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THE EFFECT OF AVIATION DISASTERS ON THE STOCK MARKET

JOCHEM HAVELAAR 431442

SUPERVISED BY R. XING

ABSTRACT

In this thesis the stock market reaction after an air crash is examined. The stock market reaction is measured using abnormal returns. Airlines involved in the crash experience a significant negative cumulative abnormal return of minus 3,2 per cent in the period from the crash until two days after the crash. During this period no reaction was found for the competitors of the involved operator and other operators. Regarding the manufacturers of the crashed airplanes, no reaction is found as well. Even when the cause of the crash could be attributed to the manufacturer, no abnormal returns were obtained.

Keywords: event study, air crashes, abnormal returns

1. Introduction

An air crash has several financial consequences for involved firms like the airlines, such as a burden in revenue due to consumers who avoid the operator, the loss of an airplane, and payments to bereaved families. An accurate measure in order to determine this financial impact on a firm is to evaluate the stock price reaction of the firm. This is justified by economic theory in which prices reflect the company's future cashflow generating capacity. A negative price reaction implies riskier or lower cashflow expectations by investors (Chance & Ferris, 1987). In order to investigate the financial impact of an air crash, the research question in this thesis will be:

How does the stock market react on aviation disasters in the short term?

In this thesis the market is defined as operators and manufacturers of airplanes, since these firms are the most likely to experience a stock price reaction after a crash. To answer the research question, the abnormal returns of the stock on the days surrounding the event are determined. Abnormal returns are calculated as the actual return minus the expected return. Regarding the involved operators, a significant financial impact is found in this thesis. Involved operators experience a negative cumulative abnormal return of almost 3,2 per cent one day after the crash. During this period no reaction was found for the competitors of the involved operator and other operators. However, in later periods significant negative returns were found for the non-competitors, which were compensated again in the long term. Regarding the manufacturers of the crashed airplanes no reaction is found. Even when the cause of the crash could be attributed to the manufacturer, no abnormal returns were obtained.
After evaluating the abnormal returns, some models are produced which explain the abnormal returns of a stock after a crash. These models are based on several crash-specific characteristics such as the amount of fatalities and continent of establishment. In the future this model can be used by investors to construct a profitable trading strategy when an air crash occurs. Unfortunately, the coefficients of the variables in the models are significant in just one of the constructed models. The model with significant coefficients is the model which explains the abnormal returns of the manufacturer, in the period from the day of the crash until 30 trading days after the crash.

Most of the research conducted on this topic so far only calculates the abnormal returns after an aviation disaster, but does not construct an explanatory model of these abnormal returns. Moreover, the main papers regarding air crashes and stock market reactions are conducted before the September 11th attacks. Which is important because, after those attacks major changes have been made in the aviation industry in order to improve safety (IATA, 2011). On top of that, the amount of fatal accidents per year decreased drastically (Aviation Safety Network, 2017). Since the aviation industry has been subject to changes, it is interesting to investigate whether the stock market reaction on aviation disasters changed as well or remained nearly the same after the September 11th attacks. Furthermore, an extension in comparison to prior research will be made. Not only the stock price reaction of the involved operator will be evaluated, but the stock prices of the involved manufacturer and the operators that are not involved in the crash will be evaluated as well. Lastly, this thesis examines the stock market reaction on global scale, rather than focusing on the United States only.

2. Literature Review

2.1 Hypothesis 1

The stock price of the operator involved in the crash reacts negatively to the air crash.

As mentioned before, an air crash will have several financial consequences for the operator. The negative abnormal returns are found in several papers. Chance and Ferris (1987) found a statistically significant average negative return of 1,2 per cent on the day of the event itself. The negative reaction could be found at more than half of the crashes, with the largest negative return being 11,4 per cent. In this paper a negative correlation between the amount of deaths and the abnormal returns was found as well. However, in the days after the event, no significant reaction could be found. In this paper, 49 air crashes concerning the operators on the American and New York Stock Exchange are investigated.

In another paper also a negative reaction is been found (Bosch & Eckard, 1998). However, in this paper a significant price reaction can be found in the periods starting from the day of the crash until the two days after the crash. Within these days, a reaction of minus 2,7 percent was found. The reactions from the third until the fifth day are negative as well, but insignificant. Bosch and Eckard (1998) only used American listed airlines as well.

Furthermore, Ho, Qiu and Tang (2012) found a negative price reaction. On top of that, they found a more negative abnormal return when the amount of fatalities increased. If the crashed caused only up to 10 deaths, the abnormal returns disappeared after one week. In comparison, if more than hundred people did not survive the crash the negative impact was larger and more persistent.

Lastly, the negative return is found by Borenstein and Zimmerman (1988) as well, who state that shareholders experienced a 0,94 per cent loss on the day of the crash.

2.2 Hypothesis 2

The stock price of the operators not involved in the crash also react negatively, except for the operators that are substitutes of the involved operator.

In two of the already mentioned papers the researchers also investigate the stock return reaction of operators that are not involved in the crash. A negative reaction in these stocks would indicate that investors view an air crash as an industry-wide problem. Unfortunately, no significant reaction is found in the paper of Chance and Ferris (1987). However, the paper of Bosch and Eckard (1998) does show a reaction of the stocks of operators that are not involved. They distinguish the two effects as follows:

1) A negative reaction for all carriers/operators, caused by the raising concerns of the commercial air systems, which leads to a reduced demand for all operators.
2) A positive reaction for the operators that are substitutes of the operator which is involved in the crash, due to the consumer-switching effect.

According to the paper of Bosch and Eckard (1998), other papers do not find any reaction of the stocks of the operators that are not involved because these papers do not split the net effect on stock price. In this paper, the substitutes are selected using the route overlap with the crashed operator. Unfortunately, such data is not publicly available on global scale. Therefore, in order to get at least reliable substitutes, the substitutes indicated by the Orbis database will be used in this thesis. However, this still implies a limitation of this thesis.

2.3 Hypothesis 3

The stock price of the manufacturer involved reacts negatively to the air crash.

Since an air crash influences the manufacturer in terms of liability and potential more costly safety standards, the hypothesis that the manufacturer would experience negative stock returns was tested in the paper of Chance and Ferris (1987) as well. However, no significant reaction could be found.

On the other hand, in a slightly different paper, a reaction of the manufacturers can be found (Maloney & Mulherin, 2003). This paper does not examine the stock price of manufacturers after an air crash, but after the crash of a space shuttle.

2.4 Hypothesis 4

The fourth hypothesis depends on the results of the third hypothesis. If the stock of the involved manufacturer does react significantly negative to the air crash, the hypothesis will be: **The stock price of the manufacturers that are not involved in the crash react negatively as well, except for the manufacturers that are substitutes of the involved operator** (4.1).

This hypothesis is based on the same foundation as mentioned before, regarding the second hypothesis.

However, when no reaction is found regarding the third hypothesis, so the stock return of the manufacturer involved does not react significantly negative to an air crash, then the hypothesis will be: **The stock return of the manufacturer involved only reacts negatively to an air crash if the cause of the crash could be attributed to the involved manufacturer** (4.2).

The potential reason why the first paper could not find a reaction, is because it did not take the cause of the crash into account. In another paper, a reaction of the stock price of the operator could only be found if the cause of the crash could be attributed to this operator. In this paper, the assumption is made that the cause of the crash was known within a few days after the crash, and on many occasions it was known on the day of or the day after the crash (Mitchell & Maloney, 1989). These results regarding the operators are extended to the manufacturer in this thesis.

3. Data

In order to answer the research question and investigate the hypotheses which are mentioned in the previous section, several categories of data need to be collected.

The first category of data consists of information about the unexpected events, namely the air crashes. This data is obtained from two different resources, namely the Aviation Safety Network (ASN) and the Bureau of Aircraft Accidents Archive (BAAA). Those individual databases contain information about the date and time of the crash, operator of the flight, number of fatalities, cause of the crash, and manufacturer of the airplane. To guarantee the reliability of the database for this thesis, that is being constructed manually, these two databases are cross-referenced.

Not all of the air crashes in the ASN and BAAA databases are used in this thesis. The crashes must meet certain criteria in order to get selected. Firstly, the crashes must have occurred in the period after the 11th September attacks in 2001. Those attacks had several implications for the aviation industry and therefore only the crashes after 11 September 2001 are taken into account (IATA, 2011).

Secondly, the stock return history of the operator or manufacturer needs to be available in the Thomson Reuters DataStream database. The stock return history of the operator is needed in the first and second hypothesis, and the stock return history of the manufacturer is needed in the third and fourth hypothesis. For some crashes only the stock return history of the manufacturer is available, which results in two different samples. From now on, these samples will be distinguished as the operator sample and the manufacturer sample. The operator sample contains crashes involving operators that are listed during the crash and will be used in the first and second hypothesis. The manufacturer sample contains crashes involving manufacturers that are listed during the crash and will be used in the third and fourth hypothesis. In addition, in case certain operators are partly or wholly owned by a larger operator, the effect on the stock returns will be evaluated by using the stock return performance of the shareholder.

The third criteria concerning the air crashes differs between the two samples. In order to be selected, the crashes in the operator sample must result in at least one fatality. In order to be used in the manufacturer sample, only the crashes with at least 50 fatalities are included. Using such values is in line with previous literature, where at least one (Bosch & Eckard, 1998) and at least ten fatalities (Chance & Ferris, 1987) are used. This third criteria is used to ensure that only the events with significant impact are selected in the sample. A stricter criteria for the manufacturer is used because it is expected that manufacturers experience less negative abnormal returns comparing to the operators. A reason for this expectation is that most of the manufacturers are also active in other markets and therefore not only generate income in the aviation industry.

A fourth criteria is only applied to the manufacturer sample after no reaction is being found when testing hypothesis 3. In that case, hypothesis 4.2, where the cause of the crash is taken into account, will be tested. As mentioned before, the causes of the crash can be found in the ASN and BAAA databases. The causes are divided into four groups, namely 'Human Factor', 'Technical Failure', 'Terrorism', and 'Other'. Only 'Technical Failure' will be attributed to the manufacturer. This criteria will narrow the manufacturer sample to the crashes which can be attributed to the manufacturer. However, when a reaction can be found after testing hypothesis 3, this criteria will not be applied. In that case, hypothesis 4.1, where the cause of the crash is not taken into account, will be tested.

When a database fulfilling the mentioned criteria is constructed, this results in two separate samples containing air crashes after 11 September 2001, involving a listed operator and/or manufacturer, with at least a certain amount of fatalities. The descriptive statistics of both samples are shown in Table 1.

TABLE 1: DESCRIPTIVE STATISTICS

Note: The middle column shows some descriptive statistics of the sample used to test the hypotheses regarding the operators. The last column shows the same descriptive statistics of another sample, which is used to test the hypotheses regarding the manufacturers.

	Operator Sample	Manufacturer Sample
Crashes	36	67
Min. fatalities	1	50
Max. fatalities	298	298
Mean fatalities	74	118
First observation	08-10-2001	08-10-2001
Last observation	17-04-2018	11-04-2018

For the second and fourth (4.1) hypothesis, a second category of data, which consists of information about the main competitors of the operators and manufacturers involved in the crash, is needed. This information can be obtained using the Orbis database, which contains information of 79 million companies worldwide. As stated before, it is expected that these not-involved main competitors will experience positive abnormal returns and that non-competitors will experience negative abnormal returns. The non-competitors are the firms in the same industry as the involved firms, which are not a substitute of the involved firms. The main competitors are identified by Orbis itself, however, the competitors must meet two criteria in order to get selected.

Firstly, the stock return history of the competitors needs to be available in DataStream. Secondly, the competitors must be active in the same industry as the operator or manufacturer that is involved in the crash. This mostly is a point of attention in the manufacturer sample, because some of the manufacturers are also active in other markets where they, according to Orbis, have competitors as well. To assure that only the competitors in the aviation industry are selected, the competitors are selected based on their NACE-codes. These codes are assigned by the European Union to a certain type of economic activity (Eurostat, 2008). For the operators the NACE-code 5110 (Passenger Air Transport) is used, and for the manufacturers the NACE-code 3030 (Manufacture of Air and Spacecraft and Related Machinery) is used. In this way, the main competitors for every operator or manufacturer involved in the crash, for which a positive abnormal return is expected according to the hypothesis, are obtained. On the other hand, the hypotheses expect a negative reaction concerning the non-competitors of the operator or manufacturer involved. This implies that companies, that are not competitors of the involved companies, are needed as well. For this reason, a list is created containing all operators or manufacturers that were at least once a main competitor of an involved company. At all crashes, the stock returns of all companies on the list will be evaluated. When a company on the list is not main competitor of the then concerned operator or manufacturer, it will be used as non-competitor to test the second part of the hypotheses concerning the negative abnormal return. The list of operators consists of 69 operators, with an average of 8.5 identified competitors per involved operator. The list of manufacturers consists of 16 manufactures, with an average of 4 identified competitors per involved manufacturer. These amounts are in line with prior literature in which, by association, four to eighteen different airlines are represented per crash in total (Bosch & Eckard, 1998).

The third category of data that is required are the already mentioned stock return histories. Not only the stock return histories of the involved companies are required, but the stock return histories of the main competitors and non-competitors as well. These can be obtained using DataStream.

Lastly, some characteristics of the involved companies in the crash are needed in order to construct a model which predicts stock returns of an operator or manufacturer after the crash occurred. This model will give investors insight in how the stock prices of the involved companies are going to react. The specification of this model can be found in the following section. The characteristics that are used in the model are obtained using the Orbis database. This database will give for example insight in the market capitalisation and country of establishment, which will be variables in the mentioned model.

4. Methodology

4.1 Event Study Method

To examine the stock market reaction after an event, an event study is used. In an event study the changes in average return on the relevant stocks around the event date are analysed. The event study is performed using the DataStream Event Study Tool. This tool calculates the adjusted abnormal returns as described by MacKinlay (1997). In order to calculate the market adjusted abnormal returns, several steps, which are described in this section, have to be performed.

1. *Calculating actual returns (R_{it})*

Before calculating abnormal returns, the actual returns of the relevant stocks during the event need to be determined. To get a complete view of the returns around the event date, the returns from 5 days before until 30 days after the event date are obtained. The actual returns are calculated as the price of the stock at time t minus the price of the stock at time t-1, divided by the price of the stock at time t-1.

2. *Calculating estimated returns ($E(R_{it})$)*

After the actual returns around the event dates are determined, an estimation of the 'normal' or 'expected' returns in that specific period need to be calculated. On the date of the event, it is expected that the actual return reacts significantly. The actual return will consists of both a normal return, otherwise called the expected or estimated return, and of an abnormal return of interest. These estimated returns are obtained using the market model.

$$E(R_{it}) = \beta_0 + \beta_1 E(R_m)$$

To obtain the estimated returns, the coefficients need to be estimated. In the operator sample, the stock return data of 120 trading days to 20 trading days before the crash is used to estimate the coefficients. In the manufacturer on the other hand, a larger estimation window is used, namely the 200 to 50 trading days before the event.

In this model, the market return (R_m) is represented by the MSCI World Index. In previous literature, the researchers have chosen for indexes such as S&P500 (Bosch & Eckard, 1998), the NYSE (Chance & Ferris, 1987), or American Stock Exchange (Mitchell & Maloney, 1989). These indexes contain multiple industries, so not only the airline industry like the AXGAL Index. The MSCI World Index contains multiple industries as well, and by choosing this index comparable results are obtained. An important difference is that the MSCI World Index is globally orientated as opposed to the earlier used indexes. The use of the MSCI World Index is justified by the fact that earlier research only focused on American airlines. When the coefficients of the market model are estimated based on the stock returns in the estimation window, these coefficients can be used for predicting the normal returns around the event date.

3. *Calculating abnormal returns (AR_{it})*

As mentioned before, the abnormal return consists of the expected return that is estimated, and the abnormal return. The abnormal return is therefore calculated as the difference between the estimated return ($E(R_{it})$) and the actual return (R_{it}). This calculation is made for every trading day in the period surrounding the event date, namely the 5 trading days before the crash until 30 trading days after the crash. In this way, 36 abnormal returns per examined stock are obtained.

$$AR_{it} = R_{it} - (\beta_0 + \beta_1 E(R_m))$$

3.1 *Calculating abnormal returns – (AAR)*

In order to study the changes in returns around the event dates, the abnormal returns of the involved operators or manufacturers are accumulated for each individual day. In this way, an unweighted cross-sectional average of abnormal returns *(AAR)* on a specific day is considered (De Jong, 2007). This will give an insight on how the stock returns vary over time after the event. The *AAR* can be calculated as follows:

$$AAR_t = \frac{1}{N} \sum_{i=1}^{N} AR_{it}$$

The calculation of this average abnormal returns takes place in certain groups. For the first and third hypothesis, only the stock returns of the involved operator or manufacturer are accumulated. For the second and fourth hypothesis, the stock returns of the main competitors are accumulated and the stock returns of the other companies on the lists are accumulated separately. As mentioned, the *AAR* will give an insight on the abnormal returns on a specified day, therefore, this measure is used to evaluate the returns of the five days prior to the event date.

3.2 *Calculating abnormal returns – (CAR)*

Since not only the performance for a specific day is of interest, the abnormal returns for multiple days for one specific operator or manufacturer is accumulated. In this way, the cumulative abnormal returns *(CAR)* are obtained. Since the abnormal returns are cumulated from the start of the event period until a certain moment, a study on the performance over a longer interval is possible. For this reason, the *CAR* is calculated for all periods from the event date itself until 30 trading days after the event. The calculation of the *CAR* is as follows:

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

The calculation of the cumulative abnormal returns takes place in certain groups as well. These groups are identical to the groups which are described before, concerning the average abnormal returns for a certain point in time.

4. *Significance testing*

To conclude on the impact of an air crash on the stock market the significance of the *AAR* and *CAR* needs to be tested. This is done by using an one sample t-test, which provides information on whether the calculated returns differ significantly from zero, at a specific significance level. The significance level that is used in this thesis is a 5% significance level. The t-statistic is calculated by dividing the abnormal return by its standard error. This standard error is calculated by dividing the standard deviation of the sample by the root of the number of observations in the sample. If the returns that are found differ significantly from zero, the abnormal returns are present.

For the second and fourth (4.1) hypothesis, a two sample t-test is conducted in order to test whether the abnormal returns of the competitors differ significantly from the abnormal returns of the non-competitors.

4.2 Model Construction

After calculating the abnormal returns and testing these on significance, a model will be constructed to investigate whether the abnormal returns differ between involved manufacturers. This model will be applied to the *CAR* using multiple estimation windows, depending on the significance of the cumulative abnormal returns that have been found. The model is specified as follows:

$$CAR_i = \beta_0 + \beta_1 Manufacturer_1 + \beta_2 Manufacturer_2 + \ldots + \beta_i Manufacturer_i$$

The coefficients that will be found, will indicate whether the abnormal returns differ between manufacturers. These coefficients will be tested on significance by using a t-test, which is explained in previous sections. This model is not constructed regarding different operators, because most of the operators only have one crash available. Therefore, constructing a model for the operators will not have statistical power, because in some cases only two crashes are compared when comparing two operators. On average, 9 events are available for each manufacturer.

Secondly, another model will be constructed to investigate differences in reaction. The second model tests whether the cumulative abnormal returns differ over multiple periods. This model is only constructed for the manufacturer sample as well, since in the operator sample some of the years only have one crash available. In the manufacturer sample, an average of 4 events per year is available. The specification of this model is as follows:

$$CAR_i = \beta_0 + \beta_1 Crash2001 + \beta_2 Crash2002 + \ldots + \beta_{18} Crash2018$$

Lastly, a model with several firm-, or crash specific variables will be created in order to explain the cumulative abnormal returns. This model provides an instrument for investors to predict the stock return reaction of the involved operator or manufacturer. This model will be applied to the *CAR* using the same estimation windows as mentioned before. The model specification for both operator and manufacturer will be as follows:

$$CAR_i = \beta_0 + \beta_1 MarketCap_i + \beta_2 Fatalities_i + \beta_3 ContinentDummy_i$$

As mentioned before, the variables in the model are firm-, or crash specific characteristics. The variable *MarketCap* represents the market capitalisation of the firm in millions of euros, which accounts for differences in size between the firms. This is calculated by multiplying the amount of outstanding shares and the price of one share at the time of the crash. The variable *Fatalities* represents the number of fatalities caused by the crash and the variable *ContinentDummy* will contain multiple variables with information regarding the place of establishment of the firm. To draw a conclusion regarding the explanatory power of these variables, the variables will be tested on significance by using a t-test. Furthermore, the R^2 of the models will be evaluated in order to test whether the models have explanatory power.

5. Results

5.1 Operator Sample: Involved Operators

To answer the first hypothesis, the abnormal returns of the involved operators are determined by using the previously described methods. The first hypothesis expects significant negative abnormal returns for the stocks of the operators involved in the crash. The results regarding this first hypothesis are summarised in Table 2 on the next page. The more extensive table which also contains some descriptive statistics, can be found in Appendix A.

As can be seen in Table 2, the average of abnormal returns (*AAR*) only differs significantly from zero on the day of the event. The day after the crash is not significant enough, since a minimum significance level of 95% is used in this thesis. The results that are found are in line with prior research. For example, Chance and Ferris (1987) found a significant negative return on the day of the crash of -1,2 per cent. In this thesis an even more negative reaction is found of almost -2,0 per cent. In the days before the crash, no significant abnormal returns are found, which is in line with the expectations since an air crash is an unforeseeable event.

When a longer time period is evaluated, the cumulative abnormal returns (CAR) can be taken into account. As mentioned before, in the paper of Bosch and Eckard (1998), a significant negative *CAR* is found only for the periods regarding the first two days after the crash. The magnitude of these *CARs* where -2,1 per cent for the period [0,1] and -2,7 per cent for the period [0,2]. In this thesis roughly similar *CARs* are found in these periods. In the period regarding the day of the crash and first day after the crash, a negative return of almost -3,2 percent is found. This implies that again more negative returns are found opposed to prior research.

It is interesting to see is that the cumulative abnormal returns remain significant up until the period including at least 11 days after the crash. This is a much longer period in comparison to earlier research which only found significant returns until the period including 2 days after the crash (Bosch & Eckard, 1998). However, in other event studies, it is not uncommon to find a significant abnormal return until 11 days after the event date (Busse & Green, 2002).

Furthermore, no reversal of the stock returns is found. Although not significant after the 11th trading day, the returns remain negative for a period of 30 trading days. There is a possibility that this reversal takes place after a longer period than 30 trading days. However, this thesis focusses on the short term, therefore, it does not find a reversal, which is in line with prior research that did not find a reversal in the short term too.

TABLE 2: ABNORMAL RETURNS OF THE INVOLVED OPERATORS

*Note: In the middle column, the Average Abnormal Return (AAR) of a certain day is shown. The days are mentioned in the first column, where day 0 represents the event date. Furthermore, the Cumulative Abnormal Returns (CAR) can be found in the last column. The presented CARs are calculated from the day of the crash (0) until the day which is mentioned in the first column (a). Moreover, the significance levels, based on a two-sided t-test, are shown: *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level.*

Event Date (a)	AAR	CAR [0,(a)]
-5	-0,0016	
-4	0,0038	
-3	-0,0031	
-2	0,0004	
-1	-0,0038	
0	-0,0195 **	
1	-0,0121 *	-0,0316 ***
2	0,0058	-0,0258 ***
3	-0,0005	-0,0263 **
4	-0,0012	-0,0275 **
5	-0,0020	-0,0295 **
6	-0,0116 *	-0,0411 ***
7	0,0049	-0,0362 **
8	0,0031	-0,0331 **
9	0,0014	-0,0317 **
10	-0,0014	-0,0331 **
11	-0,0045	-0,0376 **
12	0,0038 *	-0,0338 *
13	-0,0007	-0,0345 *
14	-0,0057	-0,0401 **
15	-0,0073	-0,0474 **
16	0,0064	-0,0410 *
17	0,0002	-0,0408
18	0,0083	-0,0325
19	-0,0016	-0,0341
20	0,0034	-0,0307
21	-0,0046	-0,0354
22	-0,0026	-0,0380
23	-0,0015	-0,0395
24	0,0091 *	-0,0304
25	-0,0065	-0,0353
26	0,0000	-0,0353
27	0,0052	-0,0301
28	-0,0037	-0,0338
29	0,0079	-0,0259
30	0,0041	-0,0218

Lastly, the relationship between the *CARs* and the amount of fatalities will be examined, since Ho, Qiu and Tang (2012) found more negative returns when the amount of fatalities increased. This relationship will be examined in detail in section 5.5, where a model containing multiple firm or crash specific variables is constructed. By using the model it can be tested whether there is a significant relationship between the *CARs* and the amount of fatalities. The correlation between the *CARs* and amount of fatalities can already be examined. When examining multiple *CARs* until the period [0,3], a negative correlation of approximately -0,22 can be found. This implies that there are more negative abnormal returns when the amount of fatalities increases.

To conclude, the first hypothesis can be confirmed. The involved operators experience significant negative average abnormal returns on the day of the crash. These negative abnormal returns remain significant when accumulated for at least 11 days after the crash.

5.2 Operator Sample: Non-Involved Operators

The second hypothesis expects positive returns for the competitors of the in the crash involved operator and expects negative returns for the other operators. The results regarding this hypothesis are shown in Table 3 on the next page. In Appendix B and C, more extensive tables including descriptive statistics are presented. In Appendix D, the significance regarding the two-sample t-test on the *AARs* of both groups are shown. This test is conducted in order to test whether the returns differ significantly between the two groups on certain days.

As can be seen in Table 3, the *CARs* of the competitors on the first two days are positive, which indicates positive abnormal returns for the subsidiaries of the involved operators. This result is found in previous literature as well, predominantly due to the consumer-switching effect (Bosch & Eckard, 1998). However, in addition to the *CARs* being a lot smaller in comparison to the negative returns found at the involved operators, the *CARs* of these days are not significant as well. For this reason, the positive abnormal returns cannot be confirmed.

Furthermore, it is interesting to see that after 15 days the *CARs* of the competitors become significant. These *CARs* imply that the negative abnormal returns are slightly smaller than the negative returns of the involved operators, namely - 2,2 per cent. It could be the case that a the price reaction of the competitors is delayed, therefore, it occurs 15 days after the crash. However, there is no explanation for this delay. Moreover, the fact that the *CARs* are negative is not expected. This result does not confirm a consumer-switching effect, but indicates an industry-wide decrease in demand.

TABLE 3: ABNORMAL RETURNS OF THE NON-INVOLVED OPERATORS

*Note: In the first column the days are mentioned, where day 0 represents the event date. The following two columns represent the Average Abnormal Returns (AAR) and the Cumulative Abnormal Returns (CAR) of the competitors of the involved operator. The fourth and fifth column represent the AAR and CAR of the non-competitors. The presented CARs are calculated from the day of the crash (0) until the day which is mentioned in the first column (a). Lastly, the significance levels, based on a two-sided t-test, are shown: *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level.*

	Competitors		Non-Competitors	
Event Date (a)	AAR	CAR [0,(a)]	AAR	CAR [0,(a)]
-4	0,0002		0,0011	
-3	-0,0028		0,0010	
-2	0,0038		0,0024 ***	
-1	-0,0017		-0,0007	
0	0,0032		-0,0016 *	
1	-0,0017	0,0014	0,0007	-0,0009
2	-0,0001	0,0013	-0,0004	-0,0014
3	-0,0022	-0,0009	-0,0039 ***	-0,0053 ***
4	-0,0031	-0,0040	-0,0024 **	-0,0077 ***
5	-0,0012	-0,0051	0,0002	-0,0074 ***
6	-0,0015	-0,0066	-0,0006	-0,0080 ***
7	0,0021	-0,0045	0,0025 ***	-0,0055 **
8	-0,0037 *	-0,0082	0,0010	-0,0045 *
9	-0,0033 *	-0,0115 *	0,0023 **	-0,0022
10	-0,0021	-0,0136 **	0,0027 ***	0,0005
11	0,0013	-0,0123	0,0003	0,0008
12	0,0002	-0,0121	0,0005	0,0013
13	-0,0011	-0,0132	0,0000	0,0013
14	-0,0020	-0,0152 *	0,0013	0,0025
15	-0,0052 **	-0,0204 **	-0,0022 **	0,0003
16	0,0010	-0,0193 **	-0,0006	-0,0003
17	-0,0029 *	-0,0222 **	0,0012	0,0009
18	0,0008	-0,0214 **	0,0017 *	0,0027
19	0,0021	-0,0193 **	0,0027 **	0,0054
20	0,0019	-0,0174 *	0,0000	0,0053
21	0,0016	-0,0158	-0,0019 **	0,0034
22	-0,0021	-0,0179 *	0,0023 **	0,0057
23	0,0030	-0,0149	0,0011	0,0068
24	-0,0003	-0,0152	0,0009	0,0077 *
25	-0,0033	-0,0181	-0,0009	0,0068
26	0,0006	-0,0176	0,0014	0,0113 **
27	0,0022	-0,0154	0,0024 **	0,0137 ***
28	-0,0031	-0,0185	0,0020 **	0,0158 ***
29	0,0035	-0,0150	0,0015	0,0172 ***
30	-0,0033	-0,0183	0,0032 **	0,0205 ***

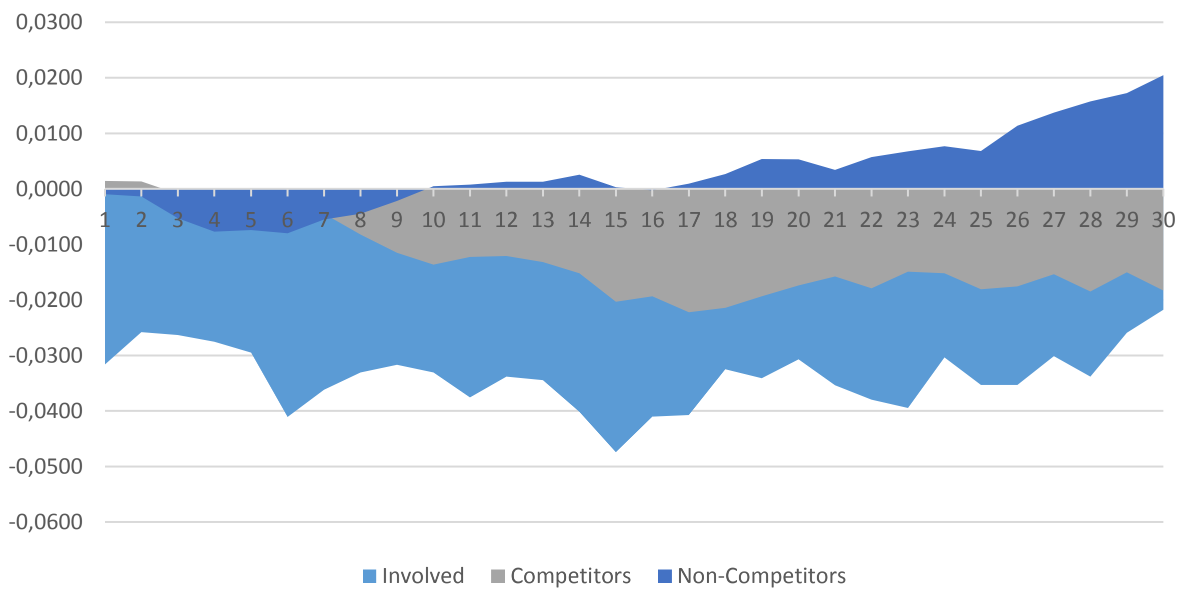
With regard to the non-competitors of the involved operators another pattern can be found. The *CARs* from three days after the crash until seven days after the crash are negative and significant. This means that the non-competitors experience significant negative abnormal returns. However, these negative returns are less negative than the abnormal returns of the involved operator. Only a reaction of -0,8 per cent is found in the period [0,6]. Since the *CARs* throughout the first two days after the crash are not significant, it can be concluded that the non-competitors of the involved operators experience both small and delayed negative abnormal returns. Additionally, the *AAR* are not significant in the first two days.

In contrast to the involved operators, the non-competitors experience a reversal after 26 trading days. As can been seen in Table 3 , the cumulative abnormal returns after 26 trading days are significantly positive. Upwards of 30 trading days after the crash a *CAR* of +2,0 per cent is found. Moreover, the *AAR* are significantly positive in these days. This indicates the market was too negative in the first days after the crash. The positive returns after 26 trading days seems to adjust for this earlier pessimism.

Different reactions can be found between the operators, depending on their relation to the crash. These differences in reaction between the involved operators, competitors and non-competitors are visualised in Figure 1.

FIGURE 1: CUMULATIVE ABNORMAL RETURNS (CAR) OF THE OPERATORS

Note: On the y-axis, the CARs are displayed, and the days are displayed on the x-axis. This results in a figure where the developments of the CARs are shown over time. The different groups, depending on their relation to the crash, are represented as shown under the figure.



To test the differences in reaction between the samples, a two-sample t-test is conducted on both the competitors and non-competitor samples. The results of this test are shown in Appendix D. Based on the *AAR,* the samples do not differ a lot, only on certain days. These days are mainly the days were a significant *CAR* for the non-competitors is found. When a two-sample t-test is conducted on the *CARs* of the two samples, significant differences are found between the *CARs* after the period [0,4] until the period [0,30]. It therefore can be concluded that the samples significantly differ from each other.

Taking the earlier mentioned results into account, the second hypothesis cannot be confirmed. Despite positive abnormal returns are found for the competitors of the involved operators, the first part of the hypothesis cannot be confirmed since the returns are insignificant. A reason for rejecting the hypothesis could be the quality of the proxy for substitutability. Earlier researches used a route- overlap which may be a better proxy than the defined competitors by Orbis. On the other hand, the two-sample t-test clearly shows a difference between the samples when the competitors, which are defined by Orbis, are used.
Despite the insignificant returns of the competitors, the negative abnormal returns of the non-competitors are significant. This part of the hypothesis can therefore be confirmed. Nevertheless, these negative abnormal returns are adjusted in the long term.

5.3 Manufacturer Sample: Involved Manufacturers

With respect to the third and fourth hypotheses, another sample is used, as explained in Section 3. The third hypothesis expects negative abnormal returns for the manufacturer of the airplane that has crashed. The results are shown in Table 4. For a more complete view, a more extensive table is included in Appendix E.

Table 4 gives a clear answer on rejecting or confirming the third hypothesis. Of all the negative *CARs* that have been found, none of them is significant. Additionally, the *AARs* are mostly insignificant except for the *AARs* on the twelfth and sixteenth day. However, there is no explanation for these *AARs* to be significantly different from zero. In the third column of the table, the percentage of manufacturers with a negative *CAR* is shown. Throughout the first few days, most of the manufacturers experience positive abnormal returns rather than negative abnormal returns, they are unfortunately insignificant. This result is in line with the results obtained by Chance and Ferris (1987), who also did not find any abnormal returns regarding the manufacturers. Apparently, the results that are obtained after the crash of a space shuttle do not correspond with the results after an air crash (Maloney & Mulherin, 2003).

TABLE 4: ABNORMAL RETURNS OF THE INVOLVED MANUFACTURERS

*Note: In the second column, the Average Abnormal Return (AAR) of a certain day is shown. The days are mentioned in the first column, where day 0 represents the event date. Furthermore, the Cumulative Abnormal Returns (CAR) can be found in the third column. The presented CARs are calculated from the day of the crash (0) until the day which is mentioned in the first column (a). In the last column, the percentage of negative CARs in the sample is shown. Lastly, the significance levels, based on a two-sided t-test, are shown: *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level.*

Event Date (a)	AAR	CAR [0,(a)]	% Negative CARs
-5	-0,0011		
-4	0,0005		
-3	0,0008		
-2	0,0026		
-1	-0,0020		
0	-0,0028		
1	0,0011	-0,0017	43%
2	0,0014	-0,0003	49%
3	0,0018	0,0015	46%
4	-0,0063	-0,0048	48%
5	-0,0039	-0,0087	46%
6	0,0001	-0,0087	51%
7	-0,0006	-0,0093	51%
8	-0,0003	-0,0096	52%
9	0,0007	-0,0089	55%
10	0,0024	-0,0065	54%
11	0,0014	-0,0050	52%
12	-0,0036 **	-0,0087	63%
13	-0,0010	-0,0096	58%
14	0,0031	-0,0066	55%
15	-0,0035	-0,0101	58%
16	0,0043 **	-0,0058	58%
17	0,0002	-0,0056	55%
18	0,0007	-0,0049	58%
19	0,0004	-0,0045	57%
20	0,0020	-0,0025	60%
21	-0,0003	-0,0028	58%
22	-0,0001	-0,0029	58%
23	0,0003	-0,0027	57%
24	0,0004	-0,0023	52%
25	-0,0018	-0,0041	54%
26	-0,0016	-0,0057	55%
27	-0,0016	-0,0074	57%
28	0,0015	-0,0059	58%
29	0,0011	-0,0022	52%
30	-0,0048	-0,0070	53%

Since no significant result can be found, the third hypothesis cannot be confirmed. Manufacturers of the crashed airplane do not experience negative abnormal returns. For this reason, hypothesis 4.2 is tested. This hypothesis tests whether the cause of the crash influences the abnormal returns of the manufacturer. The expectation is that negative returns will be found if the cause of the crash can be attributed to the manufacturer. Mitchell and Maloney (1989) did find these results with respect to the operators, therefore, this result may be extrapolated to the manufacturers.

The hypothesis is tested by using a two sample t-test which examines whether the *CARs* of a crash with a certain cause differs from the *CARs* of the other crashes. When the difference between the means of the two samples differs significantly from zero, the cause has an effect on the abnormal returns of the manufacturer. In Table 5, the mean differences per cause and significance of these differences are shown. When looking at the causes, just 'Technical Failure' is of interest because only this cause can be attributed to the manufacturer. Apart from the results regarding 'Technical Failure', the benchmark causes 'Human Factor' and 'Terrorism' will be evaluated. The cause 'Other' is not evaluated separately. Since the causes cannot be explicitly determined, this group is not of interest.

TABLE 5: CUMULATIVE ABNORMAL RETURNS OF THE INVOLVED MANUFACTURERS BY CAUSE

*Note: In the first column, the CAR periods which are evaluated are mentioned. The other columns show the CARs in those periods. The columns are separated based on the cause of the crash, which can be found in the first row. The second row shows the number of events of a certain cause. In total 67 crashes are categorised. Lastly, the significance levels, based on a two-sided t-test, are shown: *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level.*

	Human Factor		Technical Failure	Terrorism
Events	41		9	6
CAR [0,1]	-0,003		0,003	0,003
CAR [0,2]	-0,004		0,004	0,004
CAR [0,3]	0,000		-0,001	-0,001
CAR [0,4]	-0,022	*	-0,003	-0,003
CAR [0,5]	-0,033	**	-0,003	-0,003
CAR [0,6]	-0,035	**	-0,011	-0,011
CAR [0,7]	-0,040	**	-0,021	-0,021
CAR [0,8]	-0,037	**	-0,022	-0,022
CAR [0,9]	-0,029	*	-0,023	-0,023
CAR [0,10]	-0,029	**	-0,020	-0,020
CAR [0,11]	-0,029	**	-0,017	-0,017
CAR [0,12]	-0,032	**	-0,017	-0,017
CAR [0,13]	-0,041	***	-0,019	-0,019
CAR [0,14]	-0,047	***	-0,013	-0,013
CAR [0,15]	-0,029	*	-0,020	-0,020

In the Table 5, only the *CARs* until the period [0,15] are shown. After this period, no significant results were obtained and these results are therefore not shown in this thesis. When a negative difference between the means is found, the cause of interest generates less negative or more positive returns than the other causes. This can be traced back to the fact that the difference of the means is calculated as the mean of the causes and not by interest minus the mean of the cause of interest.
When evaluating the cause 'Technical Failure', a negative difference is found, which suggest a less negative or more positive reaction for the crashes that could be attributed to the manufacturer. This is exactly the opposite of what is expected by the hypothesis. However, the negative difference that is found is not significant, therefore, no conclusions about this cause can be drawn. It could be that no significant result can be found because of the assumption that the cause of the crash is known on the day of the crash itself. In some cases it takes months to exactly determine the cause of a crash. However, it could be argued that an estimation of the cause can be determined just after a few days. Subsequently, no significant result can be found when evaluating the cause 'Terrorism'.

On the other hand, a significant reaction can be found when evaluating the 'Human Factor' cause. As can be seen in Table 5, the *CARs* of the crashes caused by a human factor are significantly more positive, since a significant negative difference is found. It could be the case that the market states that this cause could not be attributed to the manufacturer, subsequently, the manufacturer cannot be blamed. Although a technical malfunction of an airplane leading to several fatalities can result into both distrust and a decrease in demand of the blamed products of the manufacturer, this is less plausible when the crash is caused by a human error. The difference in abnormal returns between the samples after two weeks is almost 5 per cent. At that moment, the crashes caused by technical malfunctioning, terrorism, and other causes experience a minus 3,5 per cent abnormal return, while the crashes caused by a human error experience a + 1,2 per cent abnormal return.

Taking the results into account, the fourth hypothesis cannot be confirmed as well. No significant results are obtained when evaluating the crashes caused by technical malfunctioning. The manufacturer does not experience negative abnormal returns, not even if the cause of the crash can be attributed to this manufacturer.

5.4 Descriptive Model: Involved Operator

As mentioned before, the models that will be constructed to investigate differences between the firms or between certain years are not constructed for the operator sample since this sample contains too few events to obtain a statistic relevant result.

For this reason, only the descriptive model is constructed. This model serves the purpose to give investors a model which explains the *CARs* of the operator stock after an air crash. When significant coefficients are found, the model gives the opportunity to investors to anticipate on an air crash and make a profit after constructing a strategy based on this model. The specification of the model is as follows:

$$CAR_i = \beta_0 + \beta_1 MarketCap_i + \beta_2 Fatalities_i + \beta_3 ContinentDummies$$

The model will be run over three periods. The first period is [0,1] in order to investigate the price reaction right after the crash. The second period is [0,11] in order to investigate the reaction in the medium short term. This period is chosen because the CAR at the end of this period is the last significant one, the period [0,12] is not significant anymore. Lastly the model is run for the [0,30] period. The results of the model are shown in Table 6.

TABLE 6: DESCRIPTIVE MODEL OF THE INVOLVED OPERATORS

*Note: The variables of the model are shown in the first column. The coefficients of these variables are shown in the following columns, separated by different time periods. MarketCap is a variable which represents the market capitalisation of the operator in order to control for firm size. The Fatalities variable accounts for the amount of deaths caused by the crash. Furthermore, the model contains dummy-variables for the continent of establishment. The Africa-variable is omitted because of multicollinearity, therefore, the coefficients of the other dummy-variables are relative to Africa. Lastly, the significance levels, based on a two-sided t-test, are shown: *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level.*

	CAR [0,1]		CAR [0,11]		CAR [0,30]	
MarketCap	0,000		0,000		0,000	
Fatalities	-0,000		-0,000		-0,000	
Asia	-0,010		-0,008		0,051	
America	0,027		0,016		0,025	
Europe	-0,012		0,029		0,067	
Africa	*(omitted)*		*(omitted)*		*(omitted)*	
Constant	-0,025	**	-0,060	**	-0,082	**

When evaluating the *MarketCap* variable, small coefficients are found. This is in line with the expectations when working with very large numbers such as the market capitalisation of a firm. However, this thesis anticipated on these expectations by working with the market capitalisation in millions of euros. Still small coefficients are found, which indicates that this variable almost has no effect on the *CARs*. The coefficients of this variable are positive in all periods, which means that larger firms experience more positive or less negative abnormal returns. This is reasonable, because an air crash will have a relative higher burden on a small operator. Larger firms with larger revenues are likely to manage the costs better after an air crash. However, the coefficients are insignificant so no clear conclusions can be drawn.

The coefficients of the *Fatalities* variable are small as well, and seem to have almost no effect on the *CARs*. This result is not in line with prior research, which found more negative abnormal returns when the amount of fatalities increased (Ho et al., 2012). Despite the coefficients being insignificant and small, they are indeed negative, which indicates more negative returns when fatalities rise. This result is obtained by evaluating the correlation between the abnormal returns and fatalities as well, as already mentioned in section 5.1. In this section a correlation of - 0,22 is found.

Moreover, dummies representing the continent of establishment of the firms are included. For every period, another continent of establishment generates the lowest abnormal return. *Europe* generates the most positive returns in comparison to the other continents in the periods [0,11] and [0,30]. So when an operator is established in Europe, less negative abnormal returns are experienced. However, these coefficients are all insignificant, therefore, no clear conclusions can be drawn.

When evaluating the models based on their R^2 the models are not good models either. The [0,1] model has an R^2 of 0,1473, which indicates that only 14% of the variability of the model is explained by its variables. In the other models, the R^2 is even lower, both approximately 0,08. Since the models have both a low R2 and insignificant coefficients, it can be concluded this model does not provide any explanatory power to the investors.

5.5 Models: Involved Manufacturer

Despite the abnormal returns of the manufacturers not being significant, models that will indicate differences between manufacturers and between certain years are constructed. The same periods are used as in the previous section, namely the [0,1], [0,11], and [0,30] period. The specification of the models are as follows:

$$CAR_i = \beta_0 + \beta_1 Manufacturer_1 + \beta_2 Manufacturer_2 + \ldots + \beta_i Manufacturer_i$$

$$CAR_i = \beta_0 + \beta_1 Crash2001 + \beta_2 Crash2002 + \ldots + \beta_{18} Crash2018$$

The results of these models are presented in Table 7 and 8, which are shown on the next page. As can been seen in Table 7, significant differences can be found in the reaction of the manufacturer stocks. Especially in the period [0,30], big and significant differences can be found. The biggest difference is between UNAC, a Russian manufacturer, and Leonardo SpA from Italy. The difference in abnormal return between those manufacturers is more than 30 per cent. In the last two models, crashes with an airplane manufactured by UNAC generate the most negative abnormal returns. In the first model, crashes with planes fabricated by Bombardier generate the most negative abnormal return.

When testing for differences with respect to different years using the second model, again no significant reactions are found in the first two *CAR* periods, as can be seen in Table 8. However, in the period [0,30] several significant results are found. In 2001, the largest negative coefficient is found, which indicates larger abnormal returns for crashes occurred in this year opposed to crashes in other years. This is interesting because in this year the September 11th attacks took place as well, which maybe had some influence on these returns. In the three following years, the coefficients become less negative, thereafter, the coefficients become more negative again. Therefore, it cannot be concluded that the abnormal returns systematically decrease over the years after the attacks.

TABLE 7: CONTROL MODEL OF THE INVOLVED MANUFACTURERS PER MANUFACTURER

*Note: The variables of the model are shown in the first column. The coefficients of these variables are shown in the following columns, separated by different time periods. The UNAC-variable is omitted because of multicollinearity, therefore, the coefficients of the other dummy-variables are relative to UNAC. Furthermore, the significance levels are shown: *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level.*

	CAR [0,1]		CAR [0,11]		CAR [0,30]	
Airbus	0,005		0,062	***	0,189	***
BAE Systems	0,007		0,066	***	0,191	***
Boeing	0,009	***	0,046	***	0,157	***
Bombardier	-0,038		0,139		0,172	***
Leonardo SpA	0,016	***	0,074		0,331	***
Lockheed Martin	0,021	***	0,077	***	0,192	***
UNAC	*(omitted)*		*(omitted)*		*(omitted)*	
Constant	-0,0103	***	-0,060		-0,182	

TABLE 8: CONTROL MODEL OF THE INVOLVED MANUFACTURERS PER YEAR

*Note: The variables of the model are shown in the first column. The coefficients of these variables are shown in the following columns, separated by different time periods. The 2018 variable is omitted because of multicollinearity, therefore, the coefficients of the other dummy-variables are relative to 2018. Furthermore, the significance levels are shown: *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level.*

	CAR [0,1]		CAR [0,11]		CAR [0,30]	
2001	0,008		-0,100	***	-0,254	***
2002	0,000		0,029		-0,040	
2003	-0,004		-0,019		-0,068	
2004	-0,036	**	0,036		-0,091	
2005	0,004		-0,009		-0,143	**
2006	-0,009		0,000		-0,163	**
2007	-0,011		-0,005		-0,156	**
2008	-0,002		0,015		-0,138	*
2009	0,018		0,017		-0,131	*
2010	-0,001		0,014		-0,092	
2011	-0,004		-0,014		-0,162	**
2012	0,005		0,031		-0,100	
2013	0,007		-0,044		-0,186	*
2014	-0,004		0,011		-0,099	
2015	-0,001		0,024		-0,086	
2016	0,012		-0,029		-0,161	**
2018	*(omitted)*		*(omitted)*		*(omitted)*	
Constant	-0,001		-0,002		0,111	**

5.5.1 Descriptive Model

Although no significant returns of the involved manufacturer stocks are found after the crash, the descriptive model also will be constructed for those manufacturers. The same specification will be used as with the model used regarding the involved operators. However, this time the market capitalisation in US dollars is used for practical matters. Furthermore, the same periods are evaluated in order to obtain comparable results with respect to the operators. The coefficients and their significance are shown in Table 9.

TABLE 9: DESCRIPTIVE MODEL OF THE INVOLVED MANUFACTURERS

*Note: The variables of the model are shown in the first column. The coefficients of these variables are shown in the following columns, separated by different time periods. MarketCap is a variable which represents the market capitalisation of the operator in order to control for firm size. The Fatalities variable accounts for the amount of deaths caused by the crash. Furthermore, the model contains dummy-variables for the continent of establishment. The America-variable is omitted because of multicollinearity, therefore, the coefficient of the other dummy-variable (Europe) is relative to America. Lastly, the significance levels are shown: *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level.*

	CAR [0,1]	CAR [0,11]	CAR [0,30]	
MarketCap	-0,000	-0,000	-0,000	***
Fatalities	-0,000	0,000	0,000	***
Europe	-0,002	0,011	0,053	*
America	*(omitted)*	*(omitted)*	*(omitted)*	
Constant	0,003	-0,009	-0,003	

In this model, the *MarketCap* variable is again accompanied by small coefficients. Additionally, this time the market capitalisation in millions is used, because small coefficients were expected. However, the coefficients remain small despite using the market capitalisation in millions of dollars. It is interesting to see that the coefficients of the *MarketCap* variable are not only small, but they are negative rather than positive as well. This indicates that, when a firm becomes larger, the *CARs* become more negative or less positive. This is not in line with the expectations because larger firms with larger revenues are likely to manage the costs after an air crash better than smaller firms. The relative burden on a larger firm is expected to be lower, therefore, a less negative reaction is expected by larger firms. According to the model, this is not the case since negative coefficients are found in all the periods. However, only in the last model the coefficient differs significantly from zero.

The *Fatalities* variable also remains small, which indicates that the amount of fatalities does not have any effect on the abnormal returns of manufacturers. Furthermore, this variable has another sign as expected as well, because in two periods a positive coefficient is found. This indicates less negative or

more positive abnormal returns when the amount of fatalities increases. This is not reasonable and not in line with prior research (Ho et al, 2012). In the period [0,30], the positive coefficient is significant.
The variables representing the continent of establishment are insignificant in all the periods. In two periods, the manufacturers in Europe experience more positive abnormal returns as opposed to the manufacturers in America, according to this model. This is the case in the model with the involved operators as well, where in the same periods the coefficients for the *Europe* variable are higher opposed to the *America* variable.

When evaluating the models based on their R^2, the models are not good models neither. The first two models both have a R^2 lower than 0,02. This means that only 2% of the variability of the model is explained by its variables. The third model has a R^2 of 0,14, which is comparable to the best results obtained with the models for involved operators. Only in this third model, the F-statistic is large enough to not reject the joint significance of the variables in the model. Therefore, it can be concluded that only this third model regarding the [0,30] period has some explanatory power. However, as mentioned by testing hypothesis 3, no significant abnormal returns are found in the manufacturer sample. This means that the model has significant explanatory power for insignificant abnormal returns.

6. Conclusion

During this thesis an answer is formulated on the question how the stock market reacts to aviation disasters in the short term. Firstly, the stock return reaction of the operators involved in the crash were investigated. As expected, negative abnormal returns of 3,2 per cent where found on the day of the crash until the first day after the crash. During this period, no reaction was found for the competitors of the involved operator and other operators. However, in later periods significant negative returns were found for the non-competitors, which were compensated again in the long term.
The abnormal returns regarding the involved operators are slightly more negative than the abnormal returns that are obtained in prior research. As mentioned before, most of this prior research is conducted before the September 11th attacks, which caused several changes in the aviation industry (IATA, 2011). This thesis shows that after the attacks a more negative reaction can be found.

Another contribution to this research area is the investigation of manufacturer stocks. However, the involved manufacturers did not experience any significant abnormal returns at all. Even when the cause of the crash was taken into account and attributed to the manufacturer, no abnormal returns were obtained. On the other hand, the cause did certainly have some effect, since the crashes caused by a human error experienced significantly less negative abnormal returns after a few days as opposed to the other crashes.

After identifying the abnormal returns, this thesis constructed some models to give investors a powerful tool to guide investment decisions. This is not done yet by prior researchers. Taking the earlier mentioned results into account, the model regarding the involved operators would be most valuable, since this model would explain the significant abnormal returns. Unfortunately, the models regarding the involved operators did not have explanatory power. The best model constructed in this thesis is a manufacturer model for the period from the day of the crash until 30 trading days after the crash. However, this model explains not-significant abnormal returns.

Lastly, a few limitations are identified in this thesis. As mentioned before, the substitutability proxy is not as good as used in prior research. In this thesis, the substitutes are identified by database Orbis, while in prior research the route-overlap is used as a proxy for substitutability. For future research, it could be an idea to solve this limitation by thinking of another proxy for substitutability. Moreover, future research could think of enlarging the models that are made for investors. By adding more variables, other results may possibly be obtained, which can lead to a powerful investment tool.

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8. Appendix

A: Operator Sample: Involved Operators

TABLE 2.1: ABNORMAL RETURNS OF THE INVOLVED OPERATORS - EXTENDED

Note: The first three columns are identical to the original table which is incorporated in Section 5.1. The last four columns are added, containing the standard deviation of the CARs, the minimum CAR on a specific day, the maximum CAR on a specific day, and the percentage of involved operators with a negative CAR on a specific day. The days are mentioned in the first column, where day 0 represents the event date. The significance levels are in accordance with the original table.

Event Date (a)	AAR		CAR [0,(a)]		St. Dev. CAR	Min. CAR	Max. CAR	% Negative
-5	-0,0016							
-4	0,0038							
-3	-0,0031							
-2	0,0004							
-1	-0,0038							
0	-0,0195	**						
1	-0,0121	*	-0,0316	***	0,05576	-0,18831	0,08647	72%
2	0,0058		-0,0258	***	0,05557	-0,21136	0,09375	69%
3	-0,0005		-0,0263	**	0,06100	-0,21343	0,12881	78%
4	-0,0012		-0,0275	**	0,06849	-0,26787	0,09448	64%
5	-0,0020		-0,0295	**	0,07192	-0,29840	0,14309	67%
6	-0,0116	*	-0,0411	***	0,07794	-0,24344	0,09004	69%
7	0,0049		-0,0362	**	0,08181	-0,24526	0,12588	61%
8	0,0031		-0,0331	**	0,09024	-0,22076	0,13340	64%
9	0,0014		-0,0317	**	0,09104	-0,24931	0,14265	64%
10	-0,0014		-0,0331	**	0,09496	-0,25108	0,14869	58%
11	-0,0045		-0,0376	**	0,09968	-0,25345	0,22686	64%
12	0,0038	*	-0,0338	*	0,10242	-0,25542	0,24854	61%
13	-0,0007		-0,0345	*	0,11591	-0,30083	0,25353	64%
14	-0,0057		-0,0401	**	0,11536	-0,28926	0,24198	64%
15	-0,0073		-0,0474	**	0,12868	-0,39896	0,24730	64%
16	0,0064		-0,0410	*	0,14286	-0,40643	0,26387	61%
17	0,0002		-0,0408		0,15051	-0,51259	0,23371	61%
18	0,0083		-0,0325		0,15248	-0,38189	0,36561	61%
19	-0,0016		-0,0341		0,15231	-0,42939	0,36382	64%
20	0,0034		-0,0307		0,14374	-0,37514	0,32646	61%
21	-0,0046		-0,0354		0,13238	-0,34516	0,23455	61%
22	-0,0026		-0,0380		0,14103	-0,39470	0,25685	58%
23	-0,0015		-0,0395		0,14603	-0,36908	0,30964	67%
24	0,0091	*	-0,0304		0,14335	-0,35654	0,24830	61%
25	-0,0065		-0,0353		0,15304	-0,46196	0,27733	63%
26	0,0000		-0,0353		0,15424	-0,48362	0,25542	60%
27	0,0052		-0,0301		0,15331	-0,48580	0,23571	63%
28	-0,0037		-0,0338		0,16680	-0,49291	0,27997	57%
29	0,0079		-0,0259		0,16141	-0,45966	0,26866	54%
30	0,0041		-0,0218		0,15780	-0,34005	0,32357	57%

B: Operator Sample: Competitors

TABLE 3.1: ABNORMAL RETURNS OF THE NON-INVOLVED OPERATORS - EXTENDED

Note: The first three columns are identical to the original table which is incorporated in Section 5.2. The last four columns are added, containing the standard deviation of the CARs, the minimum CAR on a specific day, the maximum CAR on a specific day, and the percentage of involved operators with a negative CAR on a specific day. The days are mentioned in the first column, where day 0 represents the event date. The significance levels are in accordance with the original table.

Event Date (a)	AAR		CAR [0,(a)]		St. Dev. CAR	Min. CAR	Max. CAR	% Negative
-5	0,0039							
-4	0,0002							
-3	-0,0028							
-2	0,0038							
-1	-0,0017							
0	0,0032							
1	-0,0017		0,0014		0,04372	-0,26576	0,23299	46%
2	-0,0001		0,0013		0,04933	-0,25333	0,20537	51%
3	-0,0022		-0,0009		0,05926	-0,40751	0,19235	52%
4	-0,0031		-0,0040		0,06650	-0,42465	0,19959	55%
5	-0,0012		-0,0051		0,07594	-0,42637	0,27157	57%
6	-0,0015		-0,0066		0,08496	-0,43676	0,25633	54%
7	0,0021		-0,0045		0,08767	-0,56434	0,27415	55%
8	-0,0037	*	-0,0082		0,08996	-0,46456	0,30199	57%
9	-0,0033	*	-0,0115	*	0,09993	-0,48001	0,31576	55%
10	-0,0021		-0,0136	**	0,10278	-0,50387	0,32782	55%
11	0,0013		-0,0123		0,11420	-0,51357	0,45147	54%
12	0,0002		-0,0121		0,12156	-0,52225	0,49168	53%
13	-0,0011		-0,0132		0,12821	-0,53223	0,52280	52%
14	-0,0020		-0,0152	*	0,13274	-0,65177	0,49397	54%
15	-0,0052	**	-0,0204	**	0,14016	-0,67622	0,44004	56%
16	0,0010		-0,0193	**	0,13574	-0,66378	0,47737	58%
17	-0,0029	*	-0,0222	**	0,14022	-0,67088	0,45044	56%
18	0,0008		-0,0214	**	0,14101	-0,71268	0,47099	54%
19	0,0021		-0,0193	**	0,14106	-0,73971	0,45504	58%
20	0,0019		-0,0174	*	0,14422	-0,87007	0,47864	53%
21	0,0016		-0,0158		0,14892	-0,87698	0,51631	54%
22	-0,0021		-0,0179	*	0,15525	-0,87368	0,47356	51%
23	0,0030		-0,0149		0,16012	-0,90030	0,50886	49%
24	-0,0003		-0,0152		0,16556	-0,91013	0,51137	53%
25	-0,0033		-0,0181		0,17501	-0,91628	0,51107	51%
26	0,0006		-0,0176		0,17611	-0,90435	0,58787	54%
27	0,0022		-0,0154		0,18362	-0,89320	0,66678	55%
28	-0,0031		-0,0185		0,18701	-0,89085	0,66429	56%
29	0,0035		-0,0150		0,19363	-0,95399	0,66684	56%
30	-0,0033		-0,0183		0,19672	-1,02258	0,65755	57%

C: Operator Sample: Non-Competitors

TABLE 3.2: ABNORMAL RETURNS OF THE NON-INVOLVED OPERATORS - EXTENDED

Note: The first three columns are identical to the original table which is incorporated in Section 5.2. The last four columns are added, containing the standard deviation of the CARs, the minimum CAR on a specific day, the maximum CAR on a specific day, and the percentage of involved operators with a negative CAR on a specific day. The days are mentioned in the first column, where day 0 represents the event date. The significance levels are in accordance with the original table.

Event Date (a)	AAR		CAR [0,(a)]		St. Dev. CAR	Min. CAR	Max. CAR	% Negative
-5	-0,0005							
-4	0,0011							
-3	0,0010							
-2	0,0024	***						
-1	-0,0007							
0	-0,0016	*						
1	0,0007		-0,0009		0,0494	-0,5355	0,4589	52%
2	-0,0004		-0,0014		0,0604	-0,6443	0,5190	52%
3	-0,0039	***	-0,0053	***	0,0692	-0,6900	0,4599	54%
4	-0,0024	**	-0,0077	***	0,0758	-0,6831	0,7454	56%
5	0,0002		-0,0074	***	0,0829	-1,0627	0,6436	55%
6	-0,0006		-0,0080	***	0,0916	-1,1404	0,5703	53%
7	0,0025	***	-0,0055	**	0,0906	-0,7537	0,6026	53%
8	0,0010		-0,0045	*	0,0973	-0,7716	0,6080	52%
9	0,0023	**	-0,0022		0,1049	-1,0048	0,5885	51%
10	0,0027	***	0,0005		0,1097	-1,2054	0,5832	50%
11	0,0003		0,0008		0,1106	-1,0805	0,5757	49%
12	0,0005		0,0013		0,1160	-1,0829	0,6215	49%
13	0,0000		0,0013		0,1236	-1,0831	0,6522	49%
14	0,0013		0,0025		0,1266	-1,0852	1,0666	50%
15	-0,0022	**	0,0003		0,1343	-1,3041	1,0672	51%
16	-0,0006		-0,0003		0,1405	-1,5922	1,0706	50%
17	0,0012		0,0009		0,1450	-1,3925	0,6944	50%
18	0,0017	*	0,0027		0,1493	-1,3945	0,8535	50%
19	0,0027	**	0,0054		0,1647	-1,3980	1,2602	50%
20	0,0000		0,0053		0,1576	-1,4067	0,8643	50%
21	-0,0019	**	0,0034		0,1575	-1,4118	0,7276	51%
22	0,0023	**	0,0057		0,1661	-1,2467	1,1608	50%
23	0,0011		0,0068		0,1784	-1,1021	1,6364	50%
24	0,0009		0,0077	*	0,1811	-0,9068	1,7374	50%
25	-0,0009		0,0068		0,1776	-0,9059	1,5258	50%
26	0,0014		0,0113	**	0,1851	-0,9052	1,7107	50%
27	0,0024	**	0,0137	***	0,2007	-0,9045	2,1363	50%
28	0,0020	**	0,0158	***	0,2019	-0,9035	1,9780	49%
29	0,0015		0,0172	***	0,2136	-0,9026	2,1752	49%
30	0,0032	**	0,0205	***	0,2256	-0,9300	2,3725	49%

D: Operator Sample: Two-Sample T-Test

TABLE 3.3: ABNORMAL RETURNS OF THE NON-INVOLVED OPERATORS - EXTENDED

*Note: The first three columns are identical to the original tables which are incorporated in Section 5.2. The last column is added to display the significance of the two-sample t-test. This t-test tests whether the samples of the competitors and non-competitors differ significantly from each other. The significance levels are presented as: *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level.*

Event Date (a)	Competitors		Non-Competitors		Two-sample T-test
	AAR		AAR		AAR
-4	0,0002		0,0011		
-3	-0,0028		0,0010		**
-2	0,0038		0,0024	***	
-1	-0,0017		-0,0007		
0	0,0032		-0,0016	*	*
1	-0,0017		0,0007		**
2	-0,0001		-0,0004		
3	-0,0022		-0,0039	***	**
4	-0,0031		-0,0024	**	
5	-0,0012		0,0002		*
6	-0,0015		-0,0006		
7	0,0021		0,0025	***	
8	-0,0037	*	0,0010		***
9	-0,0033	*	0,0023	**	***
10	-0,0021		0,0027	***	
11	0,0013		0,0003		
12	0,0002		0,0005		
13	-0,0011		0,0000		
14	-0,0020		0,0013		
15	-0,0052	**	-0,0022	**	
16	0,0010		-0,0006		
17	-0,0029	*	0,0012		
18	0,0008		0,0017	*	
19	0,0021		0,0027	**	
20	0,0019		0,0000		
21	0,0016		-0,0019	**	
22	-0,0021		0,0023	**	
23	0,0030		0,0011		
24	-0,0003		0,0009		
25	-0,0033		-0,0009		*
26	0,0006		0,0014		
27	0,0022		0,0024	**	
28	-0,0031		0,0020	**	***
29	0,0035		0,0015		
30	-0,0033		0,0032	**	***

E: Manufacturer Sample: Involved Manufacturers

TABLE 4.1: ABNORMAL RETURNS OF THE INVOLVED MANUFACTURERS - EXTENDED

Note: The first three columns are identical to the original table which is incorporated in Section 5.2. The last four columns are added, containing the standard deviation of the CARs, the minimum CAR on a specific day, the maximum CAR on a specific day, and the percentage of involved operators with a negative CAR on a specific day. The days are mentioned in the first column, where day 0 represents the event date. The significance levels are in accordance with the original table.

Event Date (a)	AAR		CAR [0,(a)]	St. Dev. CAR	Min. CAR	Max. CAR	% Negative
-5	-0,0011						
-4	0,0005						
-3	0,0008						
-2	0,0026						
-1	-0,0020						
0	-0,0028						
1	0,0011		-0,0017	0,0177	-0,0619	0,0403	43%
2	0,0014		-0,0003	0,0295	-0,1006	0,1116	49%
3	0,0018		0,0015	0,0339	-0,1355	0,1024	46%
4	-0,0063		-0,0048	0,0461	-0,1566	0,1632	48%
5	-0,0039		-0,0087	0,0579	-0,2032	0,1425	46%
6	0,0001		-0,0087	0,0650	-0,2102	0,1603	51%
7	-0,0006		-0,0093	0,0745	-0,2705	0,1543	51%
8	-0,0003		-0,0096	0,0696	-0,2364	0,1407	52%
9	0,0007		-0,0089	0,0615	-0,1789	0,1223	55%
10	0,0024		-0,0065	0,0561	-0,1427	0,1474	54%
11	0,0014		-0,0050	0,0557	-0,1433	0,1285	52%
12	-0,0036	**	-0,0087	0,0600	-0,1613	0,1493	63%
13	-0,0010		-0,0096	0,0675	-0,1921	0,1509	58%
14	0,0031		-0,0066	0,0716	-0,2209	0,1639	55%
15	-0,0035		-0,0101	0,0690	-0,1733	0,1701	58%
16	0,0043	**	-0,0058	0,0630	-0,1488	0,1754	58%
17	0,0002		-0,0056	0,0664	-0,1656	0,1611	55%
18	0,0007		-0,0049	0,0732	-0,1635	0,1906	58%
19	0,0004		-0,0045	0,0754	-0,1697	0,1987	57%
20	0,0020		-0,0025	0,0787	-0,1757	0,2259	60%
21	-0,0003		-0,0028	0,0850	-0,1742	0,2436	58%
22	-0,0001		-0,0029	0,0847	-0,1877	0,2169	58%
23	0,0003		-0,0027	0,0869	-0,1614	0,2580	57%
24	0,0004		-0,0023	0,0916	-0,1662	0,2427	52%
25	-0,0018		-0,0041	0,0887	-0,1767	0,2226	54%
26	-0,0016		-0,0057	0,0965	-0,2144	0,2202	55%
27	-0,0016		-0,0074	0,0983	-0,2283	0,2165	57%
28	0,0015		-0,0059	0,0940	-0,2066	0,2070	58%
29	0,0011		-0,0022	0,0917	-0,2083	0,2219	52%
30	-0,0048		-0,0070	0,1054	-0,3365	0,2289	53%