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Fatal accidents in the mining industry – do investors react rationally?

A quantitative study of the how information of completely unanticipated casualties is spread and perceived among investors

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Abstract

The mining industry is characterized by a hazardous working environment for its employed blue-collar workers and a general complexity of valuation for investors. By theories of behavioral finance, corporate social responsibility, and others outlined in the following, this makes a setting where one could plausibly expect reactions and even overreactions among investors to fatal accidents incurred among employed miners related to the mining operations. To investigate this, an event study was performed, studying cumulative abnormal returns of the event date and its following nine days. Furthermore, a trading strategy based on the hypothesized market abnormality was simulated and analyzed. T-tests were conducted on the initial negative reactions, the rebound tendency, and the complete event window, both with winsorized and non-winsorized residuals. While the study failed to confirm the hypothesized tendencies at the 5% level of significance and the trading strategy was concluded not superior, the shape of the results, when plotted, were in line with them. However, these results should be viewed and interpreted with caution; this due to not only the test's de facto insignificance and weakness, but also by the criticism of intentionally searching for patterns in data.

Foreword

First and foremost, I would like to thank my supervisor Thomas Fischer, who has been of great support and guidance throughout the work of this thesis. I would further like to thank Jens Mattsson and Lukas Björklund for having served as great discussion partners, something which has contributed to an improved final product.

Contents

1. Introduction

In the following section, the background against which the interest spawned to conduct the study will be presented, followed by the related problem discussion and the purpose of the study stemming from the prior. Lastly will be outlined the disposition of the remaining parts of the report.

1.1 Background

Two features characterizing the U.S mining industry include work-related danger and investment-related complexity. As for the former, the industry is associated with exposure of employed miners to a multitude of lethal dangers, including sudden ones such as ignited methane and coal dust which may carry mass-death consequences as well as equipment-related accidents or falls, which typically carry fewer deaths (Saleh and Cummings, 2011). For investors in the industry, concern of fatal accidents may stem from more sources than empathy alone. Camm and Girard-Dwyer (2004) extensively assessed the true costs associated with injuries of miners attributable to their work and inferred that for every dollar of directly related cost there are additional indirect costs of three to five dollars. In addition to the mentioned somewhat directly profit-deducting implications of mining accidents, there are implications of corporate social responsibility, which arguably seems to have grown in importance in recent years, to bear in mind. As defined by Panda (2018), corporate social responsibility means that a corporation should care for more than their shareholders, among all else its employees. Thus, fatal accidents can be expected to impact the stock price of a mining company. However, accounting for such an event can be expected to be a difficult task. To be described in more detail in section 3.1, Baurens (2011) outlines a general complexity of mining-related valuation and there seems to be an ongoing debate as to whether investors in general can be expected to do so adequately. There exist proponents of the Efficient Market Hypothesis as described by for example Fama (1970), who believe that stock prices effectively reflect the underlying value of a company, a theory that may have been further practically enabled through social media's rise, and its impact on news' travel speed as outlined by Phillips (2012). There are also those who argue in line with behavioral finance, as described by Bloomfield (2008), meaning that psychological biases and the like may cause investors to price stocks irrationally. Levy (2002) draws on work of Simons (1955, cited in Levy, 2002) as well as of Kahneman and Tversky (1979, cited in Levy, 2002), outlining typical biases and in what settings they are common. As will be shown in later sections, it is reasonably close at hand to expect several of these to be attached to events of mining fatalities. Lastly, Baurens (2010) mentions mean reversion as a way by which analysts predict prices in the mining industry.

1.2 Problem discussion

In a time of increased attention to sustainability, care for individuals and preferences that go beyond mechanical profit maximization of a firm, it may be considered interesting to investigate impacts from this tendency in the mining industry, as repelling as it was described in the section above, in terms of investors' measurable reaction to fatal accidents. Building on this reasoning, one would through an efficient-market perspective expect the market to react instantly and negatively to a fatal accident, in parity with its anticipated possible direct (such as legal consequences) and indirect (such as weakened brand value) costs, outlined. However, in line with the mean reversion ideas attached to the mining industry, mentioned by Baurens (2010), it is quite close at hand to investigate whether market-psychology forces compose a strong determinant of prices in this field, and whether they impact in the way expected by some of the leading theories of behavioral finance. The results from such an investigation could provide insights about the extended impact of corporate social responsibility, behavioral finance, and efficient market theories – as well as the nature of their mutual relationship. Moreover, finding an exploitable pattern in the market, in contrast to what would be suggested as possible by the Efficient Market Hypothesis (EMH) as described by for example Fama (1970), would likely be considered highly interesting by a large community and perhaps even upsetting among some. The debate as to what degree the market is efficient is an ongoing one. Any added clarity to this debate could hence be regarded as useful in some sense.

1.3 Purpose

The purpose of this report is to investigate whether lethal single or two-person accidents are incorporated immediately in stock prices by investors, and if so, to an irrationally large extent. An irrationally large extent would mean that the stock price would tend to rebound subsequent to an initial downturn, which will be considered an overreaction, as done by for example Howe (1986). Using the results of Barret et al. (1987) as benchmark, a reaction will be considered immediate if the event is incorporated in the stock price within two days, including the event day. Thus, the report has the primary intention of answering the following question: Do stock investors overreact to fatal accidents in mining? Closely attached, as secondary and third purpose the study wishes to investigate whether the market at all seems to react to a fatal mining accident, and whether a trading strategy based on an overreaction tendency could seem feasible. This study, building on and aligning theories of market psychology, efficient markets, and stockholders' care for stakeholders, adds to existing science in the way that it, through quite a narrow scope, investigates the degree to which the formerly mentioned theories apply in a field and a circumstance not exhaustively investigated earlier, and concerning less significant events (as far as the author knows).

1.4 Disposition

This report is structured in the following way: in section 2 and 3, relevant theories and previous literature in the light of which the thesis should be view will be presented. Section 4 will present a hypothesis built on inferences from the preceding sections. Thereafter, section 5 describes the methodology and the rationale behind its employment. Section 6 will present delimitations and critique to the former, relevant to be aware of when analyzing the results. Lastly, the obtained results are presented in section 7 as well as a discussion based on these, followed by a conclusion in section 8. Both discussion and conclusion tie back to the previous sections.

2. Theories

2.1 Efficient market hypothesis

A central theory of finance through which financial tendencies, relationships or properties are often viewed or against which they are contrasted is the Efficient Market Hypothesis (EMH). Eugene Fama (1970) defined an efficient market as one that "always fully reflects available information" (1970, p.383). In the same work he further assesses three levels of efficiency; weak level of efficiency would imply that historical data is reflected in prices, semi-strong that publicly available data is reflected in the prices and a strong level would mean that insider information is reflected in trading prices. Fama (1970) lines out three premises sufficient for market efficiency as that trading is free of charge, information is free to all investors, and investors share the same homogeneous opinions and perceptions about stock pricing. As Fama in 1970 assesses the empirical evidence for the three levels of market efficiency, he concludes that the strongest form, while not a precise depiction of reality, may function well as a standard for assessment of EMH deviations. As for the semi-strong, he argues that the empirical evidence, though not complete, supports the occurrence. Lastly, the weak efficiency – which by the time of his work was the most intensively assessed, holds a majority of empirical evidence in favor (Fama 1970). The EMH constitutes a model that aligns with and logically explains the random-walk tendency of stock market prices, which Fama in 1965 found evidence for. The random walk idea, as explained by Fama in 1965, proposes that stock prices move arbitrarily and unrelated to past movements. Fama, in the same work, later stresses that the idea of the random walk of stock prices thus constitutes an opposing belief to those of market cyclicality or any sort of historical patterns, and argues against the idea of the ability to create feasible strategies based on such, thereby challenging the beliefs of technical analysts or chartists as Fama (1965) calls them. As this research will investigate the degree to which public information is adequately impounded in stock prices upon report, all results will be contrasted to the semi-strong level of market efficiency to assess whether it seems to hold.

2.2 Behavioral Finance

Opposing views to the EMH are held, among all else, by some proponents of behavioral finance. This theory emerged from the question of why markets fail to adequately react and respond to available information and it comprises an attempt to explain this tendency and the corresponding apparent large set of market anomalies with a, in relation to the former, small set of human psychological biases (Bloomfield, 2008). Barberis and Thaler (2003) explain that what constitutes the fundament to the theory is the limit to arbitrage, in essence investors' incapability to exploit market inefficiencies and constitute the price correcting mechanism explained by Grossman and Stiglitz (1980, cited in Barberis and Thaler, 2003) as well psychology, which corresponds to the by Fama (1970) outlined preconditional behavior of investors for market efficiency to hold. Important for the scope of this research is especially the branches of behavioral finance concerning investors' tendency to react irrationally to new information. More precisely, this thesis will investigate circumstances in the light of overreactions, as mentioned and defined in the purpose section. As presented by Levy (2002), part of behavioral finance is investors' ability and inability to rationally anticipate risk and probabilities. Simon (1955, cited in Levy, 2002) outlines that humans, when facing uncertainty rely on only a few factors to anticipate likelihood. According to Levy (2002), this simplification may lead to psychological biases among humans in probability judgement. Among the most important of these, Levy (2002) argues, are biases based on availability, representativeness, anchoring and adjustments. Representativeness bias, described by Levi, in short means that people tend to overestimate the probability that things belong to the same groups based on shared features, while availability means an overestimation of likelihood of events that more easily come to mind (Levy, 2002). For example, Levy mentions that events that stir up strong emotion may be perceived as more likely to occur than they actually are, exemplifying with people's too large estimate of likelihood of terror attacks based on impactful perception from news. Anchoring and judgement bias refers to humans' too slow update of perceived probabilities to new information, compared to what would have been rational (Levy, 2002). Lastly, of essence for this report is decision theory as constructed by Kahneman and Tversky (1979, cited in Levy, 2002) and its implications regarding so called framing. Framing, as Levy explains, means that humans anticipate probabilities differently depending on how things are presented to them. Levy exemplifies with experiments on patients, where the outcome showed differing perceptions of outcome certainty between communicated 10% mortality and 90% survival probability. The Corporate Finance Institute (CFI) asserts that framing bias is particularly likely in cases of much uncertainty or where many factors are to be accounted for (CFI, n.d.).

2.3 Corporate social responsibility

Corporate social responsibility (CSR) which arguable seems to have grown in importance over the last years, concerns in some sense an ethical dimension of business. The literature assessing the topic is of an immense magnitude, and as are the numbers of definitions and specifications (Carrol, 1999). Carrol (1999) investigated and explained the development of CSR and its definitions, starting as far back as the 1940s. Having looked through much empirical work surrounding CSR, the author of this report chose to use Panda's (2018) definition when applying the theory in the examination of the mining industry and investor behavior, as well as on which to build the related hypothesis. The reason for this applicability to the investigated matter. Panda defines CSR as ”the continuing commitment by business to behave ethically and contribute to economic development while improving quality of life of the workforce and their families as well as of the local community and society at large” (Panda, 2018, p.97). As Panda builds on the former he states a corporate citizenship, which he likens to a natural symbiose-like relationship between corporation and local life. He means that this is a reciprocal relationship of mutual benefit, and even seems to argue that the latter is the more important benefiter, stressing that the corporate citizenship exists for “meeting community needs” (Panda, 2018, p.97). Panda, moreover, stresses the way companies can naturally utilize CSR to gain marketing-related brand value. Assessing companies' needs to leverage CSR activities through usage of internal and external CSR communicators and PR professionals, and stressing that pure company objectives and stakeholder goals may be closely intertwined in CSR work. As for feasibility of CSR-related commitment, McGuire, Sundgren and Schneeweis (1988) investigated the relationship between firm performance and perceived qualitative commitment as researched by Fortune (1983,1986, cited in McGuire, Sundgren & Schneeweis, 1988). The researchers found a strong positive relationship between preceding financial performance and perceived CSR quality. Although the team of researchers mention that this could likely be related to the fact that a firm that has been performing well has more money to spend on CSR activities, the result was nevertheless an interesting one in the direction of profitability of CSR. This in line with Panda's (2018) reasoning of CSR as a strategy in pure company-related interests as well as well in line with the reasoning of Davis (1960, cited in Carroll, 1999), concerning alignment between long-run profitability and CSR investments. In addition, the results found by the three showed that CSR commitment could yield reduced risk (McGuire, Sundgren & Schneeweis, 1988).

3. Previous literature

3.1 Complexity of mining valuation

While stressing a general complexity of mining company valuation, Baurens (2010) rejects many of the available methods for mining-company valuation as non-useful or inapplicable. CFI (2019) argues that the premier way by which to evaluate a mining company or asset is through a discounted cash flow model (DCF). A DCF approach is something that also Baurens proposes as a possible way of estimating the value of a mining company. She outlines, however, the construction and implementation of one as a difficult task for an investor, including many levels of uncertainty and many steps of estimation. Multiple diffuse risk factors need to be incorporated in the discount factor, which has a large impact on the final valuation. Then, she explains, there is uncertainty attached to the minable matter, concerning both its amount as well as its condition. Revenue may, according to Baurens (2010), be estimated based on historical data of extraction rate and price. However, the former cannot be easily implemented in the case of new exploration, and the latter may in the mining industry be subject to steep fluctuations (Baurens, 2010). Lastly, costs associated with mining companies comprise a wide, diverse spectrum. To summarize Baurens' description of it, operating costs include a multitude of factors and differs among companies and sub-sectors, capital costs are hard for investors to anticipate, and lastly, taxes are diverse across countries and exposed to the possibility of impactful changes (Baurens, 2010). In short, as perceived from the reasoning of Baurens, DCF valuation in the mining industry is a complicated task, but there seem not to be any simpler method close at hand with which to replace it.

3.2 Supporting evidence of behavioral finance and overreaction theory

A study conducted by De Bondt and Thaler in 1985 investigated the overreaction phenomenon out of the hypothesis that extreme price movements will generate reversals and that the magnitude by which they first moved was proportional to the generated reversal or adjustment as they put it (De Bondt & Thaler, 1985). Creating 16 simulated non-overlapping portfolios with three-year buy-and-hold long positions (from 1933 through 1980) in the worst performing stocks of the previous year, they obtained strong evidence in support of the overreaction theory. Measuring CARs from the portfolios which they called the loser portfolios and comparing the results to the opposite strategy (buying the previous year's winner stocks) they showed that the former portfolio which outperformed the market in terms of return by approximately 20%, by far outperformed the latter, which underperformed against the market by 5%. Moreover, the research showed that the loser portfolio not only beat the winner portfolio in matter of return, but also in risk – generating a significantly lower volatility. Further results of the study showed a strong skewness of the overreaction in the direction of the loser stocks. Although, as De Bondt and Thaler themselves stress, they have not completely explained the tendency, it serves as a strong example of market irregularity and a significant exception from the EMH which further investigations could build on (De Bondt & Thaler, 1985). Following on the same course as De Bondt and Thaler (1985), Howe (1986) a year later conducted a study on individual stocks' performances following reported news, arguing, in line with De Bondt and Thaler (1985), that the more impactful the news, the more substantial would the related investor overreaction be expected to be. By this reasoning, Howe concentrated his research on stocks that upon reported news had had their corresponding price deviate by more than 50% in a week, a deviation that Howe implicitly considered a reaction to news. Observing data spanning from 1963 to 1981, his research proved a significant overreaction tendency among investors to extreme news by a significant reversion tendency of the stock prices. In contrast to De Bondt and Thaler (1985), however, Howe's results were stronger for the stocks that had initially experienced positive overreaction, so called good news stocks which reverted towards previous lower prices quite evenly over the course of the following year. As for the bad-news stocks however, although weaker results were derived for these, the reversion tendency was nevertheless significant as well. Furthermore, the bad-news stocks differed from the good-news stocks in the way that they reverted in a much shorter time period, 20 weeks, before showcasing negative returns once again. Also, these stocks showed the strongest positive returns in week one through five following the event, of which the strongest was the first week. Howe (1986) concluded that he had indeed found a market irregularity subjectable to exploitation by active traders. (Howe, 1986). Attaining similar results as Howe (1986), Dyl and Maxfield (1987, cited in De Bondt 1989) studied daily stock reactions to news. Observing news-attributable positive and negative deviations of, on average, 16% and -12.2% respectively, the two found significant evidence of rebounds. In line with the results of Howe, their results as well showed a quick rebound, spanning over the ten days upon incorporation of the bad news. Lastly, Brown, Harlow and Tinic (1988, cited in De Bondt, 1989) observed short-term reversions, including all stock changes of more than 2.5%. Interesting for this study is not only the fact that their study concerned companies of comparable size as those of this one, but also that they could conclude that their results showed significant rebounds to daily negative deviations. For this rebound as well, the duration was measured to an average of 10 days. Tying back to this, De Bondt (1989) states that the shorter the duration of the initial price reaction, the faster will be the following rebound. Criticism building on the idea that short-term rebounds may be rational in the sense that returns correlate with increased volatility is also rejected by De Bondt. He argues that such short-term increased volatility hardly can be of economic relevance (De Bondt, 1989).

Although the above mentioned studies showcased significant examples of irregularities, contrasting to the implications of the EMH, they arguably lacked supporting rationale as to why their spotted irregularities tend to occur. An answer to this type of issue was provided by Daniel, Hirshleifer, and Subrahmanyam in 1998. Based on investors' propensity to overreact to inferences based on private information compared to public, and investors' biased conviction to attribute positive results to their own stock-picking ability, the authors proposed a model to align tendencies of the seemingly contrasting behaviors of for example post earnings announcement drift and reversals such as the results obtained by De Bondt and Thaler (1985). Arguing that what appeared to be an underreaction to news could be a continuous overreaction, following inferences of additional information. Their rationale seemed to be that initially investors may cause a reaction on the stock price based on more personal predictions and valuation estimates. As public data that confirms investors' initial estimates becomes available, this fuels overconfidence among the same investors, that further exaggerates the price movements in the stock, in the same direction as initially – thus showcasing the drift that has been taken for an underreaction tendency. Their model as such, predicts public news to generate short-term price development of the same sign as the initial market reaction (an underreaction, or drift) and long-term reversals (Daniel, Hirshleifer & Subrahmanyam, 1998). Daniel, Hirshleifer and Subrahmanyam's theoretical model has been widely assessed and can be viewed as one of the more important steps in the direction of accounting for psychology when modelling financial markets, as claimed by for example Thaler (1999).

3.3 Modern defense of the efficient market hypothesis

As a few examples, the above paragraphs concerning research that challenges EMH while constituting important work in the area, only makes a fraction of the research evidence against the EMH. On the other end of the spectrum, however, is a deep scientific work defending the EMH. Fama (1998), for example, weighs previous research results both in support of the EMH as well as against it. Fama in this work admits not only that the market that there are proven tendencies of both over- and underreactions. He withholds though, that the EMH pertains as an adequate model of financial markets due to two reasons: Firstly, he holds that even though it sometimes may appear as though individual events are the results of overreactions, these tendencies are somewhat cancelled out by equally frequent underreactions, which he also claims to be depicted in reality according to empirical evidence. His second argument is that the results finding underreaction or overreaction irregularities tend to be conditional on the model used to derive the results, applying different methods. Furthermore, Fama (1998) argues against behavioral finance's implications from the standing point that itself has no better alternative model. Fama also responds to the implications of De Bondt and Thaler (1985) and argues that the by him perceived implications of their work – overreactions to news as a generalized behavioral finance prediction – is not convincingly proven through other empirical work. Fama also refutes the model of Daniel, Hirshleifer, and Subrahmanyam (1997, cited in Fama 1998), that the model in a sense only works for certain events and lacks genera application. He further addresses what he calls a bad-model problem of the tests that have generated results implying underreactions or overreactions. He argues that they fail to adequately simulate returns (Fama, 1998). More recently, Malkiel (2003), defends the EMH. Assessing previous empirical work, including that of Fama (1998) Malkiel refutes challenges to the EMH on multiple occasions. In agreement with Schwert, (cited in Malkiel 2003) Malkiel argues that irregularities evaporate as they become known to the public and that the reasons for this may be either data mining or because of rational exploitation correcting prices back to EMH. Malkiel further assesses evidence for overreaction tendencies, addressing among all else the work of De Bondt and Thaler (1985). Although he admits the significance of research implying overreaction tendencies, he argues against their capacity to refute the efficient market hypothesis. Primarily, he rests this point of view on what he claims to be an absence of general applicability of the relationships, much in line with the standpoint of Fama (1998). Malkiel seems to argue that the evidence is based on historical patterns but that these proven patterns seem not to be utilizable in strategies to derive abnormal profits. As this is the case, Malkiel means that the EMH in fact holds well.

3.4 Earlier assessments of accidents and stock reactions

Scholtens and Boersen (2011) investigated accidents in the energy sector and their impact on stock prices. Although this study did not focus on human casualties, there are similarities with this report in the sense that the two examined an industry in which accidents seem quite difficult to prevent. A few interesting findings were attained through this study. Primarily, the authors concluded that in contrast to much of the previous literature presented by them, they could not seem to draw strong general conclusions of negative reactions of the market to energy accidents. They only did so as they limited the scope of the study and specified the post-event period. As the authors perceived this result, this was a sign of a fact that investors seem to anticipate possible future accidents and base their valuation of the present stock price accordingly, and that accidents in the energy sector could be viewed by investors as something inevitable and normal.

More closely connected to the study of this report, Barrett et al. (1987) investigated the impact on stock prices of completely unanticipated events, and more specifically the reaction time to the news of the event, and whether the market could be shown to show tendencies of either over or underreaction, in line with some previous literature of which some has been mentioned also in this report, in the earlier part of this section. More precisely, it concerned airplane crashes of commercial flights, from the 1960s to the 1980s. In essence, the compliance with the investigation of this report lies with the fact that the study conducted by the group, in contrast to many other event studies concerned events of which the market could do no previous calculations, estimations and no information could be expected to have been leaked. For this reason, the study concerned only the days following the event as arguably no relevant information could be expected to be derived from the last days prior to the event.

Firstly, the market seemed to react effectively and instantly to the news of the crash, in line with the efficient market hypothesis. There was a significantly negative drop in stock prices (perhaps not too surprisingly considering the magnitude of the events) on the event day which carried on the next day. The authors reasoned that this was likely due to the fact that some accidents could take place closely before market closing or took place in an area considered to some investors as remote. Studying this vast number of airplane crashes, the authors could observe a stock price rebound over the 20 days after the event. However, this was not proven to be significant and thus the study could be regarded as to be in line with the EMH and a contradiction to the implications of for example Howe (1986), mentioned earlier.

4. Hypothesis and reasoning behind its construction

The hypothesis, to be called H1 for later reference, is that the market will initially react negatively and instantly to the news of the event, to later rebound. In other words, the market is expected to overreact to an accident. This hypothesis is built upon the theories of the efficient market hypothesis, CSR and investor psychology, mentioned in section 2 and 3 and applied to the climate of the mining industry and its attached hazardous characteristic and its underlying complexity of estimation mentioned in section 1. Based on Fama's (1970) second-level market efficiency feature of new information being immediately incorporated in stock prices, the information of a lethal accident attributable to a mining operation will be expected to be incorporated initially during the day of the event, and the day after. Based on the results and reasoning of Barrett et al. (1987), this makes logical sense as the event time may be close to market closing and investors may be remotely located. As to the degree to which the second level of market efficiency as described by Fama (1970) can reasonably be expected to hold in terms of the speed at which the information is available and incorporated there are a few things worth mentioning. Firstly, although both these elements can plausibly be assumed to be smaller than in the case of an event carrying a larger number of deaths or simply being of a more extreme impact, there are some arguments in favor. Considering both the severity of the impact argued for in the next paragraph, as well as the substantial increase in speed by which information can spread as a result of the emergence of social media as described by Phillips (2012), the author argues that it is reasonable to examine whether the information may be as quickly incorporated as two days.

A large difference to much previous work is that the magnitude of these events are comparably small – one fatal accident compared to an airplane crash or a major oil leak may very well be expected to have a much smaller impact on the stock price. Nevertheless, there are strong arguments mentioned above from scientifically recognized sources implying that fatal accidents may very well be of significant impact to a company, even one of major size. Two strong arguments include, firstly, CSR and for example Panda's (2018) stressing that companies' corporate citizenship and CSR as their continuous commitment to the quality of life and welfare of them and their families. Combined with Panda's extended reasoning of CSR's connection to a company's brand value and Davis' (1960, cited in Carroll, 1999) and McGuire, Sundgren and Schneeweis' (1988) implications of a positive relationship of CSR and profitability, this undoubtedly implies that a fatal accident related to the mining service may have a negative impact on the company responsible for operations and related safety standards and precautions. Secondly, there is the purely economic standpoint, as assessed by Camm and Girard-Dwyer (2004), concerning all mechanically applicable costs for a company related to an accident, from direct costs such as medical inquiries, legal settlements, and implementations of expanded safety, to indirect costs such as disrupted operations, investments in new human capital and negative effects on productivity of other miners (Camm & Girard-Dwyer 2004). As described by the two, these costs could plausibly be of non-negligible impact even for a large corporation. Conclusively, these arguments make it reasonable to assume that a mining casualty could significantly impact a company.

Lastly, as for the overreaction hypothesis, there are a few characteristics in the assessed events that make it arguable to expect, or at least investigate, a tendency to overreaction. Primarily, this is derivable from the complexity attached to the task of an investor of quantifying an accident into a rational price deduction of the related stock. In the case of a mining fatality, the author reasons that the underlying complexity of valuation as described by Baurens (2011) and the likely even harder task of quantifying the total economic impact of a fatal accident, make for a setting of much uncertainty, hence, investors may tend to be even more exposed to the type of biases as mentioned by in the theory section by Levy (2002). In the studied scenario, representativeness as described by Levy (2002) would mean that investors would believe accidents to be more likely to reoccur in the future than what would be rationally the case based on probability theory. Representativeness similarly comprised an essential part of the hypotheses of De Bondt and Thaler (1985) as well as Howe (1986). Availability bias based on emotion as described by Levy (2002), may be induced due to the morbid manner in which miners are fatally injured – something which could likely cause framing bias as well, in the sense that a strong negative visualization of the impact may induce a deviated reference point for probability. In short, psychological biases based on uncertainty could arguably be expected to induce irrational anticipation of impacts from fatal accidents. As overreaction can be viewed as a sign of investor irrationality, the author believes that a setting for much irrationality may increase the magnitude of an overreaction. While this reasoning is somewhat contrasting to that of Daniel, Hirshenleifer and Subrahanyam (1998) as the latter team's model predicts underreaction based on public information signals, the author believes that their model does not strongly refute his reasoning. The two most important reasons for this is firstly, that the model of Daniel, Hirshenleifer and Subrahanyam, while making a good job at describing post-announcement drifts and long-term reversals, seems not applicable to cases of short-term overreaction – which comprise the subject of investigation of this study. Empirical evidence by Howe (1986), Dyl and Maxfield (1987, cited in De Bondt 1989), as well as Brown, Harlow and Tinic (1988, cited in De Bondt 1989) attest this. Nor does their model, by the critique by Fama (1998) seem to work in general, in cases not concerning small companies exposed to information asymmetry – which there is no reason to assume regarding the companies observed in this study.

5. Method

5.1 Data

5.1.1 The databases

To ensure a scientifically reliable, unbiased source from which events could be systematically drafted – a single extensive database was searched for. Due to reaching the above criteria above and beyond, in addition to providing an extensive range of accidents which could also be verified through other sources such as online newspapers, the list of fatality reports provided by The Mine Safety and Health Administration (MSHA) (n.d.), an organ of the United States Department of Labor, was chosen. The list provides, in chronological order, detailed information of every mining fatality in the United States and whether the death was attributable to the mining service. This information includes, among all else, the date of the accident – an important specification related to the specification of the event window, assessed in the method section. All stock price, dividend, market capitalization, quotation and index data and the like used were provided by Bloomberg.

5.1.2 The accidents

Accidents included were chosen both due to, as previously mentioned, their nature of being able to be systematically collected and compared as well as the earlier assessed hypothesis that an accident costing a worker's life may significantly impact the associated company. From the list, every one of the latest 180 accidents were individually investigated and the accident was included in the research if it reached the following two criteria: the first criterion was that the cause of death was attributable to the mining industry and the job conducted by the individual. The author raised this criterion as a death not related to the line of service of the individual could not as directly motivate a strong concern among investors as to damage of brand, costs of legal services, new investments in safety or the like and the multiples of these costs as mentioned by Camm and Girard-Dwyer (2004). This concern constituted a theoretical fundament upon which the study was conducted. As for the distinction of whether an accident fulfilled this criterion, the report followed the conclusion of the MSHA (n.d.). The second criterion was that the company associated was one for which detailed daily stock information covering the accident could be collected. In other words, a, during the time surrounding the event, publicly traded stock company.

5.1.3 The companies

As the associated company, the company which's stock's daily return was investigated, the mine controller, as presented by the MSHA (n.d.) was investigated. As presented by the fatality reports, and as the author has interpreted the Federal Register of 2000, the mine controller carries the responsibility of ensuring safety and safely conducted operations of a mine in the United States. For this reason, an incident in a mine of which a company is regarded as a mine controller, can plausibly be directly connected negatively to the company. In most cases, the mine controller was also the direct employer of the victim as presented in the fatality reports. As an illustrative example, the market seemed to hold mining giant Glencore responsible for a catastrophic accident in June 2019 concerning non-contracted miners who illegally had infiltrated the mine. Shares of the company plunged 5% upon the news, even though Glencore, as described by the article, could hardly be considered to carry the responsibility of the event, and also claimed no impact on operational ability (Reuters, 2019).

In some cases, a subsidiary company was reported by the MSHA (n.d.) as the mine controller. In these cases, the parent company was considered to be the responsible company and the stocks of this company were investigated for the event period. The task of investigating whether a company was an affiliate and which company was its parent company was one of varying difficulty, and it is thus possible that the author for this reason omitted companies that should have been included in the study based on this fact. Out of 180 investigated accidents, 38 incidents reached the above two mentioned criteria. Out of the 38 remaining incidents, 8 had to be excluded due to overlapping event windows (this is explained in section 5.2). Thus, 30 events were examined in the study. Of these, only one included more than one (two) fatally injured individual. While a larger number of events would have been preferred as this would have strengthened the test (MacKinlay, 1997) and thus provided more reliability to the results (Button et al. 2003), 30 is still a number of events large enough to assume a fairly normal distribution (Mordkoff, n.d.), a basis on which the tests and applicable inferences in this study are conditioned. The systematic extraction of events is depicted in Figure 1.

The 30 incidents that in the end were included in the study corresponded to 22 different companies, Cemex was included three times and Alliance Resource Partners, as the most frequent company to occur, appeared five times. While all belonged to the mining industry as defined by the MHSA (n.d.), the companies constituted a to some extent diverse collection of mining companies. As the reader may infer through consultation with table 3 in section 10.1, the largest company in the test, CRH PLC, at 21.576 billion USD was approximately 770 times larger than the smallest company, Cloud Peak Energy Resources, in terms of market capitalization by the last trading day of year of 2018, as provided by Bloomberg and depicted in the appendix table. By the closing day of the year of its investigated accident though, the market capitalization of the latter was above half a billion USD – a fact that to some extent reflects the dynamics of the industry in question. Moreover, the companies differed in terms of substance mined related to the accident. A fairly even distribution among precious (30%) and non-precious metals (10%), stone (33%), and coal (27%) comprised the sample of substances mined included in the study. Upon further investigation done by the author, it strongly appeared as though the substances mined, reflected the core business of the company in question.

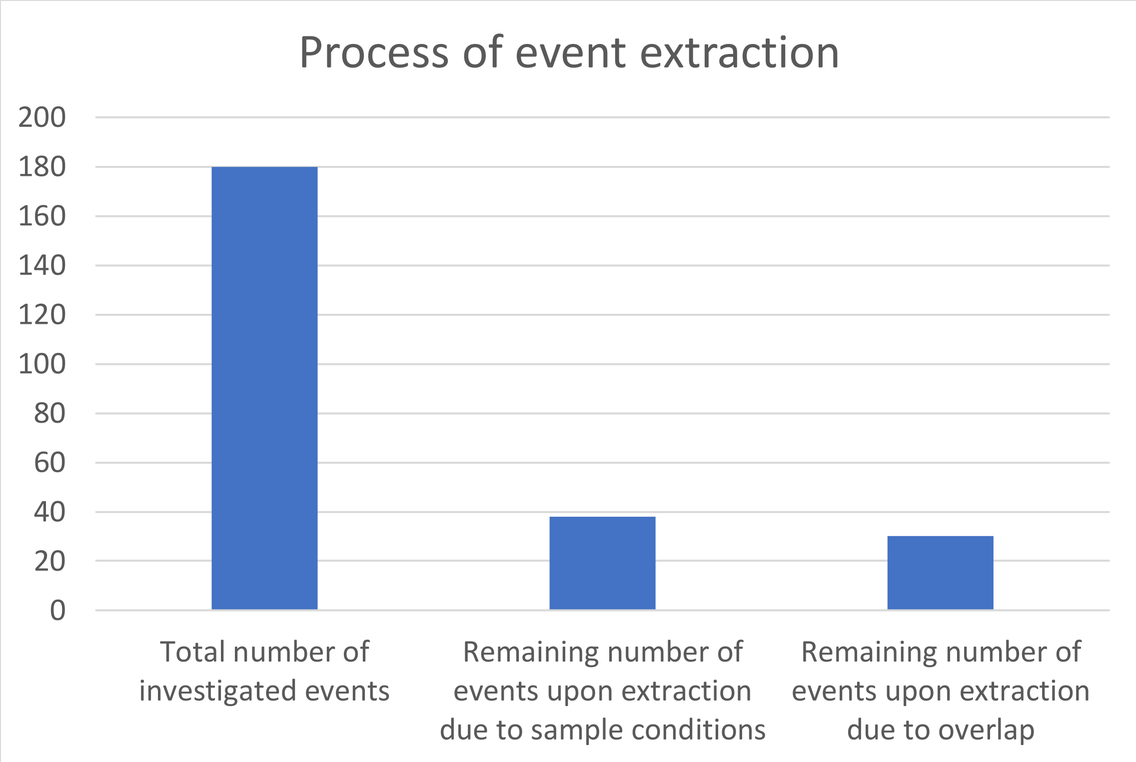

Figure 1. The exclusion of events during the study.

5.2 Event study

To test the hypothesis mentioned above, the author chose to carry out an event study, a popular method in finance to investigate the impact of a specific event, and done by for example Howe (1986) and Barret et al. (1987). The essential task of the event study is to investigate the degree to which the period of interest related to an event deviates from what would have been expected, had the event not taken place, and whether this can be shown to be significant. Thereby, an impact of the event can be shown. There is a multitude of ways to conduct this sort of experiment and the author of this study chose to use single-index market model, in which the expected return is derived through the equity's preceding correlation with the market portfolio. For the market portfolio, an index is used as proxy. In line with the reasoning of MacKinlay (1997), the use of a multivariate model was considered, as the securities observed belonged to roughly the same industry and hence there could have been possible gains in terms of variance reduction from implementing such a model. However, by the arguments and evidence provided by Brown and Warner (1985) stating that there is no proof of more involved models being more adequate to use than the simpler single-factor model, the author opted to use the latter. In addition, the decision was based on the results attained by Barret et al. (1987) in their comparable study, where the researchers compared the results obtained through the single-factor market model (the method they showcased in their study) with results derived through usage of other relevant models, and found negligible differences among the results obtained. Moreover, although the companies all belonged to the mining industry, they differed in terms of mined substances, as outlined in section 5.1.3. Hence, the gains of estimating expected returns by including multiple factors in model were anticipated to be smaller than had the sample been characterized by more homogeneity, as explained by MacKinlay (1997). Due to a risk of misspecification and the related risk of rejecting the null too easily (Brown & Warner, 1985), a non-parametrical test was not performed. Aware of the smallness of the sample, as well as the fact that the events were picked from roughly the same industry rather than completely randomly, the author considered it reasonable to complement with a test where the abnormal returns were winsorized before the null hypothesis was tested, as was done in earlier research by Armour, Mayer, and Polo (2017). They explain that winsorizing means changing outlier observations outside of an extremeness-acceptance threshold to the most extreme value inside of the threshold. Consequently, as the three explain, the impact of the most extreme abnormalities is eliminated to decrease outsider bias and according to Wilcox (2014) add robustness. For this study, the extremeness-acceptance threshold was set to 5%, hence, outlier values above the 95th percentile were changed to the 95th percentile value, and values below the 5th percentile were changed to the 5th percentile value. Using the market model, future returns are predicted based solely on previous variance and abnormal return, as in the formula below, where $R_{i,t}$ is the return of stock i at time t, $R_{m,t}$ the return of the market at time t, β the slope of the linear relationship, alpha the intercept and epsilon the error term with expected value zero. All following derivations of estimators were based on the formulas presented by MacKinlay (1997).

$$R_{i,t} = \alpha_i + \beta_i * R_{m,t} + \varepsilon_{i,t}$$

To create estimates of the parameters of the market model, 250 pre-event daily stock returns of each individual equity were regressed by the ordinary-least-squares method against the 250 pre-event daily returns of the main index of the stock exchange on which the equity was listed. To prevent any confusion; the dependent variable was in this case comprised by the stock return and the explanatory variable the return of the index. The estimate of beta (β) represents the estimated slope, based on the regression. The intercept value of the regression was used as the estimate of alpha, which by the construction of the market model in all regressions took values very close to zero.

Against the US-listed companies, the index used was the S&P 500. The other indices used are depicted in table 3, next to the company in question. The reason why the companies were not all regressed against the same index was that there would have been trading-day mismatch discrepancies, had the daily returns not been compared to returns of an index with identically matching trading days. In one case (Arcelor Mittal), the US depositary receipt was studied. This was considered reasonable as the receipt was traded on average more than two million times a day, hence was considered liquid enough not to yield any of the non-synchronous-trading related distortions described by Brown and Warner (1985), and, for the case of this study, practically interchangeable with the company's stock. The daily stock returns were calculated through the use of the by Bloomberg provided total return index, in order for the results not to be affected by possible dividend payouts in the event window. Upon comparison, the derived estimators from implementation of this method were practically identical to those derived through the usage of price data only, why it was considered that any misspecification stemming from this was negligible, and that the gains of not having the test results distorted from potential dividend payouts made it feasible to use the former model for daily return. Daily returns (R_t) were calculated as the indexed value of a certain day (P_t) minus the indexed value of the prior day (P_{t-1}), divided by the indexed value of the prior day. For the sake of clarity, the formula is depicted below.

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$

The estimation period, L_1, was based on the 250 immediately preceding trading days before the event. As MacKinlay (1997) explains, with a long estimation period the variance of the abnormal returns due to sampling error will approach zero, hence, serial correlation among the abnormal returns stemming from this will be practically eradicated – a necessary condition for the assumption of normally distributed abnormal returns (MacKinlay, 1997) on which the calculations and results of the test are conditioned. Based on previous event studies, such as the one carried out by Barett et al. (1987), the author inferred 250 days to be regarded as a sufficiently long period. In one case there were no data available for all 250 preceding trading days. The longest possible period was used in that case. The event window, in other words the days of which cumulative abnormal returns were studied, consisted of the event day and the nine following days. Multiple reasons formed the decision to observe exactly ten days. First and foremost, in order to prevent correlation among the abnormal returns, overlap among the event periods needed to be prevented, as explained by MacKinlay (1997). Longer event periods would have meant overlap as the events observed were quite closely clustered in time. Secondly, MacKinlay (1997) claims that a smaller event window generates stronger statistical results. Thirdly, Howe (1986), who performed a similar study, observed the strongest overreaction rebound in the first weak following a negative event. Similarly, Dyl and Maxfield (1987, cited in De Bondt 1989) as well as Brown, Harlow and Tinic (1988, cited in De Bondt, 1989) observed the strongest rebound in short-term reversals in ten days. For this reason, a ten-day event window including the event day was considered long enough to investigate the hypothesized stock-price impact.

In contrast to many other event studies, which concern for example consequences of legal actions against a company, or mergers and acquisitions, this event could be regarded as completely unanticipated and the day of the accident surely determined – as this was reported exactly by the MSHA (n.d.). For this reason, there was not expected to be any valuable information concerning the event to be obtained from observation of the preceding days. Thus, the event period does not include any, to the event, prior days. To avoid having the estimate of abnormal returns influenced by the event itself, the study, in line with others and with the reasoning of MacKinlay (1997) separated estimation period from event period. Below is depicted the timeline to the event study conducted, where the estimation window is comprised of the 250 days, from τ_0 preceding the event (τ_1), which included with the nine days thereafter, until τ_2, comprised the event window.

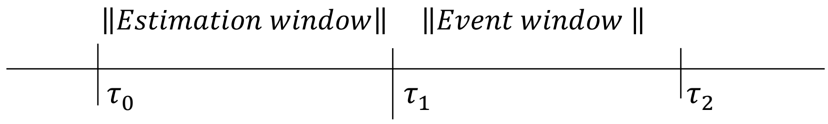

Figure 2. Timeline of the event study.

The expected daily returns ($ER_{i,t}$) of a specific stock (i) were calculated as the beta estimate (β_i) times the daily return of the corresponding index, plus the alpha estimate (α_i).

$$ER_{i,t} = \alpha_i + \beta_i * R_{m,t}$$

The daily abnormal returns ($AR_{i,t}$) of a specific stock (i) were calculated as the actual one-day return of the stock ($R_{i,t}$) at specific day (t) subtracted by the expected one-day return as predicted by the market model ($ER_{i,t}$) at the same time.

$$AR_{i,t} = R_{i,t} - ER_{i,t}$$

The OLS estimate of the variance of the abnormal returns of a single security, based on the 250-day estimation window is derived as depicted below, where t denotes a day in the estimation window. MacKinlay (1997) asserts that variance of the abnormal returns in an event period will be defined by additional variance due to sampling error in the other OLS parameters. With a large estimation window however, the impact of this shrinks to non-significance. (MacKinlay, 1997).

$$\sigma_{\varepsilon}^2 = \frac{1}{L_1 - 2} \sum_{t=1}^{t_{250}} (R_{i,t} - ER_{i,t})^2$$

CARs of a single stock were calculated as the aggregate of the abnormal returns of a single stock. Average CARs ($\overline{\text{CAR}}$), the focus of the study and on which the final test was done, were calculated as the aggregated average abnormal returns. CARs over a period were thereby calculated as the summarized abnormal return corresponding to all events over the period, divided by the number of events (N).

$$CAR(t_1, t_n) = \sum_{t=1}^{t_n} AR_t$$

$$\overline{CAR}(t_1, t_n) = \frac{1}{N} \sum_{1}^{N} CAR(t_1, t_n)$$

The variance estimator of each security's CARs (σ_i^2) was calculated as the estimated variance of the abnormal returns of the specific security, multiplied by the number of days in question.

The variance estimator of the average cumulative abnormal return across all securities (Var $\overline{(CAR)}$) was then calculated as the sum of the variances of the period concerned, divided by the number of assets squared.

$$\sigma_i^2(t_1, t_n) = \sigma_\varepsilon^2(t_n - t_1 + 1)$$

$$\text{Var } \overline{(CAR)} = \frac{1}{N^2} \sum_{i=1}^{N} \sigma_i^2(t_1, t_n)$$

Finally, to test the null hypothesis, that CARs followed a t-distribution with 29 degrees of freedom, a student's t-test was performed to assess the likelihood of the CARs accumulated from the most negative day to the most positive, belonged to the same distribution as the abnormal returns of the estimation period. The rationale being that if the largest difference in the event window could not prove to be significant, none would. A t-test was considered more appropriate than a z-test in this case as the population standard deviation was not known, and the sample was quite small (Encyclopædia Britannica, 2019). The t-test was also used in similar studies presented in the previous literature section, such as the one carried out by De Bondt and Thaler (1985). The significance-level at which to reject the null was set to 5%. Therefore, a t-statistic larger than 2.045 or smaller than -2.045 would have generated a rejection of the null hypothesis, given the 29 degrees of freedom applicable. If this probability were less than five percent, the null hypothesis would have been rejected. The probabilities were calculated according to the formula below, where T denotes the obtained t-value, p the probability, ϕ the cumulative distribution function of a t-variate with 29 degrees of freedom, and M the measured difference in CARs between day two and day nine. In a similar way, the significance of the two-day negative CARs were calculated for both the non-winsorized and winsorized abnormal returns; they were derived by dividing the two-day CARs by the estimated two-day variance. The probability derivations were done similarly to, for example, Barret et al. (1987).

$$\text{T} = (M/(var(\overline{CAR})))$$

$$p = 2 * (1 - \phi(T))$$

Regarding the hypothetical question as to whether a buy-and-hold strategy based on the rebound could constitute a superior trading strategy, the return from buying upon the initial negative reaction and selling on the rebound, based on the sample results, was calculated as the product of the daily returns plus one, subtracted by one. See the formula below.

$$(AR_t + 1) * (AR_{t+1} + 1) \ldots * (ARn + 1) - 1$$

6. Additional delimitations and critique

6.1 Data

The study observed only companies operating in the United States. While this should admit more comparability among the companies than had been the case with a more diverse sample, it also limits inferences about differing companies and across nations. Ideally for the sake of precision of the results, the study would only include cases where the fatally injured are the only victims, passing away close in time to the accident. In a few cases the victim did not die on the same day, but a few days later. Also, in a couple of cases, people other than the single person were non-lethally injured. These instances were not considered to significantly distort the results, why the corresponding events were still included in the study.

6.2 Event study

As mentioned, the limited sample size meant a lower strength of the test, as reasoned by McKinlay (1997). This to a further degree exposes the results to among all else sampling errors and type-II errors. A sampling error, as described by Investopedia (2019) means that the observations included in the sample did not represent the population well, a problem more likely to occur with a small sample (Investopedia, 2019). As for the risk of committing a type II-error, which means omitting to reject a false null hypothesis (Investopedia, 2019), it is likewise greater with lower strength (Button et al. 2013) which by assessment in earlier sections could characterize this test due limited sample size, by the reasoning of MacKinlay (1997). Moreover, this study built on many theories and assumptions, which could increase the likelihood of being wrong somewhere on the way – in line with the principle of Occam's razor. This principle, in short, has it than one should, when possible, opt for a theory including less assumptions, to increase the likelihood of being right (Encyclopædia Britannica, 2018). However, the author argues that involving many assumptions and theories was necessary to allow for a reasonable investigation in this quite scarcely investigated area of science. Concerning the event time, while still, as outlined in the hypothesis section, an arguably interesting time interval to observe and which's length generates certain attributes, it would have been of interest to watch a longer time horizon as complement. This so as there may be interesting fluctuations over the longer haul that would have been missed by this limited study.

As the test was restricted to fatal single-accidents, the expected reaction and overreaction is smaller, by the reasoning of both Howe (1987) as well as De Bondt and Thaler (1985), who all were of the belief that the larger the news, the larger the expected stated tendencies. If this is so, which would be reasonable, then it would be more difficult to find a significant result in this study. As this may be, however, it was an interest of the study to shed light on the question of whether these smaller events could generate the hypothesized reactions to test the practical extent of some of the theories used, as well as (as far as the author knows) breaking new ground in terms of investigated area.

7. Results and Discussion

7.1 Results

As depicted in figure 3 and table 1, in line with H1, the abnormal returns reflected a general tendency of initial downturn, to rebound after two days. None of the results are significant however; for the non-winsorized two-day CARs, the t-statistic was -1.313, corresponding to a calculated probability of 20% that those CARs, or extremer, could have been obtained in a scenario with no accident. Calculating the difference between the nine-day CARs and the two-day CARs, the two-sided t-test yielded a t-value of 1.894 and a probability of 6.82% of reaching this result, given a t-distributed variable with 29 degrees of freedom. The ten-day non-winsorized CARs were non-significantly positive by 1.09 % with a t-value of 0.83.

Figure 3. Graph of non-winsorized average cumulative abnormal returns, including event date, by event time in days.

Day	AR	CAR
10	-0,00363943	0,01087256
9	0,00214406	0,01451199
8	0,00878732	0,01236793
7	-0,00025464	0,00358062
6	-0,00083364	0,00383525
5	0,00268456	0,00466889
4	0,00750981	0,00198433
3	0,00217121	-0,00552548
2	-0,00533905	-0,0076967
1	-0,00235765	-0,00235765

Table 1. Non-winsorized abnormal returns, including event date (1).

With winsorized abnormal returns, the variance of the CARs measured was visibly smaller during the time following the event - an intuitive result. For the winsorized CARs, the t-statistic for the two-day CARs was -0.925, corresponding to a 36% probability, similarly interpretable as for the non-winsorized two-day CARs. As can be seen in figure 4 and table 2, extracting the most extreme values kept the derived CARs from turning as negative in day two as was the case with the non-winsorized CARs, and in day nine from not turning as strongly positive. Calculating the difference between the two-day CARs and the nine-day CARs in the same way as for the non-winsorized CARs, the two-sided t-test yielded a t-value of 1.121 and a corresponding probability of 27% of reaching this result, given a t-distributed variable with 29 degrees of freedom. The ten-day winsorized CARs were non-significantly positive by 0,49% with a t-statistic of 0.38.

Figure 4. Graph of winsorized average cumulative abnormal returns, including event date, by event time in days.

Day	AR	CAR
10	-0,00280943	0,004916577
9	0,000570399	0,007726008
8	0,005555754	0,007155609
7	-0,000488628	0,001599855
6	-0,000325488	0,002088483
5	0,001304231	0,002413971
4	0,004126076	0,001109739
3	0,002405425	-0,003016336
2	-0,005141569	-0,005421762
1	-0,000280193	-0,000280193

Table 2. Winsorized abnormal returns, including event date (1).

The hypothetical trading strategy according to the CARs would have meant buying on upon the negative incorporation of day two and selling after the positive incorporation of day nine. This would have generated an abnormal holding-period return of 2.24% in the case of the non-winsorized abnormal returns, and for the winsorized returns 1.32%.

7.2 Discussion

Although not significantly so, the test does show a tendency of the market responding quickly and negatively to a fatal event. This is plausibly in line with both the second-level market efficiency reasoning of Fama (1970), concerning the immediacy of news incorporation and availability of information, as well as Phillips' (2012) reasoning of social media's expansion allowing for substantially increased speed by which information may travel. Moreover, the two-day duration of incorporation of the information, as observable from the charts, is similar to the results obtained by Barret et al. (1987) concerning the incorporation time corresponding to airplane accidents. The tendency also aligns with the implications of Camm and Girard-

Dwyer (2004) surrounding the severe costs associated with fatally injured workers for mining companies. The fact that the average CARs tend to rebound after two days is in line with both the reasoning as well as the results obtained by Howe (1986), Dyl and Maxfield (1987, cited in De Bondt 1989), as well as Brown, Harlow and Tinic (1988, cited in De Bondt 1989). It also complies with the author's general reasoning concerning the mining sector as one of uncertainty and likely accommodation of psychological biases, and how this could induce further overreaction. All of which were mentioned in section 4 and comprised cornerstones to H1. In short, the general shape of the development of the CARs aligned well with H1.

As for the hypothetical trading strategy, both tests showed that it seemed not to be much of a superior trading pattern, even if hypothesizing leverage and short-selling – if one accounts for the bad-model risk, as mentioned by Fama (1998) and the incapability of the test to statistically prove the overreaction. This aligns with the skepticism of Malkiel (2003). It can thus be concluded, that a simple and seemingly exploitable trading strategy as presented by De Bondt and Thaler (1985) has not been discovered, in line with the reasoning of Fama (1970) and Malkiel (2003). Moreover, while one may base the reasoning of a seven-day buy-and-hold trading strategy from day two on the results obtained by Howe (1986), as the author of this report has done, constructing this sort of trading strategy, to some degree based on chart-depicted results, could plausibly be subject to the data-mining-related critique of Malkiel (2003). This reasoning may further be relevant to have in mind when analyzing any of the results based on the simulation. As the tests performed were not significant at the 5% level, however, the study fails to statistically confirm neither the results of the researchers mentioned in the above paragraph, nor the impact of CSR as described by neither of Panda (2018), McGuire, Sundgren and Schneeweis, (1988), nor by Davis' (1960, cited in Carroll, 1999), and it thereby cannot support the author's reasoning and hypothesis of a single fatal accident being enough to significantly and immediately impact the stock price of a company considered liable for the safe conduct of operations at the mine.

The author reasons that there are multiple possible explanations as to why neither reaction nor overreaction-related cumulative abnormal returns could not be statistically significantly proven. Firstly, concerning the initial reaction to the accident, it could be either that the market simply does not react, or that the reaction, while present, is plainly not significantly visible in the data studied by the test conducted. Regarding the former, the idea that the market does not react to new information of accidents related to a company aligns with the results obtained by Scholtens and Boersen (2011); it is possible that the mining industry, like the energy sector generally as the two observed and inferred, displays a tendency of accidents composing an inevitable consequence of the business. Hence, the accidents do not generate strong reactions in stock prices. It could, of course, also be that the market in fact has not become aware of the information. This would somewhat contrast to the reasoning of Fama (1970) and Phillips (2012) as outlined in the first paragraph of this section.

As for the second alternative, there are multiple possible explanations as to why a negative reaction, while present, could not be significantly proven in this case. It could be that these events were just not impactful enough compared to the largeness of the market capitalization of their related stocks to show significant results at this, compared to much earlier research, relatively small sample. Arguably close at hand lies to hypothesize a sampling error or a type-II error. Applying Investopedia's (2019) earlier mentioned description of a sampling error on this case; it could have been that other factors impacted the CARs observed to an extent that they failed to depict well the general CARs subsequent to a fatal accident. Similarly for a type-II error, as earlier explained by MacKinlay (1997) and Button et al. (2013); applied on this case it could have been that the actual impact of a fatal accident on a stock price and its rebound, could not be statistically proven to be different from zero due to its smallness in comparison to the large variance estimator resulting from a sample size of 30.

Due to the fact that the negative reaction was so small, the difference between day two and nine, which constituted the largest difference in the test, could not be statistically proven even as the ten-day-period CARs in question drifted to a net positive. Had it been the case that the initial reaction was statistically proven, yet the rebound not so, discussion as to why that would have been the case would have been in place. As this was not so, however, the author reasoned that speculating about the reasons to such an imagined scenario was beyond the scope of this report. The fact that the rebound was in total stronger than the negative initial reactions makes for a somewhat counter-intuitive result, as one would have expected a negative, while slightly so, net result. However, the net increase in CARs during the event window is far from significant, generating t-values of 0.83 and 0.38 respectively, indicating that they were derived by chance. The results could be explained as although a fatal accident might be incorporated in the stock price, on such large companies as observed, other major external factors impact the stock price to a further degree, which on a sample consisting of only 30 events likely could result in a minor positive abnormal return over the period. Again, as the obtained t-values indicate.

8. Conclusion

The primary purpose of this study was to answer the question: do stock investors overreact to fatal accidents in mining? It has not managed to confidently do so. Neither did it find proof of significant negative reactions, nor an exploitable trading pattern generating abnormal returns. However, while not significant at the 5% level, the results obtained did imply tendencies that shareholders, even of very large mining companies, react negatively and quickly to a fatal accident of a miner. Moreover, the results, when plotted, depicted a strong rebound tendency following the negative initial reaction. Nevertheless, it is in place to stress that these results should be interpreted with much caution. Not only were they not significant, but the test was also based on a fairly small and homogenous why the strength of the test was relatively low (MacKinlay, 1997) which also decreases the reliability of the obtained results (Button et al. 2003). Moreover, it is relevant to be somewhat skeptical to perceived patterns from charts, by the reasoning of Malkiel (2003). The fact that neither an initial reaction nor a following rebound, and together comprising an overreaction, could be statistically proven could have been due to the smallness of the sample and the relatively small impact of the events on their companies. Such a failure could also be the result of a sampling error. For this reason, the author encourages further similar investigation regarding minor fatal accidents as those assessed in this report, with an increased sample size. Furthermore, this report was restricted to shed light on the impact of fatal accidents including one to two individuals. As far as the author knows however, there is much research to be done regarding overreactions to accidents of larger magnitude, to which stronger reactions can be expected – again, in line with the reasoning of Howe (1986). It would also be of interest with a cross-national study, investigating whether differences among nations exist, and to what extent this might be so. Lastly, later researchers might want to add a multivariate test for comparison, as MacKinlay (1997) suggests. As the author of this report in hindsight concluded, it could have been feasible as a complement.

In conclusion, the study has in a unique way investigated market reactions and psychological forces attached to mining-related casualties, by a hypothesis built on an alignment of theories. At this sample size, significant, reliable results could not be attained. However, the study has in some sense contributed to further induce interest to build on this or a similar hypothesis and conduct further investigation, to obtain more clarity in the question of how markets react to fatal accidents in the mining industry. Interested in such information may for example be researchers of CSR, mining-company investors or even safety regulators.

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10. Appendix

10.1 Table of events

Event date	Company	Mined substance	Country of quotatio	Index used for market model	Market cap by year-end 2018 (billions of USD)
November 5 2019	Arcelor Mittal	Iron ore	USA	S&P 500 (Depositary receipt)	21.056
September 5 2019	Alliance Resource Partners	Coal	USA	S&P 500	2.221
June 10 2019	Vulcan Materials	Crushed, broken limestone	USA	S&P 500	13.018
March 7 2019	Cemex	Crushed, broken limestone	Mexico	S&P Mexbol	7.229
January 5 2019	Alliance Resource Partners	Coal	USA	S&P 500	2.221
November 11 2018	Newmont	Gold ore	USA	S&P 500	18.399
October 25 2018	Freeport-McMoran	Copper ore	USA	S&P 500	14.939
June 15 2018	Freeport-McMoran	Copper ore	USA	S&P 500	14.939
Feb 6 2018	Arch Coal	Coal	USA	S&P 500	1.48
October 31 2017	Silver Standard Resources	Gold ore	Canada	S&P/TSX Composite Index Canada	0.4185
September 20 2017	Cementos Argos	Cement	Colombia	COLCAP Index	4.3615
July 27 2017	Grupo Mexico	Copper ore	Mexico	S&P Mexbol	16.009
May 6 2017	Westmoreland Coal Company	Coal	USA	S&P 500	Defaulted
December 21 2016	Kinross	Gold ore	USA	S&P 500	4.038
August 9 2016	Cemex	Cement	Mexico	S&P Mexbol	7.229
April 11 2016	The Chemours Company	Titanium ore	USA	S&P 500	4.819
March 22 2016	Martin Marietta	Lime	USA	S&P 500	17.269
March 8 2016	CRH PLC	Construction sand and gravel	Ireland	ISEQ All-Share Ireland	21.576
July 25 2016	Vulcan Materials	Crushed, broken limestone	USA	S&P 500	13.018
January 19 2016	Alliance	Coal	USA	S&P 500	2.221
December 29 2015	Barrick Gold	Gold ore	USA	S&P 500	15.798
August 19 2015	Alliance Resource Partners	Coal	USA	S&P 500	2.221
May 18 2015	Buzzi Unicem	Cement	Italy	FTSE Italy	3.4238
January 8 2015	MDU Resources	Construction sand and gravel	USA	S&P 500	4.673
November 18 2014	Alcoa alumin	Alumina	USA	S&P 500	4.911
July 23 2014	Cemex	Cement	Mexico	S&P Mexbol	7.229
June 20 2014	Cloud Peak Energy Resources	Coal	USA	S&P 500	0.028
April 28 2014	Klondex	Gold Ore	USA	S&P 500	0.467
March 25 2014	Alliance Resource Partners	Coal	USA	S&P 500	2.221
February 27 2014	Martin Marietta Materials	Crushed, broken limestone	USA	S&P 500	10.806

Table 3. Events