Risk Assessment in Emerging Equity Markets: The case of South African

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DECLARATION

I, Donald Sibanda, declare that the research work reported in this dissertation is my own, except where otherwise indicated and acknowledged. It is submitted to fulfill the requirements for the Masters of Management in Finance and Investment degree at the University of the Witwatersrand, Johannesburg. This thesis has not, either in whole or in part, been submitted for a degree or diploma to any other institution or university for a similar qualification.

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Signature of Candidate Date

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Signature of Supervisor Date

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I want to dedicate the document to my partner Naniki and to my daughter **S**imple **S**imphie who passed away during my studies (6th July 2012). I took away so much time from you Simphie and want to honour you by completing my studies and obtaining the Masters qualification.

Abstract

South Africa is gripped by a poor investment culture with a large number of adults not investing. There is need to inform would be investors about alternative forms of investments like the stock market. The research estimates the amount of risk exposure for a South African equity portfolio using Value at Risk (VaR). The research reviews literature to get an understanding of the commonly used risk measure for financial markets. It looks at pros and cons of using VaR in determining risk exposure for the financial markets. The research will explore all possible methods of calculating VaR these are namely; Historic simulation, Monte Carlo simulation and Variance covariance method. VaR for the purpose of this research is calculated using the variance covariance method An equity portfolio is constructed using PE ratio as cut off criteria (cut off range 10<PE<12), this made the size of the portfolio small (20 stocks that complied with the selection criteria). The research will give an estimate value of amount of exposure to be expected in an equity portfolio.

Abbreviations

Altx	Alternative Exchange
ASISA	Association for Savings and Investments South Africa
ES	Expected Shortfall
EVT	Extreme Value Theory
FDI	Foreign Direct Investment
FSB	Financial Services Board
GDP	Gross Domestic product
JET	Johannesburg Equity Trading
JSE	Johannesburg Stock Exchange
MC	Monte Carlo
PE	Price to Earnings
SA	South Africa
SASI	South African Savings Institute
VaR	Value at Risk

Table of Contents

List of Tables

List of Figures

1 INTRODUCTION

The South African savings culture is poor as there is a tendency to perceive investment channels like financial markets as high risk. This tendency may be attributed to lack of information regarding risk hence the need to inform potential investors. According to Assaf (2009), in financial markets, extreme price movements may correspond to market correction during ordinary periods, to stock market crashes or to foreign exchange crises during extraordinary periods. Financial disasters are mainly attributed to poor supervision and management of financial risk according to Assaf (2009). Bonghoon *et al* (2006) said a developing country's benefit from opening its equity market is greater if it attracts more foreign direct investment (FDI) or engages in more trade with developed countries. The opening of the equity markets is a potential source of risk that must be well managed to avoid a financial crisis. Financial risk emanates from different areas of the financial markets; Brown and Kapadia (2007) researched on firm specific risk in the United States equity markets. The research discovered that new listings have a higher level of risk, hence the reason of constructing a portfolio containing stocks that have been listed for more than 5 years. According to Campbell *et al*. (2002) the whole market may not be volatile but individual stocks in the market may be highly volatile supporting the notion that there is firm specific risk that needs to be acknowledged. Jayanth and Varma (1999), In volatile financial markets, both market participants and market regulators need models for measuring, managing and containing risks. Shahiem and Biekpe (2003), Value at Risk and Expected Shortfall emerged as standard tools for measuring market risk. According to Polbennikov and Melenberg (2005) there is ongoing debate in the financial literature on which risk measure to use in risk management.

The research aims to give investors insight on the quantum and nature of risk exposure related to an equity portfolio in case they want to invest in the equity market. It looks at possible and feasible risk measures that can be used to estimate the risk exposure for the equity portfolio. There are a number of ways that can be used to measure risk and the study will concentrate on two risk measures that are widely used in the financial markets namely value at risk (VaR) and expected shortfall (ES). An equity portfolio is constructed from shares listed on the Johannesburg Stock Exchange (JSE). The portfolio will be constructed using different strategies to obtain an optimal equity portfolio.

1.1 Purpose of the study

This study aims to develop a possible risk measure that will be use to estimate the amount of risk exposure investors in the equity markets face. According to Adam *et al*. (2008) stock markets are highly volatile in nature and this brings upon risk of loss due to the fluctuation in share price. Volatility of share pricing is not easy to forecast and predict as shocks in the economy can derail any methodology that would have been used to make the predictions. This will assess the risk in an equity portfolio using possible risk measures that are currently being used in the financial sector. It reveals the most likely risk measures to be used in the assessment of risk (calculation of risk value). For the purpose of this study the assessment of risk will be limited to the equity markets; this is not to say that other sectors of the financial markets do not have risk or that they have less risk compared to equity markets. This study will show how much risk exposure is possible in the equity markets, even though it provides a good opportunity for investors as the size of this market has grown over the years and still continues to grow.

1.2 Context of Study

South Africa has a very poor investment culture, according to the South African Savings institute (SASI) 72% of adults in the country are not saving. This is due to a number of issues namely;

- People have not been taught to save,
- People are not sure where to save and
- People don't have enough information about different savings channels.

The issues listed above are just a few reasons why the investing culture is so poor in the country. This study aims to close the information gap and make potential investors knowledgeable about equity markets such that they are comfortable in saving through this channel. Figure 1 shows a summary of the percentage returns that were realised over twenty years looking at different investment channels;

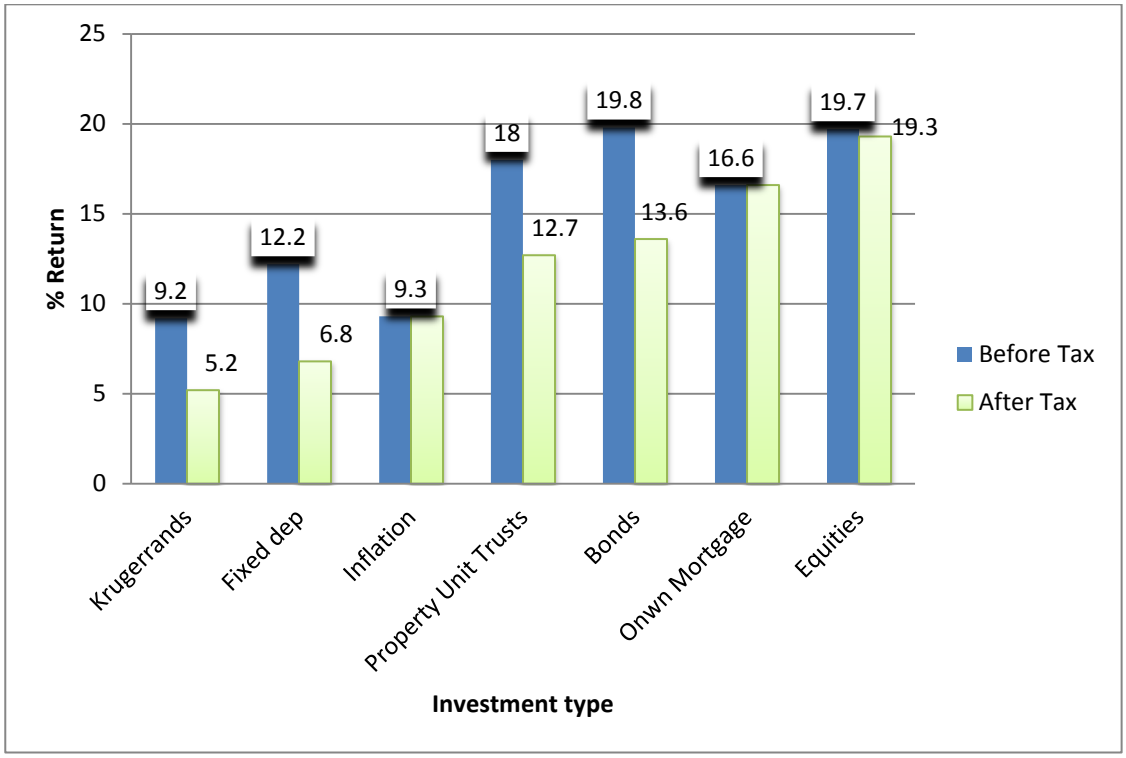

Figure 1: 20 year average annual returns- before and after tax (1985-2005)[1]

[1] Source: JP Morgan

The graph shows investment into equity markets yielding the highest after tax returns compared to the rest of the investment channels. In general the traditional high risk investments have yielded better returns compared to the low risk investments. The most common investment type is the fixed deposit as that is the one most people can easily access. Information on returns for this investment type (fixed deposit) is clearly stated in the contract.

According to a study by Finmark Trust[2], the study targeted 19 million people from the age of 16. It was discovered that 32% of adults have a bank account, but does not say whether it is used for savings or not. From the study 2% do not have a bank account and use other formal savings forms. About 15% of the target population use formal savings methods. The remaining 51% of the target population does not use any formal or informal savings instrument. Only 16% of the target population actually use the bank accounts for saving purposes. This research further strengthens the fact that there is a poor savings culture amongst people in South Africa. The study confirms that people cannot access basic savings products easily. This study will give potential investors an insight on alternative investment channels through understanding the amount of risk involved in the equity markets. The return from equity markets is most favourable as seen in the graph of Figure 1.

1.3 Problem Statement

There is a poor understanding of the financial markets in South Africa, this is due to the lack of information filtering to potential investors. Lack of education and training are holding many South Africans back from taking charge of their own savings and investments according to a self-investment survey released by online trading platform, Global Trader. There exists a culture among South Africans of "relying on other people to manage their financial well-being"[3].

The financial markets arena is ever diversifying trying to find sectors that exhibit minimal risk during any investment period. This is proving to be a tough call for both investors and investment advisors as the financial markets are ever on a volatile path according to

[2] Avanz Capital Ltd (2012), The private equity climate in Africa: Embracing the lion

[3] Source: http://www.peherald.com/news/article/7480 ,

Sohnke (2008) which makes it a bit difficult to forecast the behaviour over long periods. Macro economic factors have driven investments towards the emerging markets as it has been presumed that they are safe havens for investors. The recent global crisis left the financial markets depressed across different markets, though emerging markets did not suffer as much as the rest of the world markets. According to Chinzara and Aziakpono (2009), globalization together with technological improvements has made it difficult for the emerging markets to be isolated from the rest of the world markets, thus a recession in the world markets eventually filters to the so called emerging markets. As much as these markets are entwined there is still a belief that the emerging markets are not as exposed to recessionary shocks as the established markets are. Financial markets are diverse and for the purpose of this research the main focus is the equity markets for emerging markets.

1.4 Significance of the Study

The research will discuss portfolio risk measures. This research will also inform investors about the relative risk associated with equity markets in the South African financial Markets and quantify it. There is a perception that the equity markets are high risk arena and yet they cannot quantify the risk. The research will attempt to quantify the risk and inform potential investors so they can benchmark against their risk appetite. The equity market is one of the most vital areas of the market economy as it provides companies with access to capital and the investors with a chance to own a slice of a company and future potential gains that are based on the performance of the company in future.

1.5 Background Literature on SA Equities

In SA equities are traded on both the JSE main board and Alternative exchange (Altx). The main board lists big and mature companies and smaller companies are listed on the Altx. Equities have been traded since the establishment of the JSE as stated in section 2.1. Equity trading in SA has progressed over the years, figure 2 shows a huge increase in the private equity investment as a percentage of GDP between 2010 and 2011.

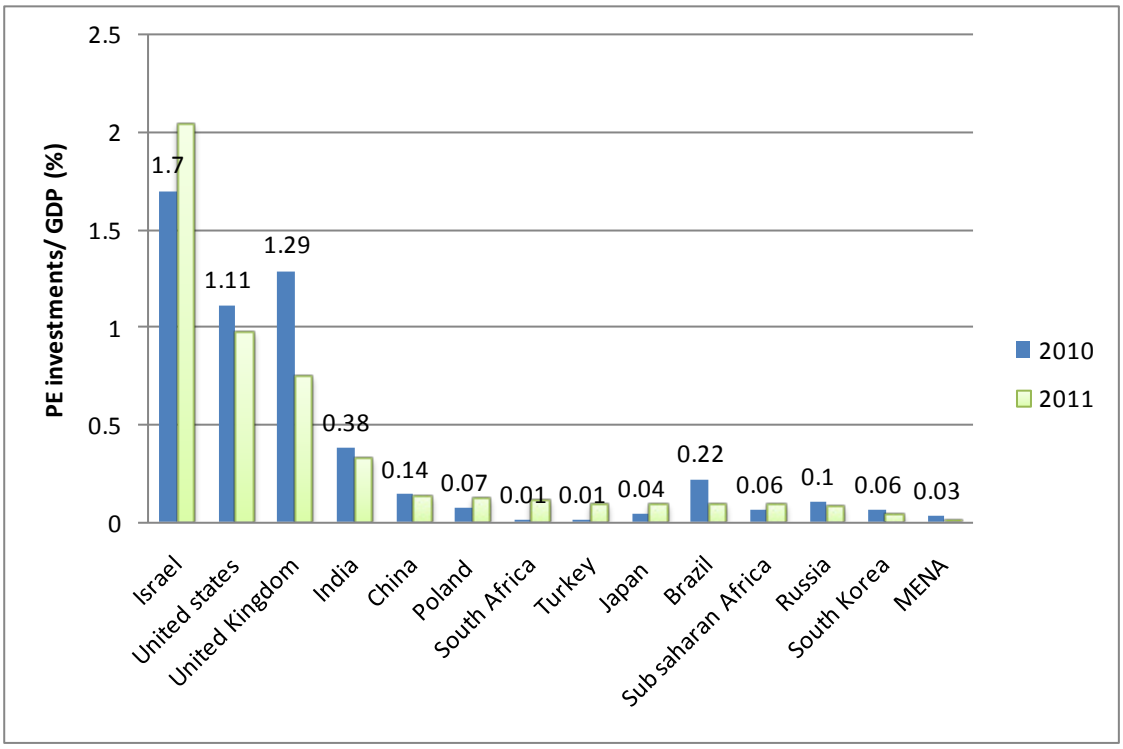

Figure 2: Private Equity Penetration- 2010 & 2011 (Percent of GDP)[4]

Currently the equity market has over 400 companies listed from 35 different industry sectors. The total market cap as at end of February 2013 was R7892 billion, the most dominant sectors in the market in terms of market cap are Mining (20.3%), Tobacco (11.94%), Beverages (9.75%) and Banks (8.3%). Mining is seen to be the key driver of the equity markets looking at the large contribution it makes in the overall equity market capitalization. It is then expected that any shock in the system that is targeted at the mining sector will greatly affect the financial markets. The sectors that contribute the lowest to the total equity market cap are Leisure and Goods (0.02%), Other securities (0.04%), Technology Hardware (0.05%) and Automobiles (0.06%). The details about other sectors and what their contributions are to the total market cap are in Appendix D.

[4] Source: Avanza Capital Ltd (2012)

1.6 Research Outline

This research will discuss methods used to assess risk in equity portfolios. It will profile the SA equity markets looking at the type of companies listed. The research will identify possible risk measures that can be utilised to calculate the risk exposure. After identifying the possible risk measures construction of an equity portfolio will occur, the risk measures will then be used to estimate the value of risk exposure for the particular portfolio. The research will look at both VaR and ES as possible risk measures, advantages and disadvantages for both measures will be explored. The VaR will be calculated using one of the methods that are commonly used in estimating VaR. An equity portfolio will be constructed using a particular strategy and daily price data will be utilised to calculate returns for 5 years. The equity portfolio will consist of stocks from different sectors so as to capture sector specific risk.

2 LITERATURE REVIEW

Brown and Kapadia (2007), profiles the risk involved in the equity markets and general performance of equity markets. Lumengo and Mutema (2009) confirms that the share prices are highly volatile hence opening up the markets to risk of loss. The review touches on the following:

- The Johannesburg Stock Exchange,
- Overall JSE profile,
- Performance of the equity markets in the JSE and
- Risk measures.

2.1 The Johannesburg Stock Exchange

In South Africa equities are mainly traded in the Johannesburg Stock exchange (JSE), which was established in 1887 and has been in existence since then and later became a member of the world federation of exchanges (1963). The JSE over the years has undergone changes that have seen it keep abreast with the rest of the trading markets that are in developed economies. As early as the time of establishment of the JSE market risk was already being talked about as a major concern, part of the reforms the market underwent was to try and minimize the amount of risk exposure to the investors by monitoring closely the performance of investments. The most key reform was the introduction of the stock exchange control Act which was legislated in 1947; this Act went a long way in minimizing risk that stemmed from lack of control in the market as capital requirements were not enforced before then for members and brokers.[5]

A number of different products are traded in the JSE and trading has been made simple for all that want to take part. As much as the JSE has been undergoing transformation to try and minimize any gaps, there is still the issue of risk that cannot be eliminated. In the markets financial risk can calumniate itself in different forms, hence the need to know more about financial risk and be able to quantify it for the sake of risk takers. The JSE as part of its reform has enacted different legislations to help counter some of the financial risks that may befall the market. In 1995 amendments were made to the legislation

[5] Source: JSE background information, www.jse.co.za

applicable to the JSE and these resulted in the deregulation of the stock exchange through the introduction of the limited liability corporate and foreign membership. The JSE went on to further introduce the Johannesburg Equity Trading (JET) system which is an order driven, centralized and automated system. The introduction of the JET made it easy to eliminate a lot of the risk associated with human error. In 1999 the JSE introduced the insider trading Act as part of its ongoing reforms meant to improve the functionality of the market. In the same year the JSE introduced the electronic settlement system in collaboration with four largest commercial banks in the country, this system made it easy for payments to be made and on time reducing liquidity risk that was a common in the market.[6]

Figure 3 shows the JSE's profile over the years looking at how many companies are listed, new listings, number of delisting, foreign listing and domestic listing. The market is diverse in that it lists both domestic and foreign companies. In 2007 a record high for number of new listings was achieved and the number has been declining since and in the same year a record high for the number of delisting was achieved and the number has been declining over the years. The number of domestic listings has been declining from 2007 to 2012 and foreign listing increasing steadily over the same period; this can be a cause for concern as this will make the JSE very sensitive to international economic occurrences.

[6] Source: JSE background information, www.jse.co.za

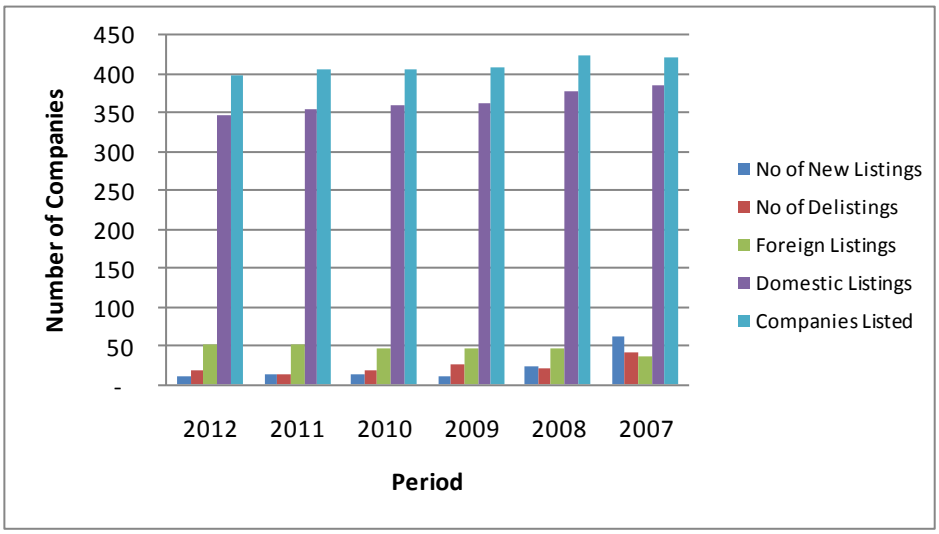

Figure 3: Overall JSE Equity Market Profile, 2007 to 2012[7]

As much as there has been an increase in the number of foreign listings this is still at a manageable level in terms of minimising market risk pertaining to ownership of foreign assets by investors. According to the financial mail Prescient Africa Equity was the highest performer in 2012 with a return of 48.5% followed by Investec Emerging Companies (40,7%), Nedgroup Entrepreneur (40,1%), Nedgroup Financials (39,8%) and Stanlib Industrial (37,5%). The worst performing funds were resource funds. Old Mutual Gold gave a negative 14,5% - foreign cash funds were not a comfortable place for investors in 2012, with the Old Mutual dollar fund giving 1,3% and Absa's 4,4%. Sharia funds performed poorly, particularly Element Islamic Equity, which gave a meagre 4,4%.

2.2 Overall JSE Profile

The JSE lists both domestic and foreign companies, the exchange has grown and matured a seriously over the years. As mentioned it has evolved in such a way that trading has been made efficient and secure. The exchange trades over 48 different products namely commodities, derivatives, equities, etc. The product range has increased over the years between the listed categories. The JSE consist of a main board and the AltX (alternative exchange). AltX is a division of the JSE. It runs parallel to the main board its main focus is on good quality, small and medium size companies that are not able to

[7] Source: JSE, http://www.jse.co.za/Home/Market_Data.aspx

list on the main board. It has also been called the incubator for the main board as it helps companies prepare for the main board listing.

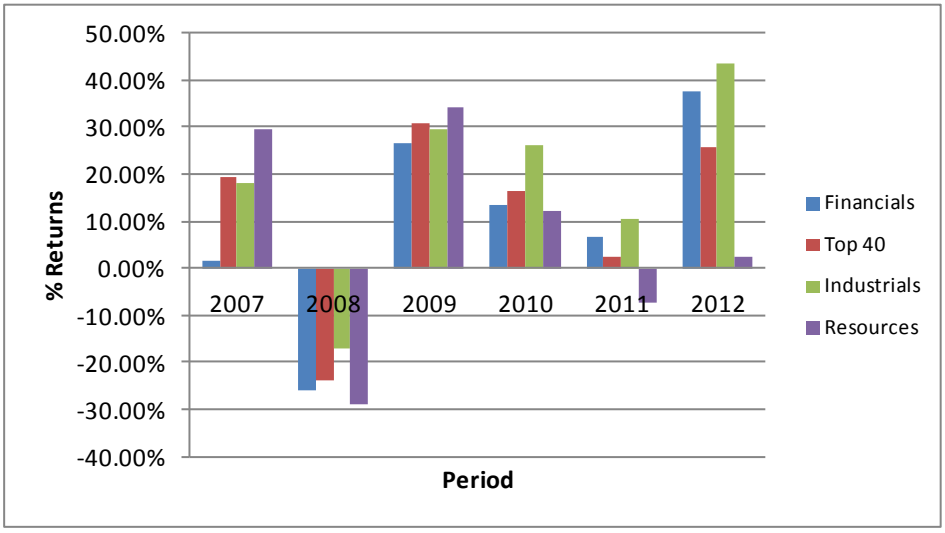

Figure 4: Annual Returns by Investment Type, 2007-2012[8]

Figure 4 illustrates the performance of 4 investment instruments from 2007 to 2012 for different investment types. It can be seen that all the investment types were affected badly by the recession that occurred in 2008 and they recovered in the following year. During the Euro-zone crisis, in 2011, the investment returns were again affected and returns fell. This shows that the domestic stock exchange is linked to foreign markets.

Figure 5 shows the performance of some of the assets in the JSE over 12 years; this paints a very good picture but does not illustrate volatility of the financial markets as it gives an average for the 12 year returns.

[8] Source: JSE, returns data

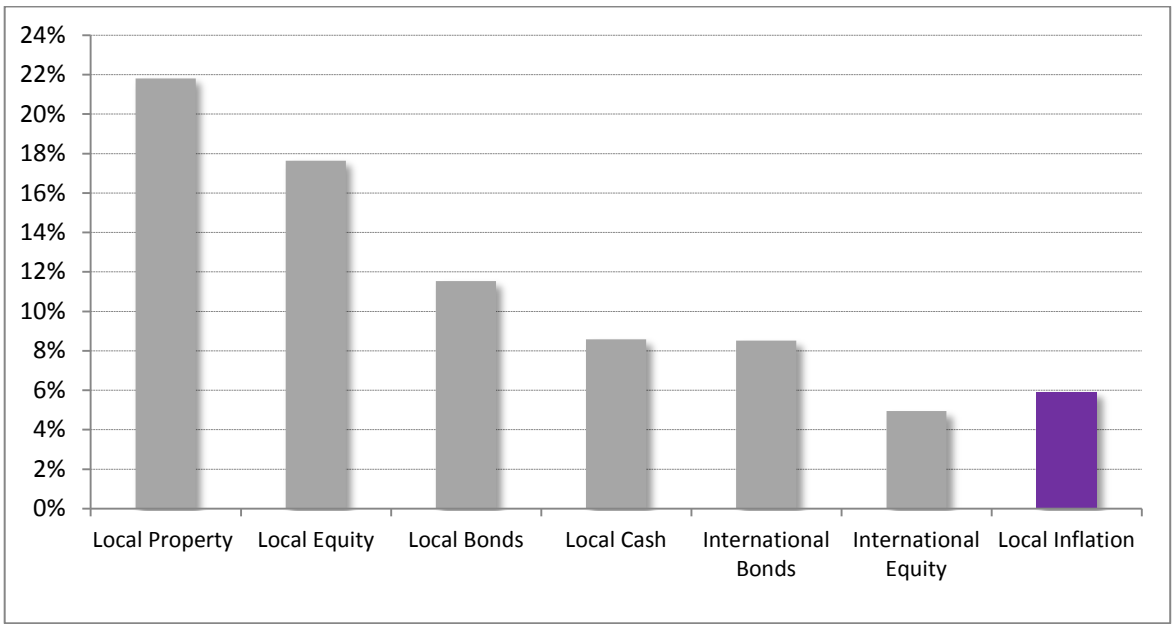

Figure 5: 12 Year Annualized Asset Class Returns[9]

From Figure 5 it can be seen that the local equity assets have yielded healthy returns over the 12 year period following the local property assets that are top performers. Returns from local cash assets have yielded the lowest returns considering the four listed local assets. It is interesting to note that all the annualised returns for these assets were above the local inflation rate with local property and equity assets yielding almost double the value of the inflation over the years at approximately 22% and 18% namely. The international equity performed below inflation meaning that the investors in this arena did not enjoy their return on investment.

Figure 6 shows cumulative return for some investment sectors that are listed on the JSE. It can be seen that Industrials have outperformed all other sectors and is followed by the top 40 by a very wide margin; the lowest performance is by the resources.

[9] Source: Morning star, financial information (2013)

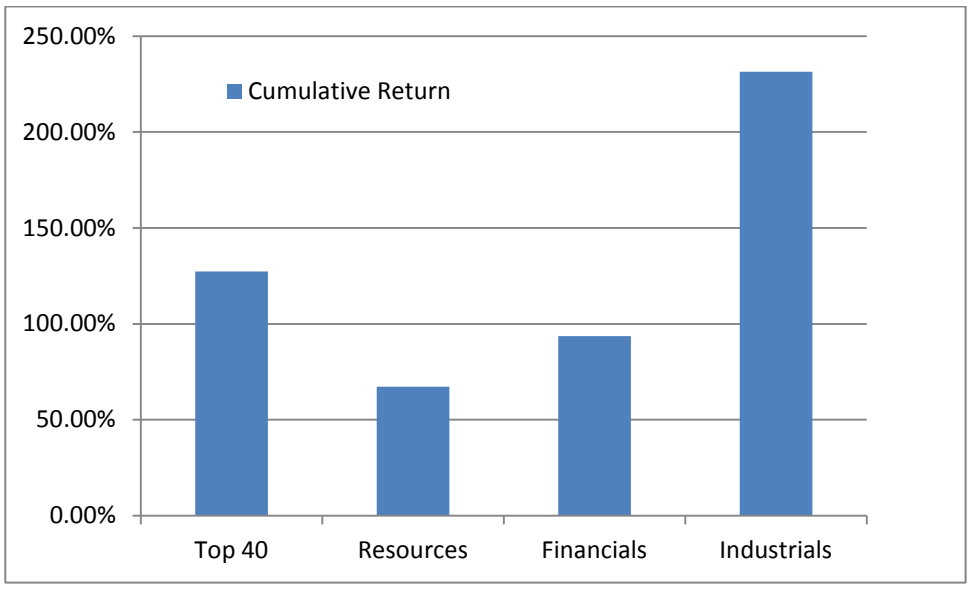

Figure 6: Cumulative Returns, 2006-2013[10]

The JSE's strong performance can be mistaken for a build up in investor confidence and a sign that the South African markets are turning around. According to Marriott Asset Management over 15 months ended June 2012, domestic investors ascended into the market, withdrawing R44bn from money market accounts and investing R47bn in balanced funds. Foreign investors have reportedly been pouring money into SA stock and bond markets in belief that they will get a higher return.

The JSE has other different investment vehicles like mutual funds and hedge funds; they also have risk exposure like the equity funds. A hedge fund is an investment vehicle that can undertake a wider range of investment and trading activities than other funds and is not restricted to any type of assets for example equities, bonds, etc. Generally only open to certain types of investors specified by regulators. The diversification of the portfolio goes a long way in helping mitigate risk of losing when chips are down in one sector can always make up from another sector. There is a foreseeable movement of hedge funds to the mainstream due to the amendment to regulation 28 of the Pension Fund Act. This Act determines where pension funds may invest and now with the amendment they can now invest up to 10% of their funds into the hedge funds from the 2.5% which was only stated under the category of assets as "other". In addition, there are current discussions being held between the Financial Services Board (FSB) and the Association for Saving and

[10] Source: JSE returns data

Investment SA (ASISA) to make these funds available to retail investors as well, of course at much lower initial capital barrier. The current Hedge Fund market is estimated at around R35bn. Hedge funds are a growing sector in the South African financial markets and according to Stephen Cranston (2012) financial analyst, new rules allowing SA pension funds to invest in hedge funds could, in theory increase the size of the industry to R300 billion. A mutual fund is an investment vehicle that has a pool of funds collected from many investors for the purpose of investing in different assets such as equities, bonds, money market instruments and similar assets.

2.3 Performance of the Equity Markets in the JSE

According to fin24.com the overall JSE was observed to be performing well during June 2012 trading period, this saw an increase in the revenues due to huge trading volumes and inflow of investments from foreign investors.

Reported trades	2012	2011	2010	2009	2008
Trades	24,824,788	24,746,289	23,758,618	20,950,750	17,398,986
Volume (mil)	58,025	66,349	71,252	82,855	83,778
Value (Rmil)	3,196,679	3,196,679	2,990,123	2,796,077	3,263,065

Table 1: Turnover on the Equity Markets [11]

In Table 1 above it can be seen that the amount of trades have increased over the years but the this has not translated in an increase in a value of trade looking at year 2012 and 2008. This has seen a decline in the volume of trade this can be attributed to the global financial crisis that affected most markets and there is still the ongoing Euro crisis. The volume of shares traded in 2008 is more than that in 2012 and yet the value of trade for the two years is more or less the same. This could be attributed to increase in share price over the year.

[11] Source: JSE returns data

Reported trades	2012	2011	2010	2009	2008
Purchases	481,822	429,494	485,495	524,492	586,986
Sales	490,464	445,026	449,085	449,074	641,425
Net (Sales)/ Purchase	-8,642	-15,532	36,419	75,418	-54,439

Table 2: Foreign trading on the Equity Markets (Rmil)[12]

Table 2 shows the amount of foreign trade that takes place in the equities market. There has been a huge decline in the number of purchases looking at years 2008 and 2012. It can be seen that foreign trade in the local equity markets seem to be falling over the years as more sales than purchases are being recorded meaning that foreign investors are not holding onto their stocks.

[12] Source: JSE financial data

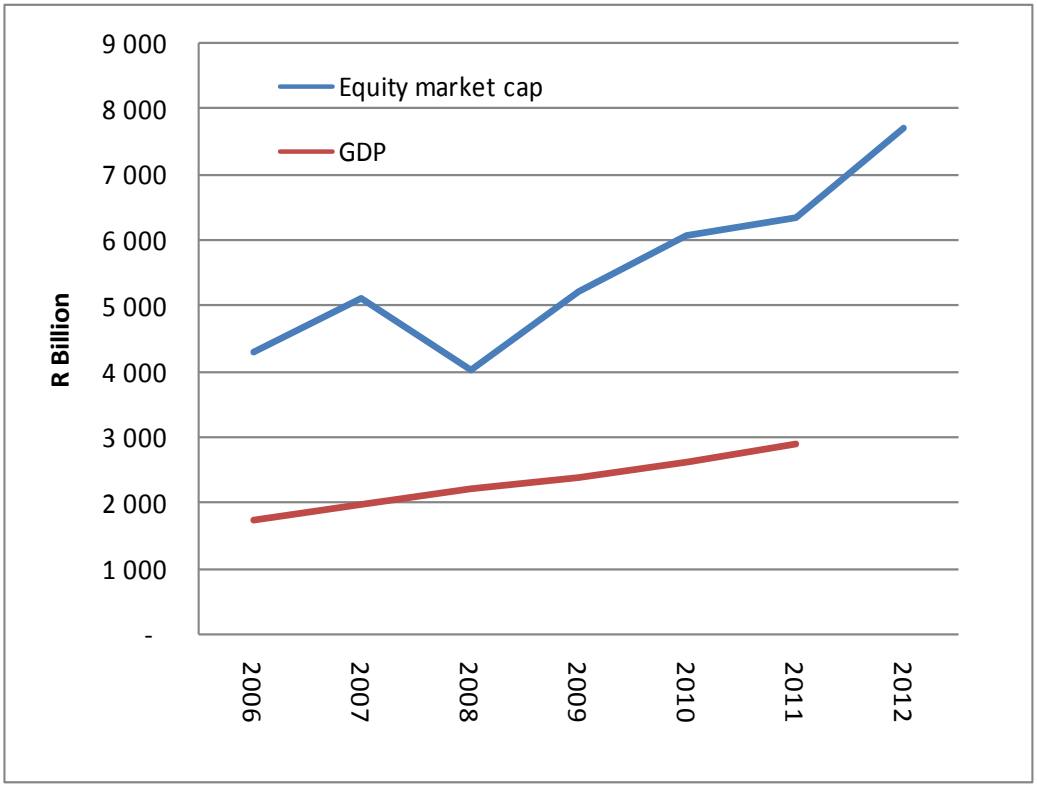

Figure 7: GDP vs Equity Market Capitalization, 2006-12[13]

Figure above shows how the equity market capitalisation has evolved over the years, generally the value of the equity assets has increased over the years. There was a steady increase in the cap value from 2006 to 2007, then it fell in 2008 (this fall can be attributed to the recession). This shows that it is difficult to divorce the stock market from the economy. The equity market capitalization has been growing faster than GDP, which over the years has had a steady increase in size. It can be seen that from the fall in the market size that happened in 2008 to the recent market size 2012, the market cap for the equity market has almost doubled.

[13] The graph was generated from data that was obtained from the reserve bank website and data from the JSE financial data published on the website

2.4 Assessment of Equity Portfolio Risk

There is a serious concern when it comes to the quantification of risk in the financial markets; there are many know measures of risk and these are namely volatility/ standard deviation, semi-variance (or downside risk), mean- variance approach, Expected shortfall (ES) and Value at Risk (VaR). It has become a norm to use Value at Risk (VaR) and Expected Shortfall (ES) to measure market risk. VaR is regarded to be weaker than ES since ES encourages diversification and VaR doesn't but the key advantages that VaR has is simplicity and that it is easier to back test compared to ES. VaR is used to measure risk exposure at a given probability. This is a good indicator of maximum risk a portfolio can be exposed to according to Viral *et al*. (2010) and expected shortfall is conditional VaR. According to Guermat (2003) there are three key methods of calculating VaR, namely variance co-variance method, historic simulation and Monte Carlo simulation (The Basle Committee[14], 1996; Beder, 1995; Hendricks, 1996; Mahoney, 1996; and Alexander and Leigh, 1997). These methods are focused on the whole distribution and this can prove to be a challenge when extreme market conditions occur which can cause the methods to fail and may mislead the risk manager. This has brought rise to the method called the extreme value theory (EVT). The EVT focuses on the tail end of the distribution and test have proven that EVT out performs the other methods during extreme conditions in the accuracy of calculating VaR (Danielsson and de Vries (1997b)).

The mean variance approach was introduced by Markowitz (1952) and used to be industry standard measure of risk. According to Polbennikov and Melenberg (2005) as much as the variance has computational advantage it is still not a satisfactory risk measure from the risk measurement perspective. It is very difficult to divorce financial market volatility from market crisis because a crisis is mainly formed from the lack of risk management. The only way to manage risk is if you are able to measure it, this is what most literature points to. If risk is not mitigated or controlled the end result is a crush in the financial markets. A crush in the markets is influenced by a lot of variables and normally builds up over time, hence the need to manage risk. Research by Campbell *et al*.2002 came up with puzzling results as it showed that firm specific volatility had increased in the US stock markets over the years and the market volatility had remained

[14] Basle Committee on banking supervision (1996), Amendment to the capital accord to incorporate market risks

unchanged. This was because at the time the US economy had stabilised but still the firm-specific volatility increased while it was expected to behave like the market volatility, stabilization in the economy makes it easy for investors to invest. Exchange rate instability has been identified as one of the major outcomes of financial liberalization in the emerging markets; this was discovered by Wyplosz (2001). The openness of the financial markets is another potential risk variable that needs to be monitored, this means that foreign direct investment (FDI) will have to be viewed with a different outlook as they can also be another vehicle for risk to enter the financial markets.

Investors are mainly focused on systemic risk in the markets compared to non systemic risk reason being that non systemic risk can be diversified and systemic risk cannot hence the need to be able to measure the systemic risk. As much as there is regulation out there designed to limit institutional risk like the Basel Accord they are not sufficiently focused on systemic risk according to Viral *et al*. (2010).

As part of the regulatory innovation, the Basel Committee [15](1996) approved the use of an internal method for modelling VaR instead of the strict use of the benchmark model. This has influenced the methodology that is used in this document for the modelling of VaR as it attempts to follow international best practise.VaR is defined as the maximum loss not exceeded with a given probability over a given period. This measure does not give any information about how severe the loss is which is exceeded. ES is defined as conditional VaR and according to Acerbi and Tasche (2001) ES has been profiled as the smallest coherent and low invariant risk measure to dominate VaR. According to Carlo *et al*. (2008) ES is a key tool for financial risk management. VaR has a number of limitations and disadvantages namely;

- VaR can be misleading as some people translate it as a measure that can inform them on the most that can be lost if its calculated at 99% confidence level and this gives investors a false sense of security.
- It does not measure worst case loss as it does not say anything about the size of loss.
- VaR becomes difficult to calculate for large portfolios because you don't just estimate the return and volatility only; you also need to estimate the correlation between the different assets.

[15] http://www.bis.org/publ/bcbs23.htm

- The different VaR calculation methodologies give different results for VaR, this makes the reliance on VaR questionable.

As much as VaR has a lot of weaknesses and limitations it also provides good advantages;

- It is easy to interpret as it gives a risk estimate in a single number, it is easy to understand.
- VaR can easily be compared across different assets and portfolios; another advantage of this risk measure is that it is usually available in various type of financial software. It is a measure that is utilised by everyone to estimate risk.

ES is not much better than VaR as it has its disadvantages namely;

- It is difficult to back test and this means that checks cannot be done on this calculation by supervisors,
- It is difficult to calculate and understand.

The two disadvantages stated are key to the continued use of VaR instead of ES which has been cited as superior to VaR. It would be great to use a coherent risk measure to calculate the possible risk exposure as it is more informative in that it can provide a view of both conservative and worst case scenario. A coherent risk measure has to conform to the following conditions;

(i). *Monotonicity*: this property refers to the fact that if an asset portfolio A has returns than another portfolio B, then the risk measure for portfolio A is greater.

(ii). *Translation invariance*: If an amount of cash K is added to a portfolio, the risk measure of the portfolio should go down by K. As cash is regarded as risk free.

(iii). *Homogeneity*: If the size of a portfolio is changed by a certain factor $\boldsymbol{\lambda}$ while keeping relative amounts of different items in the portfolio the same should result in the risk measure being multiplied by the adjustment factor $\boldsymbol{\lambda}$.

(iv). *Subadditivity*: the risk measure for two or more portfolios after they have merged should be no greater than the sum of their individual risk measures

These factors must be satisfied for a risk measure to be classified as a coherent risk measure, ES satisfies all properties whereas VaR only satisfies the first three conditions. These three conditions are straight forward given that the risk measure being used is denotes the amount of cash that needs to be added to a portfolio for its risk to be

acceptable. The forth condition states that diversification helps to reduce risk and this is mainly experienced in hedge fund portfolios. VaR does not satisfy all these conditions but satisfies only the first three compared to ES that satisfies all four conditions according to Tasche (2002) and is therefore a natural coherent risk measure that is alternative to VaR. The research will look at calculating both ES and VaR for equity portfolio that will be constructed for the purpose of the research. This will give a full view of the extent of risk exposure investors will face in the equity markets.

2.4.1 VaR Measures

Bohdalova (2007), there are three measures that are commonly used for the calculation of VaR that give a good estimator for the risk measure for a portfolio. These methods use historic data to calculate the risk measure, Reuse (2010);

2.4.2 Variance-Covariance Model

It was originally developed by JP Morgan and is currently regarded as the primary method for the calculation of VaR. The method observes movement of asset prices over time and uses probability theory to compute the possible maximum loss. This is done by calculating the standard deviation of the movement of an asset price and assuming a normal distribution with possible maximum loss within the required probability (usually 95%).

This method can use matrices to calculate the VaR by calculating the volatility of the portfolio of assets. Below is as an example of how volatility of a two asset portfolio would be calculated;

$$Vol_p = \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2\sigma_1\sigma_2\rho_{1,2}}$$

Where:

- $w_1$is the weighting of the first asset
- $w_2$is the weighting of the second asset
- $\sigma_1$is the standard deviation or volatility of the first asset
- $\sigma_2$is the standard deviation or volatility of the second asset

- $\rho_{1,2}$is the correlation coefficient between the two assets

Then VaR is computed as follows;

$$VaR_{1-\alpha} = Z_\alpha \times \sigma_p \times P$$

Where

- $VaR_{1-\alpha}$ is the estimated VaR at the confidence level 100 × (1–α) %.
- Z_α represents the number of standard deviations on the left side of the mean, at the anticipated standard deviation
- P represents the value of the portfolio

The calculation of VaR becomes a bit complicated when there are many assets in the portfolio, this brings rise to the use of matrices to compute the volatility of the portfolio as shown below;

$$\sigma_p^2 = [w_1 \cdots w_n] \begin{bmatrix} \sigma_{11} & \cdots & \sigma_{1n} \\ \vdots & & \vdots \\ \sigma_{n1} & \cdots & \sigma_{nn} \end{bmatrix} \begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix} = w' \sum w$$

Where:

- w is the vector of the individual weights of the n assets.
- w' is the transpose vector of w
- ∑ is the covariance matrix of the n assets

Calculation of VaR using the matrices is simplified by the use of software packages like excel that is easily available. There is no limit to the size of the matrix as long as there is internal consistency and to test for internal consistency, the matrices computation must satisfy the following condition;

$$w' \sum w \geq 0$$

2.4.3 Historical Simulation

This method involves the valuation of the entire portfolio of a financial institution a number of times. The fundamental assumption of this method is that it looks at the past in order to make an assumption about the future. The method basically says the past is a good indicator of the future; this is not always true as there are shocks in the systems that are unforeseen. This method uses daily collected historic data and is not as simple as the variance covariance method. The following steps are followed during the calculation of VaR;

(i). Identify the historical data period (usual a longer period to have many data points for accuracy)
(ii). Determine historical percentage price changes in all relevant forward curves
(iii). Apply historical changes to the current forward curves to generate shocked curves
(iv). Revalue the portfolio using the shocked curves and determine the change in the portfolio value
(v). Use the set of changes in the portfolio value to construct a distribution of potential changes
(vi). Determine the VaR from this distribution based on the selected confidence level

Sharma (2012), one advantage that Historic simulation (HS) has is that it does not use distributional assumptions to calculate VaR. And this makes it perfume better than methods that use distributional assumptions. A problem with HS noted by Sharma (2012) is that owing to discreteness of extreme returns and very few observations in tails the VaR measures are expected to be highly volatile and erratic. It was observed by Danielson and De Vries (1997) that under/ over prediction of VaR by HS is more severe in-case of an individual stock than index.

2.4.4 Monte Carlo simulation

It is a statistical technique that is used to estimate the probability of certain outcomes by running multiple trial runs (simulations) using random variables/ numbers. It can be used for analysis of risk by building models of possible results by substituting a range of values. It calculates results over and over using different random values from the probability functions. The Monte Carlo simulation (MC) can involve a large number of recalculations before it is complete and produces distributions of possible outcome values. These probability distributions are a more realistic way of describing uncertainty in variables of risk analysis.

The MC follows an algorithm that is similar to the one used in the historic simulation, the main difference is the first step of the algorithm. Below is the detailed step by step procedure for the MC:

Step 1: This is where the length of T of the analysis period and divide it equally into N (number of observations) of small time changes/ increments Δt *(i.e.* $\Delta t = T/N$*).*

Step 2: It entails the drawing of a random number from a random number generator and update the price of the asset at the end of the time change.

Generation of the random numbers usually follows a specific theoretical distribution; this at times is regarded as a weakness of the MC over the historical simulation which uses an empirical distribution. Generally in this method when simulating random numbers the normal distribution is used.

Step 3: Here step 2 must repeated until reaching end of the period T of analysis at the equal Δt intervals.

Step 4: Repeat step 2 and 3 a large number K of times to generate K different paths for stock over T.

Step 5: Ranking of the K terminal stock prices from the smallest to the largest, extract the simulated value in this series that corresponds to the desired (1-α)% confidence level (95% or 99% usually) and deduce the relevant VaR, which is the difference between S*i* and the αth lowest terminal stock price.

2.4.5 Back-testing

Back testing is a method used to test the accuracy of risk measurement models, this helps to bring credibility in the results that are obtained from a risk model. Most firms as stated in section 2.4 above use VaR as their risk measure. These firms are facing increasing pressure both internally and externally to provide estimates of the accuracy of their risk models, Carlos and Maksim (2006). The use of VaR extends from being a pure risk measure to risk control and is used in areas such as VaR based stress testing and capital allocation. This makes it more necessary for the risk models to produce more accurate numbers as a lot of decision making is dependent on it. In order to ensure the accuracy risk managers and officers regularly back test the models used and evaluate alternative models if the results are not satisfactory. Since VaR models provide a framework for the measure of risk, if a particular model does not perform its intended task properly then it should be refined or replaced and the risk measurement process must continue and calculate using new method.

3 RESEARCH METHODOLOGY

This section discusses the methodology followed in doing this research. This involved construction of an equity portfolio and then using different risk measures to assess the risk exposure for the created portfolio. The risk will be assessed using VaR and ES as risk measures. The return data will need to be cleaned so as to make calculation easy. The same risk measures will be used to assess risk in the whole JSE and compare the risk exposure with the equity portfolio. The risk measure will be computed utilising the daily returns data for a 5 year period. The aim is to develop a single risk measure for both the equity portfolio constructed and for the JSE. The risk measures will give an estimate of how much investors would be exposed to if they were to invest in that space. It should be noted that the risk measure gives an estimate of the loss amount. The actual loss can either be more or less than the value that is calculated.

3.1 Portfolio Construction

The portfolio is constructed using stocks from the JSE equity markets and will consist of between 20 and 30 stocks; the selection of stocks depends on a combination of different strategies for selection. The strategy uses the at Price-Earnings (P/E) ratios for stocks that fall in the set a range (10< P/E <12) stocks were selected. A high P/E suggests that investors are expecting higher earnings growth in the future compared to companies with a lower P/E. However, the P/E ratio does not tell the whole story by itself. It is important that investors note an important problem that arises with the P/E measure, and to avoid basing a decision of stock selection on this measure alone. This portfolio is constructed to help assess amount of risk in a portfolio that is not constructed with risk mitigation as the key driver of setting up the portfolio. The portfolio consists of stocks from different sectors like mining, property, chemical, etc.

The portfolio initially was going to have around 26 stocks but has been reduced to 20 listed companies. The initial selection included companies that were new listings and the observation period is five years, hence those that fall below this period have been removed from the portfolio. Table 3 shows the various sectors contained in the portfolio and number of stocks from the different sectors that constitute the equity portfolio.

Sector	Number of stocks
Mining	6
Construction & Materials	1
General Industrials	1
Support Services	1
Equity Investment Instruments	1
Industrial Engineering	3
Industrial Metals & Mining	1
Automobiles & Parts	1
Chemicals	1
Travel & Leisure	1
Technology Hardware & Equipment	1
Electronic & Electrical Equipment	1
Financial Services	1

Table 3: Portfolio Profile[16]

The equity portfolio is composed of 13 different industry sectors and mining accounts for 30% of the total composition followed by Industrial engineering sector that accounts for 15% of the portfolio.

3.2 Data Collection

All the data was collected from Bloomberg which is an interactive financial data warehouse that keeps track of all the trading that happens in all stock markets. The data warehouse is able to supply data for daily, weekly, monthly and yearly trade for any particular stock that is listed on any stock exchange. For the purpose of this research data is collected for daily to increase the number of data points, the more the data points the better the accuracy of any model. The data is cleaned to make sure it is easily comparable for the different assets, as data is downloaded there is a problem in getting all the pricings aligned well according to the date. Another challenge is that some assets are new listings and other delist during the set period and this is proving to be a challenge to choose and asset that has been listed for the full five year period.

[16] This table shows the sectors from which the stocks included in the portfolio are selected from and it can be seen that the mining sector represents 30% of the total portfolio. The full details about the company is in the table 4

There are different ways of determining the weights by different portfolio managers, some use past performance data to allocate weights, while others use size of the stock in the overall market, etc. The research utilises the market cap size to determine weighting in the portfolio and this is shown in Appendix B, with mining companies having the largest weighting. The lead companies in terms of high weights are namely; BHP Biliton (46.67%), Anglo American (27.22%) and Kumba Iron Ore (13.67%). This can create a problem for the portfolio as its key contributors are from one sector, this would mean if shocks occur in the mining sector the portfolio will be highly exposed.

4 EMPIRICAL RESULTS

Table 2 contains the list of stocks that form part of the equity portfolio constructed according to 3.1. The portfolio contains stocks from different sectors and is mainly dominated by mining sector. This means that the equity portfolio is not balanced well and will tend to be sensitive to any economic shock that affects commodities. For the purpose of this research the portfolio was used as is because it met the short listing criteria. The size of the market capitalization was mainly influenced by the fact that the portfolio contained a greater number of mining stocks than any other sector. The mining sector is a capital intensive industry. This means that most mines sell shares to raise capital for company operation.

Alpha	Name	PE	EY	MarketCap	ClosingPrice
PHM	Phumelela Game Leisure	10.22	9.78	717,047,531	930
PAN	Pan African Resource plc	10.39	9.63	3,512,054,914	242
PNC	Pinnacle Tech Hldgs Ltd	10.49	9.53	3,122,639,403	1837
ELR	ELB Group Ltd	10.51	9.52	1,113,994,000	3290
HDC	Hudaco Industries Ltd	10.57	9.46	3,927,656,065	11500
HCI	Hosken Cons Inv Ltd	10.57	9.46	13,289,980,864	9700
ZED	Zeder Inv Ltd	10.79	9.27	2,934,265,551	300
BCF	Bowler Metcalf Ltd	10.81	9.25	672,053,302	760
AGL	Anglo American plc	10.83	9.23	364,829,242,684	25958
IVT	Invicta Holdings Ltd	11.13	8.99	6,184,539,409	8300
BIL	BHP Billiton plc	11.14	8.97	625,667,357,622	29289
AFT	Afrimat Limited	11.36	8.81	1,103,120,572	770
RLO	Reunert Ltd	11.45	8.74	15,109,519,945	7535
PET	Petmin Ltd	11.49	8.70	1,263,428,932	219
ASR	Assore Ltd	11.58	8.64	56,875,891,800	40740
HWN	Howden Africa Hldgs Ltd	11.66	8.58	1,902,857,706	2895
ARI	African Rainbow Min Ltd	11.76	8.50	40,927,846,375	18990
MTA	Metair Investments Ltd	11.76	8.50	4,934,406,156	3235
OMN	Omnia Holdings Ltd	11.85	8.44	9,232,728,474	13729
KIO	Kumba Iron Ore Ltd	11.86	8.43	183,212,710,021	56888

Table 4: Constructed Equity Portfolio[17]

[17] Data was obtained from JSE research department for all listed equity stocks and was cleaned according to the portfolio construction criteria described in **section 3.1**

Table 4 details the companies that form the constructed equity portfolio. The highest contributor to the market capitalization value is BHP Billiton followed by Anglo platinum and Kumba Iron ore. The lowest contribution to the portfolio market capitalization is by Pumelela game leisure which is part of the tourism sector. The full portfolio breakdown by sector is found under the section 3.1.

	E Portfolio	Top 40	All share
Mean	0.00054	0.00035	0.00035
standard dev	0.00794	0.01573	0.01436

Table 5: Statistics of the Portfolio vs Top 40 and All share

Table 5 compares the Equity portfolio to the Top 40 and the All share index, the equity portfolio has a larger average return compared to the other two stocks. He equity portfolio has the lowest standard deviation meaning also the volatility is the lowest, normally it is said that high risk means higher return in this case it does not seem to be correct.

The portfolio contains 20 observations with a mean of 0.00054 and standard deviation of 0.00794. Data on share price was obtained over 1279 days in five years and the market capitalization of this portfolio is R 67 billion, this is calculated by averaging the total market caps for all the stocks. The portfolio capitalization figure can be misleading as it does not give the true value of the portfolio. The portfolio return for the portfolio is calculated by multiplying individual weights per stock return and sum up the results. The stock weighting is determined by the market cap contribution by each stock to the total R67 billion.

The VaR figure for the portfolio is R 0.876 billion and this makes up 1.3% of the value of the portfolio. The calculation was done using the variance covariance methodology and the matrices that were used for the calculation are by the Appendix.

5 CONCLUDING REMARKS

The constructed portfolio as mentioned in chapter 4 is not well balanced. The VaR figure calculated will give a good indication of the risk exposure to a potential mining investor. This is because 30% of the stocks are from the mining sector; this is still a good measure for risk exposure that can be used to benchmark expected losses. The study has managed to estimate a value for the expected loss at 95% confidence interval. The challenge with the outcome is that it does not give an indication of what future losses will be like. The value obtained from the research does not give a full explanation of the magnitude of loss; this is one of the disadvantages for the use of VaR as a risk measure. The result says that loss is 1.3% of the market capitalization, it can be inferred that if an investor wants to invest in a portfolio of similar composition loss from the portfolio is estimated at 1.3% of the total amount invested. This figure can be misleading as much as it does not give the worst case scenario on loss; investors may enter into an investment anticipating that loss cannot be beyond the 1.3% mark. There is a need to have a measure that is able to explain fully the dynamics on the risk in the equity portfolio. It would not be wise to base investment decisions just by considering VaR alone, VaR must be one of the factors considered in making the decision.

Investors must look at developing a robust investment criterion that will incorporate many different indicators (VaR should be one of the indicators that an investor can look at before investing). The investors must develop an understanding for key economic drivers that affect the financial markets as a whole. The research has shown that VaR is widely used measure for the risk exposure with both advantages and disadvantages as shown in section 2.4. Even though VaR has more disadvantages than advantages it is still the widely used risk measure in the financial sector.

There is a need to utilise a more comprehensive strategy when constructing a portfolio of stocks so as to avoid having portfolio that is sector biased. Sector biased portfolios run a risk of high exposure when the sector suffers shocks, hence the need to have a mixed portfolio to help counter any shocks that befall one sector. This solution only assists if there are sector specific shocks not if the whole market is shocked (i.e. all the sectors are shocked).

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Appendix A

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	Phumelela	*PAN AFRICAN RESOURCE PLC*	*Pinnacle Tech*	*Elb Group*	*Hudaco*	*Hosken Cons Inv*	*Zeder Inv Ltd*	*Bowler Metcalf*	*Anglo American plc*	*Invicta*	*BHP Billiton plc*	*Afrimat*	*Reunert Ltd*	*Petmin Ltd*	*Assore Ltd*	*Howden*	*African Rainbow Min Ltd*	*Metair*	*Omnia*	*Kumba*
Phumelela	0.00050138	-1.78973E-05	7.5567E-06	1.98029E-05	9.68E-06	2.28357E-05	8.93784E-06	1.04E-05	2.58171E-05	-1.49E-06	1.44346E-05	3.84262E-05	2.73E-05	-5.64E-06	1.35076E-05	3.2E-05	1.86911E-05	8.84343E-06	7.15E-06	8.04E-06
PAN AFRICAN RESOURCE PLC	-1.79E-05	0.001451576	8.7767E-05	2.6702E-05	5.152E-05	5.8638E-05	8.40983E-05	-1.29E-05	0.000227905	1.14E-05	0.00018426	5.82185E-05	3.5E-05	8.53E-05	8.49132E-05	4.72E-05	0.000213777	8.76435E-05	4.07E-05	0.000158
Pinnacle Tech	7.5567E-06	8.77674E-05	0.00069722	3.19726E-05	3.435E-05	6.84109E-05	5.48112E-05	1.82E-05	0.000147812	2.6E-05	0.000122767	1.3469E-05	8.99E-05	9.38E-05	9.20896E-05	2.73E-05	0.00015303	-2.2442E-05	5.04E-05	0.000114
Elb Group	1.9803E-05	2.6702E-05	3.1973E-05	0.000599358	3.293E-05	8.31952E-07	-8.5032E-06	2.14E-05	7.398E-05	1.57E-05	7.79757E-05	-1.5179E-05	3.59E-05	4.02E-05	-4.3903E-06	-3.31E-05	4.51426E-05	3.23144E-05	8.88E-06	3.34E-05
Hudaco	9.6805E-06	5.15218E-05	3.4353E-05	3.2929E-05	0.0003074	2.05267E-05	4.24785E-05	1.31E-05	9.79307E-05	5.82E-05	8.79863E-05	3.83012E-05	5.02E-05	3.49E-05	4.05402E-05	1.53E-05	8.43969E-05	3.28782E-05	4.52E-05	7.09E-05
Hosken Cons Inv	2.2836E-05	5.8638E-05	6.8411E-05	8.31952E-07	2.053E-05	0.000432071	4.87872E-05	6.53E-06	6.92448E-05	1.51E-05	6.48601E-05	5.09312E-05	5.61E-05	2.58E-05	3.43133E-05	1.79E-05	4.46866E-05	-7.4826E-05	2.21E-05	6.87E-05
Zeder Inv Ltd	8.9378E-06	8.40983E-05	5.4811E-05	-8.5032E-06	4.248E-05	4.87872E-05	0.000396301	1.09E-05	8.00727E-05	1.13E-05	8.19214E-05	1.74873E-05	6.02E-05	4.26E-05	2.4148E-05	-1.66E-05	8.51849E-05	3.52665E-06	4.28E-05	5.82E-05
Bowler Metcalf	1.0405E-05	-1.29455E-05	1.8173E-05	2.13723E-05	1.313E-05	6.53137E-06	1.0856E-05	0.000354	4.90012E-05	9.79E-06	4.35035E-05	-5.046E-06	1.26E-05	3.27E-05	-5.1188E-05	3.95E-05	4.36504E-05	2.66082E-05	4.55E-06	3.1E-05
Anglo American plc	2.5817E-05	0.000227905	0.00014781	7.398E-05	9.793E-05	6.92448E-05	8.00727E-05	4.9E-05	0.000835771	6.58E-05	0.000640948	4.36406E-05	0.000174	0.000147	0.000217064	2.86E-05	0.000492027	2.06475E-06	8.39E-05	0.000429
Invicta	-1.488E-06	1.13511E-05	2.5985E-05	1.56879E-05	5.824E-05	1.51347E-05	1.13364E-05	9.79E-06	6.58309E-05	0.000422	5.27217E-05	2.61526E-05	2.07E-05	3.22E-05	3.87701E-05	3.81E-05	6.15252E-05	1.52789E-05	2.56E-05	5.65E-05
BHP Billiton plc	1.4435E-05	0.00018426	0.00012277	7.79757E-05	8.799E-05	6.48601E-05	8.19214E-05	4.35E-05	0.000640948	5.27E-05	0.000696357	4.00825E-05	0.000175	0.000138	0.00017041	1.61E-05	0.000419432	-1.4825E-05	7.02E-05	0.000352
Afrimat	3.8426E-05	5.82185E-05	1.3469E-05	-1.5179E-05	3.83E-05	5.09312E-05	1.74873E-05	-5.05E-06	4.36406E-05	2.62E-05	4.00825E-05	0.000855811	2.38E-05	5.76E-05	6.08345E-05	6.38E-06	7.14027E-05	-1.9058E-05	3.17E-05	4.76E-05
Reunert Ltd	2.7273E-05	3.49535E-05	8.9859E-05	3.59235E-05	5.024E-05	5.6138E-05	6.02409E-05	1.26E-05	0.000173764	2.07E-05	0.000175293	2.37782E-05	0.000389	8.31E-05	5.70632E-05	2.01E-05	0.000145535	-1.7811E-06	8.44E-05	0.000136
Petmin Ltd	-5.641E-06	8.52624E-05	9.3765E-05	4.02389E-05	3.495E-05	2.57687E-05	4.25823E-05	3.27E-05	0.000146913	3.22E-05	0.000137554	5.75721E-05	8.31E-05	0.000864	0.000107786	1.58E-05	0.000160267	-1.1556E-05	6.51E-05	0.000179
Assore Ltd	1.3508E-05	8.49132E-05	9.209E-05	-4.3903E-06	4.054E-05	3.43133E-05	2.4148E-05	-5.12E-05	0.000217064	3.88E-05	0.00017041	6.08345E-05	5.71E-05	0.000108	0.001058642	-9.5E-07	0.000243357	1.50134E-05	3.37E-05	0.000191
Howden	3.2026E-05	4.72361E-05	2.7283E-05	-3.3119E-05	1.529E-05	1.79397E-05	-1.6569E-05	3.95E-05	2.85743E-05	3.81E-05	1.60909E-05	6.37524E-06	2.01E-05	1.58E-05	-9.4963E-07	0.000551	2.48551E-05	2.47303E-05	1.21E-06	3.89E-05
African Rainbow Min Ltd	1.8691E-05	0.000213777	0.00015303	4.51426E-05	8.44E-05	4.46866E-05	8.51849E-05	4.37E-05	0.000492027	6.15E-05	0.000419432	7.14027E-05	0.000146	0.00016	0.000243357	2.49E-05	0.000842773	-2.4603E-05	9.07E-05	0.000415
Metair	8.8434E-06	8.76435E-05	-2.244E-05	3.23144E-05	3.288E-05	-7.4826E-05	3.52665E-06	2.66E-05	2.06475E-06	1.53E-05	-1.4825E-05	-1.9058E-05	-1.78E-06	-1.16E-05	1.50134E-05	2.47E-05	-2.4603E-05	0.001126162	5.18E-05	1.63E-05
Omnia	7.1531E-06	4.07472E-05	5.0395E-05	8.8786E-06	4.518E-05	2.2082E-05	4.28243E-05	4.55E-06	8.38992E-05	2.56E-05	7.01557E-05	3.16979E-05	8.44E-05	6.51E-05	3.37413E-05	1.21E-06	9.06851E-05	5.17868E-05	0.000354	7.59E-05
Kumba	8.0361E-06	0.000158285	0.00011423	3.34208E-05	7.09E-05	6.86953E-05	5.82237E-05	3.1E-05	0.000428924	5.65E-05	0.000352481	4.76174E-05	0.000136	0.000179	0.000190584	3.89E-05	0.000414715	1.62868E-05	7.59E-05	0.000759

Appendix B

W=	Phumelela Game Leisure	0.0005
	Pan African Resource plc	0.0026
	Pinnacle Tech Hldgs Ltd	0.0023
	ELB Group Ltd	0.0008
	Hudaco Industries Ltd	0.0029
	Hosken Cons Inv Ltd	0.0099
	Zeder Inv Ltd	0.0022
	Bowler Metcalf Ltd	0.0005
	Anglo American plc	0.2722
	Invicta Holdings Ltd	0.0046
	BHP Billiton plc	0.4667
	Afrimat Limited	0.0008
	Reunert Ltd	0.0113
	Petmin Ltd	0.0009
	Assore Ltd	0.0424
	Howden Africa Hldgs Ltd	0.0014
	African Rainbow Min Ltd	0.0305
	Metair Investments Ltd	0.0037
	Omnia Holdings Ltd	0.0069
	Kumba Iron Ore Ltd	0.1367

Appendix C

σ_p^2 =	$W'\Omega W$ =	6.31169E-05
	σ_p =	0.007944616

$VaR = Z_\alpha \times \sigma_p \times P$

Z_α =	1.645
σ_p =	0.007944616
P =	R 67 billion
VaR =	0.875615876
% loss to value of portfolio	1.3%

Appendix D

Sector	Market Cap Rands	Share of Total Market Cap
Automobiles	5 049 774 320	0.06%
Banks	654 858 475 200	8.30%
Beverages	769 260 640 290	9.75%
Chemicals	30 822 121 142	0.39%
Construction and material	70 740 991 262	0.90%
Electronic and electrical	25 305 202 467	0.32%
Equity investment instrument	90 892 466 548	1.15%
Financial services	148 974 523 816	1.89%
Fixed line telecoms	7 915 915 250	0.10%
Food and drug retailers	164 269 506 497	2.08%
Food producers	151 222 551 994	1.92%
Forestry and paper	72 266 808 095	0.92%
General Industrials	219 052 545 267	2.78%
General retailers	229 289 559 411	2.91%
Health care equip	112 865 645 553	1.43%
Household goods	47 868 539 890	0.61%
Industrial engineering	16 258 465 830	0.21%
Industrial metals	205 078 818 428	2.60%
Industrial Transportation	74 708 733 065	0.95%
Leisure Goods	1 247 946 233	0.02%
Life Insurance	344 779 300 239	4.37%
Media	255 847 293 330	3.24%
Mining	1 602 533 613 410	20.30%
Mobile Telecoms	517 369 322 652	6.56%
Non life insurance	25 123 962 145	0.32%
Oil and Gas producers	249 911 337 843	3.17%
Other securities	2 982 618 337	0.04%
Personal goods	376 487 712 534	4.77%
Pharmaceuticals & Biotechnology	90 305 736 751	1.14%
Real Estate Investment	291 352 622 036	3.69%
Software and Computer	18 899 073 202	0.24%
Support Services	13 890 432 117	0.18%
Technology Hardware and Equipment	4 214 334 606	0.05%
Tobacco	942 396 808 781	11.94%
Travel and Leisure	58 378 229 944	0.74%
Total Market Cap	**7 892 421 628 484**	**100.00%**