MAF007 How effective was diversification during the 2008 global financial crisis?

Hawinkels, J., Morley-Jepson, S., Wood, L., Rajaratnam, K, & Parsons, S
University of Cape Town

Abstract

Portfolio diversification refers to an investment strategy of investing in a variety of assets in an attempt to reduce or eliminate overall investment risk within that portfolio. This research paper extends prior research on the effect of portfolio concentration on diversification on the Johannesburg Stock Exchange.

This preliminary study, expanding on the work of Neu-Ner and Firer (1997), investigates the relationship between portfolio concentration and diversification prior to, during and after the 2008 global financial crisis. This research also applies alternative risk measures, and introduces the concept of Principal Component Analysis using the methodology of Meucci (2010) in order to generate a measure of the effectiveness of portfolio diversification during these three periods.

The research conducted shows that during the financial crisis, the level of downside risk in a portfolio was substantially higher than in the pre-crisis and post-crisis periods. It also finds that diversification was most effective prior to the crisis, while during the crisis, increased diversification was required to maintain consistent risk exposure levels within the market.

In the pre-crisis period the standard deviation of value and growth shares is almost identical, suggesting that the level of risk evident in the two types of shares was similar. Over the crisis and post-crisis periods value shares are associated with lower levels of risk than growth shares.

Keywords: 2008 global financial crisis, concentration, diversification, equally-weighted portfolio, financial crisis, portfolio risk, weighted portfolio, diversification, portfolio risk, principal component analysis, systematic risk

INTRODUCTION

The principle of diversification is an essential component to creating any well-constructed portfolio. This principle is that the unsystematic risk unique to each particular asset can be mitigated through diversification. In well-diversified portfolios unsystematic risk is eliminated and therefore a portfolio consisting of different types of assets that are differently correlated with one another will have insignificant unsystematic risk.

The main principles of the modern portfolio theory are based on analysing and evaluating sensible portfolio choices based on risk-return trade-offs and efficient diversification (Gartner, Rödder & Rudolph, 2009). Post-modern portfolio theory takes into account

portfolio managers' specific goals and attempts to avoid negative risks (deviations from the mean return) and seek positive risks instead (Gartner, Rödder & Rudolph, 2009). Investors are often more concerned with negative deviations from the mean because they represent the financial risk associated with losses.

In addition to risk management, many investors choose to allocate their funds across various *styles* rather than among individual securities in the portfolio construction process. The Johannesburg Stock Exchange (JSE) defines a *style* as "an investment strategy that groups companies by their apparent different rates of return" (JSE, 2014). The popularity of style investing has led to the creation of style indices by the JSE. Two of the more popular investment styles used by investors are *value* and *growth*.

A concentrated portfolio represents increased risk to a portfolio manager because the large weighting of the shares within the portfolio limits the amount of attainable diversification (Kruger, 2008). There is no broadly accepted measure to determine how diversified a portfolio is, as well as where diversification arises in a given portfolio. One of the most widely used measure of concentration is the Herfindahl-Hirschman Index (Bikker & Haaf, 2000), calculated as the sum of the squares of the market share (expressed as a fraction) of each asset in the market. Meucci (2010) uses the technique of Principal Component Analysis (PCA) as a means to determine the commonalities, or principle components, that contribute to defining a portfolio as being diversified.

Concentration risk has been a major role player in the recent instability of many financial systems (Raubenheimer, 2010). However there is limited research on portfolio concentration and its effect on the level of attainable diversification in a South African context. Neu-Ner and Firer (1997) stated that as the size of a portfolio increases, the risk of the portfolio is reduced because of the elimination of unsystematic risk. They found that in order to achieve create a well-diversified portfolio on the Johannesburg Stock Exchange (JSE) it was necessary to hold at least 30 randomly selected shares.

The 2008 global financial crisis provides a unique period in our recent market history that is rich with research possibility. To date, no comprehensive studies exist that have attempted to explore the findings of earlier research into portfolio diversification and concentration on the JSE within this period of extreme volatility and uncertainty.

RESEARCH OBJECTIVE

The primary aim of this research paper is to better investigate the relationship between diversification and portfolio concentration in order to better understand how portfolio concentration affects portfolio managers. A minor aim of this paper is to extend Hawinkels *et al.* (2014). As a result, we follow Hawinkels *et al.* (2014) in constructing this research.

The paper will expand on the findings of Neu-Ner and Firer on the effects of portfolio diversification within the JSE context, by establishing the level of attainable diversification in a portfolio when taking into account only the negative deviations from the mean return. It

will also explore alternative risk measures, as well as introduce the concept of concentration and its effect on portfolio diversification.

The focus will be specifically on the period of the 2008 global financial crisis, and the study will be divided into pre-crisis, crisis and post-crisis time periods. During each period the performance of the value and growth styles over these time periods will be analysed and compared.

The paper will employ the research methods of Meucci (2010) in conjunction with the Herfindahl-Hirschman Index as a means of quantifying diversity.

This paper is organised as follows: In Section 3, prior research relevant to the study as well as the theory behind concentration, its presence in a South African context and the measurement of concentration is reviewed. Section 4 breaks down the research methods used in this research paper. Section 5 presents the results that were determined. Finally, Section 6 concludes.

LITERATURE REVIEW

Concentration: definition and measures

According to Kruger (2007), single-share concentration occurs when the market capitalisation of an exchange is disproportionately attributable to the value of one share. When this single-share concentration is present, the combined weighting of the other shares on the exchange is overshadowed (Raubenheimer, 2010). The large weighting of shares within a portfolio, which characterises a concentrated portfolio, restricts the amount of unsystematic risk that can be diversified away. Concentration may therefore be defined as the degree to which a portfolio deviates from an equal weighting (Bradfield & Kgomari, 2004).

Concentration risk can be further broken down into name and sector concentration. The former refers to the level of risk resulting from the distribution of exposures to its borrowers, while the latter to the distribution of exposure to particular sectors. (Figini & Uberti, 2013).

Concentration is a concern in the banking sector, where it refers to the number of loans in a portfolio. Increasing the number of loans in a portfolio achieves minimum concentration (or maximum diversification), whereas diversifying the number of sectors represented in the portfolio achieves minimum sectoral concentration. (Figini & Uberti, 2013).

Sector concentration can be misleading because two companies in the same sector may be less correlated than two companies in different sectors. It is therefore considered more appropriate to focus on portfolio concentration instead of sector concentration.

There are several ways to measure concentration. The Herfindahl-Hirschman Index (HHI) is the most popular (Bikker & Haaf, 2000), and is calculated as the sum of the squares of the market share of each firm in the market. A high HHI index means a high degree of market concentration, approaching a maximum as the number of firms in the industry approaches

one. Rhoades (1995) identified a limitation in the use of the HHI index as a concentration measure, since it does not take into account the effects of correlation between shares of the firms.

A common measure of benchmark concentration is the Effective Number of Shares, which is measured by determining the number of equally-weighted shares required to achieve a level of share-specific risk equal to that of the original portfolio (Kruger & Van Rensburg, 2008), with the degree of concentration increasing as fewer equally-weighted shares are required to replicate the risk in the portfolio.

The Figini and Uberti Index (as it shall be referred to here) was developed in response to the absence of a complete measure of credit concentration (Figini & Uberti, 2013). This index is measured between one and zero, and incorporates sub-indices measuring both the risks of single name positions and sectoral credit risk. It also takes into account share correlation, which is one of the deficiencies of the HHI Index.

Concentration in South Africa

There is a significant level of concentration present in the JSE, which results in many of the inefficiencies in the existing equity benchmarks (Kruger & Van Rensburg, 2008). The five largest shares account for 40% of the All Share Index (ALSI) (Raubenheimer, 2010), and 50 shares account for 90% of the index weight. Both the high degree of concentration and the correlation between JSE-listed shares limit the ability of investors to diversify risk (Neu-Ner & Firer, 1997; Bradfield & Kgomari, 2004).

The lack of liquidity in the JSE also means that portfolio managers have to favour higher-capitalisation shares, limiting their exposure to those at the lower end (Bradfield & Kgomari, 2004). This in turn results in a bias toward resource shares, since these form the bulk of large-cap shares on the JSE (Kruger & van Rensburg, 2008). Thus portfolio managers must accept greater sector concentration in order to protect their liquidity. (Bradfield & Kgomari, 2004).

The effect of concentration on portfolio risk

Markowitz (1952) identified that diversification was not always successful in reducing risk, due to the correlation of shares in the same industry. He noted that in order to reduce risk the "right kind" of diversification is necessary.

In a three-year study on the JSE, Bradfield and Kgomari (2004) identified the inverse relationship between portfolio risk and concentration. This same inverse relationship was observed by Kruger and Van Rensburg (2008) whilst investigating equity benchmarks in a South African context. These studies emphasize the significant impact of concentration on portfolio risk.

The effect of concentration on diversification

Bradfield (1993) sought to uncover the effect of portfolio concentration on the level of attainable diversification in a portfolio on the Johannesburg Stock Exchange. In examining

how portfolio concentration affected the level of diversification attainable in a JSE portfolio, Bradfield (1993) observed that, in comparison to the New York Stock Exchange, a JSE portfolio requires approximately five times as many shares to be "completely" diversified, and that, consistent with the characteristics of an emerging market, South African shares were associated with higher levels of systematic risk when compared to those on the NYSE.

In investigating the benefits of diversification on the JSE, Neu-Ner and Firer (1997) observed that the risk of a one-share portfolio can be reduced by a quarter through the addition of a second share, and halved by adding five shares, continuing to a maximum reduction of 80.5%, for which more than 200 shares are required.

In their three-year study of concentration on the JSE, Bradfield and Kgomari (2004) found that the high correlations between South African shares limited the benefits of diversification. Their findings also indicate that the positive correlation between larger weighted assets increased the overall risk in a JSE portfolio.

Concentration and risk: previous approaches and empirical findings

In a three-year study using data closing price data of all JSE-listed shares from June 1993 to June 1996, Neu-Ner and Firer (1997) determined the point at which the addition of further shares to a JSE portfolio ceases to further reduce risk.

After removing debentures and convertible debentures together with all shares listed and delisted during this period, as well as, a research population of 532 shares was identified. Portfolios were constructed assuming equal investment in each share. N shares then were randomly selected with the mean return and standard deviation of the portfolio calculated. This was repeated 1 000 times and the average of the mean and standard deviation for each instance was then averaged across the 1 000 instances.

This study found that the full benefits of diversification require a portfolio of at least 30 randomly chosen shares. The study also found that as the number of shares in a portfolio increases the dispersion of risk in the portfolio reduces, making risk more predictable. Elton and Gruber (1977) illustrated that as the number of shares held in a portfolio approaches the total number of shares, the risk of a portfolio (standard deviation) approaches the risk of the equally weighed portfolio of that population. Based on this, Neu-Ner and Firer (1997) concluded that for randomly selected shares, the equally weighted portfolio of all shares in the population should be used as a benchmark to compare other, less diversified portfolios.

Bradfield and Kgomari (2004) studied the impact of market concentration on diversification on the JSE. They chose to test four portfolio construction scenarios with varying weighting characteristics (see Table 1 below). Portfolio risk was calculated using the variance and covariances between shares in the prior three-year period.

Table 1: Four scenarios under evaluation

Scenario	Stock weighting	Correlation between stocks
1	Equally weighted	Zero correlation assumed
2	Equally weighted	Correlated
3	Market capitalisation weighted	Correlated
4	General equity stocks	Correlated

Bradfield and Kgomari (2004) then tested the relationship between concentration and standard deviation (i.e. how much risk can be diversified away). The ALSI was used as a proxy for the market index (the ALSI consisted of 165 shares at the time the study was conducted in 2004). See Bradfield and Kgomari (2004) for the methodology followed in that study.

The main result of the Bradfield and Kgomari's study is that for equally weighted portfolios, average covariance is the major determinant in portfolio risk. Additionally, they found that the portfolio variance for the weighted stock portfolio is 16%, while the average covariance is 15.5%. This indicates that the average risk for the equally weighted portfolio tends to converge to the average covariance (see Elton, Gruber, Brown and Goetzmann (2003) for proof).

Additionally, they found that 45 stocks are required on the JSE before the marginal reduction in risk becomes of little further diversification advantage.

Kruger and van Rensburg (2008), followed Bradfield and Kgomari (2004) in isolating the risk associated with concentration. Using data from 30 June 1999 to 30 June 2002, they compared the risk of the benchmark portfolio to risk of an equally weighted portfolio in an attempt to isolate the portion of risk attributable to concentration.

Kruger and van Rensburg's paper determined that the effective number of shares required to achieve the same level of diversification as the ALSI is 16.52 shares. The remaining 149 shares on average provided little benefit to diversification. When comparing the benchmark and an equally weight portfolio, they estimated that market concentration added 2.33% in additional risk.

Previous work emphasises the importance of concentration and its consequences for risk management; however this research was mainly conducted prior to the 2007-2008 financial crisis. This research paper differs from previous research as it aims to determine the effect of portfolio concentration on the level of attainable diversification in a portfolio, across three distinct periods on the JSE. Several different risk measures have been used in prior research; however the level of attainable diversification within a portfolio, when taking into account only negative deviations from the mean returns, has not been explored. This is particularly

useful to portfolio managers because this is the downside risk associated specifically with losses.

Style investing has become a popular method of investing for portfolio managers, where the two most common methods are value and growth investing. Prior research has not explored the performance of these two methods and therefore this research paper aims to compare the performances of the two methods across multiple periods.

RESEARCH METHODS

Data set and time periods

This research focuses on three broad time periods namely; Pre-crisis period, Crisis period and Post-crisis period. We define the Pre-Crisis period as being from January 2005 to September 2007, the Crisis period from October 2007 to March 2009, and the Post-crisis period from April 2009 to December 2013.

In order to ensure the consistency of the data set, only the shares that were present in the All Share Index (ALSI) across all three time periods were included in our analysis. This is consistent with the method followed by Neu-Ner and Firer (1997) who excluded shares that were listed and delisted during their sample period. This has the effect of reducing systematic risk present in our results. Taking the above into consideration, there were 113 shares that were present in the ALSI over all three periods, and these shares formed the base of the data set. Total returns index daily closing price data on these 113 shares from January 2005 to December 2013 were used to generate our results.

Mean returns and standard deviation

Unsystematic risk is unique to each asset and therefore has the ability to be eliminated through portfolio diversification (Neu-Ner & Firer, 1997). Diversification may be more or less effective during different economic time periods.

The aim of this study is therefore to determine the minimum number of stocks required in randomly selected portfolios to achieve a level of diversification using equally-weighted shares, during the pre-crisis, crisis and post-crisis periods. In order to determine this we use the share price data from each of the periods to determine the mean returns for each of the 113 shares present on the ALSI. For example, we randomly created a three-share portfolio and calculated its mean return and standard deviation; this was simulated 10 000 times and for each three stock portfolio created the mean return and standard deviation was recorded. This process as a whole was then repeated for a four-share portfolio, and then a five-share portfolio and so on until a portfolio of 113 randomly selected shares was created. For each randomly selected portfolio the mean return and standard deviation is determined, and then the average return per unit of risk is calculated.

Downside deviation

The risk or standard deviation associated with any investment can be separated into both upside and downside risk. Standard deviation, which is the most widely used measure of

risk, has some limitations because it treats all deviations from the mean, both positive and negative, equally. Investors are more concerned with negative deviations from the mean as this represents the financial risk associated with losses. Downside deviation is a measure of the downside risk inherent in the investment. This raises an interesting question about how the downside deviation of a portfolio is affected by concentration.

In order to compute downside deviation, the approach above needs to be altered in order to calculate downside deviation values rather than standard deviation values. Standard deviation is the measure of dispersion in share returns from the mean, whereas downside deviation is a measure that focuses on the returns that fall below a minimum threshold (T). It is calculated using the formula below, where R is the return of the share and T is the mean return of the share over a period of time.

$$Downside\ deviation = \sqrt{\frac{\sum_{i=1}^{n}(R_i - T)^2}{n}}, where\ R_i < T$$

Value vs growth

In the portfolio construction process, many investors choose to allocate their funds across various styles rather than among individual securities. An additional aim of this paper is to analyse and compare the performance of the value and growth styles over the identified time periods.

Value shares are defined as shares which tend to show high book-to-market ratios in relation to other firms (Piotroski, J, 2001). In order for a share to be classified as a value share by the JSE, and hence be part of the Value Index, a share must have a high enough Value Ranking (VR) (JSE, 2014).

Shares are assigned a VR based on the following measures:

- Book-to-price ratio
- Dividend yield
- Sales to price ratio
- Cash flow-to-price ratio

Growth shares are defined as those shares which are expected to exceed the average return of the market. Such shares are characterised by steadily increasing revenue and earnings growth. As with the Value Index, growth stocks are assigned a Growth Ranking (GR). This ranking is based on the following growth measures:

- Three-year historic earnings per share growth
- Three-year historic sales growth
- Two-year forward earnings per share growth
- Two-year forward sales growth
- Return on equity x (1 - payout ratio)

Using the composition of the Value and Growth indices at the beginning of each period as a proxy, the 113 shares making up the data set were identified as either *value*, *growth* or *neither*

(for the purpose of this particular analysis, the *neither* shares were then discarded). Due to the high frequency at which the JSE indices are re-evaluated, the simplifying assumption was made that if a stock was classified as either *value* or *growth* at the start of the period, it would remain as a value or growth share for the entire time period under consideration. The assumption is also that no new shares are added to the respective indices after the first day of each time period.

Having split the shares into value and growth, the process of portfolio construction as described in section 4.2 was repeated, this time building portfolios consisting exclusively of either value or growth shares.

Concentration

This paper applies the Figini and Uberti Index in a portfolio management context. The Figini and Uberti Index is defined as follows:

$$I = \frac{x'Mx}{b\ \max[r_i]}\ ,\quad i = 1, \ldots\ldots, n,$$

Where:

n = number of shares

b = the normalization factor defined as $b = \frac{1}{min[r_i]},\ i = 1, \ldots, n.$

$x' = [x_1, \ldots, x_n]$ The vector of the share of a single stock in the portfolio

r_i = Risk (standard deviation) associated with each share

$M = M_I + C$ (correlation matrix); where

$$M_1 = \begin{bmatrix} b_{r_1} - 1 & 0 & \cdots & 0 \\ 0 & b_{r_2} - 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & b_{r_n} - 1 \end{bmatrix}$$

$$C = \begin{bmatrix} 1 & \rho_{12} & \cdots & \rho_{1n} \\ \rho_{12} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & \rho_{n-1,n} \\ \rho_{1n} & \cdots & \rho_{n-1,n} & 1 \end{bmatrix}$$

Once established, the new portfolio concentration measure is applied to each time period under consideration, enabling us to evaluate the variation in concentration of the ALSI across the periods. By adding an extra step into the portfolio construction process described in section 4.2, we investigate the relationship between concentration and the number of shares in a portfolio. This was done by measuring the average concentration of a portfolio of n shares ($1 \leq n \leq 113$). We make the simplifying assumption that there is no thin trading on the JSE.

Based on the definition of the Figini and Uberti Index, we hypothesize that the concentration levels will increase in the crisis and post-crisis periods. This belief is based on the increased

correlations between shares over a crisis period (all shares are affected by the crisis). This increase in correlation corresponds to an increase in concentration.

A Principal Components Approach

In portfolio management, a well-diversified portfolio is one that is not exposed to individual shocks. As for portfolio concentration, there is no broadly accepted measure of how diversified a portfolio is. Existing measures include the Herfindahl-Hirschman Index (HHI) (mentioned previously) and the percentage of risk explained by the systematic factors in a systematic-plus-idiosyncratic factor model. While these methods are useful to portfolio managers, neither measure highlights where diversification, or the lack thereof, arises in a given portfolio. With this is in mind, this paper uses the HHI index in conjunction with the methodology set out by Meucci in his 2010 paper "Managing Diversification" to generate a measure of how diversified a portfolio is. For the purpose of this paper, this measure will be called the M Measure.

The HHI Index is calculated by squaring the market share (expressed as weightings) of each firm competing in a market and then adding the resulting numbers together. The M Measure makes use of the following formula in establishing the weightings used in the HHI index calculation:

$$p_n = \frac{\widehat{w}_n^2 \, \lambda_n}{Var\{R_w\}}$$

Having established the weightings, p_n, of shares in the portfolio, the M measure applies these weightings to the HHI index (for a detailed description of the M methodology, see Appendix 1).

Results

Mean returns and standard deviation

To eliminate unsystematic risk evident in a portfolio, portfolio managers increase the number of shares in their portfolios. As expected, we found that as the number of shares in the randomly selected portfolios increased, risk was reduced. The returns of the portfolios tend to flatten out after a certain point. This can be seen on Figure 1 below when the number of shares in the portfolio reach about 55 shares. We infer that this is the point where the portfolio is well-diversified and portfolio managers will start to get the same level of return even if they continue to add shares to their portfolio beyond this point.

Comparison of the mean returns and standard deviations of the randomly selected portfolios across the three defined periods shows that for different market conditions, portfolio managers need to hold different amounts of shares for certain levels of standard deviation. The vertical line on Figure 1 below shows that for any given number of shares in a randomly selected portfolio, during the pre and post-crisis periods there is less risk than during the crisis period. This is because during the crisis period the market is extremely volatile and there is a lot of uncertainty around share price movements. The horizontal line on Figure 1 below indicates that for any given level of standard deviation, portfolio managers will need to

hold fewer stocks in his portfolio during the pre and post-crisis periods. This indicates that it is much more difficult for portfolio managers to diversify their portfolios during the crisis period because there is lot more risk present during this period.

Figure 1 below provides important information because it shows that if a portfolio manager was only allowed to take on a certain level of risk (the horizontal line), in the pre and post-crisis periods the portfolio manager could hold about 5 stocks but in the crisis period he would have to diversify more and hold about 17 stocks.

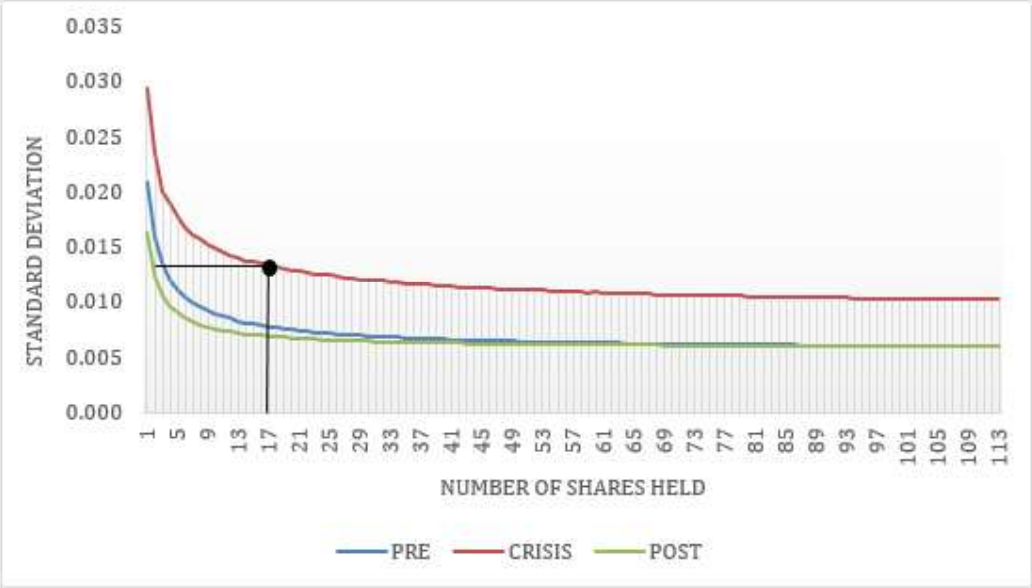

Figure 1: The relationship between standard deviation and the number of shares in a portfolio across the three periods.

Figure 2 below indicates that risk decreases as the number of shares in the randomly selected portfolios increases. After a certain point the returns flatten out.

Figure 3 below shows the average return per unit of risk and indicates that as the number of shares in a portfolio increases, the average return per unit of risk increases, but at a decreasing rate. This is because as more shares are added to the portfolio it reduces the standard deviation. However once again returns seem to flatten out at a certain point, and therefore return per unit of risk increases. It increases at a decreasing rate because less and less risk is diversified away each time another share is added to the portfolio.

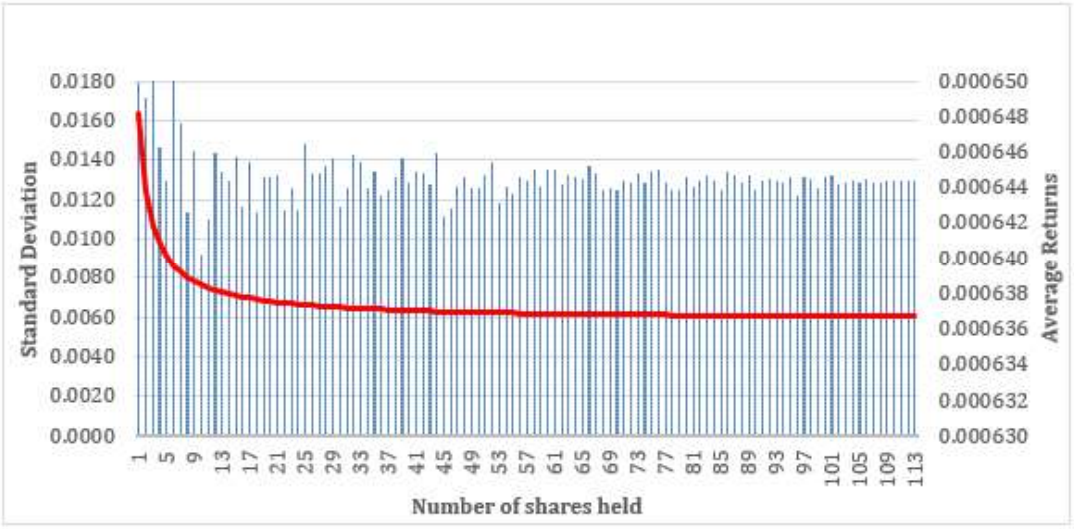

Figure 2: The relationship between post-crisis standard deviation and average return with the number of shares in a portfolio.

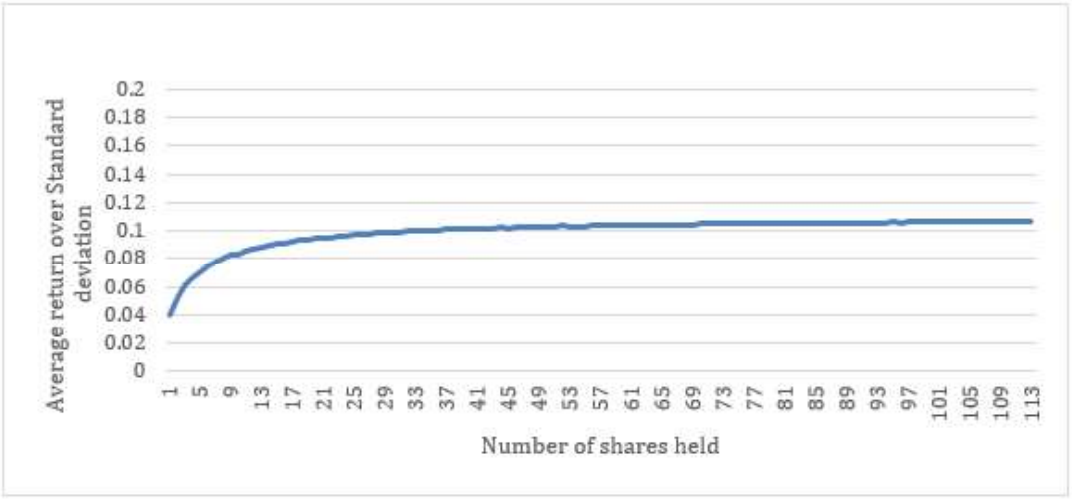

Figure 3: The relationship between post-crisis average return per unit of risk and the number of shares in a portfolio.

Downside Deviation

According to the market conditions faced by investors during the pre-crisis period, which was characterized by a boom in the economy and inflated asset prices (Claessens & Ayhan Kose, 2013), the fact that there is more downside deviation within a portfolio during the pre-crisis period when compared to the post-crisis period is in line with the risk-return tradeoff inherent in all investments. Risk-return theory states that in order to make higher returns, more risk needs to be taken on (Markowitz, 1952). This relationship is explained in the graph below, which demonstrates that for the same number of shares, during the pre-crisis period there is more downside deviation present in the portfolio when compared to the post-crisis period.

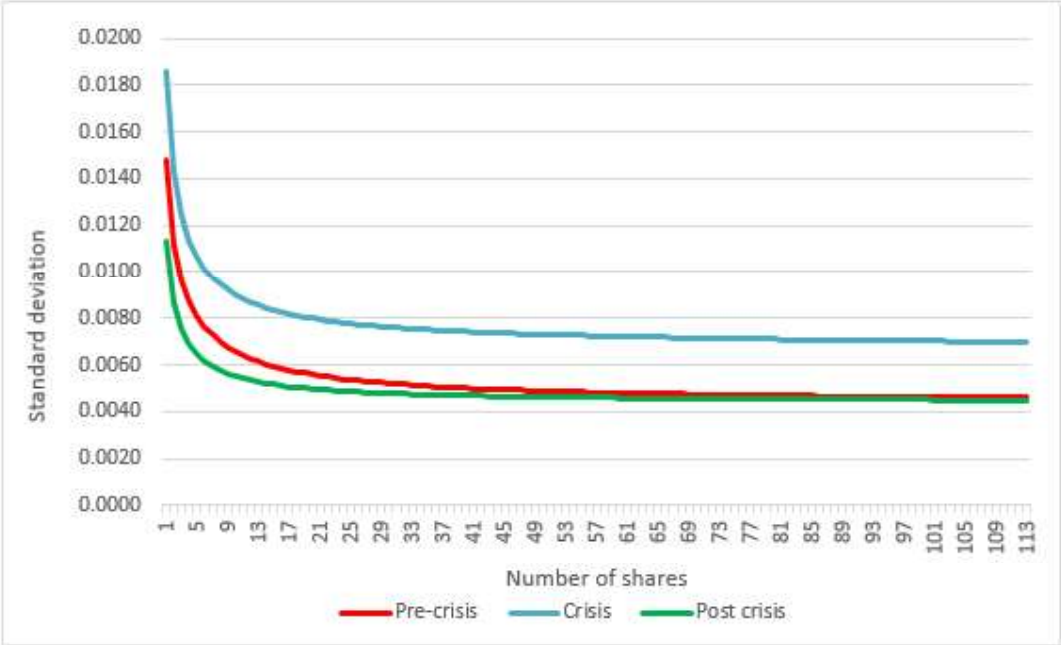

Figure 4: The relationship between downside deviation and number of shares in a portfolio across the three periods.

During the crisis period, market conditions are in recession and asset prices are falling. Most, if not all, assets experienced downward trends and therefore made negative returns. This is illustrated in Figure 4 where there is a higher level of risk across all investments.

The post-crisis period is characterized by a recovering economy and financial markets are on an upward growth pattern. Asset prices are starting to experience small upward trends and positive growth once again. As can be seen from the graph above, during the post-crisis period the benefits of diversification in terms of reducing downside deviation are maximized, and the risk inherent in all portfolios is much lower than in the pre-crisis and crisis periods.

For the pre-crisis period, if a portfolio of one randomly selected share is held, the amount of downside deviation in the portfolio is around 0.01477. If a portfolio of 113 shares is held, the level of downside deviation in the portfolio is approximately 0.00459. If we compare this to a portfolio comprising of one randomly selected share, adding an additional 112 shares to the portfolio reduces downside deviation by 68.88%.

During the crisis period there is more volatility present in the market and therefore less risk can be eliminated through diversification. During the crisis period, a one share portfolio has a downside deviation of 0.01863 which is significantly higher than the pre-crisis and post-crisis periods. This is consistent with retracting financial markets at the time. If a portfolio of 113 shares was held then downside deviation would be roughly 0.00683. This shows that the addition of 112 shares to the portfolio has the effect of reducing downside deviation by 62.52%

The benefits of diversification are exaggerated during the post-crisis period, because more risk can be diversified away. A randomly selected share, on average, during the post-crisis period has a downside deviation of 0.0113. By holding a portfolio of 113 randomly selected shares, downside deviation can be reduced to 0.00449. The additional 112 shares therefore reduce downside deviation by 60.19%.

Value vs growth portfolios: pre-crisis period

Figure 5 compares the relationship between the standard deviation of value shares and the number of shares to the relationship between the standard deviation of growth shares and the number of shares. As of 3 January 2005 (beginning of the pre-crisis period), there were 80 shares on the ALSI classified as *value* and 52 shares classified as *growth*. (Note that it is possible for a share to be included in both categories). As shown below, the standard deviations of value and growth are almost identical throughout the pre-crisis period indicating that the risk inherent in choosing value and growth shares was very similar. This could be a result of some shares being defined as both value and growth.

As illustrated below, standard deviation decreases as the number of shares increases which is consistent with portfolio theory and results discussed above. The risk appears to level out after using 31 shares in a portfolio. The corresponding standard deviation associated with this number of shares is 0.0077.

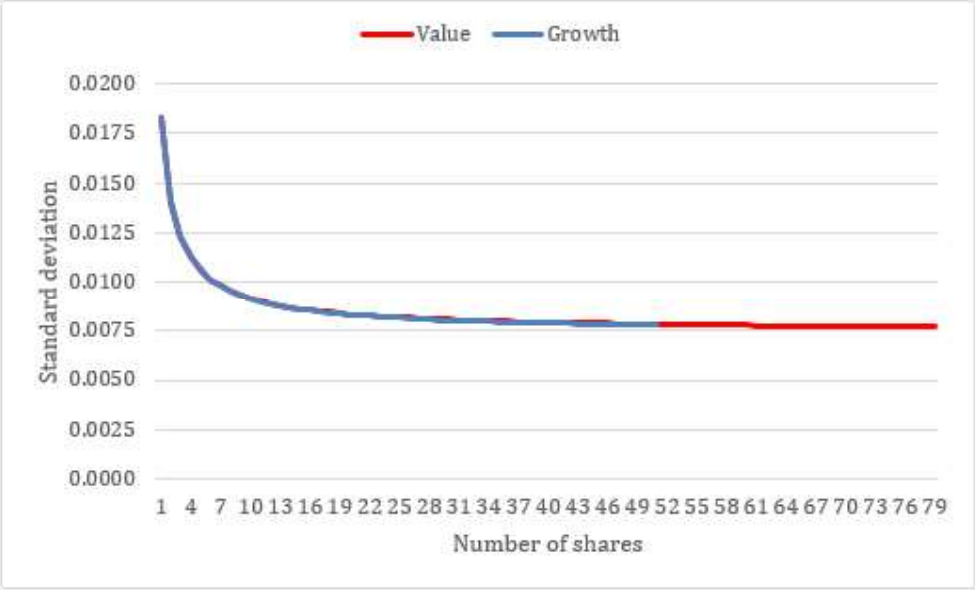

Figure 5: A comparison of pre-crisis value and growth shares.

Value vs growth portfolios: crisis period

Over the crisis period, 86 shares on the ALSI were classified by the JSE as *value* shares and 43 as *growth*. Figure 6 illustrates the performance of value and growth shares from a risk management perspective. Adding one more share to a portfolio of value shares reduces the risk of that portfolio by a greater amount than if the portfolio were constructed with growth shares. This is evident from the steeper slope of the value curve. Despite value shares being

more effective in diversifying away risk in portfolios consisting of a small number of shares, the two graphs appear to converge as the number of shares increases. The risk associated with value and growth seem to level out at 31 shares, which is in line with the pre-crisis analysis. The level at which standard deviation levels out is, however significantly higher with a portfolio of 31 shares being associated with a standard deviation of 0.0125. This finding is consistent with the conditions inherent in a crisis period (more risk).

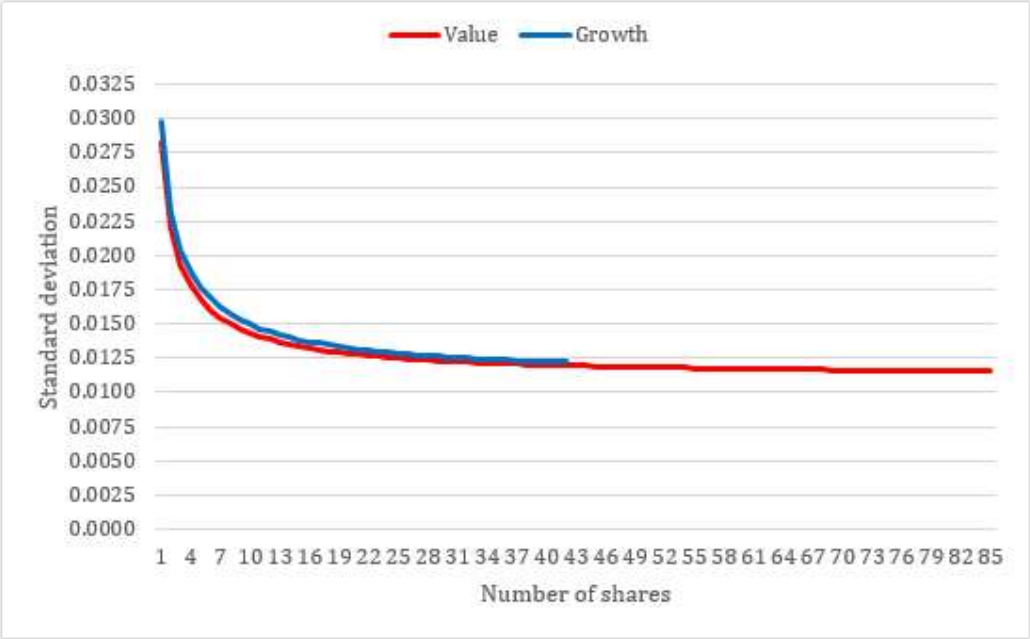

Figure 6: A comparison of crisis value and growth shares.

Value vs growth portfolios: post-crisis period

Using the JSE Value and Growth indices as a proxy, the ALSI consisted of 81 *value* shares and 63 *growth* shares at the start of our post-crisis period. Unlike the previous periods, the post-crisis period sees the persistent separation of the value and growth graphs, illustrated in Figure 7 below. As with over the crisis period, the marginal benefit of an additional share being held in a portfolio is greater for value shares than for growth shares. This benefit appears to exist across all number of shares, not just for portfolios consisting of a small number of shares, which was the case over the crisis period. Consistent with both other periods, standard deviation appears to level out for both value and growth at 31 shares. This number of shares is associated with an average standard deviation of 0.007 and 0.00725 for value and growth respectively.

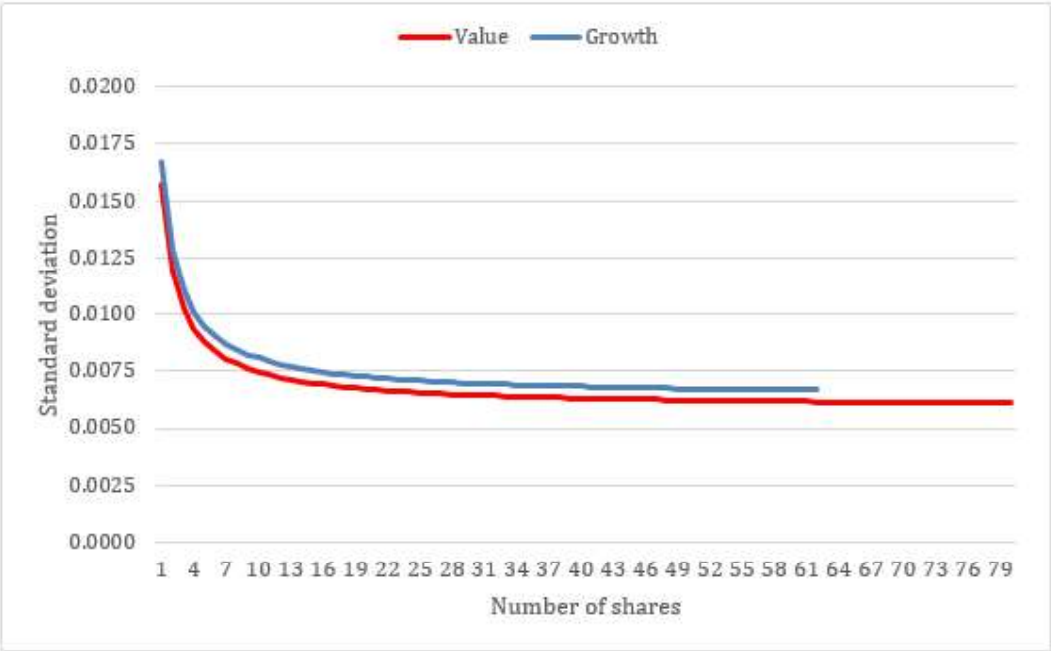

Figure 7: A comparison of post-crisis value and growth shares.

Concentration

Figure 8 graphs the relationship between the number of shares in a portfolio and its concentration across the time periods under consideration. Concentration in this instance is measured using the Figini and Uberti Index discussed in Section 4.5. All three graphs exhibit the general trend that as the number of shares increase, concentration decreases. This is consistent with previous literature as well as portfolio theory discussed earlier.

As illustrated by Figure 8 below, concentration remains relatively consistent across all three periods. Concentration appears to level out when holding a portfolio of 20 shares. After this point, holding an extra share does not have a significant impact on the level of concentration present in the portfolio. This holds true across all three time periods under consideration. The post-crisis period appears to be the one in which concentration is the highest across all numbers of shares.

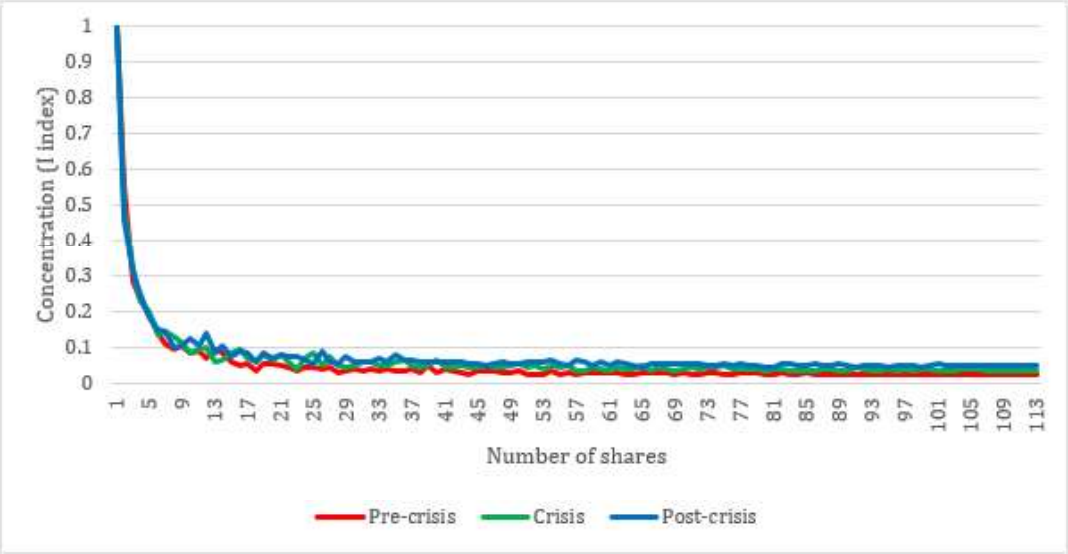

Figure 8: The relationship between concentration and the number of shares in a portfolio.

M Measure

Figure 9: The M Measure across multiple time periods.

The M Measure considers the degree of portfolio diversification. Figure 9 indicates that the pre-crisis and post-crisis periods have similar characteristics, while the crisis period is clearly significantly different. In the pre-crisis and post-crisis periods the percentage of risk explained by the systematic factors (shares) increases as more factors are added to a portfolio. This is reflected by the increase in the M Measure as we move along the x-axis. In the crisis period the M Measure remains relatively flat as more factors are added, indicating that a lower percentage of risk is explained and therefore that portfolios in the crisis period are less diversified than in the pre-crisis and post-crisis periods. This corresponds to results shown in

Section 5.1, indicating that it is more difficult to diversify a portfolio during the crisis period, because less risk can be explained and therefore diversified away.

CONCLUSION

Market concentration is present, to some degree, in most of the major stock markets around the world, and impacts the way in which portfolio managers construct their portfolios as well as restrain their investment decisions. Concentration risk has been a relatively hot topic of discussion due to the recent credit crisis, specifically with regards to credit portfolios (Figini & Uberti, 2013). Portfolio diversification works to partly alleviate this exposure while at the same time eliminating unsystematic risk. Due to the risk reduction benefits associated with diversification, it is important for portfolio managers to be aware of how many shares are required to be fully diversified and additionally, which strategies are available that will maximize risk reduction in times of distress.

Having determined the mean returns and standard deviations of randomly selected portfolios over the three periods, we can conclude that during the pre- and post-crisis periods there is less risk and it is therefore easier for a portfolio manager to diversify a portfolio.

In contrast, increased volatility of the market and uncertainty of share prices are characteristics of the crisis period that make it necessary for a portfolio manager to hold more shares in a portfolio to achieve the same level of risk as in the pre- and post-crisis periods. This finding should be used by portfolio managers in future crisis periods to manipulate the number of shares they hold in their portfolios in order to maintain a constant level of diversification.

As one would expect, during a financial crisis the level of downside risk in a portfolio is substantially higher than in the pre-crisis and post-crisis periods. The period associated with the lowest levels of downside risk is the post-crisis period. An interesting finding is that the greatest benefits from diversification could have been achieved in the pre-crisis period.

In the pre-crisis period the standard deviation of value and growth shares is almost identical, suggesting that the level of risk evident in the two types of shares was similar. Over the crisis and post-crisis periods value shares are associated with lower levels of risk than growth shares. This can once again be used by portfolio managers seeking to diversify risk in a crisis.

There is scope to extend this work on concentration and diversification to other markets, and to explore the potential benefits of international diversification.

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Appendix 1: M Measure methodology

In uncorrelated markets, the individual shares within a portfolio constitute additive sources of risk. This relationship is shown below:

$$Var\{R_w\} = \sum_{n=1}^{N} Var\{w_n R_n\}$$

Where:

w_n= the weighting of share n in the portfolio

R_n= the return of share n

This relationship, however, does not hold in correlated markets. Although correlated, it is possible to determine the sources of risk that are uncorrelated and hence additive.

A principal component decomposition of the returns correlation matrix, $\sum$, uncovers the uncorrelated sources of risk. This differs from the methodology followed by Meucci (2010) where the returns covariance matrix was used.

$$E' \sum E \equiv \Lambda$$

In the above expression, Λ is the diagonal matrix that contains the eigenvectors of $\sum$ and the columns of matrix E, are the respective eigenvectors. The eigenvectors in matrix E define a set of N uncorrelated portfolios whose returns are decreasingly responsible for randomness within the market. The eigenvalues contained in matrix φ correspond to the variances of the uncorrelated portfolios. Note that the above decomposition holds for any market with a well-defined covariance.

In the portfolio construction process, portfolios can either be made up of the original securities with weights w, or as a combination of the uncorrelated principal portfolios i.e. with weights $\widetilde{w} = E^{-1}w$.

The diversification distribution is generated through the following equation:

$$p_n = \frac{\widehat{w}_n^2 \, \lambda_n}{Var\{R_w\}}$$

In the equation above, p_n can be thought of as the R^2 from a regression analysis of the total portfolio returns on the n^{th} principal portfolio. R^2 represents the portion of variance explained by the variables in a model.