Profitability of Applying the Moving Average Trading Strategy to JSE Listed Mining Companies

MINN7044 RESEARCH PROJECT

Name: Joshua Kilani

Student No: 0409834X

SCHOOL OF MINING ENGINEERING

Supervisor: Mr Clinton Birch

A research report submitted to the Faculty of Engineering and the Built Environment, School of Mining Engineering, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of MSc (Eng) (50/50).

Date: August 2021

DECLARATION

I declare that this report is my own, unaided work. I have read the University Policy on Plagiarism and hereby confirm that no Plagiarism exists in this report. I also confirm that there is no copying nor is there any copyright infringement. I willingly submit to any investigation in this regard by the School of Mining Engineering and I undertake to abide by the decision of any such investigation

Joshua Omeiza Kilani

This 30th Day of August 2021

ABSTRACT

The commodity markets have a unique cyclic investment characteristic, fundamentally driven by economic interconnectedness through global and local correlations. Such a market provides a dynamic opportunity for industry professionals to leverage their industry knowledge to create a system that can profitably navigate the various market conditions. The assessment of various trading strategies is the first step in formulating such a system. This report undertakes to empirically investigate the moving average technical analysis operating tool, through the quantitative assessment of historical data, to compare the performance of the trading strategy against that of the traditional buy and hold strategy for mining companies in the Johannesburg Stock Exchange (JSE) over a 10- year period from 2007 -2017.

The moving average is the most algebraic of the technical analysis operating tools and therefore the most amenable to quantitative assessment. The report provides a comprehensive overview of the topics of technical and fundamental analysis, as well as a review on the fundamental performances of the companies over the study period. This is followed by the comparison of the results attained from the moving average strategy to those of the traditional buy and hold strategy over the study period.

The study reveals that the performance of the moving average strategy varies depending on the parameters of the moving average and stock price resolution. The combination of parameters yield variable performances in comparison with the buy and hold strategy and do not reveal any particular trend. The study however does confirm that, unlike the buy and hold strategy, the moving average strategy does not require favourable market conditions in order to yield positive results, instead only requiring volatile share price action.

ACKNOWLEDGEMENTS

I would like to thank my wife Elizabeth who supported me fully and unconditionally through this whole process and endured my numerous conversations about various aspects of the project. For their emotional and financial support in my studies, I would like to thank my parents. I would further like to thank Brett Van Coller and Peter Hollick for affording me the time and space away from work as well as the financial support to complete my Masters. I would also like to give a massive thanks to my supervisor Clinton Birch for introducing me to the research topic during a classroom presentation and for his guidance while still allowing me space and trust to run with the topic. I would like to thank Daniel Jacobs for helping me with a key formula on the excel model and assisting me in fixing the price crossover error in the model. Finally, I would like to thank my nephew for keeping me company in my home office during the late nights that characterised the last stretch of the research project.

This research project is a culmination of over 3 years of work and is an embodiment of my character, I am extremely proud in seeing it through and hope it adds value to the global pool of research.

Contents

List of Figures

1 CHAPTER 1: INTRODUCTION

1.1 Research Background

Historically commodities and commodity companies have been viewed as less elegant investment classes on the stock market (Barrie, 2007). In financial markets, the commodity space is poorly understood due to its multi variable layers of complexity, and non-linear/non-stationary prices (Nazário, et al., 2017). However, there is an opportunity in the commodity space based on market correlations and interconnectedness that can be exploited by knowledgeable industry professionals (Chen, et al., 2010). Speculation in the volatile commodity space involves the analysis of often incomplete historical data to create future projections (Barrie, 2007). The nature of commodity markets requires a scenario-driven or situational forecasting method and investment model, as opposed to the traditional buy and hold strategy (Rzepczynski, 2017). Forecasting for the purpose of increasing investment returns intersects the practices of econometrics, investment analysis, corporate finance and behavioural consumer economics (Nazário, et al., 2017). The assessment of various current forecasting methods is the first step in formulating an adjustable situational method for forecasting mineral prices and commodity company share prices (Griffioen, 2003). The end goal is to create a multiple layered, hybrid forecasting method that funnels market information in such a way that allows an investor to outperform current individual methods (Kroner, et al., 1993; Nazário, et al., 2017).

1.2 Research Aims and Objectives

The aim of this research report was to provide a thorough empirical investigation of the moving average technical analysis operating tool in its application to the Johannesburg Stock Exchange (JSE) listed mining companies. The research involved a quantitative assessment of the application of the simple moving average strategy over historical mining stock price data and comparing this with the fundamental performance of the same mining stock. “Although technical analysis is not a new subject there are still many ways to study it and many new techniques that can be researched and applied using it” (Nazário, et al., 2017: 10). A large number of papers dealing with technical analysis act as evidence of the relevance of the topic for both financial markets and academia. This research report is the first academic work on the application of technical analysis for JSE listed mining companies. Unlike other sectors, the various commodities within the mining sector provide dynamic fundamental correlations both locally and internationally. Individual commodities have unique investment characteristics and associated investor psychology. It is hoped that this research report will contribute to existing knowledge by appending another layer of a systematic and scientific approach to the testing and demystification of technical analysis.

1.3 Research Questions

The main research question is whether the moving average crossover strategy applied within the mining sector of the JSE as an investment strategy would have yielded excess returns compared to the traditional buy and hold strategy over the study period with the various associated transaction costs taken into consideration.

Secondary questions that arise from this are; whether the moving average strategy is more effective than fundamental analysis as an investment tool? Is there a mineral sector in which the moving average crossover strategy is most effective? Is a short term or long-term moving average range more profitable? And what effects does the resolution of price time series have on profitability?

1.4 Structure of the Report

Chapter 2 provides background and overview on the topics of fundamental analysis and technical analysis. Followed by more specific information about the moving average strategy in the form of a review and consolidation of all available literature. Chapter 3 describes the scope of work and how data was collected and compiled for the buy and hold strategy and moving average strategy. Chapter 4 summarises company and commodity fundamental performances and presents the results of both the buy and hold and moving average strategies. Chapter 5 analyses and discusses the results while Chapter 6 concludes and answers the research questions, highlighting additional findings and drawing attention to some of the limitations of the study. The report ends with recommendations for future work.

2 CHAPTER 2: LITERATURE REVIEW

2.1 Brief Comparison of Fundamental and Technical Analysis

The differences between fundamental and technical analysis have been compared to astronomy and astrology (Lo, et al., 2000; Nazário, et al., 2017). Fundamental analysis is concerned with the contributing economic factors and is firmly grounded in quantitative finance, whereas technical analysis relies solely on the historical price data, even so, chartists do concede that economic factors influence the operational dynamics of technical analysis (Lo, et al., 2000; Nazário, et al., 2017). Technical analysis involves loose inductive reasoning based on the belief that price formation occurs in regular, recurring patterns while quantitative finance is algebraic and numerical (Lo, et al., 2000; Menkhoff & Taylor, 2006). The choice between technical analysis and fundamental analysis reflects the investor's perceptions of price discovery and fair value (Menkhoff & Taylor, 2006). Volatility induced due to financialization and the action of market participants is more amenable to technical analysis while volatility induced by economic factors is more amenable to fundamental analysis (Menkhoff & Taylor, 2006). However economic shocks have the ability to destroy the fundamental analysis of a stock, however technical analysis can still be profitable within economic shocks (Menkhoff & Taylor, 2006). Furthermore, unless the investor is an industry insider that is privy to confidential information then one could argue that a private investor could never obtain all the necessary information required to conduct a comprehensive fundamental analysis. Therefore, all fundamental assessments represent low confidence data that is susceptible to business risks such as account irregularities, reporting deficiencies, data protection and scandals (Fernando, 2010). Although technical analysis is easier and more widely applicable than other techniques most technical traders fail to be profitable (Harlow & Teweles, 1972; Nazário, et al., 2017). This is partly because the equity investor's strategy is unconditional in that they always have the opportunity to convert their investments into very long term buy and holds relying on the long run to solve their bad calls (Fernando, 2010; Harlow & Teweles, 1972).

2.2 Technical Analysis

Technical analysis is a set of charting rules used to predict future price movements by the identification of non-linear regularities in noisy historical price and volume data (Lo, et al., 2000; Menkhoff & Taylor, 2006; Nazário, et al., 2017; Zoicaş-Ienciu, 2012). Geometric shapes are predominantly what distinguish buy and sell signals allowing for a high level of subjectivity and incoherence (Gerritsen, 2016; Zoicaş-Ienciu, 2012). The application of technical analysis requires volatility which makes it a suitable technique for commodity markets (Menkhoff & Taylor, 2006). Technical analysis appeals to a lot of people because of its relative ease of use and the fact that it does not require a finance background (Menkhoff & Taylor, 2006). However, this has also caused technical analysis not to receive the same level of academic scrutiny nor acceptance as the more traditional approaches (Lo, et al., 2000). As technical analysis contains limited algebraic and numerical parameters it is difficult for academic studies to capture its multiple dynamics and nuances (Hilliard, et al., 2013). Technical analysis has been described as the orphan of the financial markets, has been compared to astrology and dubbed as voodoo finance or the alchemy of finance (Gerritsen, 2016).

Essentially technical analysis is an instrument for the efficient processing, assimilating and disseminating of market information, its proponents claim that within technical analysis all fundamental and non-fundamental influences of price movement are absorbed in the theory and can be queried with a set of operating tools (Menkhoff & Taylor, 2006). In technical analysis observed price movements are attributed to the cumulative effect of economic, monetary, political and psychological forces on investor sentiment (Hung & Zhaojun, 2013).

2.3 Origins and Early Work

Technical analysis is related to the Dow Theory assumption that price discounts everything (Griffioen, 2003). Based on this relation Charles Dow has been incorrectly dubbed as the forefather of Technical Analysis when in fact Charles Dow was a staunch fundamentalist who only used his averages to measure market cycles not to generate trading signals (Griffioen, 2003). Technical analysis was actually first employed in the 18th - century Japanese rice markets by Munehisa Homma who was the true founding father of technical analysis and the candlestick chart (Nazário, et al., 2017). One of the first academic studies that considered technical analysis was Cowles in 1933 titled “Can Stock Market Forecasters, Forecast?” (as cited in Nazário, et al., 2017). This paper and subsequent earlier studies found that technical analysis was of little profitable use in financial markets (Nazário, et al., 2017). In fact, disproving the validity of technical analysis was the objective of most early academic work (Zoicaş-Ienciu, 2012). This led to a disconnect of how technical analysis was valued in academic circles as opposed to within corporate circles in financial markets (Brock, et al., 1992; Menkhoff, 2010; Menkhoff & Taylor, 2006; Zhu & Zhou, 2009). However, more modern papers are beginning to disprove this, instigated by the landmark studies of: (Brock, et al., 1992; Neely, et al., 1997; Sweeney, 1986).

2.4 Moving Averages

There are three categories of operating tools within technical analysis being; sentiment indicators, flow of funds indicators and market structure indicators (Hung & Zhaojun, 2013; Vandewalle, et al., 1999). The moving average is a market structure indicator and is one of the most utilised of the technical tools (Gerritsen, 2016; Hung & Zhaojun, 2013; Zoicaş-Ienciu, 2012). This is because the moving average is not subjective by nature and can be described in an algebraic expression and therefore can be more easily programmed into a computer and tested statistically (Murphy, 2017;

Zoicaş-Ienciu, 2012). The moving average is a generic trend following tool that scrutinizes the phase of the prevailing trend (Hung & Zhaojun, 2013; Vandewalle, et al., 1999; Zoicaş-Ienciu, 2012). There are 3 types of moving averages; simple moving averages weighted moving averages and exponential moving averages (Hung & Zhaojun, 2013). When two simple moving averages are compared it is called the variable moving average (Hung & Zhaojun, 2013). Unlike the simple moving average, the weighted moving average involves various weighting factors (Gerritsen, 2016). The exponential moving average gives a higher weighting to the most recent closing price as the moving average advances (Gerritsen, 2016). The difference between the average and the moving average is that the moving average is not cumulative because the data range always stays the same (Technical Analysis, 2011; Wilder, 2009).

The moving average creates a series of averages from a subset of the full database, this subset is based on the number of days in the moving average range (Khorram & Sheshmani, 2015). The moving average is calculated by dividing the price time series within the chosen data subset by the number of days (Khorram & Sheshmani, 2015). Once the moving average is determined for the first data subset, the subset range is shifted forward and averaged (Technical Analysis, 2011). This is repeated over the full data set such that successive averages have been calculated with a new value entering the sum accommodated by the oldest value dropping out as it progresses down the data set (Gerritsen, 2016; Khorram & Sheshmani, 2015; Technical Analysis, 2011). The line connecting all the average points is the moving average and it is constructed adjacent to the stock price time series (Technical Analysis, 2011; Vandewalle, et al., 1999). The moving average smooths out short-term fluctuations and highlights longer term trends (Technical Analysis, 2011). Figure 1 below shows an example of 3 different moving averages adjacent to the price time series data.

Figure 1: A candlestick price time series for DRD Gold showing the 5 day (green), 10 day (grey) and 20 day (red) moving averages. (Image generated using **(IG, 2020)**.

Khorram & Seshmani (2006:2) mathematically described in the equation (1) below the simple moving average for (n) days over a period of (t) with (P) signifying the closing price of the stock:

$$MA_t(n) = n^{-1} \sum_{i=0}^{n-1} P_{t-I} \quad (1)$$

The research report will utilize the simple moving average price crossover strategy, which generates a buy signal when the moving average crosses the price time series of a particular stock from above and a sell signal when the moving average crosses the price time series of a particular stock from below (Hung & Zhaojun, 2013; Khorram & Sheshmani, 2015; Vandewalle, et al., 1999; Wilder, 2009; Zoicaş-Ienciu, 2012). Deciding on the appropriate length of the moving average range is a trade-off between the frequency of false signals and potential returns (Khorram & Sheshmani, 2015; Zoicaş-Ienciu, 2012). Therefore, the moving average range is dynamic and different for each price time series as well as proportionate to the level of risk that the investor is willing to take (Khorram & Sheshmani, 2015; Zoicaş-Ienciu, 2012). One to nine-day moving average ranges are considered short-term moving averages and 10-200 day moving average ranges are considered as long-term moving averages (Gerritsen, 2016). Another way to minimise the risk as opposed to increasing the range of the moving average is to apply a price threshold or confidence band to a short-term moving average (Lönnbark & Soultanaeva, 2008; Wilder, 2009).

There is a lack of consensus with regards to the predictive capability and profitabile application of the moving average strategy with studies by Wong et al., 2003; Chong and Ng, 2008; Metghalchi et al., 2008 (as cited in Gerritsen, 2016) on the Singapore and Swedish stock exchanges. Tian et al., 2002 (as cited in Gerritsen, 2016) concluding that moving average strategies could be profitably applied in Chinese markets. Zhu & Zhou, 2009 (as cited in Zoicaş-Ienciu, 2012) rigorously assessed the predictive capability of the moving average rules and found it very useful in volatile markets. Conversely, Kwon & Kish, 2002 (as cited in Gerritsen, 2016) found poor profitability in the study of moving average strategies. Wilder, (2009) concluded in his Honours report that moving averages could not predict future prices and were not a useful method to invest with, although his was a brief first pass assessment.

2.5 General Academic Literature

At present, there are mixed results in the bodies of work, with abundant research on technical analysis producing variable performances (Nazário, et al., 2017; Zoicaş-Ienciu, 2012). Some of the studies that support the value of technical analysis to some extent are; Pruitt & White, 1989; Neftci, 1991; Brock et al., 1992; Chang & Osler, 1994; Osler & Chang, 1995; Neely et al., 1997; Noely & Weller, 1998; Allen & Karjalainen, 1999; Manzur & Chew, 2003; Chong & Ng, 2008; Metghalchi et al., 2008 and Neely et al. 2013 as cited in (Gerritsen, 2016; Lo, et al., 2000; Zoicaş-Ienciu, 2012). Further studies indirectly allude to the viability of technical analysis such as; Tabell & Tabell, 1964; Treynor & Ferguson 1985; Brown & Jenning 1989; Jagadeesh & Titman 1993; Blume, Easly & O'Hara 1994; Chan et al. 1996; Lo & Mackinlay 1997; Grundy & Martin 1998 and Rouwenhorst 1998 (as cited in Lo et al., 2000). On the other hand, some studies that dispute the viability of technical analysis are Alexander 1964; Kwon & Kish 2002; Tian et al. 2002; Marshall & Chan 2005; Marshall et al. 2009 and Schulmeister 2009 (as cited in Fernando, 2010; Gerritsen, 2016; Zoicaş-Ienciu, 2012). Perhaps the greatest challenge to technical analysis comes from Fama & Blume in 1966 titled "Filter Rules and Stock Market Trading" and Fama in 1970 titled "Efficient Capital Markets: A Review of Theory and Empirical Work". Both these papers argue that the efficient market hypothesis and associated random walk hypothesis proves that excess returns cannot be earned based on historical price movements as there is no correlation between the past and future movements (Fama & Blume, 1966; Fama, 1970).

2.6 Technical Analysis and Statistical Models

Many studies have combined technical analysis with statistical models and fuzzy logic (Nazário, et al., 2017; Ye, et al., 2016). Moshiri and Moravat , 2006 (as cited in Khorram & Sheshmani, 2015) used linear and non-linear statistical models to predict returns on the Tehran Stock Exchange using the autoregressive integrated moving average (ARIMA), autoregressive fractionally integrated moving average (ARFIMA), generalized autoregressive conditional heteroskedasticity (GARCH) and artificial neural networks (ANN). Sinaee et al., 2005 (as cited in Khorram & Sheshmani, 2015) also used ANN and ARIMA using the observed stock prices, oil prices, dollar value and inflation results as inputs and found ANN to produce more robust results. Tehrani et al., 2010 (as cited in Khorram & Sheshmani, 2015) used the root mean square error (RMSR) to test for the most effective fluctuation model between ANN and ARIMA and confirmed the superiority of ANN. Lönnbark & Soultanaeva, (2008) applied technical analysis rules to Baltic stock markets and statistically tested their findings with both t-test and block bootstrap only to get conflicting results. Therefore, the choice of methodology for statistically testing the profitability or predictability of technical analysis is crucial to the results, with unconditional models generally outperforming conditional models (Khorram & Sheshmani, 2015; Lönnbark & Soultanaeva, 2008). Other studies that combined statistics with technical analysis trading rules are: Bisoi & Dash, 2014; Wei et al., 2011; Ticknor, 2013; Kazem et al., 2013 (as cited in Nazario et. al., 2017).

2.7 Popularity and Ease of Use of Technical Analysis

Goodman, 1979 (as cited in Menkhoff &Taylor 2006) was one of the first academic researchers to investigate the use of technical analysis in FOREX markets. Presently technical analysis is most used amongst FOREX traders, this has been attributed by Curico & Goodhart, 1993 (as cited in Menkhoff & Taylor 2006) to the volatility reducing or smoothing effect of the application of technical analysis in FOREX markets.

Part of the popularity and extensive application of Technical analysis is due to the ease of use and low intellectual entry requirements, this was highlighted by (Menkhoff, 2010) when he stated that the visual mode of technical analysis is more conducive to the human cognition. De Mark, 1994 (as cited in Gerritsen, 2016) also described technical analysis as more of an art than a science. Despite these notions Campbell Lo and Mackinlay, 1997 (as cited by Lo et al., 2000) highlighted the inhibitive jargon of technical analysis as a major barrier to entry.

2.8 Market Efficiency and Technical Analysis

Based on the numerous tests of the profitability of technical analysis in financial markets, it seems that technical analysis works best in the less efficient, emerging markets of developing countries (Gerritsen, 2016; Zoicaş-Ienciu, 2012). Gunasekarage and Power 2001 researched the predictability of technical trading strategies in the Bombay Stock Exchange, the Colombo Stock Exchange, the Dhaka Stock Exchange and the Karachi Stock Exchange and found that it could generate excess returns (Hung & Zhaojun, 2013; Lönnbark & Soultanaeva, 2008). Wang et al., 2015 (as cited in Khorram & Sheshmani, 2015) in an analysis of the Shangai Stock Exchange also found that less efficient markets are more amenable to technical analysis. Paris and Vasquez, 2000 (as cited in Lönnbark & Soultanaeva, 2008) found technical analysis to be profitable in the Chilean stock market. Chang, 2004 (as cited in Lönnbark & Soultanaeva, 2008) found technical analysis profitable in most of the emerging South Asian markets. Gan and Yao, 2013 (as cited in Hung & Zhaojun, 2013) showed that technical analysis provides greater predictability in the developing markets of Malaysia, Thailand, Indonesia and the Philippines than in

the more developed Singaporean market. Marshall et al., 2009 (as cited in Gerritsen, 2016) found technical trading strategies not to be profitable in the USA. Although most readings show that technical analysis works best in less efficient and emerging markets (Gerritsen, 2016; Hung & Zhaojun, 2013). Fong & Yong, 2005 (as cited in Gerritsen, 2016) found technical analysis not to be profitable in New Zealand. Furthermore, there are a few studies opposing the findings that technical analysis works best in emerging markets such as Ratner and Leal, 1999 (as cited in Lönnbark & Soultanaeva, 2008) who found that technical trading rules have poor predictability in 10 emerging Asian and Latin markets. Further complicating this, other studies such as; Blume, Easley & O'Hara 1994 and Bokhari et al.,2005 (as cited in Fernando, 2010; Lönnbark & Soultanaeva, 2008) suggest that the effectivenes and applicability of technical analysis trading rules are also dependent on the market cap of the stock and that small-cap stocks are more appropriate than large-cap stocks.

2.9 Temporal Considerations

Timeous identification of buy and sell signals are critical in the profitable real-time application of technical analysis. Sweeney, 1988 (as cited in Zoicaş-Ienciu, 2012) was first to address the timing problem between signal price and the actual enacted transaction price. Bessembinder & Chan, 1998 (as cited in Zoicaş-Ienciu, 2012) further emphasised that the difference between the signal and transaction price was most detrimental to profitability. Furthermore, on some occasions, the decision making information is only evident beyond the Markov/ stopping time (Menkhoff & Taylor, 2006). In addition to timing problems related to market entry and exit, there is also the issue of selecting the correct time period for the moving average, there is no consensus in the litreture as to which time period performs best. Lui and Lau, 2006 (as cited in Hung & Zhaojun, 2013) applied 1-200 day variable moving averages on 9 Asian market indices and found the 20 day and 60 day to be the most profitable. Khorram & Sheshmani, 2015 found the 5, 25, 48, 50 and 89-day simple moving averages to perform the best. And Hung Zhaojun, 2013 concluded that, the shorter length moving averages were more profitable but also riskier than longer ones.

2.10 Transaction Costs

"Commissions and slippage are to traders what death and taxes are to all of us" (Elder, 1993).

The biggest issue with any type of trading through a brokerage is the associated transaction costs by means of commissions, fees and market order slippage. However, again there is no consensus as to whether transaction costs make the strategy unprofitable. Sweeney, 1988 (as cited in Hung & Zhaojun, 2013) showed that the profitability of the trading rules depended on the level of transaction costs. However Beck & Goldreyer, 2002 and Hung & Zhaojun, 2013 (as cited in Hung & Zhaojun, 2013) showed that technical trading rules could still be profitable after taking into consideration transaction costs. On the other hand and in contradiction, Fama & Blume, 1966; Jensen and Benington, 1970; (as cited by Hung & Zhaojun, 2013) showed that technical analysis did not provide excess returns in US equity markets compared to the buy and hold strategy due to transaction costs. Bessembinder & Chan 1995 (as cited in Fernando, 2010) confirmed the predictability of stock prices in Japan, Hong Kong, South Korea, Malaysia, Thailand and Taiwan, although, the profitable application of this was all negated by transaction costs. Gerritsen, 2016; Fernando, 2010; both state that transactional costs make technical trading rules uneconomic. Bessembinder & Chan 1998 (as cited in Fernando, 2010) state that any study attempting to reflect reality must consider transactional costs, hence in this study the actual transactional costs have been applied to both the moving average strategy and the buy and hold strategy.

2.11 Literature Gaps in Technical Analysis

The resolution of the price time series used (i.e. monthly, weekly, daily, 4 hourly, 2 hourly, 5min etc.) is not discussed in any published academic papers, even though, this would play an important role in profitability. No JSE listed stock nor any country's mining sector has ever been tested in a published academic paper with technical trading rules. In all the studies of technical analysis there isn't any paper that really provides a good empirical understanding of technical analysis mechanisms, particularly on the way technical rules generate signals (Zoicaş-Ienciu, 2012), however, this is beyond the scope of this research report. Furthermore, technical analysis is widely referenced however the available knowledge is poorly consolidated (Nazário, et al., 2017).

3 CHAPTER 3: METHODOLOGY AND RESEARCH STRATEGY

3.1 Scope of Work

The research project involved conducting the moving average crossover strategy arbitrarily utilizing 3 moving average ranges selected from a Fibonacci series culminating in the 3-day, 13-day and 55-day moving averages being used. According to the moving average price crossover strategy, a buy signal will activate a long position in the market which will be maintained until a subsequent sell signal is indicated, which will activate a short position in the market as shown in Figure 2.

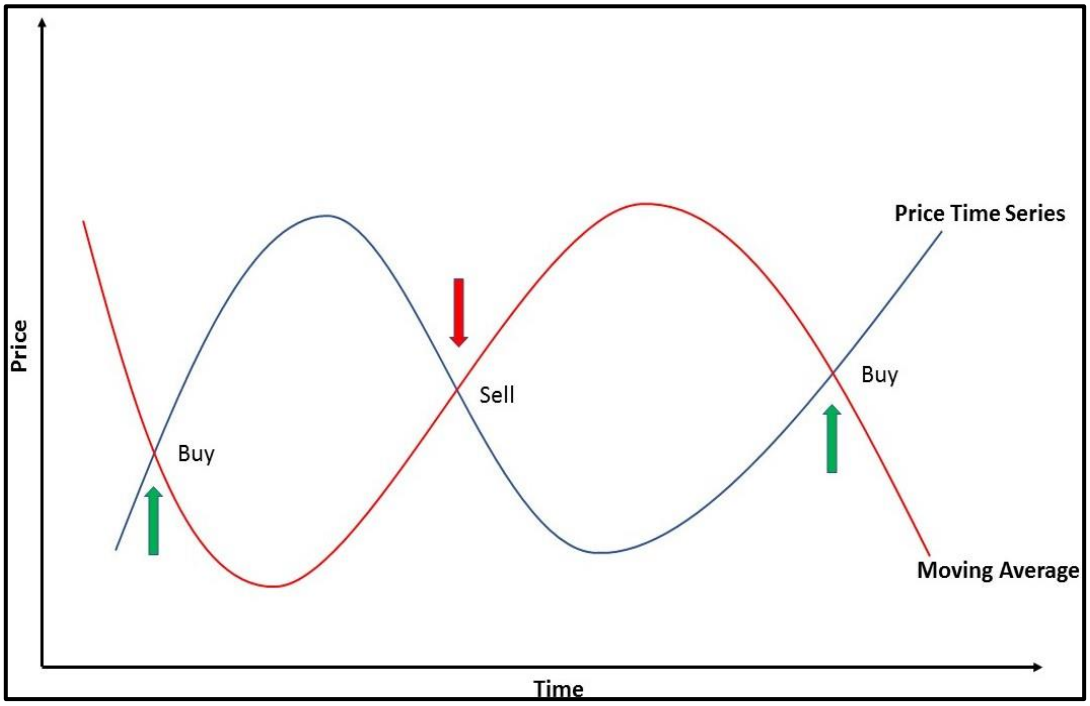

Figure 2: Basic illustration of the simple moving average trading strategy as utilised in the research project

The investor remains in the market in a short position and therefore would profit from any corresponding decrease in share price while in a short position. The moving average crossover strategy was carried out on 14 JSE listed mining companies at a monthly, weekly and daily price time series resolution, for a period of 10 years from the 1st of January 2007 to the 1st of January 2017. The use of historical data is more convenient than attempting to directly model the price action and

reporting on the observations (Pritsker, 2005). The mining companies were selected based on the following criteria;

- Companies must be listed on the JSE main board
- Companies must have been listed within the study time period
- Companies must have at least one mining operation within South Africa
- Companies must have a Market Cap of at least R 645 million as per conventional micro-cap categorisation
- The company must still have been listed on the JSE at the end of the study period

The results for each company was compared against the traditional buy and hold strategy, furthermore, the predictive power of the moving average crossover strategy was compared to that of financial ratios and the fundamental performance of the companies.

Table 1, Figures 3 and 4 show the key value statistics and relevant information of the selected companies.

Table 1: List of selected companies with relevant information (data as of November 2017 acquired from: **(News 24, 2017)**

Name	Sector	Category	Market Cap (millions)	PE Ratio	Dividend Yield
Anglo American Platinum Limited	Platinum	Medium cap	83 000	129.87	0.00%
Anglo American Plc	Diversified	Large cap	258 000	11.59	2.21%
Anglo Gold Ashanti Limited	Gold	Medium cap	50 000	64.1	1.04%
DRDGOLD Limited	Gold	Micro cap	1 700	26.88	2.98%
Gold Fields Limited	Gold	Medium cap	40 000	18.83	2.26%
Harmony Gold Mining Company Limited	Gold	Small cap	9 700	3.74	4.49%
Impala Platinum Holdings Limited	Platinum	Medium cap	26 500	-35.59	0.00%
Northam Platinum Limited	Platinum	Small cap	14 600	-28.9	0.00%
Wesizwe Platinum Limited	Platinum	Micro cap	830	2.74	0.00%
African Rainbow Minerals Limited	Diversified	Small cap	16 000	142.86	2.67%
Assore Limited	Base Metals	Medium cap	27 700	6.51	5.54%
Kumba Iron Ore Limited	Iron	Medium cap	55 900	6.52	6.09%
Lonmin Plc	Platinum	Small cap	4 330	-0.42	0.00%
Merafe Resources Limited	Chrome	Micro cap	3 310	6.23	3.64%

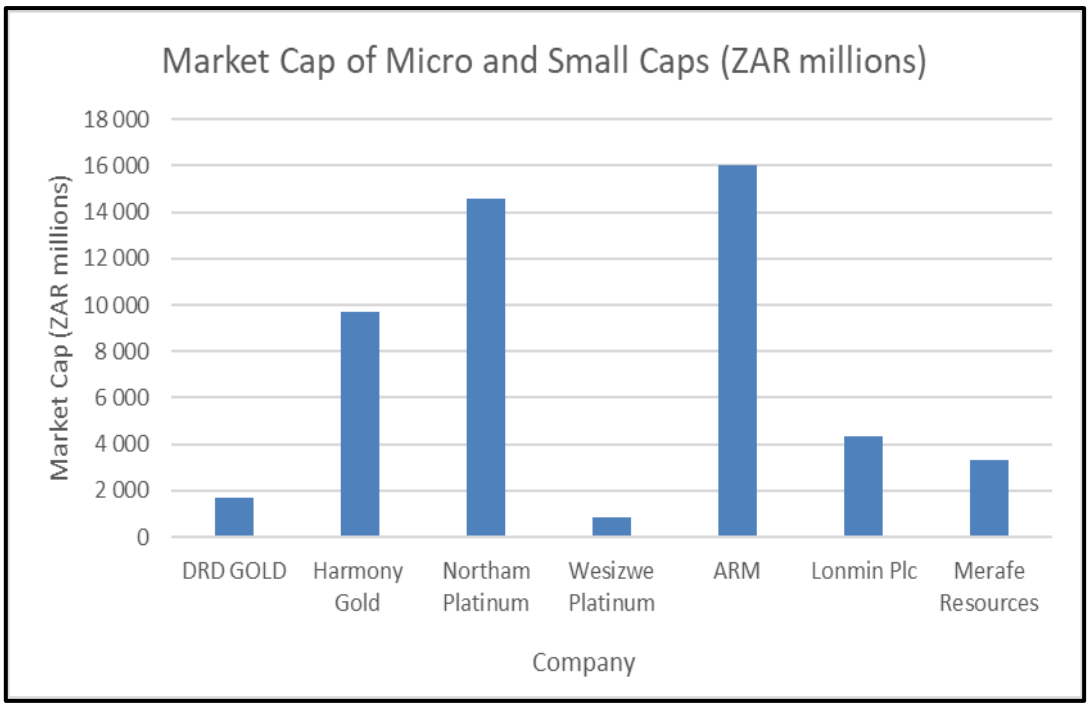

Figure 3: Market cap for micro and small cap JSE listed mining companies (data as of November 2017 acquired from **(News 24, 2017)**.

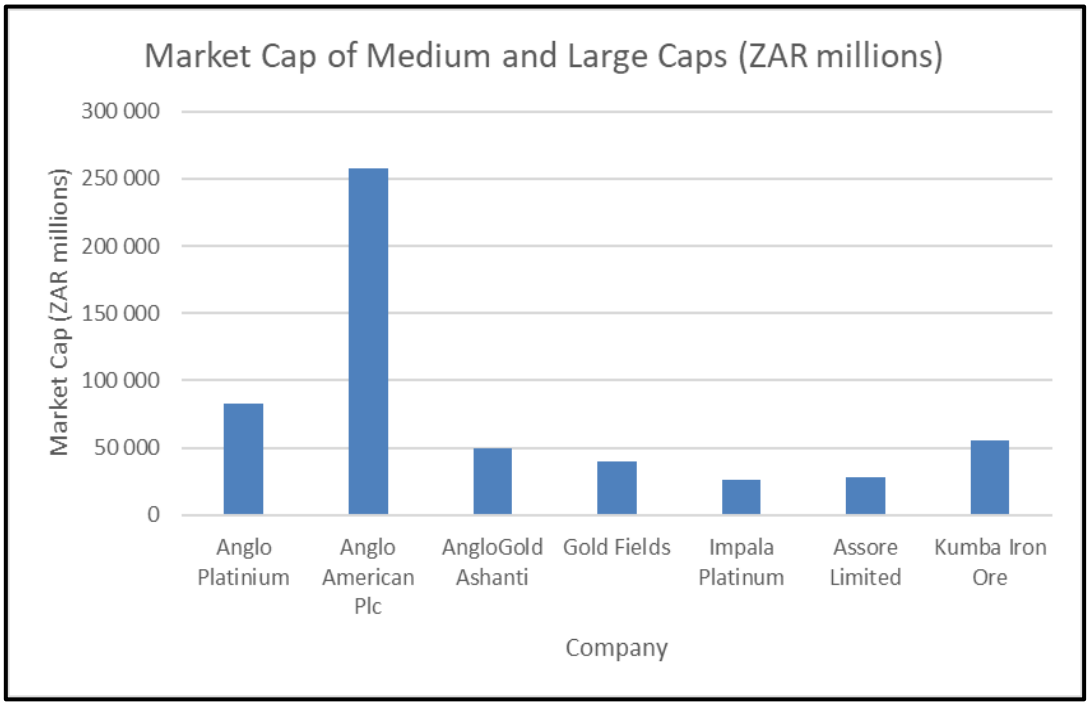

Figure 4: Market cap for medium and large cap JSE listed mining companies (data as of November 2017 acquired from **(News 24, 2017)**.

3.2 Data Collection & Compilation

3.2.1 Stock price data

Monthly, weekly and daily closing prices of the selected JSE listed mining companies were attained from the online brokerage platform, sharenet.co.za. Data for each company at each resolution was compiled from the platform by the researcher in 45 individual excel files.

The size of the monthly closing price time series data set over the study period is 121 closing prices per company, resulting in 1 694 monthly entries in total. The size of the weekly price time series data set over the study period is 522 closing prices per company resulting in 7 308 weekly entries in total. The size of the daily price time series data set over the study period is 2 520 closing prices per company resulting in 35 280 daily entries in total. In total 44 282 individual closing prices have been used for all 14 companies.

A separate excel back-testing trading model (an example of which is shown in Appendix 1) was created for each of the companies at each of the price resolutions (daily, weekly and monthly), the excel model had the following data fields;

Date: The date of the information in that row

Close: The closing price for the particular time period

Adjusted Close: This field was placed in firstly to convert the closing price from Cents to Rands, which could be dealt with more intuitively and also to allow for later additions of formulae that could simulate bid price and ask price differences. For this project, no formulae were added to simulate such differences.

Moving Average: The moving average at the current interval. (The moving average creates a series of averages from a subset of the full database, this subset is based on the number of days in the moving average range, it is not cumulative because the data range always remains the same. So as the moving average moves forward a new value enters the sum, and the oldest value drops out). There is an additional field with a period parameter as discussed below that is referenced to the formula to allow for easy analysis of various moving average periods.

Adjusted Moving Average: Same as above except the formula has been modified using an IF statement to allow it to ignore the first set of entries that are less than the moving average period in order to remove any errors. That is the moving average can only be calculated after the selected period of days.

Direction: This field keeps track of which direction each and every entry falls within. A buy signal occurs if the current adjusted moving average field is less than the current closing price, but the previous adjusted moving average field is more than the previous closing price. A buy or long position is held until the closing price crosses the moving average again in an inverse manner. A sell signal occurs if the current adjusted moving average field is more than the current closing price, but the previous adjusted moving average field is less than the previous closing price. A sell or short position is held until the closing price crosses the moving average again in an inverse manner. The dependence of the trade direction on the relationship between the moving average and price is illustrated in Figure 5.

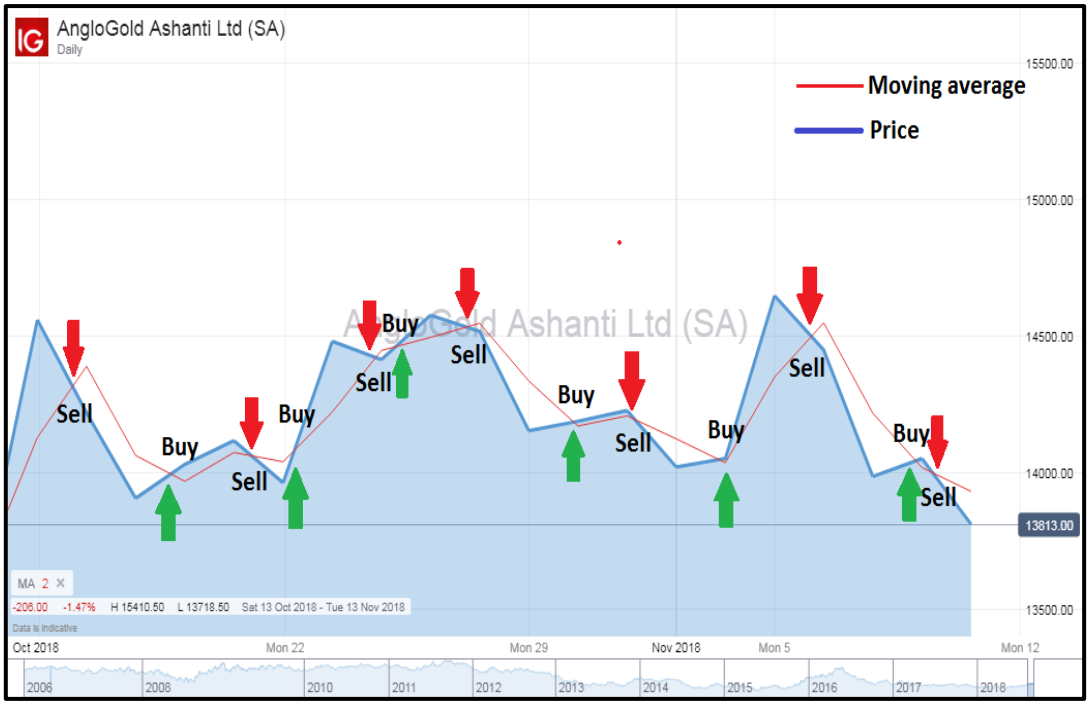

Figure 5: A mountain price time series for Anglo Gold Ashanti Ltd (SA) adjacent to a moving average line illustrating the relationship between the moving average and price (Image generated using **(IG, 2020)**.

Trade Signal: This column only shows the transitions between buy (long) and sell (short) positions, in other words, it highlights each change in trade direction.

Transaction Number: This column counts each change in trade direction from the trade signal column as an individual trade. Therefore, tallying how many trades were initiated for the particular share at the selected variables (period and resolution) for the duration of the study.

Transaction Price: This is the price at which a position is opened, if the trade signal is not empty (i.e. a buy or sell signal has been initiated) then this column makes use of the closing price at that interval, if empty then it keeps the previous value therefore, keeping a running position from the opening price for the duration of the position

Trade Direction: Similar to the direction field in that it tells us at any given time in the series whether we are holding a long or short position. However, in this field the long position is represented by a 1 and the short position is represented by a -1.

Profit and Loss per share: This field calculates the profit or loss made on a single share from the price at which the position was opened to the price at which the position is closed or reversed. As the model reflects a long and short account there is a Profit or Loss (PL) at the close of every transaction whether it was a sell or a buy and once a signal is initially initiated the model remains in the market for the duration of the study period or until the model runs out of cash. When a buy is initiated it means the model enters the market in a long position, therefore if the price goes up a profit would be realised and if the price goes down a loss would be realised. An initiated sell means the model enters the market in a short position, therefore if the price goes down a profit would be realised and if the price goes up a loss would be realised.

Running Cash: This field displays the cash in hand, the model for each share starts with an arbitrary amount of R1 000 000, this is the amount that is put into the first trade, thereafter based on the profits and or losses the subsequent accumulative amount in this field is what will be placed in consequent trades

Quantity: The quantity field shows the number of shares traded and is simply the running cash divided by the prices of the shares at the opening of the position. In this field the quantity is only calculated at the opening of a trade upon which it is used to calculate the PL for the close of the previous position.

Gross Profit and Loss: This field calculates the total profit or loss as the quantity multiplied by the profit and loss per share

Transaction fees: This field applies a transactional fee as stipulated in the "Transaction Fee Percentage" field which is discussed below at the initiation of a position. For this project, a transaction fee of 0.2% of the amount in running cash was applied as per the fees implemented by the broker IG.

Net Profit and Loss: This field represents Gross PL less transaction fees.

Returns Percentage: This field calculates the percentage return at the closing of each position. Calculated as the fraction of the profit and loss per share at the closing of a transaction to the share price at the opening of that same transaction.

Daily returns %: This field represents the daily percentage return of the stock from the first day of the study. Calculated as follows: (Current day closing price – previous day's trading price) / (Previous day closing price) in percentage.

Buy and hold value; This field shows the hypothetical periodic value of a holding if the share was purchased outright on day 1 of the study with an amount of R 1 000 000

3.2.1.1 Fields for input parameters

The following two fields were used in order to ensure that the model was "smart" and could be run with various input parameters. This not only allows for the analysis of the various input parameters used in this research project but also allows for the future input of any combination of input parameters. Furthermore, these fields allow for the establishment of a platform from which a live trading model can be built in the future.

Moving Average Period

The most important of these fields is the moving average period this field allows for the entry of any moving average period which will then be fed into the Moving Average field discussed above.

Transaction Fee Percentage

This field allows for the entry of any transactional charge rates which gets fed into the Transaction Fees field which is used to calculate Net Profit as discussed above.

Strategy Result

This field sums up the Net Profit and Loss Field for the whole study period to determine the overall profit or loss of the strategy for the particular stock at the particular resolution and moving average period, culminating into the total returns of the trading strategy.

3.2.1.2 Data Validation of the back-testing model

Stock price data can vary with respect to the type, method of collection and source (Holton, 2004), central to quality control for this study was that all data were collected from the same source in a standardised format.

The first stage of data validation was aimed at validating the quality of the data within the model and consisted of filter searches through the various fields looking for any errors or anomalous values, verifying formulas used in the various fields and ensuring no copy and paste errors occurred during the application of the model to the various individual excel sheets for each stock at each resolution.

The second stage of data validation was aimed at testing how well the model functioned in terms of simulating trades. 10 consecutive randomly selected trades were calculated manually for each stock at each price resolution culminating in 420 manually tested trades. The project had a total of 25 880 trades, therefore, the number of trades manually tested made up 1.6% of the data.

Manually testing the data was able to highlight an issue that occurred when the Adjusted Close and Moving Average were equal but subsequently never cross-cut (therefore deflected) an additional second signal was generated as shown in Figure 6. In order to rectify this error, the trade signal column was edited to ensure that if the Adjusted Close and Moving Average were equal (i.e. touched) no trade signal would be generated.

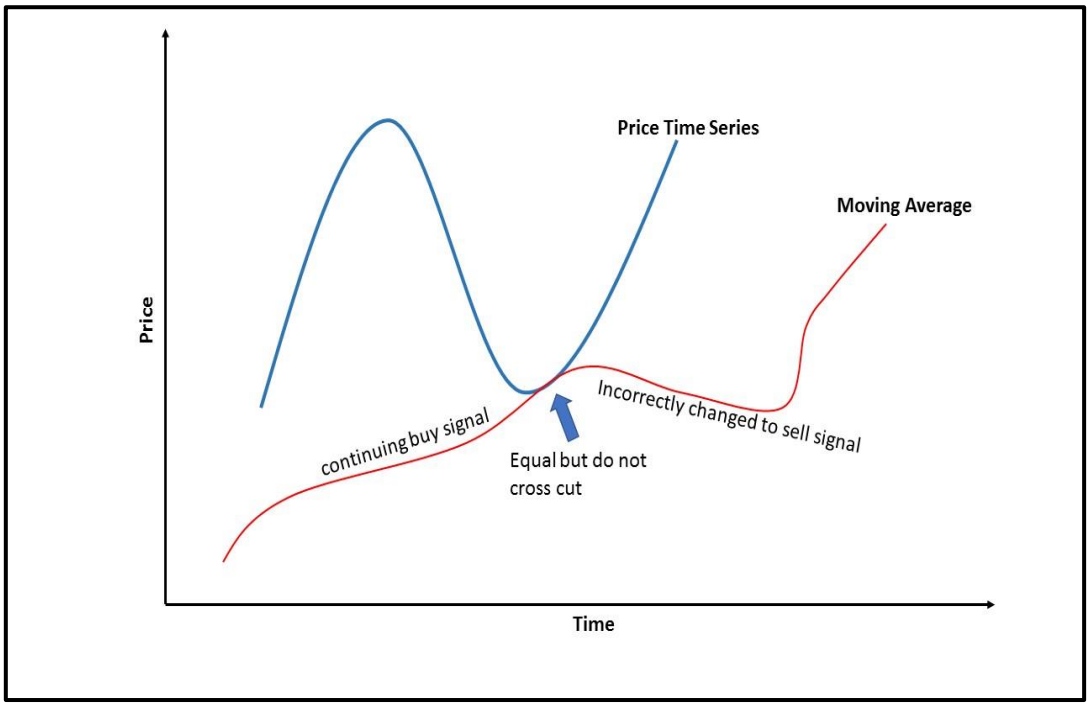

Figure 6: Image illustrating an initial error with the back-testing model which was picked up by the data validation

3.2.2 Measurements and Analysis

The research involved an empirical analysis of the application of the moving average crossover strategy on historical price data from the 1st of January 2007 to the 31st of January 2017 for the monthly, weekly and daily resolutions using an initial investment size of R1 000 000. The full amount of the initial investment was used on the 1st trade and the resultant sum of profits or losses were used wholly on consecutive trades. Therefore, no trading risk management plan was applied as is recommended by (Elder, 1993). Returns were calculated and compared to each other as well as to that gained by the traditional buy and hold strategy from the closing price at the start date to the closing price at the end date. For the moving average crossover strategy, the experiment ended if losses occur beyond the initial investment size as would occur in reality. Transaction costs were considered as per the respective brokerage firm's fee structure (IG for the moving average strategy and Standard Bank Group (SBG) Securities for the buy and hold strategy). It is important to note that utilizing the realistic transaction costs for each strategy allows for a fairer comparison of the strategies, the buy and hold strategy has substantially less transaction costs as it only consists of 2 transactions per company, this is a strength of the strategy that must not be discounted in the study.

4 CHAPTER 4: RESULTS

4.1 Traditional Buy and Hold Strategy

Summary statistics for the results of the buy and hold strategy for all companies combined are presented in Table 2.

Table 2: Summary Statistics for the Results of the buy and hold strategy

Summary Statistic	Value
Mean	R1 359 888,65
Standard Error	R609 110,72
Median	R568 433,50
Standard Deviation	R2 279 083,63
Kurtosis	10,97
Skewness	3,20
Minimum	R33 698,00
Maximum	R8 912 152,00
Sum	R19 038 441,05

The chart in Figure 7 presents the results of the traditional buy and hold strategy for the individual companies over the period of the study. Transactional fees as stipulated by SBG securities have been

accounted for, these consist of a R99 per month administrative fee applied over the study period as well as a 0.5% brokerage fee applied for the initiation of the purchase.

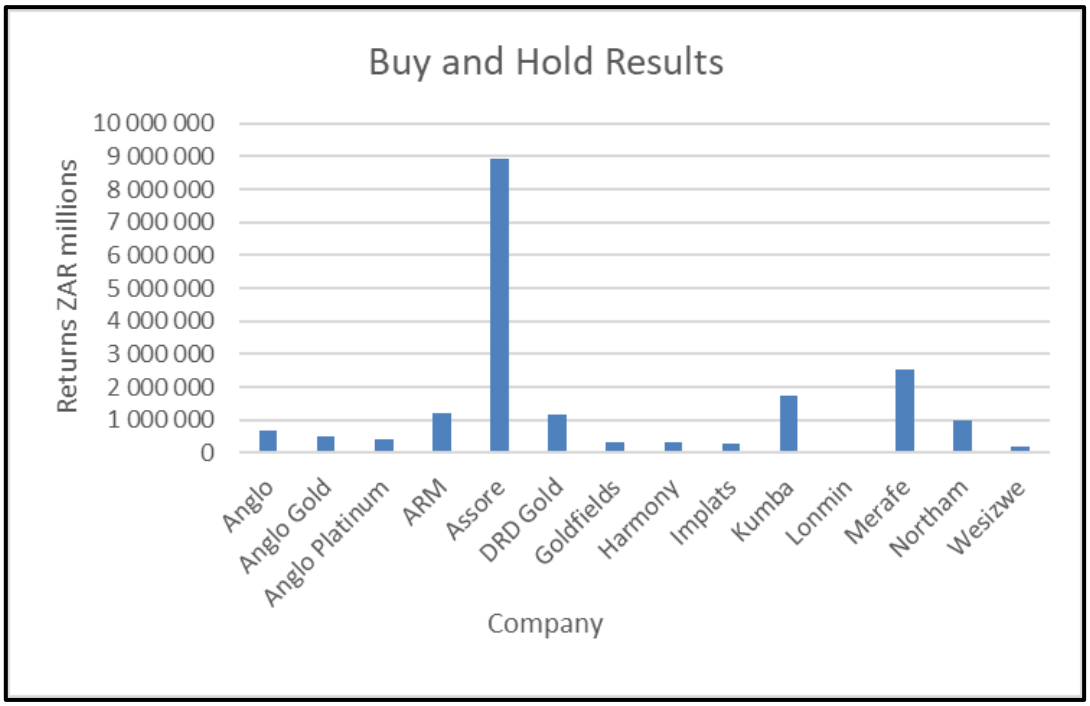

Figure 7: Buy and hold results for all the companies over the period of study

Five out of the fourteen companies; ARM, Assore, DRD Gold, Kumba and Merafe yielded positive returns under the buy and hold strategy.

4.1.1 Fundamental Performance

The beginning of the study period coincided with high commodity prices carried over from 2006 (Figure 8), this was mainly driven by unprecedently high demand from Asia.

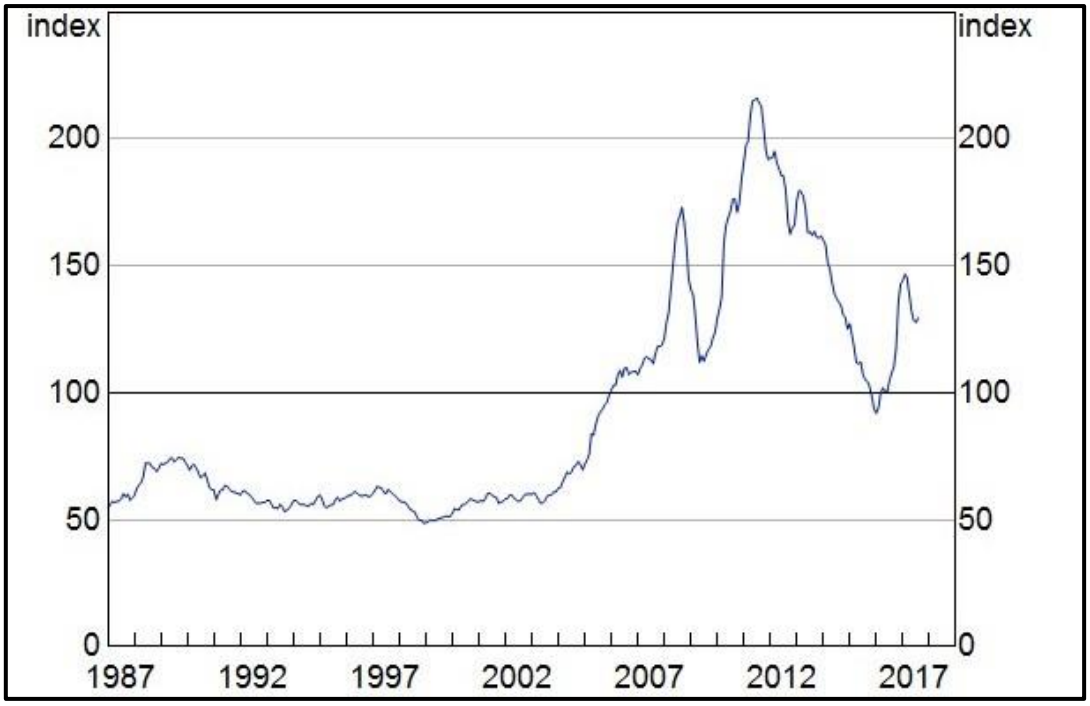

Figure 8: RBA Index of Commodity Prices, SDR 2015/16 average = 100 **(Ganon, 2017)**

The beginning of the study period also coincided with the dawn of the "mega-mergers' where a sort of market Darwinism prevailed, ushering in a new brand of young CEO's (in terms of both age and / or tenure) such as Cynthia Carrol, Mark Cutifani, John Sayers and David Brown who marked their arrivals by emphasis on bold and aggressive actions to leverage the increased operating cash flows of the prevailing positive market conditions. Capital expenditure at the start of the study period was very high as companies scrambled to channel the positive cashflows into potential growth opportunities, those that managed to promote organic growth such as Kumba through Kolomela, ARM and Assore through Khumani and Merafe through their Premus Technology R&D were consequently more robust throughout the study period. The prevailing market conditions and rising commodity prices of 2006 to early 2007 resulted in rapid payback for companies that used their increased liquidity to fund compatible growth (Price Waterhouse Coopers, 2007; Price Waterhouse Coopers, 2008).

By the middle of 2007 certain sectors of the industry were experiencing signs of a slowdown, with operating costs across the board stealthily increasing by 38% albeit masked by profitability which increased across the board by 32%. These were the early manifestations of the 2007 – 2008 global financial crisis. Base metals and bulk commodities continued to grow driven mainly by China, India and other emerging markets. The gold spot price also benefited from the general economic slowdown due to its hedging and "safe haven" characteristics. Furthermore, the margins of the diversified companies and companies operating in emerging markets were the highest, proving the benefit of global diversification (Price Waterhouse Coopers, 2008).

In 2010 increasing operation costs were finally translated to decreased revenue, undoubtedly marking a turnaround. Consequently, profitability and market capitalisation continued to decrease until its lowest point in 2015. Companies resorted to increased gearing in order to fund their previously made aggressive capital expenditure commitments. The state of the market during this period of the study highlights the difficulty of making long term decisions in a volatile mining industry, where supply

always has a time lag relative to demand (Price Waterhouse Coopers, 2010; Price Waterhouse Coopers, 2014; Price Waterhouse Coopers, 2015). By the end of the study period a slight recovery in US Dollar commodity prices began particularly with chrome and manganese and companies also seemed to get better at managing costs (Price Waterhouse Coopers, 2017).

Exchange rate fluctuations throughout the study period (Figure 9) acted as a counterbalance to market volatility. This was notable; in 2010 when the strengthening Rand offset some of the potential gains from increases in US Dollar commodity prices, in 2015 when the weakening rand repelled some of the effects of rising costs, and finally in 2017 again to offset the recovery in US Dollar commodity prices (Price Waterhouse Coopers, 2010; Price Waterhouse Coopers, 2014; Price Waterhouse Coopers, 2017). Hedge fund activity and the financialization of the sector was generally antagonistic to the long-term sustainability of fundamentally based investments in the sector for the period of the study. In 2010 Financialization driven by the threat of increased rhetoric for nationalisation accelerated the market slowdown disproportionately to the industry fundamentals (Price Waterhouse Coopers, 2006; Price Waterhouse Coopers, 2010). From a regulatory perspective the uncertainty surrounding the new Mining Charter is reported to have limited capital expenditure and market capitalisation throughout the study period (Price Waterhouse Coopers, 2006; Price Waterhouse Coopers, 2017).

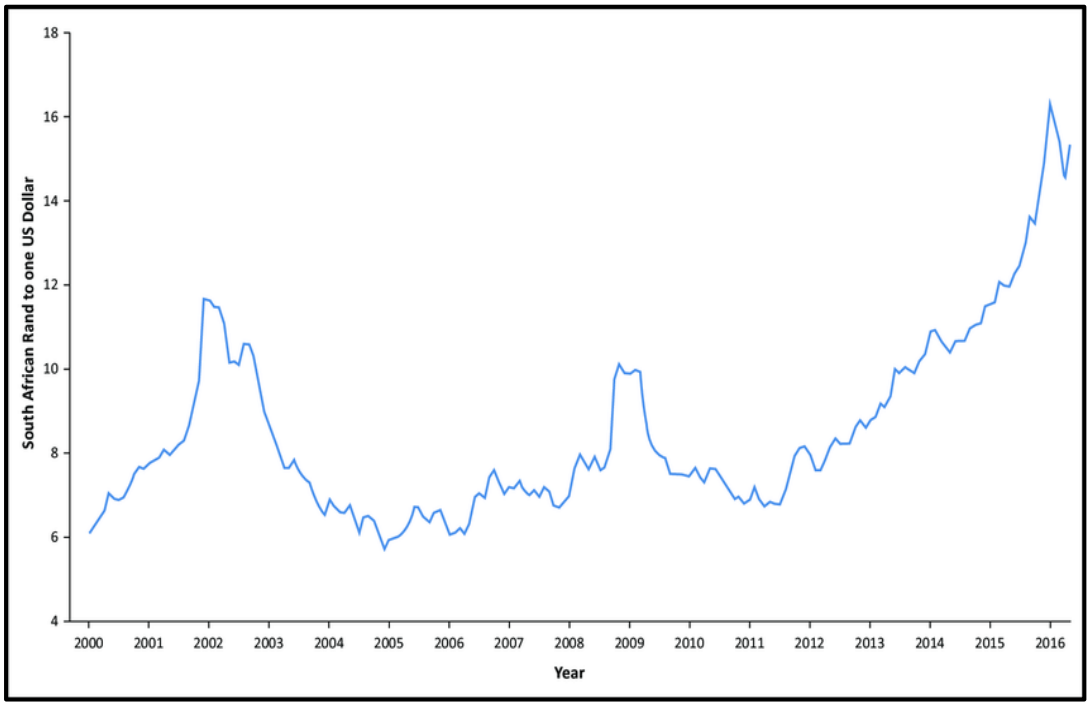

Figure 9: Rand / US Dollar Exchange Rate 2000-2016 **(Patel, et al., 2018)**

4.1.1.1 Gold Fundemental Performance

Gold as a commodity has a rich, interesting, multi-layered and complex history. Not only has it got many practical uses that span multiple industries, but it is also used as a vehicle for monetary exchange through the issuance of gold coins and bars (Carlson, 2014; This is Gold, 2018)

The gold price is significantly affected by Macro-economic factors such as fluctuations, inflation, interest rates, changes in reserve policy by central banks, geo-politics and economic crisis. In times of

inflation and currency devaluation, gold is often seen as a safe haven, which increases its price. However, these fundamental variables are not the sole driver of the gold price, nor performance of gold companies (DRD Gold Limited, 2017; Harmony, 2009).

The study period commenced with a high gold price and favourable Rand / USD exchange rate (Figure 9 - 10). This captured the impact of the fundamentally influential global financial crisis. The uncertain economic conditions coupled by booming gold prices even led the South African government to introduce amended gold royalty bills in 2008. However, by 2009 it already started to become more evident that the financial setbacks of the recession would not develop into a larger global meltdown, and that this in time would suppress the runaway gold prices. (Goldfields, 2007; Goldfields, 2008; Harmony, 2010; Neingo & Tholana, 2016).

This manifested itself in early 2013 when the gold market experienced a significant 28% correction to the upward trend resulting in the steepest price drop in 30 years. This dramatic fall in gold price cut the legs out from under most gold companies which is reflected in their performances up until mid-2016. After which, the US dollar price was more stable allowing for other market drivers to dictate individual company performances (Baxter, 2013; DRD Gold Limited, 2017; Harmony, 2014; Holland, 2014).

The physical demand for gold is primarily for fabrication purposes, jewellery, electronics, dentistry, decorations, medals and minting. The investment demand for gold comes from the central banks financial institutions and private individuals (Anglo Gold Ashanti, 2007). From a demand perspective the study period commences during a transition phase with regards to the structure of demand, which could be characterised by significant growth in investment demand and decline in producer hedging. These structural changes were compounded by the prevailing global uncertainty, credit risk and central bank policies which created more global liquidity and a bullish price cycle for gold, where demand exceeded supply (Baxter, 2013; Carlson, 2014; DRD Gold Limited, 2008). Although physical demand declined in most markets with subdued economic activity (Industrial, electronics, etc.), this was at least counterbalanced by an increase in demand from China and India, who both have a strong cultural affinity to physical gold. (Goldfields, 2013; Carlson, 2014). The investment demand for gold went beyond the traditional “safe haven” investment class to a financialization attributed to gold ETF’s, high volume gold derivative trading and futures trading. For example, in April of 2013 the equivalent of 400 tonnes of “gold” entered the market via gold-based futures. Investment demand also grew as a response to the implementation of multiple phases of quantitative easing by central banks (Goldfields, 2009; Goldfields, 2013).

Figure 11 shows that since 1970 South African Gold production has been steadily decreasing from a peak of 1 000 tonnes to its 2017 level of 138 tonnes. During this decrease South Africa lost its ranking as the worlds biggest producer and is currently only the 6th largest producer behind China, Peru, Russia, USA and Australia. South Africa is still ranked as the most gold endowed country in terms of the mineral resource, however even this is slowly decreasing possibly due to the comparative lack of greenfields gold exploration (Baxter, 2013; Neingo & Tholana, 2016).

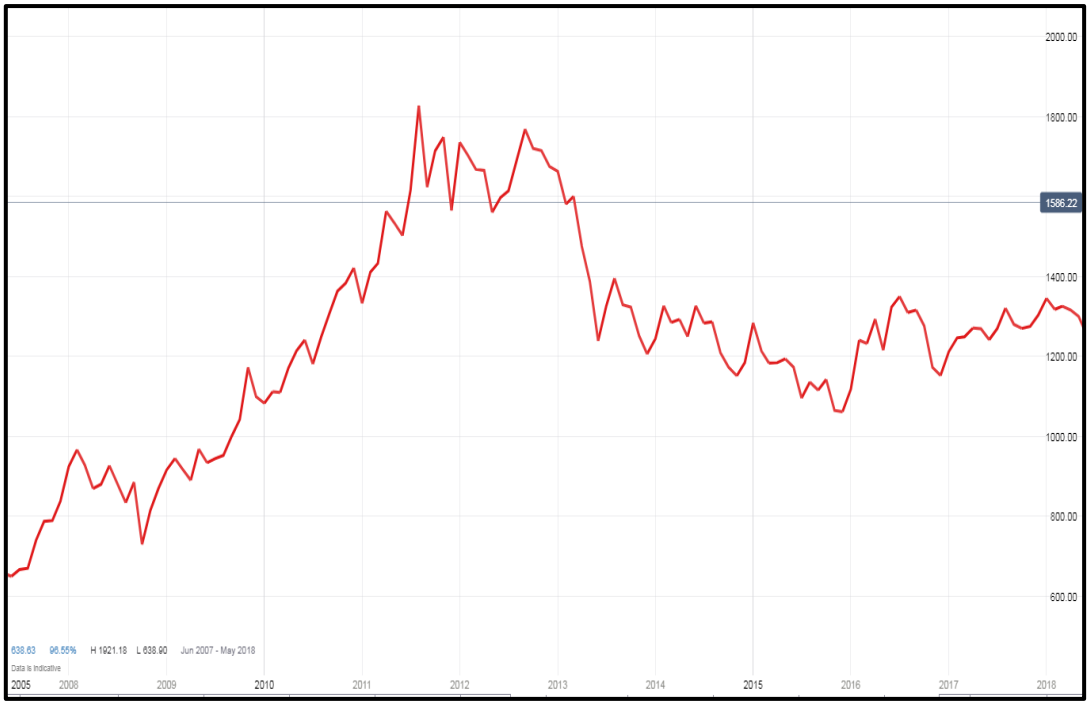

Figure 10: Gold ZAR spot price throughout the study period (Image generated using **(IG, 2020)**.

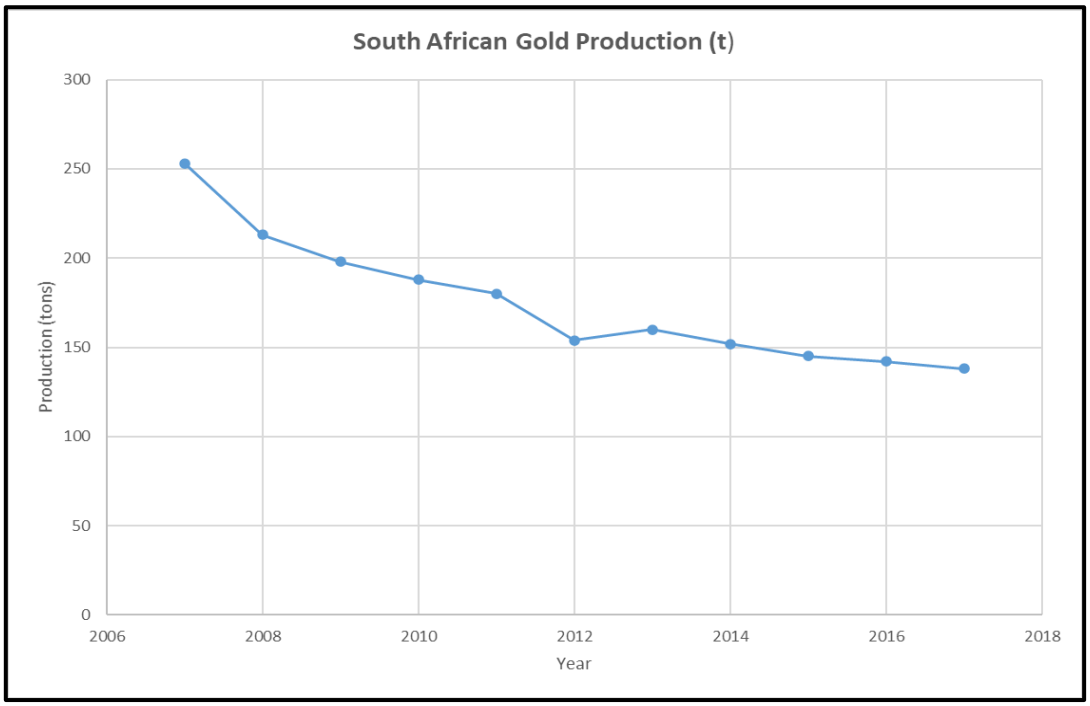

Figure 11: South African gold production over the study period (from this is gold factsheet July 2018)

The South African gold industry is faced with various technical, economic, social and operational challenges namely in the form of labour, costs and the technical aspects of South African gold deposits (Neingo & Tholana, 2016).

In South Africa the biggest effects on gold besides the global financial crisis was intermittent labour unrest, which greatly affected productivity. Labour issues always pose a challenge for any corporate participant in global markets as they strive to remain globally competitive while balancing the need to address local and community needs. The complexity is further complicated in South Africa by the fact that the South African labour force is generally drawn from a relatively lower skill and literacy base which is furthermore exacerbated by the labour unions insistence on mass employment and their resistance to mechanisation or specialised employment (Neingo & Tholana, 2016; This is Gold, 2014).

Figure 12 shows that throughout the study period the unit cost of labour in the gold industry has increased steadily while labour productivity has steadily declined

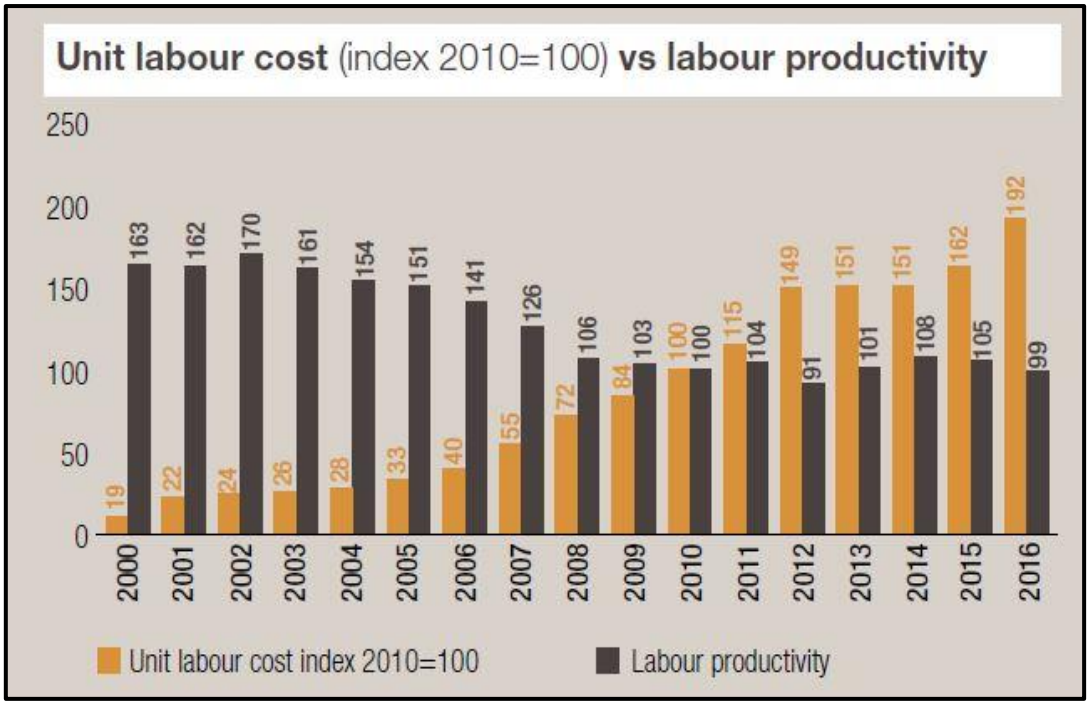

Figure 12: Unit labour costs vs labour productivity **(This is Gold, 2018)**.

Escalating input costs have always been an issue with South African gold mines with electricity being the major cost which between 2007-2012 increased in price by 238% from 18c/ KWH to 61c/KWH. Cost saving initiatives adopted by some of the gold companies at the start of this study only began to bear fruit in early 2014 (Baxter, 2013; Neingo & Tholana, 2016; This is Gold, 2014).

The South African gold industry is a mature industry, with the absence of any major new discoveries. This means most of the South African high-grade gold deposits have been exhausted and most mines are now exploiting lower grades. These resources are deeper (predominantly at depths in excess of 3km), ever more marginal and usually characterised by more complicated geology such as narrow reefs and numerous discontinuities. Not only are these deposits more complicated to mine, but there is also an inverse relationship between ore grade and the energy consumption required for the extraction and processing of ore, which has obvious cost implications (Baxter, 2013; Neingo & Tholana, 2016; This is Gold, 2018).

Resource nationalism emerged as an additional threat between 2011 and 2014, to create an overall apprehensive atmosphere over the study period with an open acknowledgement that gold in South Africa came with a substantial geographic risk (This is Gold, 2014).

4.1.1.1.1 Performance of Gold Companies

Anglo Gold Ashanti: Anglo Gold is primarily a gold producer although they do produce minor quantities of silver and uranium oxide as by-products accounting for less than 2% of their total revenue (Anglo Gold Ashanti, 2007; Anglo Gold Ashanti, 2010). The share price performance, operating profits and production for Anglo Gold over the study period are shown in Figures 13, 14 and 15.

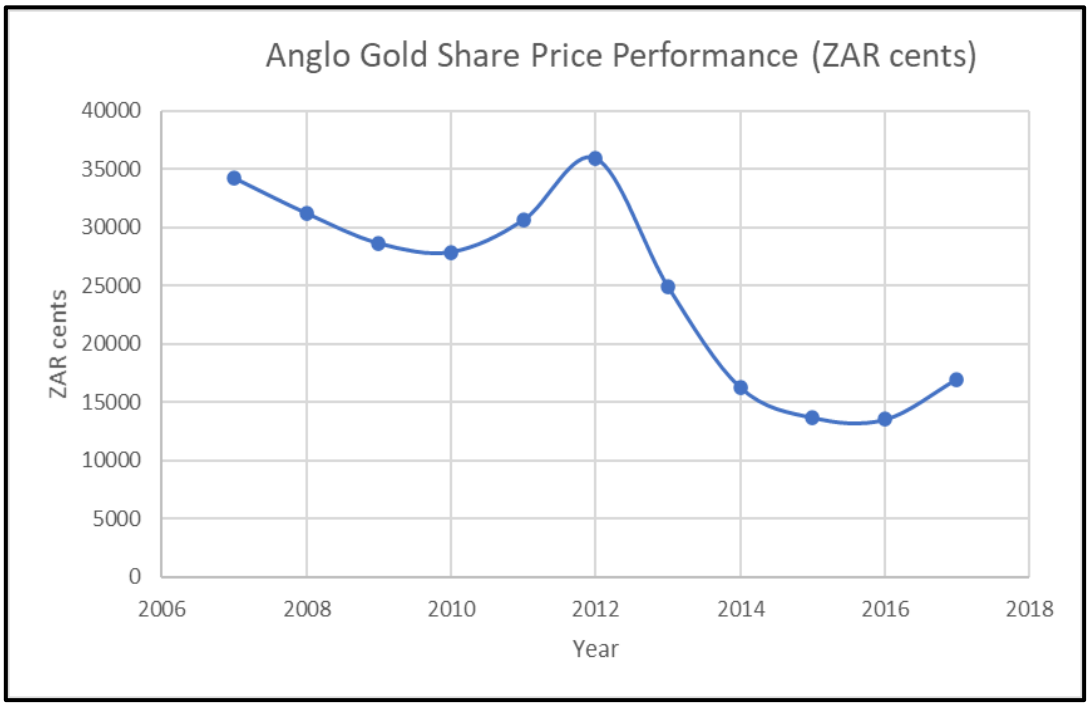

Figure 13: Anglo Gold Share Price Performance, from **(Sharenet, 2020)**

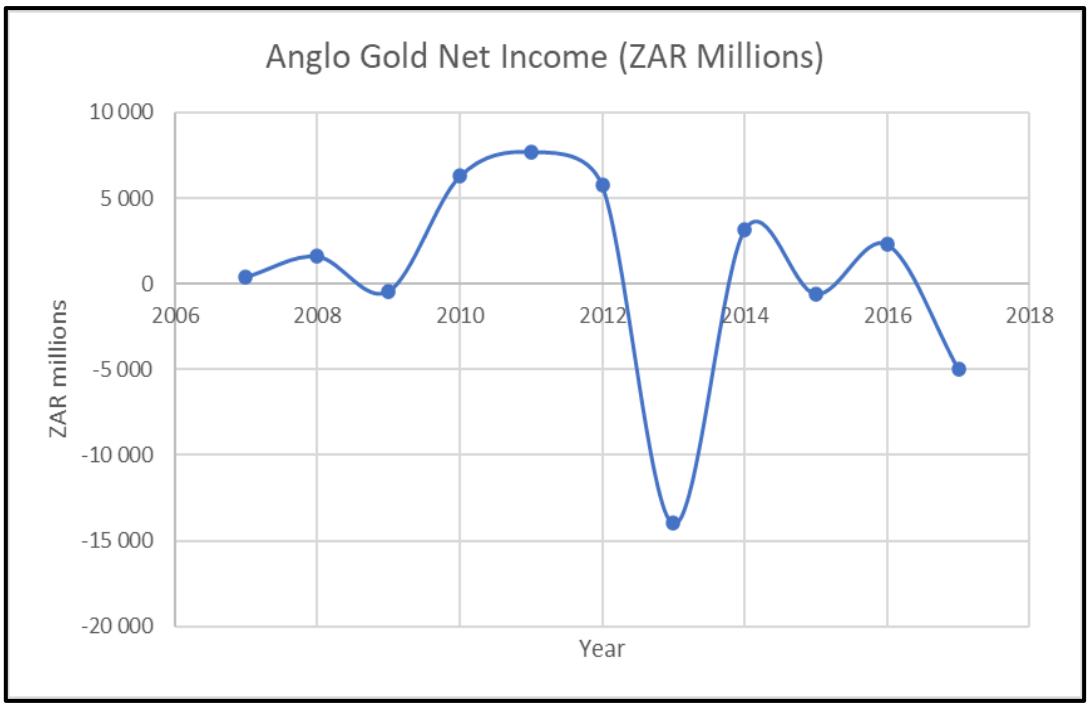

Figure 14: Anglo Gold Net Income (ZAR Millions) (Anglo Gold Ashanti, 2007-2017).

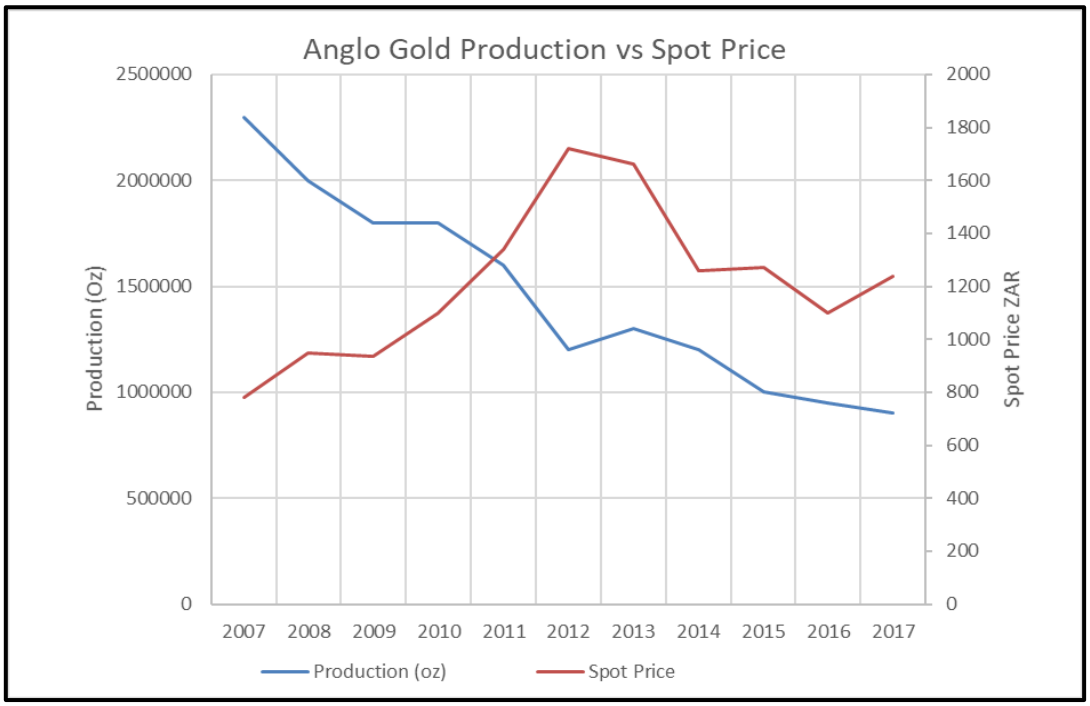

Figure 15: Anglo Gold production (Oz) in comparison to the gold spot price for the study period

Anglo Gold was one of the industry's most geographically diverse companies, even within South Africa they had 7 mining operations at the start of the study period (Anglo Gold Ashanti, 2007). However, during the study period, they underwent numerous shifts in strategic focus, ranging from a systematic approach to improving operational performance in 2008, followed by a diametrically opposite strategic focus on shareholder returns rather than production in 2009. In 2010 the company debt was

upgraded to investment grade, allowing for the increase in debt, this coupled with the soaring gold price led to the elimination of the hedge book and suspension of all hedging activities (Anglo Gold Ashanti, 2010). In 2013 more strategic instability occurred due to the replacement of Mark Cutifani with Srinivasan Venkatakrishnan and subsequent corporate restructuring (Anglo Gold Ashanti, 2013). At this point the company was also struggling to raise sufficient capital to service previously acquired debt, which effected the share price. This was amplified by the 16% decline in the gold price (Anglo Gold Ashanti, 2013).

Anglo Gold's expenditure throughout the study period was mostly in the form of capital expenditure on equipment, ore reserve development and their Mponeng, Tautona and Moab Khotsong projects. Anglo Gold favoured this over buying overpriced assets by means of acquisitions (Anglo Gold Ashanti, 2007; Anglo Gold Ashanti, 2008; Anglo Gold Ashanti, 2010; Anglo Gold Ashanti, 2014; Anglo Gold Ashanti, 2016). Anglo Gold also implemented cost control and cost saving initiatives early and although not fast enough for the gold price collapse in mid-April of 2013, it did move the company from a position near the top of the industry cost curve to the lower half by 2015 (Anglo Gold Ashanti, 2007; Anglo Gold Ashanti, 2013; Anglo Gold Ashanti, 2015). At this time the company was already planning a "footprint reduction" for its South African operations due to the comparatively high sustaining costs (Anglo Gold Ashanti, 2015).

DRD Gold: DRD gold is primarily an unhedged surface gold retreatment company, which makes it very different from the other companies. An interesting fact is how the company uses a "rehabilitation through mining strategy" as part of their business model (DRD Gold Limited, 2017). The share price performance, operating profits and production for DRD Gold over the study period are shown in Figures 16, 17 and 18.

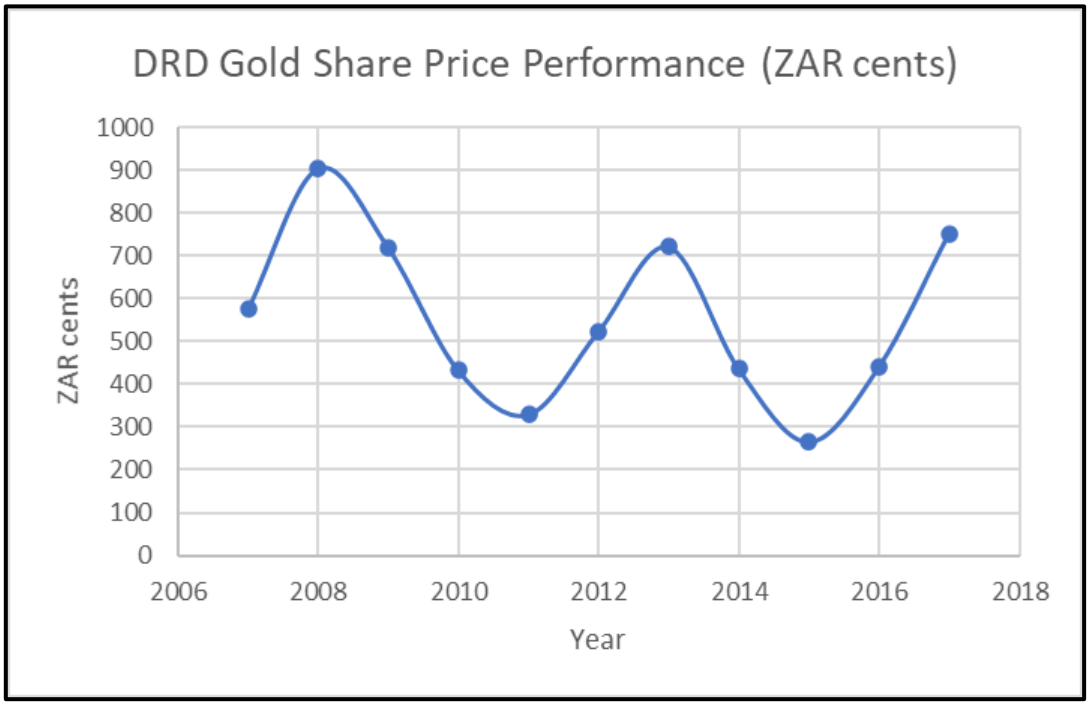

Figure 16: DRD Gold Share Price Performance, from **(Sharenet, 2020)**

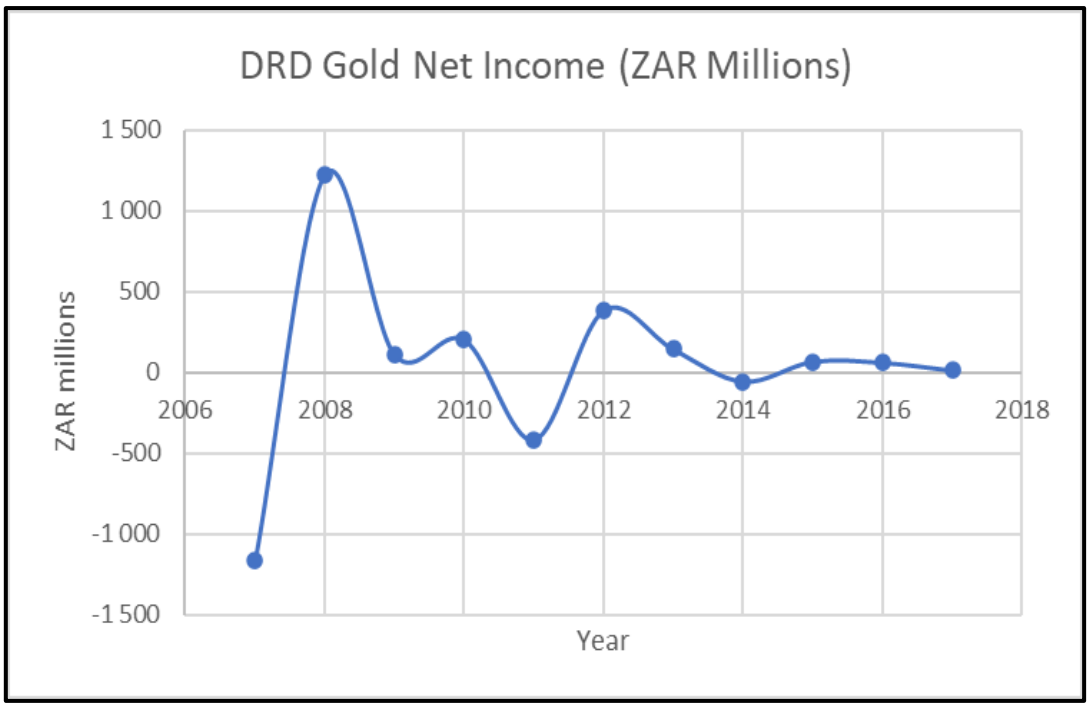

Figure 17: DRD Gold Net Income (ZAR Millions) (DRD Gold, 2007-2017).

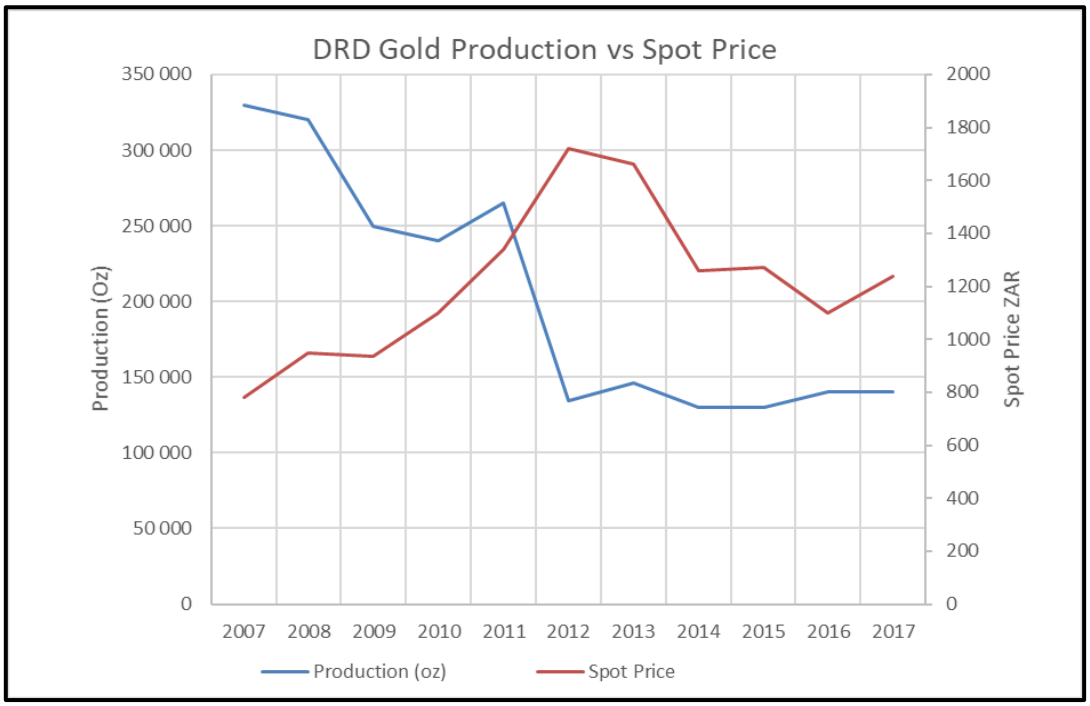

Figure 18: DRD Gold production (Oz) in comparison to the gold spot price for the study period

At the start of the study period 75% of DRD gold's production came from surface operations, with only 25% from mature underground operations (DRD Gold Limited, 2007). Prior to the study period the company attempted to geographically diversify their operations into the Australasian region, however this attempt had failed by 2007 and over the subsequent years the company disposed of all their Australasian assets to focus solely on its South African operations (DRD Gold Limited, 2007; DRD Gold

Limited, 2008). In line with this the company appointed Neil Pretorius, the former head of South African operations as the CEO of the company after John Sayers retired (DRD Gold Limited, 2008).

De-diversification both geologically and operationally led to continuous reductions in production throughout the study period. This was evident; in 2008 with commencement of withdrawals from Australasia, in 2009 with the cessation of underground operations at their East Rand mines, in 2012 with the disposal of the Blyvoor underground operations as well as in 2013 by the disposal of the underground mine in Carltonville (DRD Gold Limited, 2008; DRD Gold Limited, 2009; DRD Gold Limited, 2012; DRD Gold Limited, 2013).

The challenges incurred by DRD gold during the study period included social and community issues such as industrial and political unrest in 2007 at their Vatukoula operations as well as additional wage disputes in 2016. The company also had SHE issues at the beginning of the study period by means of a hoisting accident at Vatukoula in 2007, 2 deaths due to xenophobic violence in 2008, multiple fatalities in 2009 and subsequent DMR stoppages (DRD Gold Limited, 2007; DRD Gold Limited, 2008; DRD Gold Limited, 2009). DRD gold have also traditionally always suffered a managerial skills shortage due to the fact that they do not have the ability to attract the same level of executives as the larger firms (DRD Gold Limited, 2008).

Throughout the study period DRD gold experienced the same cost pressures as the rest of the industry and implemented similar cost and margin management strategies (DRD Gold Limited, 2008; DRD Gold Limited, 2010). Most of the DRD capital expenditure was spent on infrastructure upgrades such as opening up, developments, ramp up and plant pipelines (DRD Gold Limited, 2008; DRD Gold Limited, 2009; DRD Gold Limited, 2010; DRD Gold Limited, 2011). An exception to this trend was the acquisition of 50% of Ergogold from Mintails SA in 2009 which allowed for the exploitation of synergies with the Crown operations (DRD Gold Limited, 2009). The largest capital expenditure was in the launching of the Flotation and Fine Grind circuit (FFG) technology which took 3 years to finally work properly due to technical issues and delays (DRD Gold Limited, 2012; DRD Gold Limited, 2014; DRD Gold Limited, 2015).

Goldfields: Prior to the study period Goldfields had just acquired the South Deep mine in December 2006 and started off the study period with all measures of profitability increasing (Goldfields, 2007). With the acquisition of South Deep Goldfields inherited its hedge book, which they retired at a cost of US $ 549 million in order to benefit immediately from the rising gold price. Gold production within South Africa at the start of the study period accounted for 65% of the company's gold production (Goldfields, 2007). The share price performance and operating profits for Goldfields over the study period is shown in Figures 19, 20 and 21.

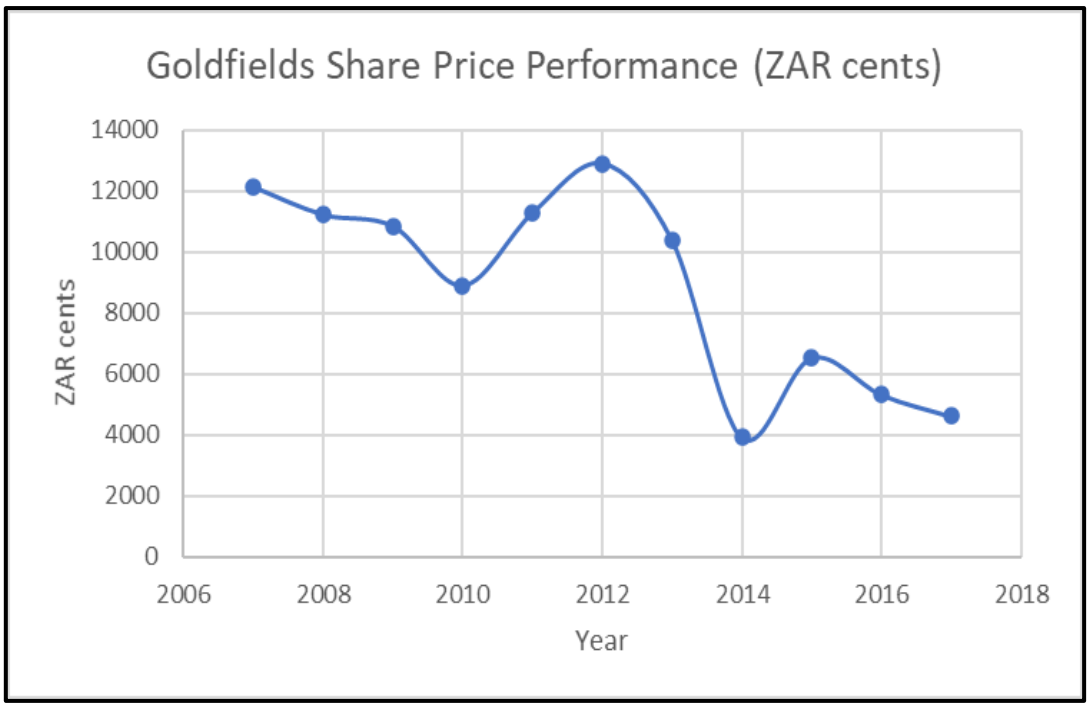

Figure 19: Goldfields Share Price Performance, from **(Sharenet, 2020)**

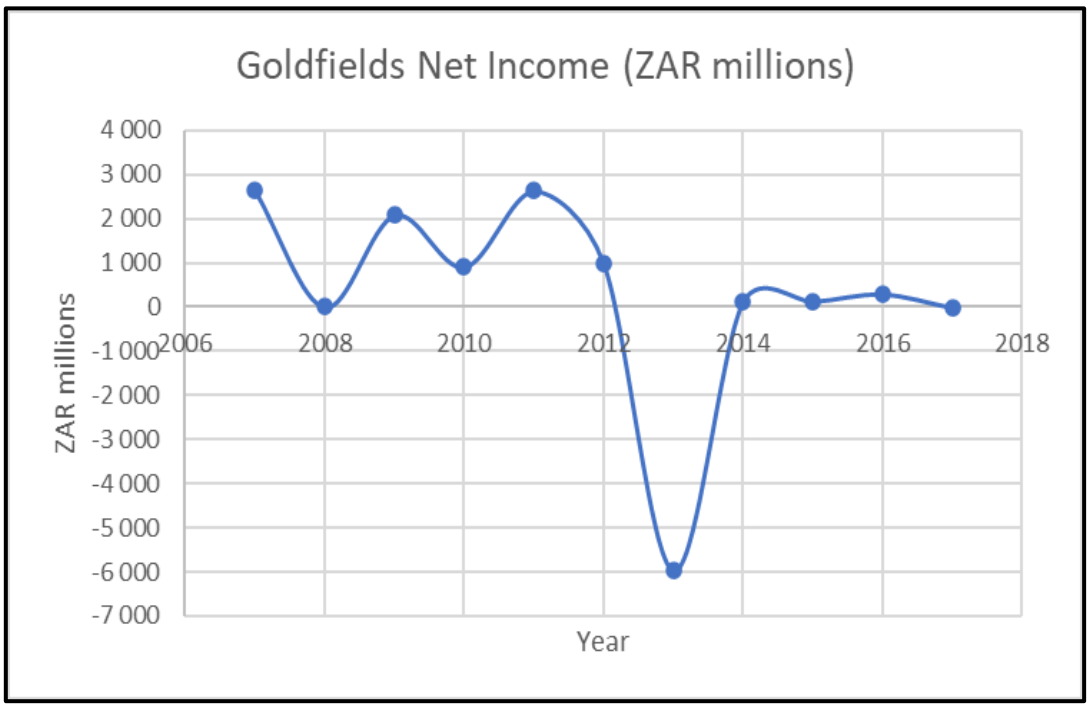

Figure 20: Goldfields Net Income (ZAR Millions) (Goldfields, 2007-2017).

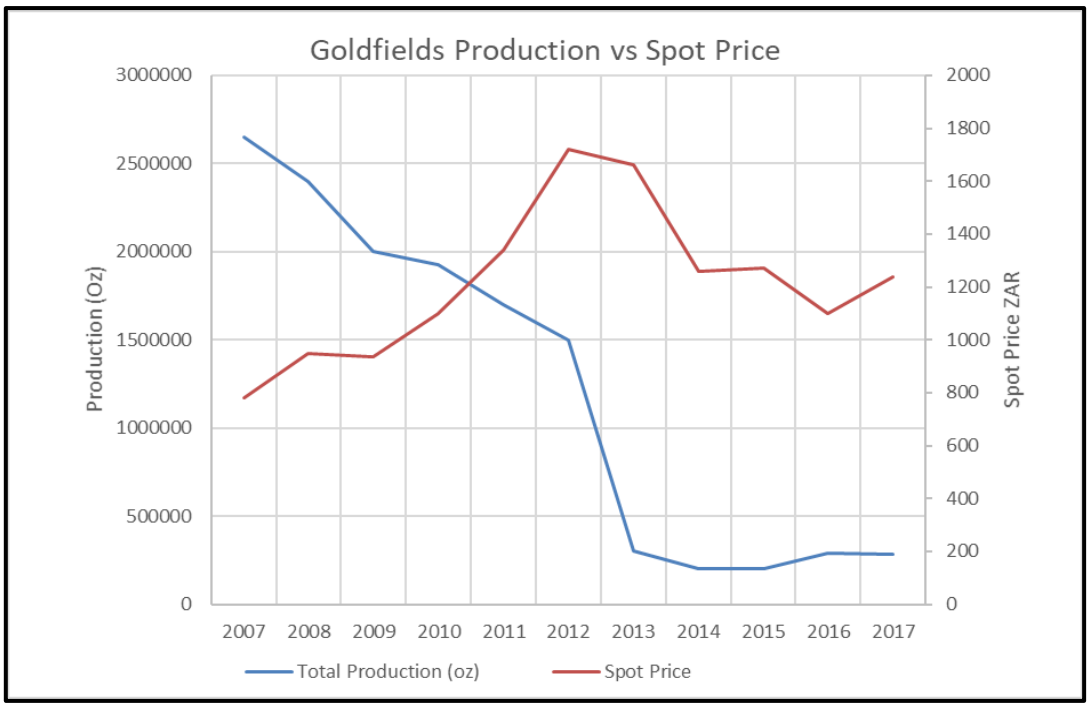

Figure 21: Goldfields production (Oz) in comparison to the gold spot price for the study period

Mining production in South Africa was hampered by safety concerns, in 2008 Nicholas Holland took over from Ian Cockerill, he immediately implemented a safety stoppage to reinforce the need for a cultural change in the way operations were conducted. He changed the operational bonus system to provide an equal weighting for production and safety leading to a subsequent decline in production (Goldfields, 2007; Goldfields, 2008). The consolidation of operations also included internal capacity building, fixing of production streams and a technical review of the South deep mine which would lead to a mechanisation strategy that would prove to be a litmus test for the South African industry (Goldfields, 2009; Goldfields, 2011). By 2009 it was already evident that the South Deep experiment had evolved from a technical study to a project central to Goldfield's South African portfolio (Goldfields, 2009).

By 2011 the production from Goldfields' other more mature operations had declined drastically leading to the unbundling of these operations. Concurrent to these divestments the company increasingly invested in their South Deep operation by increasing the plant processing capacity and installing a new ventilation shaft. This polarisation of priorities culminated in Goldfields separating their portfolio into 2 separate and independent companies with the parent company, Goldfields' only retaining the South Deep mine (Goldfields, 2011; Goldfields, 2012).

With this new leaner portfolio Goldfields chose to focus on cash returns rather than ounces, adopting a dividends first policy in an attempt to attract investors. The plan was to achieve this through leveraging the strengths of the South Deep operations namely its feasibility for mechanisation and the significant mineral resource / life of mine. This new strategy would take Goldfields from being one of the largest gold miners to a modern technologically driven mid-tier operator (Goldfields, 2012; Goldfields, 2013).

However, challenges such as fires, strikes, lower than expected grades, wage disputes and an increase in costs such as fuel and electricity caused a decline in production over the subsequent years between 2012 and 2016 (Goldfields, 2012; Goldfields, 2014; Goldfields, 2015).

However, by 2016 with the improved gold price South deep managed to generate a positive cash flow of US$12 million. And in the final year of the study Goldfields as a whole had an exceptional operational performance, with the share price improving by 24% on the JSE. The company also declared a dividend in 2017 of R0.90 per share. This performance was essentially driven by their international operations proving only that the key for success for Goldfields was to disinvest in South Africa and subsequently invest in Australasia (Goldfields, 2013; Goldfields, 2016; Goldfields, 2017).

Harmony Gold: Harmony Gold is South Africa's 3rd largest gold producer, they have operations in the Wits Basin and the Kraaipan Greenstone Belt. Which provides a good balance between mature operations and Greenfields exploration (Harmony, 2009; Harmony, 2013). The share price performance, operating profits and production for Harmony Gold over the study period is shown in Figures 22, 23 and 24.

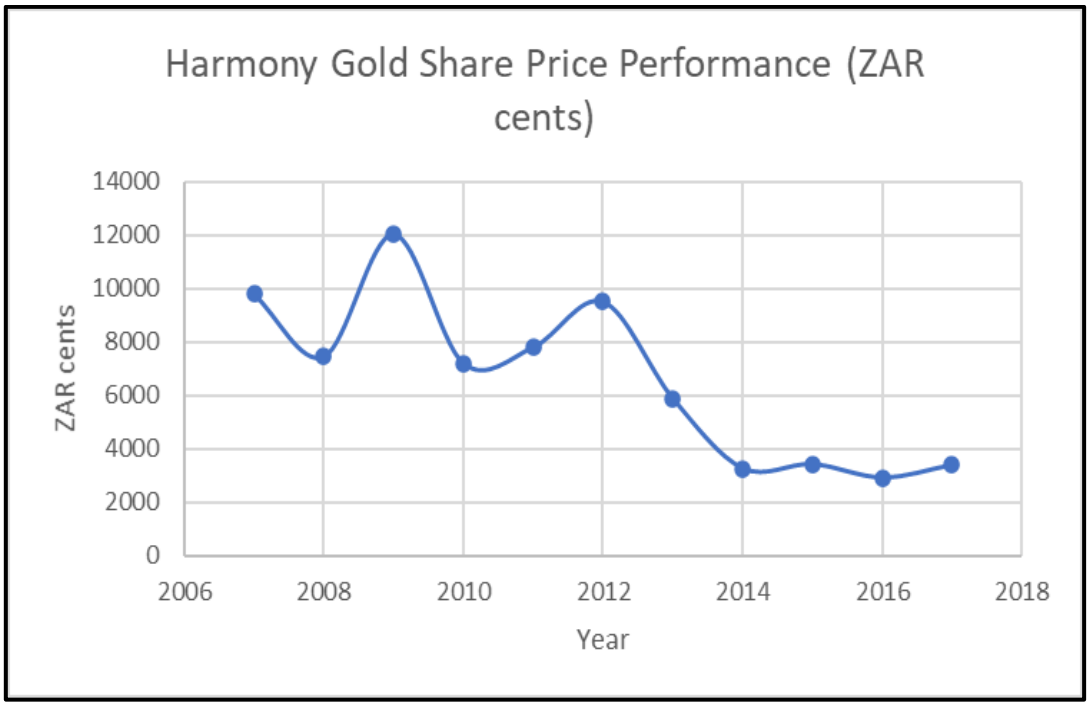

Figure 22: Harmony Gold Share Price Performance, from **(Sharenet, 2020)**

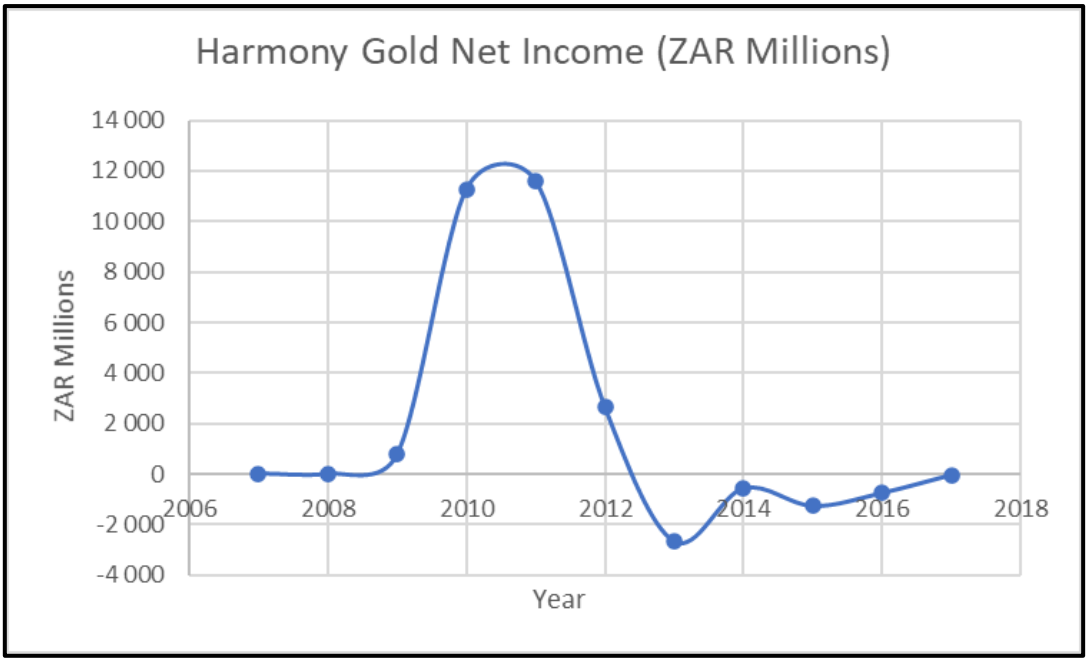

Figure 23: Harmony Gold Net Income (ZAR Millions) (Harmony 2007-2017)

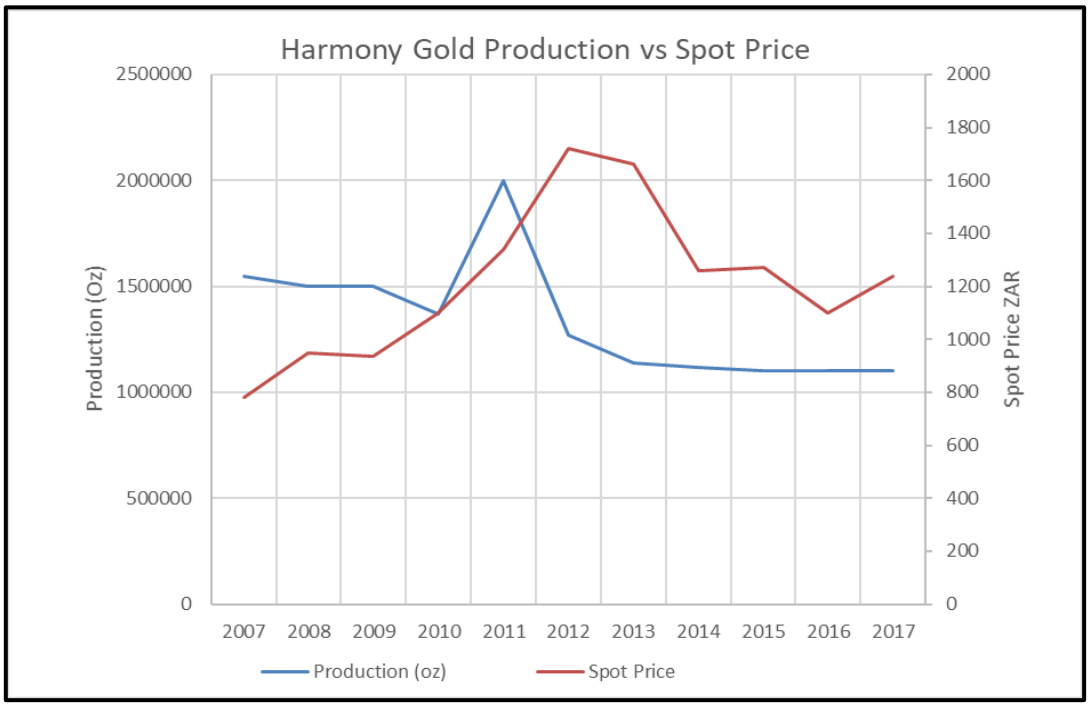

Figure 24: Harmony Gold production (Oz) in comparison to the gold spot price for the study period

Harmony's main strategy was to focus on exploration and new discoveries in order to create shareholder value (Harmony, 2015). At the start of the study period Bernard Swanepoel the visionary force behind Harmony's growth resigned as a CEO, however during his tenure he laid down a strong foundation driven by the notion that the ore body dictates operational, tactical and strategic decisions. Subsequent CEO's , Graham Briggs in 2007 and Peter Steenkamp in 2016 have pretty much stuck with this model (Harmony, 2004-2007; Harmony, 2009; Harmony, 2016).

In addition to sound operations, capital expenditure and exploration expenditure, Harmony gold also participated in the purchasing and selling of various mining operations in order to improve the operational portfolio. These transactions occurred in 2007 when they sold their Orkney shafts to Pamodzi Gold (their BBEE partner), in 2009 they also sold their Cooke operations, and in 2010 they purchased the Free State assets of Pamodzi gold. Along with most of the industry Harmony Gold closed their hedgebooks in 2007 off the back of strong gold price performance, however by the end of the study they commenced hedging activities due to market pressures, this timely decision saved them R1.76 Billion against the gold price in 2017 (Harmony, 2004-2007; Harmony, 2017).

At the beginning of the study period the cash operating costs for Harmony Gold were spiralling out of control with a 26.8% increase in 2007 alone, this was coupled by an embarrassing financial systems error which masked some of the losses to the market in the 3rd quarter. However, amid industry wide cost increases the company still remained one of the lowest cost producers in South Africa (Harmony, 2004-2007; Harmony, 2014).

During the study period the company did face the usual industry challenges such as electricity constraints, criminal artisanal mining, fatalities, underground fires and illegal strikes (however limited to their Kusasalethu operations).

4.1.1.2 Platinum Performance

Figure 25 shows the platinum spot price throughout the study period.

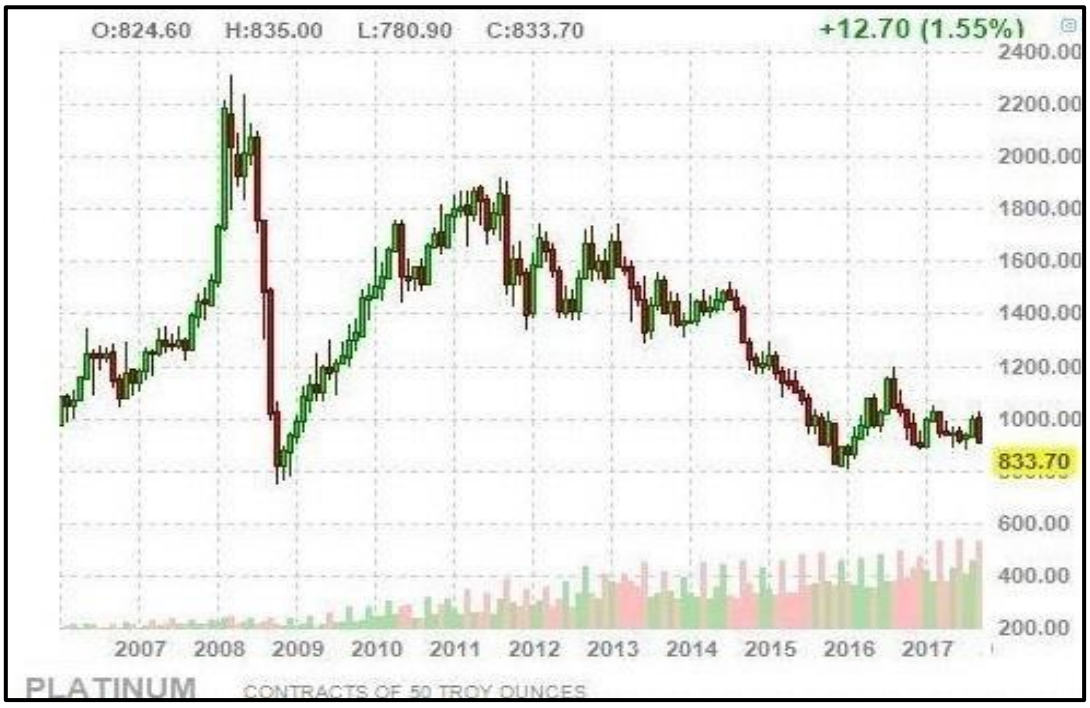

Figure 25: Platinum spot price (USD/ ton) throughout the study period (from seekingalpha.com)

In summary, the fundamental drivers dictating market factors in the platinum sector during the study period consists of a combination of legislative, social, technological, circumstantial and macro-economic variables. From a legislative perspective the biggest driver to platinum demand was derived from the series of legislations related to European Emission Standards which gained momentum just prior to the study period in 2006 with the Euro IV regulations. The series dictated increasingly tighter

legislative controls which extended throughout the study period culminating in 2014 with the implementation of Euro VIB legislations which resulted in record high diesel vehicle sales, which only began to retract in 2017 after the study period. This had a direct effect on the platinum market and was touted as the main growth potential in the sector as Platinum is the main constituent in motor vehicle catalysts and particulate filters (Johnson Matthey, 2007; Johnson Matthey, 2016; Johnson Matthey, 2018). Despite this positive fundamental legislative platform and a general bullish outlook at the start of the study period, the South African platinum industry was plagued from 2008 by a multitude of issues ranging from industrial unrest, electricity shortages, safety shutdowns and skills shortages. In addition to this the Fukishima disaster in 2011 essentially resulted in a lost year of Japanese vehicle manufacture which in turn reduced the global platinum demand and sales (Johnson Matthey, 2007; Johnson Matthey, 2009; Johnson Matthey, 2011; Johnson Matthey, 2013). The multiple uses for platinum and therefore the multiple sources of platinum demand had traditionally resulted in a less volatile market, however during the study period the main uses of platinum seemed to ebb and flow in a synchronised manner causing increasing volatility during the study period. In 2006 platinum use in the industrial, chemical and electronic sector increased due to the contemporaneous increase in demand for LCD glass, hard disk drives, fertilisers, explosives and polymers. All of which contemporaneously also began to slow down from 2012 (Johnson Matthey, 2007; Johnson Matthey, 2013). There has been a downward trend in platinum jewellery demand from the start of the study period this was exacerbated by a subsequent increase in Chinese jewellery recycling in 2012. This trend continued until global demand began to recover in 2014, however by the end of the study period Chinese platinum jewellery fabrication contracted for a fourth consecutive year as karat gold jewellery gained market share. Global levels of platinum recycling fluctuated throughout the study period however collectors of spent auto catalysts held and hoarded stock in anticipation of better prices from 2012 to 2014. With regards to substitution the price differential between platinum and palladium resulted in a general tendency to substitute the former with the later. Investment demand after declining within the first year of the study had for the rest of the period shown a steady and consistent increase, which also added to the volatility of platinum through the increased financialisaton of the commodity (Johnson Matthey, 2007; Johnson Matthey, 2009; Johnson Matthey, 2013).

4.1.1.2.1 Performance of platinum companies

Impala Platinum: The share price performance, operating profits and production for Impala Platinum over the study period are shown in Figures 26, 27 and 28.

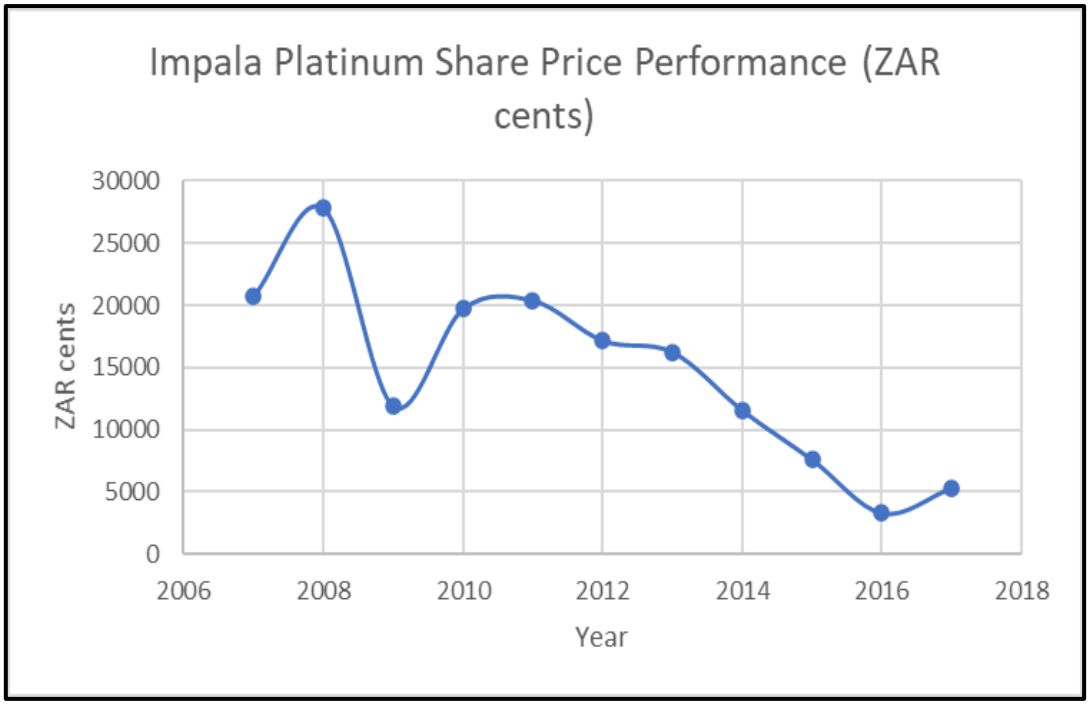

Figure 26: Impala Platinum Share Price Performance, from **(Sharenet, 2020)**.

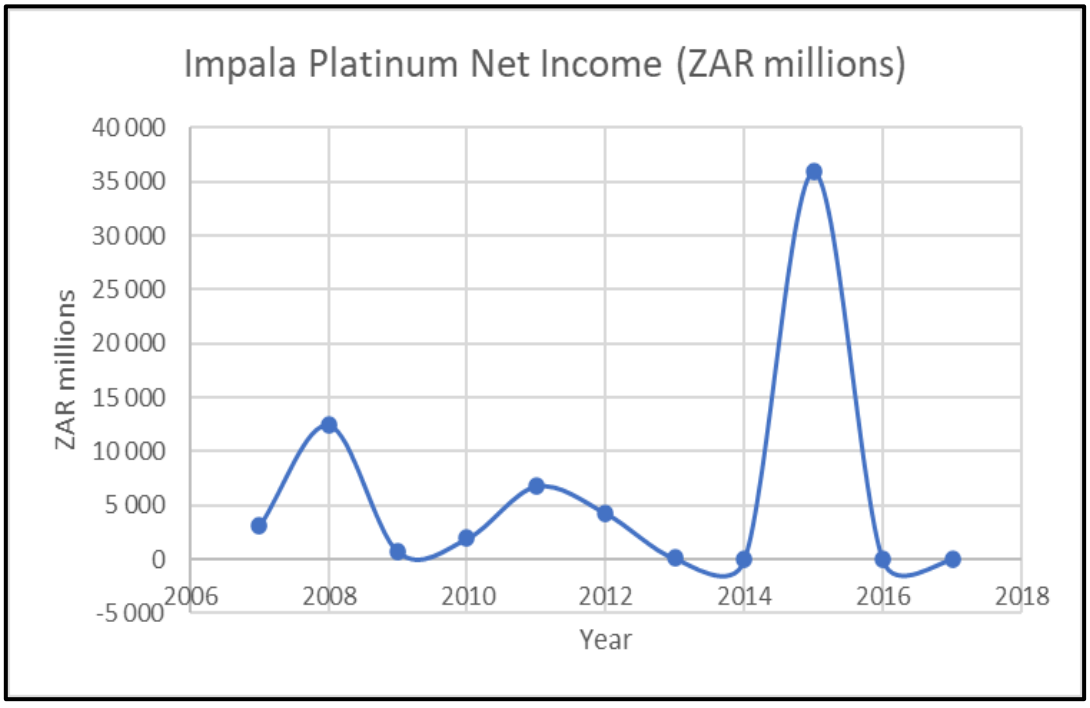

Figure 27: Impala Platinum Net Income (ZAR millions) **(Implats, 2004-2017)**

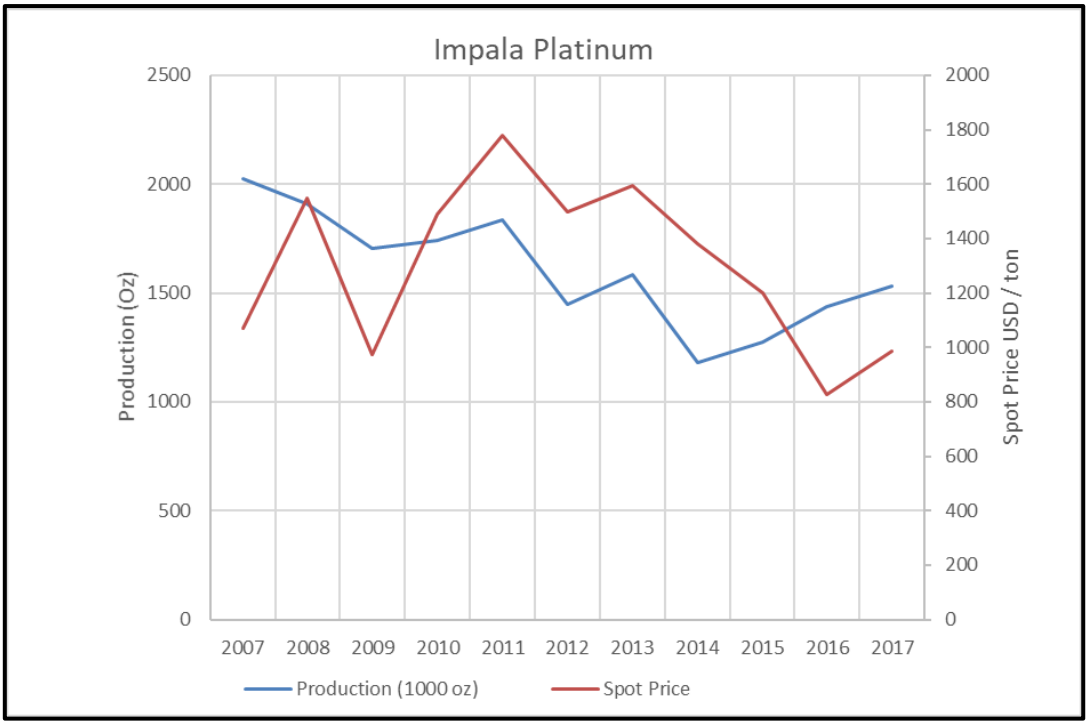

Figure 28: Impala Platinum production (USD/ton) in comparison to the platinum spot price for the study period **(Implats, 2004-2017)**.

At the beginning of the study period Impala platinum suffered from inefficient ore mixing practices, the ageing of the higher grade Merensky reef and subsequent reliance on the lower grade UG2 reef. All of which resulted in lower grades and increased dilution. The company was very active in 2008 amidst the tough local conditions described above, conditions which eventually led to the company reducing capital expenditure projects by 30%, however the company did manage to complete the feasibility study at their Marula Operations. In that same year the company also attempted to acquire Northam, however both parties couldn't come to an agreement. In 2010 the company increased their capital expenditure again and had 3 major replacement shaft projects underway (Johnson Matthey, 2007; Johnson Matthey, 2009; Johnson Matthey, 2011).

Lonmin: The share price performance, operating profits and production for Lonmin over the study period are shown in Figures 29. 30 and 31.

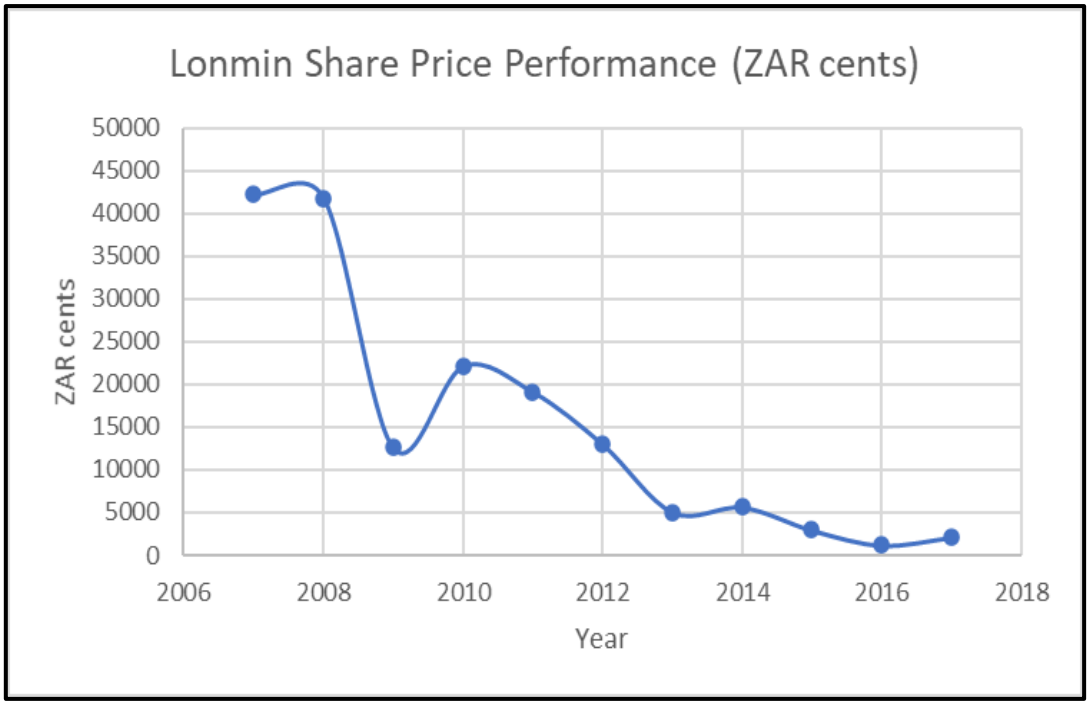

Figure 29: Lonmin Share Price Performance, from (Sharenet, 2020).

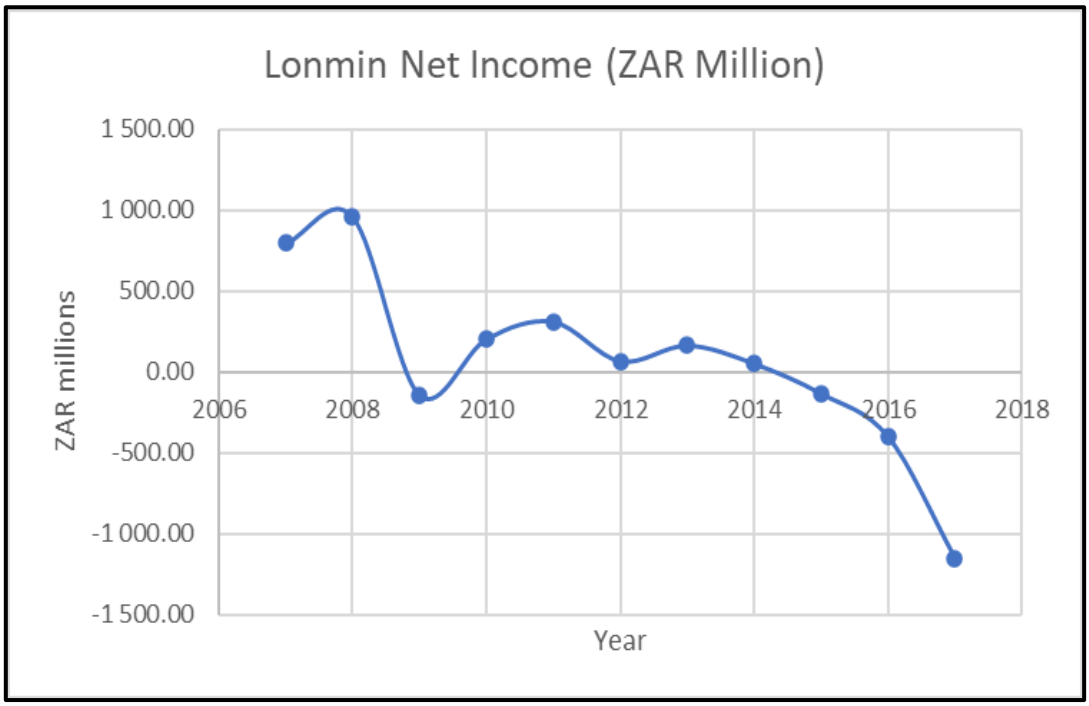

Figure 30: Lonmin Net Income (ZAR millions) (Lonmin, 2007-2017)

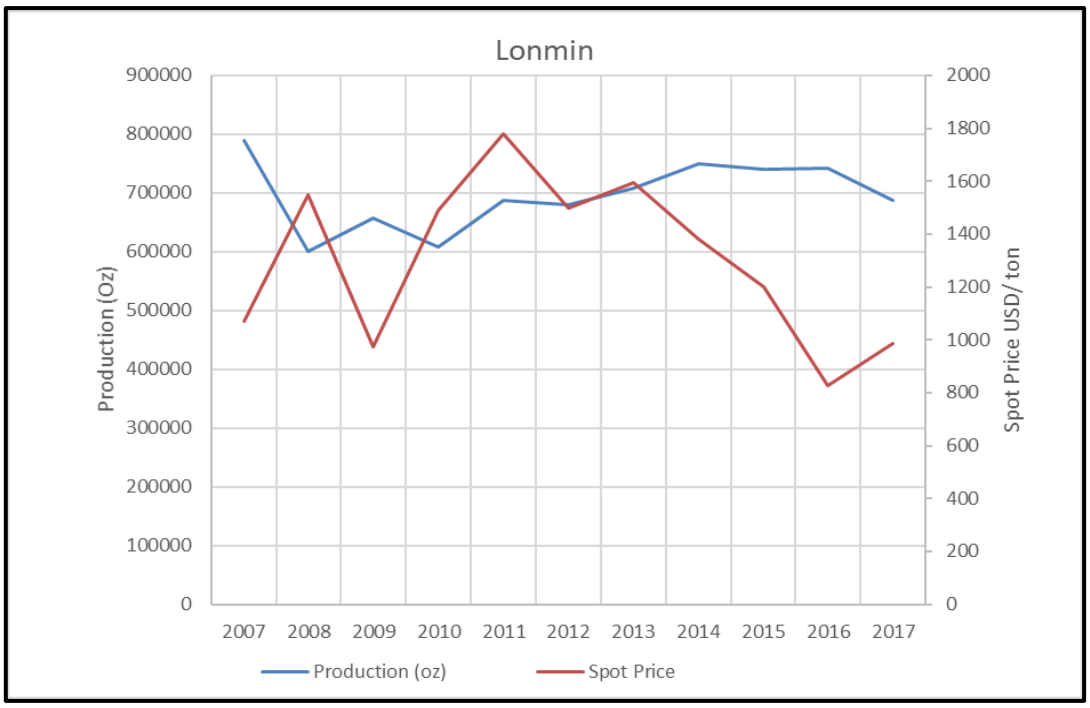

Figure 31: Lonmin production (USD/ ton) in comparison to the platinum spot price for the study period

At the beginning of the study period Lonmin was very bullish with regards to mechanisation of all its operations, and we saw the commissioning of the Hossy and Saffy shafts in early 2007. However, the onset of adverse local conditions in 2008 caused the company to revise its mechanisation strategy into one which adopted a hybrid model. Market conditions of that year also led to the closure of all of the company's open pit operations, except Pandora. From the start of the study period the company grappled with logistical issues surrounding furnace availability which hampered their ability to smelt and refine their production output. In 2012 the fateful Marikana disaster occurred which totally destroyed the very strong start to the year that the company had achieved. From that point on the company began on a downward trajectory exacerbated by a rationalisation program which although consolidating expenses also decreased future production capacity therefore leaving the company with no future growth prospects. In 2014 under severe financial pressures the company announced a rights issue in order to raise additional funds (Johnson Matthey, 2007; Johnson Matthey, 2009; Johnson Matthey, 2011; Johnson Matthey, 2013; Johnson Matthey, 2016).

The share price performance, operating profits and production for Anglo Platinum over the study period are shown in Figures 32, 33 and 34.

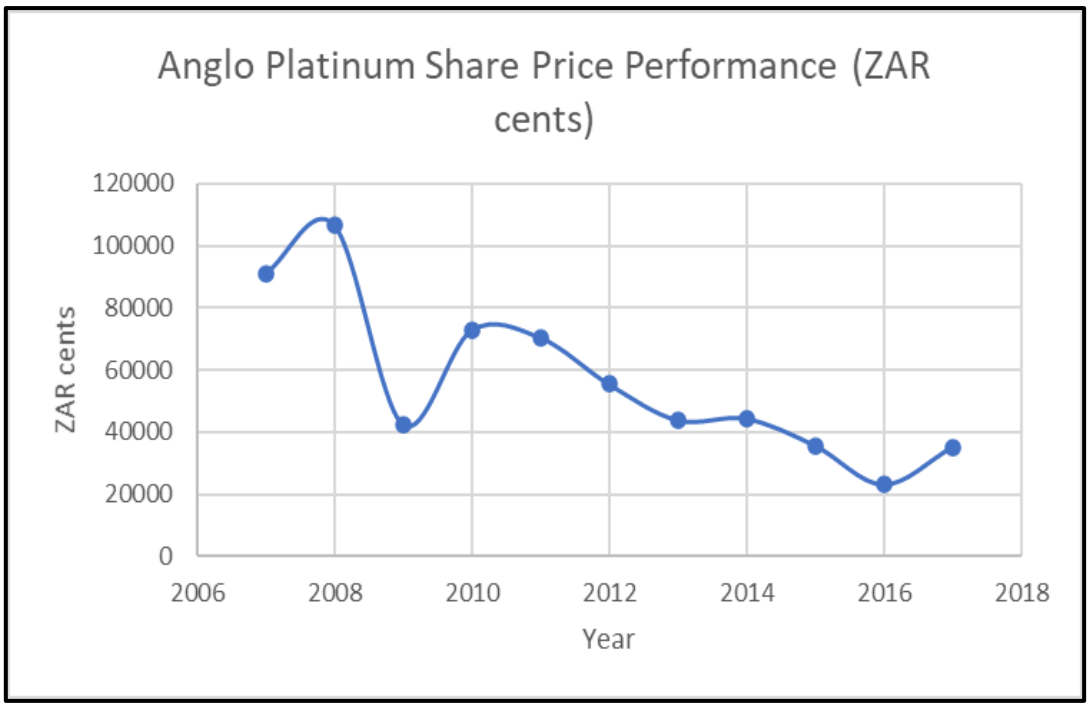

Figure 32: Anglo Platinum Share Price Performance, from (Sharenet, 2020).

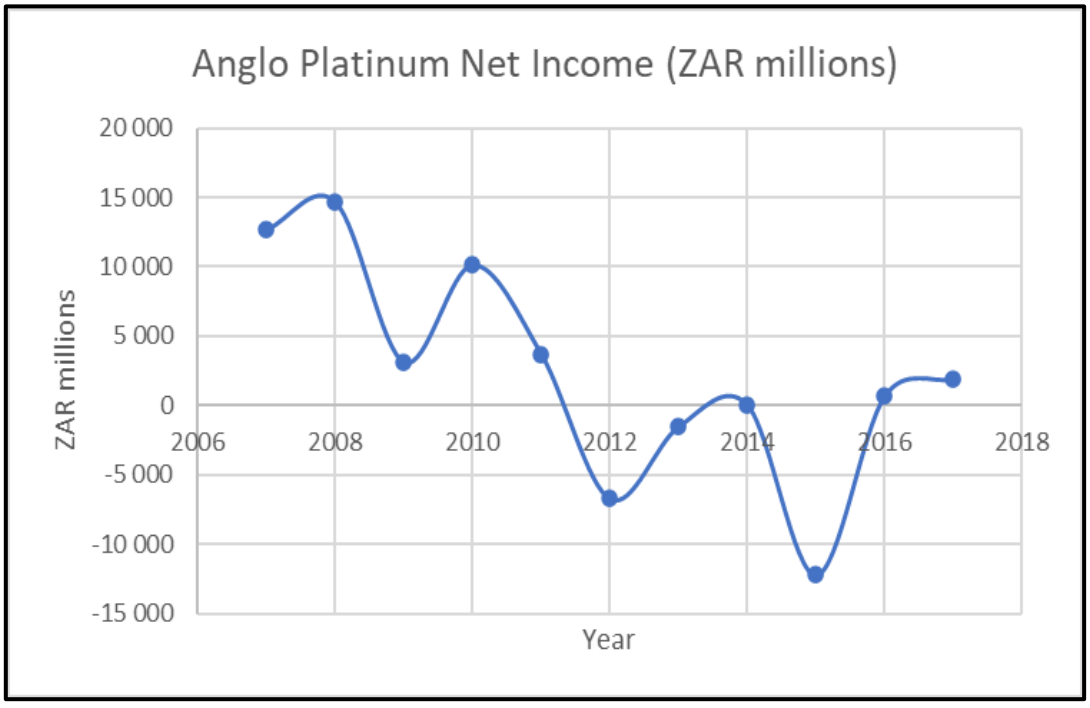

Figure 33: Anglo Platinum Net Income (ZAR millions) (Anglo Platinum, 2007-2017)

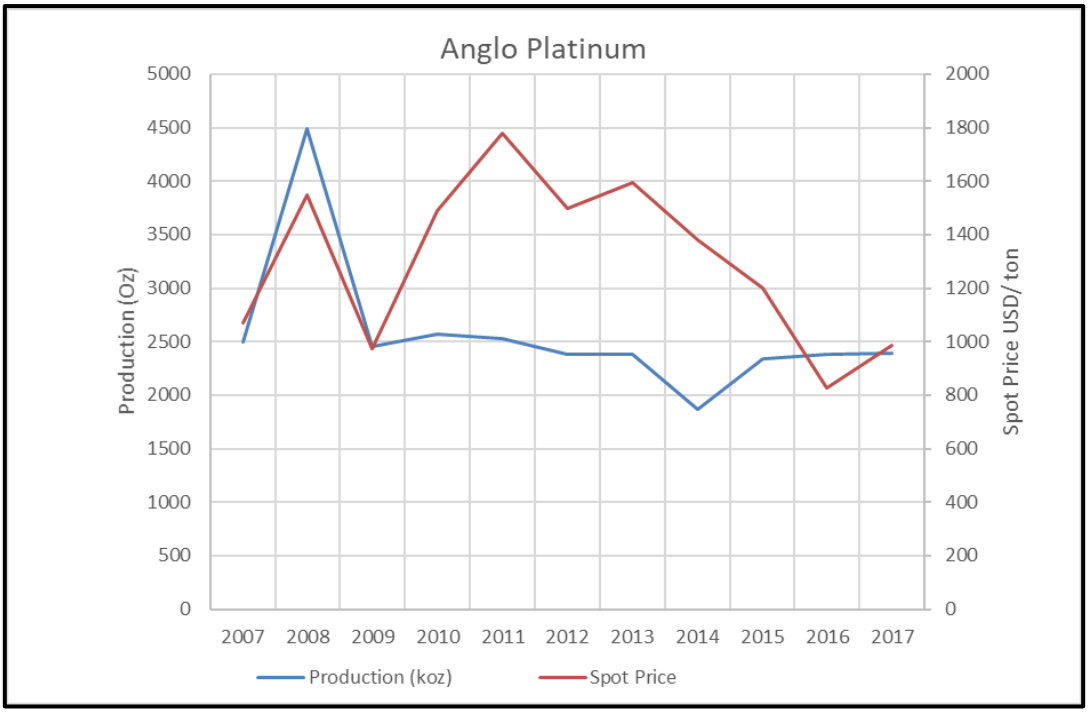

Figure 34: Anglo Platinum production (USD/ ton) in comparison to the platinum spot price for the study period

From the commencement of the study Anglo platinum encountered output challenges related to the flooding at their Amendebult operations, shutdown of their turffontein shaft as well as the shutdown of their Polokwane and Waterval smelters. The lower PGM prices of 2009 forced the company to cut back on capital expenditure plans. This was done by the closure of uneconomic shafts on the older western limb. However despite this the company managed to untangle its production lines during the study period and the output trend began to recover from 2010 onwards (Johnson Matthey, 2009; Johnson Matthey, 2011).

Northam: The share price performance, operating profits and production for Northam over the study period are shown in Figures 35, 36 and 37.

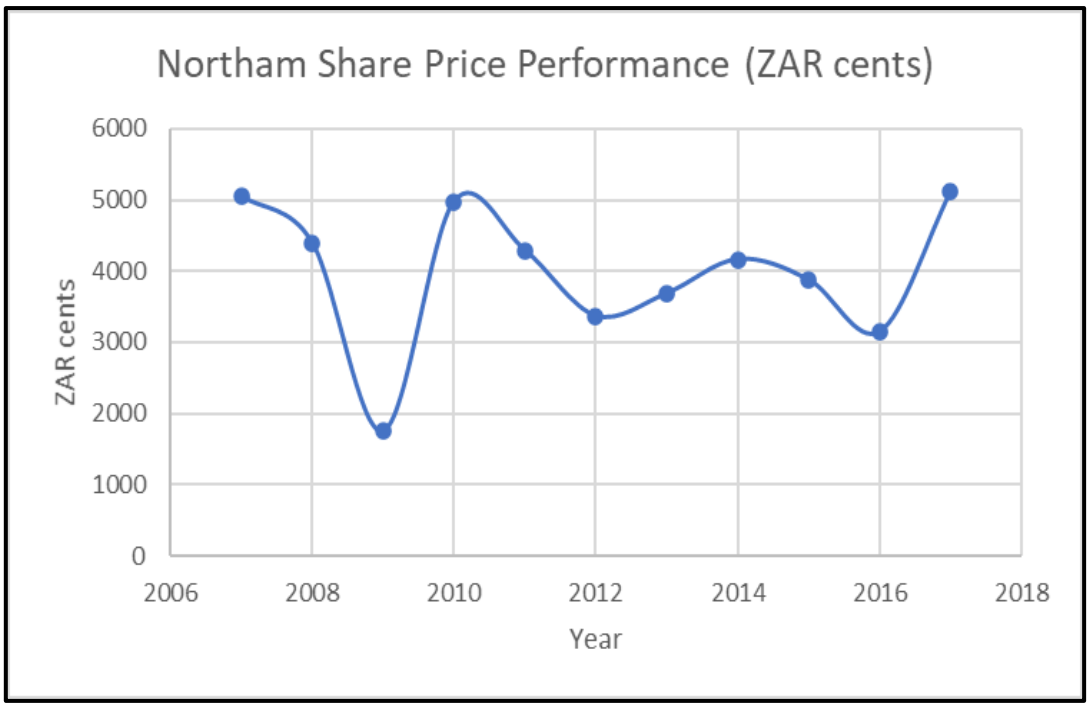

Figure 35: Northam Share Price Performance, from (Sharenet, 2020).

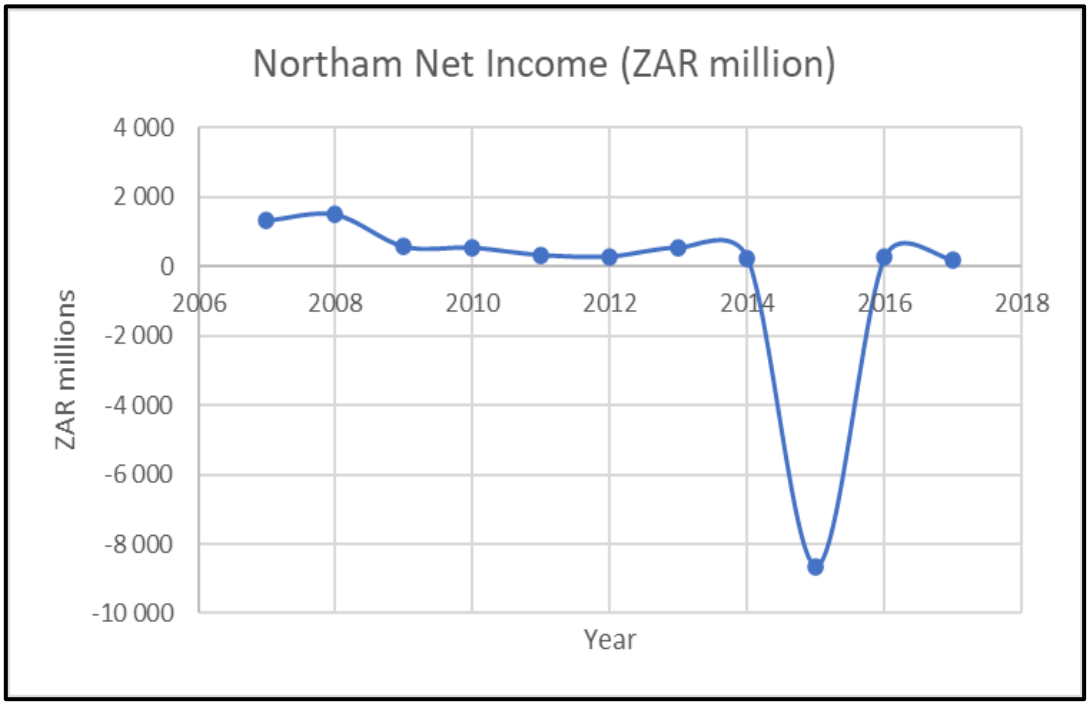

Figure 36: Northam Net Income (ZAR millions) (Northam, 2007-2017).

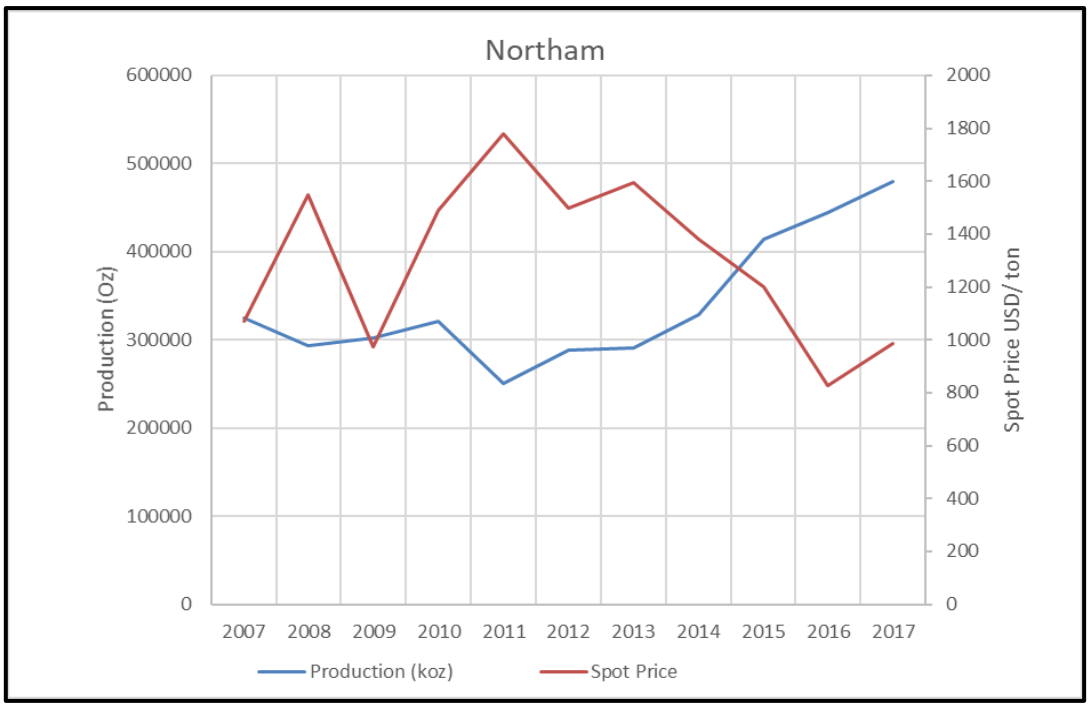

Figure 37: Northam production (USD/ ton) in comparison to the platinum spot price for the study period

During the study period, Northam did all the right things from a managerial point of view they prudently increased their growth options by making counter cyclic investment decisions which allowed them to attain well performing and diversified assets such as the Booysendal properties in 2008. Apart from a 6-week strike in 2010 the company was luckily not affected by the labour unrest which plagued the rest of the sector during the study period. In addition to this Northam consistently ranked amongst the lower cost producers in the sector. All of these factors allowed Northam to maintain a strong balance sheet (Johnson Matthey, 2009; Johnson Matthey, 2011; Mathews, 2018).

Wesizwe: The share price performance and operating profits for Wesizwe over the study period are shown in Figures 38 and 39.

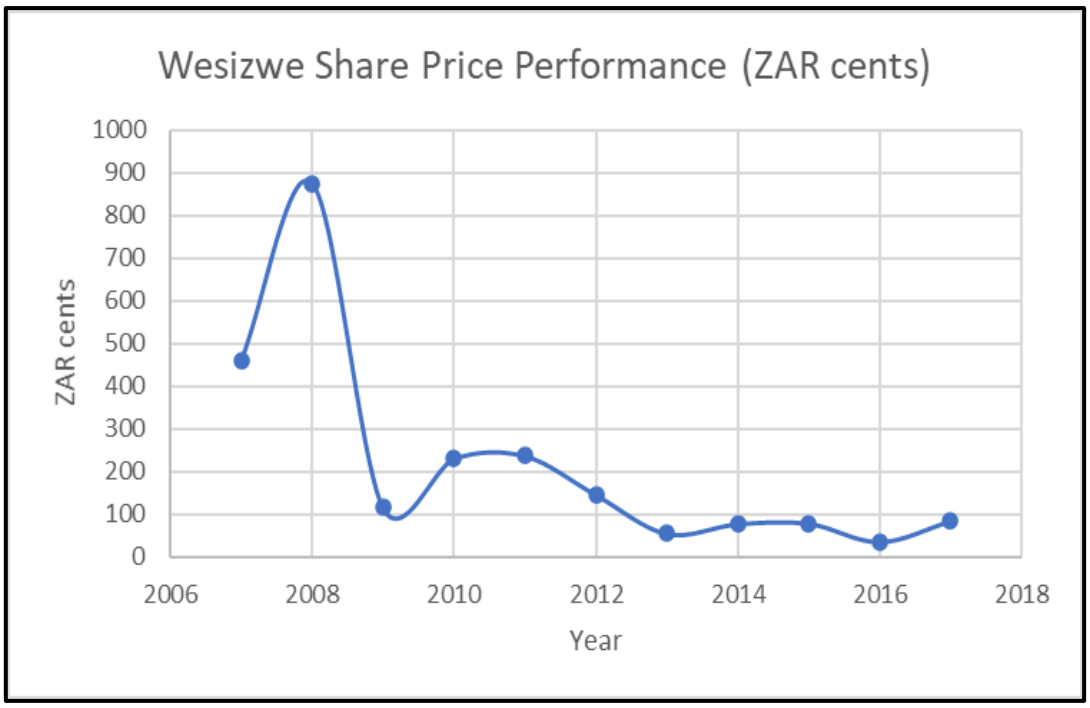

Figure 38: Wesizwe Share Price Performance, from (Sharenet, 2020).

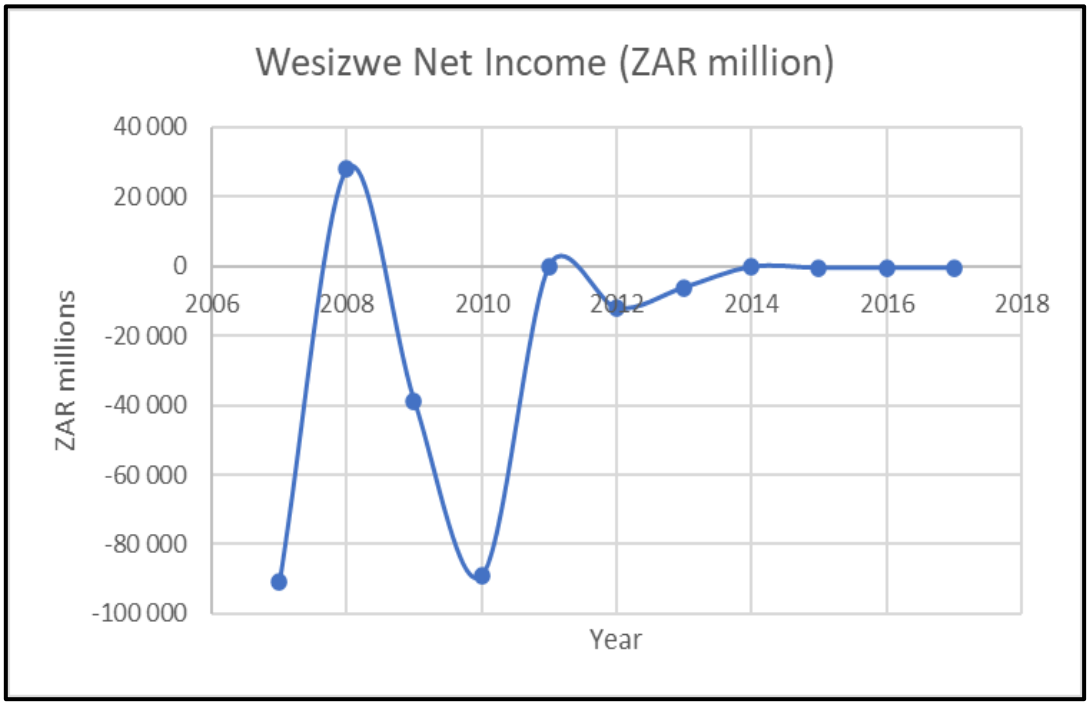

Figure 39: Wesizwe Net Income (ZAR millions) (Northam, 2007-2017).

Wesizwe is a fairly new company that was listed on the JSE in 2005, the company's principal interests are in the development of platinum projects held by their wholly owned subsidiaries, Bakobung and African Wide Minerals (Wesizwe Platinum Limited, 2007). At the commencement of the study period they successfully completed a bankable feasibility study on their core project called the Frischgewaagd-Ledig complex, this feasibility study had to be reviewed amidst the prevailing market volatility of the global financial crisis. Prior to the crisis the company was financially very strong with approximately 240 million Rand cash on hand, however the financial crisis created a heightened

liquidity risk which necessitated the acceptance of investments from the Chinese consortium, China-Africa Jinchuan in 2011. This deal was facilitated by the fact that in 2010 the company was granted all the necessary approvals by the DMR which increased the value of their total assets and mineral resources (Wesizwe Platinum Limited, 2008; Wesizwe Platinum Limited, 2010; Wesizwe Platinum Limited, 2011). The acquisition brought on many connected Chinese expertise into the re-organized board, this network paid dividend when in 2012 the company secured additional funding by means of a loan facility from the China Development Bank (Wesizwe Platinum Limited, 2012; Wesizwe Platinum Limited, 2014). From an operational perspective Wesizwe is different from other companies in the study in that they had not yet started to produce their commodity. In 2012 the company commenced with the first blasts for their ventilation and main shafts, all of which were commissioned and licensed the following year. In 2014 these shafts intersected the Merensky reef, allowing for a 300-tonne bulk sampling of the reef, the following year their shafts had reached the planned bottom (Wesizwe Platinum Limited, 2012; Wesizwe Platinum Limited, 2014; Wesizwe Platinum Limited, 2015). The results of the bankable feasibility study estimate that the company sits on a total proved reserve of 7 000 million tons at a grade of 5 g/t (Wesizwe Platinum Limited, 2017).

4.1.1.3 Iron, Manganese and Chrome Performance

The steel industry forms the predominant source of demand for manganese, iron and chrome the key driver for steel production is economic development which during the study period has been propagated by China, India and to a lesser extent Europe and the USA (Assore, 2011; d'Harambure, 2015; ul Haque, 1971). In 2009 European demand was hampered by the recession, however this was offset by Chinese demand which grew rapidly from a lower base to surpass the total global demand. By 2016 Chinese capital and infrastructural growth had noticeably declined (Mojarov, 2012; UNCTAD Trust Fund on Iron Ore Information, 2016; Unknown, 2011). A country's steel demand curve traditionally follows a predictable trend, whereby an initial sharp growth occurs with the onset of industrialisation, followed by a gradual decline due to an economic structural shift caused by the subsequent economic development. With this knowledge one can expect Chinese demand to follow the same general trend and although by the end of the study China had not yet hit peak steel, it is evident that it will no longer drive the growth in steel demand (CRU Consulting, 2017; Rio Tinto, 2012).

With regards to iron ore, the Chinese growth in supply has not matched that of demand. In fact, over the study period Chinese output which is derived from numerous small-scale operations has been decreasing. The major limiting factor for the supply through international trade of iron ore is the low transport capacity and high transport costs, this results in geographic pockets of oversupply and undersupply (Mojarov, 2012; Unknown, 2011).

Figure 40 shows the iron ore spot price, when looking at the iron ore price, it is important to understand the steel, metallurgical coal and scrap markets. The volatility experienced in the iron ore spot price during the study period is a result of pricing cycles associated with seasonal variations of Chinese inventories, and increased financialization. From 2012 iron ore became the world's second most traded commodity after oil with a market value over 3 trillion USD, this increased financialization was mainly a result of the abandonment of the benchmark system of pricing in 2010 which allowed for more liquidity (Bodley, et al., 2013; Deloitte, 2018; Kumba Iron Ore, 2006-2007; Kumba Resources, 2010; Kumba Resources, 2013; Sekiguchi, 2015).

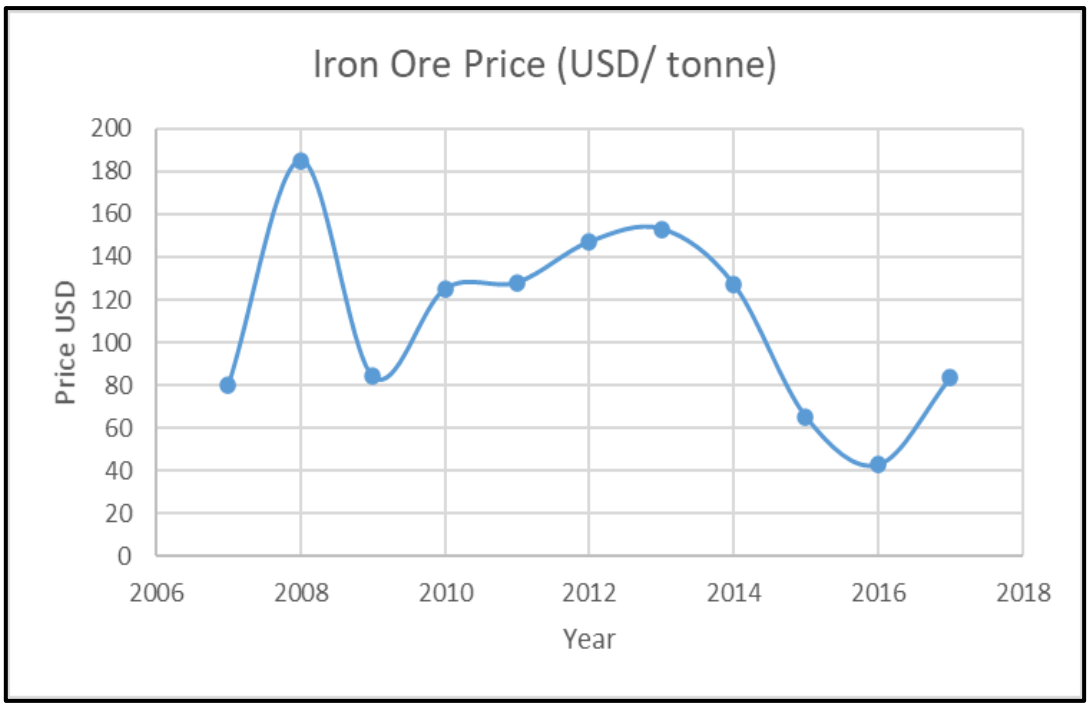

Figure 40: Iron Ore Spot Price Over the Study Period **(Garside, 2020)**

Manganese demand also derives from its use as an alloy in other metallurgical industries such as brass, bronze and aluminium as well as its use in chemicals and dry cell batteries. The chief function of manganese in steel production is to counteract the brittleness caused by impurities and increase the toughness and hardness of the steel (ul Haque, 1971).

South Africa is one of the major world suppliers of Mn ore along with India, Brazil and Gabon. Global manganese reserves are large and there is a steady flux of new projects leading to a theoretical oversupply. However, the stockpile levels of manganese are more influential on the price than reserve levels – so the market does have an artificial element to it (ul Haque, 1971).

Figure 41 shows the manganese spot price, manganese prices differ based on the grade of the ore, metal content and presence or absence of impurities but generally the price bands move together at various levels, therefore an average price can be used to track price action over the study period (ul Haque, 1971).

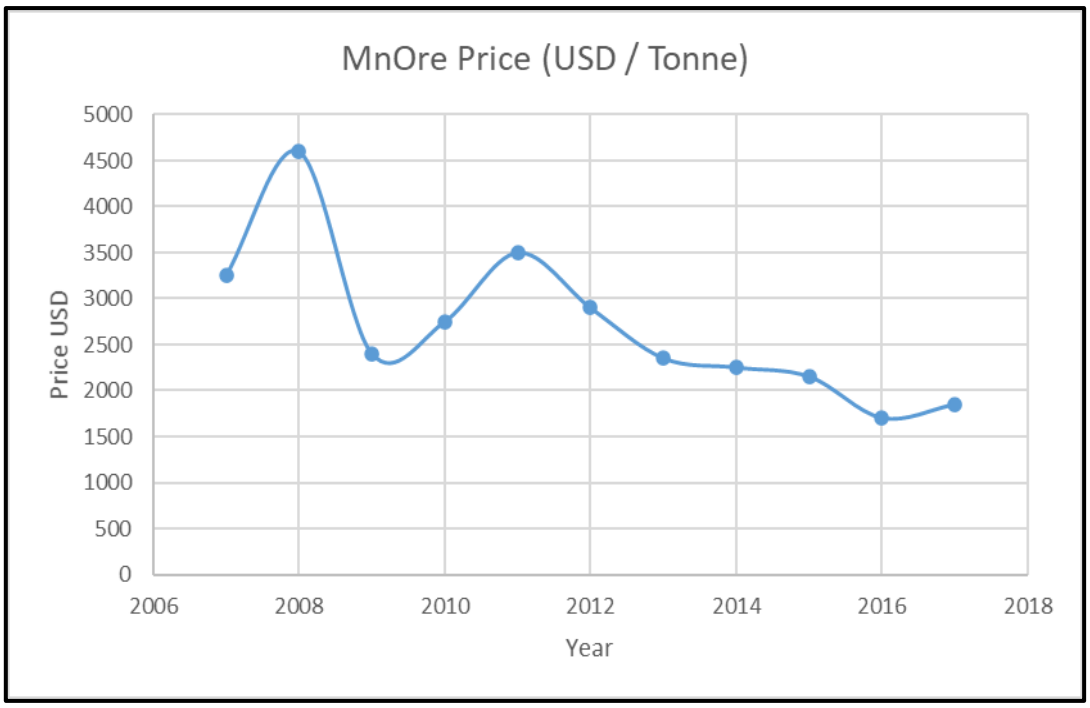

Figure 41: Mn Ore Spot Price Over the Study Period **(Metalary, 2020)**.

The demand for chrome in the steel industry has grown with the increase in the nickel price, due to the fact that ferritic grade stainless steel can substitute the need for nickel by increasing the chrome content, this dynamic made ferrochrome demand more robust and led to an overall balanced supply and demand dynamic for ferrochrome throughout the study period (Merafe Resources Limited, 2004-2007; Merafe Resources Limited, 2015). Furthermore, because the ferrochrome price is based on a quarterly derived benchmark the prices are thus less elastic to the steel price than that of nickel which further decreases market volatility (Merafe Resources Limited, 2004-2007; Merafe Resources Limited, 2011). Figure 42 shows the European Benchmark FeCr Ore price over the study period.

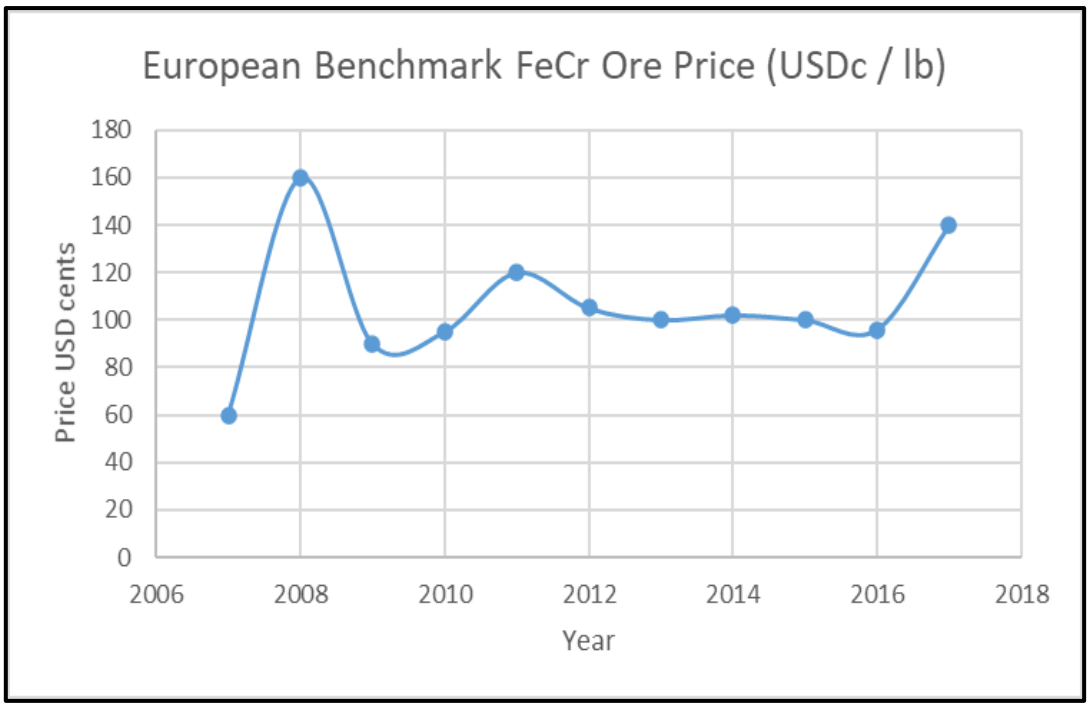

Figure 42: European Benchmark FeCr Ore Price (USDc/ lb) **(KPMG, 2018; Barnes, 2020)**.

4.1.1.3.1 Performance of iron, manganese and chrome companies

Kumba: Kumba's competitive advantage is the unique physical characteristics of their superior and consistently high-grade lump ore, this makes them the preferred supplier globally. In addition to this their product in itself is a primary raw material that is a fundamental component in countless integral items and therefore will always carry a significant demand (Kumba Iron Ore, 2006-2007; Kumba Resources, 2010). The share price performance, operating profits and production for Kumba over the study period are shown in Figures 43, 44 and 45.

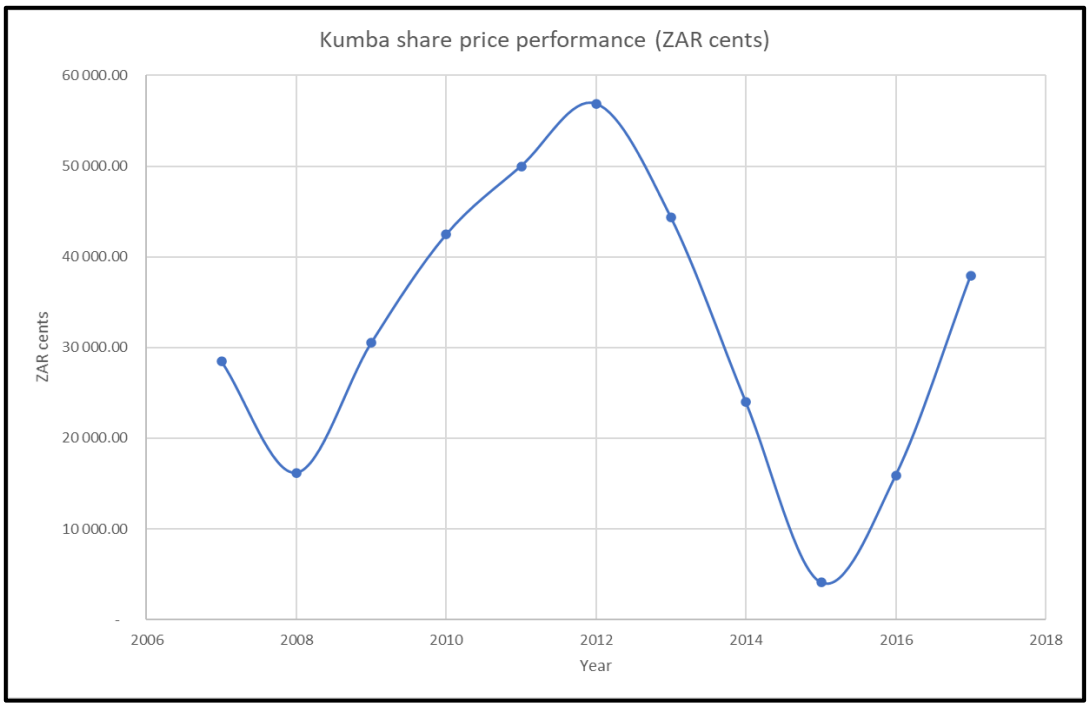

Figure 43: Kumba Share Price Performance, from **(Sharenet, 2020)**

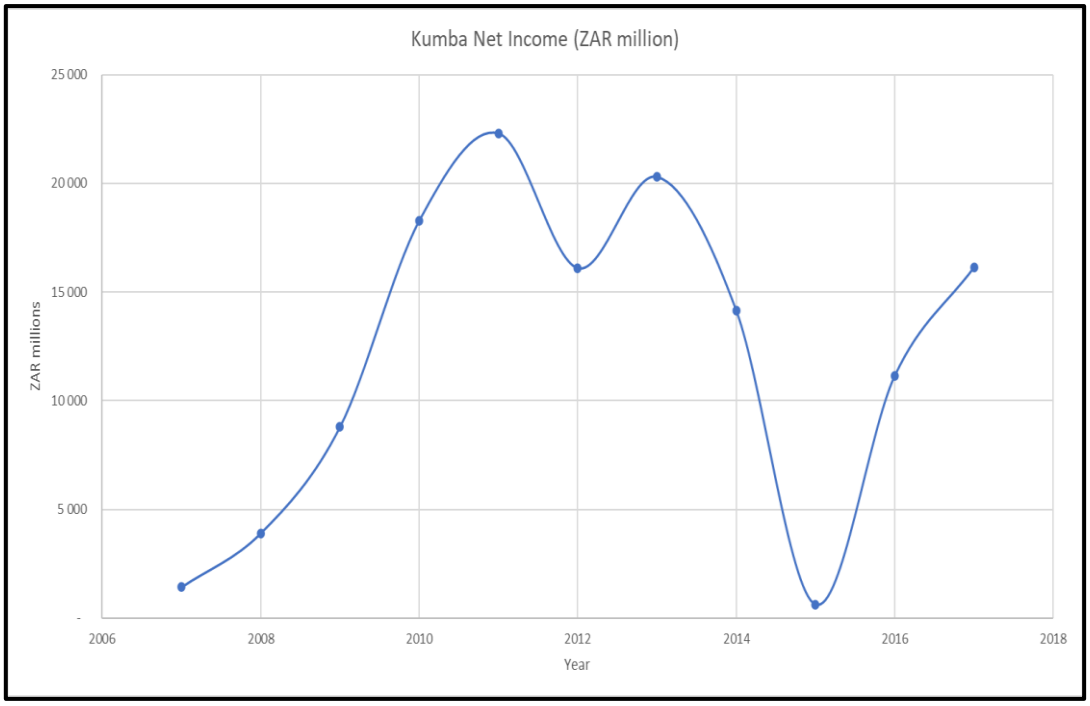

Figure 44: Kumba Net Income (ZAR millions) (Kumba Irone Ore, 2007-2017).

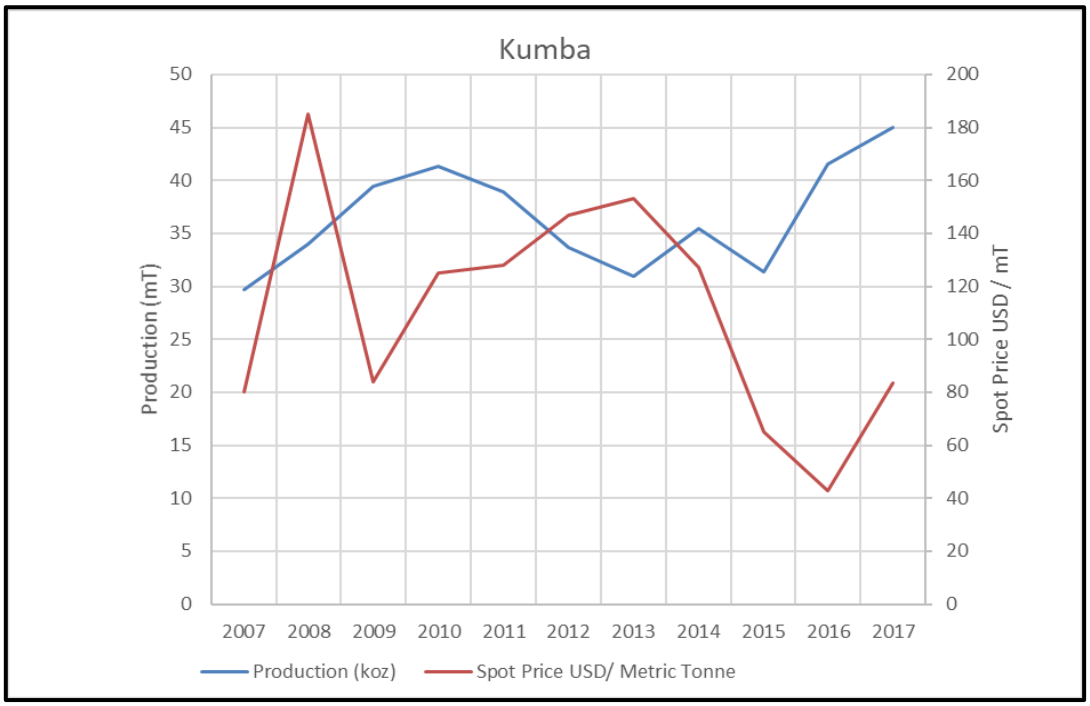

Figure 45: Kumba production (mT) in comparison to the iron ore spot price for the study period

In terms of ore production Kumba at the commencement of the study period had a strong and increasing output in line with the global supply trend culminating in record productions in 2012 and 2014. The expansion of the Kolomela exploration project also commenced at the start of the study period and production was scheduled to begin in 2012 and contribute 9mtpa to the company's output, it came online earlier than expected in 2011 and consistently contributed better than expected

tonnages, throughout the study period. Contrarily the Thambazimbi operations at the commencement of the study period were in decline culminating in the closure of operations amidst the prevailing market conditions of 2015 (Kumba Iron Ore, 2006-2007; Kumba Iron Ore, 2008; Kumba Iron Ore, 2009; Kumba Iron Ore, 2011; Kumba Iron Ore, 2012; Kumba Iron Ore, 2014; Kumba Iron Ore, 2015).

During the study period there was a significant shift in Kumba's customer base as Chinese seaborne demand continued to grow, while their local production decreased, this resulted in Kumba gaining 30 new Chinese customers in 2009 and increasing sales to China by 130%. (Kumba Iron Ore, 2010). This shift in the customer base was timely and counteracted some of the challenges Kumba faced with Arcelor Mittal regarding the interpretation of supply agreements, which required arbitration as well as the cost-plus obligations imposed on Thabazimbi ore until 2013 (Kumba Iron Ore, 2006-2007; Kumba Iron Ore, 2013).

Throughout the study period, the revenue as well as share performance of Kumba Iron Ore broadly followed the trend in iron ore price with a certain inelasticity and in some cases elasticity caused by the effect of the company production levels which acts as an independent variable (Kumba 2007-2017). As the share performance over the study period illustrates Kumba has in general undergone some volatility and experienced substantial share price drawdowns, which although highlighting just how vulnerable miners are as price takers also goes to show how amidst such market conditions a company can still deliver positive shareholder returns. Kumba accomplished this by ensuring a solid operational performance as well as leveraging off the increased financialization, by playing the spot markets with excess ore (Kumba Iron Ore, 2006-2007; Kumba Resources, 2010; Kumba Iron Ore, 2011; Kumba Iron Ore, 2015). In 2012 in the peak of their performance the then CEO Chris Griffith departed for Anglo Platinum in 2012, he was replaced by Norman Mbazima who initially adopted an "If it isn't broke, don't fix it" policy, however by 2014 amidst changing markets he had begun to implement new strategies that prioritized the reduction of exploration, R&D and capital expenditure costs (Kumba Iron Ore, 2012; Kumba Iron Ore, 2014).

The challenges faced by Kumba during the study were not necessarily unique the main themes being environmental issues related to dewatering, dust and rehabilitation and operational challenges, such as pit constraints at Sishen (Kumba Iron Ore, 2006-2007). Unlike companies in the gold and platinum sector Kumba did not suffer from mass labour unrest, probably due in some small part to the nature of their mining operations, however like the rest of the industry the company was still hindered by a lack of skilled labour (Kumba Iron Ore, 2006-2007).

Assore: Assore is predominantly an iron ore and manganese producer with a minor annual production of chrome ore. Assore's main business concern is its 50% share in Assmang which they further derive income from in their capacity as the marketer of Assmang products (Assore, 2004-2007). The share price performance, operating profits as well as iron and manganese production for Assore over the study period are shown in Figures 46, 47 and 48.

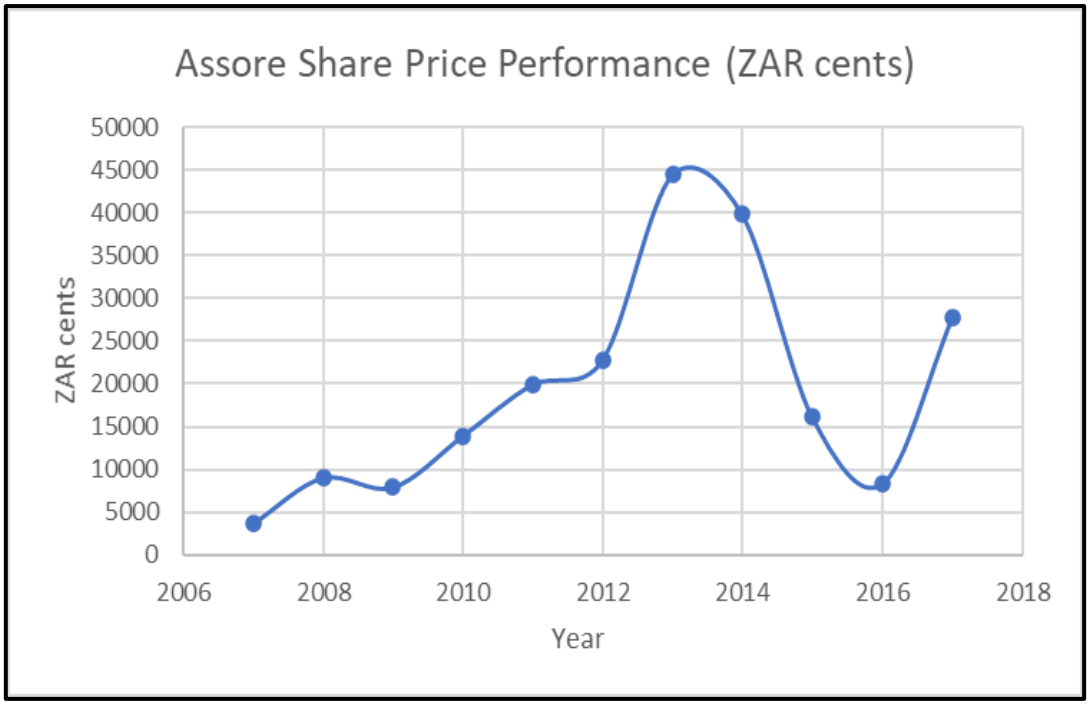

Figure 46: Assore Share Price Performance, from **(Sharenet, 2020)**

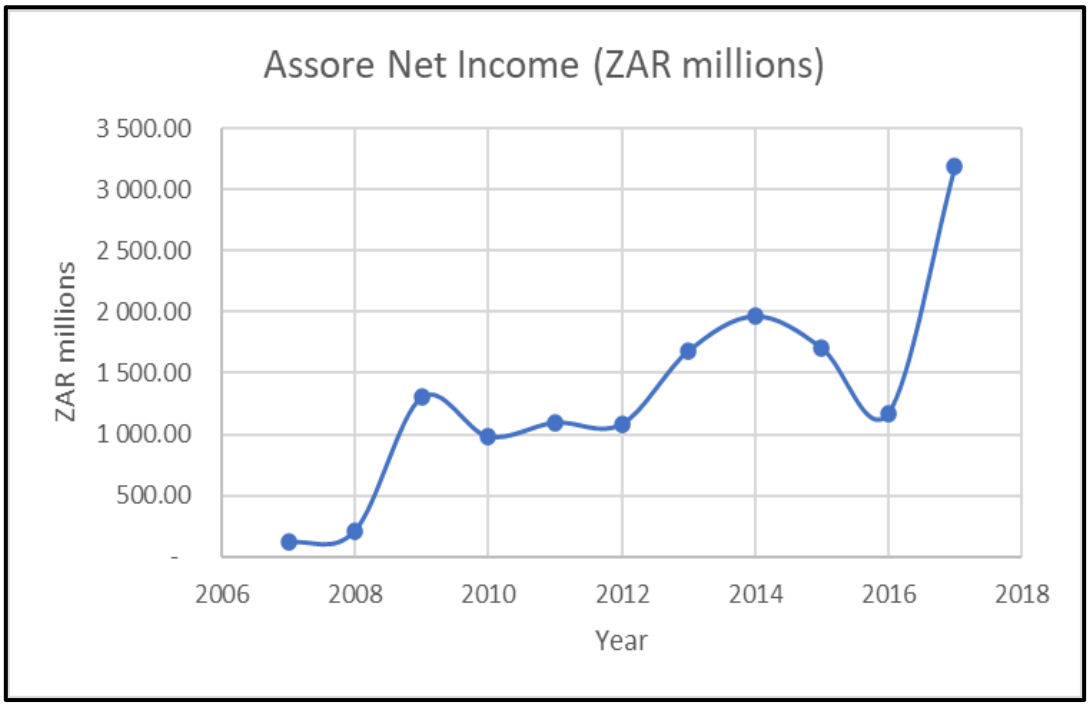

Figure 47: Assore Net Income (ZAR millions) (Assore, 2007-2017).

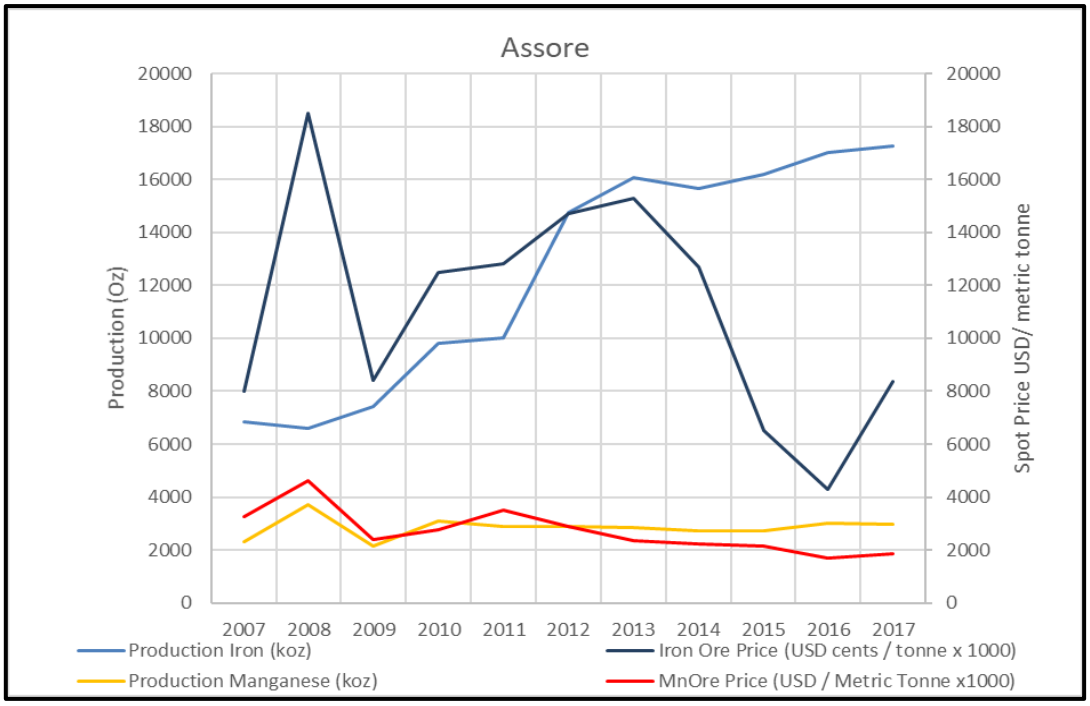

Figure 48: Iron and Manganese production (mT) in comparison to the iron and manganese ore spot price for the study period

Similar to Kumba all of the Assore products are dependent on the level of global economic growth, however Assore has the added benefit of being slightly more diversified. Iron ore is mined at the Beeshoek and Khumani open cast operations, at the start of the study the Khumani operations were still under development only commencing production in May 2008. Manganese ore is mined by Assmang in the Black Rock area of the Northern Cape Province. Small amounts of chrome ore is mined at the Assmang Dwassrivier mine in the Mpumalanga province and most of it is converted to ferrochrome which as mentioned above is utilised in the production of stainless steel (Assore, 2004-2007). The bulk of Assore's expenditure during the study period occurred within Assmang with most Capital expenditures being spent on the development, maintenance and optimisation of the Khumani operations (Assore, 2012; Assore, 2014; Assore, 2017). Assore like most of the industry commenced the study period enjoying strong demand, spearheaded by China and favourable currency exchange rates, the company was shielded from volatility due to the fact that most of their ore is sold by means of annually adjusted contractual agreements (Assore, 2004-2007; Assore, 2008).

Merafe: Merafe in its current form is a result of a merger in 2004 between Merafe and X-strata South Africa Chrome Operations, in which Merafe derives a 20.5% earnings agreement. The main business of the venture is the production and sale of ferrochrome to the stainless-steel industry, for which it is one of the world's largest supplier responsible for approximately 25% of world supply (Merafe Resources Limited, 2004-2007). The share price performance, operating profits and production for Merafe over the study period are shown in Figures 49, 50 and 51.

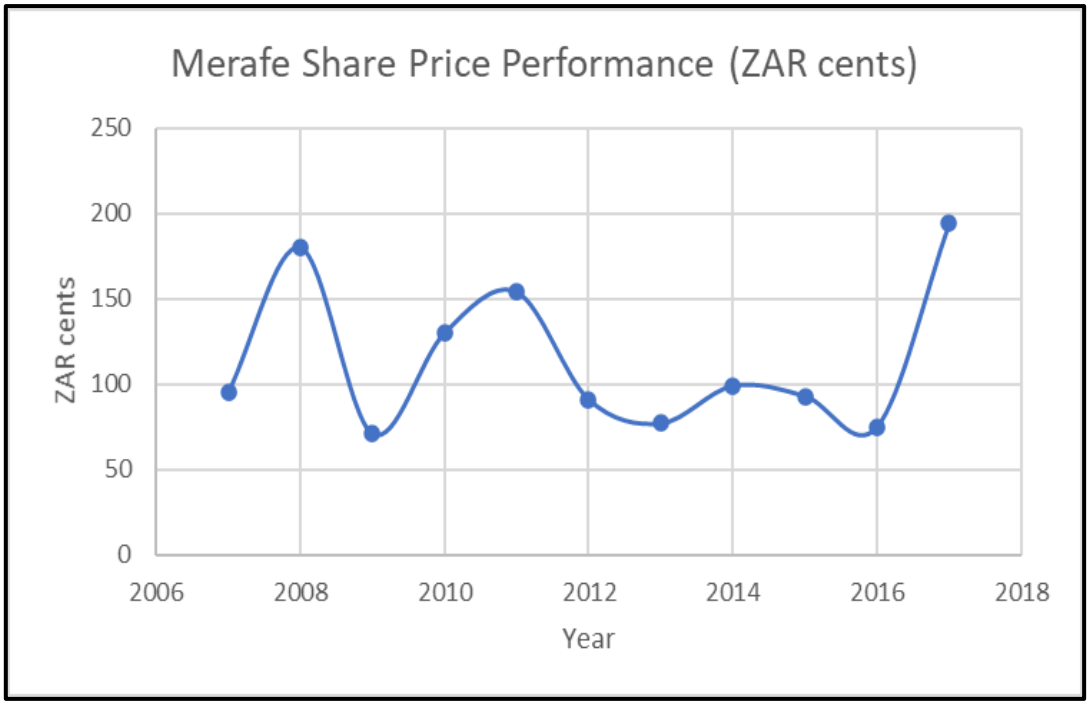

Figure 49: Merafe Share Price Performance, from **(Sharenet, 2020)**

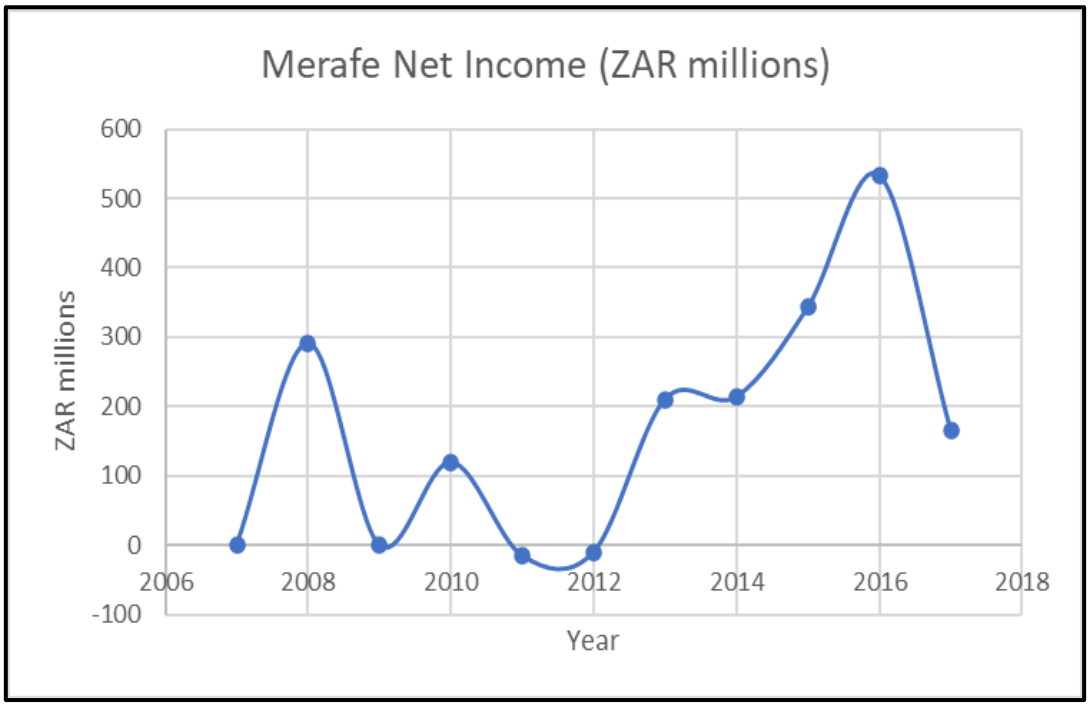

Figure 50: Merafe Net Income (ZAR millions) (Merafe Resources Limited, 2007-2017)

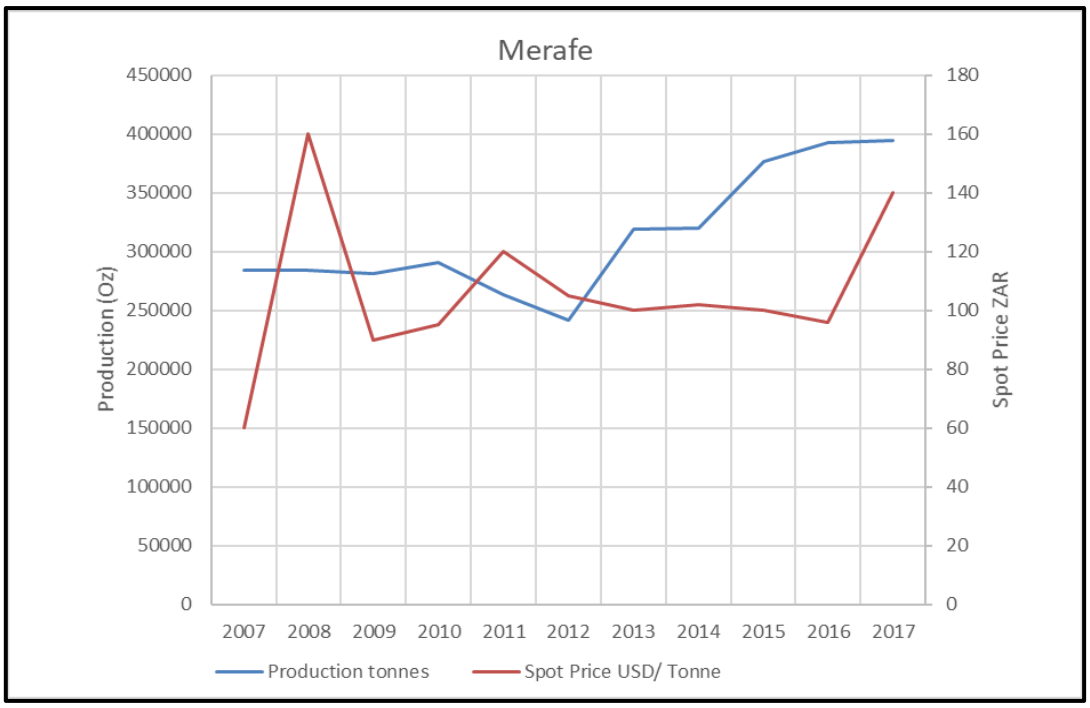

Figure 51: Merafe production (mT) in comparison to the iron ore spot price for the study period

Throughout the study period the company also actively sought growth opportunities in the coal sectors culminating in a failed JV with Sentula mining in 2009, however the coal portfolio of the business has always remained small (Merafe Resources Limited, 2008; Merafe Resources Limited, 2009).

The ferrochrome industry is very electricity intensive, increasing the sensitivity to fluctuations in electricity tariffs, in order to more efficiently manage this Merafe adopt a flexible strategy whereby they have the ability to turn furnaces on and off depending on the prevailing demand situation. In addition to this Merafe have heavily invested in the optimisation of their UG2 plants, with innovations such as “Premus Technology”, which yields the lowest average power input per tonne of ferrochrome resulting in approximately 10% savings, this has allowed the company to increase production capacity allowing them to take on and treat additional material from the Lonmin’s Marikana UG2 tailings (Merafe Resources Limited, 2004-2007; Merafe Resources Limited, 2009).

The study period began with Steve Phiri at the helm as CEO until his departure in 2010 to the platinum side of the Royal Bafokeng business portfolio, he was replaced by Stuart Elliot who was succeeded by Zanele Matlala in 2013. The overriding strategy throughout the study period regardless of who was at the helm was one of cost management and control with no real expansionary CAPEX spent during the study period except for the construction of the Tswelopole plant in 2010. Despite stringent cost management and improved production efficiencies, the operating and production costs continued to increase mainly due to massive hikes in Eskom tariffs (Merafe Resources Limited, 2008; Merafe Resources Limited, 2009; Merafe Resources Limited, 2010; Merafe Resources Limited, 2013). Considering the hiking Eskom tariffs It is a true achievement that the company continued to remain globally competitive. Particularly in 2008 when Eskom forced electricity load reductions causing the company to trigger precautionary force majeure clauses to their client’s in the case of failed delivery. Besides rising electricity costs the company also faced operational challenges related to adverse

weather conditions, geopolitical issues relating to the emergence of China as the largest producer of ferrochrome and export duties imposed by India, labour unrest which although not as widespread as in the platinum sector did result in reduced capacity over a 38 day period in 2011 (Merafe Resources Limited, 2004-2007; Merafe Resources Limited, 2010; Merafe Resources Limited, 2011; Merafe Resources Limited, 2012).

Chrome ore prices had been rising since 2004 and was at a six year high at the start of the study period. Merafe took full advantage of this by achieving record production levels, thereby maximising profits which increased by a whopping 73% in 2007 and a further 32% in 2008. With the excess cash flow the company managed to reduced their debt-equity ratio to 15% in 2007 and managed to write off all debt in 2008 (Merafe Resources Limited, 2004-2007; Merafe Resources Limited, 2008).

The company's strong early performance put them in a good position to weather the turbulence and volatility which prevailed between 2009 and 2015. In this period there was a substantial decline in global demand in Ferrochrome which led to subsequent price decreases, this was luckily offset by the company's good management, healthy balance sheet, the weakening Rand and most of all the emergence of China as the largest importer of South African ferrochrome. The Chinese involvement was made more complex by the fact that they were also the largest producer of ferrochrome globally which led to the risk of a geopolitical play between the two governments in attempts to protect their respective ferrochrome industries (Merafe Resources Limited, 2009; Merafe Resources Limited, 2010; Merafe Resources Limited, 2011; Merafe Resources Limited, 2012; Merafe Resources Limited, 2013; Merafe Resources Limited, 2014; Merafe Resources Limited, 2015). Price volatility was introduced into the market when the Metal bulletin released an Imported Charge Chrome Index (CIF China) in 2012 which increased the financialization of the commodity, this price volatility continued throughout the study period (Merafe Resources Limited, 2016; Merafe Resources Limited, 2017).

4.1.1.4 Performance of Diversified Companies

Anglo American: Anglo American is a major diversified mining group which encompasses Anglo Gold, Anglo Platinum, Kumba Iron Ore and De Beers and consists of world class mining assets spanning from platinum, coal, nickel, iron, diamonds, base metals, copper, manganese, niobium and phosphates. The company is so diversified that its stock performance can be expected to perform in a similar manner to the mining index itself (Anglo American, 2007; Anglo American, 2010). The share price performance and operating profits for Anglo American over the study period are shown in Figures 52 and 53.

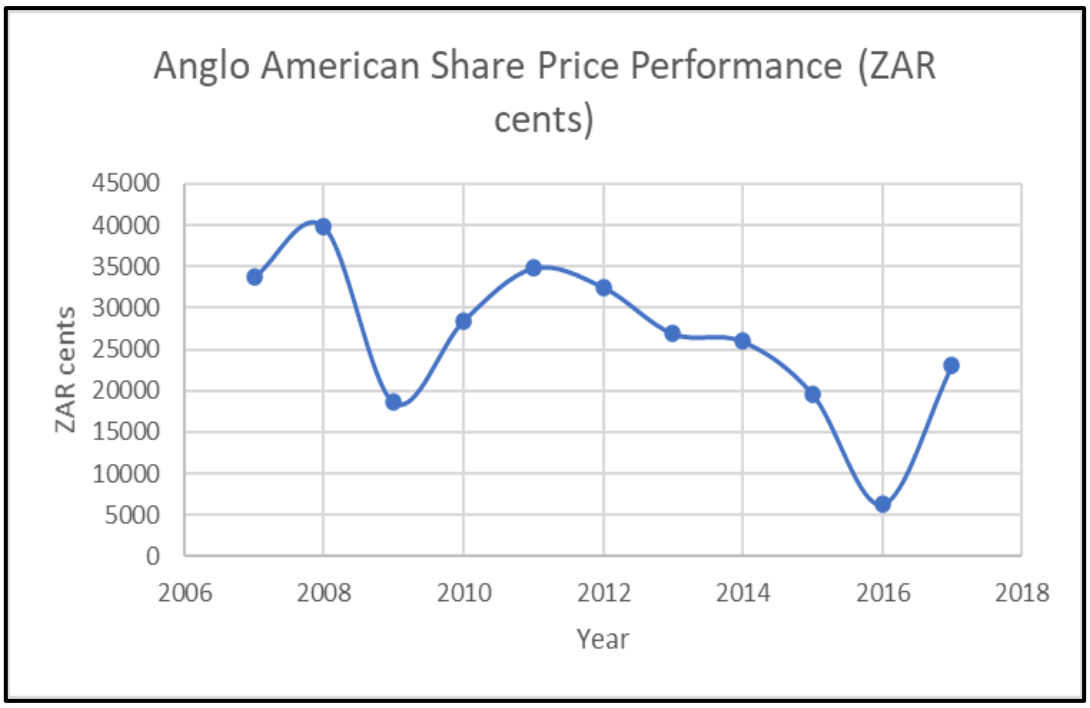

Figure 52: Anglo American Share Price Performance, from **(Sharenet, 2020)**

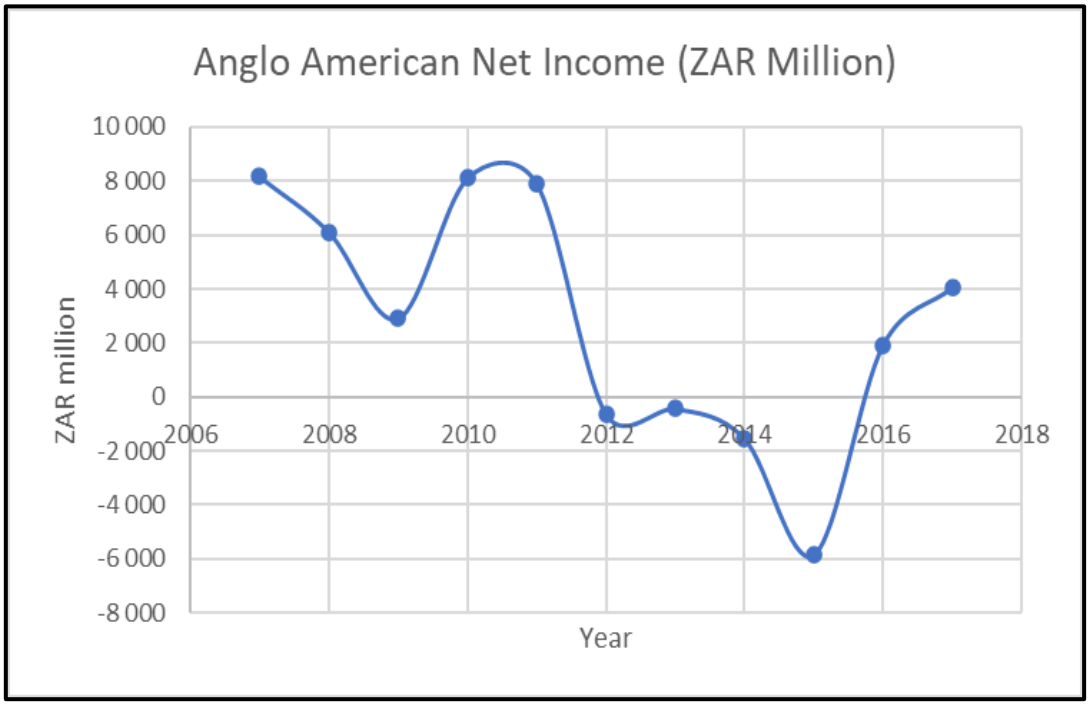

Figure 53: Anglo American Net Income (ZAR millions) (Anglo American, 2007-2017)

Anglo American started the study period with a record financial performance, achieving an operating profit of $10.1 Billion, however the situation deteriorated swiftly and drastically in 2008 due to the economic downturn. Amidst this downturn the company attempted to de-diversify, focus on cost control particularly in Anglo Platinum, operate within streamlined shared group services, implement workforce size reductions as well as scaling back on CAPEX (Anglo American, 2007; Anglo American, 2008; Anglo American, 2009).

Recovery from the downturn begun at the turn of the year with a strong performance across their busines groups leading to increased investments in multiple international and local projects culminating in the successful ahead of schedule start-up of the Barro Alto, Los Brancos and Kolomela projects in 2011 (Anglo American, 2008; Anglo American, 2009; Anglo American, 2010; Anglo American, 2011).

This was unfortunately short-lived as the 2011 Japanese tsunami disrupted global supply and transport networks, while the Arab spring revolutions drove up oil prices. This was amplified by a drop in Chinese, Indian and Brazilian GDP and turbulence in other major emerging economies leading into a gradual but protracted recession that saw commodity price weakness in all commodities in the Anglo-American basket. On top of this macroeconomic backdrop the illegal industrial action in the South African operations decimated the group's platinum portfolio. Despite this the company still managed to acquire 40% of the De Beers group and pay out a 52-cent dividend in 2012 as well as a 53 cent dividend in 2013 and 2014 (Anglo American, 2011; Anglo American, 2012; Anglo American, 2013; Anglo American, 2014). Over the study period the company's diversity was probably its saving grace particularly in 2013 and 2014, however the strategy adopted by the company to cope with the challenges over the study period was paradoxically to progressively de-diversify (Anglo American, 2007; Anglo American, 2010; Anglo American, 2014; Anglo American, 2015). Financialization of some of the company's commodities had a noticeable effect on volatility such as the sale of Chinese copper futures in 2012 which drove down the copper price as well as the 2016 shorting action of certain hedge funds which targeted the company and resulted in an unbalanced share register (Anglo American, 2012; Anglo American, 2016). The end of the study period exhibited green shoots of hope which signalled a turnaround for the company with increased consumptions of diamonds, copper, nickel and iron (Anglo American, 2017).

African Rainbow Minerals (ARM): ARM like Anglo American is also a well-diversified mining company albeit with a smaller global footprint. The company has a diverse commodity producing portfolio mainly through partnerships and shareholdings in other company's some of which are even within the study (African Rainbow Minerals, 2004-2007; African Rainbow Minerals, 2010). The share price performance and operating profits for ARM over the study period are shown in Figures 54 and 55.

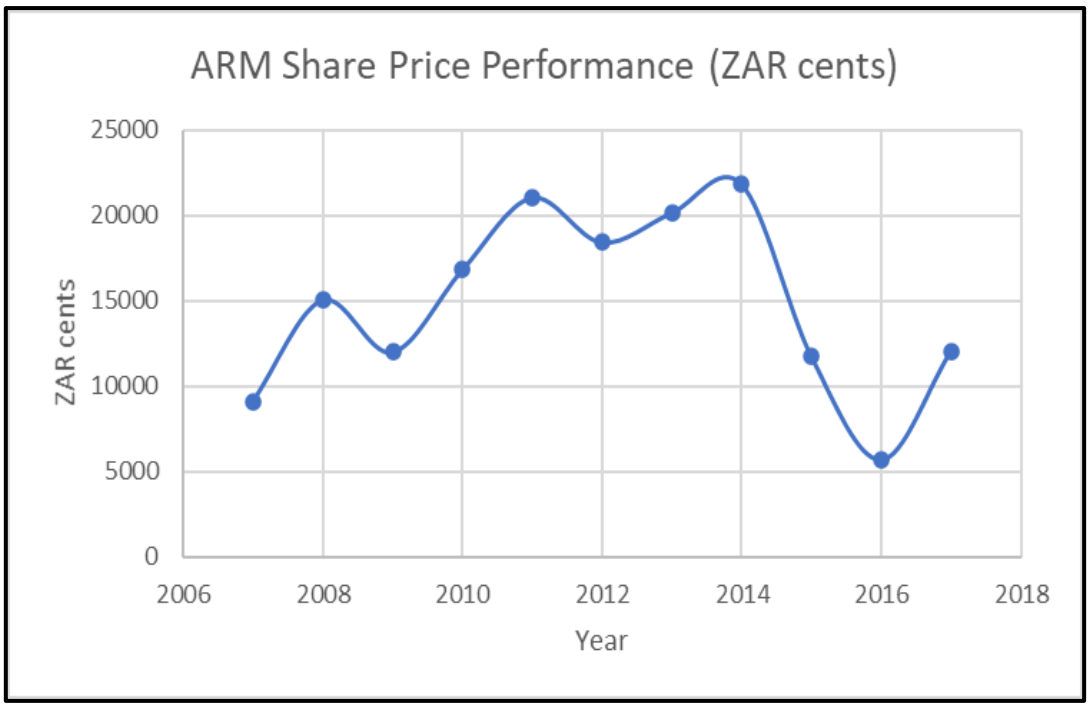

Figure 54: ARM Share Price Performance, from **(Sharenet, 2020)**

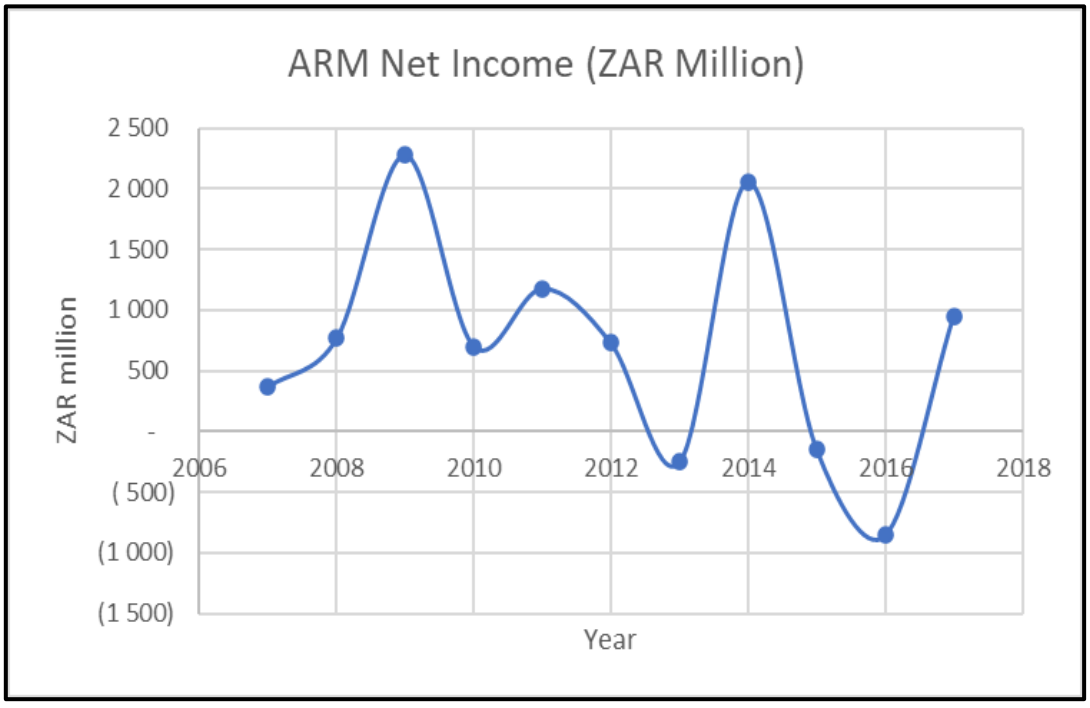

Figure 55: African Rainbow Minerals Net Income (ZAR millions) (African Rainbow Minerals, 2007-2017)

ARM has exposure to PGM's, chrome and nickel through a range of JV partnerships such as the 50/50 partnership in the Modikwa Platinum mine with Anglo Platinum, the 55/45 partnership in the Two Rivers platinum mine with Implats, and the 50/50 joint venture in the Nkomati mine with Norilisk. Arm also has exposure to iron and manganese through its 50% holding in Assmang Limited, exposure to gold through its 16% holding in Harmony Gold and exposure to coal through its 20% equity in Xstrata Coal South Africa (African Rainbow Minerals, 2004-2007).

ARM commenced the study period with record production and sales of PGM's, iron ore, manganese ore and chrome ore which resulted in volumetric growth across the business. The company consequently paid their first ever dividend at the start of the study period and have since then been committed dividend payers (African Rainbow Minerals, 2004-2007; African Rainbow Minerals, 2008).

ARM's portfolio diversity translated into resilience over the study period for example in 2007 the PGM operations were the biggest contributors to earnings, while between 2008 and 2009 as the PGM market failed there was a significant increase in the manganese price which created a framework for continual resilience amidst tough global economic conditions. Thereafter in the period between 2011 and 2013 the ferrous division become the major contributor to the group's performance, while the platinum division began to recover. In 2015 amidst lower iron ore prices the coal division carried the company (African Rainbow Minerals, 2004-2007; African Rainbow Minerals, 2008; African Rainbow Minerals, 2009; African Rainbow Minerals, 2011; African Rainbow Minerals, 2012; African Rainbow Minerals, 2013; African Rainbow Minerals, 2014).

ARM reacted to the various global economic conditions decisively and with a broad-based strategy that remained solid and consistent throughout the study period. This strategy combined the implementation of varying production and sales volumes as necessary, containing costs, deferring CAPEX while countercyclically continuing aggressive growth, ruthlessly placing high cost operations/ uneconomic operations under care and maintenance (African Rainbow Minerals, 2009; African Rainbow Minerals, 2010; African Rainbow Minerals, 2011; African Rainbow Minerals, 2015; African Rainbow Minerals, 2016).

Despite weathering the storm through good management for most of the study period, the global economic environment started to take a toll on the company, which was evident by decreasing headline earnings in early 2016. Luckily by the end of the year the global economic condition began to improve and iron and manganese prices recovered which substantially increased the group's earnings (African Rainbow Minerals, 2016; African Rainbow Minerals, 2017).

Overall ARM managed to ensure a strong operating performance on existing projects throughout the study period against a backdrop of challenging commodity markets, however excluding Khumani and Nkomati which came online at the start of the study, ARM failed to add new resource base to their portfolio during the study period (African Rainbow Minerals, 2016; African Rainbow Minerals, 2017).

4.2 Moving Average Trading Strategy

4.2.1 Performance Metrics

The performance measures of a trading system are scalars, whereas market changes are vectors making the process of quantifying performance similar to taking snapshots of a formula one race. However, these performance metrics are still very useful in providing quantifications of performance through tangible, "hard" data. The performance metrics used are listed and defined below and a table summarising all the performance metrics are provided in Appendix 2:

Number of Transactions: Quantifies the number of transactions or positions taken over the study period when using the trading strategy with the particular parameters

Positive trades: The number of individual trades that yielded a profit

Negative trades: The number of individual trades that yielded a loss

Hit ratio: The ratio of positive trades to the number of transactions this is used to determine the success rate of the trading strategy with its particular parameters. It is important to note that this metric does not take into account the monetary value of profits in each hit/ success.

Positive trades after fees: The number of individual trades that yielded a profit after transactional fees were deducted

Negative trades after fees: The number of individual trades that yielded a loss after transactional fees were deducted

Hit ratio after fees: The ratio of positive trades after transactional fees to the number of transactions

4.2.2 Three day moving average

4.2.2.1 Daily price resolution

The performance metrics for the 3-day moving average period at a daily price resolution can be found in Appendix 2. Summary statistics for the returns from the moving average strategy with these parameters (3 day moving average and daily price resolution) are provided below in Table 3. The mean denotes the overall performance of the strategy across all companies, from this a percentage return can be calculated for the moving average strategy with its parameters, as is presented in Table 12. The standard error in this case is the standard error of the mean of returns achieved by this strategy, this gives a good indication of the variability between the overall performance and potential upsides and downsides of the strategy. The standard deviation is a key risk indicator and represents the magnitude of variability in the returns achieved from the strategy parameters. The Kurtosis further communicates the likelihood of experiencing the more extreme returns, and provides another interesting layer for risk analysis. The skewness of the data speaks to the risk of the returns by highlighting the propensity of the achieved returns to be above or below the mean. The median provides an additional layer of information about the performance as well as risk, in that it further highlights the skewness of the data (whether a majority of the returns were lower or higher than the mean). The minimum returns denote the worst-case scenario under the strategy parameters and is an objective presentation of the realised risk. The maximum returns denote the best-case scenario under the strategy parameters and is an objective presentation of the upside potential.

Table 3: Summary Statistics for results from the 3-day moving average strategy at a daily stock price time series resolution

Summary Statistic	Value
Mean	R1 123 393,93
Standard Error	R542 305,99
Median	R99 940,50
Standard Deviation	R2 029 123,22
Kurtosis	1,74
Skewness	1,75
Minimum	R127,00
Maximum	R6 053 534,00

From the summary statistics in Table 3 it is evident that the returns under this strategy are positively skewed indicating frequent small potential losses coupled with a few large potential gains. Figure 56 summarises the results of the 3-day moving average at a daily price resolution and compares it to the results of the buy and hold strategy. Three out of the fifteen companies; ARM, Lonmin and Northam yielded positive returns and also yielded results greater than that of the buy and hold strategy.

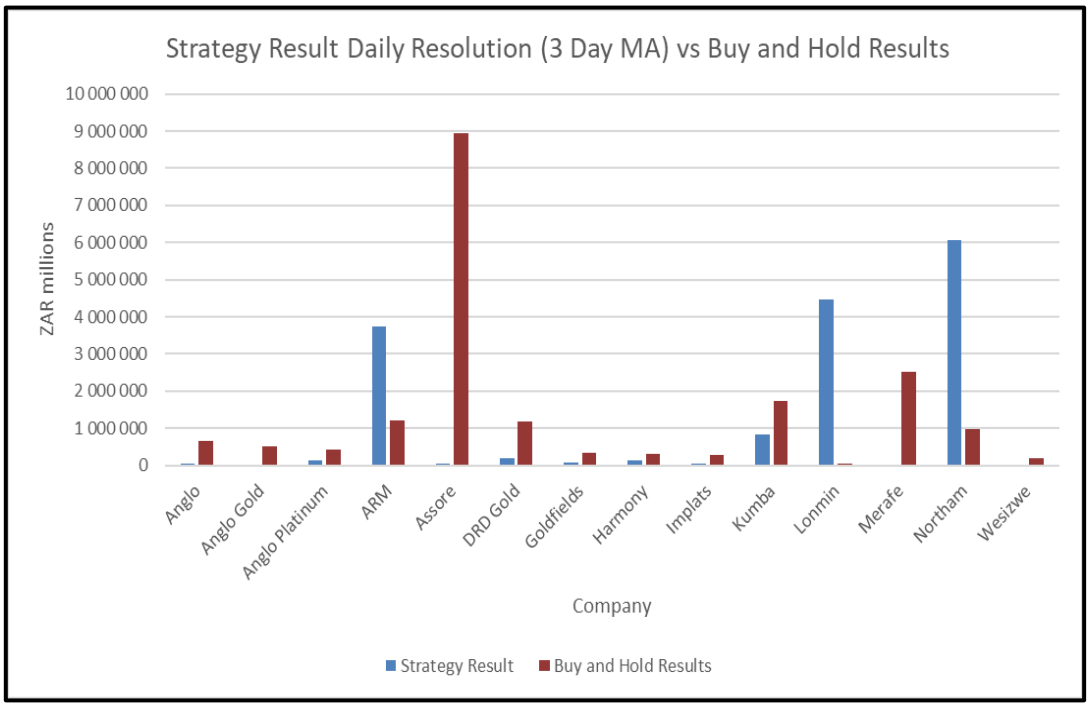

Figure 56: The results of the 3-day moving average at a daily price resolution compared to the buy and hold strategy results

4.2.2.2 Weekly price resolution

The performance metrics for the 3-day moving average period at a weekly price resolution can be found in Appendix 2. Summary statistics for the moving average strategy with these parameters (3-day moving average and weekly price resolution) are provided in Table 4. From the summary statistics in Table 4, the returns under this strategy are also positively skewed however, the strategy has relatively lower variability and risk. The lower variability and risk are also coupled with a lower potential upside. Figure 57 below summarises the results of the 3-day moving average at a weekly price resolution and compares it to the results of the buy and hold strategy. Six of the fifteen companies; ARM, Assore, BHP Billiton, DRD Gold, Kumba and Merafe yielded positive returns, while eleven of the fifteen companies; Anglo, AngloPlatinum, ARM, Assore, BHP Billiton, Goldfields, Harmony, Implats, Kumba and Northam outperformed the traditional buy and hold strategy.

Table 4: Summary Statistics for results from the 3-day moving average strategy at a weekly stock price time series resolution

Summary Statistic	Value
Mean	R770 470,14
Standard Error	R278 260,44
Median	R254 807,00
Standard Deviation	R1 041 155,24

Summary Statistic	Value
Kurtosis	1,82
Skewness	1,68
Minimum	R76 518,00
Maximum	R3 351 439,00

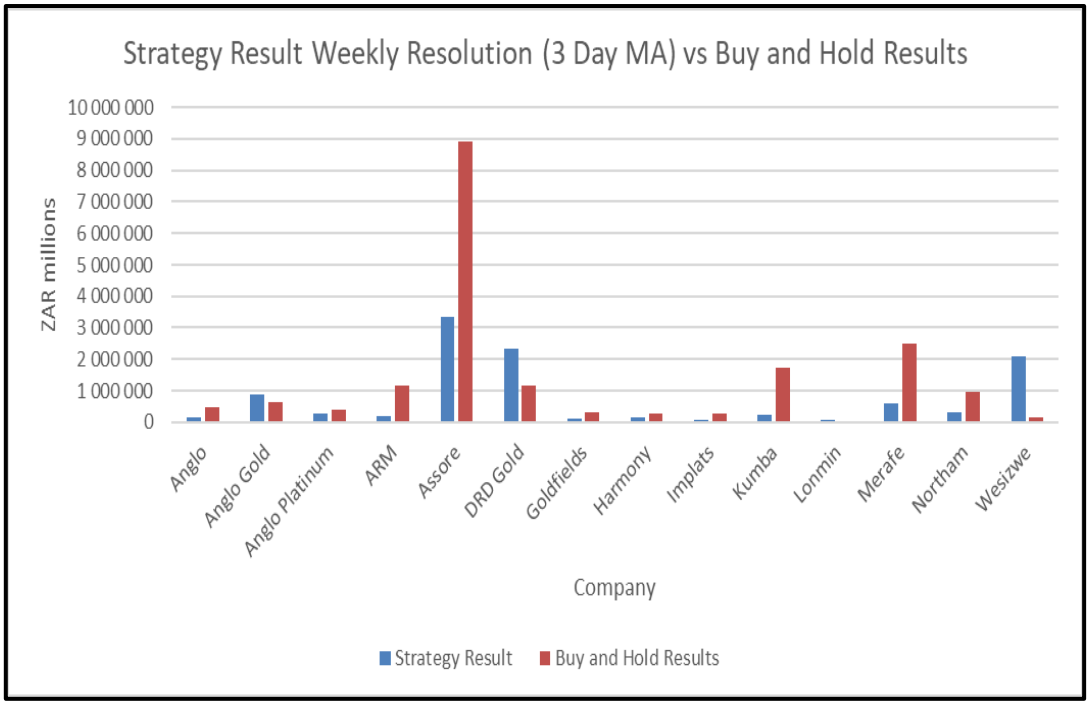

Figure 57: The results of the 3-day moving average at a weekly price resolution compared to the buy and hold strategy results

4.2.2.3 Monthly price resolution

The performance metrics for the 3-day moving average period at a monthly price resolution can be found in Appendix 2. Summary statistics for the moving average strategy with these parameters (3-day moving average and monthly price resolution) are provided below in Table 5. From these summary statistics it is evident that under these strategy parameters one can expect relatively moderate volatility most of the time with the occasional occurrence of sudden extreme results with a very high potential upside. Figure 58 below summarises the results of the 3-day moving average at a monthly price resolution and compares it to the results of the buy and hold strategy. Seven of the fifteen companies; Anglo, Arm, Assore, Kumba, Merafe, Northam and Wesizwe yielded positive returns, while nine of the fifteen companies; Anglo, Anglo Platinum, ARM, Goldfields, Implats, Kumba, Merafe, Northam, Wesizwe outperformed the traditional buy and hold strategy.

Table 5: Summary Statistics for results from the 3-day moving average strategy at a monthly stock price time series resolution

Summary Statistic	Value
Mean	R4 285 853,36
Standard Error	R1 883 684,64

Summary Statistic	Value
Median	R875 121,00
Standard Deviation	R7 048 102,55
Kurtosis	3,93
Skewness	2,07
Minimum	R0,00
Maximum	R23 728 555,00

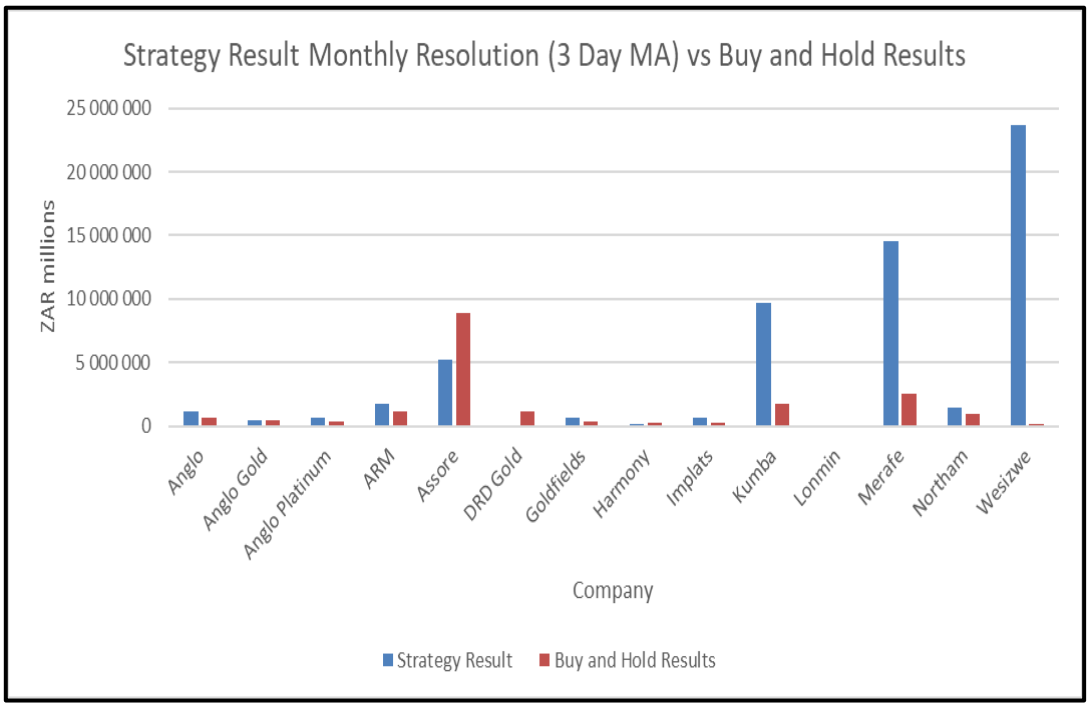

Figure 58: The results of the 3-day moving average at a monthly price resolution compared to the buy and hold strategy results

4.2.3 Thirteen-day moving average

4.2.3.1 Daily price resolution

The performance metrics for the 13-day moving average period at a daily price resolution can be found in Appendix 2. Summary statistics for the moving average strategy with these parameters (13-day moving average and daily price resolution) are provided below in Table 6. The summary statistics show that this strategy parameter is also positively skewed however, characterised by relatively high variability coupled with a propensity for extreme results. The potential upside is high, but not as high as other less volatile parameters. Figure 59 below summarises the results of the 13-day moving average at a daily price resolution and compares it to the results of the buy and hold strategy.

Table 6: Summary statistics for results from the 13-day moving average strategy at a daily stock price time series resolution

Summary Statistic	Value
Mean	R1 548 377,79
Standard Error	R753 076,47
Median	R337 489,00
Standard Deviation	R2 817 754,13

Summary Statistic	Value
Kurtosis	7,25
Skewness	2,63
Minimum	R578,00
Maximum	R10 184 141,00

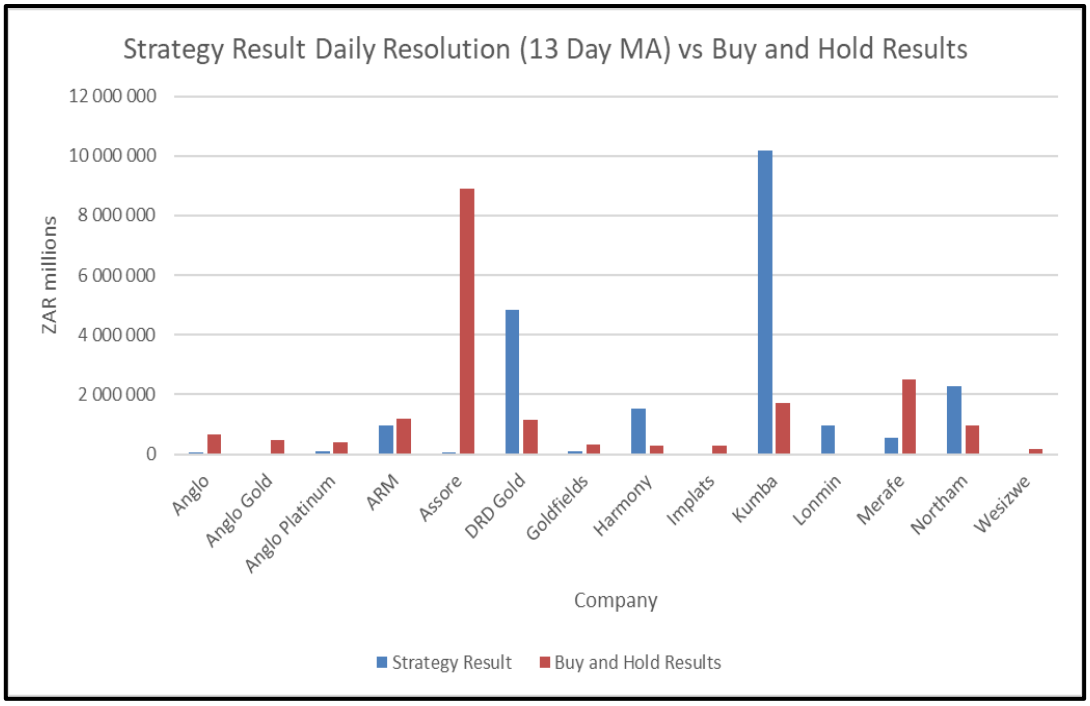

Figure 59: The results of the 13-day moving average at a daily price resolution compared to the buy and hold strategy results

Four of the fifteen companies; DRD Gold, Harmony, Kumba and Northam yielded positive returns, while five of the fifteen companies; DRD Gold, Harmony, Kumba, Lonmin and Northam outperformed the traditional buy and hold strategy.

4.2.3.2 Weekly price resolution

The performance metrics for the 13-day moving average period at a weekly price resolution can be found in Appendix 2. Summary statistics for the moving average strategy with these parameters (13-day moving average and weekly price resolution) are provided below in Table 7. Summary statistics show a positively skewed distribution of returns under this strategy with high probability of achieving positive returns and a high potential for extreme upside. Figure 60 below summarises the results of the 13-day moving average at a weekly price resolution and compares it to the results of the buy and hold strategy. Six out the fifteen companies; Anglo, ARM, Assore, Lonmin, Merafe and Wesizwe yielded positive returns, while seven of the fifteen companies, Anglo, ARM, Assore, Implats, Lonmin, Merafe and Wesizwe outperformed the traditional buy and hold strategy.

Table 7: Summary Statistics for results from the 13-day moving average strategy at a weekly stock price time series resolution

Summary Statistic	Value
Mean	R2 339 609,43

Summary Statistic	Value
Standard Error	R1 007 950,56
Median	R857 046,50
Standard Deviation	R3 771 405,67
Kurtosis	8,36
Skewness	2,77
Minimum	R52 096,00
Maximum	R14 220 105,00

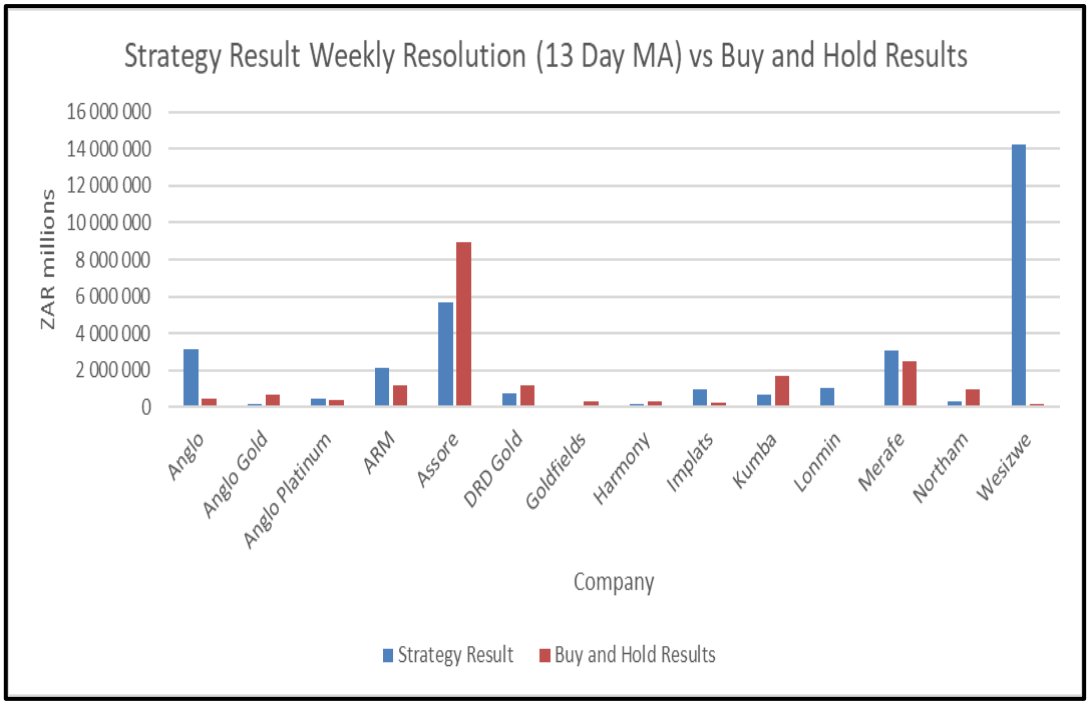

Figure 60: The results of the 13-day moving average at a weekly price resolution compared to the buy and hold strategy results

4.2.3.3 Monthly price resolution

The performance metrics for the 13-day moving average period at a monthly price resolution can be found in Appendix 2. Summary statistics for the moving average strategy with these parameters (13-day moving average and monthly price resolution) are provided below in Table 8. The summary statistics characterise this strategy parameter as one of low risk and low reward / potential upside. Figure 61 below summarises the results of the 13-day moving average at a monthly price resolution and compares it to the results of the buy and hold strategy.

Table 8: Summary Statistics for results from the 13-day moving average strategy at a monthly stock price time series resolution

Summary Statistic	Value
Mean	R645 877,00
Standard Error	R149 186,88
Median	R437 573,00
Standard Deviation	R558 206,18

Summary Statistic	Value
Kurtosis	0,25
Skewness	1,05
Minimum	0
Maximum	R1 859 319,00

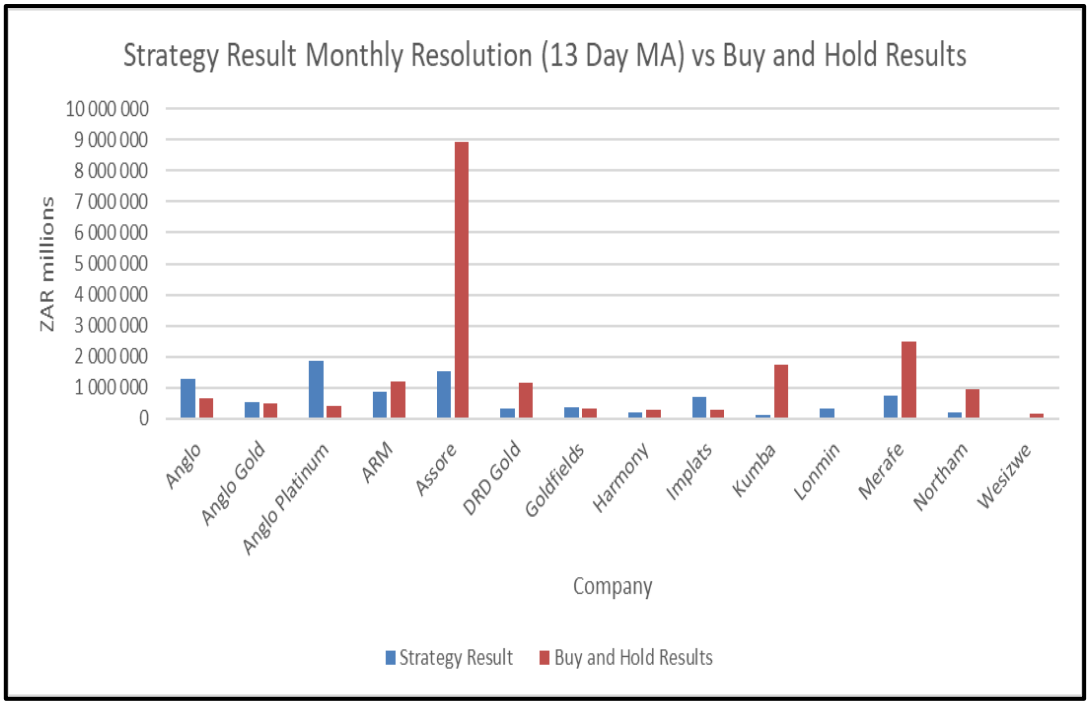

Figure 61: The results of the 13-day moving average at a monthly price resolution compared to the buy and hold strategy results

Four out of the fifteen companies; Anglo, Anglo Platinum, Assore and BHP Billiton yielded positive returns, while six of the fifteen companies; Anglo Gold, Anglo, Anglo Platinum, Goldfields, Implats and Lonmin outperformed the traditional buy and hold strategy.

4.2.4 55-day moving average

4.2.4.1 Daily price resolution

The performance metrics for the 55-day moving average period at a daily price resolution can be found in Appendix 2. Summary statistics for the moving average strategy with these parameters (55-day moving average and daily price resolution) are provided below in Table 9. The summary statistics characterise this strategy parameter as moderately volatile with a high propensity for very extreme results with moderate upside. Figure 62 below summarises the results of the 55-day moving average at a daily price resolution and compares it to the results of the buy and hold strategy. Five out of the fifteen companies; Anglo American, ARM, Kumba, Merafe and Northam yielded positive returns, while ten of the fifteen companies; Anglo American, Anglo Platinum, ARM, Harmony, Implats, Kumba, Lonmin, Merafe, Northam and Wesizwe outperformed the traditional buy and hold strategy.

Table 9: Summary Statistics for results from the 55-day moving average strategy at a daily stock price time series resolution

Summary Statistic	Value
Mean	R1 096 467,86
Standard Error	R349 193,17
Median	R668 374,50
Standard Deviation	R1 306 561,19
Kurtosis	7,88
Skewness	2,63
Minimum	R79 554,00
Maximum	R5 167 010,00

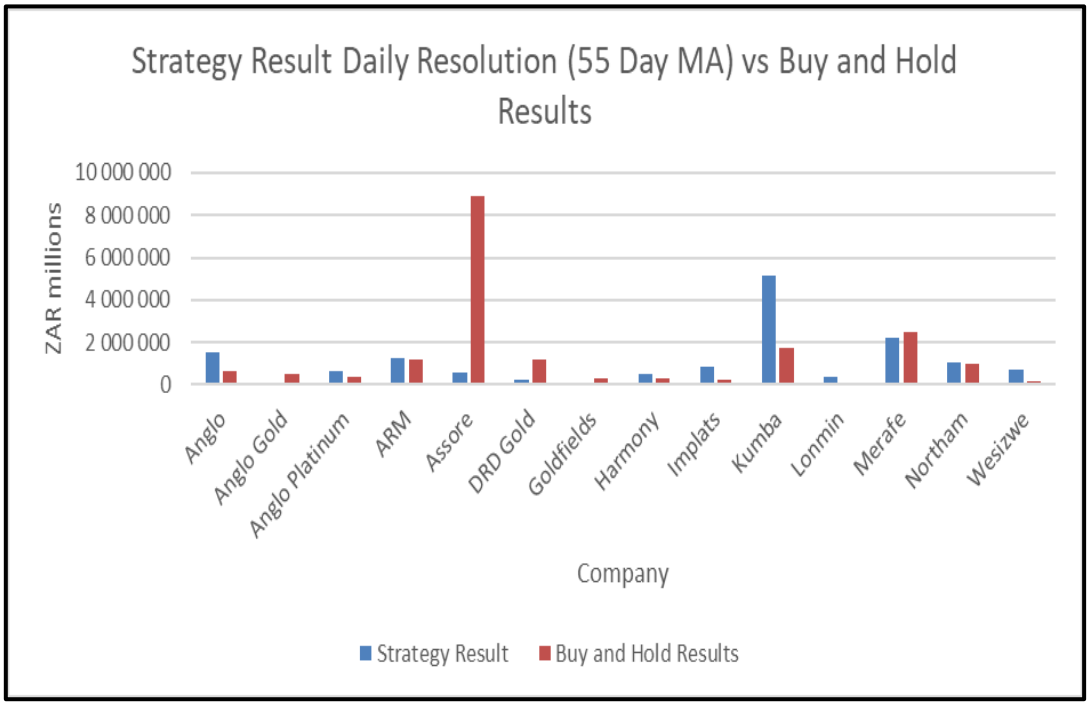

Figure 62: The results of the 55-day moving average at a daily price resolution compared to the buy and hold strategy results

4.2.4.2 Weekly price resolution

The performance metrics for the 55-day moving average period at a weekly price resolution can be found in Appendix 2. Summary statistics for the moving average strategy with these parameters (55-day moving average and weekly price resolution) are provided below in Table 10. The summary statistics characterises the strategy parameter similar to the previous parameter however with a much higher propensity to yield positive returns as well as a higher potential upside to risk ratio. Figure 63 below summarises the results of the 55-day moving average at a weekly price resolution and compares it to the results of the buy and hold strategy.

Table 10: Summary Statistics for results from the 55-day moving average strategy at a weekly stock price time series resolution

Summary Statistic	Value
Mean	R2 222 505,00
Standard Error	R815 632,40
Median	R872 920,50
Standard Deviation	R3 051 817,00
Kurtosis	8,22
Skewness	2,71
Minimum	R263 624,00
Maximum	R11 814 734,00

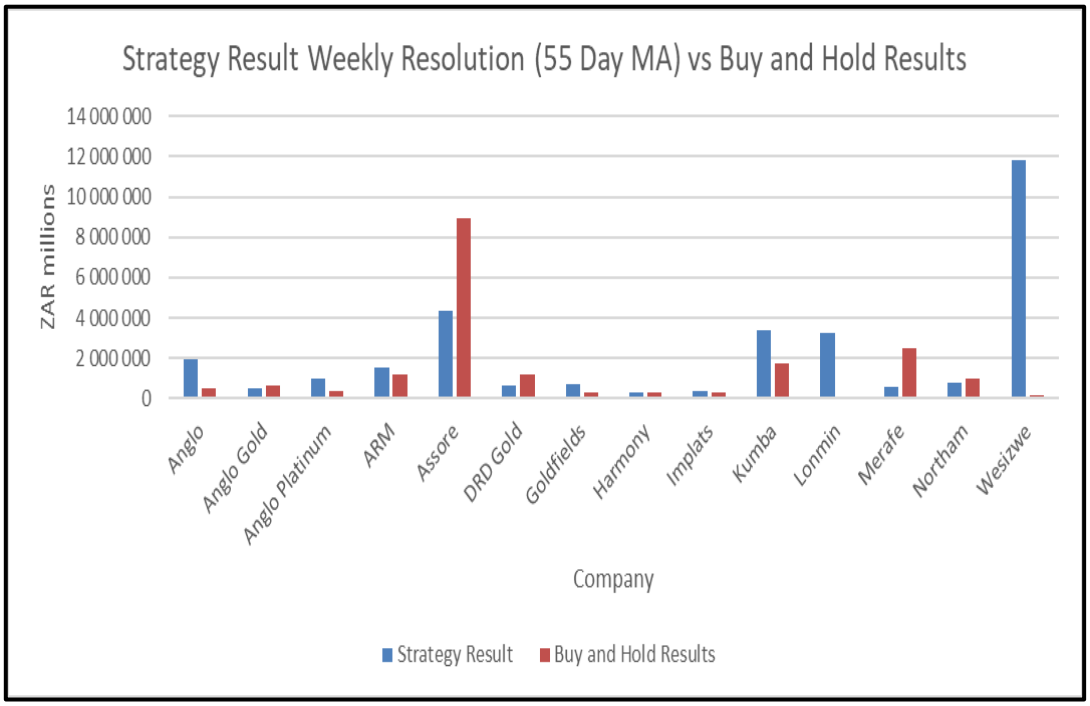

Figure 63: The results of the 55-day moving average at a weekly price resolution compared to the buy and hold strategy results

Eight out of the fifteen companies; Anglo American, Anglo Platinum, ARM, Assore, BHP Billiton, Kumba, Lonmin and Wesizwe yielded positive returns, while nine of the fifteen companies; Anglo American, Anglo Platinum, ARM, BHP Billiton, Goldfields, Implats, Kumba, Lonmin and Wesizwe outperformed the traditional buy and hold strategy.

4.2.4.3 Monthly price resolution

The performance metrics for the 55-day moving average period at a monthly price resolution can be found in Appendix 2. Summary statistics for the moving average strategy with these parameters (55-day moving average and monthly price resolution) are provided below in Table 11. The summary statistics characterise this strategy parameter as low risk with very low chances of extreme results and a propensity to not be profitable. Figure 64 below summarises the results of the 55-day moving average at a monthly price resolution and compares it to the results of the buy and hold strategy.

Table 11: Summary Statistics for results from the 55-day moving average strategy at a monthly stock price time series resolution

Summary Statistic	Value
Mean	R673 955,43
Standard Error	R66 891,42
Median	R636 368,00
Standard Deviation	R250 284,76
Kurtosis	-1,32
Skewness	0,13
Minimum	R330 220,00
Maximum	R1 050 575,00

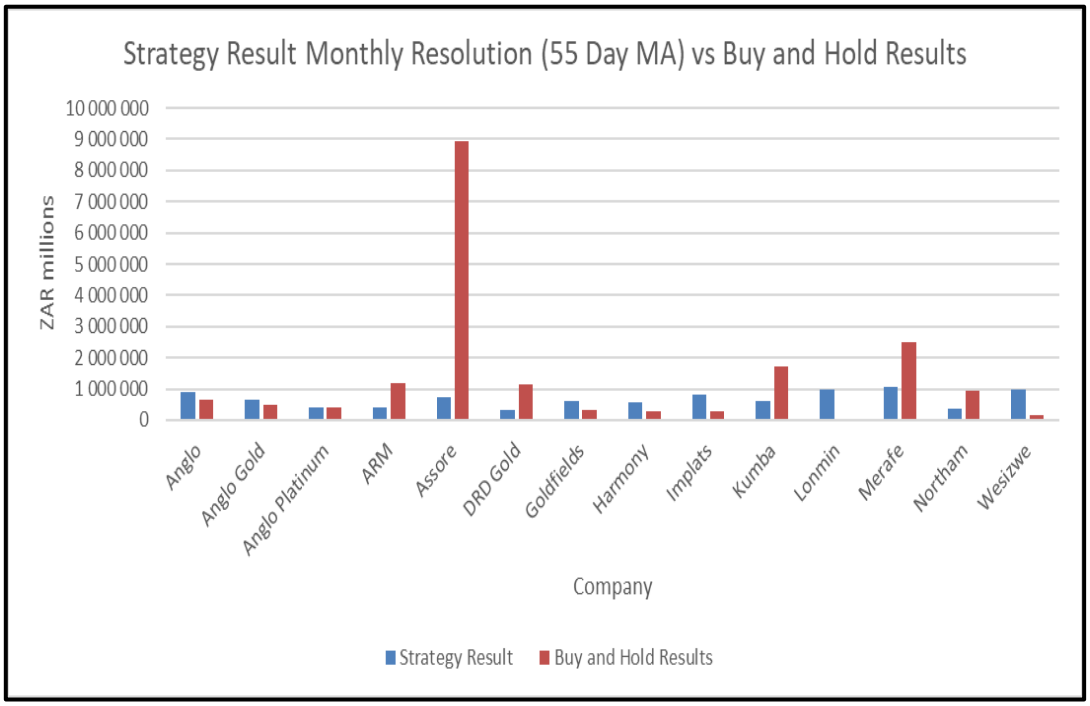

Figure 64: The results of the 55 day moving average at a monthly price resolution compared to the buy and hold strategy results

Only one of the fifteen companies; Merafe yielded a positive result, while eight of the fifteen companies; Anglo Gold, Anglo American, Anglo Platinum, Goldfields, Harmony, Implats, Lonmin and Wesizwe outperformed the traditional buy and hold strategy.

4.2.5 Summary of the moving average strategy performance

4.2.5.1 Summary Statistics

Figure 65 below summarises the performance of the different moving average strategy parameter combinations across companies in order to measure which parameter combination performs the best.

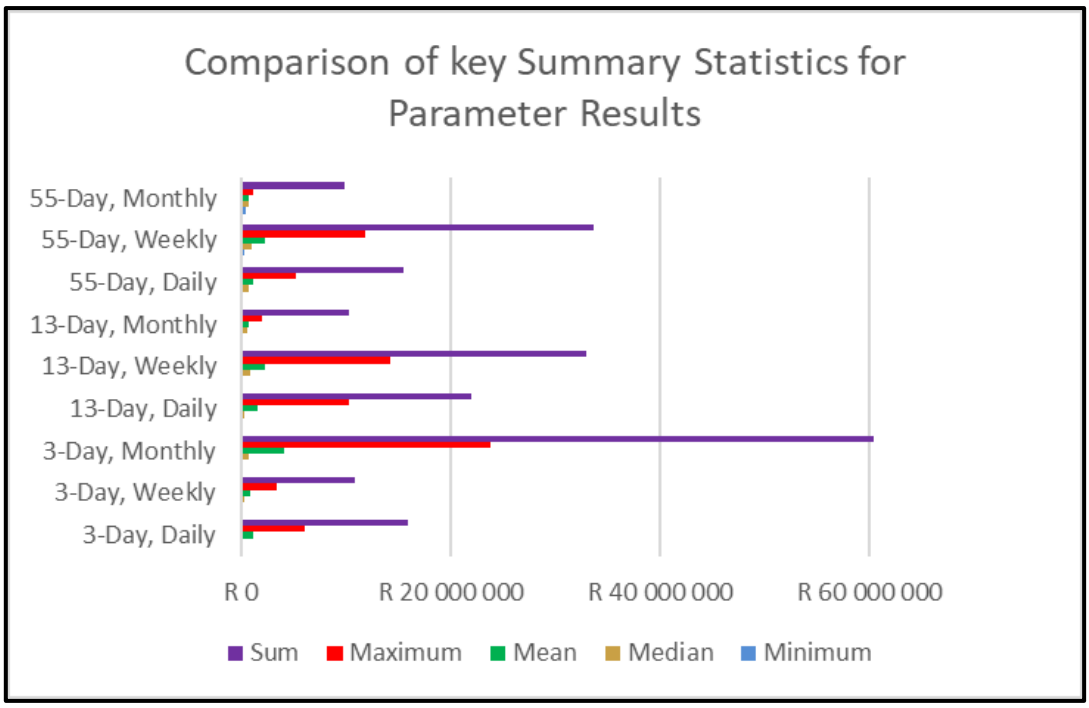

Figure 65: Comparison of the key summary statistics from the results attained by the application of the various parameters

Figure 66 below shows the percentage performance of all the companies under the buy and hold strategy and compares them to the combined percentage performance of all parameters for each company under the moving average strategy.

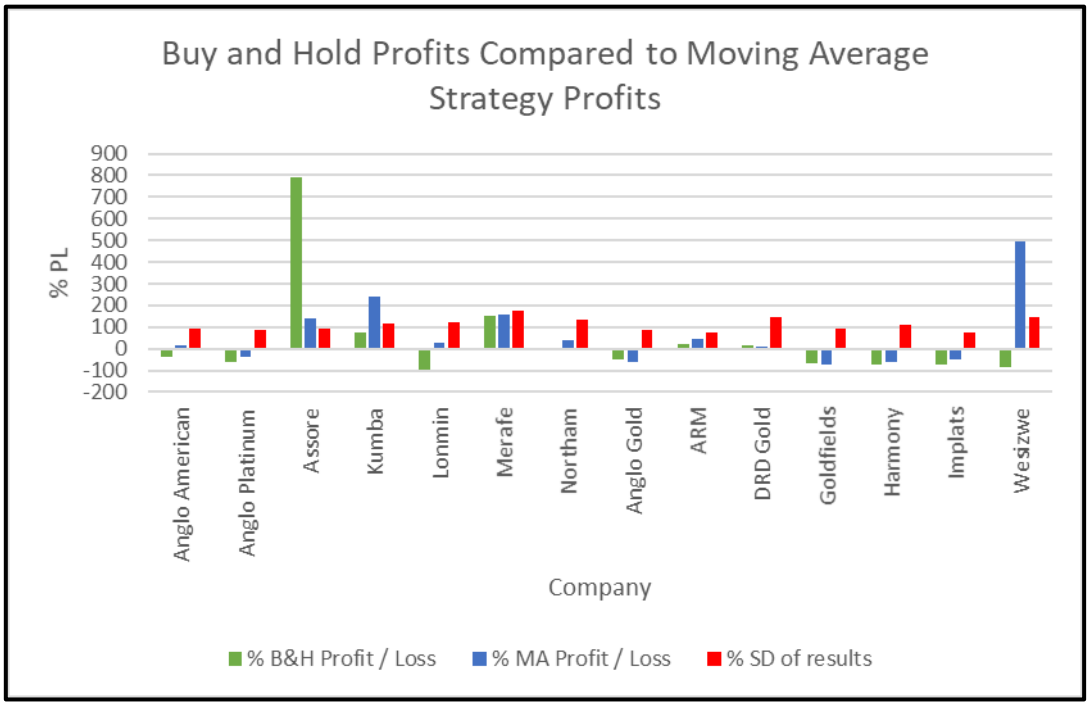

Figure 66: Percentage performance of the buy and hold strategy compared to the percentage performance of the moving average alongside the percentage standard deviation (%SD) of the moving average strategy

The %SD is a good proxy for risk and results show that the risks in applying the moving average strategy is generally greater for the Iron, Manganese and Chrome producing companies as well as Lonmin and DRD gold.

Figure 67 below shows the correlation coefficient between each of the moving average strategy parameters and the market cap of the companies. it is evident that there is no correlation between market cap and the moving average results.

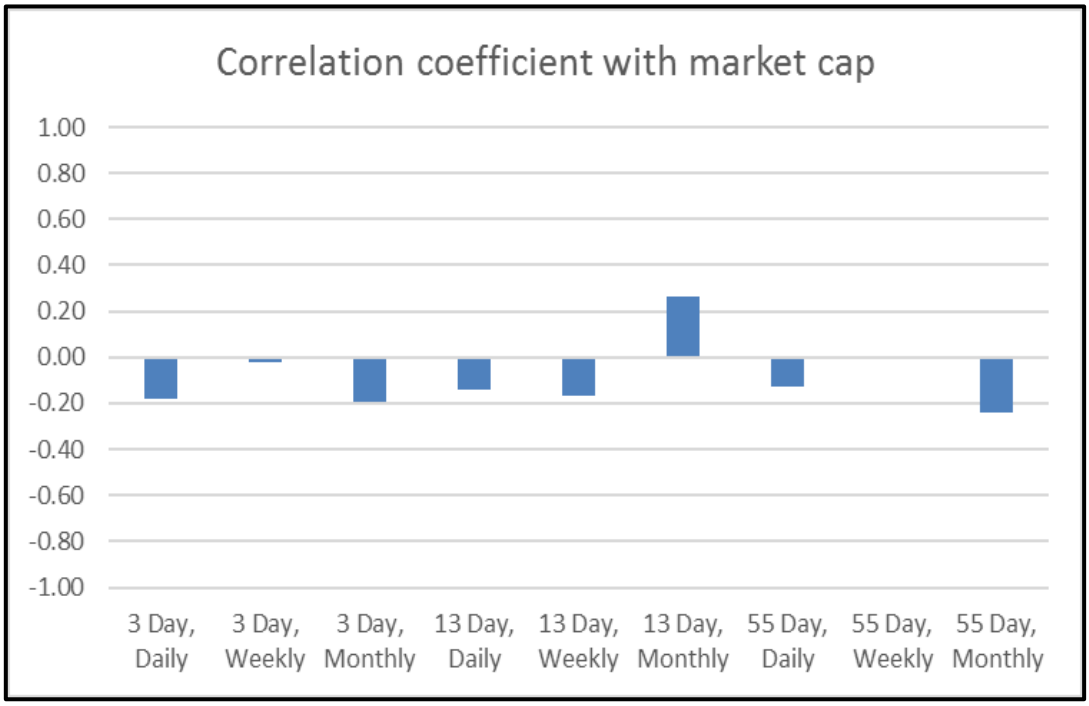

Figure 67: The correlation coefficient showing the relationship between the results from the various parameters and the market cap

Table 12 below, further illustrates the performance of each strategy across all the companies and by providing key metrics for each strategy, this table allows for objective analysis of the research question. The average returns in conjunction with the total returns provides a holistic assessment of the profitability of each strategy. The number of times the parameter was the worst & best performer further expands on the risk/ volatility of the strategy. While the number of times the strategy outperformed the buy and hold strategy and the outperformance ratio adds an additional layer to support the final objective analysis.

Table 12: Scorecard Summarising the relative performances of the various moving average parameters and the Buy and Hold Strategy

Strategy	Total Returns	# of times parameter was worst performer	# of times parameter was best performer	# of times outperforming B&H	Outperformance ratio
3 Day, Daily	12%	6	3	3	21.43%
3 Day, Weekly	-23%	1	1	4	28.57%
3 Day, Monthly	329%	2	2	9	64.29%

Strategy	Total Returns	# of times parameter was worst performer	# of times parameter was best performer	# of times outperforming B&H	Outperformance ratio
13 Day, Daily	55%	4	3	5	35.71%
13 Day, Weekly	134%	1	2	7	50.00%
13 Day, Monthly	-35%	3	1	6	42.86%
55 Day, Daily	10%	0	0	9	64.29%
55 Day, Weekly	122%	0	1	9	64.29%
55 Day, Monthly	-33%	0	0	7	50.00%
Buy and Hold	38%	0	1	NA	NA

4.2.6 Moving Average Strategy Sector Results

Table 13 below presents the total returns for each strategy per commodity group, in order to note which strategy worked best per commodity during the study. This data can be highly skewed due to the small number of companies in each sector, however it does offer some speculative insight

Table 13: Total Returns for Each Commodity

Total Returns										
	3 Day			13 Day			55 Day			B & H
	D	W	M	D	W	M	D	W	M	
Gold	-90%	-14%	-67%	62%	-72%	-64%	-76%	-47%	-46%	-34%
Platinum	114%	-43%	428%	-33%	239%	-38%	-27%	243%	-29%	-62%
Iron/ Manganese/ Chrome	-71%	39%	880%	260%	215%	-20%	166%	179%	-20%	340%
Diversifieds	89%	-84%	44%	-48%	162%	6%	39%	74%	-35%	-7%

** Colour schemes visually rank the results relative to results within the row, not the whole dataset*

4.2.7 Moving Average Strategy Company Results

Table 14 below summarises the performance of the different moving average strategy parameter combinations and the buy and hold results for each company in order to ascertain which parameter combinations beat the buy and hold strategy and performed best.

Table 14: Percentage Returns of the Buy and Hold Results and all the Moving Average Parameters per company

Company	Returns									
	B&H	3 Day			13 Day			55 Day		
		D	W	M	D	W	M	D	W	M
Anglo	-33%	-95%	-85%	11%	-93%	212%	28%	52%	96%	-10%
Anglo Gold	-49%	-100%	-11%	-58%	-100%	-86%	-49%	-88%	-48%	-34%
Anglo Platinum	-59%	-86%	-72%	-39%	-89%	-52%	86%	-36%	0%	-60%
ARM	20%	272%	-82%	78%	-2%	112%	-15%	27%	53%	-59%
Assore	793%	-96%	235%	420%	-95%	468%	51%	-39%	335%	-26%

Company	Returns									
	B&H	3 Day			13 Day			55 Day		
		D	W	M	D	W	M	D	W	M
DRD Gold	18%	-81%	132%	-91%	382%	-23%	-66%	-77%	-37%	-67%
Goldfields	-66%	-93%	-89%	-38%	-89%	-95%	-64%	-92%	-31%	-39%
Harmony	-70%	-87%	-86%	-83%	54%	-85%	-79%	-49%	-74%	-44%
Implats	-71%	-97%	-92%	-36%	-99%	-5%	-29%	-12%	-66%	-19%
Kumba	74%	-17%	-77%	864%	918%	-30%	-88%	417%	241%	-39%
Lonmin	-95%	346%	-92%	-100%	-5%	2%	-66%	-61%	226%	0%
Merafe	152%	-100%	-42%	1356%	-44%	208%	-24%	119%	-40%	5%
Northam	-3%	505%	-68%	43%	129%	-72%	-80%	5%	-26%	-65%
Wesizwe	-82%	-100%	108%	2273%	-100%	1322%	-100%	-31%	1081%	0%

** Colour schemes visually rank the results relative to results within the row, not the whole dataset*

5 CHAPTER 5: ANALYSIS AND INTERPRETATION OF RESULTS

5.1 Analysis of Traditional Buy and Hold Results

Figure 68 below shows the correlations between share price performance and the commodity spot price for the commodity produced by the company.

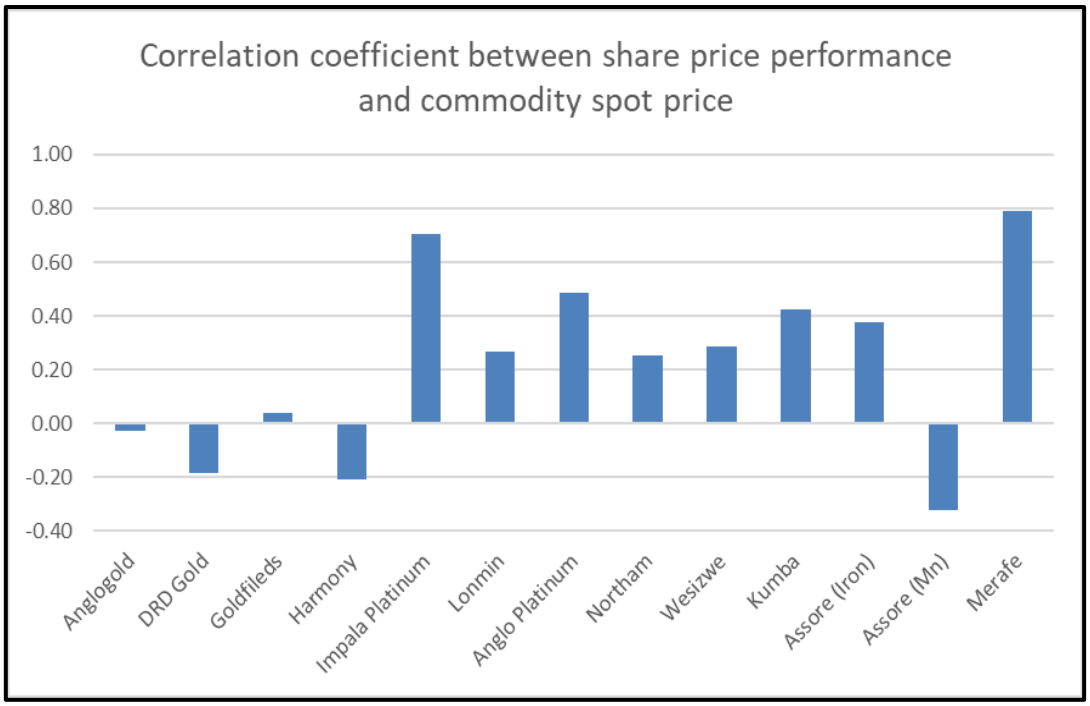

Figure 68: Correlation Coefficient between share price performance and commodity spot price

Only Merafe's share price performance had a strong correlation with the commodity's spot price over the study period. Impala platinum had a moderate correlation to its commodity spot price, while the rest of the companies all showed weak or very weak correlations.

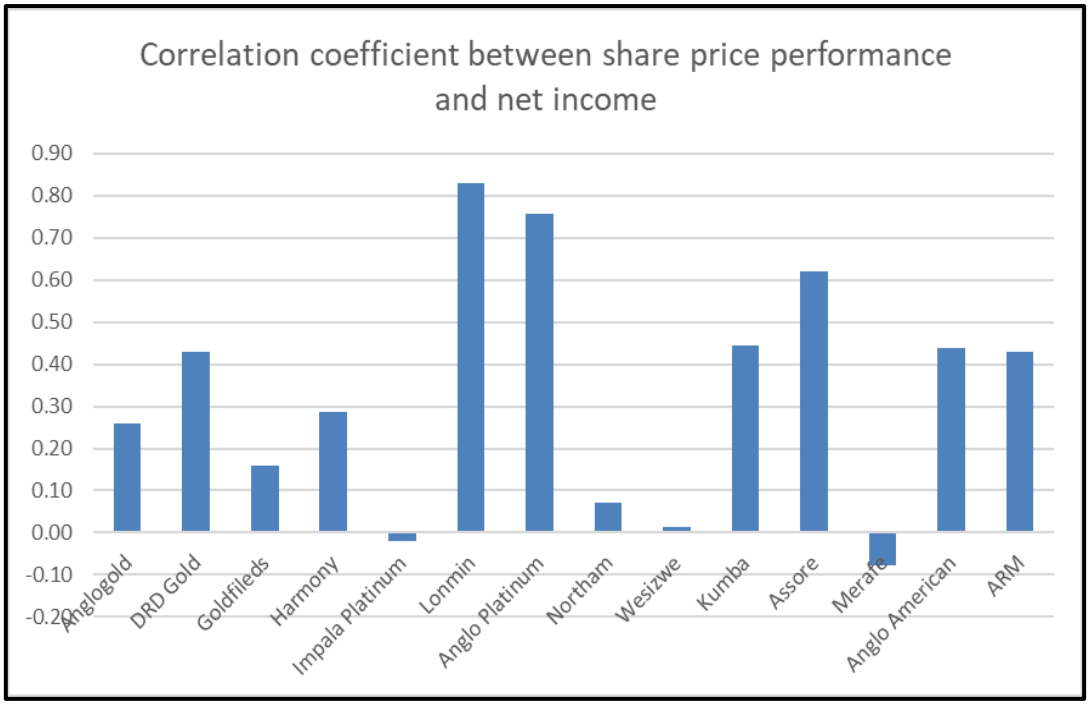

Figure 69: Correlation coefficient between share price performance and net income

Figure 69 shows that the amount of net income earned by the company is not always reflected in the contemporaneous share price performance. Over the study period only Lonmin and Anglo Platinum exhibited a strong correlation between the contemporaneous net income and the share price performance, Assore exhibited a moderate correlation while the correlations for the rest of the companies were weak or very weak.

Table 15 below summarises the mean, standard deviation and coefficient of variation of the daily share prices for all the above-mentioned companies, as mentioned above this can be used to quantify the relative volatility between the stocks over the study period and consequently the historical / realised risk of the stock.

Table 15: Mean, standard deviation and the coefficient of variation of the daily share prices

Company	Mean of share prices (ZAR)	SD of share prices (ZAR)	CoV	Commodity
Anglo Gold	243.58	79.79	33%	Gold
DRD Gold	4.93	1.85	37%	Gold
Goldfields	85.19	30.94	36%	Gold
Harmony	64.64	28.92	45%	Gold
Anglo Platinum	584.13	277.73	48%	Platinum
Impala Platinum	147.90	69.84	47%	Platinum
Lonmin	163.51	157.92	97%	Platinum
Northam	41.17	10.11	25%	Platinum
Wesizwe	2.47	3.00	122%	Platinum
Assore	190.91	107.36	56%	Iron /Manganese /Chrome

Company	Mean of share prices (ZAR)	SD of share prices (ZAR)	CoV	Commodity
Kumba	305.97	153.73	50%	Iron /Manganese /Chrome
Merafe	1.22	0.62	51%	Iron /Manganese /Chrome
Anglo American	272.84	95.66	35%	Diversified
ARM	153.68	50.01	33%	Diversified

The share price performance charts and table 15 above confirm that over the study period the selected mining stocks have had a very high variability with prices predominantly fluctuating cyclically. Over the study period Northam in the Platinum sector had the least variability, while Wesizwe also in the platinum sector had the most share price variability. The two most diversified companies, Anglo American and ARM exhibited relatively low share price variability compared to most of the other stocks.

Figures 15, 18, 21, 24, 28, 31, 34, 37, 45, 48 and 51 all show that none of the companies managed to maximise their production during rising market conditions for any extended period of time. The best in this regard was Kumba who in 2007 to 2009 and in 2015 to 2017 did manage to increase their production in line with rising prices in order to maximise received revenues. Impala platinum missed the early platinum price hikes and only managed to reduce their production in line with falling prices. Northam totally mistimed the market conditions decreasing production during the early platinum price hikes and increasing their production after 2013 during falling market conditions.

The annual reports of the various companies showed that there was no real correlation with the amount or nature of CAPEX spent and the performance of the share. However, the annual reports did show that companies who had fixed and consistent strategic goals throughout the study period generally performed better, for example; Kumba with their focus on strong operational performance, Assore with their policy of pre-selling their ore to dampen the effects of price volatility, Merafe with their focus on the cost management of their cost sensitive furnaces through their premus technology innovation and ARM through a policy of diversification.

5.2 Analysis of the Moving Average Trading Strategy

Table 12 above shows that the moving average strategy with the 3-Day Monthly parameter yielded the highest average returns as well as the joint highest outperformance ratio against the buy and hold strategy. The other parameters that yielded higher total returns than the buy and hold strategy are the 13-Day Daily, 13 Day Weekly and 55 Day Weekly. The 3 Day, Daily had the highest number of worst and best performances reflecting its volatility. Contrastingly the 55-Day Monthly never had the lowest returns over all the companies in the study period, reflecting how it is the most risk averse strategy, this is supported by the strategy's minimum returns, standard error, standard deviation and sample variance as reported in Table 11. However, it also yielded the second lowest average returns of all the companies underlining the low risk, low reward notion.

Figure 67 shows the relationship between the sum of results attained from the various combinations of parameters and the market cap of the companies. From it, we see that all parameter combinations

are not correlated to the market cap at all, therefore the size of the company has no bearing to the performance or efficacy of the trading strategy.

Table 13 shows the total returns of the various parameters for each commodity from it we can deduce that the moving average strategy did not perform well in the gold sector as all the parameters except the 13-Day, Daily yielded negative returns and with the 3-Day, Weekly were the only parameters to outperform the buy and hold strategy in this sector. Conversely all the moving average strategy parameters in the platinum industry out-performed the buy and hold strategy with the 3-Day Monthly, 13-Day Weekly, 55-Day Weekly and 3-Day Daily yielding positive returns. In the Iron/ Manganese / Chrome commodity group only the 3-Day Monthly parameter outperformed the buy and hold strategy, however all parameters except the 3-Day, Daily, 13-Day Monthly and 55-Day, Monthly yielded positive returns in this sector. As mentioned above the data for the analysis of results for each commodity will be highly skewed due to the small sample numbers used. The commodity group that has been separated as diversified poses the biggest problem in this regard, the analysis of their total returns will not be insightful due to the fact that the grouping only consists of 2 companies and because of the complexity related to the commodity spread of these companies.

Table 14 zooms in to the scale of the individual company, when viewed in this detail it becomes clear that each moving average trading strategy parameter is in itself an individual strategy with unique characteristics, variables and determinants. All of the moving average strategies are susceptible to heavy losses or large windfalls based on the synergy between the share price performance and the internal mechanics of the moving average parameters

6 CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Performance Within Commodity Sectors

The platinum sector was collectively the biggest loser under the traditional buy and hold strategy with platinum prices meandering between weak and indifferent amidst floundering demand during the study period. These fundamental flaws were further compounded by operational issues related to ageing mines and labour unrest. The relative performance of Northam within the sector was positive this is due to the fact that during the study period the company had multiple growth options, well-performing assets, a strong balance sheet and managed to become a relatively low-cost producer by diversifying out of deep level mining (Mathews, 2018). Within this environment however the moving average strategy under the 3-Day Weekly, 3-Day Monthly, 13-Day Weekly and 55-Day Weekly parameters managed to yield very positive returns and all of the moving average parameters in this sector outperformed the buy and hold strategy. Overall, both the buy and hold strategy and the moving average strategy performed well in the Iron/ Manganese and Chrome group of commodities, all of these commodities are related to steel making which had more robust and positive market fundamentals over the study period than other commodities. The moving average strategy did not perform as well as in the gold and diversified companies, both of which had less volatility over the study period. Therefore, one can conclude that the buy and hold strategy requires strong fundamentals and rising markets in order to yield positive returns, whereby the moving average strategy only requires share price volatility.

6.2 Comparison Between Strategies

In order of performance the following companies yielded positive returns under the buy and hold strategy; Assore, Merafe, Kumba, DRD Gold and Arm. In order of performance, the following companies yielded positive returns under the moving average strategy overall; Wesizwe, Kumba, Merafe, Assore, Arm, Northam, Lonmin, Anglo American and DRD Gold. However as mentioned above the study showed that each moving average trading strategy parameter is in itself an individual strategy with unique characteristics, variables and determinants and should therefore rather be treated individually in order to answer the research question.

In analysing the performance of the moving average strategy parameters individually, it was discovered that the moving average strategy with the 3-Day Monthly, 13-Day Daily, 13-Day Weekly and 55-Day Weekly parameters outperformed the buy and hold strategy. While the 3-Day Daily, 3-Day Weekly, 13-Day Monthly, 55-Day Daily and 55-Day Monthly underperformed in comparison to the buy and hold strategy. Table 16 below ranks the buy and hold strategy and the various moving average strategy parameters based on their performance over the study period.

Table 16: Ranking of Strategies Based on Performance Throughout the Study Period

Strategy	Performance Ranking
3-Day, Monthly	1
13-Day, Weekly	2
55-Day, Weekly	3
13-Day, Daily	4
Buy and Hold	5
3-Day, Daily	6
55-Day, Daily	7
3-Day, Weekly	8
55-Day, Monthly	9
13-Day, Monthly	10

The research project has shown that the price resolution has the effect of determining the amount of noise in the data, with longer price resolutions having a noise reducing or smoothing effect. It is interesting to note that the research has revealed that the most profitable parameter combination is the shortest moving average period combined with the longest price resolution used, therefore implying that achieving maximum trade volume with minimised noise leads to optimum returns.

6.3 Secondary Conclusions

6.3.1 Economics

The study confirms that mining stocks are highly variable, this can be attributed to the additional complexity of the performance of the underlying commodity market coupled with the complexity related to the corporate structure and financial performance of the company. This characteristic makes mining stocks less suitable for long term buy and hold investments.

The study also showed the inherent time lag between supply and demand through the lack of synchrony between the production and the commodity spot price which is a proxy for demand. This is an economic problem that plagues the mining industry in that they are not only price takers but the nature of the business means that any response to market conditions will be slow and usually results in mis-timing. The solution for this is for companies to think counter cyclically and prepare in advance for the next market movement.

6.3.2 Correlations

The study showed that a mining company's financial performance does not necessarily express itself in the share price performance, this is a major con for the utilisation of fundamental analysis in investing in mining companies. Furthermore, the correlation of the share price performance to the commodity spot price is either random or is determined by more complex interactions with variables linked to the company structure. Finally, there is also no correlation between the market cap and the performance of the moving average strategy, therefore the functioning of the moving average strategy is independent of the size of the company under that strategy.

6.4 Limitations of This Study

A concern of the study arises from the caution required when dealing with back-testing or any form of retrospective trading, therefore the above conclusions should not be treated as absolute but instead in application to the particular subject matter over the study period. A limitation of the research with regards to the buy and hold strategy is that the research does not take into consideration dividend payments which would improve the profitability of the buy and hold strategy. Neither does the project take into consideration the dividend allocations or dividend obligations attributable to long and short positions respectively under the moving average strategy. The results have not been inflation adjusted over the study period however this is not deemed necessary because of the comparative nature of the study as long as oranges are compared with oranges. Another limitation with regards to the moving average strategy is that there are so many variables relating to stocks, technical trading tools, moving average periods and stock price resolutions that it is beyond the scope of any single study.

6.5 Recommendations for Future Study

Future work could include the review of financial ratios for the companies over the study period in order to reveal the financial condition of a firm as well as to relatively compare the companies within the study. The usefulness of financial ratios as a forecasting and stock selecting tool could also be tested.

Monte Carlo simulation could be used to assess the risk of the moving average trading strategy, however integrating this was beyond the scope of this research project and beyond the understanding of the author. The basic premise however is that Monte Carlo Simulation would generate numerous iterations / simulations which would then be used to determine the percentage of loss (Masters, 2006; Holton, 2014; Harris, 2017). Monte Carlo methods essentially would produce an infinite stream of pseudo-random numbers, from which Bayesian inferences could be made regarding the distribution of the actual historical price data (Wiecki, 2015). Future work should utilise Monte Carlo simulation solely for the purpose of testing whether the trading model when randomly applied to JSE listed

mining stock is riskier than the traditional buy and hold strategy randomly applied to the same stock. The null hypothesis would therefore be that the strategy is less risky than the buy and hold strategy and the alternative hypothesis would be that the strategy is riskier than the buy and hold strategy.

Finally there is also a lot of scope for more abstract and less quantitative future work, focusing on the mechanics of the moving average parameters and how and why they perform under various market conditions.

7 References

African Rainbow Minerals, 2004. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2005. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2006. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2007. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2008. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2009. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2010. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2011. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2012. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2013. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2014. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2015. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2016. *Annual Report,* s.l.: s.n.

African Rainbow Minerals, 2017. *Annual Report,* s.l.: s.n.

Anglo American, 2004. *Annual Report,* s.l.: s.n.

Anglo American, 2005. *Annual Report,* s.l.: s.n.

Anglo American, 2006. *Annual Report,* s.l.: s.n.

Anglo American, 2007. *Annual Report,* s.l.: s.n.

Anglo American, 2008. *Annual Report,* s.l.: s.n.

Anglo American, 2009. *Annual Report,* s.l.: s.n.

Anglo American, 2010. *Annual Report,* s.l.: s.n.

Anglo American, 2011. *Annual Report,* s.l.: s.n.

Anglo American, 2012. *Annual Report,* s.l.: s.n.

Anglo American, 2013. *Annual Report,* s.l.: s.n.

Anglo American, 2014. *Annual Report,* s.l.: s.n.

Anglo American, 2015. *Annual Report 2015,* s.l.: s.n.

Anglo American, 2016. *Annual Report,* s.l.: s.n.

Anglo American, 2017. *Annual Report,* s.l.: s.n.

Anglo Gold Ashanti, 2004 *Annual Financial Statements Report,* s.l.: Anglo Gold Ashanti.

Anglo Gold Ashanti, 2005 *Annual Financial Statements Report,* s.l.: Anglo Gold Ashanti.

Anglo Gold Ashanti, 2006 *Annual Financial Statements Report,* s.l.: Anglo Gold Ashanti.

Anglo Gold Ashanti, 2007. *Annual Report 2007,* s.l.: s.n.

Anglo Gold Ashanti, 2008. *Annual Financial Statements 2008,* s.l.: s.n.

Anglo Gold Ashanti, 2009. *Annual Financial Statements 2009,* s.l.: s.n.

Anglo Gold Ashanti, 2010. *Annual Financial Statements 2010,* s.l.: s.n.

Anglo Gold Ashanti, 2011. *Annual Intergrated Report,* s.l.: s.n.

Anglo Gold Ashanti, 2012. *Annual Intergrated Report,* s.l.: s.n.

Anglo Gold Ashanti, 2013. *Annual Intergrated Report,* s.l.: s.n.

Anglo Gold Ashanti, 2014. *Intergrated Report 2014,* s.l.: s.n.

Anglo Gold Ashanti, 2015. *Annual Intergrated Report,* s.l.: s.n.

Anglo Gold Ashanti, 2016. *Intergrated Report 2016,* s.l.: s.n.

Anglo Gold Ashanti, 2017. *Intergrated Report 2017,* s.l.: s.n.

Anglo Platinum, 2004. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2005. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2006. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2007. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2008. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2009. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2010. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2011. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2012. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2013. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2014. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2015. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2016. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Anglo Platinum, 2017. *Anglo Platinum Limited Annual Report,* s.l.: s.n.

Assore, 2004. *Annual Report,* s.l.: s.n.

Assore, 2005. *Annual Report,* s.l.: s.n.

Assore, 2006. *Annual Report,* s.l.: s.n.

Assore, 2007. *Annual Report,* s.l.: s.n.

Assore, 2008. *Annual Report,* s.l.: s.n.

Assore, 2009. *Annual Report,* s.l.: s.n.

Assore, 2010. *Annual Report,* s.l.: s.n.

Assore, 2011. *Intergrated Annual Report,* s.l.: s.n.

Assore, 2012. *Annual Report,* s.l.: s.n.

Assore, 2013. *Annual Report,* s.l.: s.n.

Assore, 2014. *Annual Report,* s.l.: s.n.

Assore, 2015. *Annual Report,* s.l.: s.n.

Assore, 2016. *Annual Report,* s.l.: s.n.

Assore, 2017. *Annual Report,* s.l.: s.n.

Barnes, S., 2020. *Seeking Alpjha.* [Online]
Available at: https://seekingalpha.com/article/3624996-will-ferrochrome-prices-benefit-from-low-energy-prices
[Accessed 15 February 2020].

Barrie, S. W., 2007. *The Commodity Trader's Almanac.* New Jersey: John Wiley & Sons Inc.

Barton, S. D. & Woodbury, D., 2002. Where Investments Meet Mathematics. *The mathematics Teacher,* 95(1), pp. 60-68.

Baxter, R., 2013. *Crisis in SA gold mining sector? Finding a way forward,* s.l.: Chamber of Mines.

Beveridge, M., 2017. *Ferrochrome Market Overview.* s.l., CRU Global.

BHP Billiton PLC, 2004-2007. *Annual Report ,* s.l.: s.n.

Bodley, D., Bruch, S., Ralijaona, A. & Sithole, R., 2013. *The South African Iron Ore Cluster,* s.l.: Harvard Business School.

Bragg, S., 2017. *Accounting Tools.* [Online]
Available at: https://www.accountingtools.com/articles/market-value-ratios.html
[Accessed 28 February 2018].

Brock, W., Lakonishok, J. & LeBaron, B., 1992. Simple Technical Trading Rules and the Stochastic Properties of Stock Returns. *Journal of Finance,* 47(5), pp. 1731-1764.

Carlson, D., 2014. *kitco.com.* [Online]
Available at: https://www.kitco.com/news/2014-10-13/2008-Financial-Crisis-Set-Stage-for-gold-rally.html
[Accessed 22 February 2020].

CFA Institute, 2013. Chapter 9: Financial Statement Analysis. In: s.l.:CFA Institute.

Chen, K. H. & Shimerda, T. A., 1981. An Empirical Analysis of Useful Financial Ratios. *Financial Management,* 10(1), pp. 51-60.

Chen, Y.-C., Rogoff, K. S. & Rossi, B., 2010. Can Exchange Rates Forecast Commodity Prices?. *Oxford Journals,* 125(3), pp. 1145-1194.

Corporate Finance Institute, 2019. *CFI Education Inc..* [Online]
Available at: https://corporatefinanceinstitute.com/
[Accessed 02 January 2019].

CRU Consulting, 2017. *Steelmaking Raw Materials – Key Trends.* Paris, s.n.

d'Harambure, A., 2015. *Overview of the Global Manganese Industry.* Singapore, s.n.

Deloitte, 2018. *Overview of the Steel and Iron Ore Market,* Moscow: s.n.

DRD Gold Limited, 2007. *Annual Report,* s.l.: s.n.

DRD Gold Limited, 2008. *Annual Report 2008,* s.l.: s.n.

DRD Gold Limited, 2009. *Annual Report 2009,* s.l.: s.n.

DRD Gold Limited, 2010. *Annual Report 2010,* s.l.: s.n.

DRD Gold Limited, 2011. *Annual Integrated Report 2011,* s.l.: s.n.

DRD Gold Limited, 2012. *Integrated Report 2012,* s.l.: s.n.

DRD Gold Limited, 2013. *Integrated Report 2013,* s.l.: s.n.

DRD Gold Limited, 2014. *Integrated Report 2014,* s.l.: s.n.

DRD Gold Limited, 2015. *Integrated Report 2015,* s.l.: s.n.

DRD Gold Limited, 2017. *Annual Integrated Report 2017,* s.l.: s.n.

Elder, A., 1993. *Trading for A Living.* New York: John Wiley & Sons, Inc..

Fama, E. F., 1970. Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance,* 25(2), pp. 383-417.

Fama, E. F. & Blume, M. E., 1966. Filter Rules and Stock-Market Trading. *Journal of Business,* 39(1), pp. 226-241.

Fernando, P. N., 2010. *Profitability of Technical Trading Strategies in Emerging Sri Lankan Stock Market,* Colombo: University of Kelaniya.

Finance Train, 2018. *Finance Train.* [Online]
Available at: https://financetrain.com/why-lognormal-distribution-is-used-to-describe-stock-prices/
[Accessed 02 February 2019].

Ganon, M., 2017. *Next Level Corporate.* [Online]
Available at: https://www.nextlevelcorporate.com.au/nextperspective/2017/9/1/august-commodity-price-index-rise-of-1-masks-14-rise-in-hard-bulks-spot-prices
[Accessed 8 December 2020].

Garside, M., 2020. *Statista.* [Online]
Available at: https://www.statista.com/statistics/282830/iron-ore-prices-since-2003/
[Accessed 29 October 2020].

Gerritsen, D. F., 2016. Are Chartists Artists? The Determinants and Profitability of Recommendations Based on Technical Analysis. *International Review of Financial Analysis,* Volume 47, pp. 179-196.

Geyer, C. J., 2011. Introduction to Markov Chain Monte Carlo. In: A. G. G. J. X. M. S Brooks, ed. *Handbook of Markov Chain Monte Carlo.* Boca Raton, London, New York: CRC Press, pp. 3-48.

Gibson, C., 1987. How Chartered Financial Analysts View Financial Ratios. *Financial Analysts Journal,* 43(3), pp. 74-76.

Goldfields, 2007. *Annual Report,* s.l.: s.n.

Goldfields, 2008. *Annual Report 2008,* s.l.: s.n.

Goldfields, 2009. *Annual Report 2009,* s.l.: s.n.

Goldfields, 2010. *Annual Report 2009,* s.l.: s.n.

Goldfields, 2011. *Integrated Annual Review 2011,* s.l.: s.n.

Goldfields, 2012. *Integrated Annual Review 2012,* s.l.: s.n.

Goldfields, 2013. *Annual Report 2013,* s.l.: s.n.

Goldfields, 2014. *Integrated Annual Report ,* s.l.: s.n.

Goldfields, 2015. *Integrated Annual Report,* s.l.: s.n.

Goldfields, 2016. *Integrated Annual Report,* s.l.: s.n.

Goldfields, 2017. *Integrated Annual Report,* s.l.: s.n.

Griffioen, G. A., 2003. *Technical Analysis in Financial Markets,* Amsterdam: UvA-DARE.

Harlow, C. V. & Teweles, R. J., 1972. Commodities and Securities Compared. *Financial Analysts Journal,* 28(5), pp. 64-70.

Harmony, 2004. *Annual Report,* s.l.: s.n.

Harmony, 2005. *Annual Report,* s.l.: s.n.

Harmony, 2006. *Annual Report,* s.l.: s.n.

Harmony, 2007. *Annual Report,* s.l.: s.n.

Harmony, 2008. *Annual Report 2008,* s.l.: s.n.

Harmony, 2009. *Annual Report 2009,* s.l.: s.n.

Harmony, 2010. *Annual Report 2010,* s.l.: s.n.

Harmony, 2011. *Integrated Annual Report,* s.l.: s.n.

Harmony, 2012. *Integrated Annual Report,* s.l.: s.n.

Harmony, 2013. *Integrated Annual Report,* s.l.: s.n.

Harmony, 2014. *Annual Report 2014,* s.l.: s.n.

Harmony, 2015. *Integrated Annual Report,* s.l.: s.n.

Harmony, 2016. *Integrated Annual Report,* s.l.: s.n.

Harmony, 2017. *Integrated Annual Report,* s.l.: s.n.

Harris, M., 2017. *Fooled by Monte Carlo Simulation.* [Online]
Available at: https://medium.com/@mikeharrisNY/fooled-by-monte-carlo-simulation-eee0b312e489
[Accessed 20 October 2017].

Hilliard, J., Schwartz, A. & Squire, J., 2013. A Test of Technical Analysis: Matching Time Displaced Generalized Patterns. *Financial Management,* 42(2), pp. 291-314.

Hobbs, D., 2013. *The manganese industry worldwide - trends and opportunities.* Istanbul, Macquarie Commodities Research.

Holland, N., 2014. *The Sstate of the Gold Mining Sector,* s.l.: s.n.

Holton, G. A., 2004. Defining Risk. *Financial Analyst Journal,* 60(6), pp. 19-25.

Holton, G. A., 2014. In: A. Press, ed. *Value at Risk, Theory and Practice.* San Diego: Glyn Holton.

Horrigan, J. O., 1965. Some Empirical Bases of Financial Ratio Analysis. *The Accounting Review,* 40(3), pp. 558-568.

Hung, N. H. & Zhaojun, Y., 2013. Profitability of Applying Simple Moving Average Trading Rules for the Vietnamese Stock Market. *Journal of Business & Management,* 2(3), pp. 22-31.

IG, 2020. *IG.com.* [Online]
Available at: https://www.ig.com/za/cfd-trading
[Accessed 15 July 2017].

Implats, 2004. *Annual Report,* s.l.: s.n.

Implats, 2005. *Annual Report,* s.l.: s.n.

Implats, 2006. *Annual Report,* s.l.: s.n.

Implats, 2007. *Annual Report,* s.l.: s.n.

Implats, 2008. *Annual Report,* s.l.: s.n.

Implats, 2009. *Annual Report,* s.l.: s.n.

Implats, 2010. *Annual Report,* s.l.: s.n.

Implats, 2011. *Annual Report,* s.l.: s.n.

Implats, 2012. *Annual Report,* s.l.: s.n.

Implats, 2013. *Annual Report,* s.l.: s.n.

Implats, 2014. *Annual Report,* s.l.: s.n.

Implats, 2015. *Annual Report,* s.l.: s.n.

Implats, 2016. *Annual Report,* s.l.: s.n.

Implats, 2017. *Annual Report,* s.l.: s.n.

Johnson Matthey, 2007. *Platinum 2007,* Hertfordshire: Johnson Matthey.

Johnson Matthey, 2009. *Platinum, 2009,* Hertfordshire: Johnson Matthey.

Johnson Matthey, 2011. *Platinum, 2011,* Hertfordshire: Johnson Matthey.

Johnson Matthey, 2013. *Platinum, 2013,* Hertfordshire: Johnson Matthey.

Johnson Matthey, 2016. *PGM Market Report May 2016: Summary of Platinum Supply and Demand 2015,* Hertfordshire: Johnson Matthey.

Johnson Matthey, 2018. *JM PGM Market Report May 2018,* Hertfordshire: Johnson Matthey.

Khorram, M. & Sheshmani, M., 2015. What Period of Time is better to Use for Moving Average to Predict Stock Price in Tehran Stock Exchange?. *Indian Journal of Science and Technology,* 8(27), pp. 1-8.

KPMG, 2018. *KPMG Commodity Insights - Bulletin Chromite,* Canada: KPMG International Cooperative.

Kroese, D. P. & Rubinstein, R. Y., n.d. *Monte Carlo Methods,* s.l.: s.n.

Kroner, K. F., Kneafsey, D. P. & Claessens, S., 1993. *Forecasting Volatility in Commodity Markets,* Tucson: The World Bank.

Kumba Iron Ore, 2004. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2005. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2006. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2007. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2008. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2009. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2010. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2011. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2012. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2013. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2014. *Annual Report,* s.l.: s.n.

Kumba Iron Ore, 2015. *Annual Report,* s.l.: s.n.

Kumba Resources, 2010. *Board of Directors Annual Report,* s.l.: s.n.

Kumba Resources, 2013. *Integrated Report,* s.l.: s.n.

Lo, A. W., Mamaysky, H. & Wang, J., 2000. Foundations of Technical Analysis:Computational Algorithms, Statistical Inference, and Empirical Implementation. *The Journal of Finance,* LV(4), pp. 1705-1765.

Lonmin PLC, 2004. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2005. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2006. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2007. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2008. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2009. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2010. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2011. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2012. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2013. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2014. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2015. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2016. *Annual Report,* s.l.: s.n.

Lonmin PLC, 2017. *Annual Report,* s.l.: s.n.

Lönnbark, C. & Soultanaeva, A., 2008. *Profitability of Technical Trading Rules on the Baltic Stock Markets,* Umeå: Umeå University.

Masson, D. J., 2016. *Association of Financial Professions.* [Online]
Available at: https://www.afponline.org/trends-topics/topics/articles/Details/6-steps-to-an-effective-financial-statement-analysis
[Accessed 24 February 2018].

Masters, T., 2006. *Monte Carlo Evaluation of Trading Systems,* s.l.: s.n.

Mathews, C., 2018. *Business Day.* [Online]
Available at: https://www.businesslive.co.za/bd/companies/mining/2018-02-23-northam-platinum-plunges-deeper-into-the-red/
[Accessed 28 12 2018].

Menkhoff, L., 2010. The Use of Technical Analysis by Fund Managers:International Evidence. *Journal of Banking & Finance,* 34(11), pp. 2573-2586.

Menkhoff, L. & Taylor, M. P., 2006. *The Obstinate Passion of Foreign Exchange Professionals:,* s.l.: Centre for Economic Policy Research.

Merafe Resources Limited, 2004. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2005. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2006. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2007. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2008. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2009. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2010. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2011. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2012. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2013. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2014. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2015. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2016. *Annual Report,* s.l.: s.n.

Merafe Resources Limited, 2017. *Annual Report,* s.l.: s.n.

Metalary, 2020. *Metalary.* [Online]
Available at: https://www.metalary.com/manganese-price/
[Accessed 29 October 2020].

Mojarov, A., 2012. *The current state of the global iron ore market.* Paris, OECD Steel Committee.

Murphy, J. J., 2017. *Swing Alpha.* [Online]
Available at: http://www.swingalpha.com/Technical-Analysis-of-the-Financial-Markets
[Accessed 2 July 2017].

Nazário, R. T. F., e Silva, J. L. & Sobreiro, V. A., 2017. A Literature Review of Technical Analysis on Stock Markets. *The Quarterly Review of Economics and Finance,* pp. 1-12.

Neely, C., Weller, P. & Dittmar, R., 1997. Is Technical Analysis in the Foreign Exchange Market Profitable?. *Journal of Financial and Quantitative Analysis.*

Neingo, P. N. & Tholana, T., 2016. Trends in productivity in the South. *The Journal of the Southern African Institute of Mining Metallurgy,* Volume 116, pp. 283-290.

Nelson, E. G., 1947. A Brief Study of Balance Sheets. *The Accounting Review,* pp. 341 -352.

News 24, 2017. *News 24.* [Online]
Available at: https://www.news24.com/fin24
[Accessed 13 November 2017].

Northam, 2004. *Annual Report,* s.l.: s.n

Northam, 2005. *Annual Report,* s.l.: s.n.

Northam, 2006. *Annual Report,* s.l.: s.n.

Northam, 2007. *Annual Report,* s.l.: s.n.

Northam, 2008. *Annual Report,* s.l.: s.n.

Northam, 2009. *Annual Report,* s.l.: s.n.

Northam, 2010. *Annual Report,* s.l.: s.n.

Northam, 2011. *Annual Report,* s.l.: s.n.

Northam, 2012. *Annual Report,* s.l.: s.n.

Northam, 2013. *Annual Report,* s.l.: s.n.

Northam, 2014. *Annual Report,* s.l.: s.n.

Northam, 2015. *Annual Report,* s.l.: s.n.

Northam, 2016. *Annual Report,* s.l.: s.n.

Northam, 2017. *Annual Report,* s.l.: s.n..

Patel, K., Ashfaq, M. & Vuuren, G., 2018. A Regression and Comparative Study of United States and South African Yield Curves Using Principal Component Aalysis. *South African Journal of Economic and Management Science,* 21(1), p. 1626.

Price Waterhouse Coopers, 2006. *Mine, A confidence Crisis: Review of Global Trends in the Mining Industry -2013,* s.l.: Price Waterhouse Coopers.

Price Waterhouse Coopers, 2007. *Metals & Mining: Review of Global Trends in the Mining Industry - 2007,* s.l.: Price Waterhouse Coopers.

Price Waterhouse Coopers, 2008. *Global Energy, Utilities & Mining: Review of Global Trends in the Mining Industry - 2008,* s.l.: Price Waterhouse Coopers.

Price Waterhouse Coopers, 2010. *Energy, Utilities & Mining: Review of Global Trends in the Mining Industry - 2010,* s.l.: Price Waterhouse Coopers.

Price Waterhouse Coopers, 2014. *SA Mine, 6th Edition: Highlighting Trends in the South African Mining Industry,* s.l.: Price Waterhouse Coopers.

Price Waterhouse Coopers, 2015. *SA Mine, 7th Edition: Highlighting Trends in the South African Mining Industry,* s.l.: Price Waterhouse Coopers.

Price Waterhouse Coopers, 2017. *SA Mine, 9th Edition: Highlighting Trends in the South African Mining Industry,* s.l.: Price Waterhouse Coopers.

Pritsker, M., 2005. The Hidden Dangers of Historical Simulation. *Journal of Banking & Finance,* Volume 30, p. 561–582.

Rio Tinto, 2012. *Iron Ore Seminar.* s.l., Rio Tinto.

Rzepczynski, M., 2017. *IASG Alternative Investment Blog.* [Online]
Available at: http://blog.iasg.com/2017/04/13/commodity-investing-not-buy-hold-crowd/
[Accessed 29 June 2017].

Sekiguchi, N., 2015. *Steel Market Developments,* Paris: OECD/OCDE,.

Sharenet, 2020. *Sharenet.* [Online]
Available at: http://www.sharenet.co.za
[Accessed 9 June 2017].

Singh, K. & Xie, M., 2008. *Bootstarp: A Statistical Method,* New Jersey: Rutgers University.

Sweeney, R. J., 1986. Beating the Foreign Exchange Market. *The Journal of Finance,* 41(1), pp. 163-182.

Technical Analysis, 2011. *Investopedia.* [Online]
Available at: http://i.investopedia.com/inv/pdf/tutorials/technicalanalysis.pdf
[Accessed 2 July 2017].

Thacker, R. J., 1962. Income Statement Form and Classification. *The Accounting Review,* 37(1), pp. 51-55.

This is Gold, 2014. *The State of the Gold Mining Sector,* s.l.: s.n.

This is Gold, 2018. *[Fact Sheet] July 2018, The State of the Gold Industry,* Johannesburg: s.n.

Trading Economics, 2020. *Trading Economics.* [Online]
Available at: https://tradingeconomics.com/commodity/iron-ore
[Accessed 15 October 2020].

ul Haque, I., 1971. *ECONOMIC ANALYSIS OF MANGANESE MARKET,* Washington DC: NTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT.

UNCTAD Trust Fund on Iron Ore Information, 2016. *The Iron Ore Market 2016.* s.l., s.n.

Unknown, 2011. *The Iron Ore Market in 2011,* s.l.: s.n.

Vandewalle, N., Ausloos, M. & Boveroux, P., 1999. The Moving Averages Demystified. *Physica,* pp. 170-176.

Wesizwe Platinum Limited, 2007. *Annual Report,* s.l.: s.n.

Wesizwe Platinum Limited, 2008. *Annual Report 2008,* s.l.: s.n.

Wesizwe Platinum Limited, 2009. *Annual Report 2009,* s.l.: s.n.

Wesizwe Platinum Limited, 2010. *Annual Report 2010,* s.l.: s.n.

Wesizwe Platinum Limited, 2011. *Annual Report 2011,* s.l.: s.n.

Wesizwe Platinum Limited, 2012. *Annual Report 2012,* s.l.: s.n.

Wesizwe Platinum Limited, 2013. *Annual Report 2013,* s.l.: s.n.

Wesizwe Platinum Limited, 2014. *Annual Report 2014,* s.l.: s.n.

Wesizwe Platinum Limited, 2015. *Annual Report 2015,* s.l.: s.n.

Wesizwe Platinum Limited, 2016. *Annual Report 2016,* s.l.: s.n.

Wesizwe Platinum Limited, 2017. *Annual Report 2017,* s.l.: s.n.

Wiecki, T., 2015. *While my MCMC Gently Samples.* [Online]
Available at: http://twiecki.github.io/blog/2015/11/10/mcmc-sampling/
[Accessed 22 October 2017].

Wilder, E. M., 2009. *Simple Moving Averages: A Ten-Year Test,* Corvallis: Oregon State University.

World Steel Association, 2018. *World Steel in Figures 2018,* Brussels: World Steel Association.

Ye, F. et al., 2016. A Novel Forecasting Method Based on Multi-Order Fuzzy Time Series and Technical Analysis. *Information Sciences,* pp. 41-57.

Zhu, Y. & Zhou, G., 2009. Technical Analysis: An Asset Allocation Perspective on the Use of Moving Averages. *Journal of Financial Economics,* Volume 92, pp. 519-544.

Zoicaş-Ienciu, A., 2012. *Methodological Biases in Technical Trading,* Cluj-Napoca: Babeş-Bolyai University.

Appendix 1: Example of Excel Back-Testing Model

1	Moving Average	Adjusted Moving Average	Direction	Trade Signal	Transaction number	Transaction Price	Trade Direction	PL per share	Running Cash	Quantity	Gross PL	Transaction Fees	Net PL	Return %	Daily Return %	Buy and Hold Value
56	166	166	BUY	BUY	1	189.01	1	0	1 000 000.00	5290.7254	0	2000.00	-2000	#VALUE!	0.27%	2 075 208.61
57	168	168	BUY		1	189.01	1	0	998 000.00	0	0	0.00	0	0.00%	0.50%	2 085 529.21
58	169	169	BUY		1	189.01	1	0	998 000.00	0	0	0.00	0	0.00%	-8.66%	1 904 918.75
59	171	171	BUY		1	189.01	1	0	998 000.00	0	0	0.00	0	0.00%	5.72%	2 013 833.99
60	172	172	BUY		1	189.01	1	0	998 000.00	0	0	0.00	0	0.00%	-1.87%	1 976 174.79
61	173	173	SELL	SELL	2	171	-1	-18.01	998 000.00	5836.2573	-105111	1996.00	-107107	-9.53%	-4.99%	1 877 470.36
62	174	174	BUY	BUY	3	184.32	1	-13.32	890 893.01	4833.4039	-64380.9	1781.79	-66162.7	-7.79%	7.79%	2 023 715.42
63	175	175	BUY		3	184.32	1	0	824 730.28	0	0	0.00	0	0.00%	3.62%	2 097 057.53
64	176	176	BUY		3	184.32	1	0	824 730.28	0	0	0.00	0	0.00%	-4.91%	1 994 180.94
65	177	177	BUY		3	184.32	1	0	824 730.28	0	0	0.00	0	0.00%	-0.35%	1 987 263.94
66	177	177	SELL	SELL	4	168.2	-1	-16.12	824 730.28	4903.2716	-79040.7	1649.46	-80690.2	-8.75%	-7.07%	1 846 728.15
67	178	178	SELL		4	168.2	-1	0	744 040.08	0	0	0.00	0	0.00%	-1.30%	1 822 793.15
68	178	178	SELL		4	168.2	-1	0	744 040.08	0	0	0.00	0	0.00%	-6.18%	1 710 144.93
69	178	178	SELL		4	168.2	-1	0	744 040.08	0	0	0.00	0	0.00%	-5.62%	1 613 965.74
70	177	177	SELL		4	168.2	-1	0	744 040.08	0	0	0.00	0	0.00%	10.87%	1 789 415.90
71	176	176	BUY	BUY	5	181.5	1	-13.3	744 040.08	4099.3944	-54521.9	1488.08	-56010	-7.91%	11.36%	1 992 753.62
72	175	175	BUY		5	181.5	1	0	688 030.06	0	0	0.00	0	0.00%	-1.82%	1 956 521.74
73	173	173	BUY		5	181.5	1	0	688 030.06	0	0	0.00	0	0.00%	6.57%	2 084 980.24
74	171	171	BUY		5	181.5	1	0	688 030.06	0	0	0.00	0	0.00%	6.11%	2 212 340.80
75	170	170	BUY		5	181.5	1	0	688 030.06	0	0	0.00	0	0.00%	-5.13%	2 098 814.23
76	169	169	BUY		5	181.5	1	0	688 030.06	0	0	0.00	0	0.00%	-0.96%	2 078 612.21
77	169	169	BUY		5	181.5	1	0	688 030.06	0	0	0.00	0	0.00%	-6.57%	1 942 028.99
78	171	171	BUY		5	181.5	1	0	688 030.06	0	0	0.00	0	0.00%	1.76%	1 976 284.58
79	172	172	SELL	SELL	6	149.76	-1	-31.74	688 030.06	4594.2178	-145820	1376.06	-147197	-17.49%	-16.80%	1 644 268.77
80	173	173	SELL		6	149.76	-1	0	540 833.52	0	0	0.00	0	0.00%	8.51%	1 784 145.81
81	174	174	BUY	BUY	7	188.32	1	-38.56	540 833.52	2871.8857	-110740	1081.67	-111822	-25.75%	15.89%	2 067 632.85
82	175	175	BUY		7	188.32	1	0	429 011.94	0	0	0.00	0	0.00%	4.61%	2 163 043.48
83	176	176	BUY		7	188.32	1	0	429 011.94	0	0	0.00	0	0.00%	-2.41%	2 111 001.32
84	178	178	BUY		7	188.32	1	0	429 011.94	0	0	0.00	0	0.00%	-2.52%	2 057 861.22

arm | **Model** | QAQC

Appendix 2: Table Summarizing Performance Metrics for the Moving Average Trading Strategy

Company	Chart resolution	MA period	Strategy Result	Buy and Hold Results	Number of transactions	Positive trades after fees	Negative trades after fees	Hit ratio after fees
Anglo	Daily	3 Day	48 568	665 002	971	327	644	33.68%
Anglo	Daily	13 Day	66 050	665 002	377	98	279	25.99%
Anglo	Daily	55 Day	1 515 675	665 002	163	33	130	20.25%
Anglo	Weekly	3 Day	145 080	593 695	190	66	124	34.74%
Anglo	Weekly	13 Day	3 119 065	593 695	64	21	43	32.81%
Anglo	Weekly	55 Day	1 963 243	593 695	25	8	17	32.00%
Anglo	Monthly	3 Day	1 108 162	684 666	39	14	25	35.90%
Anglo	Monthly	13 Day	1 277 021	684 666	15	4	11	26.67%
Anglo	Monthly	55 Day	896 260	684 666	5	1	4	20.00%
Anglo Gold	Daily	3 Day	127	505 625	1 086	324	762	29.83%
Anglo Gold	Daily	13 Day	4 542	505 625	610	174	436	28.52%
Anglo Gold	Daily	55 Day	121 322	505 625	350	96	254	27.43%
Anglo Gold	Weekly	3 Day	888 166	480 567	187	70	117	37.43%
Anglo Gold	Weekly	13 Day	143 313	480 567	94	18	76	19.15%
Anglo Gold	Weekly	55 Day	524 780	480 567	36	6	30	16.67%
Anglo Gold	Monthly	3 Day	423 194	496 754	43	13	30	30.23%
Anglo Gold	Monthly	13 Day	514 032	496 754	18	6	12	33.33%
Anglo Gold	Monthly	55 Day	660 730	496 754	6	1	5	16.67%
Anglo Platinum	Daily	3 Day	141 080	409 883	899	330	569	36.71%
Anglo Platinum	Daily	13 Day	106 237	409 883	393	94	299	23.92%
Anglo Platinum	Daily	55 Day	643 869	409 883	173	31	142	17.92%

Company	Chart resolution	MA period	Strategy Result	Buy and Hold Results	Number of transactions	Positive trades after fees	Negative trades after fees	Hit ratio after fees
Anglo Platinum	Weekly	3 Day	278 820	328 052	191	61	130	31.94%
Anglo Platinum	Weekly	13 Day	475 873	328 052	82	23	59	28.05%
Anglo Platinum	Weekly	55 Day	1 001 041	328 052	22	7	15	31.82%
Anglo Platinum	Monthly	3 Day	606 283	386 861	45	15	30	33.33%
Anglo Platinum	Monthly	13 Day	1 859 319	386 861	9	4	5	44.44%
Anglo Platinum	Monthly	55 Day	403 283	386 861	4	0	4	0.00%
ARM	Daily	3 Day	3 723 033	1 199 005	903	319	584	35.33%
ARM	Daily	13 Day	977 956	1 199 005	373	107	266	28.69%
ARM	Daily	55 Day	1 268 793	1 199 005	171	37	134	21.64%
ARM	Weekly	3 Day	183 940	1 070 652	197	57	140	28.93%
ARM	Weekly	13 Day	2 121 929	1 070 652	71	20	51	28.17%
ARM	Weekly	55 Day	1 526 255	1 070 652	39	8	31	20.51%
ARM	Monthly	3 Day	1 777 462	1 323 013	41	19	22	46.34%
ARM	Monthly	13 Day	845 986	1 323 013	15	5	10	33.33%
ARM	Monthly	55 Day	412 401	1 323 013	8	0	8	0.00%
Assore	Daily	3 Day	44 086	8 929 032	852	257	595	30.16%
Assore	Daily	13 Day	50 769	8 929 032	365	88	277	24.11%
Assore	Daily	55 Day	612 137	8 929 032	161	26	135	16.15%
Assore	Weekly	3 Day	3 351 439	8 929 032	173	66	107	38.15%
Assore	Weekly	13 Day	5 677 142	8 929 032	55	15	40	27.27%
Assore	Weekly	55 Day	4 352 155	8 929 032	21	7	14	33.33%
Assore	Monthly	3 Day	5 197 127	8 929 032	33	14	19	42.42%
Assore	Monthly	13 Day	1 513 823	8 929 032	15	4	11	26.67%
Assore	Monthly	55 Day	739 272	8 929 032	3	0	3	0.00%
BHP Billiton	Daily	3 Day	105 620	1 868 545	916	313	603	34.17%
BHP Billiton	Daily	13 Day	266 997	1 868 545	351	101	250	28.77%
BHP Billiton	Daily	55 Day	259 403	1 868 545	189	34	155	17.99%

Company	Chart resolution	MA period	Strategy Result	Buy and Hold Results	Number of transactions	Positive trades after fees	Negative trades after fees	Hit ratio after fees
BHP Billiton	Monthly	3 Day	448 163	1 806 721	43	15	28	34.88%
BHP Billiton	Monthly	13 Day	1 160 848	1 806 721	17	8	9	47.06%
BHP Billiton	Monthly	55 Day	411 938	1 806 721	10	1	9	10.00%
Billiton	Weekly	3 Day	117 137	1 762 553	192	64	128	33.33%
Billiton	Weekly	13 Day	121 018	1 762 553	88	23	65	26.14%
Billiton	Weekly	55 Day	2 538 475	1 762 553	19	8	11	42.11%
DRD Gold	Daily	3 Day	188 452	1 176 563	905	295	610	32.60%
DRD Gold	Daily	13 Day	4 821 398	1 176 563	334	100	234	29.94%
DRD Gold	Daily	55 Day	230 491	1 176 563	167	33	134	19.76%
DRD Gold	Weekly	3 Day	2 320 229	1 255 932	167	69	98	41.32%
DRD Gold	Weekly	13 Day	767 490	1 255 932	71	22	49	30.99%
DRD Gold	Weekly	55 Day	627 673	1 255 932	33	6	27	18.18%
DRD Gold	Monthly	3 Day	88 256	1 307 292	45	18	27	40.00%
DRD Gold	Monthly	13 Day	340 260	1 307 292	19	6	13	31.58%
DRD Gold	Monthly	55 Day	330 220	1 307 292	7	0	7	0.00%
Goldfields	Daily	3 Day	71 795	342 025	913	317	596	34.72%
Goldfields	Daily	13 Day	114 016	342 025	354	94	260	26.55%
Goldfields	Daily	55 Day	79 554	342 025	193	33	160	17.10%
Goldfields	Weekly	3 Day	113 959	354 102	193	73	120	37.82%
Goldfields	Weekly	13 Day	52 096	354 102	80	17	63	21.25%
Goldfields	Weekly	55 Day	688 605	354 102	28	6	22	21.43%
Goldfields	Monthly	3 Day	619 047	380 909	49	18	31	36.73%
Goldfields	Monthly	13 Day	361 114	380 909	14	4	10	28.57%
Goldfields	Monthly	55 Day	612 006	380 909	10	1	9	10.00%
Harmony	Daily	3 Day	128 086	299 230	925	305	620	32.97%
Harmony	Daily	13 Day	1 538 416	299 230	357	96	261	26.89%
Harmony	Daily	55 Day	509 325	299 230	195	32	163	16.41%

Company	Chart resolution	MA period	Strategy Result	Buy and Hold Results	Number of transactions	Positive trades after fees	Negative trades after fees	Hit ratio after fees
Harmony	Weekly	3 Day	135 592	303 173	185	61	124	32.97%
Harmony	Weekly	13 Day	146 367	303 173	100	23	77	23.00%
Harmony	Weekly	55 Day	263 624	303 173	32	6	26	18.75%
Harmony	Monthly	3 Day	171 868	345 106	53	16	37	30.19%
Harmony	Monthly	13 Day	211 091	345 106	20	4	16	20.00%
Harmony	Monthly	55 Day	559 092	345 106	4	1	3	25.00%
Implats	Daily	3 Day	33 689	287 327	931	329	602	35.34%
Implats	Daily	13 Day	9 090	287 327	417	98	319	23.50%
Implats	Daily	55 Day	881 120	287 327	173	32	141	18.50%
Implats	Weekly	3 Day	76 518	255 928	195	67	128	34.36%
Implats	Weekly	13 Day	946 603	255 928	78	18	60	23.08%
Implats	Weekly	55 Day	336 448	255 928	42	8	34	19.05%
Implats	Monthly	3 Day	642 080	257 480	47	13	34	27.66%
Implats	Monthly	13 Day	706 131	257 480	21	4	17	19.05%
Implats	Monthly	55 Day	812 739	257 480	21	4	17	19.05%
Kumba	Daily	3 Day	827 235	1 739 642	917	315	602	34.35%
Kumba	Daily	13 Day	10 184 141	1 739 642	411	108	303	26.28%
Kumba	Daily	55 Day	5 167 010	1 739 642	143	29	114	20.28%
Kumba	Weekly	3 Day	230 794	1 445 455	198	67	131	33.84%
Kumba	Weekly	13 Day	697 296	1 445 455	75	19	56	25.33%
Kumba	Weekly	55 Day	3 409 135	1 445 455	19	4	15	21.05%
Kumba	Monthly	3 Day	9 640 489	1 745 363	37	16	21	43.24%
Kumba	Monthly	13 Day	117 833	1 745 363	11	4	7	36.36%
Kumba	Monthly	55 Day	610 193	1 745 363	4	0	4	0.00%
Lonmin	Daily	3 Day	4 463 253	50 578	882	325	556	36.85%
Lonmin	Daily	13 Day	954 283	50 578	322	101	221	31.37%
Lonmin	Daily	55 Day	391 962	50 578	178	29	149	16.29%

Company	Chart resolution	MA period	Strategy Result	Buy and Hold Results	Number of transactions	Positive trades after fees	Negative trades after fees	Hit ratio after fees
Lonmin	Weekly	3 Day	81 354	58 952	191	56	135	29.32%
Lonmin	Weekly	13 Day	1 024 952	58 952	76	21	55	27.63%
Lonmin	Weekly	55 Day	3 263 966	58 952	28	4	24	14.29%
Lonmin	Monthly	3 Day	0	50 427	48	15	29	31.25%
Lonmin	Monthly	13 Day	339 304	50 427	18	4	14	22.22%
Lonmin	Monthly	55 Day	1 000 000	50 427	0	0	0	
Merafe	Daily	3 Day	4 375	2 519 481	887	238	649	26.83%
Merafe	Daily	13 Day	560 962	2 519 481	365	88	277	24.11%
Merafe	Daily	55 Day	2 187 626	2 519 481	173	31	142	17.92%
Merafe	Weekly	3 Day	581 123	2 200 000	177	61	116	34.46%
Merafe	Weekly	13 Day	3 081 210	2 200 000	69	20	49	28.99%
Merafe	Weekly	55 Day	598 611	2 200 000	25	5	20	20.00%
Merafe	Monthly	3 Day	14 564 510	2 042 105	29	16	13	55.17%
Merafe	Monthly	13 Day	757 291	2 042 105	11	3	8	27.27%
Merafe	Monthly	55 Day	1 050 575	2 042 105	3	1	1	33.33%
Northam	Daily	3 Day	6 053 534	974 286	885	350	555	39.55%
Northam	Daily	13 Day	2 288 851	974 286	343	106	237	30.90%
Northam	Daily	55 Day	1 048 786	974 286	155	34	121	21.94%
Northam	Weekly	3 Day	318 890	813 253	179	62	117	34.64%
Northam	Weekly	13 Day	281 091	813 253	80	21	59	26.25%
Northam	Weekly	55 Day	744 800	813 253	32	10	22	31.25%
Northam	Monthly	3 Day	1 434 914	1 012 871	45	18	27	40.00%
Northam	Monthly	13 Day	199 073	1 012 871	21	4	17	19.05%
Northam	Monthly	55 Day	348 605	1 012 871	9	0	9	0.00%
Wesizwe	Daily	3 Day	202	177 083	918	224	694	24.40%
Wesizwe	Daily	13 Day	578	177 083	471	71	400	15.07%
Wesizwe	Daily	55 Day	692 880	177 083	183	26	157	14.21%

Company	Chart resolution	MA period	Strategy Result	Buy and Hold Results	Number of transactions	Positive trades after fees	Negative trades after fees	Hit ratio after fees
Wesizwe	Weekly	3 Day	2 080 678	160 000	177	58	119	32.77%
Wesizwe	Weekly	13 Day	14 220 105	160 000	59	17	42	28.81%
Wesizwe	Weekly	55 Day	11 814 734	160 000	17	6	11	35.29%
Wesizwe	Monthly	3 Day	23 728 555	184 783	35	19	16	54.29%
Wesizwe	Monthly	13 Day	0	184 783	3	0	2	0.00%
Wesizwe	Monthly	55 Day	1 000 000	184 783	0	0	0	0.00%