1, 86)	0,0039
2	4,659	(2, 85)	0,0120
3	5,722	(3, 84)	0,0013
4	4,462	(4, 83)	0,0026
8	2,488	(8, 79)	0,0184
12	1,725	(12, 75)	0,0781

Serial correlation Norwegian Air Shuttle:

Breusch-Godfrey LM test of Autocorrelation			
Norwegian Air Shuttle, comp id:10			
Lags	F	DF	Prrob>F
1	2,91	(1, 86)	0,0916
2	3,299	(2, 85)	0,0417
3	2,314	(3, 84)	0,0818
4	1,872	(4, 83)	0,1231
8	1,163	(8, 79)	0,3322
12	0,924	(12, 75)	0,5274

For the multiple–regression model on company characteristics, the variables are defined as follows:

Ln Total Assets = Natural logarithm of total assets as disclosed the latest fiscal year before ash cloud

Cash / Assets = Total cash and cash equivalents / Total assets

Leverage (D/E) = Interest-bearing liabilities / Total shareholder's equity excluding minority interest

Return on Assets (ROA) = Net income for the fiscal year ending / Total assets at the beginning of the year

Estimated Impact = Average impact of countries with operational bases and the available seat kilometers for the respective countries

For estimated impact, information on how each country was affected has been taken from Eurocontrol "Ash- cloud of April and May 2010: Impact on Air Traffic". For all financial data, information has been taken from the database Orbis.

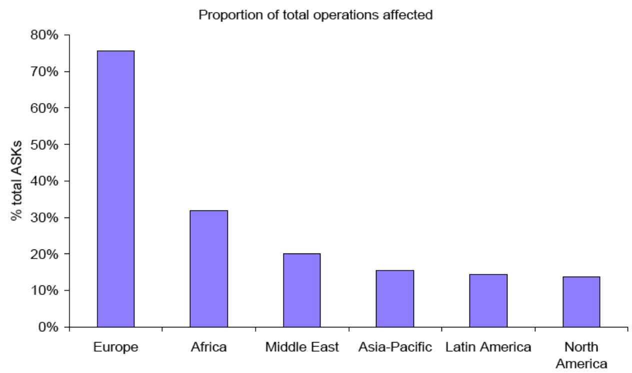
Basis for the estimated impact for company characteristics (Eurocontrol, 2010):

Estimated Fraction Cancelled	15APR	16APR	17APR	18APR	19APR	20APR	21APR	22APR	All
Albania	17%	43%	68%	77%	31%	14%	0%	0%	34%
Austria	15%	61%	98%	99%	76%	53%	21%	0%	52%
Belarus	0%	63%	86%	83%	61%	23%	14%	0%	42%
Belgium/Luxembourg	39%	96%	98%	98%	97%	72%	25%	0%	65%
Bosnia-Herzegovina	18%	33%	91%	97%	67%	31%	0%	0%	43%
Bulgaria	21%	61%	88%	96%	68%	38%	0%	0%	47%
Canary Islands	25%	34%	55%	45%	23%	1%	0%	0%	25%
Croatia	20%	40%	92%	95%	68%	39%	0%	0%	45%
Cyprus	9%	29%	46%	44%	28%	11%	0%	0%	21%
Czech Republic	12%	87%	98%	98%	89%	66%	28%	6%	60%
Denmark	60%	87%	99%	99%	97%	91%	40%	16%	72%
Estonia	24%	95%	97%	99%	96%	83%	46%	19%	68%
FYROM	16%	49%	86%	91%	69%	30%	6%	0%	45%
Finland	39%	90%	98%	100%	93%	96%	82%	64%	81%
France	20%	67%	87%	92%	77%	54%	16%	0%	51%
Germany	20%	84%	98%	99%	96%	81%	40%	2%	64%
Greece	11%	32%	47%	42%	12%	0%	0%	0%	19%
Hungary	15%	66%	98%	98%	79%	54%	16%	3%	53%
Ireland	54%	94%	98%	100%	100%	90%	48%	8%	74%
Italy	9%	30%	74%	77%	59%	26%	6%	0%	35%
Latvia	23%	95%	97%	98%	93%	75%	36%	7%	65%
Lisbon FIR	25%	40%	56%	46%	32%	0%	0%	0%	26%
Lithuania	8%	87%	90%	91%	81%	61%	25%	0%	55%

Malta			11%	32%	39%	28%	13%	0%	0%	0%	16%
Moldova			17%	50%	95%	92%	80%	43%	17%	14%	51%
Netherlands			53%	96%	98%	99%	98%	75%	33%	1%	68%
Norway			92%	73%	92%	77%	44%	50%	15%	34%	57%
Poland			10%	88%	97%	95%	89%	76%	31%	2%	60%
Romania			12%	52%	94%	97%	81%	42%	12%	1%	48%
Santa Maria FIR			0%	0%	0%	0%	0%	0%	0%	0%	0%
Serbia&Montenegro			18%	48%	92%	97%	68%	39%	0%	0%	47%
Slovakia			17%	77%	98%	97%	78%	48%	13%	0%	53%
Slovenia			20%	55%	97%	99%	70%	51%	9%	0%	50%
Spain			18%	39%	59%	66%	37%	16%	0%	0%	30%
Sweden			54%	84%	99%	99%	83%	80%	57%	32%	71%
Switzerland			13%	64%	98%	98%	94%	61%	23%	2%	56%
Turkey			13%	39%	51%	50%	31%	23%	0%	0%	26%
Ukraine			7%	38%	80%	81%	48%	25%	13%	4%	38%
UK			74%	95%	99%	99%	99%	93%	38%	6%	74%

Basis for estimated impact for portfolios (IATA, C, 2010):

Chart 3: Airlines from which region had their passenger operations most affected?



Source: IATA Economics, SRS Analyser database

Variance Inflation Factor (VIF), collinearity in multiple-regression model:

Variable	VIF	1/VIF
LnSIZE	2,92	0,341955
IMPACT	1,26	0,794859
ROA	1,45	0,69025
LEVERAGE	3,21	0,311223
CASHTA	1,6	0,626949