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Investment Strategy Based on Aviation Accidents: Are there abnormal returns?

Abstract
This article investigates whether an investment strategy based on aviation accidents can generate abnormal returns. We performed an event study considering all the aviation accidents with more than 10 fatalities in the period from 1998 to 2009 and the stock market performance of the respective airlines and aircraft manufacturers in the days after the event. The tests performed were based on the model of Campbell, Lo & MacKinlay (1997) for definition of abnormal returns, by means of linear regression between the firms' stock returns and the return of a market portfolio used as a benchmark. This enabled projecting the expected future returns of the airlines and aircraft makers, for comparison with the observed returns after each event. The result obtained suggests that an investment strategy based on aviation accidents is feasible because abnormal returns can be obtained in the period immediately following an aviation disaster.

Keywords: Aviation accidents, event study, investment strategy, abnormal returns, normal returns.

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1. Introduction

Aviation accidents, because they are uncommon events that generally cause a heavy death toll, have high social repercussion and exert a strong influence on public sentiment. The behavioral finance literature reports that certain situations can generate a misperception of reality that in turn causes stock prices to diverge from what is indicated by the underlying fundamentals. This phenomenon is called market sentiment and has been examined by Baker & Wurgler (2007). This sentiment can work both ways, either irrationally boosting or depressing stock prices, of the market as a whole or of certain firms. For example, events that cause foreboding and anxiety tend to make people more pessimistic about future returns and more averse to assuming risks (Kaplanski & Levi, 2010).

This article investigates whether the market overreacts with a pessimistic bias to the news of aviation disasters, so that level-headed investors can take advantage of the decline in the stock price of the companies associated with the accident (manufacturer and airline) by investing in these shares to obtain better returns than the market average in the ensuing period, as these stock prices rebound when the pessimism dissipates. The study of this theme is relevant because it helps understand how investors react to strongly bad news and how efficient the market is in adjusting the prices of the shares traded on exchanges.

According to Kaplanski & Levi (2010), the average loss in market value caused by a major aviation disaster is some US$ 60 billion, in contrast to the average actual loss of only US$ 1 billion. However, they also show a price reversal in approximately two days. Here we study the impacts on the stock prices of the air carriers as well as the aircraft makers and the possibility of obtaining abnormal returns from a strategy that relies on news of aviation disasters as a trigger for buying the stocks of the companies involved.

The aviation accidents considered here occurred between 1998 and 2009. However, we only analyzed those involving a company (airline or aircraft maker) with shares listed for trading on a stock exchange at the time of the accident, in the home country and/or other countries. Since there is no single definition of "aviation accident" or "aviation disaster", we only considered accidents claiming at least 10 lives.

Aviation accidents are rare and unexpected events whose occurrence depresses the stock prices of the companies involved, as mentioned by McWilliams & Siegel (1997) and Kaplanski & Levy (2010). Since aviation accidents are events that influence the stock prices of the firms involved and this influence is measureable, we formulated the following research question: Is it possible to obtain abnormal returns through an investment strategy based on aviation accidents?

More formally, we considered the null hypothesis (h_0) that an investment strategy based on purchasing the shares of companies involved in aviation disasters just after the event does not provide abnormal returns, versus the alternative hypothesis (h_1) that such a strategy does provide abnormal returns.

The concept of abnormal returns means that the stocks of the companies involved outperformed the market in general (based on a benchmark index of the exchange where the firms' shares are traded) in the period just after the event. The theoretical reason for such market behavior is the phenomenon of investor overreaction. As stated by Barberis, Shleifer & Vishny (1998, p. 7) "[...] overreaciton occurring when the average return following not one but a series of announcements of good news is lower than the average return following a series of bad news announcements".

Because aviation accidents are rare and unanticipated events, the natural method to investigate their effect on stock prices is an event study. According to the definition of MacKinlay (1997), an event study allows measuring the impact of a specific event on the market value of a particular company or the companies in a certain segment.

2. Theoretical Framework

The analysis of the return on stock market investments requires the use of theories and models that have been tested previously. For this purpose, we use the concepts defined by Campbell, Lo & MacKinlay (1997) in their book *The Econometrics of Financial Markets* as well as the article by MacKinlay (1997), "Event Studies in Economics and Finance", in which statistical and economic models were considered to measure abnormal returns. In this study, based on the premises defined by the above authors, we adopted the statistical model of risk-adjusted and market-adjusted returns.

McWilliams & Siegel (1997) reassessed the previous work of Wright et al. (1995), who used the event study method, and compared the results with the earlier ones. McWilliams & Siegel identified that during the event window selected by the latter authors, various events occurred that impacted their result but were left out of the analysis. They also observed that when including new variables, such as the size of the window, the abnormal returns found were insignificant and did not support the thesis of Wright et al. (1995).

McWilliams & Siegel (1997) also stressed that the event study method is popular due to the fact that measures based on accounting profit had been heavily criticized as not being robust indicators of the true performance of firms, hence giving rise to the need for models that more quickly reflect the occurrences in markets and that are based on the evolution of stock prices.

According to Prabhala (1997), event studies typically have two purposes: (i) to test for the existence of an "information effect" on the firm's value; and (ii) to identify factors that explain changes in the value of a firm just after the event date. Further according to him, although the event study method is widely used in empirical works, there is insufficient understanding of their consistency and power in a setting of rational expectations.

The existence of rational expectations (on average) is a cornerstone of the efficient market theory. Efficient capital markets are defined by Ross, Westerfield & Jaffe (2007, p. 277) as being those in which:

> [...] current market prices reflect available information. This means that current market prices reflect present value of securities and it is not possible to gain extraordinary earnings using available information.

According to McWilliams & Siegel (1997, p. 650), an event study should provide a true measure of the financial impact of an event, and for this purpose a set of premises must be satisfied: (i) markets are efficient; (ii) the events were not anticipated; and (iii) there were no confounding occurrences during the event window.

In a subsequent study, Barberis & Thaler (2002, p. 2) stated that behavioral finance is a new way to analyze the financial market and that this approach has much to offer because of the difficulties faced by traditional models, since some financial phenomena are better understood when applying models in which the agents are not completely rational. In this sense, Gigerenzer (2004) and **Flannagan & Sivak (2004)** studied the effect of aviation accidents on the behavior of the customers of airlines and concluded that the negative environment provoked by the September 11th attacks had a significant effect by increasing the number of cars on highways and decreasing the number of airline passengers in the United States.

Daniel, Hirshleifer & Subrahmanyam (1998) conducted an empirical study of investor sentiment. They applied psychology to support the idea of under and overreaction, even though the basis of the work was overconfidence and self-attribution. Their study differed from the subsequent article by Barberis et al. (1998). However, we believe that the two articles had the same intention, to generate empirical evidence in the field of behavioral finance.

Daniel et al. (1998) defined an overconfident investor as one who overestimates the precision of the signal of the private information received, but not of the information received publicly by all investors. Baker & Wurgler (2007) studied two scenarios. In the first, investors receive bad news and this has a strongly negative effect on the stock price. But in the second scenario, when investors receive good news, although the variation in investor sentiment is positive, the effect on the stock return is not as great as the negative effect in the first case. The results of Baker & Wurgler (2007) are coherent with the findings of Barberis et al. (1998), according to whom when there is underreaction, the average return of the shares of companies after an announcement of good news is greater than the average return in a period after the announcement of bad news. This underreaction to good news should then be corrected in the period following the announcement of the event, when the return will be greater. They defined "good news" as the announcement of greater profits than expected by the market, although they also believe there is evidence of underreaction to other types of news.

Further according to Barberis et al. (1998, p. 7), overreaction occurs when the average returns – considering a statistically representative series after the disclosure of good news – are lower than the returns of another corresponding series after the disclosure of bad news. Their explanation for this is that:

> The idea here is simply that after a series of announcements of good news, the investor becomes overly optimistic that future news announcements will also be good and hence overreacts, sending the stock price to unduly high levels. Subsequent news announcements are likely to contradict his optimism, leading to lower returns (Barberis et al. (1998, p. 7).

Kaplanski & Levy (2010) studied the effect of the news received by investors and found evidence that negative mood and anxiety that negative sentiment driven by bad mood and anxiety affects stock investment decisions. They specifically investigated the effect of aviation disasters on stock prices and found empirical evidence that the stock price of the company associated with the accident suffers significant negative effects compared to the average market price. They also found average losses of US$ 60 billion for each air disaster and noted empirical evidence of increased implied volatility after airplane crashes.

With respect to the calculation of abnormal returns, Martinez (2004) suggests that they are the difference between the normal return of the stock, if the event (accident) had not occurred, and the return actually observed after the event. He also suggests and describes some techniques considered suitable that can be followed to calculate these normal and abnormal returns.

The event study technique to identify abnormal returns was used in Brazil by Nakayasu (2006), who in analyzing the "impact of the announcement of the listing of firms in trading segments that require enhanced corporate governance in Brazil," concluded that the event "day of the announcement" of the migration to one of the three special trading segments of the São Paulo Stock Exchange (Bovespa, now called BM&FBovespa) caused a positive reaction in the market, while the event "date of adhesion" did not have any impact on the market reaction.

3. Methodology

The data on aviation accidents were obtained from the database at the site www.planecrashinfo.com, between 1998 and 2009. The number of aviation accidents and fatal victims broken down by airline considered in this article are summarized in Table 1.

Table 1
Number of fatal victims and accidents per airline

Airline Company	Number of Fatal Victims	Number of Accidents
American Airlines	427	4
Gol Linhas Aéreas	154	1
TAM	187	1
Total	768	6

Source: www.planecrashinfo.com

The number of aviation accidents and fatal victims broken down by aircraft manufacturer considered in this article are summarized in Table 2.

Table 2
Number of fatal victims and accidents per aircraft maker

Aircraft Maker	Number of Fatal Victims	Number of Accidents
Airbus	1211	7
BAE Systems	38	3
Boeing	4551	53
Embraer	114	5
Lockheed	239	6
Textron	110	10
Total	6263	84

Source: www.planecrashinfo.com

The total numbers of accidents and victims in Tables 1 and 2 differ because not all the airline companies have shares listed for trading. Considering the criterion that the airline and aircraft maker must both have shares listed on an exchange, our sample consisted of 84 accidents claiming at least 10 lives between 1998 and 2009 throughout the world. We obtained the data on stock returns (adjusted for earnings) from the Economática database and the site http://www.finance.yahoo.com.

3.1. Definition of the steps in an event study

Although there is no rigid structure for conducting an event study, we relied on the models proposed by MacKinlay (1997) and Campbell et al. (1997), with seven steps: (1) definition of the event, (2) selection of the sampling criteria, (3) measurement of the normal and abnormal returns, (4) application of estimation procedures, (5) application of testing procedures, (6) calculation of the empirical results, and (7) interpretation of the results and presentation of conclusions.

After defining the event, it is necessary to define the interval around the event (event window) to be analyzed. Although this criterion is a decision of the researcher, it is important for the event window to contain the days considered relevant to investigate the existence of an abnormal return pattern.

After identifying the events to be analyzed, it is necessary to select the sample of companies whose data will be tested. In this case our focus was on both the airlines and aircraft makers involved in each air crash, under the assumption that they will feel the main effects of the event in their stock prices.

The measure of the impact of the event depends on an adequate way to measure the abnormal return. This entails comparing the normal return of the security with the return obtained by the estimation model. The normal return is defined as the return the stock in question would have obtained if the event had not happened. For this analysis, according to Campbell et al. (1997), it is best that the date of the event not be considered in the calculations of expected returns, so as not to impair the result obtained by the estimation model. According to the model of MacKinlay (1997, p.15), for firm *i* on date *t*, the abnormal return is given by:

$$AR_{it} = R_{it} - E(R_{it}/X_t)$$

Where:

AR_{it}, R_{it} and $E(R_{it}/X_t)$ are the abnormal return, actual return and normal return for stock *i* on date *t*, respectively; and

X_t is the conditioning information for the normal return model, determined by the return adjusted by an estimation model previous to the event.

According to MacKinlay (1997), there are two common ways to model the normal returns: (1) the constant mean return model, in which X_t is a constant; and (2) the market model, where X_t is the market return. We chose the market model, which assumes a stable linear relation between the market return and the stock return.

To calculate the return of the investment in the stock of interest, we used the continuous capitalization regime, in which the natural logarithm (ln) is used to calculate the return of the stock versus a portfolio used for benchmarking. The continuous compounding model, according to equation 1, is the model suggested by Campbell et al. (1997).

The expression for this model is:

$$R_{it} = \frac{ln\ (lnP_{t)}\ )}{ln\ (lnP_{t-1})} \quad (1)$$

Where:
R_{it} = the return of stock *i* on date *t*;
$ln\ P_t$ = the natural logarithm of the price of stock *i* on date *t*;
$ln\ P_{t-1}$= the natural logarithm of the price of stock *i* on date *t-1*.

After defining the model for calculating the abnormal return, the next step is to define the "estimation window", which will result from the parameters of the estimation model. MacKinlay (1997) suggests that the "event window" should not be included in the "estimation window", so as not to influence the calculation of the parameters that will serve as the based for the estimation model. After defining the parameters of the normal returns of the model, according to Nakayasu (2008) the next step is to formulate the procedures for calculating the abnormal returns and the technique for aggregating these returns. This is the stage at which the null hypothesis (H_0) and alternative hypothesis (H_1) are formulated.

The presentation of the results, according to MacKinlay (1997), should follow the formulation of the econometric design. The analysis of the results must consider identification of possible outliers, especially when the sample is not large.

In this last step, the hypothesis is tested, to reject or not the existence of abnormal returns after the occurrence of the aviation accident. At this point it is possible to infer if the event under analysis had an effect on the market price of the air carriers and aircraft manufacturers.

3.2 Calculation using normal returns

To calculate the difference between the normal returns of the securities of the companies involved and the market indexes used for benchmarking, we used the ANOVA F-test for analysis of variance and the F-test of equality of variances between the normal daily returns and the cumulative normal returns, for both the airlines and aircraft makers involved.

After calculating the normal stock return or each company involved and the portfolio considered for comparison, according to equation 1, we sought to identify the presence of abnormal returns, based on the model suggested by Martinez (2004), which is a statistical model of market-adjusted returns. These returns are obtained by the difference between the return of the stock of interest and that of the market-tracking portfolio, in which we used the normal daily and cumulative returns, obtained between trading days +2 and +360 after the event and comparing them with the market portfolio in the same period. The formula for the market-adjusted returns is as follows:

$$A_{.i,t} = R_{i.t} - R_{m.t} \quad (2)$$

Where:
$A_{i.t}$ = the abnormal return calculated on date *t*;
$R_{m.t}$ = the market portfolio return on date *t*;
$R_{i.t}$ = the normal return of stock *i* on date *t*.

After analyzing the normal returns, we applied the T-test for two samples, assuming different variances, to compare the daily and cumulative normal returns of the shares of the airlines and aircraft makers against the portfolio returns.

3.3 Calculation using the estimation model

Based on the model for conducting an event study defined by MacKinlay (1997, p.20), we defined the expected normal returns (ER) and abnormal returns. The normal return ($R_{i.t.}$) was calculated as the expected return E(R) if the event had not happened, defined based on the intercept ($\hat{\propto} i$) and angular coefficient ($\hat{\beta} i$) resulting from the linear regression between the stock return of the companies involved (x) and the market portfolio (y) used as a benchmark.

The event study presented here was structured considering: (1) the “estimation window”, defined as the period of 60 days (closing prices) before the accident; (2) the “comparison window”, the period of 59 days (closing prices) after the accident; and (3) the “event window”, the interval of 2 days between the “estimation window” and the “comparison window”, to prevent the event’s occurrence from interfering in the result of the estimation model’s variables (Campbell et al., 1997).

To estimate the future return of the stocks, we used a simple linear regression between the return of the companies involved in the accident and the market portfolio’s return. To define the parameters of the equation ($\hat{\propto} i$ e $\hat{\beta} i$) the constant and linear regression coefficient, the independent variable was the market portfolio return ($R_{m.t}$) and the dependent variable was the firm’s observed stock return.

After defining the constant and coefficient of the regression between the return of the stock of interest and the market portfolio’s return, we identified, based on the assumptions of Campbell et al. (1997), the estimation model equation, which is the expected (normal) return of the stock:

$$E\,(R_{i,t}) = (\hat{\propto} i + \hat{\beta} i \times R\,m.t) \quad (3)$$

Where:
$E\,(R_{i,t})$ = the expected (normal) return of stock *i* on date *t*
$\hat{\propto} i$ = the estimated constant of the linear regression
$\hat{\beta} i$ = the estimated angular coefficient of the regression
$R\,m.t$ = the market portfolio return on date *t*

Based on the same assumptions of equation 3, we calculated the abnormal returns after each event, on each day (closing price) of the comparison window, according to the following formula:

$$AR_{i,t} = R_{i,t} - (\hat{\propto} i + \hat{\beta} i \times R\,m.t) \quad (4)$$

Where:
$AR_{i,t}$ = the abnormal return of stock *i* on date *t*
$R_{i,t}$ = the observed return of stock *i* on date *t*
$\hat{\propto} i$ = the estimated constant of the linear regression
$\hat{\beta} i$ = the estimated angular coefficient of the regression
$R\,m.t$ = the market portfolio return on date *t*

After determining the abnormal returns (AR) for each event, according to equation 4, in line with the assumptions of the model of Campbell et al. (1997), we calculated the abnormal returns (AR) and mean abnormal returns ($\overline{AR}$), based on the sum of the daily abnormal returns for each event, divided by the total number of events. We also ascertained the cumulative abnormal return ($\overline{CAR}$), obtained by the sum of the daily average abnormal returns ($\overline{AR}$) for each event analyzed.

After determining the average abnormal returns ($\overline{AR}$) and the cumulative abnormal return ($\overline{CAR}$), we performed new T-tests for two samples, assuming different variances. However, at this stage, the tests were based on days 15, 30, 45 and 60 of the comparison window. On the occurrence of positive abnormal returns, the T-test allowed identifying in what period of the comparison window it would be feasible to formulate an investment strategy based on aviation disasters.

3.3.1 Diagnosis of the regression model

After calculating the parameters for projecting the expected returns of the stock for each event, obtained based on the linear regression between the return of each stock and the portfolio return, we applied the linearity test of the regression function to verify the existence or not of a linear relation between the return of the stocks of the analyzed companies and the portfolio.

The linearity tests, both for the airlines and the aircraft makers, were carried out considering the return of the stocks and of the portfolios in a single time interval. The levels of significance, using Student's t-statistic for the coefficient (β) of the tested model, should present significance values of at least 10%, so we excluded from the analysis the companies that did not attain this minimum significance. Therefore, the final analysis was applied to 57 events of the aircraft makers and 5 events of the air carriers, which were the events that presented a significant linear relation.

4. Results of the Tests

The results presented below aim to identify whether the returns obtained by an investment in the stocks of the aircraft makers and airlines involved in an air crash, made the day after the event, are different in relation to the market portfolio used for benchmarking.

4.1 Tests of difference of means

The results of the T- and F-tests presented below were based on the normal return of the stocks and revealed information on the behavior of the daily returns of the aircraft manufacturers and airlines in comparison to the market portfolio considered for each event.

On stratifying the analysis, the result of the F-test for equality of the variances between the average daily returns of the aircraft makers and the average daily market portfolio returns revealed F = 3.65, significant at 0.01. This result suggests there are no indications that the null hypothesis holds (that the average variance of the daily stock returns and the average variance of the portfolios analyzed are equal).

The result of the F-test of two samples for variance between the average cumulative daily stock returns of the aircraft makers and the market returns confirmed the above results. The result of F = 2.69, significant at 0.01, indicated non-acceptance of the null hypothesis that the variances are equal, arguing that the samples have different variances.

The result of the F-test for two variances considering the general average of all the daily returns of the airline companies, of F = 7.94 and significance of 0.01, suggested there is a difference between the variances of the daily stock returns of these companies and the variance of the portfolios used for benchmarking.

The application of the F-test for two variances considering the average cumulative daily returns of the airlines and the market indexes revealed F = 67.39 and significance of 0.01, suggesting the existence of a difference between the variance of the returns, indicating the possible existence of abnormal returns.

The tests to verify the difference of variance utilized, based on the definition of Stephan et al. (2005, p. 357), revealed the existence of a difference between the variance of the returns of both the airlines and aircraft makers versus the portfolio.

We also applied the T-test for two samples, assuming different variances, to identify the difference between the average cumulative returns of the aircraft makers and air carriers and the average cumulative returns of the indexes used for benchmarking. When considering the cumulative returns up to 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 and 360 trading days after the accident, the test revealed that the null hypothesis should not be accepted (t = -7.4872 for aircraft makers and t = -3.86 for airlines), suggesting that the stock returns of the manufacturers and carriers after an accident involving their airplanes is lower than the return of the market portfolios in the same period.

The results obtained based on normal returns, although suggestive, did not allow identifying the existence of abnormal returns. Therefore, we applied new tests, as discussed next.

4.2 Results of the regression model

To be used as estimators of the expected returns, the results of the regression model in the period defined as the estimation window should present a significance level of at least 10%, so we eliminated the events that did not meet that significance threshold.

We then divided the results into four tables for better visualization. Table 3 summarizes the results obtained in the period between 2 and 15 trading days after the event (accident), along with the mean abnormal returns (Mean AR) and cumulative abnormal returns (Mean CAR) obtained for the shares of the airlines and aircraft makers and the respective values of the Z-test for statistical significance.

Table 3

Results of the event study for aircraft makers and airlines between 2 and 15 trading days after the accident

Days from the event date	Airplane Makers		Airlines	
	Mean AR	Mean CAR	Mean AR	Mean CAR
2	0.185%**	0.185%	1.147%*	1.147%
3	-0.103%	0.082%	1.009%*	2.168%
4	-0.070%	0.012%	-0.374%	1.785%
5	0.083%	0.095%	-1.431%	0.328%
6	0.214%*	0.309%	-0.068%	0.260%
7	0.454%*	0.764%	-0.123%	0.136%
8	0.371%*	1.138%	0.842%*	0.979%
9	0.027%	1.165%	-0.123%	0.854%
10	0.135%	1.302%	1.497%*	2.364%
11	0.235%*	1.540%	-0.087%	2.276%
12	0.110%	1.652%	-0.061%	2.214%
13	0.513%*	2.173%	1.100%*	3.338%
14	0.003%	2.176%	1.120%*	4.495%
15	0.689%*	2.880%	0.172%	4.674%

Notes. * 1% significance.
** 5%.significance.
*** 10% significance.

The analysis of this interval led to the identification of abnormal returns for the airplane makers on trading days 2, 6, 7, 8, 11, 13 and 15, and for the airlines on days 2, 3, 8, 10, 13 and 14.

Table 4 presents the average abnormal returns and cumulative abnormal returns and the respective Z-scores in the interval between 16 and 30 trading days after the event.

Table 4

Results of the event study for aircraft makers and airlines between 16 and 30 trading days after the accident

Days from the event date	Airplane Makers		Airlines	
	Mean AR	Mean CAR	Mean AR	Mean CAR
16	-0.082%	2.796%	0.725% *	5.433%
17	0.098%	2.896%	-1.277%	4.086%
18	-0.264%	2.625%	0.595% **	4.706%
19	0.052%	2.678%	3.388% *	8.253% *
20	-0.045%	2.632%	-2.369%	5.689%
21	-0.414%	2.207%	0.544% **	6.263%
22	0.082%	2.290%	0.654% *	6.958%
23	0.100%	2.392%	-0.833%	6.067%
24	0.405% *	2.807%	-1.526%	4.449%
25	-0.165%	2.637%	0.223%	4.682%
26	-0.067%	2.568%	-0.170%	4.504%
27	-0.065%	2.501%	-1.159%	3.293%
28	0.238% *	2.745%	-0.357%	2.924%
29	-0.113%	2.629%	-0.285%	2.631%
30	1.063% *	3.719% ***	0.486% ***	3.130%

Notes. * 1% significance.
** 5%.significance.
*** 10% significance.

As can be seen in Table 4, the greatest mean abnormal return (AR) for the aircraft makers, with 1% significance, occurred on the 30th trading day after the event, and on this same day, the cumulative abnormal return (CAR) was significant at 10%. With respect to the shares of the airlines, the highest mean AR was on trading day 19, with a return of 3.38% and on this same day the CAR was significant at 1% and reached a total of 8.25%.

The results obtained for abnormal returns up to 30 trading days after the accident suggest that an investment strategy based on investing in the stocks of the companies involved and selling the stocks 30 trading days afterward would have little statistical likelihood of producing better returns than the market in general. The reason is the weak significance of the average CAR for this period.

Table 5 summarizes the average abnormal returns and cumulative abnormal returns along with the respective Z-scores for statistical significance in the period between 31 and 45 trading days after the accident.

Table 5

Results of the event study for aircraft makers and airlines between 31 and 45 trading days after the event

Days from the event date	Airplane Makers		Airlines	
	Mean AR	Mean CAR	Mean AR	Mean CAR
31	-0.407%	3.297%	0.902% *	4.060%
32	0.055%	3.354%	-1.554%	2.443%
33	0.168% **	3.527%	0.296%	2.746%
34	-0.232%	3.287%	0.862% *	3.632%
35	0.186% **	3.480%	0.649% *	4.305%
36	-0.035%	3.443%	0.197%	4.511%
37	-0.097%	3.343%	-0.231%	4.270%
38	0.189% **	3.538%	-0.418%	3.834%
39	0.100%	3.641%	0.508% ***	4.361%
40	0.338% *	3.992% *	-0.352%	3.994%
41	0.379% *	4.386% *	-1.226%	2.720%
42	0.204% *	4.599% *	2.049% *	4.824%
43	0.013%	4.613% *	1.874% *	6.789%
44	0.124%	4.743% *	1.806% *	8.717% *
45	0.594% *	5.365% *	2.946% *	11.920% *

Notes. * 1% significance.
** 5%.significance.
*** 10% significance.

Table 5 shows that for the aircraft makers, the average abnormal returns (AR) continue having statistical significance of 1% or 5% and as of the 40th trading day after the accident, the average cumulative abnormal returns (CAR) start to occur and present significance of 1% between 40 and 45 days, when the CAR reaches 5.36% for the manufacturers and 11.92% for the airline companies.

Until the 40th trading day after the accident, although there are significant average cumulative abnormal returns, it was not possible to verify a tendency. From then on the existence of persistent statistically significant abnormal returns at 1%, 5% or 10% shows a cumulative abnormal return, with an apparent growing trend.

Table 6 shows the mean abnormal returns and cumulative abnormal returns and the respective Z-scores between 46 and 60 trading days after the accident.

Table 6

Results of the event study for aircraft makers and airlines between 46 and 60 trading days after the accident

Days from the event date	Airplane Makers		Airlines	
	Mean AR	Mean CAR	Mean AR	Mean CAR
46	-0.170%	5.186% *	-0.923%	10.887% *
47	-0.062%	5.121% *	0.542% **	11.488% *
48	0.129%	5.257% *	-0.050%	11.433% *
49	-0.427%	4.807% *	0.566% **	12.063% *
50	-0.060%	4.744% *	1.028% *	13.215% *
51	0.492% *	5.260% *	0.842% *	14.168% *
52	0.342% *	5.620% *	0.242%	14.444% *
53	0.182% **	5.811% *	1.147% *	15.757% *
54	0.225% *	6.050% *	-1.127%	14.453% *
55	-0.131%	5.910% *	-1.564%	12.663% *
56	0.435% *	6.370% *	-0.072%	12.582% *
57	-0.280%	6.073% *	1.497% *	14.268% *
58	0.055%	6.131% *	-0.247%	13.986% *
59	0.177% **	6.318% *	1.853% *	16.099% *
60	0.341% *	6.681% *	1.882% *	18.283% *

Notes. * 1% significance.
** 5%.significance.
*** 10% significance.

The results presented in Table 6 show a higher frequency of significant average abnormal returns (AR) at 1% and 5%, for the shares of both the aircraft makers and air carriers. Regarding the average cumulative abnormal returns, in both cases they are statistically significant at 1% on all days in the period between 46 and 60 trading days after the accident. On the 60th trading day, the average cumulative abnormal return reached 6.68% for the aircraft makers and 18.28% for the airlines.

5. Final Considerations

This study sought to show whether or not an investment strategy based on aviation accidents can generate abnormal returns. We applied an appropriate method, an event study, based on the model developed by Campbell et al. (1997), the one most tested and referred to in the literature. For this purpose, we also investigated concepts of behavioral finance, such as over and underreaction, since aviation disasters are unexpected events in the capital market and are thus prone to causing sudden shifts in investor sentiment.

The hypothesis tested was that a strategy based on aviation accidents would generate abnormal returns, for which we analyzed the stock performance after accidents claiming more than 10 fatalities of all the airlines and aircraft manufacturers with stocks listed for trading.

To create a model that could define the future stock returns, we considered the reference portfolios of the market of each country where the companies involved in the accidents are listed, namely the Dow Jones Index of the New York Stock Exchange, the Ibovespa of the São Paulo Stock Exchange and the CAC40 of the Paris Bourse.

The F-test for difference of variance, applied to the normal returns, demonstrated the existence of a difference between the variances of the normal returns of the stocks of the airlines and airplane makers versus the market portfolios. In turn, the ANOVA F-test revealed the existence of at lease one sample in which the variance of the mean was different. These results suggested the need for specific tests for this study.

Therefore, we applied the T-test for difference of means, assuming different variances. We analyzed the average normal returns (daily and cumulative) of all the events, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 and 360 trading days after each accident. This permitted identifying the average normal stock returns of the airlines and aircraft makers were lower than the respective average portfolio returns. Since these tests were based on the difference between the normal returns versus the portfolios, these results were insufficient to indicate or reject the presence of abnormal returns.

Although the tests mentioned so far were not conclusive, they served to diagnose the need to find a statistical model that better reflected the reality of the data and brought less bias in its interpretation. The new tests had to be robust regarding the premise that the data were normally distributed. The aim of these tests was to provide a base to infer whether or not, statistically, an investment strategy based on aviation accidents could generate abnormal returns. For this purpose we used an estimation model based on the market model, as developed by MacKinlay (1997) and Campbell et al. (1997). According to these authors, the market model eliminates most of the errors committed by other models that also are used to calculate asset returns.

The results obtained by applying the model Campbell et al. (1997) revealed the existence of abnormal returns both for the aircraft makers and airlines. However, the average cumulative abnormal returns were only significant as of the 40th trading day after the accident for the manufacturers and 45 trading days afterward for the airlines.

The T-tests applied to the two samples, presuming different variances, used to compare the mean daily abnormal returns (mean AR) for both types of companies presented strong fluctuation, indicating positive and negative abnormal returns on trading days 15, 30, 45 and 60. The results obtained also indicated that on the 60th trading day post-accident, which was the last day analyzed, the mean CAR was 6.68% for the aircraft makers and 18.28% for the air carriers.

Overall, the results obtained indicate it is possible to obtain abnormal returns through an investment strategy based on aviation accidents. Thus the returns obtained by a strategy formulated according to the points presented here would be higher than those obtained from an investment in an index-tracking fund in the respective markets.

Because of the complexity of the financial market variables involved in calculations of the behavior of securities, it must be stressed that other events could have happened during the periods analyzed, influencing the calculation of the returns, and consequently the model for estimating normal and abnormal returns. However, since the statistical tests followed the premise that the data were normally distributed, we believe the results obtained were not greatly influenced by exogenous variables that could not be controlled in the model used.

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