

*PLATINUM SHARE PRICES AND THE MARIKANA TRAGEDY: AN EVENT
STUDY*

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DECLARATION

I hereby confirm that, except for the references specifically indicated and acknowledged in the text, this work is wholly my own, and has not been handed in or submitted to any other University, Technikon or College for degree purposes.

Signed:

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ABSTRACT

An event study is an economic tool of analysis that has begun to gain popularity in recent empirical literature. It is a technique that gives a researcher the opportunity to map out the reaction of a firm's stock to an event, usually making use of daily or monthly data. However, up to this point, event study methodology has generally been applied to more traditional phenomena capable of affecting equity value, such as dividend and macroeconomic policy announcements, and there have only been a few exceptions to this.

This study looks at what impact the tragic shootings at Lonmin mine in Marikana on August 16th 2012 had on the share prices of platinum mining firms based in South Africa using event study methodology. It makes use of the technique to investigate how the share prices responded to the tragedy over a number of trading days, including the day of the shootings. To be best of our knowledge, no attempt has been made to analyse the impact on share prices using events of this nature.

For the investigation, daily returns data was used for each firm. The abnormal returns and cumulative abnormal returns to each were then calculated and compared with their respective expected returns in order to determine whether investors in the shares of that particular firm reacted positively, negatively or not at all.

The evidence found suggests that tragedies of this nature are capable of influencing share prices in the same manner as more traditional economic phenomena. Overall, only one firm was found to have been negatively affected by the shootings in a persistent manner, while the shares of the other firms examined reacted in a manner that was positive overall, but varied according to individual firm characteristics such as size. These findings conformed to our *a priori* expectations. In addition, the results also confirm the benefits of applying event study methodology to a wide variety of phenomena that fall outside the boundaries usually associated with business.

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LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
ALSI	All Share Index
AMCU	Association of Mineworkers and Construction Union
AMS	Anglo American Platinum
ANCYL	African National Congress Youth League
AQP	Aquarius Platinum
AR	Abnormal Return
CAR	Cumulative Abnormal Return
CAPM	Capital Asset Pricing Model
COSATU	Congress of South African Trade Union
FTSE	Financial Times-Stock Exchange
IMP	Impala Platinum
JSE	Johannesburg Stock Exchange
KPSS	Kiatkowski-Phillips-Schmidt-Shin
LON	Lonmin Platinum
NOR	Northam Platinum
NUM	National Union of Mineworkers
OLS	Ordinary Least Squares
RBP	Royal Bafokeng Platinum
SAPS	South African Police Service

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CHAPTER ONE

INTRODUCTION

1.1 CONTEXT OF THE RESEARCH

African countries have been blessed with vast mineral wealth. Deaton (1999: 23) noted that “African economies are heavily reliant on the export of primary commodities.” South Africa is no exception to this phenomenon. It is a nation that, like many others, is well-endowed with a considerable mineral resource base. One of the resources that South Africa specialises in extracting and exporting, as well as the resource that is the focus of this study, is platinum.

Because South Africa holds such a massive contribution to the global production of platinum, it goes without saying that disturbances within the platinum mining industry would have significant ramifications not only for South Africa, but the world at large. The platinum sector is not only important for its significant financial, logistical and economic presence, but also for the direct and indirect employment opportunities that stem from economic ventures of this nature.

South Africa is also a heavily unionised country that appears to have sectors and industries that are prone to industrial action. Over the past decade strike action, whether protected or unprotected¹, has formed a regular part of the country’s economic and political landscape, and numerous articles and analysis can be found in various media sources discussing this phenomenon. Industrial action in various sectors of the economy is by no means a strictly South African occurrence. However, the frequency and occasionally violent nature of some strikes, as well as the relative size and influence of the unions that operate in the various economic sectors, result in South Africa being a more notable research topic than others.

Generally speaking, the annual period of increased industrial action throughout various sectors and industries in South Africa is known as the ‘strike season’. It usually begins in earnest during mid-year (June), and it generally runs up until September. Strike action generally involves attempts by established trade unions such as the National Union of Mineworkers (NUM), Solidarity and Congress of South African Trade Unions (COSATU) and their members to achieve improved sectoral wage contracts and/or additional

¹ In South Africa, an unprotected strike is defined in the Labour Relations Act (1995) as strike action that does not conform to the procedural requirements of an industrial action as set-out within the Act.

employment benefits from employers, regardless of whether the employers may be from the public or the private sector. For the purposes of this study, because ‘strike season’ has become an annual occurrence that is largely predictable in terms of both timing and sectors affected, it was assumed that, in this manner, the industrial action that immediately preceded the shootings had little effect on the share prices analysed. However, there is scope for a more in depth analysis of this issue in future.

The event that this study examines occurred in the second half of 2012. On August 16th 2012, several miners involved in an illegal strike at the Lonmin platinum mine in Rustenburg were fatally wounded by members of the South African Police Service (SAPs).

1.2 OBJECTIVE OF THE STUDY

The objective of this study is to examine the reaction of platinum share prices listed on the Johannesburg Stock Exchange (JSE) to the events at Marikana in 2012.

1.3 MOTIVATIONS FOR THE STUDY

On August 16th 2012, several miners involved in an illegal strike at the Lonmin platinum mine in Rustenburg were fatally wounded by members of the South African Police Service (SAPS). Much has been written and discussed about the tragedy at Marikana, and the discourse on the socio-economic and financial ramifications continues to this day.

As South Africa has such a significant contribution to the global production of platinum, it goes without saying that disturbances within the platinum mining industry could potentially have significant ramifications not only for South Africa, but the world at large. However, for some reason or other, empirical investigations of the tragedy have not occurred at the same pace as other forms of analysis, at least up to this point. To the best of our knowledge, no empirical study has yet been conducted that focussed specifically on either the events at Marikana or the broader platinum sector within the context of unrest in that sector and industrial action.

This study looks at platinum shares listed on the JSE. Specifically, the study makes use of event study methodology to examine whether the tragic events at Lonmin mine in Marikana in 2012 affected the share prices of six platinum mining firms listed on the JSE in view of the tragedy. As noted by Binder (1998: 111), event study methodology has become the “the standard method of measuring security price reaction to some announcement or event.”

The use of an event study does not appear to have been employed often within the context of emerging market economies. The vast majority of the event studies that have been performed on stock markets, as well as the research that has taken place on event study methodology theory itself, have focused primarily on the European and American stock markets (or their data), with a distinct lack of studies on African equity markets, particularly that of South Africa which holds the distinction of having the largest and most technologically developed financial markets in the region.

A recent attempt to address this deficiency in the literature was made by Gupta and Reid (2013) in their analysis of the impact of macroeconomic surprises on industry-specific stock returns in South Africa, where a number of the macroeconomic variables under consideration were found to affect stock returns significantly. Another recent empirical study by Botha and de Beer (2013) explored whether national sporting performance in South Africa was capable of influencing investors to the extent that altered returns to stocks on the JSE in a statistically significant way. The main conclusion drawn from this study was that although there was some evidence that pointed to a relationship between the two, national sporting performance did not significantly explain abnormal returns that occurred on the JSE over the analysis period.

The deplorable violence that occurred at Lonmin mine can be categorised as being a non-economic anomaly or occurrence. A number of prior studies have been conducted with the view of identifying how a wide range of non-economic variables may impact prices on stock and other financial markets. Previous research has made use of event study methodology to examine potential relationships between returns to equity markets and non-economic events that include the weather, sleep patterns, seasonal affective disorder, and mega sporting events (Botha and de Beer, 2013), as well as the popular uprisings and political movements that occurred during the Arab Spring uprisings in the Middle East over the course of 2011 (Abdelbaki, 2013).

A study by Guidolin and La Ferrara (2010) looked at the economic effects of the onset of violence on equity markets, using evidence from a large sample of violent conflicts at both the local and inter/intra-state levels. The focus on the 'onset' of the conflicts rather than the conflict themselves was necessary in order to gauge the true response of the financial markets under investigation in their study. In spite of the fact that the focus of the research undertaken in the Guidolin and La Ferrara (2010) paper is markedly different from the focus

in this paper, the fact that violence exists as a connecting strand suggests two things. Firstly, the use of event study methodology as the tool of analysis in this paper is correct. Secondly, it is both possible and plausible to apply event study techniques to phenomena that do not fall within the traditional categories of investigation within financial research.

In contemporary times, financial data is widely available in large volumes and high frequencies. The nature of event studies is such that, depending on the goals that have been set out, various frequencies of data can be made use of. As a result, due to the nature of the event being considered in this study, it is appropriate to use higher frequency data in the form of daily trading observations for the estimations. Therefore, daily data is used in this study.

To the best of our knowledge, this is the first empirical study in South Africa that analyses the impact of the tragic events of this nature on stock markets. The size and importance of the mining sector both locally and internationally make study of this nature extremely relevant, particularly in an era of financial globalisation and high-speed transmission of information.

The insight and results obtained from this study will be of interest to industry analysts and investors, as this paper employs a different method of analysis on financial phenomena that runs complementary to more traditional tools (such as technical and fundamental analysis).

1.4 METHODS OF STUDY

In order to carry out our empirical investigation, it is necessary to create the necessary foundation. As a result, our first port of call is to carry out an in-depth review and discussion of the required empirical and theoretical literature, both historical and contemporary. During the review of the literature, there will be focus on both the seminal and contemporary papers that are most relevant to the goals of our study.

For our empirical study, we will make use of daily stock market return data for the six platinum mining firms operating in South Africa that form the components of the FTSE/JSE Platinum Mining Index. The dataset for each firm will canvass the period 2012/03/22 to 2012/09/07. The formal econometric methodology that will be used in this paper is an event study. Before this event study techniques are applied, we will perform a number of descriptive statistical statistics which include reports on the mean, maximum, minimum, standard deviation, skewness, kurtosis and the Jarque-Bera test for normality. This analysis is done in order to examine the distributional properties of the data before the application of the formal event study procedures and techniques.

The event study procedure involves the several steps. The first is the defining the normal returns to each absence of the event under consideration, using an estimation period that is set for a time period before the event and at a length that is sufficiently long to form a valid map of the returns. This step is performed by regressing the returns to each firm against an index that represents returns to the market. The second step will involve defining an event window that includes the day of the event being investigated (in this case, the shootings that occurred at Marikana). Third step is to calculate the abnormal returns and cumulative abnormal returns experienced to each share over the course of the event window using the difference between the expected returns and the actual returns on any particular day. For the fourth step, standard *t*-tests will be used in order to determine whether the ARs and CARs found (if any) are statistically significant. Lastly, a discussion will take place for each firm that will attempt to offer reasons may explain the results found, using the tragedy and the surrounding events and socio-economic and political contexts as frames of reference.

1.5 ORGANISATION OF THE STUDY

The study is organised as follows: The next chapter conducts a survey of theoretical and empirical literature on event study methodology. It is divided into two main sections. The first examines the basic theory and origins of event study analysis, while the second examines a number of important prior empirical studies, both historical and recent. Chapter 3 discusses the data that will be made use of, while it also sets out the methodology that will be adopted and employed in order to achieve the objective. The outcome of this empirical study and its results are presented and analysed in Chapter 4. Lastly, the conclusions and areas of further research are highlighted in Chapter 5.

CHAPTER TWO

ANALYTICAL FRAMEWORK

2.1 INTRODUCTION

Having set out the context for our study by stating the motivations and objective of this study, we now set out and explore the analytical framework for the event study techniques that we will use for the objective set out in Chapter 1. This chapter is divided into two sections. The first section examines the theoretical foundations for event studies, with a focus on the origins of the techniques and issues of concern that may arise during the empirical analysis. The second section discusses a number of past empirical studies that have made use of event study as their primary investigation tool. These past studies include the seminal papers by Brown and Warner (1980; 1985) and contemporary papers that utilise event studies in looking at unconventional events such as natural disasters, event that arguably fall within broadly the same category as the tragedy we investigate in this paper.

2.2 EVENT STUDIES: ORIGINS

Event studies are a fairly recent addition to the toolkit of empirical analysis within the financial context. The idea for and concept behind event studies arose from the seminal paper put forth by Fama, Fisher, Jensen and Roll (1969). However, it has been argued that the ‘seed’ for event studies was introduced by Dolley (1933). As noted by Binder (1998: 111), the methodology created by Fama *et al* (1969) has become the “the standard method of measuring security price reaction to some announcement or event.”

The purpose of the Fama *et al* (1969) paper was to investigate how stock market prices adjust to new information. This research was conducted within the context of a stock split.² The Fama *et al* (1969) paper analysed abnormal price movements surrounding the time of the split and hypothesised that there would be no significant price change after a stock split occurred, because all the relevant information would be reflected in the post-split price already. Their hypothesis was an investigation of the semi strong Efficient Market Hypothesis (EMH), a concept that will be discussed in detail later in this research, and their empirical investigation served to confirm this form of the EMH.

² A stock split is a corporate action in which a company's existing shares are divided into multiple shares, as discussed by Reilly and Brown (2012: 152).

The Fama *et al* (1969) paper is noted for the methodology it introduced in analysing financial phenomena such as the stock split announcement they investigated. The methodology they created and employed in their investigation forms the basis for methodologies used in event studies that followed. The need for research techniques such as event studies is important because of the need to measure the effects of an economic event on the value of a firm (Mackinley, 1997: 13).

In spite of event study techniques being fairly recent addition to empirical studies, the body of literature relating to event studies is very large and continuously growing. This fact is put into perspective in a succinct manner by Kothari and Warner (2007). In conducting a review of the econometrics of event studies, the authors attempted to quantify the size of the body of literature produced on event studies over the period 1974 – 2000, canvassing five prominent financial journals. They found that, during the period reviewed, there were 565 event study results reported throughout the five journals.

As revealed by Henderson (1990: 282), there are two main forms of event studies that a researcher can make use of. The first are market efficiency studies, and they deal with how quickly and correctly a market to a particular type of new information. The second forms are known as information usefulness studies. These deal with analysing how company returns react to a specified type of information. Due to the nature of these forms, event studies have several applications.

However, event studies are not without problems. Brown and Warner (1980) placed great emphasis on the importance of taking care in defining and selecting event dates. Specifically, they noted that, as the number of days, months or other intervals used increased within an event window (because of an inability to pinpoint an exact event date/period), the power of the event methodology decreases (Brown and Warner, 1980: 224-27). The ‘power’ of an empirical test refers to “the probability of rejecting a false null hypothesis” (Enders, 2010: 234). A test with good power will correctly reject a null hypothesis during the statistical testing phase of the research.

Henderson (1990: 292) discussed the potential issues that arise during the use of econometrics techniques. The models used in econometrics for testing rely on a set of assumptions regarding such as normally distributed residuals with zero mean, constant variance and the absence of autocorrelation. The problems with these assumptions lies in the fact that, within the financial context, research evidence has found that returns to securities

are not normally distributed; an issue that is made even worse “in the case of daily returns that are increasingly popular in event studies”. Such issues gave rise to the creation and use of nonparametric event studies, an area that will be discussed in detail in a forthcoming section.

In recent years, there has been an increase in attempts to review an event study as a statistical tool. For example, Ahern (2009) found evidence demonstrating that it is possible to introduce severe biases during an event study if, during the sample selection stage, securities grouped by certain common characteristics such as market capitalisation and book-to-market ratio are selected. This suggests that greater care should be taken in sample selection procedures.

Barakat and Terry (2010), in a re-evaluation of event study methodology, found evidence that event studies that make use of cumulative abnormal return (CAR) can lead to misleading inferences regarding market efficiency and behaviour after the event has occurred.

2.2.1 Parametric vs Non-Parametric Event Study

Since the introduction and inception of event study methodology, much literature has been produced on the subject. Out of this vast body of literature, two main procedures for conducting an event study have been regularly discussed. These are parametric and non-parametric event studies, statistical notions that are widely used across different research subjects and professions.

Parametric statistical procedures rely on a number of detailed assumptions such as the probability distribution of returns to the security (Cowan, 1992). Related assumptions to this concept include expectations concerning normality, homogeneity of variance, and the presence of independent errors.

The parametric event study techniques that are of use today were heavily influenced by the methodology introduced by Brown and Warner (1985). In that paper, the authors examined test statistic performance using daily data, while also discussing the underlying assumptions of event studies in depth. They concluded that standard parametric methods display both good specification and good test power when daily data is used. Their findings in that paper influenced many authors since they were published, and there appears to be consensus among many including, for example, McWilliams and McWilliams (2000) and Corrado (2011) that empirical work in finance and accounting relies heavily on the methodology of Brown and Warner (1985).

Nonparametric statistical procedures form a stark contrast to traditional parametric procedures. Nonparametric methods developed because, as noted by Corrado (2011: 214), prior research highlighted the potentially serious effect that non-normality could have when making use of returns data from different sources. Specifically, security returns data that are not normally distributed can lead to both poorly specified parametric tests and imprecise inferences because the assumptions of normality upon which parametric tests have been based are violated. Cowan (1992) found evidence supporting the view that event studies using parametric techniques were the most prevalent, while emphasising the disadvantages of the detailed assumptions about probability distribution upon which they are based.

2.2.2 Behavioural Economics: theory and practice

In the same way as event study methodology can be viewed as a fairly recent development in economic research, the same can be said of behavioural economics and theory upon which it is based. Two key assumptions dominate, and have shaped traditional literature on financial markets. The first assumption holds that individuals collect and make use of all available information in making decisions of a financial nature that are considered to be rational, while the second assumption holds that such individuals have a capacity to process information that is unlimited, which allows them to continuously update their beliefs using the recently acquired information (Garca, 2013: 297). These assumptions mean that individual investors form and hold rational expectations using all the information available to make financial decisions.

Behavioural economics is an area of important research because it investigates the implications and results that arise from dropping the two assumptions (and, as a consequence, the rational expectations too) briefly discussed above. That is, behavioural economics examines how individuals make decisions when all the information required to make a rational and informed decision is not available; and when investors are incapable of processing all the information in an efficient manner. In the words of Robinson and Hammit (2011: 1410), behavioural economics look into why humans' actual financial behaviour often violates the assumptions and models upon which neoclassical economic theory is based, and "insights from psychology, sociology, and other fields (are used to) consider how human behaviour may deviate from this model".

To achieve this, behavioural finance delves into other research spheres outside of financial, such as psychology and sociology. Hursh and Roma (2013: 98) defined the field of

behavioural economics as a series of “cognitive processing hypotheses” that are based within the Psychology research, seeking to use these principles to explain violations of neoclassical theory and assumptions that are often found in practice.

Although the field of behavioural finance is an interesting area of research, it will not be dealt with further for the purposes of our study. The reason for this is there is still much debate and controversy surrounding the propositions it expresses. In addition, it also lacks of adequate level of empirical foundation that is required for use in this paper. Lastly, it is not necessary to make use of behavioural finance theory as our research is already well founded in traditional Efficient Market Hypothesis theory and research. As a result, the tenets of this area will be relied upon in our study.

2.2.3 Benchmark models

There are a number of measurement techniques that can be made use of when event studies are conducted. Abnormal and Cumulative Abnormal returns are two examples that have been made use of widely for the purposes of event studies. However, in order to understand abnormal returns of any type, it is necessary to consider them against benchmark, which is known as the benchmark model. The creation of the benchmark model is a crucial first step in running the actual simulations, and its importance cannot be understated. Brown and Warner (1980: 207) confirmed that it was necessary, noting that the specification of “a model generating ‘normal’ returns” is necessary before abnormal returns can be measured and reviewed.

Further, Brown and Warner (1980) noted that there are three types of models in event studies, namely that are made use of in event studies, namely *Means Adjusted Returns* model, the *Market Adjusted Returns* model, and the *Markets and Risk Adjusted Returns* model. All three models will be expanded upon in greater detail in Chapter 3.

However, twenty-nine years later, Ahern (2009: 469), in an analysis of sample selection and event study estimation techniques, stated that in contemporary times, “the most commonly used prediction method (of normal returns) is the market model.” The Market model is created by regressing the security’s returns on a constant term and a market index. The Market model is also similar to the Market Adjusted Returns model mentioned by Brown and Warner (1980) previously, as both require the selection of a market index.

2.2.4 Abnormal Returns

Ma, Pagan and Chu (2009: 238) revealed that “most event studies examine abnormal returns” around an event date (the event date can be specified, or it can be inferred if a specific date cannot be pinpointed), and these are commonly used as “indicators of value creation or destruction” with respect to that particular security.

Abnormal returns to a particular stock or security are calculated as the difference between the stock’s actual return and its expected return over a specified period (Pinnuck, 2005: 200). Additionally, Cowan (1993: 52) revealed that, within the context of predicting returns to financial securities using statistical modelling, “abnormal returns in event studies are (function as) prediction errors.”

2.2.5 Cumulative Abnormal Returns

There are a number of measurement techniques that can be made use of when event studies are conducted. Cumulative abnormal returns (CARs) are an example of such measures, and these shall be discussed in the forthcoming section.

Cumulative abnormal returns are one of the means that can be used to measure responses to an event. In the words of Lee and Connolly (2010: 354), CARs estimates “measure an abnormal effect of a particular event on the value of a firm, assuming that stock prices instantly reflect the impact of such an event.” Obtaining CARs is done by summing the difference between the expected return on a security, and the actual return on the security after the event being investigated has occurred.

One of the most important uses of the CAR concept is in determining whether or not the event being considered displayed some level of persistence. If this is found to be the case, the CARs for successive periods must be statistically significant and either positive or negative (depending on what impact the event(s) had). This usefulness means that throughout event studies, measures of CARs are widely used.

2.3 TRAGEDIES vs. NATURAL DISASTERS

As has been touched upon in the previous chapter of this research, almost no empirical investigation has been conducted using event study methodology to examine the effect of a tragedy on financial markets. Over the course of this research, only a handful of empirical examples could be found that could reasonable be viewed as being similar to, or at least

within the same category as an event such as the Marikana tragedy. Two potential reasons exist that may be able to explain this inconsistency.

Firstly, tragedies are not in the same category, and also do not occur as frequently as other types of events that affect financial markets (such as merger and acquisition announcements and stock splits). Nevertheless, they may have a similar impact as these more traditional events. And secondly, following on from this, although a great deal of literature continues to be contributed to event study research as a whole to this day, ‘extraordinary’ events have not been offered the same amount of attention.

However, an exception to this arises in cases where the ‘extraordinary’ event in question is a natural disaster. Naturally disasters are generally large-scale events that are more likely to have a greater effect on markets than other events that cannot match their magnitude. Two such natural disasters that have been examined using event studies were BP’s oil spill environmental disaster at Deepwater Horizon in 2010, and the tsunami-caused nuclear disaster that occurred in Japan’s Fukushima region in 2011. The event studies that were employed to examine these two natural disasters will be discussed in detail in the following chapter, as they form an important starting point for conducting the event study proposed in this paper.

2.4 EVENT STUDIES: THEN AND NOW

Two seminal papers by Brown and Warner (1980; 1985) have broadly shaped the direction of event studies over the last thirty-plus years. In 1980, Brown and Warner conducted a number of simulations using different event study methodologies. One of the goals was to discover the statistical ‘power’ of the various methodologies. Brown and Warner (1980: 206) described the power of a test as “the probability, for a given level of Type I error and given level of abnormal performance, that the hypothesis of no abnormal performance will be rejected.”

A Type I error occurs when a researcher rejects a null hypothesis when it is, in fact, true; while a Type II error occurs when a researcher fails to reject a null hypothesis that is, in fact, incorrect. In both cases, the null hypothesis is the absence of abnormal returns. Tests with high power will correctly reject or accept null hypotheses, making them ideal for correctly detecting the presence of abnormal performance

To do an event study, one must create a ‘general model’, which is necessary to test for abnormal returns. The three most commonly used general models in event study research were used by Brown and Warner (1980). The three are: the *Mean Adjusted Returns*, *Market Adjusted Returns* and the *Market and Risk Adjusted Returns* models. Earlier, Ahern (2009: 469) noted that the most commonly used model today is the Market model, a model that bears several similarities with the Mean Adjusted Returns model.

2.4.1 Mean Adjusted Returns model

This model assumes that *ex ante* expected return for a security i is equivalent to a constant K_i which can differ across different securities. The return is expressed in Equation 2.1 as follows:

$$E(R_{it}) = K_{it} \quad [2.1]$$

The predicted *ex post* return on the security i in time period t is equal to K_i . The abnormal return ε_{it} is equal to the difference between the observed return, R_{it} , and the predicted return is defined by Equation 2.2 as:

$$K_{it} : \varepsilon_{it} = R_{it} - K_{it} \quad [2.2]$$

The Mean Adjusted Returns model has the distinction of being consistent with the Capital Asset Pricing Model (CAPM) referred briefly in the previous chapter. The CAPM predicts that a security’s expected return is constant under the assumptions that the security has constant systemic risk and that the efficient frontier is stationary.

2.4.2 Market Adjusted Returns model

The Market Adjusted Returns model assumes that *ex ante* expected returns are equal across all securities, but they are not necessarily constant for a given security. Due to the fact that portfolio management theory holds that the market portfolio of risky assets M is equal to a linear combination of all the securities, and as per Equation 2.3, it follows that:

$$E(R_{it}) = E(R_{mt}) = K_{it} \quad \text{for any security } i \quad [2.3]$$

The *ex post* abnormal return on any security i is given by the difference between its return and the return to the market portfolio, as demonstrated by Equation 2.4:

$$\varepsilon_{it} = R_{it} - R_{mt} \quad [2.4]$$

In the same manner as the Mean Adjusted Returns model, the Market Adjusted Returns model is also consistent with the Capital Asset Pricing Model if all the securities have systemic risk of unity.

2.4.3 Market and Risk Adjusted Returns model

This model assumes that some form of the CAPM generates expected returns. Brown and Warner (1980) make use of Black's (1972) two-parameter Asset Pricing Model, which is expressed in Equation 2.5 as follows:

$$E(R_{it}) = E(R_{zt}) + \beta_i[E(R_{mt}) - E(R_{zt})] = K_{it} \quad \text{for any security } i \quad [2.5]$$

where R_{zt} is the return on the minimum variance portfolio of risky assets which is uncorrelated with the market portfolio. In the Black model expresses the abnormal return ε_{it} in Equation 2.6 as being equal to:

$$R_{it} - [R_{zt}(1 - \beta_i) + \beta_i R_{mt}] \quad [2.6]$$

For emphasis, it should be noted that the return to the three models discussed above, R_{it} , which will be realised by security i in time period t , is given by Equation 2.7 as:

$$R_{it} = K_{it} + \varepsilon_{it} \quad [2.7]$$

where K_{it} is the expected return given by the particular benchmark model being used, and ε_{it} , which is unknown at the beginning of time period t , is the component which is abnormal or unexpected.

2.4.4 Sample creation and abnormal performance

For their simulations, the authors made use of publically available monthly data from June 1971 to February 1977 sourced from the Centre for Research in Security Prices (CRSP) at the University of Chicago. A hypothetical event month was then generated for each security, with equal probability of these hypothetical events occurring during one of the months within the range. Brown and Warner (1980) artificially introduced abnormal performance into a given sample. This was done by transforming the actual data for the given sample.

Once abnormal performance has been introduced into the sample returns, abnormal performance measures are calculated using the three returns-generating models mentioned previously. Brown and Warner (1980) made use of three types of statistical tests, and these

were standard t -tests, and two nonparametric statistical measures in the form of the sign test and a Wilcoxon signed rank test. The findings that Brown and Warner (1980) made in testing the null hypotheses are beyond the scope of this research. However, it suffices to note that, in general, all the methodologies regularly succeeded in detecting abnormal performance of 1% and 5%. Critically, these results are dependent on whether the time of event has been correctly identified.

Brown and Warner's follow-up paper in 1985 is a continuation of their 1985 paper discussed in the foregoing section. Daily data and the properties surrounding its use in event study methodology were investigated. The paper is relevant to the study we are carrying out because this research also makes use of event study techniques using daily data. The notable concepts that were discussed in the paper included non-normality of data, and the estimation of both variance and excess returns.

Empirically, Brown and Warner (1985) made use of three models for the measurement of excess returns. These are the Mean Adjusted Returns, Market Adjusted Returns and the OLS market models. The first two models are taken from Brown and Warner (1980). The null hypotheses tested were that the mean day '0' excess return (that is, the event day) for the simulations is equal to zero. All three displayed good test power, suggesting one may be somewhat indifferent with regards to the choice of a methodology. Additionally, rejection frequencies of these methodologies are three times those observed when monthly data in Brown and Warner (1980), suggesting that substantial gains to test accuracy and test power occur when the time of the event under investigation is specified precisely.

Based on all the findings of Brown and Warner (1985), it is possible to conclude that there the use of daily data in our research will provide a straightforward and advantageous way of examining the impact of the incident at Marikana on the platinum share prices of the firms being investigated.

2.5 NATURAL DISASTER-BASED EVENT STUDIES

A number of event studies that have been undertaken in recent years will now be discussed in this section. They offer methodological insights and techniques for our research. In addition, the nature of these case studies is such that they can reasonably be regarded as being comparable to the Lonmin tragedy in terms of impact, in both the human sense, and the financial sense.

Capelle-Blancard and Laguna (2010) looked at the financial implications of industrial disasters (in this case chemical disasters) that occurred across a number of countries, all of which had significant consequences on the stock market. The period of study was 1990 - 2005.

Capelle-Blancard and Laguna (2010: 195) incorporated explanatory variables that included a *human harm* variable that took into account the number of fatalities and injuries caused by the accidents, a dummy variable for *pollution*, a *reputation* variable which act as a signal about the environmental riskiness of each firm in the absence of perfect information, and an *abnormal media coverage* variable that to capture the visibility of each individual firm at the time of the corresponding incidents (which may have an effect on stock returns through channels such as increasing the number of informed investors).

Motivations were given by Capelle-Blancard and Laguna (2010: 197) to explain the decreases in stock market value. The reasons cited include, but are not limited to the costs associated with the damage to fixed assets such as property, loss of and damage to inventory, raw materials and finished products, increased riskiness perception of the firm as a result of the incident(s) which in turn could lead to a change in market capitalisation if investors decide to rebalance their portfolios away from the firms, and additional liabilities such as personal injuries or any environmental penalties applicable.

Capelle-Blancard and Laguna (2010: 198) made use of the market model for their research, and this model was specified by Equation 2.8 that follows:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \quad [2.8]$$

The normal relationship between observed returns to a given security i at time t , $R_{i,t}$, and the market returns at the same time, $R_{m,t}$, is given above. The term $\beta_i R_{m,t}$ is the portion of the return to security i on day t that is caused by market-wide factors. In addition, the parameter α_i measures the portion of the average daily return to the stock that is not due to market movements. Finally, $\varepsilon_{i,t}$ is a measure in the change in value to the firm's stock on day t that cannot be attributed to either movements that take place in the market or the average daily return of the firm.

On the day of the event, the deviation of the daily return to each individual security from its expected daily return value is known as the prediction error (abnormal returns), and is taken

as an unbiased estimate of the financial impacts of the event. Abnormal returns/prediction errors are calculated using Equation 2.9:

$$AR_{i;t} = R_i - \hat{\alpha}_i - \hat{\beta}_i R_{m;t} \quad [2.9]$$

The terms $\hat{\alpha}_i$ and $\hat{\beta}_i$ are estimates of the α_i and β_i parameters respectively that were discussed before. Ordinary Least Squares (OLS) procedures for the estimation of unknown parameters were used in order to estimate the market model parameters. The results found by Capelle-Blancard and Laguna (2010) suggest that stock markets react negatively and quickly to incidents of this nature, with differences in the magnitudes of losses for individual firms being caused by the nature and unique traits of both the accidents and the firms themselves.

Ferstl, Utz and Wimmer (2012) conducted a study into the financial effect of the 2011 Japanese Fukushima-Daiichi nuclear disaster on the value of nuclear and alternative energy stock worldwide. In contrast to the previous research that has been done on the financial impact of nuclear disasters that have occurred in the past which made use of event study methodologies structured on the CAPM, Ferstl *et al* (2012) took an alternate approach. The authors opted to make use of the three factor model developed by Fama and French (1993).

Fama and French (1993) identified common risk factors that could affect that level of returns to stocks and bonds. While such a broad investigation is beyond the scope of this paper, it is important to note that the three factor model Fama and French (1993) developed was found to be a better measure of the firm-specific risk factors that affect returns. This is one of the main reasons that motivated the use of this three factor model by Ferstl *et al* (2012), as their focussed research looks at only nuclear energy and alternative energy firms.

For the return to a single asset, the Fama and French three factor model is specified as follows by Equation 3.10:

$$R_t = \beta_0 + \beta_M M_t + \beta_{SMB} SMB_T + \beta_{HML} HML_t + \varepsilon_t \quad [2.10]$$

The term R_t is the return to the stocks of a specific firm, M_t is the return to the market portfolio, SMB_t is the return to the small-minus-big portfolio³, and HML_t is the return on the high-minus-low portfolio⁴. Finally, ε_t represents the excess returns that occurs on day t .

³ The small-minus-big portfolio accounts for the spread in returns between small- and large-sized firms.

⁴ The high-minus-low portfolio accounts for the spread in returns between value and growth stocks in arguing.

Ferstl *et al* (2012) developed two testable hypotheses for both nuclear energy and alternative energy respectively. For nuclear energy firms, the hypothesis was whether or not the event affected ARs and CARs for these stocks. For alternative renewable energy firms, the hypothesis was whether or not the event affected ARs and CARs for these firms.

Three conclusions were made. Firstly, the Fukushima-Daiichi nuclear disaster was incorporated into the stock prices of both nuclear energy and alternative energy firms within the space of a few days after its occurrence. This conclusion is notable because it appears to provide support for the concept of semi strong market efficiency. Additional results of importance include significant negative abnormal returns found for the nuclear energy firms in France, Germany and Japan during the first trading day immediately the incident, as well as non-significant abnormal returns being found for firms based in the United States.

Secondly, the mean CARs for nuclear energy firms were negative throughout the entire event window used, while an inverted effect was seen for alternative energy firms, experienced positive performance in most countries when short and medium term reactions to the incident were considered. These findings confirmed the expectations by Ferstl *et al* (2012) at the outset of their study.

Finally, Ferstl *et al* (2012) concluded that majority of the ARs found during the course of the post-event window were caused by confounding events (extraneous variables that are correlated with both the dependent and independent variables under investigation). Confounding events included an election victory by the Green Party in a German state, and a default on annual interest payments by Raser Technologies (RZTI) in the US.

Overall, it can be said that the research by Ferstl *et al* (2012) provides valuable empirical insight into the financial effect when specific firms are targeted. In particular, this paper makes use of techniques that are relevant for our own research.

Further insights into the financial impacts of large-scale disasters on the share market are provided by Gangopadhyay, Haley and Zhang (2010). They examined share price behaviour in response to two hurricanes that occurred in 2005 – Hurricane Katrina and Hurricane Rita. These hurricanes occurred within three weeks of each other. The combined effect of both led to catastrophic levels of both human and economic loss. Event study techniques were used to analyse the financial impacts of both hurricanes on the share prices of insurance firms responsible for loss of life and property damage in the affected areas.

Two counterbalancing hypotheses were identified in the research that had the potential to explain how investors would view the impact of the catastrophes on the shares of insurance firms (which may lead to the restructuring of portfolios should this be deemed necessary).

The first hypothesis is the proposition that hurricanes will affect the insurers negatively by affecting the ability of each individual insurance firm's reserves to absorb damage claims that will arise as an additional consequence. The second hypothesis suggests that, as a direct consequence of the event, insurers will likely experience an increase in demand for their services and/or increase insurance premium rates for policies.

In their empirical results, Gangopadhyay *et al* (2010) made a number of interesting findings. For Hurricane Katrina, both average daily ARs to firms with and without exposure in the US states that suffered, and CARs (also to both exposed and non-exposed firms) all revealed a significantly negative response to the disaster. These results, which appear to fit well with the proposition that investors could have anticipated and responded to negative events in New Orleans, lend support to the first hypothesis (that investors respond to uncertainty regarding the ability of firms to fully absorb damage claims).

When Hurricane Rita was considered instead, Gangopadhyay *et al* (2010) found that the firms (both exposed and non-exposed) experienced an oscillating combination of both significantly negative and significantly positive average daily ARs, possibly caused by the changing features of Hurricane Rita that resulted in investors continually updating their expectations about its severity and, as a consequence, expected loss. In terms of the cumulative abnormal return measures, it was found that both firms with insured exposure and those without experienced significant positive CARs during the event window, providing evidence in support of the first hypothesis. This is because it can be argued that investors took a more favourable view of the insurance firms in the areas impacted by Hurricane Katrina after their degree of exposure was taken into account. Overall, the work of Gangopadhyay *et al* (2010) presented reasonable and consistent relationship between these natural disasters and the share prices of firms.

2.6 AN EVENT STUDY: VIOLENCE

It has been mentioned before that there is very little event study literature covering the types of event(s) under investigation in this paper, to the best of our knowledge. However, the empirical study conducted by Guidolin and La Ferrara (2010) is a notable exception to this.

This section discusses their contribution to the literature. In the same manner as the event studies based on natural disasters, the focus of this paper is only related to our research in an indirect manner. Nevertheless, it is particularly important to review this paper because violence and the ensuing loss of life is a common thread that exists between our research and Guidolin and La Ferrara (2010).

To begin with, Guidolin and La Ferrara (2010) applied event study techniques to analyse the impact that violent conflicts have on asset markets. Internal and interstate conflicts were used to determine whether they had an effect on a variety of key economic variables and asset markets. These variables included stock and exchange rates, as well as the market for oil and commodity prices. The core aim of the paper was find whether a relationship exists between the onset of violent conflict and the perceptions of investors.

For their methodology, Guidolin and La Ferrara (2010) make use of two different approaches. The first was the market model, using event windows and the calculation of CARs. This model has already been discussed exhaustively in the various papers reviewed before, so further discussion therefore with-held.

The second alternative approach is referred to as the ‘dummy regression approach.’ This method involves estimating a set of regressions that make use of dummy variables to represent various possible event dates, using a full sample of data. In reality, it is essentially an augmented form of a market model for determining the presence of abnormal returns. The dummy variable approach is specified in Equation 2.11 below:

$$r_t = \alpha + \beta r_t^I + \gamma I_t + \varepsilon_t \quad t = 1, \dots, \tau \quad [2.11]$$

The full length of the sample is denoted by the term τ , while the stochastic white noise process is given by the term ε_t . I_t is the indicator variable (the dummy variable) which takes a value of 1 over the event period, and 0 otherwise. Additionally, the term γ is a measure of the impact that the event has on the return to assets. It is this parameter γ that is tested for statistical significance to determine if the event resulted in abnormal returns to the asset markets.

Weekly data was used that included international stock indices for countries that included the USA, the UK, France and Germany, as well as the rest of the world. Also, general and agricultural commodities spot indices that include a variety of resources including cocoa, corn, soya beans, and precious and industrial metals commodities are also used.

Guidolin and La Ferrara (2010) combined the data with various political events that were categorised as possible triggers of the various violent conflicts that were being investigated, as well as conflict. Conflict data was obtained from PRIO-Uppsala Armed Conflict Dataset 4-2008, and only conflict episodes that begun in a precise week were selected as part of the data requirements, with the only other defining characteristic of the dataset being the creation of a subset within the data of conflicts described as intense (distinguished by estimates casualty counts that exceed 1,000). The number of conflict episodes in their work totalled 101.

To begin with, Guidolin and La Ferrara (2010) used the second war in Iraq was used as a case study. Using CARs, it was found that the onset of that conflict had a led to increasing CARs to the MSCI World Index over a number of weeks, a result that was statistically significant at the 1% level, suggesting that global financial markets viewed the conflict in a positive light. Similar results were obtained when MSCI indices for individual countries were looked at instead, but these results were not always statistically significant.

When the commodity markets were analysed, the CARs were found to be negative for both the overall and agricultural commodities indices. The interpretation given for this argued that this could have come about as a result of aggressive rhetoric and posturing between the Saddam Hussein regime and the international community, leading to increased negative perceptions surrounding commodities and excess demand motivated by a desire to hoard commodities in the event that an extremely unlikely but severe event occurred. Also, the most severe negative CARs were seen in the market for oil futures, which can be explained by the uncertainty surrounding the disruption of oil production that a violent conflict would cause.

Guidolin and La Ferrara (2010) then found, when using the full set of conflicts, that all case studies except the Japanese stock index exhibited positive reactions to their respective conflicts that exceeded the negative reactions. In addition, all incidences of positive reactions were found to always exceed 5% across all countries. The conclusion drawn from this is that investors that react positively to the onset of a conflict do so because they believe that conflicts result in higher expected future profits and/or lower uncertainty, and they cite the case study of Iraq to support this proposition. Further, it was argued that what causes fluctuations in the share valuations is the uncertainty that surrounds that immediately precedes a conflict and not the onset and continuation of conflicts themselves.

When commodity prices were looked at, conflicts in the Middle East were found to have the greatest impact on commodities (accounted for by, in particular, investor fears about possible

disruption of oil supply from the Middle East, a region with rich oil reserves), with a striking 45% of conflict onsets in that region being found to have a negative and significant impact on oil futures in particular. Using the dummy variable approach, Guidolin and La Ferrara (2010) noted that ARs to stocks in the US were found to positively and significantly react to conflict news, on average, and this was the case for all conflicts the US was involved in. Similar positive and significant abnormal returns were also found for the UK, but not for either France or Japan. Overall, the conclusion that can be drawn from their work is confirmation that violent conflicts do have an effect on financial markets, with the size of the effect being dependent on a variety of factors including geographical location, foreign policy and economic size.

2.7 CONCLUSION

This chapter sets out the analytical framework that will be utilised in this study. In order to create a solid foundation for the empirical study, the relevant theory and concepts that inform and shape event studies was reviewed.

The literature discussed in this chapter was divided into two sections. The first section dealt with important elements surrounding the empirical technique that include the origins of event studies and a discussion of common measures that are regularly made use of such as Cumulative Abnormal Returns (CARs). The second section examined a number of event studies that have been conducted in the past. This included the simulations run by Brown and Warner (1980, 1985) in their twin seminal papers. Lastly, event studies performed using natural disasters and violence as the focus events were also examined to serve as broad precedents for our own empirical analysis.

The next chapter sets out the methodological steps and procedures that will be used to achieve our objective.

CHAPTER THREE

DATA AND METHODOLOGY

3.1 INTRODUCTION

This chapter sets out the analytical and methodological framework that will be used to achieve the goals of this research. As noted in Chapter one of this paper, the primary issue is to analyse whether or not the six platinum firms under investigation experienced statistically significant abnormal returns in response to the tragedy at Marikana. The data and sample sizes used are firstly examined. This is followed by an analysis of the event study methodology that will be employed. Included in this critical discussion will be the OLS Market Model (the benchmark model that generates normal returns to each share) and the overall event study procedure for detecting abnormal and cumulative abnormal returns.

3.2 DATA

3.2.1 Sources and properties of the data

For our data, six listed firms on the Johannesburg Stock Exchange (JSE) were selected as the target firms for our event study. As South Africa is a nation rich in mineral resources and raw materials, there are a number of firms listed on the JSE that focus on the extraction of a range of resources. However, of these firms, only the six of them have an established and historical specialisation in platinum mining in South Africa were selected for our research. These six firms have market capitalisations that are quite large compared to other firms that may have interests in platinum mining in South Africa, with the market capitalisation of the smallest firm out of the six being R3.16 billion, and the market capitalisation of the largest firm being R80.61 billion.

These firms are Acquarius Platinum Limited, Anglo American Platinum Limited, Impala Platinum Holdings, Lonmin Plc, Northam Platinum Limited and Royal Bafokeng Platinum Limited. The market capitalisations for all six platinum mining firms, as well as their corresponding identifying symbols on the JSE are given in Table 3.1. As can be seen from the market capitalisation figures given below, there is a significant difference between the market capitalisation of Anglo American Platinum, arguably the market leader in both firm size and reputation, and the market capitalisation of Acquarius Platinum, the smallest platinum mining firm of the six. The other four firms in the table take up positions in between these two firms,

offering a broad spectrum (from small to large) of market capitalisations that can arguable be said to be representative of the platinum mining sector in South Africa.

TABLE 3.1 – MARKET CAPITALISATIONS – TOP 6 FIRMS

SYM	COMPANY	MARKET CAP
AMS	Anglo American Plat Limited	80.61bn
IMP	Impala Platinum Holdings Limited	56.49bn
LON	Lonmin Plc	25.35bn
NHM	Northam Platinum Limited	13.37bn
RBP	Royal Bafokeng Platinum Limited	7.96bn
AQP	Aquarius Platinum Limited	3.16bn

Source: McGregorBFA, 2013.

In addition, the shares of these six firms also have the distinction of being the component shares for the FTSE/JSE Platinum Mining index that forms part of the FTSE/JSE Africa Index Series, a further reason that motivated the selection of these six firms. Thompson Reuters Datastream was used as the source for all data requirements for all the firms.

As we have already discussed before, the event study conducted in this paper makes use of daily data. In addition, trading 5-day weeks were used instead of traditional 7-day weeks, as no trading of financial instruments occurs during weekends. To that end, 120-day datasets (and thus 120 observations) for each firm were constructed using 5-day week JSE trading data, and the data obtained stretches back to midway through the year 2011, before ending in 2012 (the year that the shootings took place). The start and end dates for each dataset are identical, with the beginning of the datasets (the furthest date in the past) being marked by 2012/03/22, and the end being marked by 2012/09/07. The date of the Marikana, 2011/08/16, hereafter referred to as day '0', is contained within the datasets for all the firms. Zero returns to the firms were considered to be valid results were also consider to be valid results.

There are a number of reasons why a decision was made to make use of data over a 120-day period. As previously discussed, the first motivation for the use of an estimation period of this length is because it allows researchers to determine how stocks should behave in cases

where no event is present. For the purposes of our study, the length of the estimation period will be 100 days for each of the firms, encompassing the first 100 observations of the 120-day datasets for each firm. Throughout the literature surveyed in this study, a number of past researchers have made use of 250-day estimation periods, which were valued as being able to provide useful and reasonable estimations of the market model parameters when short-term event studies are being conducted (Brown and Warner, 1985; Corrado, 2008; Ahern, 2009). In contrast to this, the use of 100-day event windows in this paper was decided upon because we consider a period of this length to be sufficiently far enough in the past to obtain reasonable parameter estimates for the market model, while also simultaneously being recent enough to provide relevant estimates for the model.

The second motivation is that for the analysis conducted with each platinum firm, two separate event windows are used. The first window is made up of the five trading days before and the five trading days after that surround the tragedies. The second window consists of the ten additional trading days that immediately follow the last trading days of the first window. This will be discussed in greater detail in Section 3.3.6 of this Chapter.

For the specification of the market model, data from the FTSE/JSE All Share Index (ALSI) was used. As the analysis in this paper is limited to the local equity listings on the JSE, share and index prices used are captured in Rand values. Again, in the interests of clarity, the use of daily data in this paper was chosen because lower frequency data (in the form of weekly or monthly data) is incapable of capturing changes to share and index prices within a day, leading to distortions in market reaction analysis (Chinzara and Aziakpono, 2009: 9).

The use of daily data in financial modelling is not without drawbacks. The main one that occurs arises because of the existence of non-trading days. Non-trading days usually occur on public holidays, and the main consequence of such days is the closure of the stock market (and thus no trading on that particular day). There are several ways that can be used to deal with this issue, and a solution suggested by authors Chinzara and Aziakpono (2009) and Chang, Nieh and Wei (2006) is the removal of such days altogether from the data sample. However, because our data set is relatively small compared to large daily data samples used in other papers, non-trading days were not removed, as their inclusion should not have a significant effect on the empirical findings.

3.2.2. *A priori* expectations

Before the event study can be conducted, it is perhaps prudent to conduct a brief discussion of *a priori* expectations in this research. It has been noted that the firms that are being examined offer a broad picture of the size and scope of the platinum mining sector in South Africa. Following on from this, we would expect the larger firms like Anglo Platinum and Impala Platinum to not be as reactive to the events at Marikana. The reasoning behind this is that it is quite possible that the size and reputation of large, dual-listed firms like Anglo is so expansive that even if there was a reaction on the part of investors in its shares, it is doubtful that investors would view events not directly involving Anglo as being tied to or significantly affecting the fortunes and potential of the company in the long-run.

Although commodities are generally volatile in nature (with the platinum sector often proving to be a severe example of this in recent years), the fact that the violence occurred in only one mine as opposed to multiple ones, it is possible that the shares of firms that are of a sufficiently large size would not react to such an event because it falls beyond the realms of more traditional factors affecting platinum share prices such as changes in the exchange rate and macroeconomic policy announcements that may have a significant impact on the industrial and mining firms.

On the other hand, one would expect Lonmin Plc itself and the other firms with similar size and/or proximity to Lonmin to be more reactive to the event. There are a number of potential factors that are capable of explaining a negative reaction by such firms in response to the events at Marikana. Investors in these shares may react to the loss of and/or damage to inventory and output, as well as any property damage that may have occurred. In addition, the high loss of life and controversy that surrounded the violence may act as a signal that indicates to investors that the riskiness of the firm has increased in response to the event (Capelle-Blancard and Laguna, 2010).

Further, because of their lower relative size in comparison to a larger, more established firm like Impala Platinum, investors may take a more negative view if the firms in which they invest are, for example, located in close proximity to the event, or if they share a number of similar characteristics with the firm where the event manifested. In the case of the former possibility, there is recent evidence of mining unrest spreading beyond a single firm, whereas

in the case of the latter, investors may take a dim view of the prospects of smaller firms in a highly volatile operational climate such as this.

Lastly, because the platinum mining sector is such that it has high barriers to entry and a small number of reasonably-sized participants responsible for the majority of the production, it follows that this sector is highly competitive. As a result of this, we would expect competition to be a significant force in this industry. Thus, we would expect the shares of rival firms exhibit positive abnormal returns while the one that experienced the negative event exhibits the opposite.

3.3 METHODOLOGY

Discussion earlier in this paper on the various methods of using an event study to uncover and analyse stock market anomalies made reference to parametric and nonparametric tests (see Chapter 2). To summarise, parametric event studies are applied in cases where the data in question is normally distributed, whereas nonparametric event study techniques are used when returns are found to be non-normally distributed.

3.3.1 Procedural steps

As a starting-point for the analysis, this study will firstly compute descriptive statistics of each individual share and for market model index (in the form of the JSE ALSI index) in order to assess whether returns are normally distributed. This is done in view of the assumption that continuously compounded returns follow the normal distribution. This will determine whether parametric or non-parametric event study approaches will be used to detect abnormal returns to platinum mining firm share. The descriptive statistics computed for the purposes of this study are the arithmetic mean, standard deviation, skewness, kurtosis, maximum, minimum, autocorrelations, Jaque-Bera and the Ljung-Box Q-statistics.

3.3.2 Descriptive statistics

Descriptive statistics are an essential part of data analysis. They form one part of the starting point of our analysis (with the other part being tests for stationarity). There reported descriptive statistics that will be discussed in this paper will be sample means, median, maximum, minimum, standard deviation, skewness, kurtosis and the Jarque-Bera statistics for

each data series. The descriptive statistics will be discussed at length in the empirical results chapter of this study.

3.3.3 Stationarity tests

The first step in performing statistical modelling on financial data is to consider the stationarity of the data under investigation. Gujarati (2005: 496) defined a stationary process as one which has a constant mean and constant variance over time, with a covariance that is also not serially correlated over time as well. Brooks (2008: 319) noted that if a regression is performed using two unrelated variables that are trending over time, a high R^2 value may result. Such a result would look useful at first glance, but the regressing of nonstationary data does not yield any empirical value, and this phenomenon is known as a spurious regression. In addition, if forecasting was an explicit goal that formed part of the study, any forecasts obtained using nonstationary data would not be of any empirical use.

In this paper, two of the most commonly used tests for stationarity are performed on the data. The first is the Augmented Dickey-Fuller (ADF) test, and the second is the Kwiatkowski *et al.* (KPSS) (1992) test. In the case of the former, the ADF test tests for the presence of a unit root. If a unit root is found to be present, this suggests that the data in question is nonstationary. Critically, the null hypothesis in an ADF test states that a unit root is present. The rejection criteria for the ADF test is as follows: if the observed test statistic for the ADF exceeds the critical ADF value, the null hypothesis can be rejected, suggesting that the data is stationary.

The second test for stationarity differs from the ADF in that it is a more direct test than the ADF. The KPSS (1992) test was developed as a means of testing stationarity that runs complementary to tests for unit roots such as the ADF test. However, the KPSS (1992) test has greater test power than the ADF test, so its results should be used as a benchmark in cases where the both tests arrive at different conclusions.

3.3.4 The OLS Market model

To find out if any of the shares being investigated experienced abnormal returns, a benchmark model for normal returns is required. The importance that the market model holds in event studies means that the selection of a suitable comparative stock market index is of

paramount importance. Using the market model for modelling normal returns is motivated by the large body of literature that which provides evidence that this method and the parametric tests used within it are sufficient for detecting abnormal returns exists (see Malatesta, 1986; McDonald, 1987; Armitage, 1995; Corrado, 2007). For the purposes of this event study, the index that will be used to estimate the market model is the FTSE/JSE All-Share Index (ALSI). This index was chosen over other indices capable of being representative of the market, such as the FTSE/JSE Top 40 Index, because it provides the most comprehensive picture of market movements and reactions within the context of the South African stock exchange landscape.

The parameter estimation period as suggested by Brown and Warner (1985) is used to calculate the Beta value of a stock. The Beta value is the slope coefficient obtained by regressing the returns to index on the returns to the stock. It can also be viewed as a measure of the volatility of the stock in relation to the market as whole (Panayides and Gong, 2002). Further, Panayides and Gong (2002) suggested that an 11 day event window is quite capable of fully captures the effects of an event of interest. For this reason, an event window of this length is used in this study. The window begins 5 days prior to the event date (16 August 2012) and ends 5 days after.

As has been discussed in the preceding section, this study makes use of two separate parameter estimation period of 100 and 250 days respectively in formulating a benchmark for normal returns to each firm. Additionally, care has been taken to ensure that, during the parameter estimation period, no other event that could reasonably be expected to be of great significance, took place that could potentially have resulted in abnormal returns to the firms.

3.3.5 The Event Study procedure

There are a number of steps that will be undertaken in order to complete the event study. The first step in the procedure is to calculate the actual returns to each platinum share and the market index using their respective share prices and index value for the estimation periods being used. The formula for computing actual returns to each firm is given by Equation 3.1 below as follows:

$$R_{it} = (P_{it} - P_{i(t-1)}) / P_{it} \quad [3.1]$$

where R_{it} is the actual return to firm i , P_i is the price/value of the share/index and $P_{i(t-1)}$ is the price/value in the previous period.

The second step requires the regressing of the returns to a given platinum stock i on the returns to a market index m over the estimation period (100 days). For our purposes, the platinum stocks are the six platinum firms under investigation (AMS, IMP, LON, NHM, RBP and AQP), while the market index m is the FTSE/JSE All-Share Index (ALSI). Performing this form of a regression yields two parameter estimates. These are the intercept coefficient (the y – intercept) and the slope coefficient (the Beta value), and they are denoted as α_i and β_i respectively. Equations 3.2.1 and 3.2.2 below express these two concepts as follows:

$$R_{it} = \alpha_i + \beta_i(MKT_t) + \varepsilon_{it} \quad [3.2.1]$$

$$E(\varepsilon_{it}) = 0; var(\varepsilon_{it}) = \sigma^2 \quad [3.2.2]$$

where R_{it} is the return to the share i at time t , while α_i and β_i are parameter estimates of the regression equation. Equation 3.2.1 above is the market model specification that is employed in this study for obtaining parameter estimates. The term MKT_t denotes the return on the market index in time period t , while $E(\varepsilon_{it})$ is the expected value of the error term ε_{it} and σ is its variance. Within the market model, the assumption is made that the ε_{it} term is serially uncorrelated with the market (in this case, the JSE Stock Exchange in the form of the ALSI index), with a zero mean and constant variance.

The third step requires the estimation of abnormal returns for each share. As previously discussed, the abnormal return (AR) to a stock is defined as the difference between the actual return to the platinum stock and the expected return \hat{E}_{it} to the same stock as generated using the benchmark model for normal returns. The daily abnormal return for day t , AR_{it} , during the event period is computed by Equation 3.3 as follows:

$$AR_{it} = R_{it} - \hat{E}_{it} \quad [3.3]$$

The next step is the calculation of the cumulative abnormal returns (CARs), which are simply the aggregation of the multi-day ARs for each firm. Mackinlay (1997) noted that CARs are important in event studies because they allow for the monitoring of periodical inferences for the event of interest, while Coutts (1994) revealed that CARs are often made use of in cases where it is unclear when the information content of an event becomes available to investors and the general public. The use of CARs in this study relies on the motivations given by the former. The formula for the calculation of the CARs is given by Equation 3.4 as follows:

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR \quad [3.4]$$

where the components of the equation are the cumulative abnormal return for an individual firm over, the event window (t_1, t_2) , and the summation of its abnormal returns between period t_1 and t_2 respectively. The next step after the calculation of the ARs and CARs is to test them for statistical significance. In the case of the hypothesis tests for both, Mackinlay (1997) stated that it is assumed that their distributions are normally distributed, and these assumptions are expressed for each by Equations 3.5.1 and 3.5.2 in the following manner:

$$AR_{it} \sim N(0, \sigma_i^2(AR_{it})) \quad [3.5.1]$$

$$CAR_{it}(t_1, t_2) \sim N(0, \sigma_i^2(t_1, t_2)) \quad [3.5.2]$$

Hypothesis test statistics also need to be obtained for both. The test statistic for the ARs is obtained using the ratio of an abnormal return over an event day t to its estimated standard deviation from the normal return estimation period (using the market model above). For the CARs, the test statistic is computed using the ratio of a cumulative abnormal return against its estimated standard deviation. The formula for the AR t-statistic is given by Equation 3.7 below:

$$AR: t - statistic = AR_{it} / \sigma(AR_{it}) \quad [3.7]$$

The null hypothesis for the test above is that the AR is zero, and this hypothesis is same for each of the six platinum firms. The interpretation of the null hypothesis would be that there has been no reaction by the firm to the event. Below, the formula for generating the CAR t-statistic is also given by Equation 3.8 as follows:

$$CAR: t - statistic = CAR_{it} / \sigma(CAR_{it}) \quad [3.8]$$

In a similar manner to the test on ARs, the null hypothesis for the test above is that the CAR is zero, and it is the same for each of the firms. Again, the interpretation of the null hypothesis would be that there has been no reaction by the firm to the event.

3.3.6 Event window selection

The final requirement for conducting an event study is the specification of either one event window (or multiple event windows as may be required in some instances). Event windows

isolate and define the event time period to be examined and thus form the core aspect of our event study. The abnormal returns and cumulative abnormal returns that are calculated using the returns to the shares within the windows will be tested for statistical significance using the method set out in the previous section.

In addition, during the discussion of the ARs and CARs found in Chapter 4, the portions of the window that occur before the event will be denoted by a minus sign (for example, day -1 refers to the trading day immediately before the event), while the portions of the window that occur after the event will be distinguished by a positive sign (for example, day +2 refers to the second day after the event has occurred). For the purposes of our study, we make use of two separate event windows.

The first will be a 10-day event window. This window consists of five trading days before and five trading days after the event day '0' (specified throughout the duration of this study as being August 16th 2012). The second event window that will be made use of is an additional 10-day window that occurred directly after the last trading day of the first window. Throughout the discussion of the empirical results in later Chapters, the first window used will be referred to as the initial window, while the other window used will be referred to as the extended window. The initial window consists of the trading days that occur during the period 2012/08/09 to 2012/08/23, while the extended window contains trading days over the period 2012/08/24 to 2012/09/06. Using two event windows will allow us to determine whether any of the ARs and CARs that may be found during the analysis that will be done using the various event windows persists over a period of time, or is short-lived.

The reasoning for this is that extending the window by a further ten trading days from the end-point of the original of the 10-day window will enable us to find out whether or not the investors in each platinum share respectively have fully absorbed and reacted to the event, and the presence of significant ARs and CARs (if either are found to be present in any of the returns) acts as an indicator of this.

If the assumption is made that it only takes a few days for investors to fully react to an event, then one would expect smaller and insignificant ARs and CARs after a sufficiently long period of time (in this instance, days) has elapsed after the event. Thus, we are able to determine if any responses found remained consistent as the number of trading increased, as well as if any drastic changes were noted that would have been ignored had only one event

window been used. However, a variety of factors can explain why this may not occur, and an attempt will be made to discuss this where applicable.

3.4. CONCLUSION

The analytical and methodological framework that will be used in this event study was set out in this chapter. Firstly, the sources and properties of the different returns series calculated and used are specified, followed by a description of the different data samples and estimation periods used in the research. *A priori* expectations for the research are also briefly set out in this chapter in order to better contextualise the empirical results portion of this study. The methodology to be used was discussed and motivated in detail. Aspects that form a part of this discussion include descriptive statistics such as sample mean, variance, maximum and minimum; and tests for stationarity in the form of the ADF and KPSS tests. The market model that generates normal returns to each share is then discussed in detail because of the fundamental role it performs in carrying out an event study. Finally, the testing procedures for the hypothesis tests that will be conducted on the ARs and CARs are set out. The analytical and methodological framework set out in this chapter will now be applied to the various returns series in order to achieve the goals of this study as set out in the Chapter one.

CHAPTER FOUR

EMPIRICAL RESULTS AND ANALYSIS

4.1 INTRODUCTION

Having formed our theoretical foundation, examined the existing the relevant and recent empirical literature and set out the analytical and methodological framework that will be used, we now undertake the empirical portion of our study to answer the research objective set out in Chapter 1. The Chapter is organised in the following manner: Section 4.2 details stationarity for each firm; Section 4.3 examines the descriptive statistics; Section 4.4 discusses the results obtained using the initial 10 day event window; Section 4.5 details the results obtained using the extended 10 day event windows, and Section 4.6 provides the conclusion.

4.2 STATIONARITY TESTS

As discussed before in the previous chapter, the ADF and the KPSS tests were performed on the parameter estimates of the market model regressions for the platinum firms individually to determine their stationarity and order of integration. From the graphical plots of the returns to the firms contained within the Appendix, no trends in the data were detected. As a result, the stationarity tests were conducted with the ‘no trend’ assumption. The results for the six platinum firms are given in Table 4.2 below. The results obtained from the ADF tests reveal that the null hypothesis of a unit root being present in the residuals can be rejected for all the firms at level terms.

Using the KPSS test on the parameter estimates, the results obtained fail to reject the null hypothesis that the residual series under investigation is stationary for the residual series of all the platinum firms at level terms. From these results, we can safely conclude that the data under consideration in this event study are stationary. As a consequence, they can be described as being integrated of the order $I(0)$. This validates their use in the OLS estimation procedures.

TABLE 4.2: UNIT ROOT & STATIONARITY IN PLATINUM SHARE PRICES

FIRM	ADF	KPSS	Order
AMS	-9.2537	0.11163	I(0)
IMP	-9.583	0.05136	I(0)
LON	8.64171	0.10751	I(0)
NHM	-7.8562	0.10228	I(0)
RBP	8.06898	0.05423	I(0)
AQP	-9.5495	0.24817	I(0)

Notes: ADF 1% critical value = -3.434 and the KPSS 1% critical value = 0.739

4.3 DESCRIPTIVE STATISTICS

The descriptive statistics for the platinum firms are given in Table 4.3. They allow us to make a number of basic but useful inferences about each of the firms that are being examined in this study. These descriptive statistics were generated using the 100 day estimation period

Interesting results are found when the mean daily return results to each firm are examined. From the results, Aquarius, Anglo and Northam displayed positive mean daily returns over the sample period, while Lonmin, Impala and Royal Bafokeng displayed negative mean daily returns. The differences in these statistics can be explained by a multitude of factors that extend to their individual contexts and unique characteristics. These include, but are not limited to, aspects such as production considerations that are unique to the firms, or the implementation of long-term strategic decisions. However, due to the fact that the mean return figures found for all firms are, for all practical purposes, zero, the distinction between the positive and negatives returns for the firms is superficial. This observation is a reflection of the general weakness experienced by the platinum mining subsector in preceding years. A broader analysis than this is, however, beyond the scope of this research.

The standard deviation results for the data samples are also notable. Standard deviations can be viewed as a measure of how volatile the returns to a firm have been over the sample period. Five of the six firms under review have similar standard deviations, which lie in the

range 0.011736 to 0.016234. The shares of Anglo Platinum, Impala Platinum and Northam Platinum appear to be the least volatile of the six firms. Anglo and Impala are the largest and second-largest capitalised firms respectively, and also arguably the most widely-known and respected platinum-mining firms, so we can conclude that such a finding fits in well with *a priori* expectations.

The difference between the maximum and minimum daily returns for each firm can be interpreted as additional indications of the volatility that each platinum share may have experienced over the sample period. In this case, the statistics suggest that after Aquarius (minimum of -0.1008% and maximum of 0.1071%), no other firm experiences maximum and minimum values that are comparable to this. The next firm (Northam) experiences a minimum daily return of -0.0398% and a maximum daily return of 0.0596%. Northam is followed by Lonmin, which experienced a minimum of -0.03986% and a maximum of 0.04694%. Of the remaining three firms, the one that appears to have the least extreme daily returns is Royal Bafokeng. It experienced a minimum of -0.0341% and a maximum of 0.0332%. These results suggest that Aquarius is the most volatile of the platinum firms for the estimation period used in the case.

Next, the skewness of the firms is examined. Skewness refers to any asymmetry from the normal distribution found in statistical data, and there can be either positive skewness (if the data is skewed to the right of the data average), or negative skewness (if the data is skewed to the left of the data average). During instances where a dataset is normally distributed, the skewness would be zero. When this statistic is considered for our platinum firms, a number of interesting observations are noted.

Firstly, four out of the six firms under investigation have returns that are negatively skewed over the sample period. Acquarius displays a skewness of -0.126531, while the returns to Implats have a negative skewness of -0.156159. The other two firms that display negative skewness in their returns are Anglo and Northam and they each have skewness values that are notably larger than those of Acquarius and Implats. The skewness value for Anglo is -0.720948, while the skewness value for Northam is -0.459499.

Only Lonmin and Royal Bafokeng have returns that are positively skewed, with values of 0.400960 and 0.383959 respectively. Within the context of financial investment, returns that display positive skewness are more desirable than returns that display negative skewness. This is because returns that are negatively skewed are viewed as evidence that there is a

greater likelihood of losses than of gains to the share over time. As a result, this should motivate investment in such a share if the assumption is made that investors are rational and risk-averse. If skewness was the only input that an investor was required to take into account in the decision-making process, the shares of Lonmin and Royal Bafokeng would be the shares likely to be invested in within the platinum mining sector.

The next descriptive statistic to be examined is the kurtosis, which is a measure of the 'peakedness' of the statistical distribution for the data being used. The value for kurtosis when dealing with normally distributed data is three. From an analysis of the kurtosis values for the six firms, it can be seen that they all display positive kurtosis, which can be viewed further evidence is provided that support the conclusion that all are non-normally distributed. The kurtosis values for the firms lie in the range 3.405499 to 4.509154. Clearly, all the values exceed three. Thus, the returns to the firms are characterised by fat tails (and are thus leptokurtic). The importance of kurtosis lies in the fact that when its values exceeds three, this implies that there is a higher frequency of extremely large deviations from their respective means than would be the case if the returns were normally distributed.

The final descriptive statistic that will be discussed is the Jarque-Bera (JB) statistic. The results for this statistic are mixed. Using the probability values associated with each respective JB statistic, the null hypothesis of normality was accepted for three of the firms, while it was rejected for the other three. The firms for which the null hypothesis was accepted were Aquarius, Implats and Lonmin. In contrast, the firms for which the null hypothesis of normality was rejected were Anglo, Northam and Royal Bafokeng. In spite of the mixed results found using the JB statistic, it is still prudent to make use of the same parametric regression techniques as previous research has confirmed that they generally provide a good fit in the use of both normal and non-normal data. This is discussed in greater detail below.

During empirical studies, the non-normality of data would be regarded as being an important issue in the use of daily data because this directly affects which statistical testing methods can be used. As discussed previously in Chapter 2, non-normal data is generally tested using nonparametric testing methods. However, this ceases to be an issue within the context of event studies. The reason for this is that several papers have examined the issue and found that it does not pose serious threat to the validity of results obtained. Brown and Warner (1985) found that parametric tests were well specified using even very small samples, and also that no obvious impact could be pinpointed. This finding has subsequently been

confirmed in evidence provided by others including Corrado and Zivney (1992) and Corrado (2007).

TABLE 4.3: SUMMARY OF DESCRIPTIVE STATISTICS

Firm	AMS	IMP	LON	NHM	RBP	AQP
Mean	6.31E-19	-7.36E-19	-4.03E-19	2.98E-19	-5.83E-19	8.88E-18
Median	0.000405	-0.000981	-0.002176	0.001194	0.001417	8.49E-05
Maximum	0.028983	0.036666	0.046944	0.050606	0.033179	0.107083
Minimum	-0.047248	-0.037628	-0.039866	-0.039896	-0.034144	-0.100841
Std. Dev.	0.013961	0.013532	0.016234	0.01675	0.011736	0.037012
Skewness	-0.720948	-0.156159	0.40086	0.383959	-0.459499	-0.126531
Kurtosis	4.429696	3.446649	3.405499	4.402079	4.509154	3.545801
Jarque-Bera	17.00778	1.22528	3.329631	10.54154	12.87867	1.493
JB Probability	0.000203	0.541918	0.189226	0.00514	0.001597	0.474023

Now that the descriptive statistics for each firm have been analysed, we now proceed with the analysis of the formal event study testing for abnormal returns and cumulative abnormal returns using the methodology set out in the previous chapter.

In the first section, the ARs and CARs results that were obtained for each firm using the 10 day event window will be discussed in detail. A discussion of their statistical significance and their implications will also form part of the analysis. In the second section, the ARs and CARs results obtained making use of extended 10 day event windows will then be discussed in a similar fashion. Again, their significance will also be taken into consideration during the analysis. In addition, graphical representations of the ARs and CARs for each firm are provided in Figure 4.1 through to Figure 4.6 for the 10 day windows and Figure 4.7 through to Figure 4.12 for the extended windows.

4.4 EVENT STUDY RESULTS – 10 DAY EVENT WINDOW

An analysis of the ARs and CARs for the six firms is conducted in the section below using a 10 day event window. As noted previously, a summary of the *t*-statistic results for each firm in both cases (ARs and CARs) is provided in the Appendix. For the *t*-tests that will be used in

testing statistical significance for each AR and CAR, the calculated values were compared against two-tailed *t*-critical values. The number of degrees of freedom (df) used for the tests in this section, calculated as $n - 1$ where n , the number of days in the event window, is 10. Table 4.4 below provides a summary of the key dates that will be used to explain the ARs and CARs calculated and discussed in the sections that follow.

TABLE 4.4: SUMMARY OF KEY DATES

DATE	EVENT/ANNOUNCEMENT
2012/08/10	Wildcat strike at Lonmin Mine begins - 3,000 workers involved.
2012/08/13	Market reaction to violence and fatalities over the weekend.
2012/08/14	Police deployed to mine area.
2012/08/15	First government statement - Mineral Resources Minister Shabangu.
2012/08/16	Shootings take place - several fatalities.
2012/08/17	First Police statement - Police Commissioner Phiyega.
2012/08/19	Declaration of week of national mourning by President Zuma.
2012/08/20	First court appearance - 257 arrested miners.
2012/08/21	Media reports suggesting miners initiated fatal confrontation.
2012/08/22	Mining union AMCU excluded from wage negotiations.
2012/08/23	National day of mourning is held in South Africa for the victims; Judge Farlam Commission of Enquiry formed; pronouncement that there should be a mining revolution by ex-ANCYL leader Julius Malema
2012/08/29	First suggestions by media that there were other sights where shootings took place.
2012/08/30	National Prosecuting Authority charges 270 miners.
2012/08/31	AMCU rejects negotiated peace deal citing exclusion from the process.
2012/09/02	Murder charges against miners dropped.
2012/09/05	Increased intimidation and threats of violence from striking mine workers.
2012/09/06	Strike continues; output at Lonmin mine remains at zero

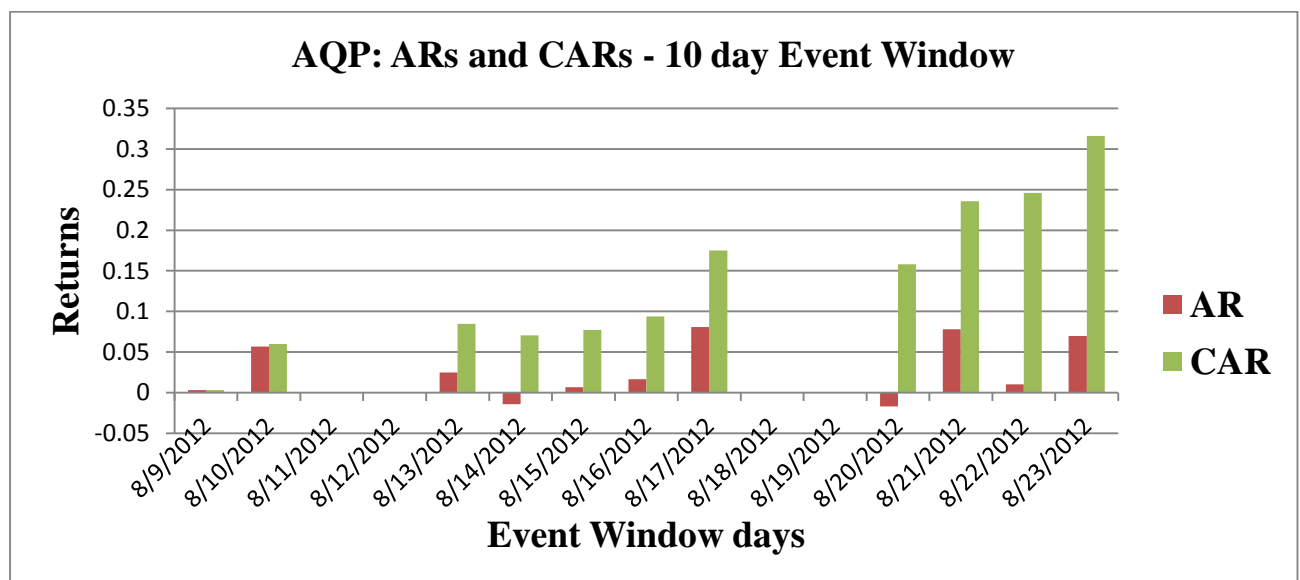
4.4.1 Aquarius

Figure 4.1 below provides an overview of the ARs and CARs experience by Aquarius Platinum (AQP) using the 10-day estimation window. From these results obtained, we can see that the shares of ACQ appear to have experienced positive abnormal returns in the days immediately following day '0'. Specifically, positive abnormal returns to ACP shares can be seen on days +1, day +3 and day +5. The ARs that occurred on these three days are all statistically significant. However, they are only statistically significant at the 10% level of significance, which is generally means that the evidence, although present, is weak. No

noteworthy abnormal returns to AQP shares were found on day '0' at any level of significance. This lack of reaction fits well with the timing of the tragedy, as information about it took some time to disseminate. Its scale and impact only became fully clear in the days that followed day '0'.

In terms of the CARs, we find positive CARs for all days including day '0'. The CAR on day '0' is statistically significant at the 5% significance level, while all the CARs that occur after day '0' are all significant at the 1% level. Thus, we can use these CAR results to conclude that the impact of the event persisted for some time after day '0'. As a result, it can be argued that investors in the AQP reacted in a positive but weak manner to the tragedy, based on the positive ARs and CARs that were found. As Aquarius Platinum is the firm with the smallest market capitalisation out of the six that make up the FTSE/JSE Platinum Mining Index, a possible reason for the positive abnormal returns may be investors reacting positively to the because of the direct and negative impact the shootings had on Lonmin, a rival whose misfortune would benefit the other firms in the sector. This can explain why investors in ACP shares would view the tragedy as an event that would increase the value of that firm because of the potential belief that the firm may stand to gain in some manner.

FIGURE 4.1: ARs AND CARs: AQUARIUS PLATINUM



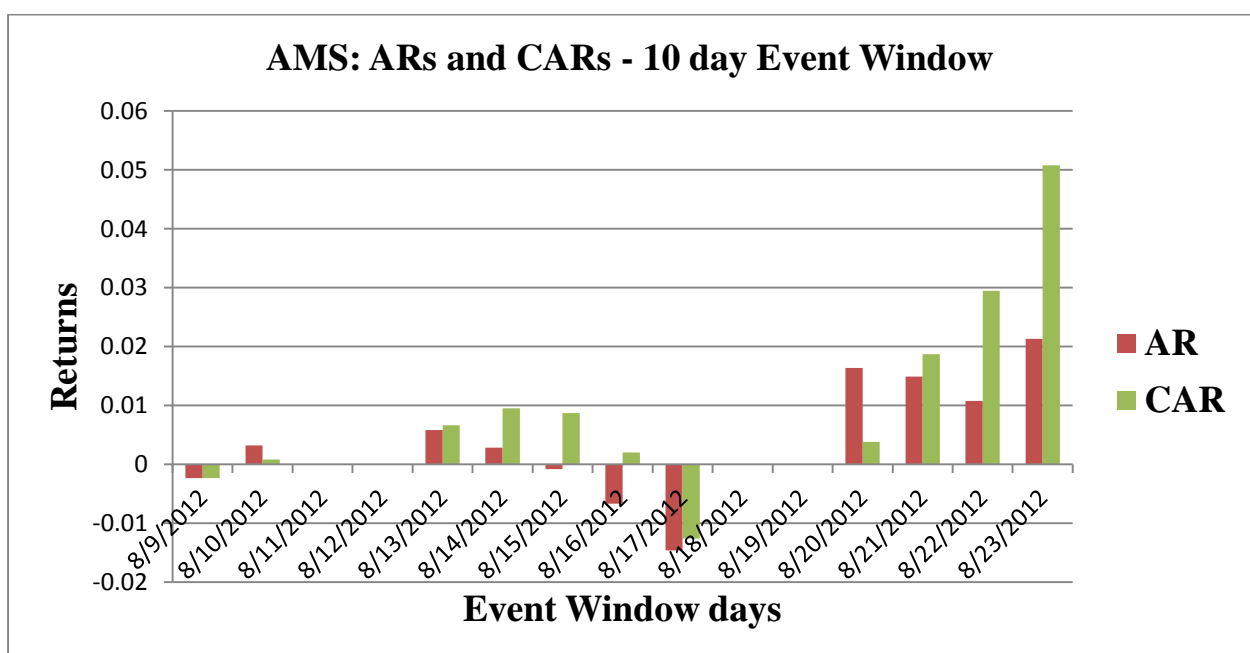
4.4.2 Anglo American (Amplats)

Figure 4.2 illustrates the ARs and CARs that were experienced for the shares of Amplats (AMS). The results obtained show that the AMS shares experience abnormal returns on all

five days of the post-event window, as well as on day '0' itself. The ARs that were experienced by the shares were negative on both day '0' and day +1. However, neither of these was found to be significant at any conventional level. In terms of positive ARs, those for the days +2 through to +5 were found to be positive. When these were tested in the same manner as the negative ARs, the same result of no significance at any level was also found, in spite of the relatively large ARs (both positive and negative) that the AMS shares experience during the event window.

Similar results are found when the analysis is extended to the CARs. Here, apart from the negative CAR found on day +1, relatively large CARs are found on days +3 through to +5. However, when the *t*-tests were used on the CARs in the same manner as the ARs, none of them were found to be statistically significant at any conventional level with exception of days +4 (where the positive CAR found for this day was only found to be significant at the 10% level) and day +5 (a positive CAR significant at the 5% level). This suggests that the impact of the event was very short-lived. As a result, we can conclude that, in the case of Amplats, investors did not react to the events at Marikana, with the basis for this conclusion lying in the statistical insignificance of the ARs and CARs. A possible reason for this lack of reaction is that Amplats's status as the largest and most established of the platinum mining firms is such that it possibly takes a larger or more direct shock on Amplats in order to affect investor behaviour.

FIGURE 4.2: ARs AND CARs: ANGLO AMERICAN PLATINUM

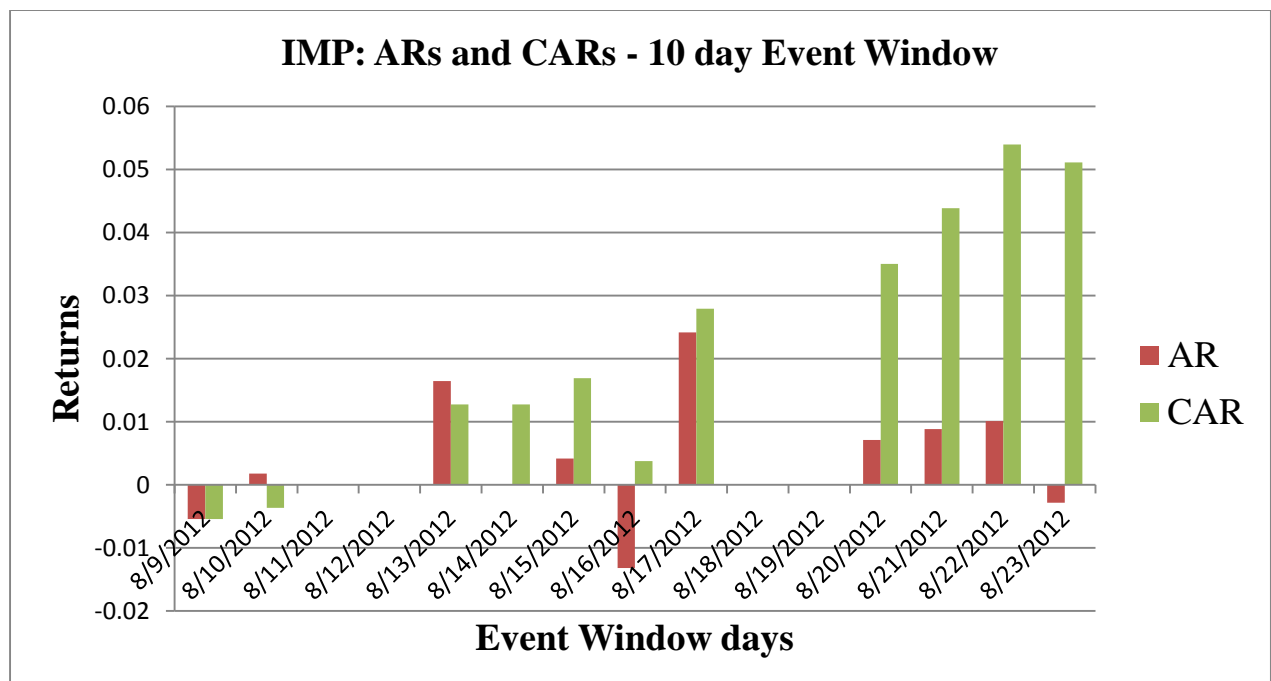


4.4.3 Impala (Implats)

When the shares for Implats are considered, Figure 4.3 below reveals that mixed performance was found for their abnormal returns and cumulative abnormal returns over the course of the event window. The ARs found during the course of the window were mostly positive, with the highest ARs being found to have occurred on days -2 and +1. In contrast to these, on the event day itself, negative abnormal returns were found. Although these results are interesting, none of the ARs, whether positive or negative, were found to have been significant at any conventional level.

The results found for the CARs are slightly different than those that were found for the ARs. The most important result to note is that all of the CARs from the post-event portion of the window are significant at some level. The CAR on day +1 is significant at the 10% level, while the CAR on day +2 is significant at the 5% level. Finally, the CARs for the remaining three days of the window are significant at the 1% level. The significance of these CARs suggests the events at Marikana had a longer lasting impact on Implats shares than was seen in the AMS shares. These findings are similar to those made for the AQP shares. Based on the ARs and CARs results that have been discussed, it is possible to conclude that although there is some evidence of an impact with some level of persistence, the overwhelming statistical evidence is that investors did not respond to the tragedy at Marikana.

FIGURE 4.3: ARs AND CARs: IMPALA PLATINUM



4.4.4 Lonmin

The ARs and CARs for Lonmin Platinum are, perhaps, the empirical results that hold the greatest significance in this study. As the firm that owns the site at which the tragic event took place, it can be regarded as one of the main, if not the main, focal point. In a similar fashion to Implats, Lonmin experienced mixed AR and CAR performance during the course of the window as displayed by Figure 4.4.

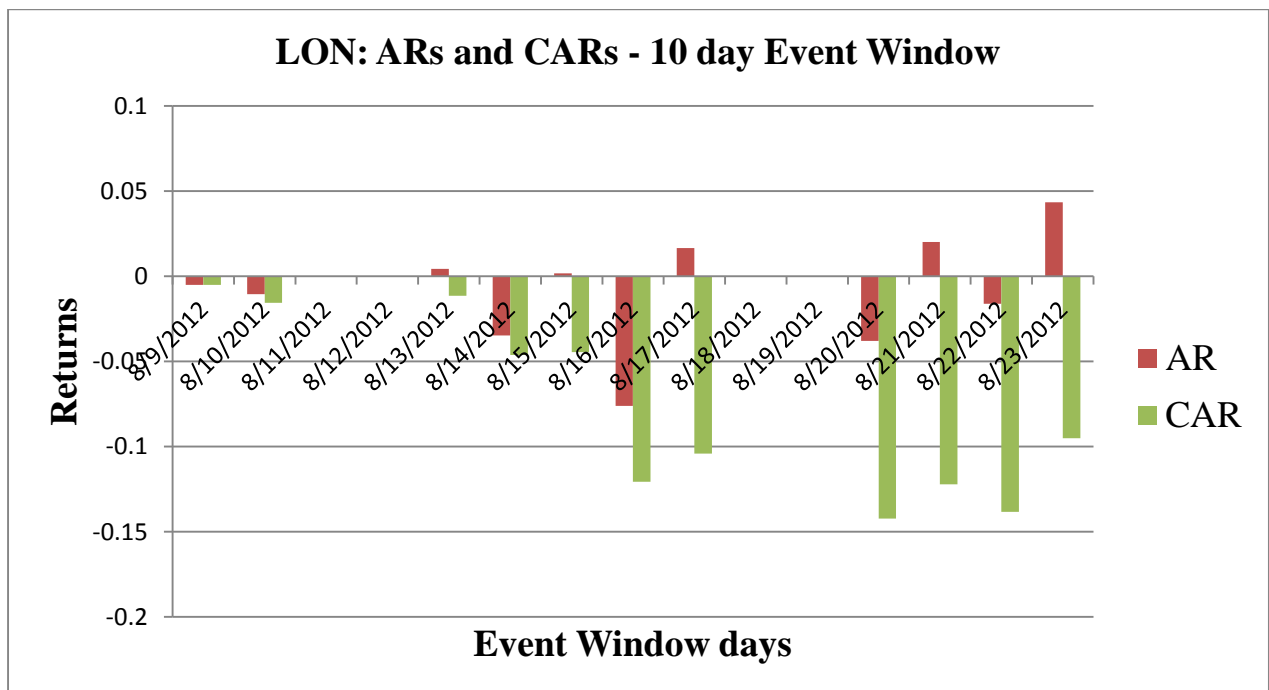
In the case of the abnormal returns to LON shares, negative and relatively large ARs were found on day -2, day '0' and day +2, while slightly smaller negative AR also found on day +4. However, only the negative ARs on day -2, day '0' and day +2 were found to be statistically significant (at the 10%, 1% and 5% levels respectively). These negative ARs fit our *a priori* expectations for Lonmin in particular, as it follows that an event of this magnitude and nature (that is, an incident that directly impacts current and future production, productivity and so forth) would negatively affect investor confidence, which is manifested in the form of negative ARs. In addition, the negative AR that occurred on day -2, as well as the other relatively minimal positive and negative ARs that occurred on the other days of the pre-event portion of the window can be attributed to the violent strike action that precipitated and immediately preceded the tragedy.

Interestingly, positive ARs were also experienced by the shares during the post-event portion of the window. These positive ARs occurred on day +1, day +3 and day +5. Of these three, only the positive AR that occurred on day +5 is significant at any level (5%). There are a number of different explanations that can be used to explain the occurrence of this positive AR. One possible explanation is that investors reacted positively to the public statements made in support of the actions taken by SAPS on the event day in the days immediately following it. In this case, the positive AR would be a sign of the LON share price "bouncing back" in response to the release of further information in the aftermath of the tragedy.

Finally, the transition of the ARs between positive and negative on what amounts to a daily basis may be explained by the nature of the how the information about the tragedy became available. There was a distinct lack of clarity and confirmed information just after the shootings occurred, and it took a number of days for all the information necessary to form a clear picture to come out. As a result, the transition may reflect the reactions of investors to the emergence of new details surrounding the event.

When the CARs are also examined, we find strictly negative CARs throughout the entire duration of the event window. Large and strongly negative CARs were found on day '0' and every day of the post-event portion (days +1 to +5). In terms of statistical significance, all CARs from day -2 to day +5 are significant (with most being significant at the 1% level and the rest at the 5% level). These CAR results provide strong evidence that the tragedy had a persistent and sustained negative impact on the shares of the Lonmin. The negative CARs that occurred in the run-up to the shootings can be explained by the striking that had taken place in the weeks prior to the tragedy. In addition, the transition of the ARs between positive and negative on different days is supported by the fluctuation of the negative CARs, particularly for day '0' to day +5 (seen in the differing lengths of the negative CARs. Overall, we can say that the tragedy had a direct and negative impact on investor confidence in LON shares, and such a conclusion provides strong evidence for our *a priori* expectations.

FIGURE 4.4: ARs AND CARs: LONMIN PLATINUM



4.4.5 Northam

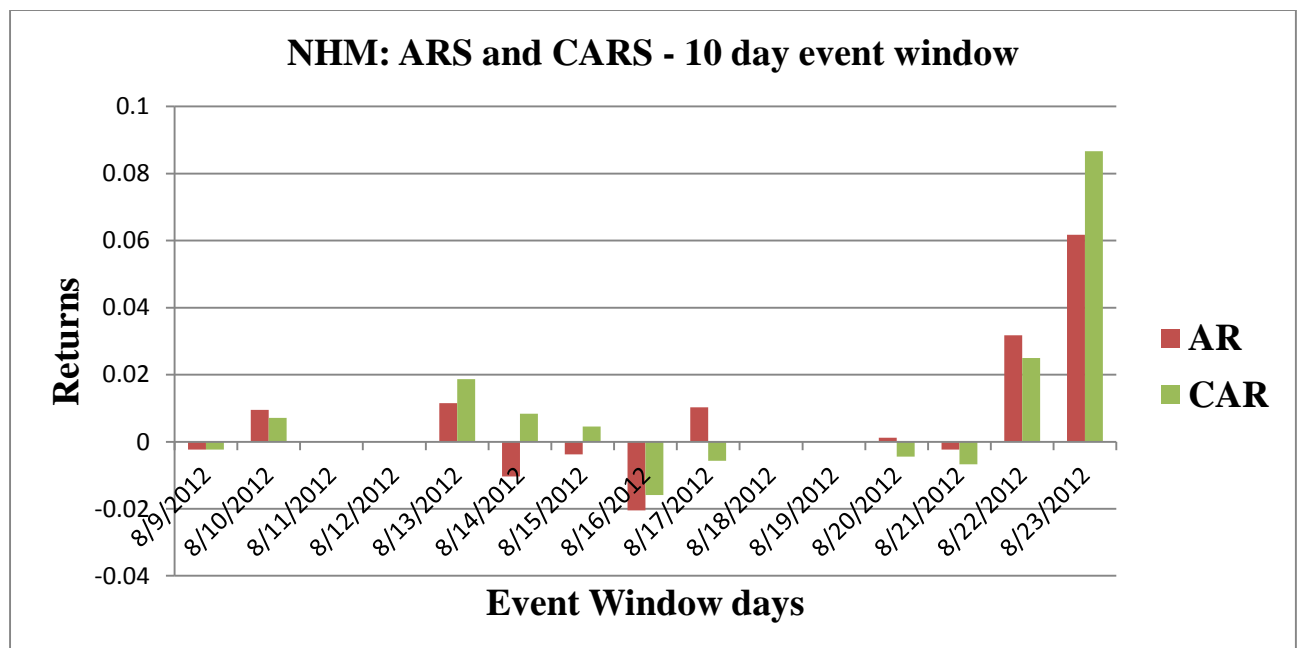
The ARs and CARs experienced by the NHM shares over the course of the event window are provided in Figure 4.5 below, and the results of their performance were also found to be mixed in the same manner as some of the firms examined before. Beginning with the ARs, small positive ARs were experienced by NHM shares on day -4, day -3 and day +1. In addition, large positive ARs occurred on day +4 and on day +5. However, on the positive

ARs on days +4 and +5 were found to be significant (at the 10% and 1% levels respectively). Negative ARs of reasonable size were only found on day -2 and day '0'. However, crucially, neither of these negative ARs is significant at any conventional level.

Mixed CAR performance is also revealed for the NHM shares when these are considered as well. Minimal CARs were found on the majority of the days making up the event window. The CARs of notable size that occurred during the window were found on day -1 (positive), day '0' (negative), day +4 (positive) and day +5 (positive). Of these CARs, on the CAR that occurred on day +5 was found to be significant (at the 1% level).

From the analysis of the AR results (especially the significant positive AR experienced by the shares on day +5), it can be argued that investors in NHM shares reacted positively to the tragic event, but only after more information was made available in the days that followed the tragedy. This appears to be supported by the CAR results, which suggest that there was no reaction by investors to event until the fifth trading after it had occurred. A possible explanation for this may be that investors may have viewed the negative impact of the event on Lonmin in particular as being a positive development for Northam Platinum, a rival platinum mining firm that is roughly equivalent in size and stature (although not so in terms of market capitalisation as provided earlier in Table 4.2), particularly after more details surrounding the shootings emerged.

FIGURE 4.5: ARs AND CARs: NORTHAM PLATINUM

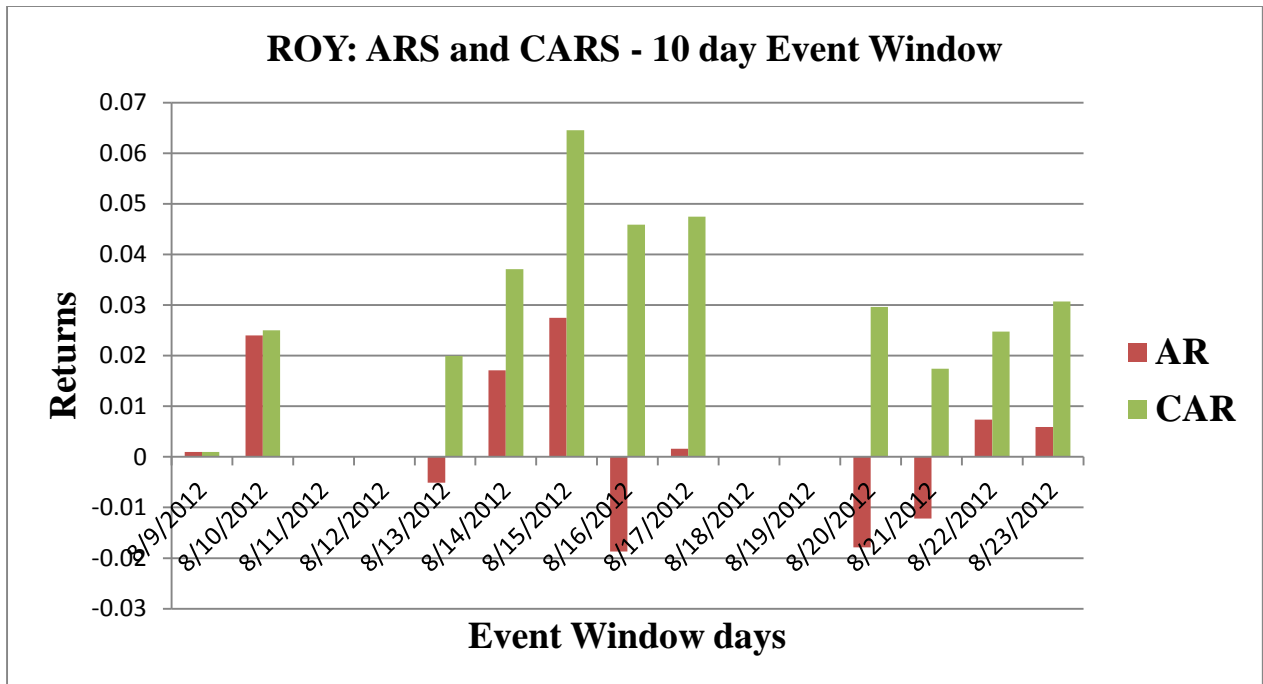


4.4.6 Royal Bafokeng

The final ARs and CARs that will be examined in this section are those that occurred to shares of Royal Bafokeng Platinum, one of the firms with comparatively small market capitalisation. A graphical presentation of the ARs and CARs for RBP shares is given in Figure 4.6 below. In many ways, the RBP shares continue the pattern found in the majority of the other firms analysed in experiencing a mixture of positive and negative ARs. Positive ARs that were of reasonable size were experienced by the shares on day -4, day -2, day -1, day +4 and day +5, with the largest of these being the ARs that occurred during the pre-event portion of the window. Only the positive ARs that occurred on day -4 and day -1 were found to be significant at any of the conventional levels (at the 10% and 1% levels respectively). Negative ARs were found on day -3, day '0', day +2 and day +3. In contrast to test results for the positive ARs, none of the negative ARs were found to be significant at any level.

The results for CAR performance are also interesting. Here, strictly positive CARs of varying size were found for the shares across all the days of the event window. In terms of statistical significance, the majority of the CARs experienced by the shares are significant (at the 1%, 5%, and 10% levels). The only CARs that are not significant at any of the conventional levels are those that occurred day -5, day -3 and day +3. The CARs that occurred during the pre-event portion of the window may be explained by the investors reacting positively to the troubles being experienced by a rival (in the form of the strikes running up to the shootings). From this evidence, it is possible to conclude that investors in RBP shares reacted positively to the violent strike action that precipitated Marikana but not the shootings themselves. In addition, the impact of the violent strike action persisted for some time.

FIGURE 4.6: ARs AND CARs: ROYAL BAFOKENG PLATINUM



4.5 EVENT STUDY RESULTS – EXTENDED 10 DAY EVENT WINDOW

This section continues and extends the analysis performed in the preceding section. In order to further investigate how the shares for each of the firms reacted in the days that followed the shootings at Marikana, the lengths of the post-event portions for the event windows used were extended by an additional ten trading days after the end of the initial post-event portion (which ended on 2012/08/23). As a result of this alteration, the trading days that will be discussed for each firm fall on and between the dates 2012/08/24 and 2012/09/06 (as before, each event day that will be denoted by the positive sign to highlight the fact that it forms part of the post-event portion of the window). The motivation for the extensions of this manner is to examine any change in the behaviour of the shares that may have occurred after more time has been given for investors to react in the aftermath of the tragedy. The criteria and techniques used for statistical significance testing of the additional ARs and CARs that have been calculated remain the same as before.

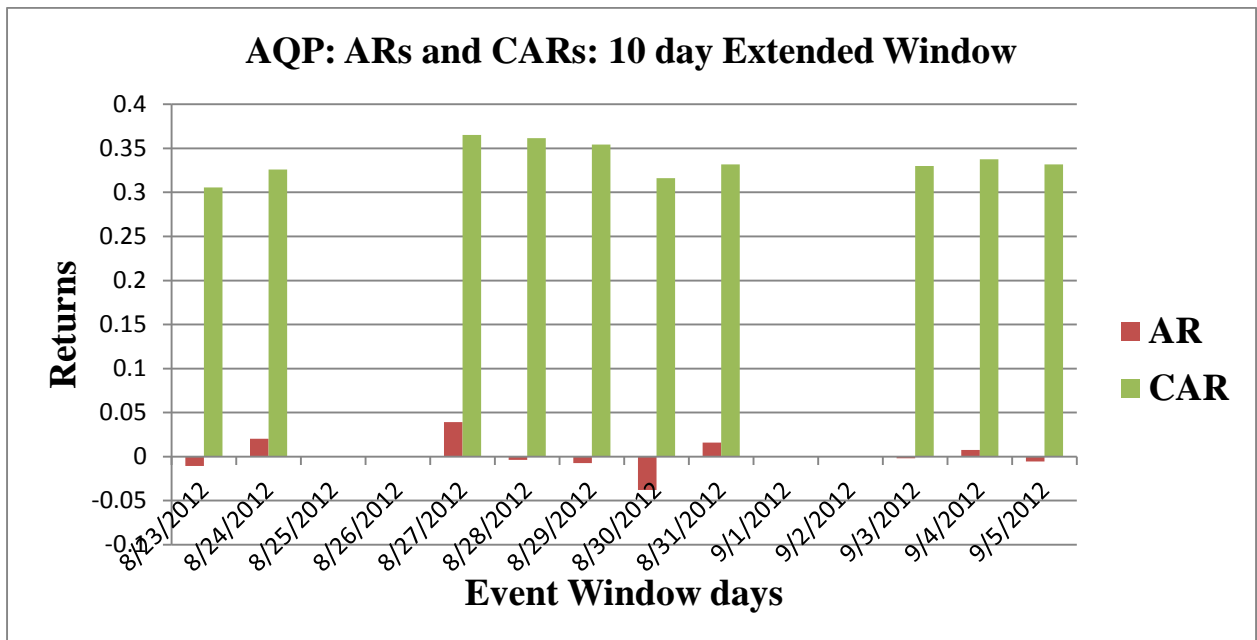
4.5.1 Aquarius

The ARs and CARs to AQP shares over the course of the extended window are given in Figure 4.7 below. When the ARs are examined, extremely small values for both the positive and the negative ARs were seen. In most of the days of the extended window, these positive and negative ARs were near-zero, with none of them being greater than 0.05 on any particular trading day. As expected, none of these were found to be statistically significant at any of the conventional levels.

In contrast, the results found for the CARs continue the trend that began when the initial event window was used. Here, all the CARs were found to be relatively large and positive. In addition, all of these positive CARs were also found to be statistically significant at below the 1% level, a continuation of a trend that began immediately after the shootings (on day +1). When a comparison of the ARs and CARs between the initial and extended event window is carried out, there are two main notable differences between the two. The first is the non-significance and decrease in size of the ARs that occurred during the extended window. The second is that whereas the positive CARs in the initial window gradually increased in the days immediately before and after the event, the highly significant positive CARs found in the extended window were persistently high.

In light of these results, it is possible to conclude that investors in AQP shares reacted positively and immediately to the tragedy. This positive reaction is supported by evidence from both the ARs and CARs that occurred during the initial window, and very strong evidence from the CARs in the extended window, suggesting that the positive reactions of investors persisted for a number of trading days.

FIGURE 4.7: ARs and CARs: 10 day Extended Window – AQP



4.5.2 Anglo American

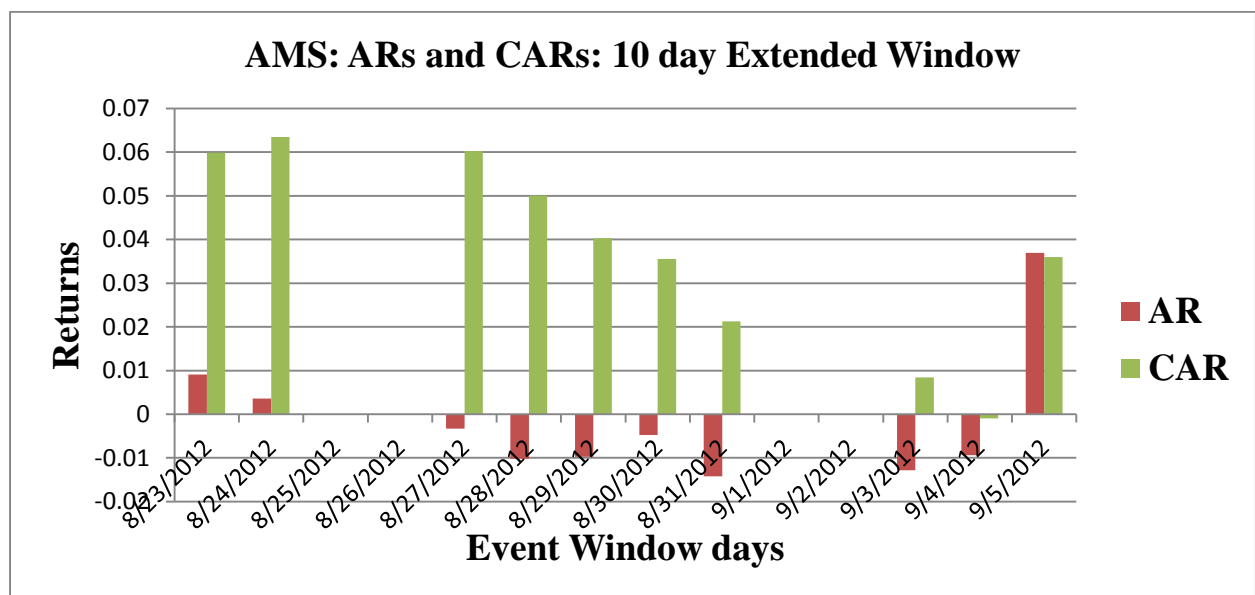
Figure 4.8 below is a graphical representation of the ARs and CARs experienced by AMS shares during a period that begins six trading days after the events at Lonmin mine. Positive ARs occurred on only three days of the window: day +6, day +7 and day +15. Of these, only the AR that occurred on day +15 was found to be significant (at the 5% level). On the other end of the scale, negative ARs of small but varying size were noted for the remainder of the days that make up the window. Importantly, none of them were found to be statistically significant at any conventional level.

The CARs to the AMS shares offer an interesting picture regarding the level of persistence of the event on the shares. Across the entire event window, the CARs were found to be strictly positive, with the exception of day +14 which experiences a very small negative AR. With respect to significance, seven out of the nine positive CARs experienced on the additional

trading days that make up the extended event window were found to be significant (most of them at the 1% level, with the others at least at the 5% level). The sole negative CAR that occurred on day +14 was not found to be significant.

In comparing the AR and CAR results from the extended window with the ARs and CARs from the original event window, two main differences are seen. The first is that the only significant AR experienced by AMS shares occurred fifteen trading days after the event happened (a positive AR on day +15). The second is that significant CARs were found during the extended window that displayed an upward trend. From these results, it is possible to conclude that AMS shares did not react directly to the shootings at Marikana. A handful of significant ARs and CARs were found when the event window was extended and these significant CARs suggest that AMS shares reacted to new information as it was released days later, but these cannot be directly attributable to the shootings.

FIGURE 4.8: ARs and CARs: 10 day Extended Window – AMS



4.5.3 Impala

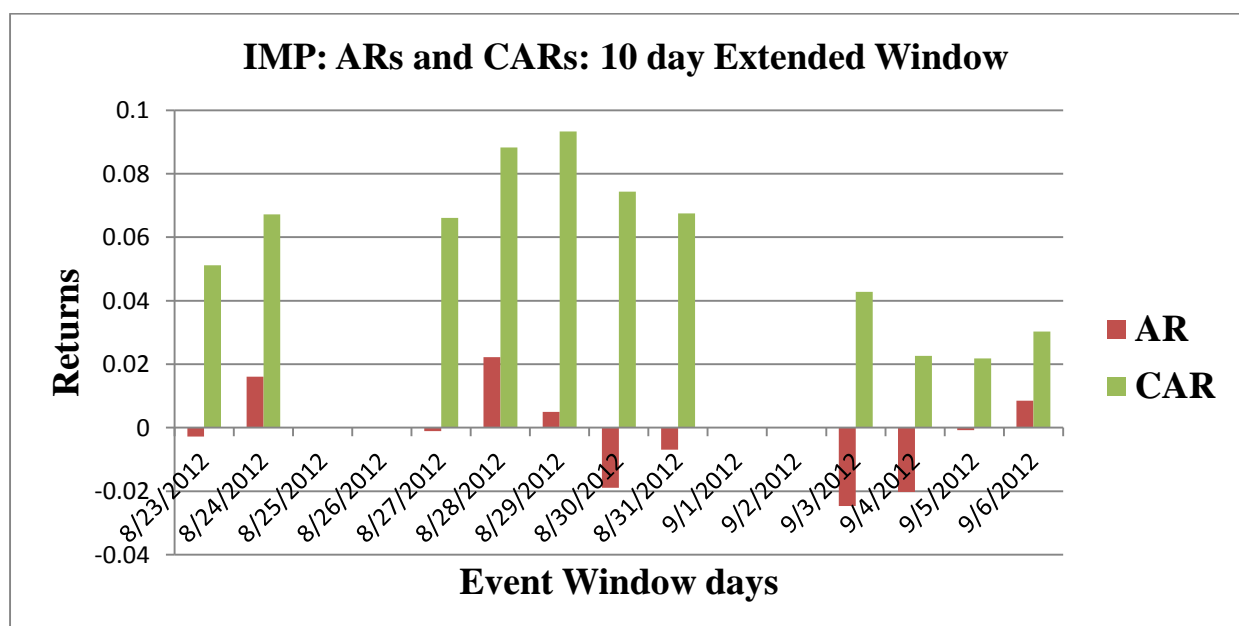
Figure 4.9 below provides a graphical representation of the ARs and CARs experienced by Implats shares during the extended window. In terms of the abnormal returns, a mixture of positive and negative ARs can be seen, with the occurrence of negative ARs dominating those that were positive (which were found on six of the ten trading days that make up the window). However, when tested for significance, none of these positive ARs were

significant. In fact, only the negative AR that occurred on day +12 was found to be statistically significant at any level (10%).

A different picture emerges when the CARs are looked at as well. Large, positive CARs are seen on the first seven days of the window (day +6 up to day +11). From day +12, the size of the positive CARs dramatically reduces, and this continues on days +13 and +14, which both have positive CARs that are less than half the sizes of those that occurred earlier in the window. Statistically, all of the CARs from day +6 to day +11 are significant at the 1% level or lower. For the days that form the remainder of the window, only the CARs on day +12 and +15 are significant (at the 5% level).

When we make a comparison between the initial event window and the extended one, a number of findings are notable. Firstly, with the exception of the negative AR that occurred on day +12, all of the ARs (both positive and negative) were found to be small and insignificant. Secondly, the persistent positive CARs that were experienced by the shares in the days and weeks appear to decrease after a number of weeks have passed. Finally, overall, the CARs in the latter window are larger than the initial window. From these findings, it is possible to conclude that the event had a positive impact on IMP, an impact that persisted for several trading days before it began to revert.

FIGURE 4.9: ARs and CARs: 10 day Extended Window – IMP



4.5.4 Lonmin

In the same manner as the analysis done of Lonmin before, the AR and CAR results displayed in Figure 4.10 below are likely to be of the great interest in this study. Given the observations made using the initial window, it is important to explore the ARs and CARs that occurred during the trading days that followed. From the outset, it is quite clear that, again, the findings made for LON shares differ substantially from those found for the other shares. Only a few examples of positive ARs were found in the window (on day +6, day +8 and day +15). Of these, only the AR that occurred on day +6 was significant at any level (10%). The results that were found for negative ARs are quite striking. In this category, negative ARs were found on the remaining seven days of the window. However, they are all quite small, with the some (such as on days +7, +10 and +12) being very close to zero. In terms of significance, only the negative ARs on days +9 and +14 were significant (both of which are the two largest abnormal losses experienced by LON shares).

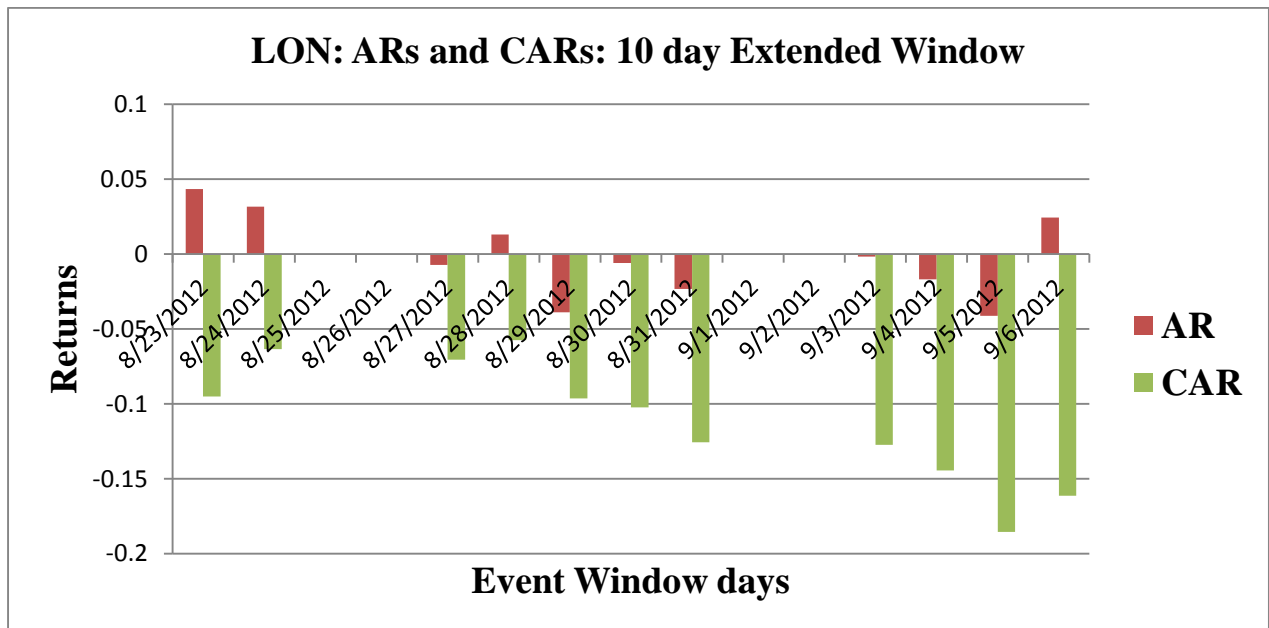
When the results for the CARs are considered, more interesting observations were made. With no exceptions, all the CARs that came about during the extended event window were strictly negative. In fact, the size of these negative CARs increased on an almost daily basis through the window. The only exceptions to this occurred on day +8 and day +15. In addition, these CARs are all comparatively large in size. Significance testing provides further evidence in support of this, as all of the CARs were found to be significant at the lower than the 1% level.

From an analysis of both event windows, a number of important observations must be noted. Looking the abnormal returns, it is quite clear that although there are sporadic examples of small positive ARs throughout the combined event window (of which only a few were significant), the majority were found to be strongly negative and significant in most cases. Specific days that should be highlighted across the event window include the event day itself, day +2 (which is the first trading day of the week that followed the shootings) and day +14. It is clear that all three are a representation of market reaction to new information, either immediately or after a period of gestation such as a weekend (as is the case of the abnormal loss experienced on day +2).

When the CARs are examined, they offer an interesting picture of how the investors in LON shares reacted to the shootings. A core finding to note is that the shootings had an impact that lasted for several trading days after they took place. Based on the fluctuations that occur in

CARs across both windows, it is quite evident that investors reacted in a strong and negative manner each time to new details or controversies surrounding the event came about. Thus, it can be stated that the ARs and CARs from the extended window provide strong evidence supporting the conclusion investors in LON shares reacted negatively to the events at Marikana, a finding that confirms our *a priori* expectations.

FIGURE 4.10: ARs and CARs: 10 day Extended Window – LON



4.5.5 Northam

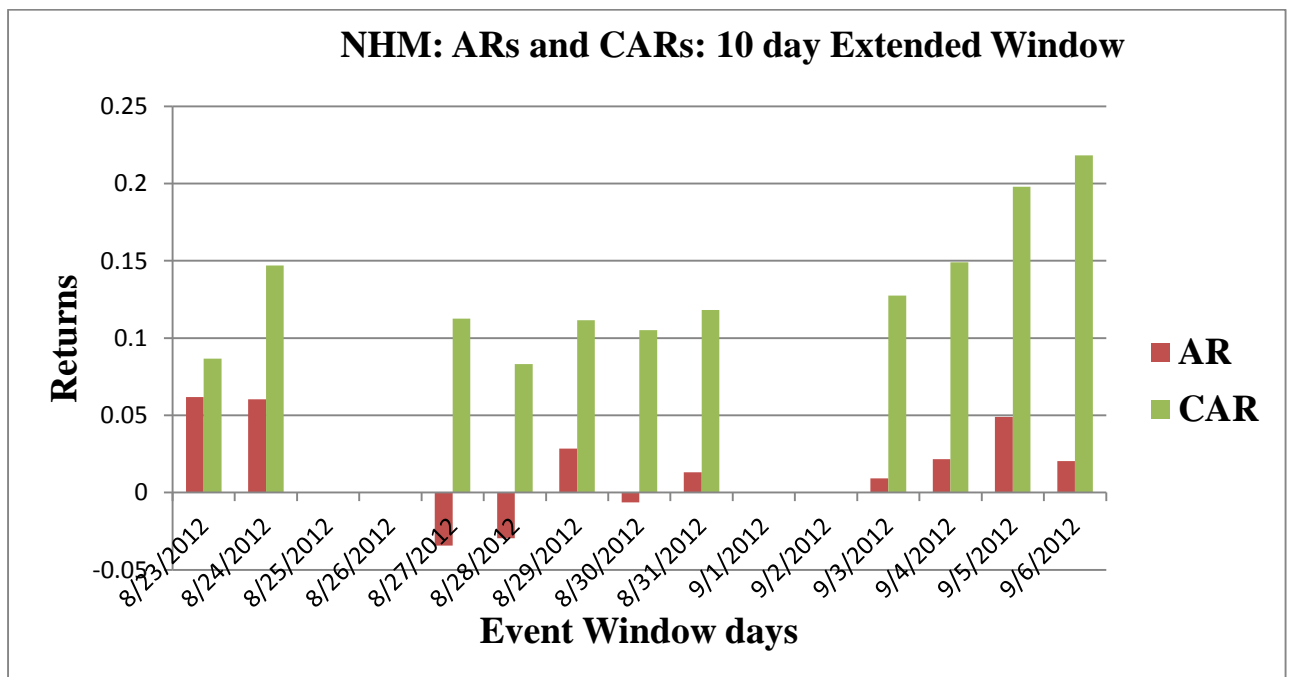
The ARs and CARs that occurred to NHM shares are given in Figure 4.11 below. With respect to the discussion of the ARs, a mixture of positive and negative ones can be seen. Positive ARs were found on seven out of the ten additional trading days. Although these ARs are varied in size, they are all relatively small in size, with the largest one being about 0.065. Statistically, a number of these positive abnormal returns were found to be significant. However, of these, only the ARs that were experienced on day +6 and day +14 were found to be significant, at the 1% and 5% levels respectively. When the three negative ARs are looked at instead, on the AR that occurred on day +7 was found to be significant at any of the conventional levels.

The picture provided by analysing the CARs for the shares appears to mirror those presented by most of the other platinum mining firms (with the exceptions of Lonmin Platinum and Royal Bafokeng Platinum). Once again, all the CARs were found to be strictly positive for

this extended window. However, a number of things must also be noted. Firstly, the CARs, although positive, appear to stabilise at comparatively lower levels during the trading days +7 to +11. After this, the positive CARs begin to increase from day +12 to +15. All the CARs for this extended period were found to be highly significant (at lower than the 1% level).

Comparing the initial and extended windows also presents interesting findings. After an initial period of no reaction/under-reaction in the days immediately after the tragedy, the reaction in the NHM shares that began in the final two days of the initial window (particularly on day +5) was carried over into the extended period when the ARs are considered. The same phenomenon holds true when the CARs are taken into account as well. In addition, through both windows, all the ARs and CARs that displayed any level of statistical significance are all, without exception, positive. All of this evidence suggests that investors did not react immediately to the shootings. Rather, the evidence suggests that investors only responded after more details surrounding the shootings were revealed in the days that followed, and this response was a sustained and positive one. The fluctuations seen in the CARs of the extended window are a representation of investor response to new information.

FIGURE 4.11: ARs and CARs: 10 day Extended Window – NHM



4.5.6 Royal Bafokeng

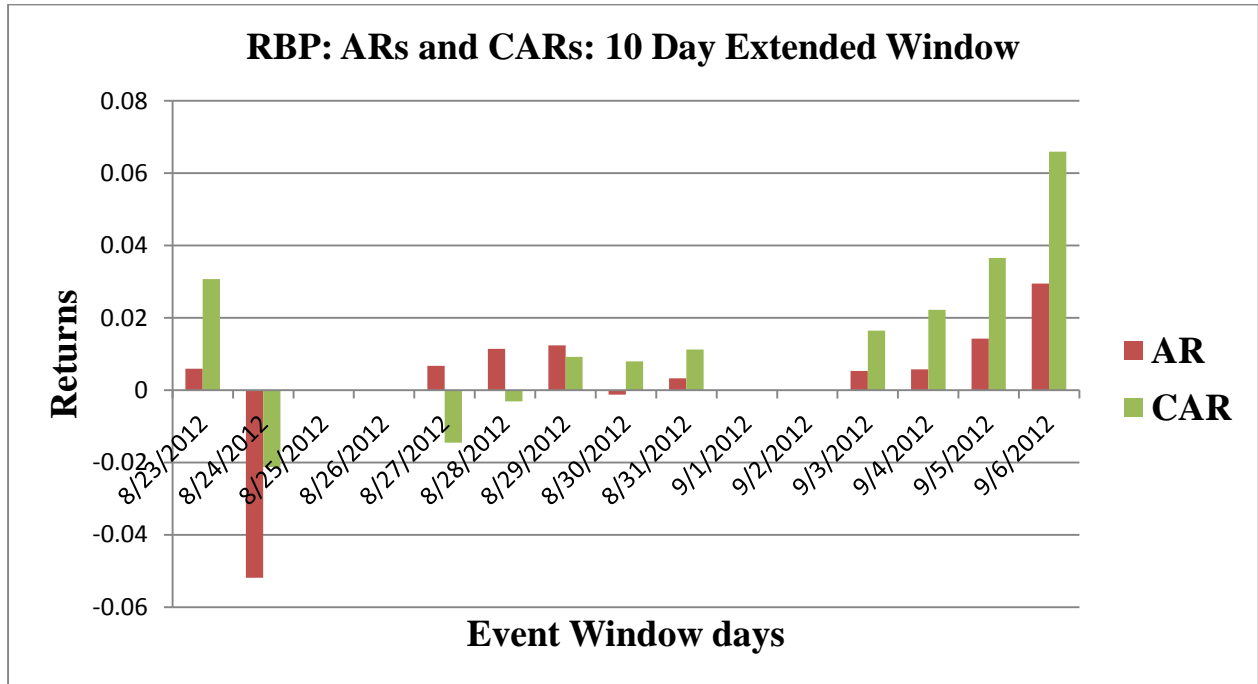
The final ARs and CARs that will be examined using the extended event window are those that occurred for the shares of Royal Bafokeng Platinum. Again, graphical representations of these are provided in Figure 4.15 below. One of the first things that is immediately notable about the AR results for the shares is that, in the same manner as the other firms (except Lonmin), positive ARs dominate throughout trading days of the extended window. Again, it is evident that these positive ARs are quite small, with the only ARs of reasonable size occurring on days +14 and +15. The rest are all relatively small. When tested for significance, the only AR that was found to be significant was that which occurred on day +15. Over the same period, only two negative ARs were experienced by the shares, on day +6 and day +10. The first negative AR is comparatively quite large, while the second one is negligible. Accordingly, when their significance is examined, the negative AR on day +6 is highly significant (at the 1% level) while the AR on day +10 is not significant at all.

When the CARs to the shares are taken into account, mixed performance is again seen that mirrors the results found for the other firms to some extent. Once again, positive CARs dominate throughout the period, with these being experienced on seven out of the ten trading days. These begin on day +9 and gradually increase during the remaining days of the window. Statistically, only the positive AR that occurred at the end of the window was found to be significant (day +15 at the 5% level). In contrast to this, for the first three days of the extended window, the CARs are negative. However, none of these were found to be significant at any conventional level.

A comparison of both of the event windows brings up a number of interesting findings. Firstly, while most of the other firms have displayed a level of consistency between the windows, the shares of RBP appear to be more volatile. Specifically, when the ARs are examined closely, there are more swings between positive and negative ARs over all fifteen post-event days for the RBP shares than is seen for the shares of all the other platinum firms except Lonmin. Therefore, such a finding suggests that these shares were more sensitive to the release of information than the other firms. Further, when the CARs for both periods are looked at closely, we find that RBP shares once again follow a transition that is different than that seen for the other firms. Here, the CARs swing from negative (during the first three days of the extended window) to positive for the remaining days, a result that contrasts with all other firms (excluding Lonmin) which experienced positive and almost universally

significant CARs. From this analysis, it is possible to conclude that, after an initial period of uncertainty and negative reaction to the shootings, the investors in RBP shares reacted positively to the events are Marikana.

FIGURE 4.12: ARs and CARs: 10 day Extended Window – RBP



Looking at all the firms together, a number of interesting trends emerge. One of the more interesting ones is the fact that using the extended window (and thus additional trading days to further our analysis) and balancing out between the positive and negative ARs and CARs that occurred to each share, we can see that the effect of the tragedy is positive for all the firms except Lonmin. This is the case even though the levels and significance of the positive ARs and CARs differs substantially between the five firms that experienced this phenomenon. A reason that can explain these findings is competition. In particular, two aspects of competition in the platinum mining sector are important.

The first is the relative sizes of the firms that make up this sector with respect to their market capitalisations, and the second that follows on from this is the barriers to entry that exist in this sector (brought about primarily by the extreme capital requirements associated with mining in general and platinum mining in particular). The combination of these is such that is a high level of competition between participants in the sector. Such a situation would be more vigorous in cases such as this one, where the size firms, although not the only ones engaged in platinum mining, are nevertheless the largest and most distinguished of them. Thus, the

demise of one would benefit the positions, both current and future, of the others. In light of this, we argue that this reasoning adequately explains why, through the extended event windows, all the firms except Lonmin experienced positive abnormal returns of varying sizes.

An additional trend that should also be taken note of is the fact that for all firms except Lonmin, it takes several trading days for the CARs experienced by them to form a consistent pattern. This can be viewed as being consistent with the timing of the release of information surrounding the shootings. It is clear from the evidence that all the firms reacted at in an almost uniform manner on a number of key dates. This result is also consistent with our *a priori* expectations, with the only differences expected being the sizes and directions of the reactions by investors in each individual share.

4.6 CONCLUSION

The results of the empirical investigation done to determine the impact of the shootings at Marikana on the share prices on the selected platinum mining firms are presented in this chapter. In this chapter, we began by presenting and discussing the results of stationarity tests performed and the descriptive statistics for the data. The overall picture that was obtained from this analysis was that the data used for each firm contained properties that are commonly found and expected when financial data is considered. These properties include non-normal distribution and excess kurtosis.

Following this, the abnormal returns and cumulative abnormal returns for each firm were calculated using the initial 10 day event window that took into account trading days that fell before, on and after the shootings using the event study techniques and procedures set out in Chapter 3. The results of this investigation revealed that investor reaction, although found to be mixed when the pre- and post-event portions of the window were looked at, was consistently negative across all firms with the interesting exception of Aquarius. Thereafter, the ARs and CARs for each firm over the extended 10 day event window were also analysed using the same techniques and procedures. Here, the behaviour of the ARs and CARs revealed that, as expected, all firms except Lonmin experienced positive ARs and CARs of various size that were driven by the positive sentiments of the investors for each of these five firms.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSION AND AREAS OF FURTHER RESEARCH

5.1 SUMMARY OF THE STUDY AND CONCLUSIONS

This study examined the financial impact of the tragic shootings that occurred at Lonmin mine in Marikana on August 16th 2012 using event study methodology. Specifically, it investigated how the six platinum firms selected for analysis reacted to the shootings on the day they occurred and for a specified number of trading days after they occurred. The research made use of daily trading data for each of the six firms that make up the FTSE/JSE Platinum Mining Index and the FTSE/JSE All-Share Index. The six firms in question were Aquarius, Anglo American, Impala, Lonmin, Northam and Royal Bafokeng. A total of six market models for generating normal returns to the shares of each firm were estimated.

The starting point in our analysis was to conduct a review of the theoretical and empirical literature that was applicable to the content being investigated and the techniques used. This was done in order to attain the necessary understanding of the relevant procedures and models that can be used in event studies. Included in this discussion were a review of the origins and motivations for event studies as empirical investigation tools, and pertinent issues and debates that must be taken into consideration such as the use of parametric versus nonparametric testing procedures.

Following on from this, a review of the empirical literature allowed us to examine how event study methodology has been applied in prior empirical studies using nonconventional events that can be grouped broadly within the same category as the tragedy that is the focus of this study. This section also included a survey of the seminal papers by Brown and Warner (1980; 1985) on event study methods in general and the use of daily data respectively.

In order to achieve the objective for this paper, the methodology to be followed for the event study was first set out in detail. This methodology included the specification of the market model, how abnormal returns and cumulative abnormal returns are calculated, as well as the event window lengths and how they were selected. The empirical study was then carried out using, first, the initial event window and second, the extended window. The results found for this inquiry were quite varied. Using the initial window, it was found that most of the shares

experienced negative returns either on day 'o' or at some point during the two days that followed this. These negative returns are attributable to the shootings, either directly or indirectly. Using the extended window, the shares of five firms out of six exhibited almost universal positive returns of varying size. Overall, it was shown that investors in the shares of most of these platinum mining firms reacted in a positive manner to the shootings at Marikana over the entire period under investigation (the combined length of both the initial and extended event windows), with only of the six firms being an exception to this.

Differences in how investor perception and reaction transformed over the course of our period of analysis were found at individual firm level, where the shares were found to have reacted at different times and with different magnitudes. For example, Amplats, as a large and well-established firm, exhibited strong under-reaction in its shares to the shootings in the few trading days that occurred afterwards; in contrast, Aquarius is the only firm that experienced consistently positive returns both immediately before and immediately after the tragic event.

The sole firm found to have experienced a high occurrence of negative returns to its shares in response to the tragedy was the firm responsible for the mine where the shootings occurred, Lonmin. Such a finding also conformed to our *a priori* expectation that tragic events of this nature have negative consequences for both the shares of the firms and, if the event in question is large and persists for long enough, the productivity and future prospects too. The findings also confirmed the *a priori* expectation that, in small sectors where there is a high level of competition, investors in the shares of rival firms react positively to negative event experienced by another, possibly so long as that event is highly localised to the firm that experienced it.

5.2 AREAS FOR FURTHER RESEARCH

While this study examines the impact of the tragic event on the shares of a small number of firms in the platinum sector, the socio-economic and political consequences were not isolated solely within this industry, a view that is supported by the various debates, media coverage and industry and governmental responses that have been seen since.

Thus, it is highly possible to extend the analysis such that the event study methodology made use of in this research is used on other industries. These other industries include, but are not limited to, the automotive industry or other resource extraction sectors such as gold mining. It

would also be worthwhile to conduct a similar investigation using the shootings as the focal event once again, but on a much larger and broader scale. Examples of this include analysing the response of the FTSE/JSE All-Share Index, or examining the impact on the shares of the firms that make up the FTSE/JSE Resource 10 Index. Either would offer broader pictures at both the economy-wide and industry-specific levels.

Lastly, the findings made in this research have significant policy implications for the South African mining sector. Specifically, the findings in this paper can contribute to the ongoing debates in, firstly, the relationship between mineworkers and their employers, and secondly, on the mode and level of involvement of the South African government (with specific reference to the Department of Mineral Resources) in resolving conflicts between mineworkers and their private employers.

In addition, the findings also have the potential to inform debates on competitive practices in similar economic sectors that are characterised by significant barriers to entry such as the substantial initial financial investment required in the mining sector. Following on from this, it would be interesting to determine whether the results achieved in this paper would have differed had there been several other firms in the platinum subsector.

References

- AHERN, K.R., 2009. "Sample Selection and Event Study Estimation." *Journal of Empirical Finance*. 16: 466 – 482.
- ARMITAGE, S. 1995. "Event Study Methods and Evidence on Their Performance." *Journal of Economic Surveys*. 8: 25 – 52.
- ANDERSON, T.M., 1983. "Some Implications of the Efficient Capital Market Hypothesis". *Journal of Post Keynesian Economics*. 6(2): 281 – 294.
- BARAKAT, M. and TERRY, R., 2010. "A Re-evaluation of Event-study methodology." *Journal of International Finance and Economics*. 10(4): 13 – 49.
- BERRY, M.A., GALLINGER, J.W., and HENDERSON, G.V., 1990. "Using Daily Stock Returns in Event Studies and the Choice of Parametric versus Non-Parametric Test Statistics." *Quarterly Journal of Business and Economics*. 29(1): 70 – 85.
- BINDER, J.J., 1985. "Measuring the Effect of Regulation using Stock Price Data." *The RAND Journal of Economics*. 16(2): 169 – 183.
- BOTHA, F., and de BEER, C., 2013. "Does National Sporting Performance Affect Stock Market Returns in South Africa?" *Journal of Economic and Financial Sciences*. 6(1): 67 – 82.
- BROWN, S.J. and WARNER, J.B. (1980). "Measuring security price performance." *Journal of Financial Economics*. 8: 205 – 258.
- BROWN, S.J. and WARNER, J.B. (1985). "Using daily stock returns: The case of event Studies." *Journal of Financial Economics*. 14(1): 3 – 31.
- BINDER, J.J., 1998. "The Event Study Methodology Since 1969". *Review of Quantitative Finance and Accounting*. 11: 111 – 137.
- BBC NEWS, 2012. [Online] *South Africa Lonmin mine killings: Zuma announces inquiry*. Available: <http://www.bbc.co.uk/news/world-africa-19301690>. [Accessed: 2 March 2013].
- CAPELLE-BLANCARD, G. and LAGUNA, M-A., 2010. "How does the Stock Market Respond to Chemical Disasters?" *Journal of Environmental Economics and Management*. 59: 192 – 205.

- CHAMBER OF MINES OF SOUTH AFRICA, 2013. [Online] *Platinum Group Metals*. Available: <http://www.bullion.org.za/content/?pid=86>. [Accessed: 8 March 2013].
- CHINZARA, Z., and AZIAKPONO, M. A., 2009. "Dynamic returns linkages and volatility transmission between the South African and the major world stock markets". *Journal of Studies in Economics and Econometrics*. 33(3): 69-94.
- CORRADO, C.J., 1989. "A Nonparametric test for Abnormal Security-price performance in event studies." *Journal of Financial Economics*. 23(2): 385 – 395.
- CORRADO, C.J. and ZIVNEY, T.L., 1992. "The Specification and Power of the Sign Test in Event Study Hypothesis Tests Using Daily Stock Returns." *Journal of Financial and Quantitative Analysis*. 27(3): 465 – 478.
- COUTTS, J.A., MILLS, T.C., and ROBERTS, J., 1994. "The Market Model and the Event Study: A Synthesis of the Econometric Criticisms." *International Review of Financial Analysis*. 3(2): 149 – 171.
- COWAN, A.R., NAYAR, N., and SINGH, A.K., 1990. "Stock Returns before and after Calls to Convertible Bonds." *The Journal of Quantitative and Financial Analysis*. 25(4): 549 – 554.
- COWAN, A.R., 1992. "Nonparametric Event Study Tests". *Review of Quantitative Finance and Accounting*. 2:343 – 358.
- COWAN, A.R., 1993. "Tests for Cumulative Abnormal Returns over Long Periods: Simulation Evidence." *International Review of Financial Analysis*. (2): 51 – 68.
- DEATON, A., 1990. "Commodity Prices and Growth in Africa." *Journal of Economic Perspectives*. 13(3): 23 – 40.
- DOLLEY, J.C., 1933. "Characteristics and Procedures of Common Stock Split-ups." *Harvard Business Review*. 11:316 – 326.
- D.M.E, 2007. [Online] "A Strategic Framework for Implementing Sustainable Development in the South African Minerals Sector: Towards Developing Sustainable Development Policy and Meeting Reporting Commitments." Discussion Document, Department of Minerals and Energy. Available: <http://www.info.gov.za/view/DownloadFileAction?id=78956>. [Accessed: 13 March 2013].

- DU PLESSIS, C., 2013. [Online] “Marikana families sue police for millions.” City Press. Available: <http://www.citypress.co.za/news/marikana-families-sue-police-for-millions/>. [Accessed: 7 March 2013].
- ECOPARTNERS, 2011. [Online] Synopsis of the first report of mineral resources and reserves in South Africa. Internal Client Report. Available: <http://www.kwikwap.co.za/ecopartners/docs/Mineral%20Resource%20and%20Reserves%20of%20South%20Africa.pdf> [Accessed: 27 February 2013].
- ENDERS, W., 2010. *Applied Econometric Time Series*. John-Wiley & Sons: New Jersey.
- FAMA, E.F., FISHER, L., JENSON, M.C., and ROLL, R., 1969. “The Adjustment of Stock Prices to New Information.” *International Economic Review*. 10(1): 1 – 21.
- FAMA, E.F., 1991. “Efficient Capital Markets: II”. *Journal of Finance*. 46(5): 1575 – 1617.
- FAMA, E.F. and FRENCH, K.R., 1993. “Common Risk Factors in the Returns on Stocks and Bonds.” *Journal of Financial Economics*. 33: 3 – 56.
- FERSTL, R., UTZ, S., and WIMMER, M., 2012. “The Effect of the Japan 2011 Disaster on Nuclear and Alternative Energy Stocks Worldwide: An Event Study.” *BuR – Business Research*. 1 (5): 25 – 41.
- FTSE/JSE, 2004. [Online] Guide to Calculation Methods for FTSE/JSE Africa Index Series. Available: <http://www.jse.co.za/Products/FTSE-JSE.aspx>. [Accessed: 14 March 2013].
- GANGOPADHYAY, P., HALEY, J.D., and ZHANG, L., 2010. “An Examination of Share Price Behaviour Surrounding the 2005 Hurricanes Katrina and Rita.” *Journal of Insurance Issues*. 33 (2): 132 – 151.
- GARCIA, M.J.R., 2013. “Financial Education and Behavioural Finance: New Insights into the Role of Information in Financial Decisions.” *Journal of Economic Surveys*. 27(2): 297 – 315.
- GUIDOLIN, M. and LA FERRARA, E., 2010. “The Economic Effects of Violent Conflict: Evidence from Asset Market Reactions.” *Journal of Peace Research*. 47: 671 – 684.
- GUPTA, R., and REID, M., 2013. “Macroeconomic Surprises and Stock Returns in South Africa.” *Studies in Economics and Finance*. 30(3): 266 – 282.

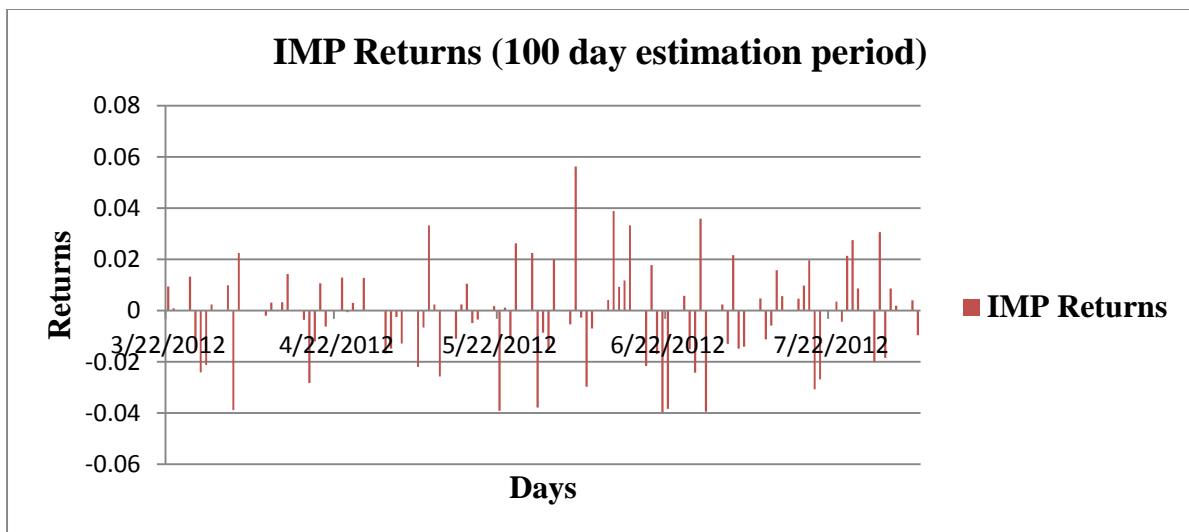
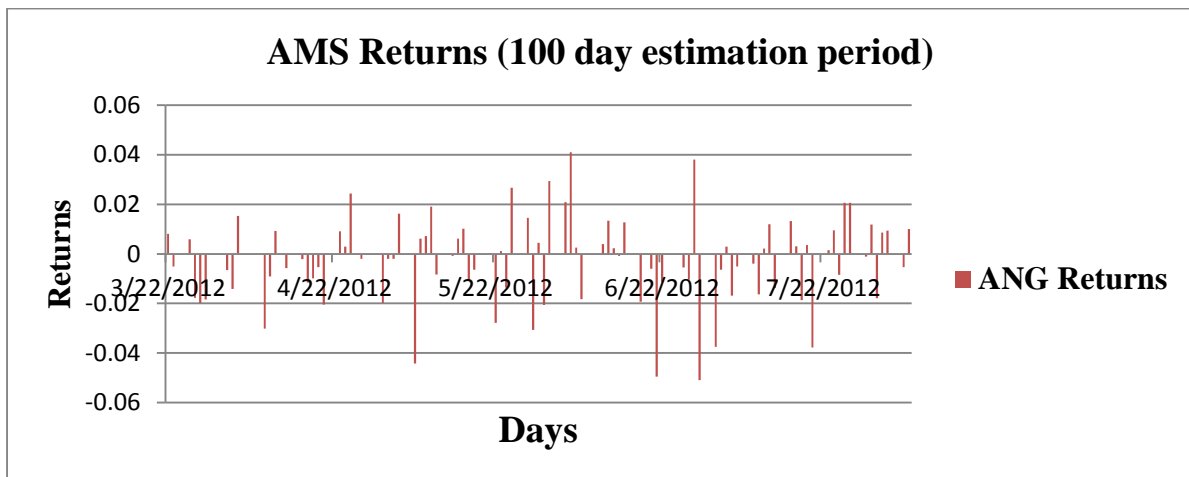
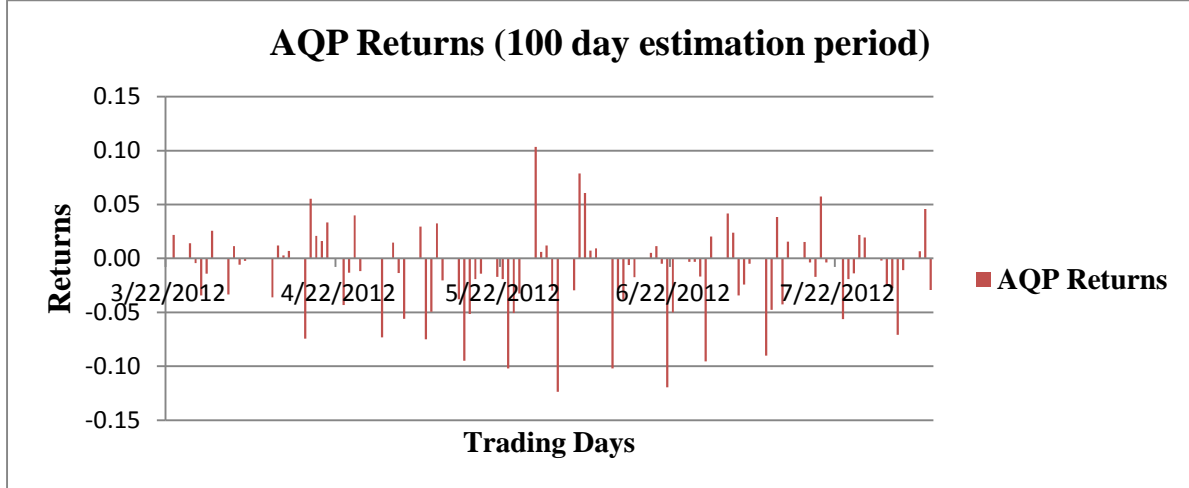
- HENDERSON Jr, G.V., 1990. "Problems and Solutions in Conducting Event Studies." *The Journal of Risk and Insurance*. 57(2): 282 – 306.
- HURSH, S.R., and ROMA, P.G., 2013. "Behavioural Economics and Empirical Public Policy." *Journal of the Experimental Analysis of Behaviour*. 99: 98 – 124.
- KNIGHT, R.F., 1980. "The Efficient Market Hypothesis and a changes to L.I.F.O". Masters's Thesis, Dept. of Mathematical Statistics, University of Cape Town.
- KOLARI, J.W., and PYNNONEN, S., 2011. "Nonparametric rank tests for event studies." *Journal of Empirical Finance*. 18: 953 – 971.
- KOTHARI, S.P., and WARNER, J.B., 2007. "Econometrics of Event Studies." in B.E. ECKBO (Ed.), *Handbook of Corporate Finance*, Vol. 1, Chap 1. (Elsevier/North-Holland, Handbooks in Finance Series.)
- LEE, S. and CONNOLLY, D.J., 2010. "The Impact of IT News on Hospitality Firm Value Using Cumulative Abnormal Returns (CARs)." *International Journal of Hospitality Management*. 29: 354 – 362.
- LEHMANN, E.L., 1975. *Nonparametrics: Statistical Methods based on Rank*. Holden-Day: San Francisco, CA.
- LOFERSKI, P.J., 2010. [Online] Platinum Group Metals. Report for the 2010 US Geological Survey Minerals Yearbook, 2010. Available: <http://minerals.usgs.gov/minerals/pubs/commodity/platinum/myb1-2010-plati.pdf>. [Accessed: 28 February 2013].
- LOFERSKI, P.J., 2011. [Online] Platinum Group Metals. Report for the 2011 US Geological Survey Minerals Yearbook, 2011. Available: <http://minerals.usgs.gov/minerals/pubs/commodity/platinum/myb1-2011-plati.pdf>. [Accessed: 28 February 2013].
- LUOMA, T., 2011. "Nonparametric Event Study Tests for Testing Cumulative Abnormal Returns." *Acta Wasaensia*. 254: 1 – 88.
- MA, J., PAGAN, J.A. and CHU, Y., 2009. "Abnormal Returns to Mergers and Acquisitions in Ten Asian Stock Markets." *International Journal of Business*. 14(3): 235 – 260.

- MACKINLEY, A.C., 1997. "Event Studies in Economics and Finance." *Journal of Economic Literature*. 35:13 – 39.
- MAIL & GUARDIAN, 2012. [Online] *Lonmin's burning: Mtetwa says over 30 killed*. Mail & Guardian. Available: <http://mg.co.za/article/2012-08-17-lonmins-burning-25-people-killed-in-shootout> [Accessed: 4 March 2013].
- MALATESTA, P., 1986. "Measuring Abnormal Performance: The Event Parameter Approach Using Joint Generalised Least Squares." *Journal of Financial and Quantitative Analysis*. 21: 27 – 38.
- MALKIEL, B.G., 1989. "Is the Stock Market Efficient?". *Science*. 243(4896): 1313 – 1318.
- MASTER BUILDERS ASSOCIATION, 2012. [Online] *The importance of platinum mining and production in South Africa*. Available: http://www.masterbuilders.co.za/news/2012/October/the_importance_of_platinum_mining_and_production_in_south_africa.htm. [Accessed: 9 March 2013].
- McDONALD, B., 1987. "Event Studies and Systems Methods: Some Additional Information." *Journal of Financial and Quantitative Analysis*. 22(4): 459 – 504.
- McWILLIAMS, T.P. and McWILLIAMS, V.B., 2000. "Another Look at Theoretical and Empirical Issues in Event Study Methodology." *Journal of Applied Business Research*. 16(3): 1 – 12.
- MULHERIN, J.H., 2007. "Measuring the Costs and Benefits of Regulation: Conceptual Issues in the Securities Market." *Journal of Corporate Finance*. 13: 421 – 437.
- NEW YORK TIMES, 2012. [Online] *Mine Strike Mayhem Stuns South Africa as Police Open Fire*. Available: http://www.nytimes.com/2012/08/17/world/africa/south-african-police-fire-on-striking-miners.html?_r=0. Accessed: 7 March 2013.
- OANCEA, D., 2008. [Online] *Platinum in South Africa*. Available: <http://www.infomine.com/library/publications/docs/Mining.com/Sep2008e.pdf> [Accessed: 23 February 2013].
- PANAYIDES, M. & GONG, X., 2002. "The Stock Market Reaction to Merger and Acquisition Announcements in Liner Shipping" *International Journal of Maritime Economics*. 4(1): 55- 80.

- PENDALL, D.L., and CHO, C., 2013. "Stock Market Reaction to Contagious Animal Disease Outbreaks: An Event Study in Korean Foot-and-Mouth Disease Outbreaks." *Agribusiness: An International Journal*. 1 - 14
- PINNUCK, M., 2005. "What is the Abnormal Returns Performance of Mutual Funds due to Private Earnings Information?" *Journal of Contemporary Accounting & Economics*. 2: 193 – 215.
- REILLY, F.K. and BROWN, K.C. (2012). *Analysis of Investments & Management of Portfolios*. South-Western: Cengage Learning.
- ROBINSON, L.A., and HAMMITT, J.K., 2011. "Behavioural Economics and Regulatory Analysis." *Risk Analysis*. 31(9): 1408 – 1422.
- SCHWERT, G.W., 1981. "Using Financial Data to Measure the Effects of Financial Regulation." *Journal of Law and Economics*. 24(1): 121 – 158.
- SOUTH AFRICAN GOVERNMENT INFORMATION, 2012. [Online]. Mineral Resources.
Available: <http://www.info.gov.za/aboutsa/minerals.htm> [Accessed: 27 February 2013].

APPENDIX

FIGURE A1: GRAPHICAL PLOT OF RETURNS TO PLATINUM SHARES



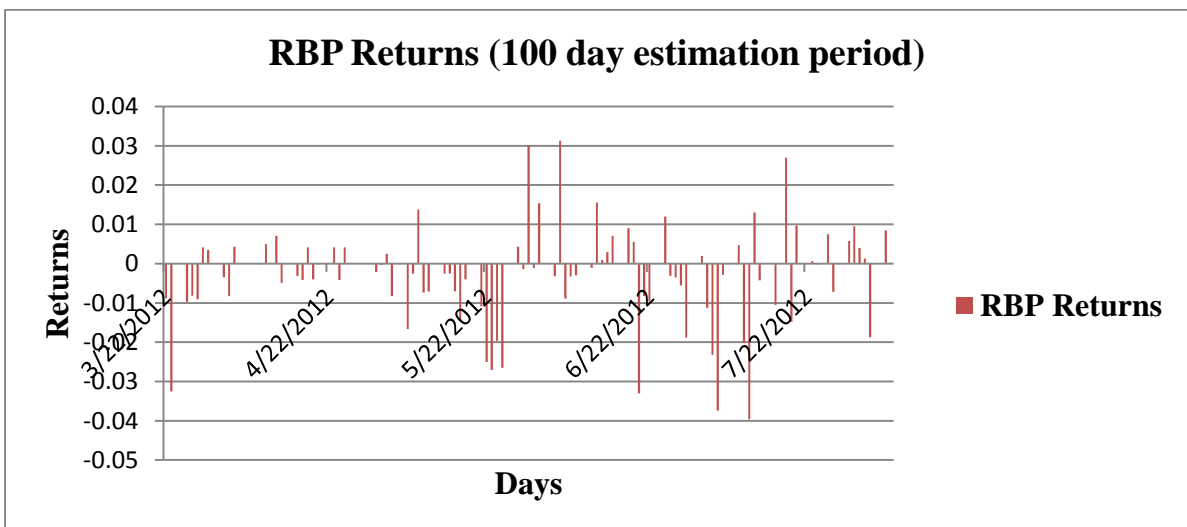
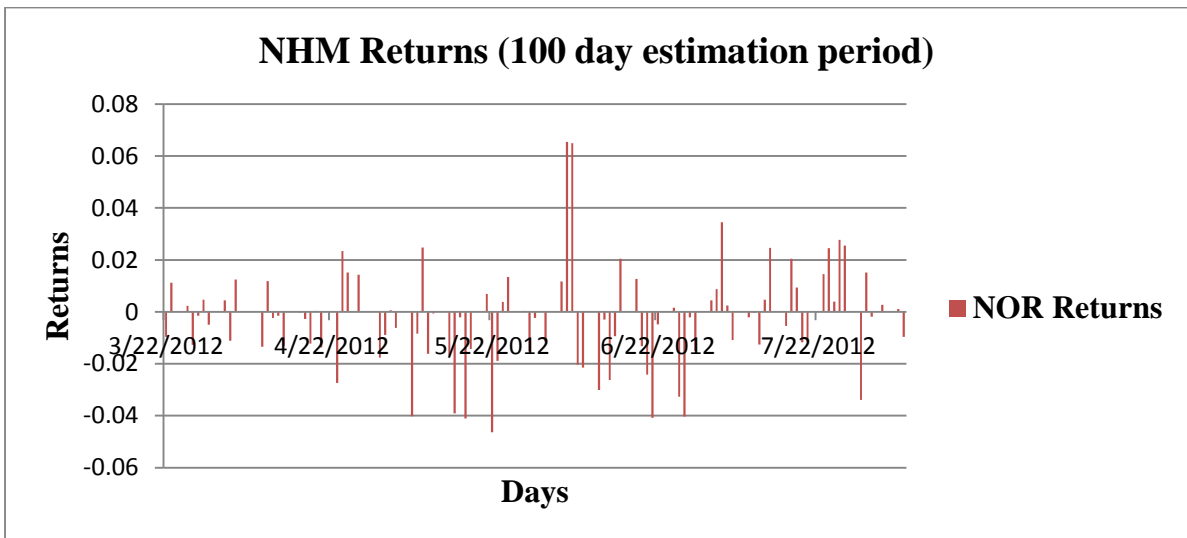
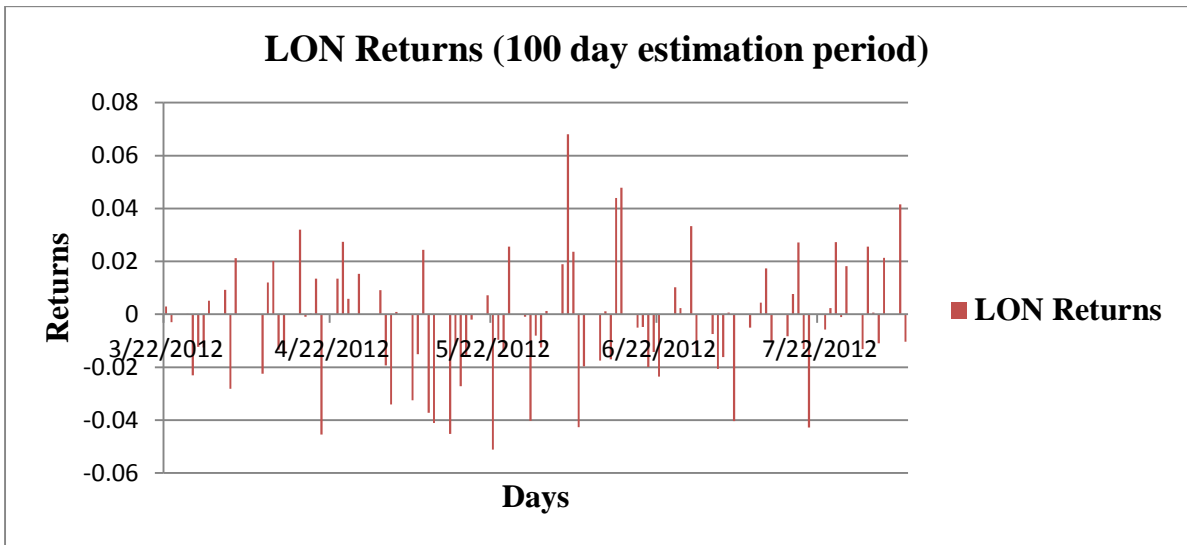


FIGURE A2: t – statistics (observed)**FIGURE A2.1: AQP**

Date	[E] r	AR	CAR	AR t-test	CAR t-test
2012/08/09	-0.0031	0.003095	0.003095	0.083583	0.0835827
2012/08/10	-0.00944	0.056754	0.05985	1.532446	1.6160292
2012/08/13	-0.027	0.024951	0.0848	0.67371	2.2897393
2012/08/14	-0.01043	-0.01426	0.070542	-0.38501	1.9047318
2012/08/15	-0.02149	0.006725	0.077267	0.181584	2.0863162
2012/08/16	-0.00601	0.016712	0.093979	0.451255	2.5375716
2012/08/17	-0.03429	0.080898	0.174877	2.184379	4.7219503
2012/08/20	-0.01134	-0.017	0.157881	-0.45892	4.2630321
2012/08/21	0.009638	0.077862	0.235744	2.102396	6.3654283
2012/08/22	-0.03337	0.01038	0.246123	0.280271	6.6456997
2012/08/23	-0.00123	0.069855	0.315978	1.886178	8.5318775
2012/08/24	-0.02807	-0.01046	0.305513	-0.28257	8.2493095
2012/08/27	-0.00895	0.020403	0.325916	0.550902	8.8002111
2012/08/28	-0.02043	0.0393	0.365216	1.061155	9.8613664
2012/08/29	-0.01476	-0.00376	0.361454	-0.10156	9.7598071
2012/08/30	-0.0342	-0.00731	0.354142	-0.19745	9.5623614
2012/08/31	-0.00326	-0.03807	0.316068	-1.02805	8.5343088
2012/09/03	-0.00758	0.015797	0.331865	0.426538	8.9608466
2012/09/04	-0.02048	-0.00192	0.329943	-0.0519	8.9089451
2012/09/05	-0.01792	0.007499	0.337442	0.202481	9.1114263
2012/09/06	0.022511	-0.00567	0.331773	-0.15306	8.9583696

FIGURE A2.2: AMS

Date	[E] r	AR	CAR	AR t-test	CAR t-test
2012/08/09	0.002355	-0.00235	-0.00235	-0.16865	-0.168651
2012/08/10	-0.00088	0.003199	0.000845	0.229133	0.0604815
2012/08/13	-0.00985	0.005807	0.006651	0.415859	0.47634
2012/08/14	-0.00139	0.002851	0.009502	0.204173	0.6805135
2012/08/15	-0.00704	-0.00079	0.008711	-0.05665	0.6238608
2012/08/16	0.00087	-0.0067	0.002007	-0.48012	0.1437454
2012/08/17	-0.01357	-0.0146	-0.0126	-1.04584	-0.902091
2012/08/20	-0.00186	0.016396	0.0038	1.174266	0.2721744
2012/08/21	0.008854	0.014907	0.018707	1.067595	1.339769
2012/08/22	-0.0131	0.010771	0.029478	0.771387	2.1111561
2012/08/23	0.003308	0.021307	0.050785	1.525955	3.6371106
2012/08/24	-0.01039	0.009117	0.059902	0.652921	4.2900319
2012/08/27	-0.00063	0.003596	0.063497	0.257517	4.5475487
2012/08/28	-0.00649	-0.00327	0.060225	-0.23436	4.3131885
2012/08/29	-0.0036	-0.01016	0.050061	-0.72793	3.5852544
2012/08/30	-0.01352	-0.00974	0.040325	-0.6973	2.8879545
2012/08/31	0.002269	-0.00479	0.035532	-0.34322	2.5447373
2012/09/03	6.43E-05	-0.01424	0.021289	-1.02005	1.5246886
2012/09/04	-0.00652	-0.01285	0.008438	-0.92041	0.6042783
2012/09/05	-0.00521	-0.00938	-0.00095	-0.67201	-0.067732
2012/09/06	0.015424	0.03697	0.036024	2.647708	2.5799761

FIGURE A2.3: IMP

Date	[E] r	AR	CAR	AR t-test	CAR t-test
2012/08/09	0.00544	-0.00544	-0.00544	-0.40195	-0.40195
2012/08/10	0.000733	0.001765	-0.00368	0.130396	-0.27156
2012/08/13	-0.01229	0.016444	0.012769	1.215033	0.943475
2012/08/14	-1.5E-06	1.49E-06	0.01277	0.00011	0.943585
2012/08/15	-0.0082	0.004144	0.016915	0.306203	1.249788
2012/08/16	0.003282	-0.01317	0.003743	-0.97322	0.276569
2012/08/17	-0.01769	0.024175	0.027918	1.786245	2.062814
2012/08/20	-0.00068	0.007117	0.035035	0.52585	2.588663
2012/08/21	0.014884	0.008827	0.043862	0.652237	3.240901
2012/08/22	-0.01701	0.0101	0.053962	0.74626	3.987161
2012/08/23	0.006826	-0.00283	0.051135	-0.20892	3.778245
2012/08/24	-0.01308	0.01603	0.067165	1.184419	4.962665
2012/08/27	0.001096	-0.0011	0.066068	-0.08101	4.881654
2012/08/28	-0.00742	0.022197	0.088265	1.640081	6.521735
2012/08/29	-0.00321	0.00502	0.093285	0.370941	6.892676
2012/08/30	-0.01763	-0.0189	0.074386	-1.39642	5.496255
2012/08/31	0.005315	-0.00689	0.067495	-0.50916	4.987090
2012/09/03	0.002112	-0.02467	0.042827	-1.82268	3.164415
2012/09/04	-0.00745	-0.02024	0.022589	-1.49538	1.669038
2012/09/05	-0.00555	-0.00078	0.021811	-0.05748	1.611558
2012/09/06	0.024431	0.008531	0.030342	0.630351	2.241909

FIGURE A2.4: LON

Date	[E] r	AR	CAR	AR t-test	CAR t-test
2012/08/09	0.005041	-0.00504	-0.00504	-0.31044	-0.31044
2012/08/10	-0.00029	-0.0106	-0.01565	-0.65314	-0.96357
2012/08/13	-0.01505	0.004227	-0.01142	0.260354	-0.70322
2012/08/14	-0.00112	-0.03487	-0.04629	-2.14783	-2.85105
2012/08/15	-0.01042	0.001752	-0.04454	0.107897	-2.74315
2012/08/16	0.002595	-0.07606	-0.1206	-4.6844	-7.42755
2012/08/17	-0.02117	0.016451	-0.10415	1.013172	-6.41438
2012/08/20	-0.00189	-0.03806	-0.14221	-2.34378	-8.75816
2012/08/21	0.015739	0.019992	-0.12221	1.231257	-7.5269
2012/08/22	-0.02039	-0.01615	-0.13836	-0.99441	-8.52131
2012/08/23	0.00661	0.043331	-0.09503	2.668641	-5.85266
2012/08/24	-0.01594	0.031646	-0.06338	1.949035	-3.90363
2012/08/27	0.00012	-0.00719	-0.07057	-0.44272	-4.34634
2012/08/28	-0.00953	0.013085	-0.05749	0.805886	-3.54046
2012/08/29	-0.00476	-0.03891	-0.0964	-2.39658	-5.93704
2012/08/30	-0.02109	-0.00603	-0.10243	-0.37136	-6.3084
2012/08/31	0.004898	-0.02324	-0.12567	-1.4316	-7.7400
2012/09/03	0.00127	-0.00176	-0.12743	-0.10811	-7.84811
2012/09/04	-0.00957	-0.0169	-0.14433	-1.04097	-8.88908
2012/09/05	-0.00741	-0.04123	-0.18556	-2.53921	-11.4283
2012/09/06	0.026555	0.02431	-0.16125	1.497213	-9.93108

FIGURE A2.5: NHM

Date	[E] r	AR	CAR	AR t-test	CAR t-test
2012/08/09	0.002372	-0.00237	-0.00237	-0.14162	-0.14162
2012/08/10	-0.00101	0.00952	0.007148	0.568313	0.426691
2012/08/13	-0.01037	0.011519	0.018667	0.687629	1.114320
2012/08/14	-0.00154	-0.01034	0.008327	-0.61724	0.497084
2012/08/15	-0.00743	-0.00381	0.004514	-0.22763	0.269455
2012/08/16	0.000822	-0.02043	-0.01592	-1.21953	-0.95007
2012/08/17	-0.01425	0.01025	-0.00567	0.61187	-0.33820
2012/08/20	-0.00202	0.00122	-0.00445	0.072824	-0.26538
2012/08/21	0.009158	-0.00233	-0.00677	-0.1388	-0.40418
2012/08/22	-0.01376	0.031724	0.024953	1.893737	1.489562
2012/08/23	0.003368	0.06173	0.086683	3.68493	5.174492
2012/08/24	-0.01093	0.060272	0.146955	3.597906	8.772398
2012/08/27	-0.00075	-0.03434	0.112616	-2.04985	6.722545
2012/08/28	-0.00687	-0.0295	0.083119	-1.76084	4.961706
2012/08/29	-0.00384	0.02837	0.111489	1.69355	6.655257
2012/08/30	-0.0142	-0.00642	0.105064	-0.38352	6.271736
2012/08/31	0.002282	0.013137	0.118201	0.784206	7.055942
2012/09/03	-1.9E-05	0.009278	0.127479	0.553864	7.609806
2012/09/04	-0.00689	0.021571	0.149051	1.287676	8.897481
2012/09/05	-0.00553	0.048925	0.197975	2.920531	11.81801
2012/09/06	0.016018	0.020377	0.218353	1.216413	13.03443

FIGURE A2.6: RBP

Date	[E] r	AR	CAR	AR t-test	CAR t-test
2012/08/09	-0.001	0.000998	0.000998	0.085036	0.085036
2012/08/10	-0.00234	0.024016	0.025015	2.045509	2.130546
2012/08/13	-0.00604	-0.00509	0.01993	-0.43311	1.697437
2012/08/14	-0.00255	0.017129	0.037058	1.458889	3.156326
2012/08/15	-0.00488	0.027465	0.064523	2.339229	5.495555
2012/08/16	-0.00161	-0.01867	0.045854	-1.59008	3.905478
2012/08/17	-0.00758	0.001632	0.047486	0.13898	4.044458
2012/08/20	-0.00274	-0.01788	0.029605	-1.52294	2.521514
2012/08/21	0.001686	-0.01221	0.017392	-1.04018	1.481331
2012/08/22	-0.00738	0.007382	0.024774	0.628705	2.110036
2012/08/23	-0.0006	0.005924	0.030698	0.504523	2.614559
2012/08/24	-0.00626	-0.05194	-0.02124	-4.42358	-1.80902
2012/08/27	-0.00223	0.006728	-0.01451	0.573011	-1.23601
2012/08/28	-0.00465	0.011365	-0.00315	0.968003	-0.26800
2012/08/29	-0.00346	0.012346	0.0092	1.051551	0.783548
2012/08/30	-0.00756	-0.00125	0.007945	-0.10682	0.676724
2012/08/31	-0.00103	0.003256	0.011202	0.277345	0.954069
2012/09/03	-0.00194	0.005271	0.016472	0.448908	1.402977
2012/09/04	-0.00466	0.005769	0.022242	0.491376	1.894353
2012/09/05	-0.00412	0.014278	0.036519	1.216067	3.110419
2012/09/06	0.004401	0.029472	0.065991	2.510144	5.620563