# A FRAMEWORK FOR EVALUATING THE BENCHMARK RISK OF SOUTH AFRICAN EQUITY PORTFOLIOS

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# Abstract


The aim of this study is to identify and quantify those primary aspects of risk which impact on the construction of benchmark indices as well as active portfolios in the South African market.

The appropriateness of the application of the new FTSE classification structure with regard to the particular structure of the local exchange on 30 June 2002 has been placed in question. An initial cluster analysis of the index returns underlying the new classification demonstrated that there were significant behavioural anomalies amongst the new index structure with many Financial-Industrial indices now grouped closely with Resources stocks. A principal factors analysis of the market sectors indicated that the strong Financial-Industrials and Resources dichotomy was present within the market but also demonstrated that a number of Financial-Industrial indices, most notably Basic Industries and Cyclical Consumer Goods, demonstrated either loadings on both factors or loaded solely on the Resources factor rather than their own Financial-Industrials factor. An investigation on a share level found that in most cases one or two large cap shares were responsible for the behaviour of their sectors as a whole and that each of the shares in question was either dual-listed or had significant exposure to foreign markets.

Analysis of current benchmark alternatives in the market demonstrated the excessive levels of concentration present on the local exchange. While the All Share Index (ALSI) comprised 161 shares as at 30 June 2002 it was found to be approximately equivalent to an equally-weighted portfolio of only 16 stocks. This measure was found to improve for the alternative benchmarks but only marginally so with the Shareholder Weighted Index (SWIX) demonstrating the lowest concentration levels with an effective number of stocks of 31. Employing a similar methodology to Bradfield and Kgomari (2004) the impact of concentration on overall portfolio risk in the market was investigated and it was found to account for nearly 2.4% of overall market risk. While this value is lower than that found in the aforementioned study it is still significant and indicates the importance of concentration in assessing portfolio risk.

In order to investigate the relationship between the risk factors identified by the factor analysis and the measures of risk used to evaluate the benchmarks, risk-optimized passive portfolios were constructed. Concentration, as measured by the effective number of stocks measure, was minimised according to a set of liquidity and regulatory (mutual and pension fund) constraints in order to generate optimal portfolios for varying fund sizes. It was found that concentration increased rapidly as fund size increased. Assuming a maximum trade-out period of 5 days, funds smaller than R2 billion were able to achieve as much as 3 times the effective number of stocks the ALSI was, however, market levels of risk and concentration were reached at a fund size of R4 billion.

The impact of liquidity on fund holdings was demonstrated by a clear shift in allocation from illiquid Financial-Industrial shares to liquid Resources shares as fund size increased. Fund managers may therefore have no choice when faced with liquidity constraints but to accept bigger positions in more volatile Resources stocks.

An investigation of a combination of active and passive portfolios found that the Sharpe ratios for the risk-optimized passive analysis were superior to the appraisal ratio of the active portfolio. The Sharpe ratios were found to improve as fund size increased and weight was transferred to the higher-return Resources stocks within the passive benchmarks. As a result the active weights within the optimal active-passive portfolio decreased as fund size increased.

# Declaration

I, Ryan Kruger, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other University. I empower the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

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# 1

# Introduction

The aim of this study is to ascertain the primary dimensions underlying equity portfolio risk on the Johannesburg Stock Exchange (JSE) and investigate their application in passive benchmark construction as well as their interaction with optimal active portfolios.

Benchmarks form an integral part of fund management, both for active managers who seek an appropriate index against which to evaluate their performance, as well as passive fund managers who seek an index to track. The question of what constitutes a suitable benchmark, however, is one that has perplexed both fund managers and clients alike and is currently one of the primary practical problems facing South African fund managers.

The most fundamental requirement of any benchmark is its investability – investors must be able to replicate the benchmark by being able to invest in all the securities listed in the index. This goal has become increasingly difficult to accomplish, however, as changes to the classification structure of the local exchange and issues such as market concentration and liquidity have become manifest. The result is that managing risk has become the overriding benchmark dilemma.

The topic of benchmarking has attracted increasing attention since the implementation of the FTSE/JSE Africa Index Series in June 2002. The application of the FTSE's Global Classification System (GCS) to the local exchange in particular has drawn sharp criticism from local market participants. There have been concerns that the GCS does not parallel the underlying market structure of the exchange and therefore distorts the underlying sector risk profiles, especially given the traditional Financial-Industrial/Resources allocation process typical of the SA fund management environment.

The preliminary analysis of the study will therefore focus on an investigation as to the correctness of the application of the new classification structure to the exchange. The findings may then necessitate a more robust analysis of the underlying risk factors in the market.

Traditional benchmark risk analysis has focused around two measures: total benchmark risk (as measured by standard deviation) and the benchmark's exposure to its underlying factor exposures (as measured by beta). Strongin, et al (2000), however, identify *'a massive concentration of share-specific risk in a small number of mega-cap shares'* in their analysis of US portfolio managers' performance. This excessive concentration of portfolio weights is found to contribute a disproportionate amount of risk to the total portfolio risk and represents an unrewarded risk to the portfolio manager.

Bradfield and Kgomari (2004) investigated the issue of concentration on the JSE over a three-year period. Their analysis demonstrated similar concentration issues on the exchange with almost one third of total ALSI risk attributed to the effects of concentration. In addition, they found that high correlations between shares on the exchange limit the degree of diversification that can be achieved.

The JSE's response to this dilemma has been the provision of a number of alternative benchmark indices which seek to address the concentration and liquidity issues identified. These indices will be analysed using both traditional risk measures as well as measures for concentration, liquidity and the risk factors investigated prior in order to determine their effectiveness.

Following this, the influence of these risk dimensions on the construction of risk-optimized benchmark portfolios will be investigated and quantified as a basis of comparison to the current market situation. These portfolios will then be combined with optimal active portfolios in order to investigate the optimal active-passive combination in the period under review.

**Chapter 2** provides an overview of current theory in the area of benchmark risk. A discussion is provided of the traditional Markowitz Modern Portfolio Theory of risk, return and diversification. In addition, emerging areas of interest, specifically single-share concentration and its impact on portfolio diversification and the influence of liquidity on risk and fund size will be discussed.

**Chapter 3** reviews prior local and international research relevant to the study. A discussion is provided of recent findings in the areas of benchmark concentration and risk with an emphasis on research in the South African benchmark environment. This is follow by a summary of research in the area of risk decomposition on the JSE and the factors historically found to underpin return-generation on the exchange.

**Chapter 4** provides a detailed description of the problems investigated in the study as well as the data set employed in the analysis and the methods used in its extraction. The recent changes to the classification structure of the JSE are of particular interest in the analysis undertaken in the study and a discussion will be provided of the adjustments relevant to the analysis. Both share and index data samples were constructed for purposes of the analysis and the constituents of both data sets are presented in Appendix B.

**Chapter 5** employs cluster analysis techniques in order to investigate the linkages between the sectors in the market. It is expected that this will provide a clearer picture of which sectors are closely related from a risk-based point of view, and will indicate the suitability of the new classification structure.

**Chapter 6** presents the results of a factor analysis of both the share and index data samples. The goal of the analysis is to decompose the risk factors which underlie return generation on the exchange. This will provide an insight into whether the new classification has brought about a fundamental change in the factor structure established by the prior research.

**Chapter 7** presents a risk analysis of current benchmark alternatives as well as the overall market. Traditional benchmark risk measures are assessed as is the impact of concentration on overall benchmark risk and diversification. Analysis will also be conducted of the effects of liquidity on benchmark concentration and risk. The inter-relationship between these factors as well as fund size will be assessed within the context of the local market.

**Chapter 8** consolidates the analysis and illustrates how the risk dimensions influence the construction of risk-optimized benchmark portfolios. The analysis will be extended to investigate active portfolio management and the interaction of optimal active portfolios with the optimal passive benchmarks generated by the analysis.

**Chapter 9** concludes the thesis. A summary is provided of the relevant findings in the previous chapters and conclusions are drawn and recommendations made with regard to the practical application of the findings to fund managers.

# 2

# Theoretical Overview

This chapter aims to address some of the more pertinent theoretical issues applicable to the area of benchmark risk and focuses on four areas of concern: risk, diversification, concentration and liquidity.

## 2.1 Constituents of Benchmark Risk

### 2.1.1 Risk and Diversification

While investors have always been intuitively aware of the sense in holding a diverse range of assets, Harry Markowitz was the first to quantify the relationship between risk and return, as it related to portfolios of assets, in his landmark 1952 paper.

He noted that if investors were indifferent between which assets they held and if all assets offered the same degree of reward (returns), all assets would be valued equally in the market. Given that this was not the case in practise, he concluded that a second factor was of importance in the asset allocation decision, namely the risk inherent to the asset.

Markowitz defined this asset risk as the standard deviation of the expected returns of the asset; in other words the volatility or uncertainty of asset returns. His examination of asset classes led him to separate asset risk into two components: specific or unsystematic risk which is unique to the asset class in question and non-specific or systematic risk which is common to all assets within the market.

As systematic risk is determined by general factors in the market over which the asset manager has no control, it is impossible to influence this aspect of asset risk. Modern Portfolio Theory (MPT), as formulated by Markowitz, states however that the risk profile of portfolio of shares can be reduced by introducing assets to the portfolio which are not highly correlated with one another. By combining assets in such a manner the unique elements of asset risk offset one another to a degree, thereby reducing unsystematic risk within the portfolio. If a portfolio is sufficiently well-diversified, it is thus theoretically possible to reduce the degree of unsystematic risk within the portfolio to such an extent that only systematic (market) risk remains.

Portfolio risk is therefore a function of three variables: The weights of the shares which constitute the portfolio, the standard deviations (risk) of these shares and the relationship between their returns (measured by the covariance between them).

The risk of a simple n-share portfolio may therefore be represented as follows:

$$\sigma_p^2 = \sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{j=1, j \neq i} w_i w_j \sigma_{ij} \qquad (2.1)$$

Where

$\sigma_i^2$ = the variance in the returns of share I,

$w_i$ = the portfolio weight held in share I,

$\sigma_{i,j}$ = the covariance of returns between shares I and j.



Of these three variables which determine portfolio risk, the asset manager has control only over the weights at which the shares are carried within the portfolio. It is therefore unsurprising that one of the most fundamental decisions of benchmark construction is the attribution of share weights so as to maximise the benefits of diversification and reduce benchmark risk.

This attribution decision is of special interest in the face of the increasing problem of single-share concentration. Single-share concentration is characterised by the market capitalisation of a share increasing to the point where it represents a substantial portion of the total capital weight on the exchange. The most pressing concern in this regard is the increased degree of risk it represents, as being forced to hold a single share with such a large weight within a portfolio casts doubt on the levels of diversification which can be achieved.

It has already been stated that the level of portfolio risk decreases as shares are added to the portfolio, albeit at a decreasing rate, until it eventually levels off at a point where no further risk reduction can be achieved. When there is a concentration problem, however, the level of risk associated with the portfolio increases. As the weighting of a share increases, the risk, median and variability in risk rises, thus negating the possible benefits of diversification even in large portfolios which hold the concentrated share. (Lunn, Gerber; 2000)

Highly concentrated portfolios are therefore unlikely to be fully diversified regardless of the number of shares held within the portfolio.



### 2.1.2 Measuring Index Concentration

Equation 2.1 illustrates that by adding additional shares to a portfolio it is possible to diversify away share-specific risk until only systematic (market) risk remains. This is generally accepted to take place in the ratio $1/\sqrt{n}$ for a portfolio of equally-weighted shares.

Strongin et al (2000) demonstrate that diversification results are heavily dependent on the weights at which shares are carried in a portfolio. Their work mirrors that undertaken by Hovenkamp (1986) and the measure they develop is simply the inverse of his Herfindahl-Hirschman Index (HHI) measure.

If we were to construct a portfolio of n shares we could define the returns for that portfolio as comprising an element of returns common to the market as well as an element of return specific to each of the shares in the portfolio. It is assumed that the share-specific element of returns is independently and identically distributed across the shares.

The return and variance of said portfolio could therefore be defined by:

$$R_{portfolio} = R_{common} + \sum_{i=1}^{n} w_i R_i \qquad (2.2)$$

and

$$\sigma^2_{portfolio} = \sigma^2_{common} + \sigma^3_{specific} \sum_{i=1}^{n} w_i^2 \qquad (2.3)$$

respectively.

Where

| | |
|---|---|
| $R_{common}$ | = the portion of portfolio return common to all shares held, |
| $R_i$ | = the return specific to share i, |
| $w_i$ | = the weight of share i, |
| $\sigma^2_{common}$ | = the portion of risk common to all shares held, |
| $\sigma_{specific}^{2}$ | = the risk specific to share i. |

The final term of equation 2.3 indicates the share-specific risk of the portfolio. If we were to add a further share to the portfolio at weight a, the share-specific risk for the portfolio would be given by:

$$\sigma_{portfolio\_spefic} = \sigma_{stock\_specific} \sqrt{a^2 \sum_{i=1}^{n} (1-a)^2 w_i^2} \qquad (2.4)$$

The incremental decrease in share-specific risk (the effect of diversification) is therefore given by the difference between the two terms as follows:

$$\sigma_{incremental} = \sigma_{stock\_specific} \sqrt{\sum_{i=1}^{n} w_i^2} - \sigma_{stock\_specific} \sqrt{a^2 \sum_{i=1}^{n} (1-a)^2 w_i^2} \qquad (2.5)$$

If the effective number of shares (ñ) in the portfolio is the number of equally-weighted shares required to achieve the same share-specific risk as the original portfolio then, for equally-weighted portfolios, the effective and actual number of shares are equal. For all other portfolios, the effective number is less than the actual number. The smaller the number of effective shares, the more concentrated the benchmark.

$$\tilde{n} = \frac{1}{\sum_{i=1}^{n} w_i^2} \tag{2.6}$$

Restating the incremental increase in share-specific risk in terms of effective number of shares yields the following simplification:

$$\sigma_{stockspecific}\left[\sqrt{\frac{1}{\tilde{n}}} - \sqrt{a^2 + \frac{(1-a)^2}{\tilde{n}}}\right] \tag{2.7}$$

Diversificationary benefit is maximized by holding equally-weighting shares in the portfolio. When we add shares at more than double the weight of other shares in the index, we add share specific risk to the portfolio, thereby decreasing the level of diversification. We may therefore use this as a threshold level for share weights held within an index, as indicated in equation 2.8.

$$T_p = \frac{2}{(\tilde{n}+1)} \tag{2.8}$$

As the weight increases above this level, the decrease in diversification occurs more rapidly, as the share is adding more share-specific risk than is being diversified away by adding it to the benchmark.

Bradfield and Kgomari (2004) demonstrate a similar measurement for the upper bound on share weights in a portfolio based on residual risk as opposed to the effective number of shares.

Let $\sigma_{p_e}^2$ denote the residual risk of the portfolio and $\sigma_{ie}^2$ denote the residual risk of individual portfolio assets, then

$$\sigma_{p_e}^2 = \sum_{i=1}^{N} w_i^2 \sigma_{ie}^2 \tag{2.9}$$

Taking the first differential of the portfolio's diversifiable risk with respect to asset weights would indicate the limit to which the addition of an asset to the portfolio would reduce its risk. Bradfield and Kgomari (2004) therefore investigate the effect of adding another asset to a portfolio on that portfolio's risk. They consider a portfolio of n-1 assets as a single asset for the purposes of the derivation and therefore consider a "two-asset" case.

$$\frac{d\sigma_{p_e}^2}{dw} = 2w\sigma_{1e}^2 - 2(1-w)\sigma_{2e}^2 \tag{2.10}$$

Where

$\sigma_{1e}^2$ = the unique risk of the additional asset,

$\sigma_{2e}^2$ = the unique risk of the original portfolio.

The upper bound is determined at that point where the change in unique risk is 0. Stated as per equation 2.10,

$$2w\sigma_{1e}^2 - 2(1-w)\sigma_{2e}^2 = 0 \tag{2.11}$$

Therefore,

$$w = \frac{\sigma_{e2}^2}{\sigma_{e2}^2 + \sigma_{e1}^2} \tag{2.12}$$

The upper bound on a share's weight is therefore simply the ratio of the diversifiable risk of the original portfolio to the sum of the diversifiable risks of the portfolio and the new share.

Finally, the Richard Roll measure of concentration (RRC), adapted to the measuring of portfolio concentration by Divecha et al (1992), is considered.

$$RRC = \frac{N}{N-1}\left(\sum_{i=1}^{N} w_i^2 - \frac{1}{N}\right) \tag{2.13}$$

As opposed to the HHI and effective number of shares measure, the RRC measures the departure of the portfolio under consideration from the equally-weighted portfolio, rather than determining the equivalent equally-weighted portfolio. Therefore, an equally-weighted portfolio would have an RRC of 0 and the measure will increase as the concentration of the portfolio increases.

### 2.1.3 The Impact of Concentration on Risk and Diversification

In order to illustrate the impact of concentration on overall portfolio risk, the risk of an equally-weighted portfolio is contrasted with that of a concentrated portfolio.

Consider the definition of portfolio variance presented in equation 2.1 above.

For a portfolio of equally-weighted shares, the weight attributed to each share is 1/N where N represents the number of shares in the portfolio. As per Gruber (2003) we can then reduce the equation as follows:

$$\sigma_p^2 = \sum_{i=1}^{N}\left(\frac{1}{N}\right)^2 \sigma_i^2 + \sum_{i=1}^{N}\sum_{j=1, j\neq i}^{N}\left(\frac{1}{N}\right)^2 \sigma_{ij} \tag{2.14}$$

$$= \frac{1}{N}\sum_{i=1}^{N}\left(\frac{\sigma_i^2}{N}\right) + \frac{N-1}{N}\sum_{i=1}^{N}\sum_{j=1, j\neq i}^{N}\left(\frac{\sigma_{ij}}{N(N-1)}\right) \tag{2.15}$$

$$= \frac{\bar{\sigma}_i^2}{N} + \frac{(N-1)\bar{\sigma}_{ij}}{N} \tag{2.16}$$

Where

$\bar{\sigma}_i^2$ = the average variance of the shares in the portfolio,

$\bar{\sigma}_{ij}$ = the average covariance of the shares in the portfolio,

N = the number of shares in the portfolio.

This simplification indicates that the risk of a portfolio is dependent on the average variance of the shares in the portfolio and the average covariance of the shares in the portfolio. As N increases, the variance term of equation 2.4 will eventually be eliminated, thus reducing the risk held to the average covariance of shares in the portfolio. If share returns were independent, however, the average covariance would be zero and all risk could be eliminated through diversification.

In the case of concentrated portfolios shares, shares with higher weights and higher variances will increase overall portfolio risk. Likewise, shares with higher weights and higher covariances between them will also increase overall portfolio risk. (Bradfield and Kgomari, 2004). This reinforces the findings of Strongin et al (2000) as illustrated in equation 2.6.

Bradfield and Kgomari (2004) investigate this further by once more starting with equation 2.1. They then assume that all assets in the portfolio are uncorrelated with the result that the covariance proportion of risk is eliminated and we are left with the variance proportion.

$$\sigma_p^2 = \sum_{i=1}^{N} w_i^2 \sigma_i^2 \qquad (2.17)$$

Assume that each asset has the same average variance, denoted by $\bar{\sigma}^2$. Our portfolio risk is:

$$\sigma_p^2 = \bar{\sigma}^2 \sum_{i=1}^{N} w_i^2 \qquad (2.18)$$

From our definition of the concentration index in equation 2.6, we can restate equation 2.18 as

$$\sigma_p^2 = \bar{\sigma}^2 \frac{1}{\tilde{n}} \tag{2.19}$$

As can be seen, in the presence of the simplistic assumptions above, portfolio risk is a n inverse function of concentration.

### 2.1.4 Fund Size and Liquidity Constraints

Liquidity is typically defined as the ability to trade in and out of share positions quickly, at a minimal cost. This area of asset pricing has traditionally been of great relevance to South African fund managers given the extent to which thin-trading is manifest on the local exchange.

Even so, portfolio and benchmark theory frequently only address issues of diversification in terms of benchmark risk, overlooking the additional constraints imposed by fund size and the liquidity of shares, especially with regard to benchmark concentration.

Funds in an illiquid market such as South Africa will frequently encounter problems in investing in concentrated indices depending on their size. At the upper end of the index, funds are required to hold a large proportion of their equity in a few large cap shares. The larger the fund, the greater the proportion of their resources they will need to allocate to these shares. As these substantial share investments are held across a large number of funds in the market there is frequently not sufficient availability to enable a fund to acquire the full holding in these shares that it requires, even though the market capitalisation of the share itself might be fairly large.

Fund size is also directly related to liquidity in terms of rebalancing costs. Ideally, firms would prefer to effect any changes in the weights at which they carry shares within the shortest time possible so as to limit the effects of churn and the associated costs in the delay of rebalancing their funds. Thin trade on the JSE means, however, that funds are limited in the amount of shares in less liquid shares they are able to trade on any given day. The result is that rebalancing shares at the lower end of the index will frequently take longer than those at the upper end even though the weightings of shares at the tail of the index are significantly smaller than those at the top. The problem is further exacerbated as fund size increases and the amount to be rebalanced increases. This measure of liquidity risk is typically quantified as the number of days it takes to liquidate the shares in the portfolio.

In determining the extent of the risk imposed by fund size and liquidity issues it is important to note that the two factors do not operate independently. Consider a fund wishing to assess the risk of churn associated with the shares held in its investment index. The number of days it will take to turn over the funds held in any share can be determined by the formula:

$$Days\_Trade = \frac{F * w_i}{P_i} \frac{1}{ADT_i * TA_i} \qquad (2.20)$$

More specifically,

$F$ = the size of the fund,

$w_i$ = the index weight held in share i,

$P_i$ = the price of share i,

$ADT_i$ = the average daily trade in share i over a specified period of time,

$TA_i$ = the maximum percentage of that daily trade in share i that the fund is able to account for.

Where the first term represents the number of shares held in share i and the second term is the inverse of the average number of shares in share i that the firm can trade per day.

From the above formula it is clear that the number of days' trade required to trade out of any share position increases as fund size increases. Similarly, the less liquid the share is, as indicated by the average daily trade in the share, the greater the number of days required to trade out of the position.

It is therefore clear that these considerations place additional constraints on benchmark construction. It is essential that the size of the fund and its influence on share availability and liquidity be taken into consideration in evaluating benchmark risk as the inter-relationship between the two represents an additional source of risk to any fund.

## 2.2 Active-Passive Management

Our discussion thus far has focused primarily on issues surrounding risks associated with passive fund management, largely neglecting issues of active fund risk. The latter has become increasingly important given the prevalence of the "core-satellite" approach adopted by many fund managers whereby a number of small, actively-managed portfolios are used to enhance the performance of a core, index-type fund.

Treynor and Black (1973) provide an optimization model for managers who rely on security analysis to identify mispriced shares, enabling them to determine the optimal mix between their passive index funds and an active component derived from their security analysis.

We begin with the basic assumption that all securities in the market are fairly priced. Using a simple index model we can therefore describe the returns of any share, *i*, as follows:

$$r_i = r_f + \beta(R_M - r_f) + e_i \tag{2.21}$$

Where

- $r_i$ = the return on the *i*th share,
- $r_f$ = the risk-free rate of return,
- $\beta_i$ = the beta of share i with respect to the index,
- $R_M$ = the return on the market,
- $e_i$ = the firm-specific return associated with share i.

It is assumed that the firm-specific component of returns is independent across securities and that all shares in the market can be priced as per equation 2.21. The market portfolio so derived, M, is assumed to be the passive portfolio for the purposes of the analysis to follow.

Following this, security analysis is conducted in order to identify any mispriced securities in the market. The return for each share so analysed can be written as:

$$r_k = r_f + \beta_k(r_M - r_f) + e_k + \alpha_k \quad (2.22)$$

Where

$e_k$ = the zero mean, firm-specific disturbance in returns.

$\alpha_k$ = an additional component of return attributed to mispricing.

An active portfolio comprising such mispriced securities must by definition plot in risk-return space above the market line which comprises solely zero-alpha securities. The active portfolio is not optimal, however, for reasons of diversification and risk. The optimal portfolio is therefore some combination of the passive and active portfolio.

This optimal risky portfolio occurs when the Sharpe ratio of the portfolio is maximised as this yields the portfolio with the greatest reward to volatility ratio. We can separate the contribution of the active and passive portfolios to this ratio as follows, based on our prior assumption that the firm-specific component of returns is independent across securities:

$$S_P^2 = \frac{R_M^2}{\sigma_M^2} + \frac{\alpha_A^2}{\sigma^2(e_A)} \quad (2.23)$$

Where

$\frac{R_M^2}{\sigma_M^2}$ = contribution of the passive portfolio to the Sharpe ratio of the optimal portfolio.

$\frac{\alpha_A^2}{\sigma^2(e_A)}$ = contribution of the active portfolio to the Sharpe ratio of the optimal portfolio.

The ratio of alpha to residual standard deviation is known as the appraisal ratio and it is clear that the Sharpe ratio of the optimal portfolio is maximised when this value is maximised for the active portfolio. In order to maximise this value the weight of each share, *i*, within the active portfolio is set equal its own appraisal ratio scaled by the sum of the appraisal ratios across all the shares.

$$w_i = \frac{\dfrac{\alpha_i}{\sigma(e_i)}}{\sum_{i=c}^{n} \dfrac{\alpha_i}{\sigma^2(e_i)}} \tag{2.24}$$

Once the optimal active portfolio has been constructed, the combination of the two portfolios is a basic optimization problem. Assume we allocate a weight $w$ to the active portfolio and $(1-w)$ to the index portfolio; the efficient portfolio's return is given by:

$$r_p = wr_A + (1-w)r_M \tag{2.25}$$

The optimal weight allocation for two risky assets is given by:

$$w = \frac{[E(r_A)-r_f]\sigma_M^2 - [E(r_M)-r_f]Cov(r_A,r_M)}{[E(r_A)-r_f]\sigma_M^2 + [E(r_M)-r_f]\sigma_A^2 - [E(r_A)-r_f + E(r_M)-r_f]Cov(r_A,r_M)} \tag{2.26}$$

We can rewrite the excess return, variance and covariance terms of equation 2.26 as follows:

$$E(r_A)-r_f = \alpha_A + \beta_A R_M \tag{2.27}$$

$$\sigma_A^2 = \beta_A^2\sigma_M^2 + \sigma^2(e_A) \tag{2.28}$$

$$Cov(R_A,R_M) = \beta_A\sigma_M^2 \tag{2.29}$$

Substituting these equations into equation 2.26 we find the optimal weight to be invested in the active portfolio, $w^*$, is:

$$w^{*} = \frac{\sigma_A}{\sigma_A(1-\beta_A) + R_M \dfrac{\sigma^2(e_A)}{\sigma_M^2}} \tag{2.30}$$

As per Bodie, et al (2002), if we assume a beta of 1, the optimal active weight reduces to:

$$w_o = \frac{\dfrac{\alpha_A}{R_M}}{\dfrac{\sigma^2(e_A)}{\sigma_M^2}} \tag{2.31}$$

As per equation 2.31, when the active portfolio demonstrates the systematic risk of an average asset in the market, the weight of the active portfolio is determined by the ratio of its alpha to the return on the passive portfolio which represents the relative degree of the active portfolio's "outperformance", divided by the ratio of its risk to the passive portfolio's risk. The greater its outperformance and the lower its relative risk, the higher will be the desired weight in the active portfolio.

Equation 2.31 can then be related back to the beta adjustment as follows:

$$w^{*} = \frac{w_0}{1+(1-\beta_A)w_0} \tag{2.32}$$

Equation 2.32 demonstrates that the final weight invested in the active portfolio is also dependent on its beta. The greater the beta of the active portfolio, the smaller is the benefit obtained from diversifying through the addition of the index portfolio and the greater is the weight to be invested in the active portfolio and vice versa.

# 3

# Prior Research

This section outlines significant empirical research related to the areas of benchmark risk evaluation and risk decomposition, both locally and internationally. The issues of concentration and liquidity have increasingly attracted interest from South African researchers but to date concrete research in this area is limited. A brief overview of the more pertinent research available will therefore be provided.

This will be followed by a discussion of past research into risk decomposition on the JSE and the models which underlie return generation on the JSE. This will provide a foundation from which to assess the impact of recent changes in the classification of the JSE on benchmark risk.



## 3.1 Evaluating Benchmark Risk

The issue of single-share concentration is quantified by Strongin, et al (2000). They analyse the share selection skills of portfolio managers and their influence on portfolio construction in an attempt to determine the underlying cause for the persistent underperformance of U.S. large-cap portfolio managers. They find that the root cause of underperformance is not related to portfolio manager skill but is instead a direct consequence of '*a massive concentration of share-specific risk in a small number of mega-cap shares*'.

Their analysis indicates that compensating for this concentration through passive individual share positions reduces tracking error at double the rate that it reduces returns, thereby substantially improving portfolio performance.

They therefore find it necessary that risk be managed in three separate areas:

1. Accounting for large share-specific risk inherent in large-cap shares.
2. Diversification of risk through portfolio size and composition.
3. Concentrating share-specific risk in areas where the manager has demonstrated the ability to identify better-performing shares.

It is clear from their findings that while traditional diversification is of importance, an additional risk concern is raised by the concentration inherent in large-cap shares.

Bradfield and Kgomari (2004) undertake a study of concentration on the JSE over a three-year period. They determine that the ALSI demonstrates a degree of concentration almost one and a half times greater than the average concentration of General Equity funds in the market. In order to relate the effect of concentration to overall benchmark risk, they calculate the variance and covariance elements of risk for the ALSI. The remaining portion of risk, almost one third of total ALSI risk, is attributed to the effects of concentration.

Their analysis also indicates that the benefits of diversification on the JSE are limited due to the high correlations between shares in the market. The result is that, while traditional literature indicates that as few as 10 shares are required in order to effectively diversify a portfolio, Bradfield and Kgomari (2004) find that at least 30 and as many as 45 shares are required for effective diversification on the ALSI.

They therefore conclude that it is both these high inter-correlations as well as the extensive concentration on the exchange that is responsible for limiting the impact of diversification on the JSE.

Rousseau and Zwonnikoff (2002) conduct extensive comparisons of the alternative benchmarks provided by the FTSE/JSE to deal with the prudential concerns raised by the new FTSE/JSE All-Share Index.

They find that while the shareholder-weighted benchmark (SWIX) is generally accepted by South African fund managers as the preferred alternative to the capped index benchmark (CAPI), it is better suited as a peer review benchmark rather than a prudential option for the pension fund industry. The reason for this is rooted in the approach the index takes in addressing the concentration issue, namely by adjusting the weights of dual-weighted shares for their foreign holdings. Rousseau and Zwonnikoff (2002) argue that this does not make provision for concentration issues which might be raised should non-dual-listed shares demonstrate a substantial increase in weight, as the index methodology does not provide for such an eventuality.

They also find that the costs associated with rebalancing the SWIX as well as the liquidity issues raised by re-weighting the lower-weighted constituents would be of greater significance for the SWIX than the CAPI as the latter will typically have fewer constituents reduced in weight than the former.

Analysis confirms this by indicating that rebalancing a half-weight resources portfolio to the CAPI index requires less time than it would to rebalance the same index to the SWIX index.

It should be stressed that while these findings indicate the CAPI has distinctive advantages over the SWIX, the former is not without its own shortcomings and Rousseau and Zwonnikoff (2002) thus conclude that the decision of which benchmark to apply will largely depend on which of the alternatives best suit the fund in question.



### 3.1.1 Summary

It is clear that traditional risk measures such as beta and standard deviation are no longer sufficient for purposes of benchmark risk decomposition. Risk management must now also consider the influence of the distribution of share weights within the benchmark as excessive share-specific risk seems to be prevalent in large-cap shares.

Local research confirms the relevance of these findings for the South African market. Risk analyses of the local market indicate the impact of concentration on benchmark risk by demonstrating that one third of market risk results from excessive levels of concentration. As yet, only minimal success has been achieved in addressing this issue within local benchmark indices leading researchers to conclude that the choice between current benchmark alternatives is largely dependent on fund mandate as no single option clearly dominates another.

## 3.2 Market Risk Decomposition

The work undertaken by Campbell (1979) was instrumental in illustrating the dichotomy in the return generating process underlying industrial and mining shares on the JSE. In his pioneering study, he proposed that a separate security market line existed for each sector, with the sector index fulfilling the role of the market. This finding was confirmed by Venter, Bradfield and Bowie (1992) and Bowie and Bradfield (1993), who suggest that the "*appropriate major share index should be used in the CAPM rather than the overall index for JSE shares.*" (1993:15)

Gilbertson and Goldberg (1981), on the other hand, employed the returns on the Mining and Industrial indices as explanatory variables in a two-factor model in order to compare the differences in explanatory power of that model against that of the Markowitz-Sharpe market model on the JSE. Their analysis was conducted on only three shares, but it was found that in all three cases the two-factor model offered a significantly higher degree of explanatory power than the market model and the observed relationships of the share returns to the indices under consideration indicated that the two-factor model decomposed risk in a manner the single factor model could not duplicate.

Research since then has focused on determining the correct number of factors applicable in such a multi-factor model, as well as determining the proxies for the factors in question. Applying a similar methodology to that of Roll and Ross (1980), Page (1986) was able to extract three principal factors from a correlation matrix of JSE share portfolios and then determine that two of those factors were associated with significant risk premia. Subsequent analysis led him to conclude that the two observed factors seemed highly related to the mining sector and the industrial sector respectively.

Biger and Page (1993) undertook an investigation of the performance of South African unit trusts over a five-year period from February 1988 to March 1992. Performance was evaluated using single, three and five factor benchmark models and it was observed that portfolio performance differed across the models with particular bias created by the number of factors employed. It was found, however, that the degree of explanatory power offered by the models rose sharply from the single to three factor models while the observed increase between the three and five factor models was far less significant. This led the authors to conclude that "*These findings might lend support to the contention that, in the context of the South African capital market, a three factor model may be sufficient in providing explanations to market related phenomena*" (1993:8)

In a further study, Page (1993) conducted simulation tests of artificially generated one, three and five factor economies. His findings that neither principal factor analysis nor principal components analysis are able to distinguish between these economies in the presence of simulated thin trading and 'market microstructure effects' led him to conclude that commonly employed APT procedures lack power: "*...theoretical objections aside, the multivariate procedures commonly employed in tests of the number and pricing of the factors lack power. Consequently the conclusions drawn by different researchers are to a substantial extent influenced by their predispositions to single or multifactor outcomes*" (1993)



Attempting to circumvent these perceived analytical shortcomings, van Rensburg and Slaney (1997) sought to find observable macroeconomic proxies for the factors identified under their factor analytic work. Using monthly share data over a ten-year period, van Rensburg and Slaney (1997) applied principal factors, principal components and maximum likelihood factor analysis to both the correlation and covariance matrix of share returns. The scree test indicated that at least two and no more than three factors should be extracted. Following both varimax (orthogonal) and promax (oblique) rotations it was suggested that the first two factors could be interpreted as a 'gold/mining' and an 'industrial' factor respectively, with the third factor encompassing a 'non precious metal mining' source of variation.

In addition, following regression analysis of both market and two-factor models, van Rensburg and Slaney (1997) found strong evidence for the contention that: "*the multi-factor model both meaningfully decomposes risk and has superior explanatory power than the market model when describing the time series of JSE returns.*" (1997:13)

These findings supported those of both Gilbertson and Goldberg (1981) and Page (1986) and were confirmed in subsequent work by van Rensburg (2002).

Following the reclassification of the JSE sector indices in March 2000, van Rensburg (2002) updated the work conducted by van Rensburg and Slaney (1997) and found that the Financial-Industrial and Resources indices may be used as observable proxies for the first two principal factors extracted. It was suggested that these two indices replace the All-Gold and Industrial indices suggested by van Rensburg and Slaney (1997) in future applications of the APT model.

Importantly, the findings of van Rensburg (2002) regarding the dichotomy in the return-generation process of Resources and Industrial firms on the JSE imply non-diagonality in the correlation matrix of the market model's cross-sectional residual errors. It is suggested that the factor scores of principal components extracted from the residual variance-covariance matrix be included as proxies for omitted sources of common variation which are typically overlooked in similar analysis.

### 3.2.1 Summary

Past research into segmentation on the JSE has demonstrated that a two-factor model of the underlying return-generation process on the exchange is more applicable to the South African market than a single-factor market model. The primary risk-factors identified in this manner have consistently proven to be the Financial/Industrials and Resources sectors of the market and the dichotomy in the influences of the two has been distinctive.

# 4

# Problem Statement and Data Selection

This chapter begins by detailing the primary and sub problems addressed in the study. Following this, a discussion is provided of the procedures employed to obtain the share and index samples employed in the analysis to follow. On the 24 June 2002, the JSE replaced its Actuarial Indices with the FTSE/JSE Africa Index Series, in a joint initiative with the FTSE.

The new indices are constituted according to the FTSE Global Classification System on the basis of the free float index methodology. The relevant changes to the exchange brought about by the new index series will be discussed as a precursor to the analysis to follow.

All data samples were extracted for the period 30 June 1995 to 30 June 2002 as this is the extent of the back-calculated returns information available for the new JSE/FTSE Africa Series classification. The index and share data samples were not merged for purposes of the analysis to follow as the indices are largely well-diversified in contrast to the shares, and it was felt that the correlations for the data sets would be better observable in the analysis if the two samples were kept separate.



## 4.1 Problem Statement

This study will investigate and quantify the dimensions of risk that impact on optimal benchmark construction in the South African market. As such, the problems to be addressed may be specified as follows:

a. The need to determine whether the new FTSE/JSE classification structure has been correctly applied to the local exchange and identify whether it has brought about a fundamental change in the underlying risk factors on the exchange.

b. The need to assess the appropriateness and success of the alternative benchmark indices, the SWIX and CAPI, provided by the JSE as part of its new classification structure, as well as the 50% and 80% RESI benchmarks, using a broad range of risk measures including concentration, liquidity and the risk factors identified in a.

c. Investigate the impact of the above risk dimensions on the construction of optimal benchmark portfolios. This will provide a basis of comparison between optimal levels of risk and diversification achievable by fund managers and the current state of benchmarking in the market.

d. Investigate risk from an active management perspective by means of the addition of an active component to the optimal passive benchmarks identified in the analysis.

## 4.2 The FTSE/JSE Index Series

The FTSE global classification system groups shares into specific economic sectors and sub-sectors, which are common to all indices which employ the FTSE method. It comprises three levels of classification: 10 economic groups form the upper hierarchy which is further divided into 35 sectors and 110 sub-sectors. In addition, provision is made for a number of headline, specialist and tradable indices.

### 4.2.1 Index Sample

The economic groups of the FTSE classification encompass the Resources, Industrials and Financials indices previously found in the third tier of the old JSE Actuaries classification.

The Resources index of the old classification has now been divided into two groups, Resources (J000) and Basic Industries (J010). The Resources group now comprises only mining and precious minerals indices while the Basic Industries group comprises the non-precious minerals indices, building and construction and chemicals. The latter are now classified as Industrials. It should be noted that little justification has been provided for this change beyond the JSE's desire to establish a common ground for the dissemination and comparison of data in their partnership with the FTSE. This issue will be addressed at greater length in the analysis to follow.

As a result of the division in Resources, the old Chemicals, Oils & Plastics index has been separated into Oils & Gas (J007), which forms part of the Resources economic group, and Chemicals (J011), which forms part of the Basic Industries economic group.

The Industrials index of the old classification has been broken down into General Industrials (J020), Cyclical Consumer Goods (J030), Non-Cyclical Consumer Goods (J040), Cyclical Services (J050), Non-Cyclical Services (J060) and Information Technology (J090).

The Financials index has been carried over to the new classification as the Financials (J080) economic group. It remains little changed from its old classification structure, but for the addition of the Real Estate sector.

A complete breakdown of the new classification structure is provided in Appendix A.

#### 4.2.1.1 Index Returns Calculation

Index returns for the FTSE/JSE indices were obtained from I-Net Bridge for the period 30 June 1995 to 30 June 2002. A broadly representative sample was sought and, as a result, all economic and sector indices (barring the empty *Utilities* group) as well as the Top 40, FTSE/JSE ALSI, Industrial 25, Financial and Industrial 30 and

Financial and Industrial indices were included in the analysis. In all, 49 indices were represented.

Due to the change to the FTSE Global Index Methodology, it was necessary to rebase the returns of the new indices in order to obtain historical values as their constituents differed markedly from those under the old classification, and the application of free float meant that constituent weightings had changed markedly. This data was provided on I-Net Bridge in its rebased form and as such no calculations were necessary.

Lastly, returns were obtained for the Financial-Industrial and Resources sectors for the period 30 June 1966 to 30 June 2002. These indices were an amalgamation of the new FTSE/JSE indices and the old JSE Actuaries indices and the data for the latter was also obtained from I-Net Bridge.

Total returns index data was extracted for the index return calculation and as such dividends were already accounted for in the index values. Arithmetic returns were thus calculated as follows:

$$R_{it} = \frac{(V_{it} - V_{i(t-1)})}{V_{i(t-1)}} \tag{4.2}$$

Where $R_{it}$ = return on index i in period t,

$V_{it}$ = value of index i in time t.

### 4.2.2 Share Sample

There have also been a number of significant share movements between indices as a result of the reclassification, the more noteworthy of which will be summarised. Iscor and Sappi, both significant components of the old Resources index, have now been placed with the new Basic Industries economic group.

As a result of the division of the old Chemicals, Oils & Plastics, all chemicals shares which formed part of this index under the old classification have now moved from the Resources economic group and are now placed with the Basic Industries group. These include: AECI, African Oxygen and Chemical Services.

Lastly, Richemont, the former Diversified Industrials giant now forms part of the Cyclical Consumer Goods sector.

#### 4.2.2.1 Share Returns Calculation

The following criteria were employed in determining the samples to be used in the analysis.

1. Shares under consideration must have been traded throughout the period 30 June 1995 to 30 June 2002.
2. Shares under consideration must be sufficiently liquid and demonstrate a minimum of thin trading. Unlike Reese (1993) and Slaney (1995) it was not necessary to quantify what constituted sufficient liquidity as only three of the shares considered for inclusion in the sample, Adcorp Holdings, Grindrod and Brait SA, demonstrated a noticeable number of weeks without trade and the number of these weeks represented a large proportion of the total week's trade for each of these shares. These shares were therefore excluded from the analysis.

The FTSE/JSE All-Share Index as at 30 June 2002 was taken as starting point and the above criteria were then applied to its constituents. The resultant sample encompassed 85 shares which represented 72.34% of total market capitalisation on the exchange and 52.5% of the number of All-Share Index constituents at that date.

The shares selected were also largely representative of their economic groups. The Services and Financials groups were, however, somewhat under-represented compared to the others in terms of the percentage of group capitalisation due to the large number of shares within their sectors. The other groups were all dominated by one or two large shares, typically dual-listed, which were responsible for the bulk of their sector's market capitalisation.

**Table 4.1 Representation of economic groups within the share sample**

The table below outlines the representation of the share sample as compared to the overall FTSE/JSE All Share Index. The "Percentage of group market capital" column illustrates the percentage of each economic group within the ALSI that the share sample represents. The "Percentage of ALSI market capital" column represents the percentage of the total ALSI market capitalisation that each of the ALSI economic groupings within the sample contributes. The data was obtained in monthly format from I-Net Bridge for the period 30 June 1995 – 30 June 2002.

| Economic Group | Percentage of Group Market Capital | Percentage of ALSI Market Capital |
|---|---|---|
| Resources | 78.36% | 37.23% |
| Basic Industries | 86.97% | 5.09% |
| General Industrials | 83.86% | 0.54% |
| Cyclical Consumer Goods | 95.48% | 8.43% |
| Non-Cyclical Consumer Goods | 89.14% | 6.54% |
| Cyclical Services | 68.20% | 3.14% |
| Non-Cyclical Services | 59.83% | 1.01% |
| Financials | 42.68% | 9.57% |
| Information Technology | 70.17% | 0.79% |



A list of the shares that constitute the sample as well as their respective sectors can be found in Appendix B.

Monthly returns were calculated for the share sample based on the monthly share prices and dividend schedules extracted from I-Net Bridge. As per Slaney (1995) dividends were included on the ex-dividend date rather than the payment date.

Ross, Westerfield and Jaffe (1993) found that the price of a share dropped by the amount of the dividend on the ex-dividend date. This negative return on the ex-dividend date was then offset by the positive return on the dividends accrued at that date.

Given that the net value in such an instance is zero, it is clear that the dividend is not a net return to the shareholder and instead simply represents a conversion of the investor's wealth from "share value" to "cash". (Slaney, 1995).

Thus, by including the dividend on the ex-dividend date the fall in the share price is negated and returns are smoothed over.

Once the share prices and dividends had been extracted, arithmetic returns were calculated according to the following formula:

$$R_{it} = \frac{D_{it} + (P_{it} - P_{i(t-1)})}{P_{i(t-1)}} \tag{4.1}$$

Where $R_{it}$ = return on share i in period t,

$D_{it}$ = dividend on share i for which the last day to register fell within period t,

$P_{it}$ = the price of share i at the end of period t.

In addition to the return values, the average daily trade for each share was calculated based on daily trade over a six-month period from 1 January 2002 to 30 January 2002.

### 4.2.3 The FTSE Free Float Methodology

With the advent of the JSE/FTSE Africa Index Series, the free float method of weighting companies has replaced the market capitalisation method previously employed.

In order to calculate the free float weighting of any constituent, the full market capitalisation of the constituent is multiplied by the free float factor, which is defined as the percentage of unrestricted free float of that constituent. This unrestricted free float represents the percentage of the company's shares which are freely available for trade in the market.

Due to the variability in share free floats over time and the difficulties in determining precise free float figures, free floats within the index series are applied on a banding basis, meaning that after the free float of any share has been determined it will be rounded off to a certain pre-determined percentage based on which band into which it falls.

**Table 4.2 FTSE/JSE Africa Series Free Float Banding Specifications**

The new FTSE/JSE Africa Index Series employs a free float methodology as opposed to the traditional market capitalisation approach. The free float for a share represents the percentage of its holdings which are freely available for trade in the market. The free float percentage for each share is calculated based on a set of rules set forth by the JSE and this value is then allocated to one of the bands below to find the free float factor. Shares are carried in their respective indices at their market capitalisation weight multiplied by the free float factor.

| Calculated Free Float | Free Float Band |
|---|---|
| Free float greater than 5% but less than or equal to 15% | Next highest whole % |
| Free float greater than 15% but less than or equal to 20% | 20% |
| Free float greater than 20% but less than or equal to 30% | 30% |
| Free float greater than 30% but less than or equal to 40% | 40% |
| Free float greater than 40% but less than or equal to 50% | 50% |
| Free float greater than 50% but less than or equal to 75% | 75% |
| Free float greater than 75% | 100% |

While this approach offers the advantage of ease of implementation, it is considered by many market practitioners to distort the investable universe as shares at the upper and lower end of a band are considered to have the same free float factor even though their actual free float percentages might differ by as much as 25%.

Share weights available for investment, as indicated in the JSE/FTSE All-Share Index and all indices derived from it, are therefore not in fact representative of the true investment universe and are instead only approximations of the true investment universe.

### 4.2.4 Liquidity Requirements

Liquidity is a measure of the extent that a company's or group of companies' shares trade on the exchange. While the overall level of liquidity on the JSE has shown a continuous improvement over the last 5 years as illustrated in the table below, the overall percentage of shares being turned over on the exchange is still extremely low when compared to other world bourses.

**Table 4.3 Annualised JSE Liquidity for the years ended 31 May 1998-2002**

The table below illustrates the year-on-year increase in liquidity on the JSE as measured by overall share turnover on the exchange as a percentage of total shares in issue. The data was obtained from the JSE Market Profile provided by the exchange in May 2003.

| | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|
| **Liquidity** | 26.7% | 34.6% | 35.1% | 38.5% | 39.1% |

In fact, while the JSE was ranked $14^{th}$ in the world in terms of market capitalisation in the year ended May 2002, it was only ranked 23d with regards to liquidity during that same period.

Thin trading has always been a significant problem on the JSE and there was thus some concern initially that imposing a liquidity requirement would result in a large number of shares failing to meet the FTSE Global Index Classification. To this end, the FTSE's standard index liquidity guidelines were relaxed somewhat from ten months to eight months, in order to accommodate the less liquid smaller cap shares on the JSE.

According to the Index ground rules, listed companies must turn over at least 0.5% of their issued shares per month in eight of the twelve months prior to the annual FTSE/JSE Advisory Committee Review, for inclusion into the indices. Should they not comply with this requirement, they will be removed from the indices.

# 5

# Cluster Analysis Results

The advent of the FTSE/JSE Africa Index Series has brought fundamental changes to the underlying classification structure on the JSE. While the majority of these changes have been relatively minor in scope, others, such as the division of the Resources sector, have drawn sharp criticism from some sectors of the market.

The primary concern in this regard is the perceived dichotomy in the local market between the Financial-Industrial and Resources sectors. These two sectors have traditionally been viewed as fundamentally different in both their risk and return profiles and the weight distribution decision between the two has therefore constituted one of the primary equity allocation decisions for local fund managers.

As an initial step in the analysis, a cluster analysis will therefore be carried out in order to investigate whether the new structure of the classification has been correctly applied to the local market and whether any adjustments are required in order to reflect the true risk exposures between the sectors in question.



## 5.1 Methodology

Cluster analysis is a largely descriptive technique which attempts to separate a data set into its constituent groups or clusters. Whereas a more robust technique such as factor analysis makes numerous assumptions of the data set such as a normal distribution and interval scale measurement, cluster analysis makes no such demands of the data to be analysed.

The analysis will enable us to identify the sector groupings which constitute the market. When interpreting the results of this analysis, however, it is important to note that they are based on similarities in the movements of returns between indices. It is therefore possible for two indices from different groups to be clustered together because they have experienced similar share movements in the period under review, even though these share movements might have arisen as a result of completely unrelated stimuli.

In considering this phenomenon, King (1966) indicated that the returns of all shares are affected to some extent by movements in the market as a whole. When the market shows an upward trend, all shares tend to follow suit to at least some degree. Likewise, when the market enters a downturn, most shares tend to experience at least some downward variation in their returns. It is therefore necessary to adjust the data sample in such a way as to remove this common market element of returns.

In an effort to de-trend the indices under consideration and isolate their respective Financial-Industrials and Resources components, each index and share was regressed against the All Share Index. The residuals extracted in this manner represent the portion of returns unique to each index and rather than using the standard returns, cluster analyses using the residuals of these regressions was conducted.

A series of agglomerative hierarchical clustering techniques including the Single Linkage, Complete Linkage, Centroid Method and Ward's method were applied to the index returns data set. These techniques are characterised by the computation of a distance matrix between each of the variables according to the degree of similarity between them. Elements and clusters are then fused based on these distances, depending on the technique utilised.

Of all the techniques applied, only the Complete Linkage and Ward Methods provided *dendograms* (tree diagrams illustrating the clusters formed under the analysis) from which reasonable conclusions could be drawn. The Single Linkage and Centroid Method both suffered from the chaining property, whereby the initial two elements are clustered together and this cluster then grows progressively larger as lone elements which have yet to be clustered are added to it. The result is a dendogram which fails to find any distinct clusters and has the appearance of a single chain of elements. It was thus not possible to distinguish any significant clusters under these methods.

## 5.2 Complete Linkage Model

Under the complete linkage clustering method a distance matrix is computed based on the correlations between the variables in the data set. The less correlated two elements are the larger is the distance between those elements in the matrix. Clusters are then fused based on the distance between their most remote pair of elements. As successive elements are fused, the number of clusters decreases until one cluster remains which encompass all the elements in the data set.

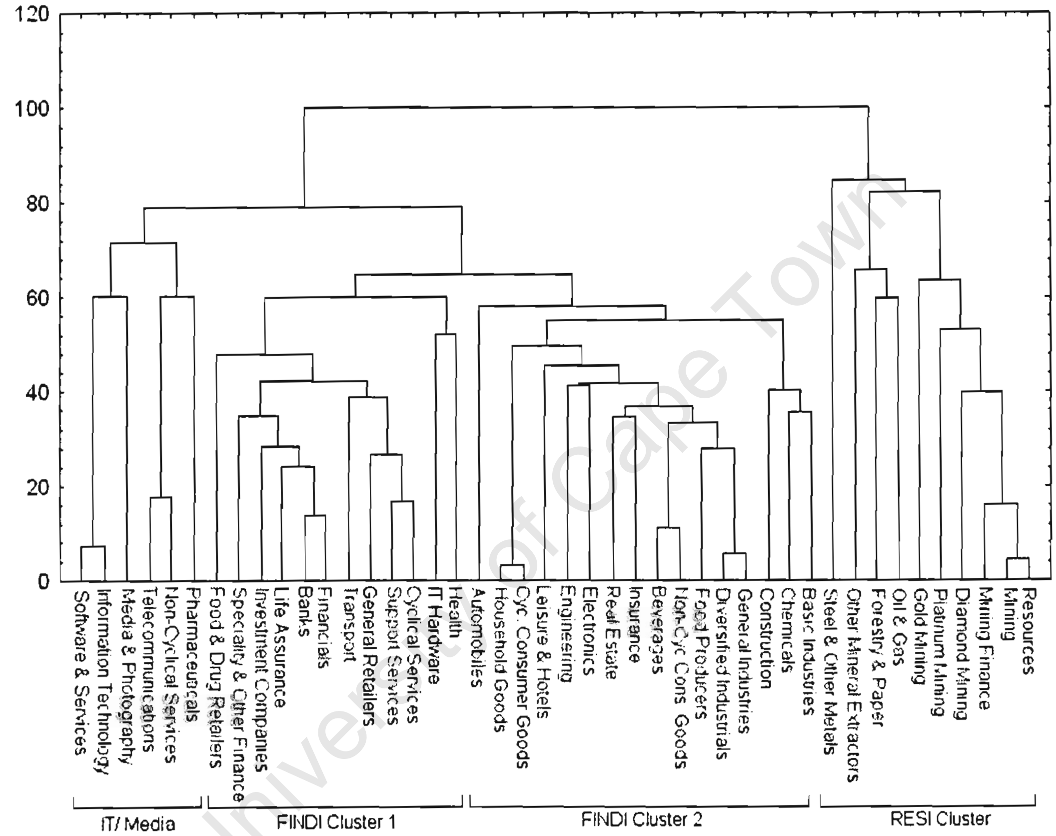
The application of a complete linkage cluster analysis to the index residuals sample yielded the tree diagram indicated in Figure 5.1, overleaf.

The distance measured on the y-axis is a measure of fit between individual elements and/or clusters. The greater the distance at which two elements are fused, the more tenuous the link between them is. Therefore, the further we move up the graph, the larger is the size of the clusters formed (as an increasing number of elements are lumped together), until at a distance beyond 100 we have a single cluster which includes all the individual indices in the analysis.

The y-axis of the dendogram has been scaled so that all distance values will lie within a range between a 0 and 100 so as to facilitate interpretation and comparison.

**Figure 5.1 Complete Linkage Cluster Analysis Dendogram**

Horizontal tree diagram representing sector groupings on the ALSI identified using the complete linkage clustering methodology. The complete linkage methodology groups data based on a distance matrix calculated using the correlations between the data. Monthly data used in the analysis was obtained from I-Net Bridge for the period 30 June 1995 – December June 2002. All sector returns were regressed against the ALSI in order to isolate the returns specific to each sector and the residuals were used in the analysis. The y-axis represents the linkage distance between clusters being formed. The shorter the distance, the stronger is the link between the clusters formed.






## 5.2.1 Number of clusters

Hierarchical clustering techniques provide no clear indication of the number of groups that should be identified from such analysis. Everett (1974) suggests that the dendogram be examined for large changes between the fusions.

Romesburg (1984) quantifies this by proposing that '*one strategy is to cut the tree at some point within a wide range of the resemblance coefficient for which the number* *of clusters remains constant, because a wide range indicates that the clusters are well-separated in attribute space.'*

Applying the above method to the dendogram it is found that the number of clusters changes frequently with little change in distance until we reach a distance of 65, where a few large clusters begin to emerge. Given the fact that the width of range for each of the changes prior to that point would be fairly small on average as a result of the frequency of the change in the number of clusters over that distance, we are justified in excluding this earlier segment from consideration.

**Table 5.1 Number of clusters formed under the Complete Linkage analysis**

The table below displays the number of clusters formed at varying linkage distances based on the complete linkage analysis. The greater the range between new clusters being formed, the greater is the stability of those clusters formed within that range. In selecting the cut-off level for the optimal number of clusters to be identified, we require both a stable range and a reasonable number of clusters within that range.

| Number of Clusters | Range of Distance | Width of Range |
|---|---|---|
| 6 | 65-72 | 7 |
| 5 | 72-79 | 7 |
| 4 | 79-82 | 3 |
| 3 | 82-85 | 3 |
| 2 | 85-100 | 15 |
| 1 | 100- | - |

The greatest width of range is provided from the distance 85-100 which would indicate that two clusters should be extracted. However, this gives too narrow a range of groupings given the data set and the second-widest range, 72-79 which yields five clusters, is selected as the cut-off point.



### 5.2.2 Cluster Identification

The first cluster is composed primarily of Information Technology, Telecommunications and Media indices and thus may be described as a Communications cluster. The presence of the Pharmaceuticals index in this cluster would seem to be spurious in nature as there are no obvious links between that sector and the other indices within the cluster. It is thus posited that it has been linked with the other sectors due to its general Financial-Industrials behaviour rather than any specific behavioural similarities on a finer scale.

The second cluster comprises the bulk of the indices which fall under the Financials-Industrials classification. Two sub-groupings emerge within this larger cluster: The first sub-grouping contains two clear Financials and Cyclical Services clusters as well as well as the Food & Drug Retailers, Information Technology Hardware and Health indices.

The second sub-grouping encompasses all the remaining Financial-Industrial indices which group together largely according to their economic sectors.

The third, fourth and fifth clusters constitute the remaining Resources and Basic Industries indices. This is interesting as the new classification has separated the entire Basic Industries sector from the Resources sector.

Cluster 3 is composed solely of the Steel & Other Metals index. Cluster 4 constitutes the bulk of the non-precious minerals resources indices on the exchange: Forestry & Paper, Oil & Gas and Other Mineral Extractors. The final cluster includes all indices related to resources and precious minerals and therefore represents the primary Resources/Precious Metals cluster.

The index constituents of each cluster are tabulated in Section 1 of Appendix C.

## 5.3 Ward's Method

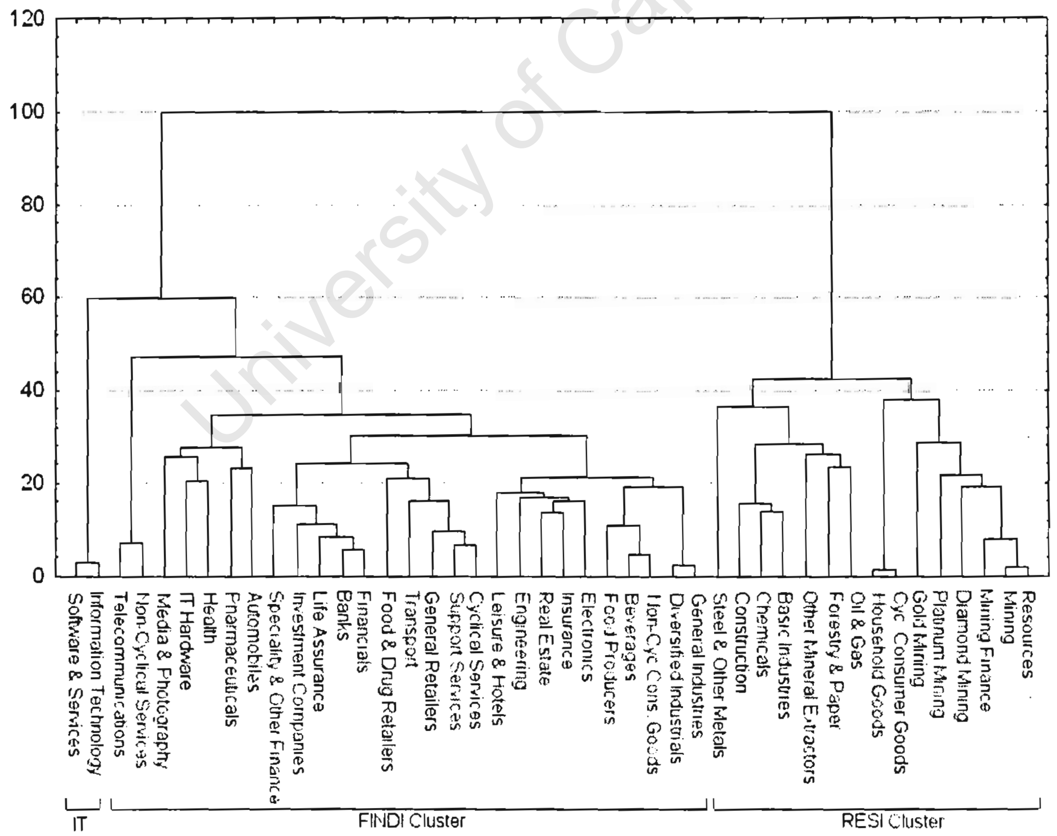
Ward (1963) proposed that as clusters are formed there is a loss of information which can be measured by the total sum of the squared deviations of every point from the mean of the cluster to which it belongs.

Ward's method therefore attempts to fuse clusters in such a way that the error terms which are generated in this fashion are minimized. As such, Ward's method is generally viewed as a more statistically exacting clustering algorithm than the other techniques typically applied.

The application of Ward's method to the index returns sample yielded the tree dendogram illustrated in Figure 5.2.

**Figure 5.2 Ward's Method Cluster Analysis Dendogram**

Horizontal tree diagram representing sector groupings on the ALSI identified using the Ward's Method clustering methodology. The Ward's Method groups data by minimising the error terms generated when two or more data points are fused based on similarities measured by correlation. Monthly data used in the analysis was obtained from I-Net Bridge for the period 30 June 1995 – 30 June 2002. All sector returns were regressed against the ALSI in order to isolate the returns specific to each sector and the residuals were used in the analysis. The y-axis represents the linkage distance between clusters being formed. The shorter the distance, the stronger is the link between the clusters formed.



### 5.3.1 Number of clusters

This dendogram provides clearer distinctions between the clusters formed than under the complete linkage method. It is observed that significant clusters only begin to emerge at a distance of 31 and this is therefore taken as a starting point. Constructing a similar distance-cluster table to that utilised in the Complete Linkage Cluster analysis, it is again found that the greatest width of range, in this case 40, yields only two clusters. The second widest range, which stretches between 47 and 60, is therefore selected and it is found that three clusters exist within this range.

**Table 5.2 Number of clusters formed under the Ward's Method analysis**

The table below displays the number of clusters formed at varying linkage distances based on Ward's Method analysis. The greater the range between new clusters being formed, the greater is the stability of those clusters formed within that range. In selecting the cut-off level for the optimal number of clusters to be identified, we require both a stable range and a reasonable number of clusters within that range.

| Number of Clusters | Range of Distance | Width of Range |
|---|---|---|
| 9 | 31-34 | 3 |
| 7 | 34-36 | 2 |
| 6 | 36-38 | 2 |
| 5 | 38-42 | 4 |
| 4 | 42-47 | 5 |
| 3 | 47-60 | 13 |
| 2 | 60-100 | 40 |
| 1 | 100- | - |



### 5.3.2 Cluster Identification

The first cluster stretches from J097 (Software and Computer Services) to J090 (Information Technology) and represents the Information Technology sector. The Media and Telecommunications indices are now placed with the primary Financial-Industrials cluster, but it should be noted that they still maintain a close proximity to the Information Technology indices.

The second cluster stretches from J067 (Telecommunication Services) to J020 (General Industrials) and again includes the bulk of the shares which fall under the Financials-Industrials classification. It is interesting to note the absence of all indices of the Basic Industries economic group from this cluster, which was not the case under the Complete Linkage technique.

Again, as under the Complete Linkage analysis, a number of clear sub-clusters emerge. Financials and Cyclical Services once more form groupings which are positioned with one another. Indices from the General Industrials, Cyclical- and Non-cyclical Consumer Goods sectors are once more positioned with one another in a small cluster separate from the other two FINDI clusters.

Basic Industries and Resources constitute the third cluster in the dendogram, stretching from J018 (Steel & Other Metals) to J000 (Resources). That the Basic Industries sector is placed with the Resources cluster makes intuitive sense given that it is an offshoot from the Resources index of the old classification.

Steel & Other Metals are again positioned alone while the Basic Industries indices again form a small sub-grouping (Chemicals, Building Materials and the Basic Industries economic group). The non-precious minerals group found under the Complete Linkage algorithm is evident again, and remains unchanged from those findings. The remaining Resources indices round the cluster off.

It is interesting to note the presence of the J034 and J030 (Cyclical Consumer Goods and Household Goods & Textiles) indices within this resources cluster. This indicates that there is a significant similarity in the movements between these Financial-Industrial indices and the Resources sector.

The index constituents of each cluster may be found in Section 2 of Appendix C.

## 5.4 Conclusions

Both clustering algorithms identified the presence of a Telecommunications/IT cluster. This makes intuitive sense given that the two sectors provide services in the communications field.

The Financial-Industrials clusters found are also of note. Both algorithms distinguish clearly between the Financials and Cyclical Services sectors and the remaining Financial-Industrial sectors. This would seem to indicate the presence of a clear dichotomy in the underlying risk profiles *within* the Financial-Industrials sector. Indeed, the clustering algorithms indicate that a number of Financial-Industrial indices are more closely related to the Resources sector than their own. Most noteworthy in this regard is the Basic Industrials sector which continues to show fundamental Resources exposure regardless of its new Financial-Industrials classification. This is an interesting phenomenon which will be explored in greater detail in the factor analysis to follow.

Finally, there is a clear distinction demonstrated in the Resources cluster between Steel, Non-Precious and Precious minerals, under both algorithms.

The analysis therefore supports the basic foundation of the new classification structure but it has raised questions about the classification of certain sectors within the Financial-Industrials sector. This has important implications for sector-based risk analysis and benchmarking risk and performance along those lines.

# 6

# Factor Analysis Results

The preliminary results of the cluster analysis have raised questions about the classification of certain indices within the new FTSE/JSE Africa Index Series reclassification. Past research (Van Rensburg, 2002) has demonstrated a clear dichotomy between the Financial-Industrial and Resources sectors in the South African market and determined that these two sectors can be used to proxy the risk underlying returns on the JSE.

While the cluster analysis is largely descriptive rather than technical in nature it has indicated that market indices continue to be grouped largely according to these two broad-based factors. It does not, however, allow us to measure the significance and magnitude of these risk exposures which precludes an investigation of the significance of the sector-based groupings derived prior or to investigate any further the anomalous index groupings identified by the analysis.

This chapter will therefore focus on a factor analysis of both the new indices and their underlying shares in order to confirm whether the FINDI-RESI two-factor risk structure still holds under the new classification or whether a new proxy set is more appropriate. The determination of the magnitude and significance of these risk factors will enable a study of the source of the misaligning influences identified by the cluster analysis.

Following this we will determine the degree to which the multi-factor risk model is more appropriate than a traditional market model for modelling underlying risk on the exchange. Lastly, we will consider the optimal risk combination of the derived factors based on historical data.

## 6.1 Factor Model Specification

### 6.1.1 Methodology

Factor analysis is a multivariate statistical technique which analyses the correlations between variables and then explains these variables in terms of their common, underlying factors.

There are two primary methods of factor analysis: principal component analysis and principal factor analysis, principal factors analysis and principal components analysis.

The difference between the two techniques lies in their approach to dealing with variance. In factor analysis, total variance is composed of common variance (that portion shared by all the variables in the sample), specific variance (that portion of the variance unique to that variable) and an error portion of variance (which arises due to inadequacy on the part of the data set and not the analysis employed).

Principal component analysis considers all three components of variance in its analysis. Principal factor analysis factors, on the other hand, are derived based on the common portion of variance only.

When we wish to identify latent factors in the data and are unaware of the magnitude of the unique or error variance and wish to eliminate it, principal factor analysis is traditionally used. (Hair *et al*, 1979)

Given that determining the exact magnitude of this unique portion of risk is unlikely without the exact figure for market risk (as represented by fully-diversified portfolio risk), principal factor analysis was selected as the extraction technique for the analysis to follow.

### 6.1.2 Factor Extraction

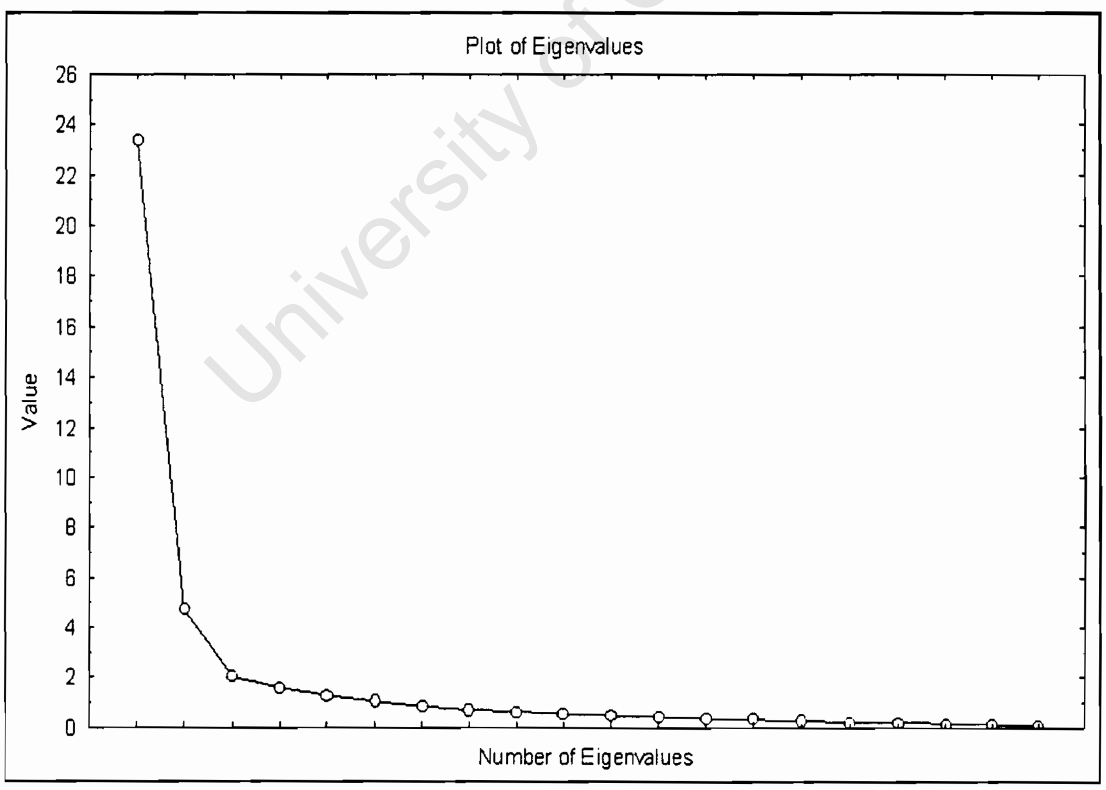
The correlation matrix of index returns was factor analysed using principal factors analysis and factors with eigenvalues greater than one were extracted.

In order to determine the number of factors significant to the analysis a number of techniques as suggested by Hair, *et al* (1979) and Cattel and Jaspers (1967) were applied to the data:

1. Following the procedure detailed by Cattel and Jaspers (1967), the last factor to be extracted is the one before the scree plot flattens out. As can be seen from the scree plot in Figure 6.1, this occurs *after* the third factor. Hair *et al* (1979) suggest that the last factor to be extracted is the one *at which the scree plot flattens out*, which can be seen to occur *at* the third factor.

**Figure 6.1 Scree plot of the index sample factor analysis**

The above figure presents the scree plot of the first 20 eigenvalues extracted from the index sample using principal factors analysis. The monthly data was obtained from I-Net Bridge for the period 30 June 1995 – 30 June 2002. Only the first 6 eigenvalues were greater than 1 and the rule of thumb provided by Cattel and Jaspers (1967) indicated that 3 factors should be extracted.



Given that the change in eigenvalue from the second to third factors is far more significant than that from the third to the fourth, it would seem evident that up to three factors should be extracted, but no more.

2. The percentage of variation criterion is an approach suggested by Hair *et al* (1979): They suggest the factor analysis procedure should be stopped once the extracted factors account for a significant portion of the variations (anything from 60% to 95%) or the last factor extracted accounts for less than 5% of the variation.

Examination of the three principal factors indicates that factors 1 and 2 account for 57.43% of the common variation in the index sample, with the factors accounting for 47.72% and 9.72% of the common variation in the index sample, respectively. Factors 3 and 4 account for only 4.13% and 3.25% of the variation respectively, however.

Given that factors 3 and 4 fail to explain significantly more variation than each other, we are again justified in extracting up to three factors, but no more. The initial analysis therefore focused on the first three factors extracted. The unabridged results of the factor analysis can be found in Section 1 of Appendix D.

**Table 6.1 Eigenvalues and corresponding explanatory power for index sample**

Eigenvalues greater than 1 which were extracted from the index sample using principal factor analysis are presented below. The corresponding degree of the variance in the underlying returns of the data sample explained by each of these factors is also presented as is the cumulative percentage of variance. Monthly data for the analysis was extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002.

| Principal Factors | Eigenvalue | Cumulative eigenvalue | Percentage of total variance explained | Cumulative variation explained |
|---|---|---|---|---|
| 1 | 23.38 | 23.38 | 47.72 | 47.72 |
| 2 | 4.76 | 28.14 | 9.72 | 57.43 |
| 3 | 2.02 | 30.17 | 4.13 | 61.56 |
| 4 | 1.59 | 31.76 | 3.25 | 64.81 |
| 5 | 1.28 | 33.03 | 2.60 | 67.42 |
| 6 | 1.05 | 34.09 | 2.15 | 69.56 |

### 6.1.3 Analysis of factor loadings

In order to simplify the factor structure, varimax (orthogonal) rotation was applied to the factor loadings. Thurstone (1947) defined the simple factor structure as yielding variables which load highly with one factor and display low loadings with the other factors, while minimising the number of high cross-loadings.

The resultant values of the rotation were then tested for significance. Hair *et al* (1979) suggest as a rule of thumb for sample sizes 50 or larger, that factor loadings greater than 0.3 be considered significant.

In an effort to identify the economic groups displaying the greatest number of significant relationships to each of the factors, the analysis was further refined by identifying the number of sectors within each economic group, including the group itself, which displayed significant loadings to each of the three factors.

**Table 6.2 Number of indices per economic group displaying significant loadings (3-factor model)**

Index factor loadings for a three-factor model obtained using principal factors analysis are varimax rotated in order to yield simplified factor structures. Resultant loadings greater than 0.3 are considered significant as per Hair, *et al* (1979). The number of significant loadings within each economic group is summarised on a factor basis. The analysis was based on monthly index data extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002.

| Economic Group | Factor 1 | Factor 2 | Factor 3 |
|---|---|---|---|
| 1. Resources | 0 (of 8) | 8 | 1 |
| 2. Basic Industries | 3 (of 5) | 5 | 0 |
| 3. General Industrials | 4 (of 4) | 4 | 0 |
| 4. Cyclical Consumer Goods | 1 (of 3) | 3 | 2 |
| 5. Non-Cyclical Consumer Goods | 5 (of 5) | 3 | 0 |
| 6. Cyclical Services | 6 (of 6) | 0 | 0 |
| 7. Non-Cyclical Services | 3 (of 3) | 0 | 0 |
| 8. Financials | 7 (of 7) | 1 | 1 |
| 9. Information Technology | 3 (of 3) | 0 | 2 |

It is evident from Table 6.2 that the Financials group and the new Consumer Goods and Services groups (which are the offshoots of the old Industrials sector), display the greatest proportion of significant loadings to factor 1. This factor can therefore be identified as primarily a "financials/industrials" construct.

Factor 2 can be seen to be dominated by the Resources and Basic Industries (an offshoot of the old Resources sector) economic groups and can thus be identified as primarily a "resources" construct.

Factor 3 loads predominantly on the Information Technology and Cyclical Consumer Goods economic groups, but all indices that load significantly on it also load significantly on either factor 1 or factor 2. It can therefore be assumed that some of the variation captured by factor 3 is also explained by factors 1 and 2. Given this and the fact that the factor has displayed only a limited contribution to the cumulative common variation explained by factors 1 and two, factor 3 will be excluded from further discussion.

Restating the factor loadings by economic group in light of the above, we find the loadings for the two-factor model are as follows:



**Table 6.3 Number of indices per economic group displaying significant loadings (2-factor model)**

Index factor loadings for a two-factor model obtained using principal factors analysis are varimax rotated in order to yield simplified factor structures. Resultant loadings greater than 0.3 are considered significant as per Hair, *et al* (1979). The number of significant loadings within each economic group is summarised on a factor basis. The analysis was based on monthly index data extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002.

| Economic Group | Factor 1 | Factor 2 |
|---|---|---|
| 1. Resources | 0 (of 8) | 8 |
| 2. Basic Industries | 2 (of 5) | 5 |
| 3. General Industrials | 4 (of 4) | 4 |
| 4. Cyclical Consumer Goods | 3 (of 3) | 3 |
| 5. Non-Cyclical Consumer Goods | 5 (of 5) | 3 |
| 6. Cyclical Services | 6 (of 6) | 0 |

| | | |
|---|---|---|
| 7. Non-Cyclical Services | 3 (of 3) | 0 |
| 8. Financials | 7 (of 7) | 1 |
| 9. Information Technology | 3 (of 3) | 0 |

It is clear from the above table that the General Industrials, Cyclical Consumer Goods and Non-Cyclical Consumer Goods groups and their sub-indices display dual loadings to both factors 1 and 2, while the Basic Industries group displays a stronger loading to factor 2 than factor 1.

This confirms the findings of the cluster analysis, and is noteworthy as past factor analysis results have indicated that there is generally a clear dichotomy between the effects of the underlying two factors on the shares or indices in the returns sample.

### 6.1.4 Selection of Proxies

The factor loadings graph (Figure 6.2) plots the factor loadings for factors 1 and 2 of each of the sector indices analysed. As is evident from the plot, we can identify two primary clusters of indices: a financials/industrials cluster which is associated with factor 1 and plots along the horizontal axis and a resources cluster which is associated with factor 2 and plots along the vertical axis. The dual-loading indices can be identified in the centre and upper-right segments of the graph.

In selecting proxies for each of the factors under consideration, it is necessary to satisfy two requirements:

a) The proxy must have a factor loading as close to 1 as possible for the one factor.
b) The proxy must have a factor loading as close to 0 as possible for the other factor.

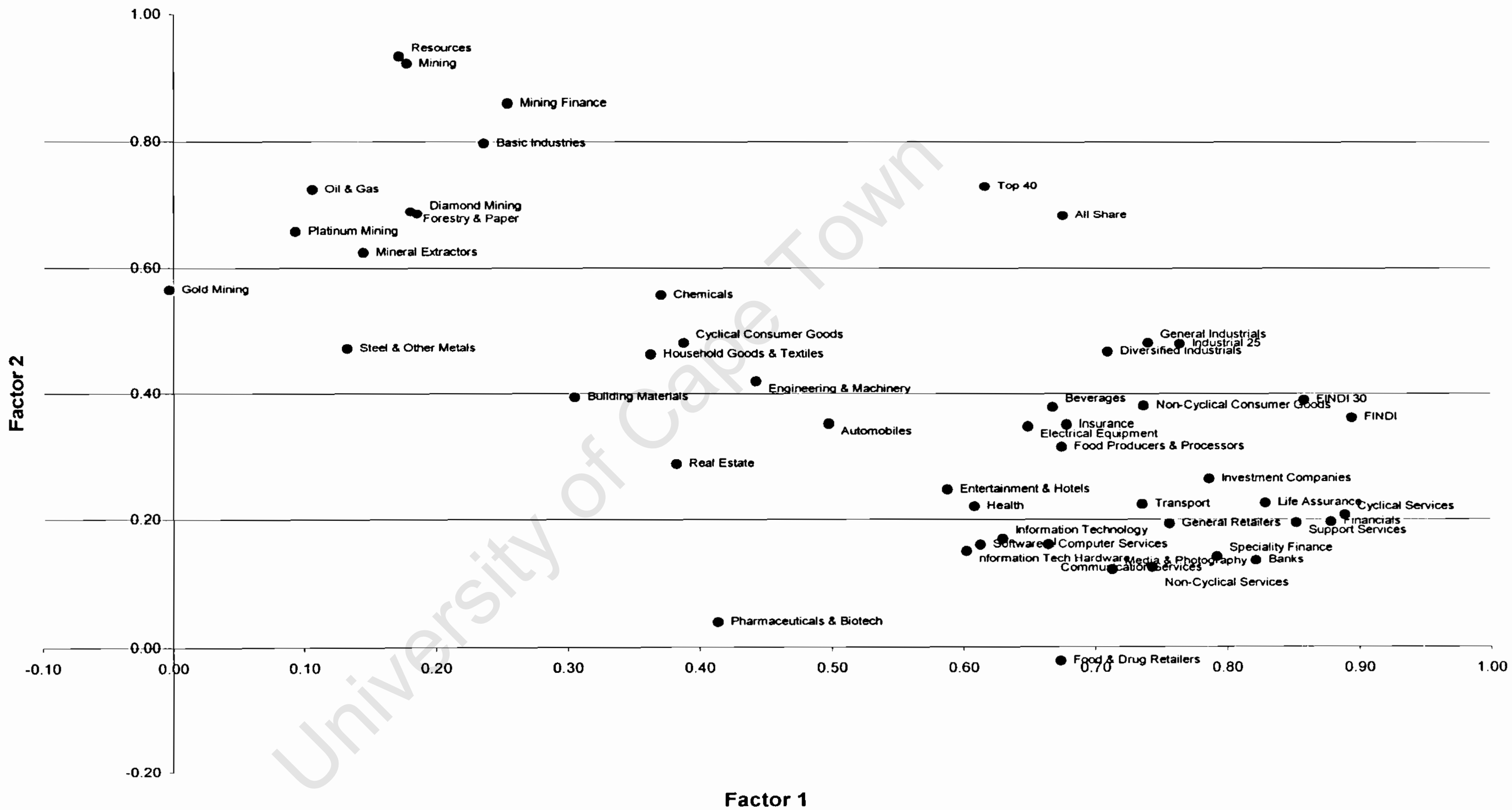





**Figure 6.2 Varimax-rotated factor loadings plot for the two-factor model**

Where it is clear that one variable shows a significantly higher loading to a particular factor, that variable may be selected as a proxy for that factor. Where more than one variable displays a similarly significant loading to a factor, the a priori knowledge of the data and its underlying meaning on the part of the researcher is necessary to determine which variable is more likely to act as proxy for that factor. (Hair et al, 1979)

Within the resources group, the Resources index (J000) clearly dominates factor 2 while also maintaining an insignificant loading to factor 1. The J000 is therefore selected as the proxy for factor 2.

We have already identified factor one as being a predominantly "financials/industrials" construct. Investigating the factor loadings of the indices contained within these sectors, we find that the Financial-Industrials (J250) index, the closest approximation to the old Financial-Industrial Index (CI21), and the Cyclical Consumer Goods economic group have the most significant factor loadings to factor one while also maintaining negligible loadings to factor 2. While the Financial-Industrials index also demonstrates a significant loading to factor 2, because of its more comprehensive nature and the fact that the differences between the loadings for the two indices are so insignificant, it is suggested that the J250 index be selected as the proxy for factor 1.

### 6.1.5 Identification of misaligned sector classifications

It is clear from the initial factor analysis of the index sample that there are a number of indices which display dual loadings as well as indices which are classified by the FTSE/JSE Africa Index methodology as falling within the Financials-Industrials sector but display Resources loadings instead.

A description of the indices in question is provided in Tables 6.4 and 6.5.

**Table 6.4 Indices which display dual loading**

A two-factor model was constructed following the principal factor analysis of the index sample. The sample was extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002. All index loadings obtained under the analysis were varimax-rotated in order to yield simplified factor loadings and then tested for significance using the rule of thumb proposed by Hair, et al (1979). All indices demonstrating significant loadings to both factors are listed in the table below.

| Index | Economic Group | Code |
|---|---|---|
| Chemicals | Basic Industries | J011 |
| Building Materials | Basic Industries | J013 |
| Diversified Industrials | General Industrials | J024 |
| Electronic & Electrical Equipment | General Industrials | J025 |
| Engineering & Machinery | General Industrials | J026 |
| Automobiles | Cyclical Consumer Goods | J031 |
| Household Goods & Textiles | Cyclical Consumer Goods | J034 |
| Beverages | Non-Cyclical Consumer Goods | J041 |
| Food Producers | Non-Cyclical Consumer Goods | J043 |
| Insurance | Financials | J083 |

**Table 6.5 Financial-Industrial indices which display Resources exposure**

A two-factor model was constructed following the principal factor analysis of the index sample. The sample was extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002. The Financial-Industrials and Resources sectors were identified as suitable proxies for factors 1 and 2, respectively. All Financial-Industrial (FINDI) indices, as classified by the FTSE/JSE Global Classification Structure, which demonstrated Resources loadings rather than FINDI loadings are presented in the table below.

| Index | Economic Group | Code |
|---|---|---|
| Forestry & Paper | Basic Industries | J015 |
| Steel & Other Metals | Basic Industries | J018 |

Following the factor analysis of the index sample, similar analysis was conducted on the share sample in order to isolate the sources of the classification misalignments identified. The JSE is a bourse dominated by a small number of large cap shares. One or two shares within each economic group tend to constitute a significant portion of the total market capital within that group with the result that those few shares have an undue influence on the performance of their sectors. For example, Richemont constitutes roughly 95% of the Cyclical Consumer Goods sector with the result that the performance of the sector largely mirrors its behaviour.

It would therefore seem likely that the indices which display loadings different from what would be expected do so not because of the underlying performance of all the shares in that index, but because of the influence of one or two large shares within the index. This is confirmed by an investigation of the shares which displayed aberrant loadings.

**Table 6.6 Shares which display dual exposure**

The table is derived from a two-factor model which was constructed using principal factor analysis on the share sample. The sample was extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002. All share loadings obtained under the analysis were varimax-rotated in order to yield simplified factor loadings and then tested for significance using the rule of thumb proposed by Hair, et al (1979). All shares demonstrating significant loadings to both factors are presented in the table below. Shares highlighted in bold are dual-listed.

| **Share** | **Economic Group** | **Sector Index** |
|---|---|---|
| **African Oxygen Ltd.** | Basic Industries | Chemicals |
| **Barloworld** | Basic Industries | Diversified Industrials |
| Ozz Limited | General Industrials | Engineering & Machinery |
| Reunert | General Industrials | Electronic & Electrical Equipment |
| **Richemont** | Cyclical Consumer Goods | Household Goods & Textiles |
| **South African Breweries** | Non-Cyclical Consumer Goods | Beverages |
| Illovo Sugar | Non-Cyclical Consumer Goods | Food & Food Producers |

**Table 6.7 Financial-Industrial shares which display Resources exposure**

A two-factor model was constructed following the principal factor analysis of the share sample. The sample was extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002. The proxies for factors 1 and 2 were identified as the Financial-Industrials and Resources sectors, respectively. All Financial-Industrial (FINDI) shares, as classified by the FTSE/JSE Global Classification Structure, which demonstrated Resources loadings rather than FINDI loadings are presented in the table below. Shares highlighted in bold are dual-listed.

| Share | Economic Group | Sector Index |
|---|---|---|
| AECI Limited | Basic Industries | Chemicals |
| Murray & Roberts | Basic Industries | Building Materials |
| Sappi | Basic Industries | Forestry & Paper |
| Highveld Steel | Basic Industries | Steel & Other Metals |
| Bell Equipment | General Industrials | Engineering & Machinery |
| **Tongaat-Hullet** | Non-Cyclical Consumer Goods | Food & Food Producers |

As can be seen from the above tables, the strong resources behaviour in each of the aberrant indices can be explained by the behaviour of just one or two of their underlying shares.

It is interesting to note that the majority of the shares displaying dual exposures are dual-listed shares (as highlighted in Table 6.6). It has long been theorized that such shares would exhibit strong resources behaviour, in addition to their traditional financials-industrials behaviour, due to the influence of foreign buyers on their prices.

The remaining shares in the tables derive a significant portion of their earnings globally or their operations are related to the resources industry (for example Ozz Limited, which provides engineering solutions to the mining industry) and as such they too exhibit strong resources behaviour.

As stated previously, asset allocation in South Africa is based largely on the exposure to Resources and Financial-Industrial risk factors in the market. It is therefore necessary that the behaviour of shares with substantial foreign influences be taken into account during benchmark construction so as to ensure that they are aligned according to their actual risk behaviour and not their classification.

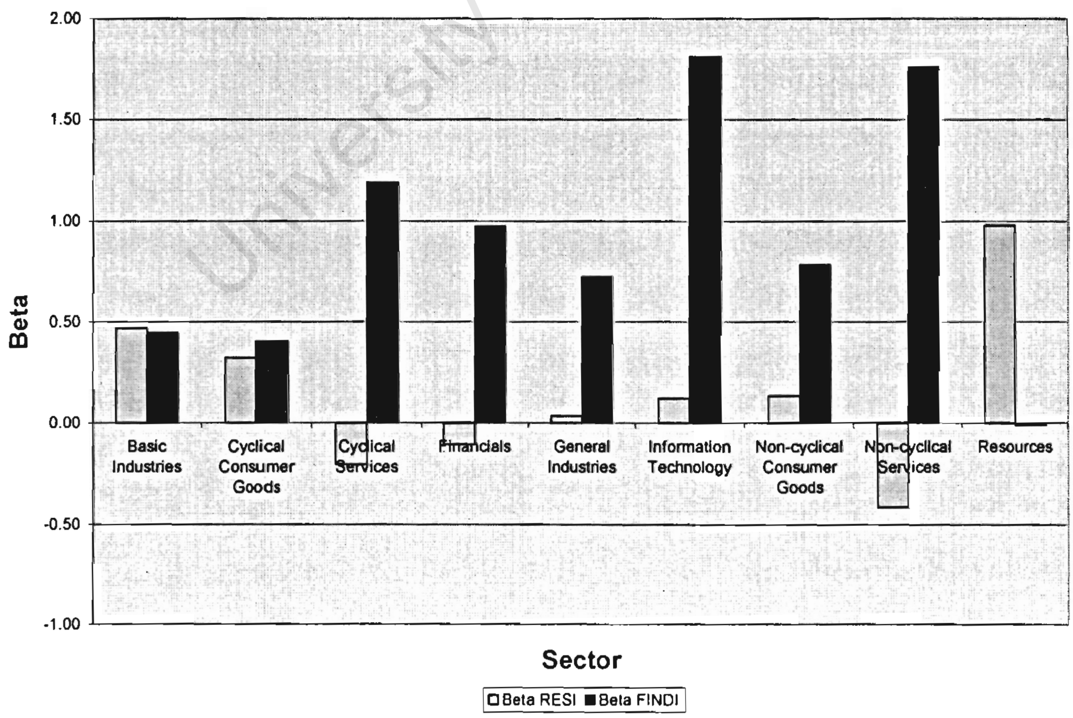
### 6.1.6 Sector Risk Exposures

Betas for each of the shares in the ALSI were obtained by conducting multiple-regressions of the share returns against the Financial-Industrial and Resources indices over a monthly three-year period from 30 June 1999 to 30 June 2002. The betas for each sector were then calculated as the cumulative share-weighted betas of the individual shares within each sector.

**Figure 6.3 Sector Beta Comparisons**

Betas were calculated for each of the shares constituting the ALSI as at 30 June 2002 by regressing the returns on each share against the Financial-Industrial and Resources indices. Data for the analysis was obtained from I-Net Bridge for the period 30 June 1999 to 30 June 2002. Shares were then grouped according to their sector classification, as per the FTSE Global Classification System, and betas were calculated for each sector based on the share's weight within the sector and its beta.






The majority of sectors display a negative resources exposure due to their primarily Financial-Industrial composition. The dual-loading sectors naturally demonstrate a combination of FINDI and RESI exposures which is most strongly evident in the Basic Industries and Cyclical Consumer Goods. This supports the findings of both the cluster and factor analysis.

The Cyclical Services, Non-Cyclical Services and Information Technology sectors all demonstrate FINDI risk exposures greater than 1 indicating above-average sensitivity to this factor. In contrast, the Financials, General Industries and Non-Cyclical Consumer Goods sectors all demonstrate less significant FINDI exposures.

## 6.2 Model Comparison: Two-Factor Model vs. Market Model

Past research has indicated that not only does a multi-factor approach meaningfully decompose risk on the JSE, it also offers a higher degree of explanatory power than single-factor models. Following the factor analysis, Ordinary Least Squares regressions were run using the index sample in order to determine whether this difference in explanatory power between the market model and two-factor still holds under the new classification. This would assist in determining whether a single- or multi-factor risk-based model would be more appropriate in benchmark and portfolio construction on the JSE.

### 6.2.1 Methodology

The models to be used in the analysis were defined as follows:

The market model using the ALSI (J203) as proxy:

$$R_{it} = \alpha + \beta_{ALSI} \; R_{ALSIt} + \varepsilon_{it} \tag{6.1}$$

Proposed two-index model:

$$R_{it} = \alpha + b_{iRESI} \; R_{RESIt} + b_{iFINDI} \; R_{FINDIt} + \varepsilon_{it} \tag{6.2}$$

Where

$b_{iRESI}$ = the sensitivity of returns on index $i$ to the returns realised on the FTSE/JSE Resources (J000) Index.

$R_{RESIt}$ = the return on the FTSE/JSE Resources (J000) Index in time $t$.

$b_{iFINDI}$ = the sensitivity of returns on index $i$ to the returns realised on the FTSE/JSE Financials-Industrials (J250) Index.

$R_{FINDIt}$ = the return on the FTSE/JSE Financials-Industrials (J250) Index in time $t$.

In regression analysis, the $R^2$ statistic reflects the degree of explanatory power of the predictive model constructed. A value of 1 reflects a perfect measure of fit while a value of 0 indicates that the predictive model is unable to explain any of the variation in the data.

Irrespective of the number of independent variables we add to a regression analysis, however, $R^2$ will never decrease and must always increase or at the very least remain unchanged. Therefore, even if an independent variable does not contribute significantly to the explanatory power of the model, this will not be reflected in the $R^2$ statistic.

The adjusted $R^2$ statistic on the other hand takes into account the degrees of freedom in the regression and only shows an increase when an independent variable is added which contributes significantly to the model.

The degree of fit offered by each model was therefore measured by the mean adjusted $R^2$ value obtained by averaging the adjusted $R^2$ value found in each regression of that model on the index and share data samples.

### 6.2.2 Index Sample

It was found that the $R^2$ values for all of the indices were significant at the 95% level of confidence.

In regressing the market model against each of the sector indices, it was found that the model was able to explain on average 41.57% of the common variation of index returns, whereas the two-factor model was able to account for 52.26% of the common variation in sector index returns. The two-factor model was therefore able to explain 10.69% more of the average variation than the market model, only a slight increase over the explanatory difference calculated in the analysis of van Rensburg (2002).

A complete breakdown of the adjusted $R^2$ values and f-statistics for each of the indices and models under consideration is presented in Appendix E.

**Table 6.8 Comparing the explanatory power of the market model and the two factor model for the index sample**

Regressions were conducted of the returns on the index sample against a single-index market model and a two-factor model based on the findings of the factor analysis. The data sample was extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002. The adjusted $R^2$ values generated for each set of regressions was averaged in order to determine the average explanatory power of each of the models. The returns of each of the models was then regressed against the residuals of the other model's initial regression in order to determine whether either of the models was able to explain some or all of the variation that the other was unable to explain.

| | Market Model | Proposed two-factor model |
|---|---|---|
| **Arithmetic mean adjusted $R^2$ of the initial regression** | 41.57% | 52.26% |
| **Arithmetic mean adjusted $R^2$ of the secondary regression** | -1.20% | 20.00% |



It should be noted that in 91% of the regressions under review, the two-index model explained a greater degree of the variation in sector index returns than the market model did.

The only indices for which the market model offered a greater degree of explanatory power than the two-index model were Engineering & Machinery (J026), Cyclical Consumer Goods (J030), Household Goods & Textiles (J034) and Real Estate (J086). The difference in adjusted $R^2$ values in each of these cases was less than 1.6% for the two models under review.

Once the initial regressions had been completed a second set of dependent variables was generated from the residuals of the initial regression. These residuals were then regressed against the independent variables for each of the two models with the purpose of determining whether either of the models was able to explain some or all of the variation that the other was unable to explain.

The residuals of the market index were regressed against the two-factor model and it was found that the two-factor model was able to account for an average of 20% of the common variation of the indices not explained by the market model.

When regressing the residuals of the two-factor model against the market model, however, it was found that the market model was unable to account for any of the variation in the two-factor model as it displayed a mean r-squared value for the regression which was virtually zero, thus yielding a negative adjusted r-squared value.

None of the f-statistics for the regression of the two-factor model residuals against the market model were significant at the 5% level, while 35 of the 43 market model residuals which were regressed against the two-factor model were significant at the 5% level.

The test statistics of each of the indices and models is presented in Appendix E.

### 6.2.3 Share Sample

The f-statistics of the initial regression indicated that 79 of the 85 share return regressions against the market model were significant at the 5% level. In contrast, 80 of the share return regressions were significant at the 5% level when regressed against the two-factor model.

**Table 6.9 Comparing the explanatory power of the market model and the two factor model for the share sample**

Regressions were conducted of the returns on the share sample against a single-index market model and a two-factor model based on the findings of the factor analysis. The data sample was extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002. The adjusted $R^2$ values generated for each set of regressions was averaged in order to determine the average explanatory power of each of the models. The returns of each of the models was then regressed against the residuals of the other model's initial regression in order to determine whether either of the models was able to explain some or all of the variation that the other was unable to explain.

| | **Market Model** | **Proposed two-factor model** |
|---|---|---|
| **Arithmetic mean adjusted $R^2$ of the initial regression** | 20.70% | 28.26% |
| **Arithmetic mean adjusted $R^2$ of the secondary regression** | 8.90% | -1.21% |

While the degree of explanatory power offered by both the two-factor and market model is significantly lower for the share sample, it is clear that the two-factor model still offers a greater degree of explanatory power than the market model. Given that the market model explains 20.70% of the variation in share returns versus 28.26% of the two-factor model, we find that the difference between the two approaches is now only slightly decreased from that found under the index sample, at 7.56%. The perceived decrease in explanatory power for both the market model and two-index model on a share level is due to the greater degree of diversification inherent in the sector indices.

A summary of the test-statistics is presented in Appendix E.

Once again the two-factor model was able to explain 85.88% more of the variation than the market model under the secondary regression analysis. No clear pattern emerged in terms of which the market model was better able to explain the variation in share returns than the two-index model as it was able to do so for at least one share from each of the economic groups excluding Non-Cyclical Services and Information Technology.

**Table 6.10 Shares for which the market model was able to explain more of the variation in returns than the two-index model**

Following an initial regression of the returns on the share sample against the returns on the market model and two-factor model, the returns on each model were regressed against the returns on the residuals of the other model generated during the initial regression. The data sample was extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002. The table below lists the shares for which the market model was able to explain more of the variation than the two-factor model.

| **Economic Group** | **Shares** |
|---|---|
| Resources | Palabora Mining |
| Basic Industries | Group Five |
| General Industrials | Delta Electrical Industries, Hudaco Limited |
| Cyclical Consumer Goods | Tiger Wheels |
| Non-Cyclical Consumer Goods | Aspen Pharmacare, Illovo, Oceana Group |
| Cyclical Services | United Service Technologies, City Lodge Hotels |
| Financials | Capital Alliance Holdings |



In all of the above cases the difference in explanatory power was found to be less than 1.9%, excepting the case of Palabora Mining where it was found to be 7.37%.

The secondary regression offers similar findings, with the market model unable to account for any of the variation in the residuals of the two-factor model while the two-factor model accounts for 8.9% of the variation in the residuals of the market model on average.

As per the index regressions, none of the secondary regressions against the market model were significant at the 5% level. In contrast, 44 of the 85 secondary regressions were not significant at the 5% level when regressed against the two-factor model. The summarised results are presented in Appendix E.

### 6.2.4 Wald Tests

In order to determine whether the dichotomy in the magnitudes of the effects of the two indices as determined by van Rensburg and Slaney (1997) still holds, Wald tests for coefficient restrictions were performed on the returns of each of the sectors in order to determine whether the sensitivity coefficients of the two indices were statistically different from one another. The null hypothesis, $b_{iRESI} = b_{iFINDI}$ was tested for each of the sectors and was rejected for 37 of the 43 sectors at the 5% level of significance and for 32 of 43 sectors at the 1% level, thus indicating that the findings of van Rensburg and Slaney (1997) persist under the new classification.

The null hypothesis could not be rejected for the Chemicals, Building Materials, Steel & Other Metals, Engineering & Machinery, Household Goods & Textiles and Real Estate sector indices.

Of those indices which could not be rejected, Chemicals, Building Materials, Engineering & Machinery and Household Goods and Textiles all showed significant dual exposures to both factors during the factor analysis.

Results of the Wald tests were likewise somewhat less conclusive for the share sample with the null hypothesis rejected at the 5% level of significance for 57 of the 85 shares in the sample and for 48 of the 85 shares at the 1% level.

Again it was found that there were shares from every sector excluding Information Technology and Non-Cyclical Services for which the null hypothesis could not be rejected.

**Table 6.11 Shares for which the null hypothesis could not be rejected**

Wald tests for coefficient restrictions were performed on the share sample in order to investigate the dichotomy in the exposures of the shares to the two factors identified in the factor analysis. The data sample was extracted from I-Net Bridge for the period 30 June 1995 – 30 June 2002. The null hypothesis stated that the beta coefficients for the two factors were equal. Shares for which the null hypothesis could not be rejected are listed in the table below. Shares in bold demonstrated significant dual-exposures for the factor analysis.

| **Economic Group** | **Shares** |
|---|---|
| Resources | Gold Fields, Western Areas Mines, Avgold, Transhex, Barplats |
| Basic Industries | **Murray & Roberts**, AECI Limited, Chemical Services, Highveld Steel, Group Five |

| | |
|---|---|
| General Industrials | Dell Electronics, **Ozz Limited**, Hudaco Limited, Bell Equipment |
| Cyclical Consumer Goods | **Richemont** |
| Non-Cyclical Consumer Goods | Aspen Pharmacare, **Illovo**, Tongaat-Hullet, Oceana Group, Rainbow Chickens |
| Cyclical Services | Allied Technologies, United Service Technologies, Unitrans, City Lodge Hotels |
| Financials | Capital Alliance Holdings, PSG Group, Centrecity Property |

Those shares which demonstrated significant dual-exposures under the factor analysis have been highlighted in the above table. A large number of the shares for which we were unable to reject the null hypothesis were identified as misaligned during the factor analysis.

## 6.3 The optimal FINDI-RESI mix

Resources constitute only a fraction of the GDP of the South African economy, a fact belied by the extensive influence they exert on the local exchange. The Resources sector has been excessively volatile in comparison to its FINDI counterpart over the last 36 years, although it has shown higher returns over that same period.

Even given this associated risk, fund managers have held an average of 57.5% of their portfolios in resources shares and only 42.5% in FINDI shares over that same period largely due to the excessive weight of the Resources sector on the exchange over the period. (Futuregrowth Asset Management, 2002)

These problems have been exacerbated in recent years as the performance of the Resources sector has led to it accounting for an increasingly substantial weighting of the market as a whole. The result is that even though the Resources sector was delivering exceptional performance, because of fund mandates to limit single-share exposure and regulations within the pension fund and unit trust industries, funds were unable to take full positions on the top-performing shares within the sector.

As a consequence, over the last 3 years, the average industry weighting of resources shares within the Asset Management Industry has been 65% of the full ALSI weighting of that sector as fund managers preferred prudence over over-exposure.

Returns from the Resources sector declined steadily between 1987 and 1997, which most fund managers interpreted as signal that they should reduce their holdings in the sector. This trend reversed itself between 1997 and 2001, however, with the result that the asset management industry's median performance was 11% p.a. while the ALSI returned 15% p.a. over the same period.

This measure of underperformance was further compounded when taking inflation into account, as the asset management industry had in fact returned 5% less than cash had over that same period. (Futuregrowth Asset Management, 2002)

The analysis to follow considers the combination of the Financial-Industrial and Resources sectors which has historically yielded the minimum overall portfolio risk as well as the combination which has yielded the maximum achievable Sharpe ratio. A minimum-variance frontier which represents the range of lowest achievable portfolio variances for corresponding levels of return is generated for combinations of these factors.

The point which yields the minimum overall variance on the frontier, the global minimum variance portfolio, represents the optimal historical risk combination for the two factors.

All calculations were based on the returns for the Financial-Industrial and Resources indices over a 36-year period from 30 June 1966 to 30 June 2002, as detailed in Chapter 4. The descriptive statistics for each of the indices over the period are presented in Table 6.12.

**Table 6.12 Descriptive statistics for the FINDI-RESI data sample**

A 36-year returns history was compiled for the Financial-Industrial (FINDI) and Resources (RESI) indices by combing the old Financial and Industrial (CI21) and Resources (CI11) indices with the new FTSE/JSE

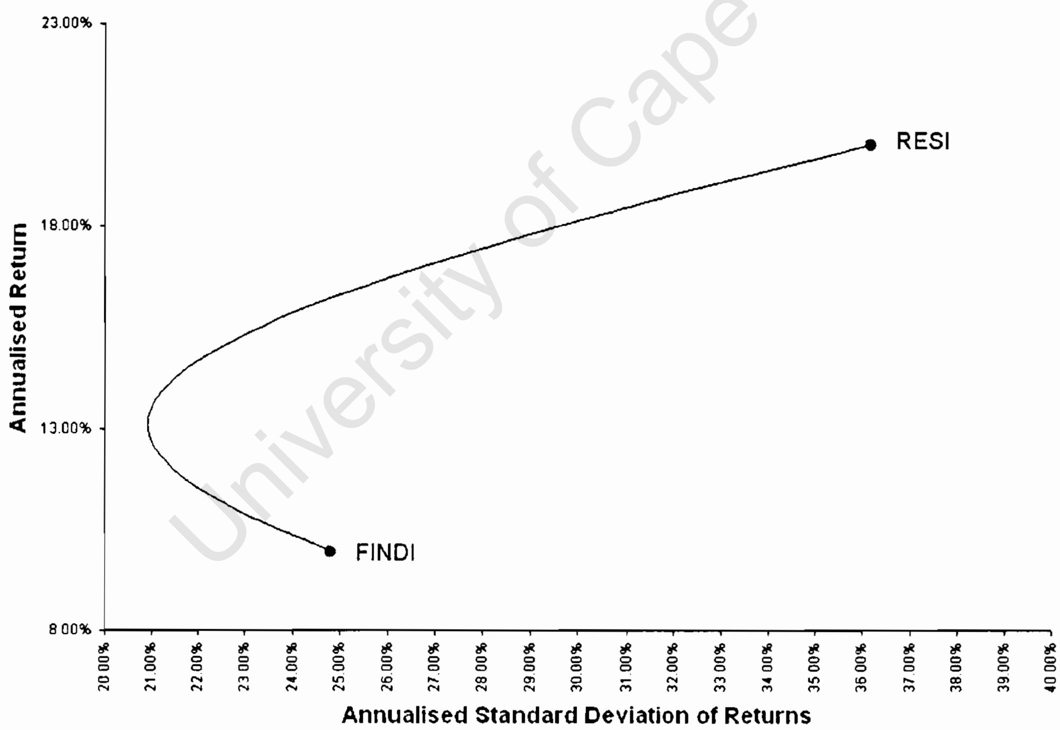
Financial-Industrial (J250) and Resources (J000) indices. All data was drawn from I-Net Bridge for the period 30 June 1966 to June 2002. Descriptive data for the sample is presented in the table below.

| | FINDI | RESI |
|---|---|---|
| Return | 11.8% | 17.88% |
| Standard deviation | 21.65% | 29.25% |
| Correlation | 0.51 | |

Following the calculation of the above variables, a bordered covariance matrix approach was employed in order to obtain the minimum standard deviations for the range of returns. This was achieved by minimising the portfolio deviation via a change in the weights of the two factors.

**Figure 6.4 FINDI-RESI efficient frontier (1966-2002)**

A minimum-variance frontier was constructed using mean-variance optimization techniques by combining the Financial-Industrial and Resources indices. Data for the sample was extracted from I-Net Bridge for the period 30 June 1966 – 30 June 2002. The point indicated on the graph, with an associated risk and return of 20.93% and 13% respectively, was found to be the global minimum variance combination on the frontier.



The findings indicate that a portfolio comprising 80% Financial-Industrials and 20% Resources has historically yielded the lowest achievable portfolio risk with an associated return and deviation of 13% and 20.93%, respectively.

Once the initial analysis had been completed, Sharpe ratios were calculated for each corresponding level of expected return. The Sharpe criterion is a measure of performance which is defined as the ratio of excess portfolio returns to portfolio standard deviation.

$$S_p = \frac{E(r) - r(f)}{\sigma} \qquad (6.1)$$

The Sharpe criterion is maximised where excess returns are maximised or portfolio risk is minimised. As the associated levels of portfolio risk generated by the analysis represent the absolute minimum achievable for each given level of return, any Sharpe ratios calculated on the basis of the minimum-variance frontier would represent the maximum achievable ratio at each level of return. Sharpe ratios were therefore calculated using the output of the minimum-variance analysis and it was found that the maximum *historical* Sharpe ratio occurred for a FINDI-RESI combination of 66% Financial-Industrials and 34% Resources.



## 6.4 Conclusions

It is clear that the two-factor risk model suggested by Page (1986), van Rensburg and Slaney (1997) and van Rensburg (2002) still holds, although the proxies for the factors have changed following the most recent reclassification of the JSE. It is now suggested that the Financials-Industrials (J250) and Resources (J000) indices be used as observable proxies for factors one and two in future applications of the two-factor model to the JSE. These factors replace the ALSI as the underlying risk factor for benchmark systematic risk.

The reclassification has also, in part, resulted in a misalignment of a number of sector indices, especially within the Basic Industrials economic group, where indices formerly classified as Resources now form part of Financial-Industrials. The analysis also indicates that the presence and behaviour of dual-listed shares and Financial-Industrial shares with extensive foreign operations on the exchange has led to a number of indices displaying loadings as both Financial-Industrials and Resources indices. This is due to the fact that such shares demonstrate significant Resources behaviour while being placed with Financial-Industrials shares. This combination brings about dual-behaviour in these indices.

These findings indicate the need to adjust the existing classification to accommodate these shares, especially for funds seeking a sector-based benchmark or those attempting to reduce their risk exposure to the resources sector. This will ensure that both fund and benchmark exposure will reflect actual share behaviour as opposed to the posited behaviour of the new classification.

It is clear that the two-factor model continues to decompose risk meaningfully on the JSE as well as giving a superior account of factors influencing returns on the JSE. It has, however, been shown that the difference in explanatory power between the two methods has become somewhat less significant than past results have indicated. This might be due in part to the misaligned index influences under the new classification.

Finally, an investigation of the ideal risk combination of the two factors identified in the analysis has indicated that an 80% Financial-Industrial and 20% Resources allocation has historically yielded the lowest overall portfolio risk whilst an allocation of 66% Financial-Industrial and 34% Resources has yielded the maximum historical Sharpe ratio.

# 7

# Comparative Benchmark Risk Analysis

It has been determined that the primary risk factors underlying return-generation on the JSE are the Financial-Industrial and Resources sectors. Research by Bradfield and Kgomari (2004) has also indicated that a significant proportion of the risk on the JSE can be attributed to the excessive degree of concentration which has implications for the levels of diversification and achievable minimum risk on the exchange.

The All-Share Index is biased towards large-cap shares and in so doing directs share selection towards these shares where active managers are less effective. In addition concentration is an unrewarded risk for managers. This is compounded by the significant degree of thin trading towards which the JSE has traditionally been exposed. This chapter therefore aims to examine and quantify the influences of these risk factors on a broad range of commonly-employed market benchmark indices as a precursor to the analysis of optimal risk benchmarks to follow.



## 7.1 Benchmark Descriptions

It has become clear that the ALSI as it stands cannot serve as a true benchmark index as it suffers from a combination of prudential concerns as well as questions about whether it is representative of the local investment universe. As a result, the FTSE/JSE has attempted to address this issue by providing market participants with two alternative indices, the SWIX and CAPI, for use as a benchmark. In addition, the down-weighted Resources (50% and 80% RESI) custom indices frequently cited as the most common alternatives to the ALSI in the past will also be considered.

### 7.1.1 The Shareholder Weighted Index (SWIX)

Four of the top five shares by market capitalisation on the FTSE/JSE All-Share Index are dual-listed. By removing the foreign holdings of such shares from the index we would make it more representative of the local investment universe. Given that these shares also account for the majority of the concentration problems on the exchange, such a procedure would also have the effect of reducing their weightings on the index, thus simultaneously addressing both areas of concern.

The SWIX is calculated by removing the foreign holdings of all dual-listed shares which form part of the ALSI. While the down-weighting of all shares would be preferred in order to maintain the correct investment proportions between the shares on the index, a lack of available information on foreign holdings and an inability to separate the free float and strategic holdings of shares through STRATE has precluded such action. The SWIX index therefore offers a closer approximation of the local investment universe than the ALSI does while still failing to provide an exact reflection of the local investment universe.



### 7.1.2 The Capped Index (CAPI)

In contrast to the SWIX, the CAPI addresses the issue of risk and concentration directly while ignoring the issues of foreign holdings and the local investment universe. The Capped Index is implemented at a 10% level on all shares which constitute the ALSI, with secondary capping applied to any uncapped shares which might be up-weighted above the 10% level.

Given that the many fund managers are unable to take full positions on the ALSI due to regulatory and/or fund restrictions, the application of the CAPI fulfils the investability criterion of a good benchmark index by allowing them to take active positions in large shares. Unfortunately, the capping level of 10% does not accommodate pension funds which are to be restricted to holdings of 5% in any single share under the new draft of Regulation 28.

### 7.1.3 Down-weighted Resources Benchmarks

The down-weighted RESI benchmarks are customized benchmarks adopted by fund managers as a response to the problem of excessive resources weightings on the exchange. The benchmark methodology adjusts all Resources shares within the ALSI, typically to either 50% or 80% of their original weights, with the excess weight redistributed amongst the remaining shares in the index in proportion to their original index weights.

Rousseau and Zwonnikoff (2002e) identify three reasons for the increasing popularity of these benchmarks:

1. Resources shares are highly volatile due to the cyclical nature of their earnings.
2. Their excessive weights make the ALSI highly undiversified.
3. Their popularity meant that they became peer benchmarks as many fund managers were underweight in the Resources sector.

## 7.2 Benchmark Holdings

A comparison of the SWIX and CAPI with the Down-weighted Resources indices favoured by many asset managers is presented below as at 28 June 2002, indicating the respective sector weights for each.

**Table 7.1 Comparison of sector weightings for benchmark alternatives**

Share constituents were obtained for the All-Share Index and Shareholder Weighted Index provided by the JSE as at 30 June 2002. From this data the constituent weights for the Capped Index (CAPI), 50% Resources Index and 80% Resources Index were calculated. Each share constituent was classified as either Financial-Industrial or Resources based on the FTSE's Global Classification System. The percentage split between Financial-Industrial and Resources shares within each benchmark was then calculated based on the free-float capitalisation of each constituent share.

| | ALSI | CAPI | SWIX | 80% RESI | 50% RESI |
|---|---|---|---|---|---|
| **Resources** | 48% | 42% | 37% | 38% | 24% |
| **Financial-Industrials** | 52% | 58% | 63% | 62% | 76% |

As an indication of the disproportionate contribution of the Resources sector to the total market capitalisation on the exchange, there were 21 Resources shares listed in the ALSI at this date versus 140 Financial-Industrial shares. The above holdings are, however, based on the new FTSE/JSE classification. In light of the factor analysis results of chapter 6, we may adjust them to reflect the actual behaviour of their constituent indices. The respective benchmark holdings may therefore be restated as indicated in table 7.2.

**Table 7.2 Comparison of adjusted sector weightings for benchmark alternatives**

Constituent shares within each benchmark are classified as Financial-Industrial or Resources according to the FTSE Global Classification System. These classifications were then adjusted based on the findings of the factor analysis. Financial-Industrial shares which displayed Resources loadings were reclassified as Resources shares. The percentage split between Financial-Industrial and Resources shares within each benchmark was then calculated based on the free-float capitalisation of each constituent share.

| | ALSI | CAPI | SWIX | 80% RESI | 50% RESI |
|---|---|---|---|---|---|
| **Resources** | 52.4% | 47.9% | 42.5% | 43.8% | 30.9% |
| **Financial-Industrials** | 47.6% | 52.1% | 57.5% | 56.2% | 69.1% |



The adjustments have a significant impact on the actual split in holdings for all the benchmarks under consideration, increasing the actual Resources holdings of each benchmark by anything from 4-7%. This represents an increased risk to fund managers invested in down-weighted Resources indices as their actual risk exposure to the sector is far more than that indicated by the current classification. It is felt that these adjusted benchmarks will be a better indicator of market performance and behaviour and provide a more correct basis for risk comparison when evaluating benchmark options.

It can be seen that the capped index has a minimal effect on reducing the weight of the Resources sector while the SWIX and Down-weighted Resources indices address the problem more directly. The reasons for this are more evident on a share level, as illustrated in table 7.3 which tabulates the share weightings for the top ten shares by free float weighting in each of the indices.

**Table 7.3 Top 10 shares by free float weighting**

The constituent share weights of each benchmark index are calculated based on the free-float adjusted market weightings of their shares, as at 30 June 2002. The top 10 shares by free-float capitalisation for each benchmark are displayed in the table below. The benchmarks considered are the All-Share Index (ALSI), Shareholder Weighted Index (SWIX), Capped Index (CAPI), 80% Resources Index and 50% Resources Index.

| | ALSI | SWIX | CAPI | 80% RESI | 50% RESI |
|---|---|---|---|---|---|
| **Anglo American** | **17.9%** | 8.0% | **10.0%** | **14.29%** | 8.9% |
| **Billiton** | 8.8% | 3.1% | 9.6% | 7.02% | 4.4% |
| **Richemont** | 8.4% | 4.8% | 9.2% | 9.91% | **12.2%** |
| **Sasol** | 5.2% | **8.6%** | 5.7% | 4.14% | |
| **SAB** | 4.8% | | 5.3% | 5.73% | 7.04% |
| **Gold Fields** | 4.0% | 3.4% | 4.4% | 3.23% | |
| **Old Mutual** | 3.8% | 3.3% | 4.2% | 4.52% | 5.6% |
| **Amplats** | 3.1% | 4.5% | 3.4% | | |
| **Standard Bank** | 3.0% | 5.0% | 3.29% | 3.54% | 4.4% |
| **Sappi** | 2.5% | | 2.7% | 2.9% | 3.6% |
| **FirstRand** | | 3.7% | | | 3.2% |
| **Remgro** | | 4.0% | | 2.82% | 3.5% |
| **Liberty Int.** | | | | | 2.7% |
| **Total** | 61.5% | 48.4% | 57.79% | 58.1% | 55.54% |

From the above table, it is clear that the reason for the limited impact of the CAPI is the fact that it addresses the weighting of Anglo American alone, while up-weighting other resources shares within the index such as Billiton and Gold Fields. Its primary use would therefore seem to be in providing a benchmark where Anglo American is brought within single-share limits for unit trust fund managers while maintaining the same proportional weightings between shares in the rest of their portfolio.

The SWIX, in contrast, was developed specifically with the pension fund industry in mind. The majority of the large resources shares are dual-listed and, in limiting their weights to only local holdings, a much greater reduction in the weighting of the Resources sector within the index is achieved.

Given that Draft Regulation 28 suggests a single-share exposure limit for pension funds to 5%, however, it is clear that it will still not be possible for pension funds to take a full position in a number of the large-cap shares in the index.

## 7.3 Benchmark Risk Exposures

From our theoretical discussion of asset risk we concluded that the expected return on a risky asset is dependent only on that asset's systematic risk as any asset-specific risk can be eliminated in a well-diversified portfolio. This systematic risk is typically measured by the asset's beta coefficient which represents the degree of co-movement between the asset's returns to the market portfolio or an underlying risk factor.

Betas for each of the shares in the ALSI were obtained by conducting multiple-regressions of the share returns against the Financial-Industrial and Resources indices over a three-year period from 30 June 1999 to 30 June 2002.

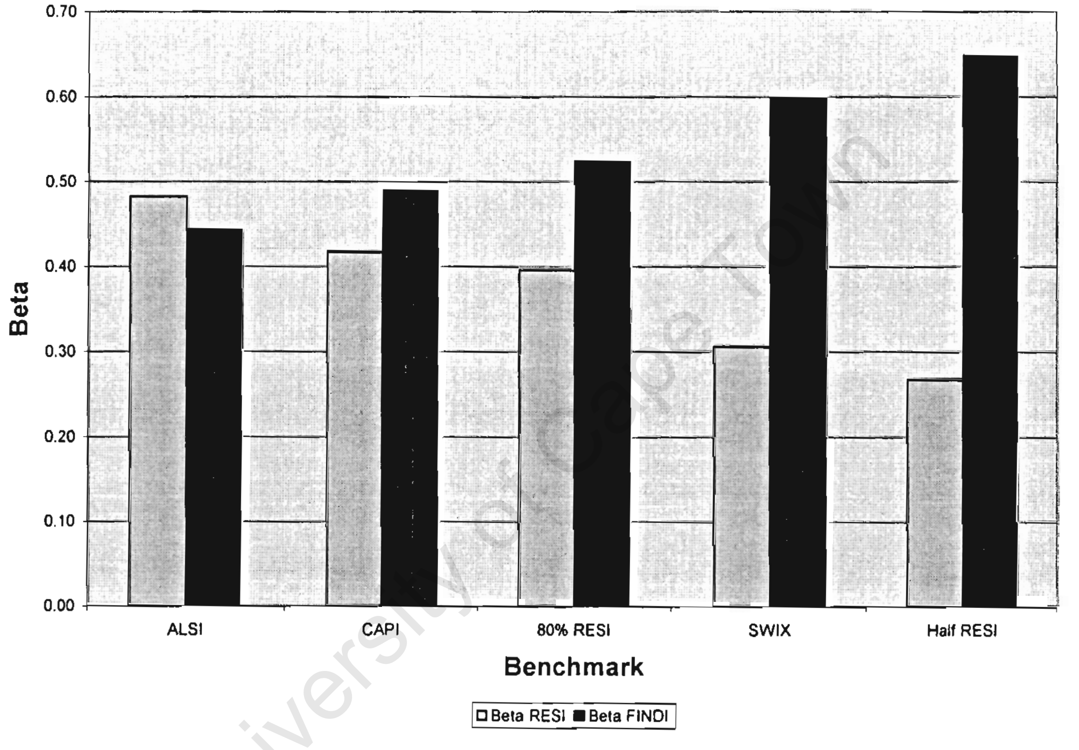
The exposure to each of these factors for each index was then obtained by aggregating each share's weighted contribution to the beta for each risk factor. The findings of the analysis are presented in Figure 7.1.

The first point of interest is the fact that all the indices in question demonstrated aggregate exposures less than 1 to each factor. An examination of the individual share beta exposures indicates that this is a result of the negative RESI exposures for the single-loading FINDI shares and negative FINDI exposures for the majority of the Resources shares.

This results in an expected shift in exposure from the RESI factor to the FINDI exposure as the resources weights decrease in the SWIX, 50% RESI and 80% RESI indices as indicated in the graph overleaf.

**Figure 7.1 Benchmark Index Beta Comparisons**

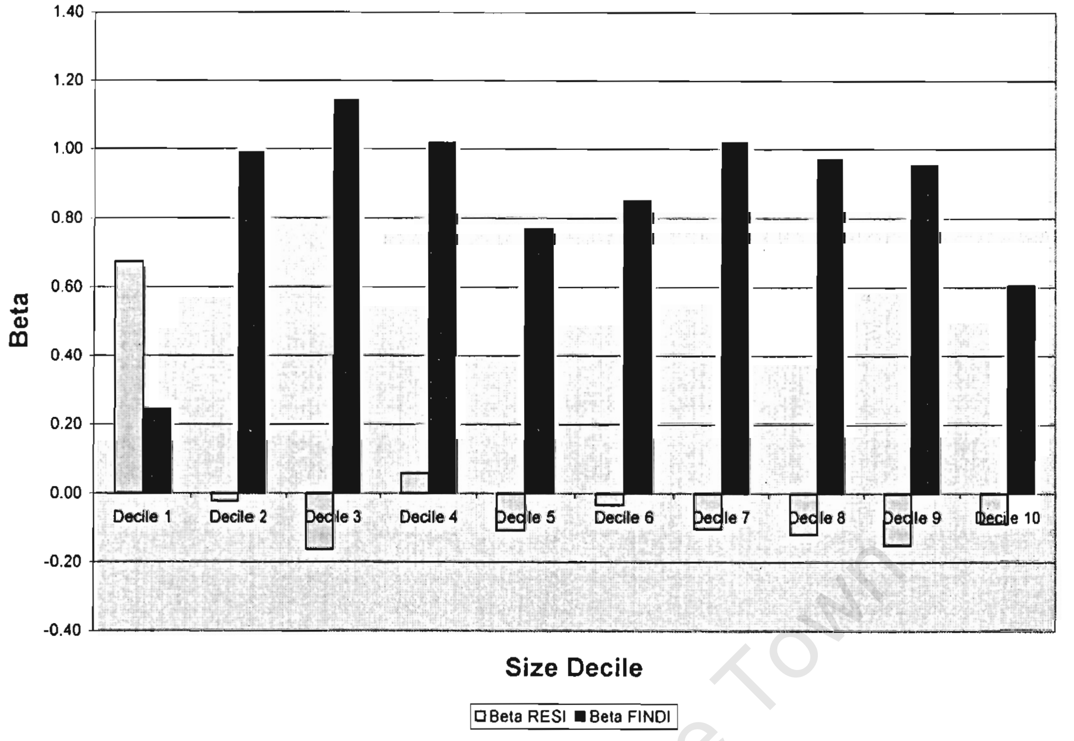
Betas for a range of benchmark indices are calculated based on the weights of their constituent shares and the betas of those shares against the Financial-Industrial and Resources indices. Share betas were calculated using regression analysis for the period 30 June 1995 – 31 June 2002. All data was extracted from I-Net Bridge. The benchmarks considered are the All-Share Index (ALSI), Shareholder Weighted Index (SWIX), Capped Index (CAPI), 80% Resources Index and 50% Resources Index.




Refining the analysis to the share level yields interesting results. Deciles were formed by market capitalisation from the shares which constitute the ALSI and the factor risk exposures for each decile were calculated. The findings of the analysis are presented in Figure 7.2.

**Figure 7.2 The interaction between size and risk exposure**

Betas were calculated for each of the shares constituting the ALSI as at 30 June 2002 by regressing the returns on each share against the Financial-Industrial and Resources indices. Data for the analysis was obtained from I-Net Bridge for the period 30 June 1999 to 30 June 2002. Shares were then grouped into deciles by market capitalisation and betas were calculated for each decile based on the share's weight within the decile and its beta.






Only deciles one and four demonstrate a positive RESI exposure. Decile one contains the bulk of the large cap resources stocks on the exchange, including Anglo American, BHP Billiton, Gold Fields, Anglogold, Impala Platinum and Harmony Gold. Decile four in contrast contains only Northam Platinum and Western Areas. It does, however, also comprise a number of the dual-loading sectors identified in the factor analysis – Illovo Sugar, Tongaat-Hulett and African Oxygen. All other deciles demonstrate a negative resources exposure due again to their primarily FINDI composition. Given the minimal contribution of decile 4, it is clear that the RESI exposures in each benchmark index are therefore largely contributed by a handful of resources shares at the top of each index.

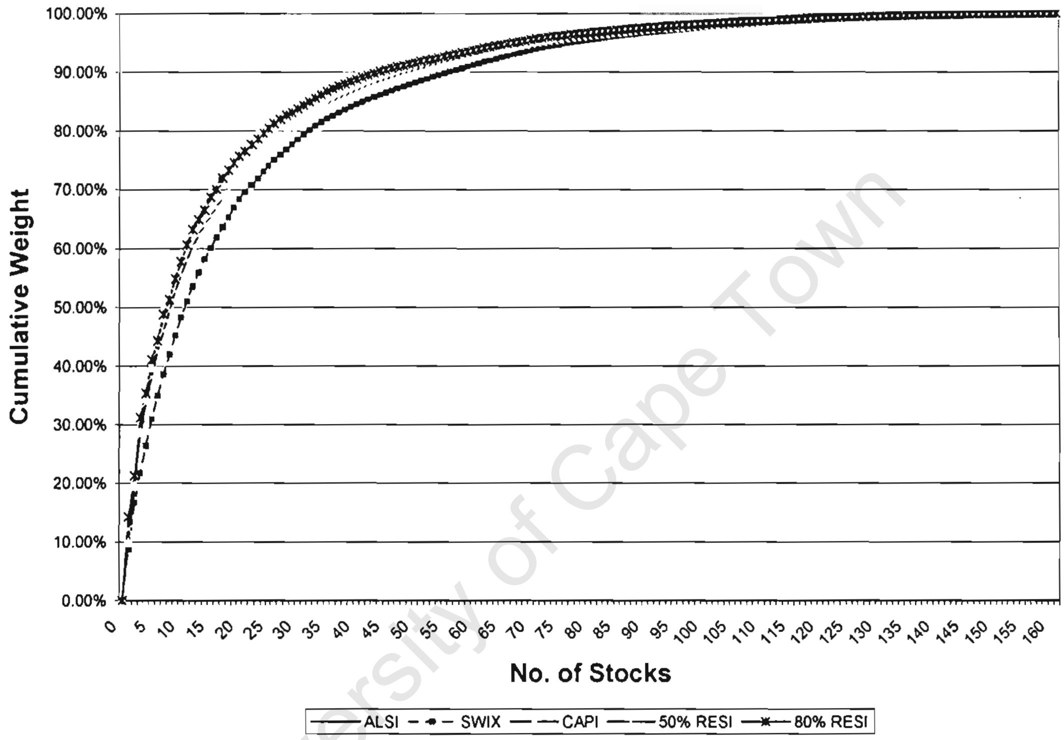
## 7.4 Benchmark Concentration

As indicated in section 7.2, the top 10 shares within each benchmark constitute a significant proportion of the total benchmark holdings. A comparison of the cumulative share weights in each benchmark index provides a good initial indication of the levels of concentration present on the exchange.

This progression of weights for each benchmark is graphically depicted in Figure 7.3.

**Figure 7.3 Cumulative benchmark share weights**

The cumulative share weights for a range of benchmark indices as at 30 June 2002 are presented in the graph below. The benchmarks considered are the All-Share Index (ALSI), Shareholder Weighted Index (SWIX), Capped Index (CAPI), 80% Resources Index and 50% Resources Index.






It is evident from the graph that the ALSI has the highest concentration of share weights of the benchmarks under consideration. The CAPI and 80% RESI demonstrate very little deviation from the ALSI while the 50% RESI and SWIX are clearly less concentrated initially.

### 7.4.1 The All Share Index

Table 7.4 illustrates the degree of concentration on the JSE using the effective number of shares measure (ñ), the single-share threshold level and Roll's measure. Even though the index comprised 161 shares, it had the same degree of diversification as an equally-weighted portfolio of only 16 shares in June 2002 when the new FTSE/JSE All-Share index went live.

**Table 7.4 Concentration Index Values for the JSE/FTSE All Share Index**

The number of effective shares in the ALSI over the period 28 June 2002 to 29 November 2002 was calculated based on the ñ criteria specified by Strongin, et al (2000). The number of shares in the index over this period was 161. For portfolio with no concentration, the ñ value should equal the number of shares in the index. The threshold value indicates the maximum share weight at which shares could be carried in the index without adding share-specific risk to the index. The more concentrated an index, the lower is the threshold value. The Richard Roll Criteria (RRC) is an additional measure of concentration that measures the deviation of an index from the equally-weighted index. Unconcentrated indices have an RRC of 0% and the value increases as concentration increases.

| | 28-Jun-02 | 31-Jul-02 | 30-Aug-02 | 30-Sep-02 | 31-Oct-02 | 29-Nov-02 |
|---|---|---|---|---|---|---|
| **CI Value (ñ)** | 16.32 | 18.43 | 18.22 | 18.52 | 18.83 | 19.46 |
| **Threshold** | 11.55% | 10.29% | 10.40% | 10.24% | 10.09% | 9.78% |
| **RRC** | 5.54% | 4.83% | 4.90% | 4.81% | 4.72% | 4.55% |

It is evident that this improved incrementally on a month-by-month basis due mainly to the strengthening of the rand at the time. The stronger local currency damaged the earnings of companies with strong foreign dealings, most of which were found within the Resources sector. The result was that Resources shares dropped in value and since they make up the biggest weightings on the index, their decreased weights decreased the level of concentration. The threshold value for the index also decreased as a result.

Even so, the actual changes in concentration were fairly insignificant, indicating that reliance on some form of "correction" in the market is unlikely to solve the concentration problem.

As a measure of the magnitude of the concentration problem caused solely by the largest single share in the index, in this case Anglo American, the All-Share Index at 28 June 2002 was adjusted to exclude Anglo. All remaining shares were then re-weighted according to their initial proportions within the index and the concentration index value for June was recalculated.

The restated figures indicated a concentration index value of 23 and a threshold of 8.34%. It is therefore evident that as at 28 June 2002, the substantial weighting of Anglo American had the effect of reducing the effective number of shares in the portfolio by more than 6. This illustrates the argument of Strongin, et al (2000) for the negative diversificationary effect "mega-cap" shares can exert within an index or portfolio.

### 7.4.2 Benchmark Comparisons

**Table 7.5 Comparison of Concentration Index Values for alternative benchmarks**

The number of effective shares for a range of benchmarks as at 30 June 2002 was calculated based on the ñ criteria specified by Strongin, et al (2000) as a measure of concentration. The number of shares in each index over this period was 161. For portfolio with no concentration, the ñ value should equal the number of shares in the index. The threshold value indicates the maximum share weight at which shares could be carried in the index without adding share-specific risk to the index. The more concentrated an index, the lower is the threshold value. The Richard Roll Criteria (RRC) measures the deviation of an index from the equally-weighted index. Unconcentrated indices have an RRC of 0% and the value increases as concentration increases. The benchmarks considered are the All-Share Index (ALSI), Shareholder Weighted Index (SWIX), Capped Index (CAPI), 80% Resources Index and 50% Resources Index.

| | ALSI | 80% RESI | CAPI | 50% RESI | SWIX |
|---|---|---|---|---|---|
| **CI Value** | 16.32 | 19.75 | 22.10 | 23.03 | 30.51 |
| **Threshold** | 11.55% | 9.64% | 8.66% | 8.32% | 6.35% |
| **Number above Threshold** | 1 | 2 | 3 | 2 | 2 |
| **RRC** | 5.54% | 4.47% | 3.93% | 3.74% | 2.67% |

Table 7.5 indicates that each of the alternatives to the ALSI provides obvious benefits with regards to decreasing the concentration problem. The SWIX approach offers the highest effective number of shares and therefore the greatest degree of diversificationary benefit. This is due to the fact that the dual listed shares tend to number amongst the top shares in terms of weight on the index. While this approach might address the current situation, however, it must be stressed that it fails to account for non-dual-listed shares which might reach excessively large weights.

The 50% Resources approach is similar in effect to the down-weighted duals approach, but fails to take into account large cap shares outside of the resources sector. The result is that shares like Richemont, which is second in terms of market ranking only to Anglo American but is not a Resources share, are up-weighted and thus the concentration problem is simply being transferred from one sector to another.

The 10% capped index is less efficient than either of these approaches, in large part because it only affects the weightings of Anglo American. By down-weighting Anglo and re-weighting the other shares within the index it is driving up the weightings of shares which had previously fallen below the 10% level. The result is that the overall effect of capping Anglo is diminished by the up-weighting of the other large-cap shares.

Lastly, we can see that the 80% Resources benchmark is only marginally less concentrated than the ALSI and is in fact the least efficient of the alternatives considered.

### 7.4.3 The Capped Index: Varying the Level of Capping

**Table 7.6 Concentration Index Values for the Capped All Share Index**

The effect of varying the level of capping applied to the Capped Index (CAPI) over a range of 4% to 10% is investigated below. The number of effective shares was calculated as at 30 June 2002 based on the ñ criteria specified by Strongin, et al (2000) as a measure of concentration. The number of shares in the index over this period was 161. For a portfolio with no concentration, the ñ value should equal the number of shares in the index. The threshold value indicates the maximum share weight at which shares could be carried in the index without adding share-specific risk to the index. The more concentrated an index, the lower is the threshold value. The Richard Roll Criteria (RRC) measures the deviation of an index from the equally-weighted index. Unconcentrated indices have an RRC of 0% and the value increases as concentration increases.

| | 10% | 8% | 6% | 4% |
|---|---|---|---|---|
| CI Value | 22.10 | 25.50 | 29.77 | 38.85 |
| Threshold | 8.66% | 7.55% | 6.50% | 5.02% |
| Number above Threshold | 3 | 3 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| **RRC** | 3.93% | 3.32% | 2.76% | 1.97% |

Since the above analysis indicated that a capping level of 10% was insufficient in dealing with the problem of single share weights in excess of the threshold level, a range of capping levels was applied to the All-Share index values at 28 June 2002 in order to determine at which level of capping a satisfactory level of diversification could be achieved. This level was determined as the capping percentage which would yield zero shares with a weighting above the threshold value for that particular index.

By capping an index, we are artificially adjusting the weightings of the shares within that index. By decreasing the over weighted shares, we are decreasing the concentration and thus increasing the effective number of shares in the index. From Table 7.6 it is evident that once we reach a capping level of 6%, the concentration problem is largely resolved at least as far as its effect on diversification is concerned, as we no longer have any shares above the threshold value. It should be stressed that this in no way implies complete or efficient diversification, only that all shares in the index are now diversifying away more unique risk than they are adding to the index.

Given that the JSE has proposed a 10% capping level it is clear that unless further losses are suffered in the Resources sector, thus reducing its contribution to the concentration on the exchange, the proposed capping level will not be sufficient to overcome the concentration problem as it currently stands.



## 7.5 Benchmark Diversification

### 7.5.1 Overall Benchmark Risk and Diversification

While the effective number of shares and RRC measures enable us to evaluate the level of concentration inherent in a benchmark, they fail to take into account the fundamental determinants of diversification, namely the standard deviation and inter-correlation of its constituent securities.

It would therefore seem to be entirely possible for one benchmark to demonstrate a lower degree of concentration than another but still have a higher degree of overall risk, simply because the difference in weights between the two benchmarks favours the one which has higher weights in less correlated shares.

Therefore, while the above analysis allows us to evaluate the alternative benchmarks from a prudential perspective, it fails to evaluate them with regards to total portfolio risk.

To this end an analysis was conducted of the overall levels of diversification achieved by each of the benchmark alternatives. Utilising the FTSE/JSE All-Share Index and alternative indices as at 30 June 2002, a series of consecutive portfolios was constructed by adding the individual constituents of the benchmark index one at a time until a portfolio encompassing all the constituents of the benchmark was created.

Due to the fact that Woolworths Holdings was only listed on the exchange in June 2002 it was not possible to calculate returns for the share and thus each benchmark was limited in size to the 157 shares ranked above Woolworths Holdings. The weight of the shares excluded from the analysis accounted for less than 0.014% of the total weight of the index and it was therefore felt that this would not significantly affect the results as the indices would have reached their maximum level of diversification (given their concentration) well before this point.

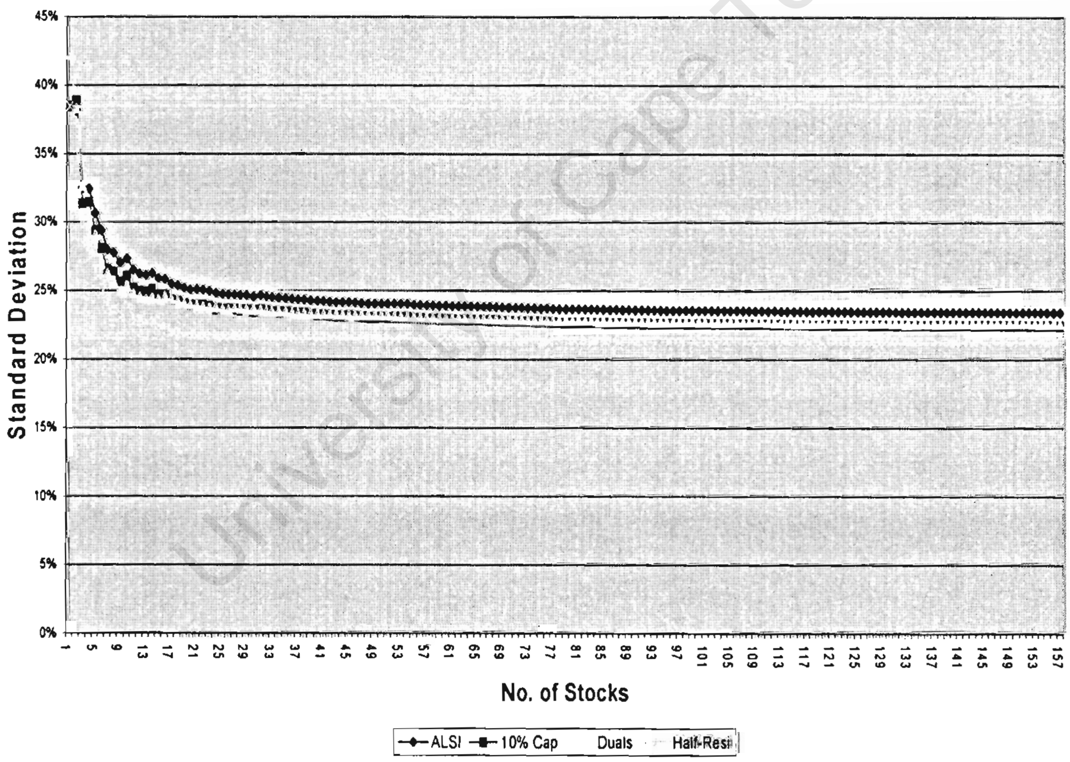
As each share was added to its particular benchmark portfolio in proportion to its weight in the index, the standard deviation of the portfolio was calculated by pre- and post-multiplying the correlation matrix of constituent returns by the matrix of constituent weights.

The resultant progression of standard deviations for each benchmark was then plotted against the number of constituents in the portfolio in order to produce a graph detailing the progressive diversification achieved by adding shares to the portfolio.

It is evident from the graph that the 50% Resources benchmark index offers the lowest total risk of the five indices under consideration. The two alternative indices put forward by the JSE, the SWIX and CAPPI, are both fairly similar in terms of risk although it must be remembered that the SWIX has been shown to be the more prudentially sound option.

**Figure 7.4 Comparative benchmark diversification**

Progressive levels of risk, as measured by portfolio standard deviation, are calculated for a range of benchmark alternatives. For each benchmark a single share is added in proportion to its overall weight in the full benchmark index and the portfolio standard deviation is calculated. This progression of shares and their effect on diversification is plotted in the above graph. The benchmarks considered for the analysis were the All-Share Index (ALSI), Shareholder Weighted Index (SWIX), Capped Index (CAPI), 80% Resources Index and 50% Resources Index.






What is interesting to note is that if all the indices were fully diversified they would all eventually converge at the same degree of risk (market risk) which is not the case, as illustrated above. This illustrates the effect of concentration on indices. Even though each of the benchmarks should be fully diversified given the number of constituents carried in each, they cannot be due to the fact that they are all concentrated to some extent.

Table 7.7 details the maximum level of diversification achieved by each of the alternatives.

**Table 7.7 Comparison of risk levels for alternative indices**

Overall benchmark risk was calculated for a range of benchmark indices by pre- and post-multiplying the correlation matrix of constituent share returns by the matrix of constituent share weights. Monthly data for the analysis was obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002. The benchmarks considered for the analysis were the All-Share Index (ALSI), Shareholder Weighted Index (SWIX), Capped Index (CAPI), 80% Resources Index and 50% Resources Index.

| | ALSI | CAPI | 80% RESI | SWIX | 50% RESI |
|---|---|---|---|---|---|
| **Risk (Standard Deviation)** | 20.39% | 19.38% | 19.49% | 18.32% | 19.23% |

## 7.5.2 Concentration as a portion of overall risk

Bradfield and Kgomari (2004) demonstrated that it is possible to isolate the concentration portion of overall market risk by first determining the risk of an equally-weighted portfolio based on the average variances and covariances of the shares in the market portfolio. The differences between this risk and the risk of the actual market portfolio illustrate the effect of concentration on risk in the market.

Employing their methodology, the risk for an equally weighted market portfolio based on a 3-year data sample stretching from 30 June 1999 to 30 June 2002 is calculated. The shorter period is considered as monthly returns data was available for more shares over this period and this data set would therefore be expected to yield better results than the 7-year sample. The average variance of shares in the market was 42.21% over the period in question. Similarly, the average covariance was calculated as 3.17%.

The variance of the portfolio is given by:

$$\sigma_p^2 = \frac{\bar{\sigma}_i^2}{N} + \frac{(N-1)\bar{\sigma}_{ij}}{N} \qquad (2.16)$$

Substituting the values for the average variance and covariance of the shares in the market we obtain a variance of 3.26% and a standard deviation of 18.06%.

The deviation of the ALSI has been calculated at 20.39%. This would imply that the degree of risk attributable to concentration in the market (i.e. to deviations away from an equally-weighted portfolio) is 2.33%. This figure is summarised for each of the benchmark alternatives in Table 7.8, below.

**Table 7.8 Comparison of concentration risk levels for alternative indices**

The standard deviation of an equally-weighted All-Share Index was calculated based on the average variance and covariance of the shares in the market as at 30 June 2002. Monthly data was obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002 for the purposes of calculating the inputs. This deviation was then subtracted from the standard deviations of a range of benchmark alternatives in order to determine the risk which could be attributed to concentration within each benchmark. The benchmarks considered for the analysis were the All-Share Index (ALSI), Shareholder Weighted Index (SWIX), Capped Index (CAPI), 80% Resources Index and 50% Resources Index.

| | ALSI | 80% RESI | CAPI | 50% RESI | SWIX |
|---|---|---|---|---|---|
| **Risk (Standard Deviation)** | 2.33% | 1.32% | 1.43% | 0.26% | 1.17% |

Bradfield and Kgomari (2004) found the concentration risk to be roughly 6% over the period 31 August 2000 to 31 July 2003. The difference in results may be attributed to the difference in periods under review as well as differences in the data sets as a number of shares had been added to and removed from the ALSI following 30 June 2002.



## 7.6 Liquidity and Fund Size

Both fund size and liquidity impose additional constraints on benchmark construction due to the increased risk they pose in terms of churn and investability.

As a precursor to investigating the influence of these constraints on optimal benchmark construction, we will analyse the relationship between fund size and liquidity risk as it applies to the benchmark alternatives considered thus far. Firstly, the average number of days' trade required to move out of any position for each benchmark is determined in order to provide a measure of comparison for benchmark liquidity. Secondly, we will determine at what fund size liquidity constraints first become an issue for each benchmark. This will be quantified as that point at which any share within the benchmark first breaches the allowed constraints on the maximum day's trade allowed for that benchmark.

As a base from which to measure fund restrictions across the different benchmarks, it is assumed that funds are able to account for up to 25% of the average daily trade in any share held. Liquidity restrictions are then measured over periods of 5 days (one working week), 10 days and 15 days, assuming that these are the maximum periods firms will allow for turning over a share position, so as to limit churn.

### 7.6.1 Average Days' Trade

As illustrated in equation 2.20, the average days' trade required to turn over any position in a fund is a measure of its size, the average trade in that share and the amount of the actual daily trade in that share that the fund is able to account for.

Were we to take the average of this value for all shares in the benchmark, we would have a rough basis for comparison of the liquidity levels across benchmarks. The analysis is conducted for a fund size of R1 billion but the liquidity ratios across the benchmarks will remain constant regardless of the fund size selected as a base due to its linear nature.



**Table 7.9 Comparison of average day's trade for each benchmark**

The average daily trade for all share constituents within a range of benchmark alternatives as at 30 June 2002 was calculated over a six-month period from 1 January 2002 to 30 June 2002. Daily data for this purpose was obtained from I-Net Bridge. The number of days it would take to trade out of any share position within each benchmark was then calculated based on the average daily trade for the share, the percentage of the total trade in the share that the fund is able to account for and the size of the fund. This value was then averaged across all shares within the benchmark to obtain the average days' trade. The maximum and minimum values refer to the maximum and minimum number of days it would take to trade out of any position in the benchmark. The benchmarks considered for the analysis were the All-Share Index (ALSI), Shareholder Weighted Index (SWIX), Capped Index (CAPI), 80% Resources Index and 50% Resources Index. The analysis was performed for a fund size of R1 billion.

| | ALSI | CAPI | 80% RESI | 50% RESI | SWIX |
|---|---|---|---|---|---|
| **Average Days' Trade** | 1.95 days | 2.13 days | 2.22 days | 2.63 days | 3.08 days |
| **No. of shares above average** | 53 of 161 | 53 of 161 | 52 of 161 | 55 of 161 | 55 of 161 |
| **Maximum** | 7.43 days | 8.14 days | 8.77 days | 10.79 days | 12.39 days |
| **Minimum** | 0.16 days | 0.17 days | 0.19 days | 0.16 days | 0.18 days |

The findings indicate that the more concentrated indices are more liquid than their less concentrated counterparts. This makes intuitive sense as the more concentrated indices are top-heavy with the result that the holdings in the less liquid shares at the lower end of the benchmarks are small. In contrast, the share weights in the less concentrated benchmark indices such as the SWIX are more broadly distributed across the index with the result that greater weights are held in the less liquid shares in the index. The result is that much smaller fund sizes are required before these holdings begin to evidence liquidity concerns.



The average days' trade for all the benchmarks under consideration is comfortably within the liquidity limits of one working week, even at a fund size of R1 billion. The maximum and minimum day' trade values for each benchmark, however, demonstrate the disparity in liquidity values on the exchange. This is indicative of the fact that the majority of shares within the benchmarks are fairly liquid and much of the liquidity problems experienced on the JSE are in fact restricted to a few illiquid shares.

### 7.6.2 Initial Liquidity Constraints

Following the comparison of average liquidity levels across the benchmark alternatives, the fund level at which each benchmark first encounters liquidity constraints was assessed. This was quantified by solving for the level at which any share in that benchmark first exceeded the maximum allowed days' trade over the three chosen periods.

**Table 7.10 Fund Size at which benchmarks first encounter liquidity constraints**

The number of days it would take to trade out of any share position within each benchmark was calculated based on the average daily trade for the share over a 6-month period from 1 January 2002 to 30 June 2002, the percentage of the total trade in the share that the fund is able to account for and the size of the fund. As fund size is increased this value is monitored until the maximum number of days to trade out of any position within the benchmark exceeds a specified period of either 5, 10 or 15 days. The more liquid the benchmark, the higher is the fund size at which this liquidity constraint is first encountered. The benchmarks considered for the analysis were the All-Share Index (ALSI), Shareholder Weighted Index (SWIX), Capped Index (CAPI), 80% Resources Index and 50% Resources Index.

| | ALSI | CAPI | 80% RESI | 50% RESI | SWIX |
|---|---|---|---|---|---|
| **Fund Size (5 day trade-out)** | R673 343 741 | R614 515 468 | R570 135 338 | R463 558 739 | R403 495 110 |
| **Fund Size (10 day trade-out)** | R1 346 687 349 | R1 229 031 304 | R1 140 270 561 | R927 117 757 | R806 990 434 |
| **Fund Size (15 day trade-out)** | R2 020 030 956 | R1 843 546 895 | R1 710 405 784 | R1 390 676 589 | R1 210 485 611 |

The findings of the analysis are provided in table 7.10 and confirm the trade-off between concentration and liquidity in the market. The results indicate that the All-Share Index provides for the greatest fund size while the SWIX allows for the smallest fund size before liquidity problems become evident.

Of particular interest is the fact that while most prominent modern funds manage assets in excess of a billion rand or more, liquidity constraints typically become a concern well before such fund sizes are reached.

## 7.7 Conclusions

The findings indicate that there are two primary determinants of benchmark risk of importance to fund managers. Firstly, it has been demonstrated that concentration impacts negatively on overall benchmark risk. It is found that roughly 2.4% of overall risk on the exchange is due to the effects of concentration. This value varies for each of the benchmarks according to their assessed levels of concentration. The results of the analysis of the contribution of concentration to overall risk are somewhat less significant than those found by Bradfield and Kgomari (2004) but this is likely due to a difference in sample periods and data sets.

The second issue is that of the overall level of diversification achieved within the benchmark. The fact that none of the indices analysed converged to a measure of risk representative of effective diversification illustrates the impact not only of concentration, but also of the high correlations between shares on the exchange.

The SWIX is shown to have the lowest degree of concentration of the indices under consideration, but its overall level of diversification is lower than the other index alternatives. The CAPI, in contrast, fairs poorly in both the concentration and diversification tests. Benchmark risk is therefore a function of both concentration and inter-correlation of shares.

The analysis has also indicated that liquidity is a significant determinant of benchmark concentration and vice versa. It has been found that the less concentrated funds experience liquidity constraints far more rapidly than their more concentrated counterparts as they are more heavily invested in less liquid shares. This liquidity risk is, however, concentrated in a few illiquid small cap shares as opposed to being distributed throughout the indices.

There is therefore a trade-off between concentration and risk which fund managers should be cognisant of when determining whether benchmarks are suitable for their particular mandates.

# 8

# Constructing Risk-Optimized Benchmark Portfolios

Lastly, the impact of the risk dimensions on benchmark construction is investigated. Optimal concentration portfolios are constructed for differing fund size levels by minimising concentration via the adjustment of index weights, relative to a set of liquidity and regulatory constraints in order to investigate the relationship between the risk elements identified in Chapters 6 and 7. These optimal passive benchmarks are then combined with an optimal active portfolio using the Treynor-Black optimization technique in order to investigate the relationship between active and passive risk in the period under review.

## 8.1 Optimal All-Share Index Constituents

### 8.1.1 Model Specification

The effective shares (ñ) measure employed by Strongin, et al (2000) is used as the measure of benchmark concentration, where:

$$\tilde{n} = \frac{1}{\sum_{i=1}^{n} w_i^2} \qquad (2.6)$$

This value is maximised for an increasing fund size subject to the constraint that the average time to trade out of any share in the benchmark is less than a specified benchmark time-period. The average time to trade out of any share position in the benchmark is calculated as:

$$Average\ Time = \frac{F * w_i}{P_i} \frac{1}{ADT_i x TA_i} \tag{2.20}$$

Where,

$F$ = the size of the fund,

$w_i$ = the index weight held in share i,

$P_i$ = the price of share i,

$ADT_i$ = the average daily trade in share i over a specified period of time,

$TA_i$ = the maximum percentage of that daily trade in share i that the fund is able to account for.

It is again assumed that funds are able to account for up to 25% of the daily volume traded for any share and the calculations are performed for maximum trade-out periods of 5 and 10 days.

As a further constraint to the analysis, share weights were monitored according to both pension fund and unit trust regulations in order to assess the effect of the new regulations on benchmark construction.

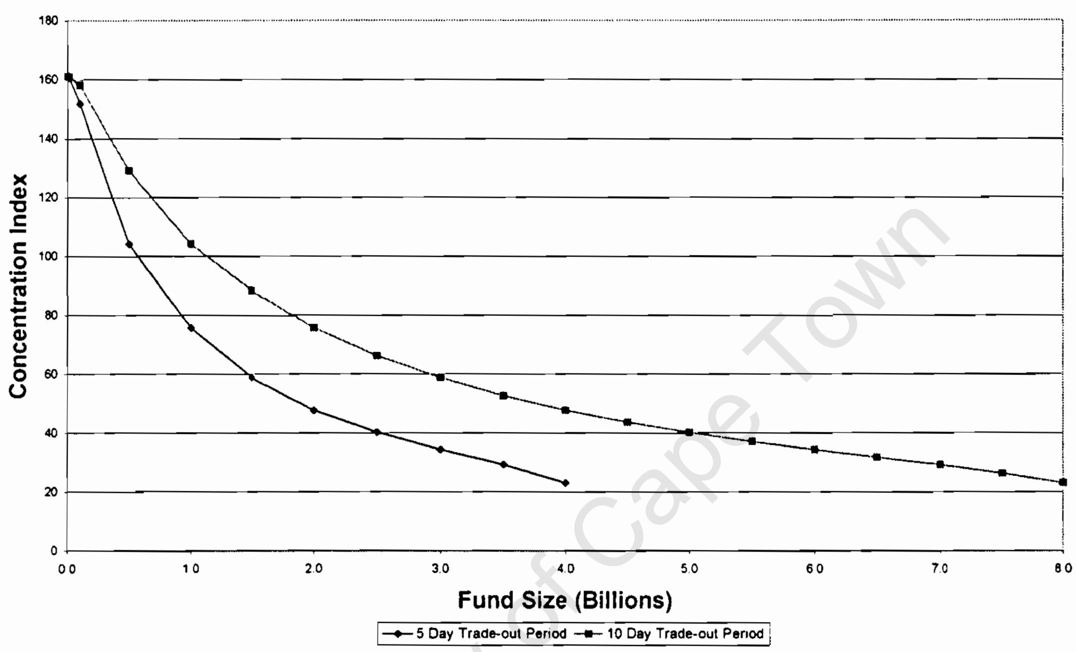
As per the Collective Investment Schemes Control Act (CIS), share positions in the unit trust analysis could not exceed the greater of either 5% if it the share had a market capitalisation less than R2 billion **or** 10% if it had a market capitalisation greater than R2 billion **or** 120% of the share's free float weight in the ALSI. This weight was further limited to a maximum of 20% as per the general equity fund specifications.

As per the proposed Regulation 28, pension fund share positions were determined subject to the constraint that the maximum weight attributable to any share within the benchmark is 5% if the share's market capitalisation is greater than R2 billion, or 2.5% otherwise.

## 8.1.2 Concentration and Overall Risk Results

**Figure 8.1 Comparison of benchmark concentration against fund size**

An optimal benchmark index is constructed for increasing fund size levels by solving for the optimal share weights which will yield the minimum achievable level of concentration subject to the constraint that it must be possible to trade out of any position within the index within 5 and 10 day periods. The optimal concentration level for each fund size is plotted in the graph above. It was not possible to conduct the analysis beyond a fund size of R4 billion for the 5-day trade-out restriction an R8 billion for the 10-day trade-out restriction due to the liquidity constraints. All shares included in the ALSI as at 30 June 2002 were included in the analysis and data for the inputs to the model were obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002.






The progression of optimal concentration levels demonstrated in Figure 8.1 above is indicative of the effect liquidity has in determining benchmark holdings and concentration as fund size increases. As is clear from the graph, the achievable minimum levels of concentration decrease at a decreasing rate with most of the impact of the liquidity constraints experienced at fund sizes smaller than R2 billion with the 5-day trade-out restrictions and R4 billion with the 10-day trade-out restrictions. Indeed, the absolute minimum achievable concentration level (161 effective shares) is more than halved at fund sizes of R1 billion and R2 billion respectively. The relevant figures are provided in Section 1 of Appendix G.

At no stage during the analysis were current market levels of concentration reached as the optimal benchmarks for all fund sizes exceed the effective number of shares calculated for the ALSI in section 7.2.2. The only barrier to managers alleviating the concentration problem in their benchmark portfolios would therefore seem to be an aversion to deviating from current market holdings possibly as a consequence of their fund mandates.

Unit trust regulations were complied with throughout the analysis. In contrast, the pension fund regulations were violated at fund sizes of R3.3 billion and R6.6 billion respectively. At these levels it was impossible to maintain the share weights of Anglo American, Sasol, Gold Fields, Amplats, Anglo Gold and Harmony Gold under the 5% maximum weight limit.

It was not possible to carry the calculations beyond fund levels of R4 billion and R8 billion respectively, as it was impossible to remain within the liquidity constraints at such levels. The concentration index value at these levels was 23.14 effective shares for both analyses.

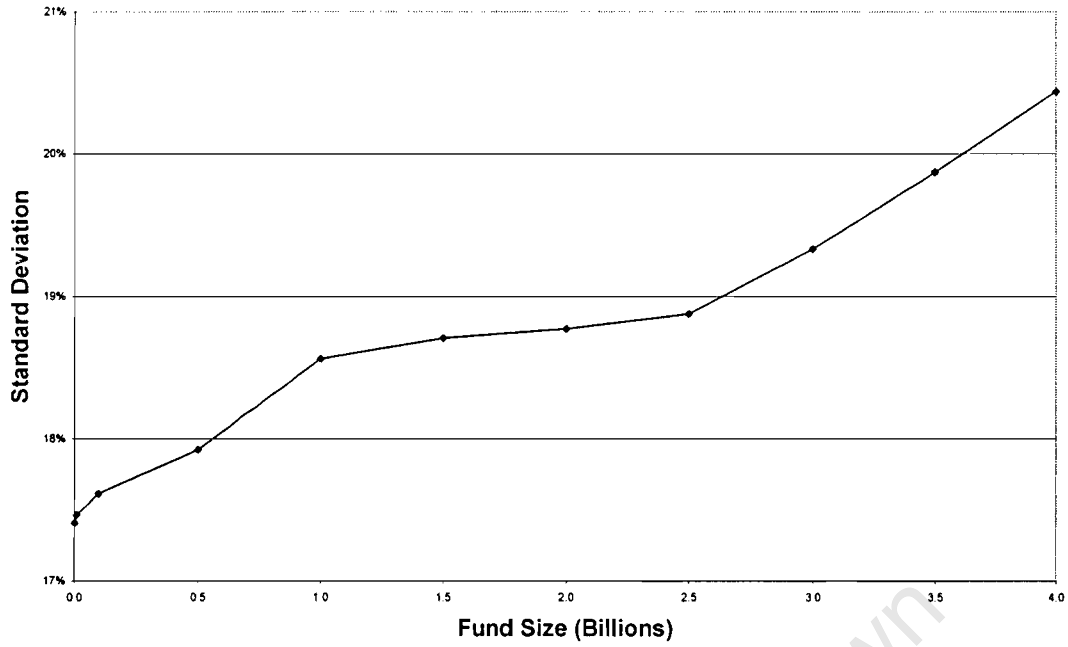
It was clear from the analysis that because of the linear nature of the liquidity constraints any findings in the optimization analysis were simply scaled based on the trade-out restrictions. For this reason the analysis to follow considers only a 5-day trade-out constraint.

With regard to overall benchmark risk it is found that the standard deviation of the absolute minimum concentration portfolio for the analysis is 2.98% lower than the standard deviation of the ALSI as measured in section 9.3.1. This value increases steadily as the level of concentration increases with fund size, as indicated in Figure 10.2. The standard deviation of the optimal portfolio at a fund size of R4 billion is only marginally higher than that of the ALSI with values of 20.44% and 20.39%, respectively.



**Figure 8.2 Comparison of overall benchmark risk against fund size**

An optimal benchmark index is constructed for increasing fund size levels by solving for the optimal share weights which will yield the minimum achievable level of concentration subject to the constraint that it must be possible to trade out of any position within the index within 5 days. The associated standard deviation for each optimal benchmark at each fund size is plotted in the graph above. All shares included in the ALSI as at 30 June 2002 were included in the analysis and data for the inputs to the model were obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002.






### 8.1.3 Share and Sector Weights

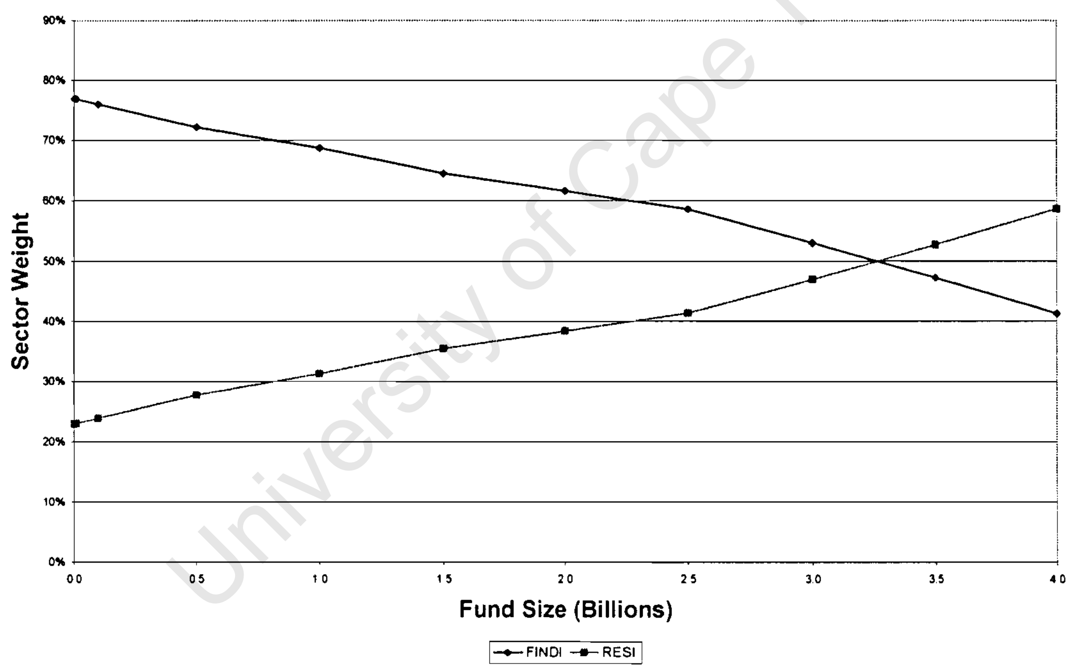
An investigation of the changes in share and sector weights in the analysis yields an interesting observation. As illustrated in Section 2 of Appendix G, much of the change in concentration for the analysis as fund size increases was the result of a forced increase in holdings in shares at the top of the index with an accompanying decrease in the less liquid holdings in shares at the tail-end of the index. The reason for this is that shares at the top of the index, especially those in the mining and minerals sectors as indicated above, are larger in terms of market capitalisation.

A comparison of the average daily trade of the shares in the ALSI as a percentage of total number of shares indicates that there is no clear delineation in daily turnover based on share size. Shares at the bottom of the index do not as a rule have a lower daily turnover than shares at the top. However, shares at the bottom tend to have a fraction of the market capitalisation of those at the top, meaning that for large fund sizes, the value of the holdings in small shares are fairly significant and require an equally significant period of time to trade out of even if they constitute only a small fraction of the overall fund holdings.

This liquidity pinch as fund size increases therefore generates an increasing single-share concentration at the top of the index which is responsible for the increasing levels of concentration evident in the findings. The top 10 shares move from a combined weight of 6.2% at an initial fund size of R1 million to a combined weight of 48.08% at a fund size of R4 billion.

**Figure 8.3 Comparison of change in sector allocations as fund size increases**

An optimal benchmark index is constructed for increasing fund size levels by solving for the optimal share weights which will yield the minimum achievable level of concentration subject to the constraint that it must be possible to trade out of any position within the index within 5 days. As the fund size increases there is a clear re-distribution of weight from Financial-Industrial shares within the benchmark to Resources shares. This is due to liquidity pinches at the bottom end of the index which gradually shifts weight to the more liquid resources shares at the top of the index. All shares included in the ALSI as at 30 June 2002 were included in the analysis and data for the inputs to the model were obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002.






A similar shift in weights is observed with regard to sector holdings within the benchmark. For smaller fund sizes which are able to accommodate an equally-weighted benchmark of all 161 shares, we find that the FINDI-RESI split is 77%-

23%. As fund size increases, however, there is a clear shift in allocation from the Financial-Industrial sector to the Resources sector, as indicated in Figure 10.3 until the FINDI-RESI split is 41.4%-58.6% at a fund size of R4 billion. Much of this can be attributed to the increase in the weights of the top 10 shares as discussed above.

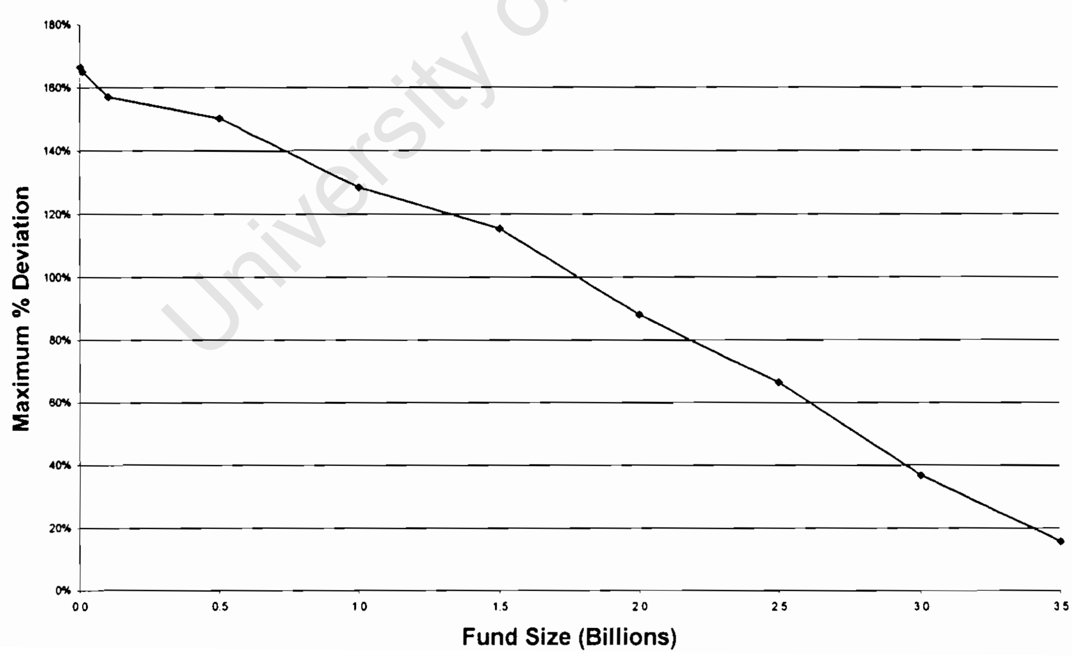
### 8.1.4 Maximum deviation from optimal benchmarks

Following the above analysis, the maximum leeway fund managers have in deviating from these optimal benchmarks by taking bets in individual share positions was assessed. This value was measured for each optimal benchmark by maximising the cumulative absolute value of bets taken on each optimal benchmark, with liquidity and unit trust regulations as constraints.

**Figure 8.4 Maximum possible deviation from optimal portfolios**

An optimal benchmark index is constructed for increasing fund size levels by solving for the optimal share weights which will yield the minimum achievable level of concentration subject to the constraint that it must be possible to trade out of any position within the index within 5 days. As the fund size increases it becomes increasingly difficult for managers to deviate away from these optimal benchmarks. The maximum deviation is calculated as the maximum weight difference between the optimal benchmark and any other benchmark which meets the liquidity constraints. All shares included in the ALSI as at 30 June 2002 were included in the analysis and data for the inputs to the model were obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002.





Based on our earlier findings, the degree of leeway afforded to managers in taking active bets decreases as fund size increases. This is an added consequence of the liquidity constraints which place an increasing limit on the range of weights within which individual shares can move.

This is encapsulated in the fact that it was impossible to calculate a measure of deviation for a fund size of R4 billion. At this fund level all share positions in the benchmark are fixed and the optimal benchmark is the only viable solution. It is therefore impossible to adjust any of the weights so as to take an active position either above or below the benchmark.

## 8.2 Optimal All-Share Index adding FINDI-RESI constraints



Following the initial analysis, additional constraints on the allowed allocations to Financial-Industrial and Resources shares within the benchmark were added to the basic model specification, based on the earlier analysis of the minimum historical variance and maximum historical Sharpe ratio FINDI-RESI allocation splits. The optimization analysis was therefore conducted twice more, each time with one of the following added restrictions:

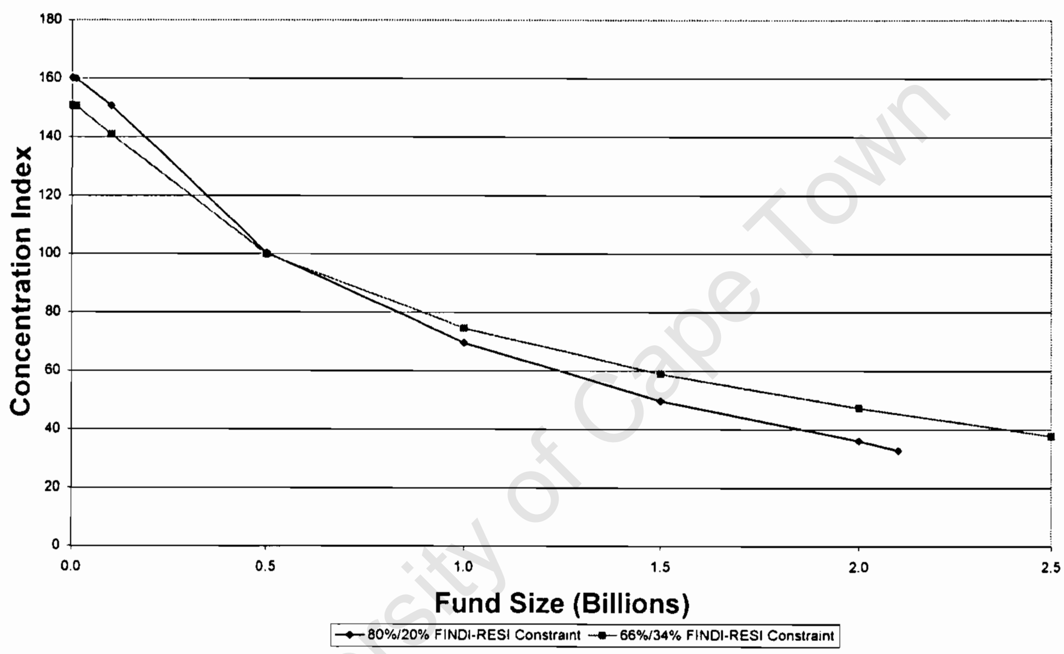
a. The allocation of share weights within the benchmark must yield an 80%-20% FINDI-RESI split as per the minimum historical variance analysis.
b. The allocation of share weights within the benchmark must yield a 66%-34% FINDI-RESI split as per the maximum historical Sharpe ratio analysis.

The optimal solution again minimised concentration subject to a 5-day trade-out period which served as a measure of liquidity constraints within the fund.

### 8.2.1 Concentration and Overall Risk

**Figure 8.5 Comparison of benchmark concentration against fund size**

An optimal benchmark index is constructed for increasing fund size levels by solving for the optimal share weights which will yield the minimum achievable level of concentration subject to the constraint that it must be possible to trade out of any position within the index within 5 days. The analysis is conducted twice, each time with an additional constraint on the allowed FINDI-RESI allocation of the share weights within the benchmark. The optimal concentration level according to fund size for each of the analyses is plotted in the graph above. It was not possible to conduct the 80%-20% constrained analysis beyond a fund size of R2.1 billion due to the liquidity constraints while the 66%-34% analysis was limited to a fund size of R2.5 billion.. All shares included in the ALSI as at 30 June 2002 were included in the analysis and data for the inputs to the model were obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002.





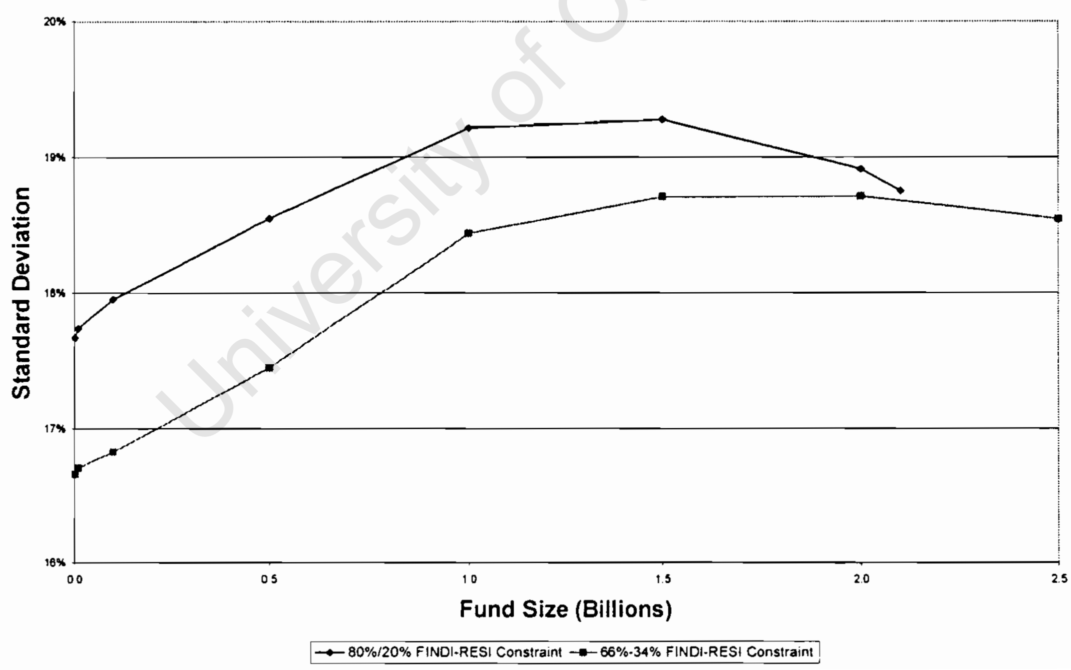

As expected, the concentration index values for both indices decrease steadily as fund size increases and increasing weight is transferred from the illiquid shares at the tail of the index to the liquid large-cap shares at the top. The 80%-20% constrained analysis demonstrates a lower degree of concentration than the 66%-34% constrained analysis up until a fund size of R500 million after which point it is marginally more concentrated than its counterpart.

It was not possible to carry the 80%-20% constrained analysis beyond a fund size of R2.1 billion as it was impossible to maintain the target FINDI-RESI mix at this level while still remaining within the liquidity constraints. The associated concentration index value was 32.8 effective shares. Unit trust regulations were again complied with throughout the analysis while pension fund regulations were violated at a fund size of R2 billion.

In contrast, it was possible to carry the 66%-34% constrained analysis to a fund size of R2.5 billion before liquidity constraints made it impossible to continue the analysis. The associated concentration index value was 37.7 effective shares. Both unit trust and pension fund regulations were complied with throughout the analysis.

**Figure 8.6 Comparison of overall benchmark risk against fund size**

An optimal benchmark index is constructed for increasing fund size levels by solving for the optimal share weights which will yield the minimum achievable level of concentration subject to the constraint that it must be possible to trade out of any position within the index within 5 days. The associated standard deviation for each optimal benchmark at each fund size is plotted in the graph above. The analysis is conducted twice, each time with an additional constraint on the allowed FINDI-RESI allocation of the share weights within the benchmark. All shares included in the ALSI as at 30 June 2002 were included in the analysis and data for the inputs to the model were obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002.



The overall degree of benchmark risk as measured by standard deviation increases steadily for both of the analyses as their levels of concentration increase. The associated risk for the 80%-20% constrained analysis is marginally higher throughout the analysis. The standard deviation for the absolute minimum concentration portfolio as per the 80%-20% analysis is 18.75%, 2.72% lower than that of the ALSI at 30 June 2002. The 66%-34% analysis yields a marginally lower deviation of 18.54% which is 2.93% lower than that of the ALSI.

A comparison of the results with the unconstrained ALSI optimization indicates that while the 80%-20% analysis yields a lower concentration index value than the unconstrained analysis, it has a higher overall risk for all fund sizes investigated. In contrast, the 66%-34% analysis demonstrates a marginally lower concentration index value than the unconstrained analysis and also a lower overall degree of portfolio risk for all fund sizes.

It is interesting to note the decrease in risk between a fund size of R1.5 and R2 billion regardless of the continued increase in concentration. This is a clear demonstration that concentration is only one determinant of risk as the decrease in risk is a result of the correlations between the shares carried at these fund sizes.

## 8.2.2 Comparative Sharpe Ratios

**Figure 8.7 Comparison of Sharpe ratios against fund size**

An optimal benchmark index is constructed for increasing fund size levels by solving for the optimal share weights which will yield the minimum achievable level of concentration subject to the constraint that it must be possible to trade out of any position within the index within 5 days. The associated Sharpe ratio at each fund level is determined as the ratio of excess index return to index standard deviation. The analysis is conducted twice, each time with an additional constraint on the allowed FINDI-RESI allocation of the share weights within the benchmark. All shares included in the ALSI as at 30 June 2002 were included in the analysis and data for the inputs to the model were obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002.

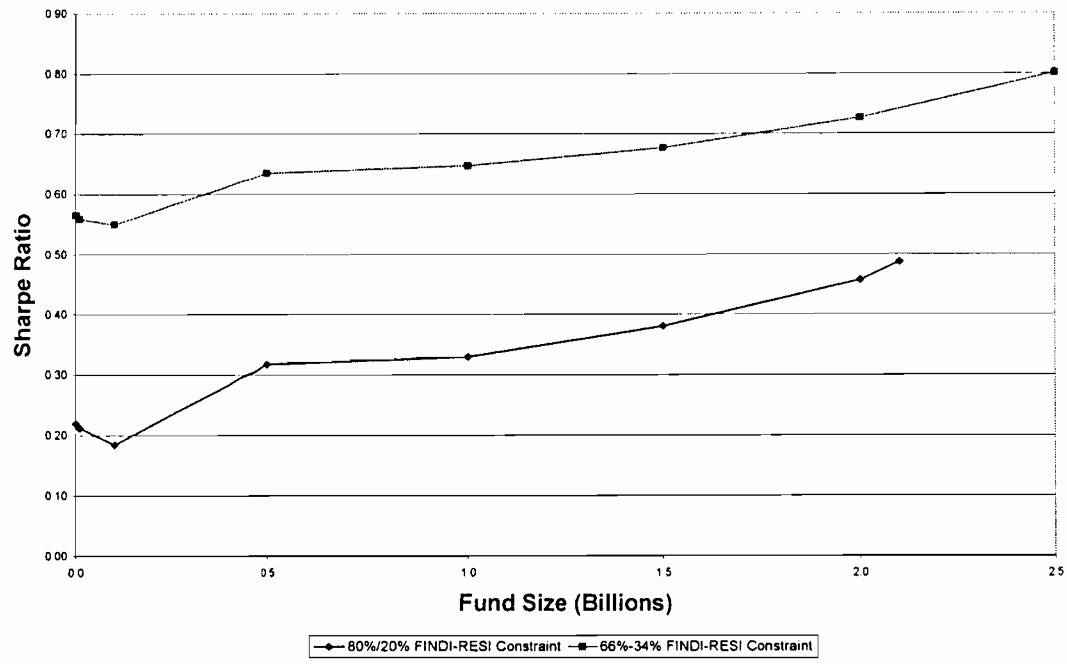



Figure 8.7 depicts the progression of Sharpe ratios for each of the analyses as fund size increases. It is clear that the 66%-34% constrained analysis demonstrates a significantly higher ratio than its 80%-20% counterpart. The findings indicate that this is due to both a higher average expected return for the 66%-34% analysis as well as lower levels of associated risk, as measured by the standard deviation of the index.

The marked increase in Sharp ratios as fund size increases is noteworthy. An examination of the findings suggests that much of the higher returns on the part of the 66%-34% analysis can be attributed to the increased weightings in the Resources shares at the top of the index. The returns on these shares were significantly higher than the average share return of 16.29% over the period under review, therefore significantly bolstering the overall index return.

While the investigation of risk indicated that the 66%-34% analysis had a lower overall degree of risk than the unconstrained analysis it demonstrated a higher Sharpe ratio only up to a fund size of R1.5 billion. This is because at fund sizes above this the unconstrained analysis yielded significantly higher returns due to its higher weighting of Resources shares while the difference in risk between the portfolios generated by the analyses was marginal at best.

## 8.3 Optimal Active-Passive Mix

Following the analysis of optimal passive portfolios the Treynor-Black optimization methodology was applied in order to investigate the addition of an active component to the passive portfolios generated at each fund size level.

### 8.3.1 Calculation of the optimal active portfolio

Each share which formed part of the ALSI as at 30 June 2002 was regressed against the ALSI (J203) index and their resultant alphas were tested for significance at the 10% level. The average significant absolute alpha was 4.10% with 11 shares demonstrating positive alphas and 8 demonstrating negative alphas, while the average annualised standard error of the significant regressions was 38.43%. The findings of the analysis are presented in table 8.1 below.

**Table 8.1 ALSI shares which displayed significant alphas**

Multiple regressions were conducted of all shares which constituted the ALSI as at 30 June 2002 against the ALSI (J203) index. The resultant alphas were tested for significance at the 5% level. All shares with significant alphas and their associated annualised standard errors are presented in the table below. Data for the analysis was obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002.



| Share Name | Alpha | Standard Error | Beta |
|---|---|---|---|
| Anglovaal | 3.83% | 30.05% | 0.36 |
| AST Group | -4.46% | 47.87% | 1.08 |
| Brait SA | -3.68% | 42.49% | 0.92 |
| Ceramic Industries | 2.41% | 22.22% | 0.21 |
| Coronation Holdings | -3.15% | 35.15% | 1.03 |
| Genbel | -2.02% | 22.91% | 1.00 |
| Gold Fields | 4.73% | 45.47% | 0.52 |
| Grindrod | 4.36% | 43.48% | 0.59 |
| Grindrod N | 4.43% | 45.03% | 0.42 |
| Harmony Gold | 4.37% | 48.04% | 0.53 |
| Impala Platinum | 3.41% | 34.88% | 1.62 |
| Liberty International | 1.63% | 5.58% | 0.44 |

| | | | |
|---|---|---|---|
| Medi-Clinic | 2.54% | 25.70% | 0.24 |
| Mvelaphanda Ltd | 10.37% | 56.10% | 0.66 |
| Oceana | 2.54% | 21.36% | 0.39 |
| Profurn | -7.49% | 82.39% | 0.55 |
| Rebserve Holdings | -3.71% | 38.79% | 1.08 |
| Tradehold | -5.77% | 46.34% | 1.05 |
| Venfin | -3.08% | 22.61% | 0.98 |

Following this, the ex-post appraisal ratio for each share was calculated based on its alpha and the standard error of the regression. The ratio represents the share's contribution to the performance of the portfolio.

Shares with a negative alpha are allocated a negative weighting within the active portfolio indicating a short position. We therefore consider the active portfolio for two scenarios. The first assumes that short selling is allowed and therefore combines all shares with significant alphas while the second does not make provision for short selling and therefore includes only those shares with positive alphas.

The weight of each share within the active portfolio was calculated by dividing its appraisal ratio by the sum of the appraisal ratios for all shares in the portfolio, as per equation 2.24:

$$w_i = \frac{\frac{\alpha_i}{\sigma(e_i)}}{\sum_{i=e}^{n} \frac{\alpha_i}{\sigma^2(e_i)}} \tag{2.24}$$

The contribution of each share to the alpha and residual risk of the portfolio as a whole was then calculated on a weighted average basis.

The results for the analysis with short selling allowed are presented in table 8.2.

**Table 8.2 Share contributions to optimal active portfolio with short selling**

All shares which had demonstrated significant alphas at the 10% level when regressed against the ALSI were used to generate an optimal active portfolio using the Treynor-Black optimization technique. The weight of each share within the active portfolio was based on its appraisal ratio which is measured by the ratio of alpha to the standard error of the estimate. This appraisal ratio was divided by the sum of the appraisal ratios for all shares in the portfolio in order to arrive at the shares weight. From these weights it was possible to calculate each share's contribution to the portfolio's alpha and residual risk. Data for the analysis was obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002. The findings of the analysis are presented in the table below.

| Share Name | Appraisal Ratio | Optimal Weight | Alpha Contribution | Residual Variance Contribution |
|---|---|---|---|---|
| Anglovaal | 0.42 | 28.29% | 1.08% | 0.72% |
| AST Group | -0.19 | -12.98% | 0.58% | 0.39% |
| Brait SA | -0.20 | -13.57% | 0.50% | 0.33% |
| Ceramic Industries | 0.49 | 32.50% | 0.78% | 0.52% |
| Coronation Holdings | -0.26 | -17.00% | 0.54% | 0.36% |
| Genbel | -0.38 | -25.58% | 0.52% | 0.34% |
| Gold Fields | 0.23 | 15.24% | 0.72% | 0.48% |
| Grindrod | 0.23 | 15.35% | 0.67% | 0.45% |
| Grindrod N | 0.22 | 14.54% | 0.64% | 0.43% |
| Harmony Gold | 0.19 | 12.60% | 0.55% | 0.37% |
| Impala Platinum | 0.28 | 18.65% | 0.64% | 0.42% |
| Liberty International | 0.44 | 29.04% | 0.47% | 0.31% |
| Medi-Clinic | 0.38 | 25.60% | 0.65% | 0.43% |
| Mvelaphanda Ltd | 0.33 | 21.94% | 2.27% | 1.52% |
| Oceana | 0.56 | 37.11% | 0.94% | 0.63% |
| Profurn | -0.11 | -7.35% | 0.55% | 0.37% |
| Rebserve Holdings | -0.25 | -16.43% | 0.61% | 0.41% |
| Tradehold | -0.27 | -17.89% | 1.03% | 0.69% |
| Venfin | -0.60 | -40.08% | 1.23% | 0.82% |
| | | **100.00%** | | |

The contributions for each share were then summed and yielded a final active portfolio alpha of 14.98%, a beta of -0.24 and residual deviation of 31.59%.

When short selling is not allowed, the active portfolio is reduced to 11 stocks which yield an active portfolio with an alpha of 3.76%, a beta of 0.5 and a residual deviation of 9.99%. Comparing the two portfolios it is clear that the negative alpha stocks on average have both a higher alpha and residual error than those with positive alphas. The findings for the analysis are presented in table 8.3.

**Table 8.3 Share contributions to optimal active portfolio without short selling**

Shares which had demonstrated significant **positive** alphas at the 10% level when regressed against the ALSI were used to generate an optimal active portfolio using the Treynor-Black optimization technique. The weight of each share within the active portfolio was based on its appraisal ratio which is measured by the ratio of alpha to the standard error of the estimate. This appraisal ratio was divided by the sum of the appraisal ratios for all shares in the portfolio in order to arrive at the shares weight. From these weights it was possible to calculate each share's contribution to the portfolio's alpha and residual risk. Data for the analysis was obtained from I-Net Bridge for the period 30 June 1999 – 30 June 2002. The findings of the analysis are presented in the table below.

| Share Name | Appraisal Ratio | Optimal Weight | Alpha Contribution | Residual Variance Contribution |
|---|---|---|---|---|
| Anglovaal Inds. | 0.42 | 11.28% | 0.43% | 0.11% |
| Ceramic Industries | 0.49 | 12.96% | 0.31% | 0.08% |
| Gold Fields | 0.23 | 6.08% | 0.29% | 0.08% |
| Grindrod | 0.23 | 6.12% | 0.27% | 0.07% |
| Grindrod N | 0.22 | 5.80% | 0.26% | 0.07% |
| Harmony | 0.19 | 5.02% | 0.22% | 0.06% |
| Impala Platinum Hlds | 0.28 | 7.44% | 0.25% | 0.07% |
| Liberty International | 0.44 | 11.58% | 0.19% | 0.05% |
| Medi-Clinicrp | 0.38 | 10.20% | 0.26% | 0.07% |
| Mvelaphanda Resources Ltd | 0.33 | 8.75% | 0.91% | 0.24% |
| Oceana Group | 0.56 | 14.79% | 0.38% | 0.10% |
| | | **100.00%** | | |



## 8.3.2 Combining the active and passive portfolios

As per Treynor-Black (1973), the optimal overall portfolio will comprise both an active and passive component. As the Sharpe ratio of this optimal portfolio is dependent on the Sharpe ratio of the passive portfolio and the information ratio of the active portfolio, the weight to be invested in the active portfolio is simply the ratio of its appraisal ratio to the Sharpe ratio of the passive portfolio, as per equation 2.31.

The earlier analysis of optimal passive portfolios demonstrated that the 80%-20% constrained analysis was inferior to both the 66%-3% analysis and the unconstrained FINDI-RESI allocation analysis. This was true with regard to both overall portfolio risk, as measured by standard deviation, as well as performance, as measured by the Sharpe ratio.

The optimal portfolios generated for 66%-34% analysis and the unconstrained analysis were therefore investigated as the optimal passive portfolios to be mixed with the optimal active portfolio generated by the Treynor-Black analysis.

For each fund size previously investigated, the weight of the active portfolio with short selling was calculated using equation 2.31 and then adjusted for its beta of -0.24 as per equation 2.32.[1] As the active portfolio beta was negative the initial active weight was adjusted downward substantially. The remaining portfolio weight was allocated to the passive portfolio.



**Table 8.4 Optimal combination of active and passive portfolios with short selling**

Treynor-Black optimized portfolios were constructed from an optimal active portfolio derived from regression analysis on the ALSI for the period 30 June 1999 – 30 June 2002 and optimal passive portfolios derived from the earlier ALSI optimizations. The 80%-20% constrained ALSI optimization was omitted from the analysis as it was found to be inferior to the other two analyses from a performance point of view, as measured by the Sharpe ratio. The weight of the active portfolio was calculated as w* with the remaining weight allocated to the passive portfolio. Data for the analysis was obtained from I-Net Bridge and the findings of the analysis are presented in the table below.

| | Initial ALSI optimal benchmarks | | | 66%-34% constrained benchmarks | | |
|---|---|---|---|---|---|---|
| Fund Size | Sharpe Ratio | $W_{actuve}$ | $W_{passive}$ | Sharpe Ratio | $W_{actuve}$ | $W_{passive}$ |
| 100 million | 0.27 | 44.30% | 55.70% | 0.55 | 29.22% | 70.78% |

[1] The calculation of the optimal active portfolio weight is dependent on the assumption that diagonality exists in the correlation matrix of shares. van Rensburg (2002) found, however, that this assumption does not hold within the South African market. Unfortunately, it was not possible to adapt the model in order to accommodate this shortcoming.

| | | | | | | |
|---|---|---|---|---|---|---|
| 500 million | 0.47 | 33.48% | 66.52% | 0.63 | 27.27% | 72.73% |
| 1 billion | 0.55 | 31.10% | 68.90% | 0.65 | 27.93% | 72.07% |
| 1.5 billion | 0.67 | 27.58% | 72.42% | 0.68 | 27.38% | 72.62% |
| 2 billion | 0.78 | 24.82% | 75.18% | 0.73 | 26.11% | 73.89% |
| 2.5 billion | 0.89 | 22.84% | 77.16% | 0.80 | 24.26% | 75.74% |
| 3 billion | 1.01 | 21.14% | 78.86% | | | |
| 3.5 billion | 1.11 | 20.11% | 79.89% | | | |
| 4 billion | 1.18 | 19.67% | 80.33% | | | |

There is a clear decrease in the weight of the active component as fund size increases for both sets of passive portfolios. This is due to the increase in distribution of portfolio weight to the shares at the top of each passive portfolio as fund size increases. As stated earlier, the mining shares which largely constitute the top of each of these portfolios generate substantial returns. As fund size increases the returns on these passive portfolios increase significantly with only marginal increases in overall portfolio risk. The ratio of risk to return for these passive portfolios is therefore more efficient than the alpha to residual error ratio of the active portfolio as fund size increases, which means a smaller position is necessary in the active portfolio to achieve the optimal overall portfolio.

The earlier finding that the Sharpe ratio for the portfolios generated by the 66%-34% analysis are superior to the unconstrained analysis at fund sizes up to R1.5 billion are reflected in the active-passive weight splits. For small fund sizes the proportion of the active portfolio weight in the optimal overall portfolio for the 66%-34% analysis is significantly smaller than for the unconstrained analysis passive portfolios. From a fund size of R2 billion, however, the active weight for the unconstrained analysis is lower than that for the 66%-34% analysis.

Similar analysis was conducted for the active portfolios generated in the absence of short selling. The findings are presented in table 8.5.

**Table 8.5 Optimal combination of active and passive portfolios without short selling**

Treynor-Black optimized portfolios were constructed from an optimal active portfolio derived from regression analysis on the ALSI for the period 30 June 1999 – 30 June 2002 and optimal passive portfolios derived from the earlier ALSI optimizations. The 80%-20% constrained ALSI optimization was omitted from the analysis as it was found to be inferior to the other two analyses from a performance point of view, as measured by the Sharpe ratio. The weight of the active portfolio was calculated as $w^*$ with the remaining weight allocated to the passive portfolio. Data for the analysis was obtained from I-Net Bridge and the findings of the analysis are presented in the table below.

| | **Initial ALSI optimal benchmarks** | | | **66%-34% constrained benchmarks** | | |
|---|---|---|---|---|---|---|
| **Fund Size** | **Sharpe Ratio** | $W_{actuve}$ | $W_{passive}$ | **Sharpe Ratio** | $W_{actuve}$ | $W_{passive}$ |
| 500 million | 0.47 | 83.59% | 16.41% | 0.63 | 68.15% | 31.85% |
| 1 billion | 0.55 | 77.66% | 22.34% | 0.65 | 69.78% | 30.22% |
| 1.5 billion | 0.67 | 68.92% | 31.08% | 0.68 | 68.42% | 31.58% |
| 2 billion | 0.78 | 62.04% | 37.96% | 0.73 | 65.26% | 34.74% |
| 2.5 billion | 0.89 | 57.11% | 42.89% | 0.80 | 60.64% | 39.36% |
| 3 billion | 1.01 | 52.88% | 47.12% | | | |
| 3.5 billion | 1.11 | 50.30% | 49.70% | | | |
| 4 billion | 1.18 | 49.21% | 50.79% | | | |

The results for the combination of the active portfolio without short selling largely mirror the prior results but for the fact that the active positions in the optimal portfolio are larger due to its beta adjustment being less significant. The same shift in weights from the active to the passive portfolio is evident as fund size increases and the Sharpe ratio for the passive portfolio improves.



## 8.6 Conclusions

While the discussion of concentration levels on the exchange concluded that market concentration on the JSE is largely responsible for much of the risk and prudential concerns faced by fund managers, it is clear that liquidity plays an equally important role in the determination of fund holdings. Funds wishing to reduce concentration in their benchmark portfolios by spreading their holdings more equitably will find themselves hampered in their efforts by the need to keep holdings at levels which enable smooth entry into and exit from less liquid shares in the ALSI.

This imposes a cap on the weights that can be attributed to shares at the tail end of the index and forces an increase in holdings in the more liquid shares at the top of the index. Given that most of these liquid, large cap shares on the exchange are resources shares, it is unsurprising that there is a marked shift from Financial-Industrials to Resources shares for optimal benchmarks as fund size increases.

These findings are of most concern to large fund managers as the analysis demonstrates that small funds with funds of R2 billion or less under management are able to achieve a more satisfactory level of concentration relative to the fund's liquidity risk, assuming a maximum trade-out period of 5 days. At a fund size of R4 billion, however, the optimal benchmark demonstrates a concentration index only 7 shares greater than the ALSI as at 30 June 2002 and a standard deviation 0.05% higher. Large fund managers may therefore be forced to exclude the less liquid shares from their benchmarks in order to create an evaluation measure which is both investable and prudentially sound.

Liquidity constraints also limit the range of investment in single shares thereby restricting the leeway fund managers have in taking active positions which deviate from the optimal benchmarks. It was found that as fund size increases, the degree of deviation fund managers can take from these optimal benchmarks decreases significantly.

It should be noted that the constraints imposed on benchmarks by the new unit trust regulations have little impact and were not violated at any stage of the analysis. In contrast, pension fund regulations were violated prior to the maximum viable fund size indicating the limitations the proposed regulations impose on the holdings of large pension fund managers.

The analysis was expanded to include the historical FINDI-RESI allocations that yielded minimum portfolio deviation and the maximum Sharpe ratio. The minimum historical deviation restriction forced an 80%-20% FINDI-RESI allocation in all optimal portfolios while the maximum Sharpe ratio constraint forced a 66%-34% FINDI-RESI allocation.

The 80%-20% failed to achieve significant reductions in portfolio deviation, yielding standard deviations at each fund size which were in excess of those generated by both the initial unconstrained analysis and the 66%-34% FINDI-RESI analysis. The 66%-34% analysis demonstrated a lower degree of risk and higher Sharpe ratios than the initial unconstrained analysis for fund sizes lower than R2 billion. For fund sizes above this, however, portfolios generated by the initial analysis yielded far higher returns while also demonstrating only marginally higher risk.

The combination of the initial analysis and the 66%-34% FINDI-RESI analysis with an active portfolio generated using Treynor-Black optimization techniques demonstrated that in the presence of short selling, the weight of the active component in the optimal portfolio was smaller than the passive component due largely to the adjustment for its negative beta. Indeed, as fund size increased and share weights in the passive portfolios shifted to the high-return resources shares these Sharpe ratios improved significantly leading to a decrease in the recommended size of the active portfolio.

The 66%-34% analysis required a smaller active portfolio component than the initial optimization analysis at fund sizes smaller than R2 billion due to its higher Sharpe ratio at these fund levels whereas the initial analysis required a smaller component for larger fund sizes.

In the absence of short selling, the initial weighting of the active component of the optimal portfolio was significantly larger due to its larger beta which resulted in a less significant downward adjustment in active weight. The findings were largely the same, however, with a clear transfer in weight from the active component to the passive component as the Sharpe ratio of the latter improved as fund size increased.

# 9

# Conclusions

The study has focused on two emerging areas of concern within the context of evaluating benchmark risk in the South African environment. The first has been the change in the classification of the FTSE/JSE which preceded the creation of the new benchmark alternatives. Benchmarking in South Africa has traditionally focused on limiting the impact of the Resources sector which has been identified as being responsible for much of the volatility and concentration problems faced on the exchange.

The question of whether the adjustments to the old classifications are in fact suitable for continued use in this manner has been notable in its absence from recent literature, however. An initial cluster analysis study indicated that there was a clear separation of sectors within the larger Financial-Industrials group. This indicated a dichotomy in behaviour within the group which was confirmed when a number of Financial-Industrials indices, most notably those within the Basic Industries and Cyclical Consumer Goods, were shown to group more closely with the Resources sector.

A factor analysis was conducted in order to investigate the source and magnitude of these effects. Van Rensburg (2002) found that a two-factor risk model with the Resources and Financial-Industrial sectors as proxies was better able to model the return-generation process on the JSE than the more traditional market model. The analysis of the new classification has confirmed this result. While the analysis of Van Rensburg (2002) demonstrated a clear dichotomy in the effects of these two factors on the return-generation process, however, this study found that a number of Financial-Industrial indices demonstrated either dual-loadings or loaded with the Resources factor only as opposed to the Financial-Industrial factor as expected.

It is evident that the proliferation of dual-listed shares and shares with extensive international operations has exposed the performance of these companies to international influences. The result has been that these shares are increasingly performing like Resources shares and therefore present an additional Resources-type exposure to fund managers. It is therefore essential that fund managers that benchmark according to their Financial-Industrial and Resources exposures adjust for these shares as necessary within their portfolios.

The second aspect of benchmarking that was investigated was an assessment of the risks associated with current benchmark alternatives commonly employed by fund managers. The goal was to investigate the risks faced by fund managers in the market using not only traditional risk measures such as volatility of returns but also concentration-based risk and liquidity.

It was found that the South African market faces excessive levels of concentration due to the disproportionate weights of a small number of shares. The ALSI index was found to be the equivalent of only 16 equally-weighted shares even though the index itself comprised 161 shares at the time. The concentration levels of the other benchmark alternatives were somewhat improved because of their more equitable distribution of weights but even so the lowest concentration levels were achieved by the SWIX which only demonstrated an equivalent number of shares of 31.



The effect of concentration on risk was demonstrated by Bradfield and Kgomari (2004). Applying their methodology to the data sample, it was found that concentration levels over the three-year period investigated accounted for roughly 2.5% of overall ALSI risk. This is due to the fact that weights held in large cap shares above a certain level cause these shares to add more share-specific risk to the index than they diversify away. (Strongin, Petsch and Sharenow (2000). This threshold value was calculated for each index and it was found that each benchmark comprised a number of shares above this level. In the case of the CAPI, it was demonstrated that a capping level of 6% (as opposed to the current level of 10%) would be required in order to bring all shares on the index under this threshold level.

The analysis has also indicated that liquidity risk plays a large, albeit indirect, part in the determination of overall benchmark risk. It impacts on concentration as it acts as a constraint on the minimum levels of concentration which could be achieved via the equitable distribution of weightings across a broad range of shares by limiting holdings in less liquid shares. The impact of these constraints was more noticeable on the less concentrated benchmarks reviewed as their distributed weights meant that greater weights were held in less liquid shares at the tail of the indices.

The earlier analysis was then combined into a model which attempted to generate risk-optimized portfolios which minimised portfolio concentration subject to predefined liquidity and regulatory constraints. The initial analysis indicated that liquidity constraints were less onerous for fund sizes smaller than R2 billion with these funds able to achieve up to triple the effective number of shares demonstrated by the ALSI as at 30 June 2002 under a 5-day trade-out restriction. This value decreased as fund size increased, however, until at a fund size of R4 billion the concentration index value was only 7 shares higher than that for the ALSI and the associated standard deviation of the portfolio was 0.05% higher.

The imposition of the liquidity constraints also impacted on the distribution of FINDI and RESI allocations within the optimal portfolios. As the most liquid shares on the index are Resources shares, as fund size increased and weight was transferred to these shares there was a clear shift in the FINDI-RESI allocation from Financial-Industrial shares to Resources shares. This highlights an interesting dilemma for fund managers as the traditional view has been that excessive resources weights in the index produce excessive levels of volatility for the fund.

As a further test of the impact that this sector-based allocation has on portfolio risk, the analysis was expanded to investigate the historical FINDI-RESI ratio that yielded the minimum portfolio deviation and the maximum Sharpe ratio. The minimum historical deviation was found to occur at a FINDI-RESI allocation of 80%-20% while the maximum historical Sharpe ratio occurred for an allocation of 66%-34%.

The optimization analysis was therefore conducted twice more with the added FINDI-RESI constraints. Findings with the 80%-20% constraint were disappointing with the analysis failing to yield an improvement in the levels of portfolio risk generated for the initial optimized portfolios. Indeed the analysis yielded lower effective numbers of stocks and higher standard deviations at all fund sizes. In contrast, the 66%-34% analysis yielded both higher effective numbers of stocks and lower standard deviations than the initial analysis for all funds smaller than R2 billion.

In order to investigate the relationship between active and passive risk in the market over the period under review an active portfolio was constructed using Treynor-Black optimization techniques. This portfolio was then combined with the optimal passive portfolios generated by the initial optimization process as well as the 66%-34% constrained FINDI-RESI analysis. It was found that the in the presence of short selling the weight of the active portfolio was small at a fund size of R100 million when compared to the weight of the passive portfolio due to a large down-weighting of the active component to compensate for its negative beta.

As fund size increased, the weight distribution in the passive portfolios shifted to the Resources shares as earlier indicated, yielding higher expected returns and increasing their Sharpe ratios further. There was therefore a decrease in the size of the active portfolio component as fund size increased and weight was transferred to the increasingly more efficient passive portfolios.

Due to its higher Sharpe ratio at smaller fund sizes, the 66%-34% constrained analysis required a smaller active component for fund sizes smaller than R2 billion while the initial unconstrained analysis required a smaller component for fund sizes above this.

In the absence of short selling the initial size of the active portfolio was significantly larger than that of the passive portfolio due to its positive beta which resulted in a smaller downward adjustment in weight. The findings were largely the same, however, with weight transferred from the active portfolio to the passive portfolio as fund size increased and the passive portfolio became more efficient.

# APPENDIX A: THE FTSE/JSE AFRICA INDEX SERIES

1. The FTSE/JSE Africa Series Sector Classification Hierarchy

**1. Resources (J000)**
Mining (J004)
Oil & Gas (J007)

**2. Basic Industries (J010)**
Chemicals (J011)
Construction & Building Materials (J013)
Forestry & Paper (J015)
Steel & Other Metals (J018)

**3. General Industrials (J020)**
Aerospace and Defence (J021)
Diversified Industrials (J024)
Electronic & Electrical Equipment (J025)
Engineering & Machinery (J026)

**4. Cyclical Consumer Goods (J030)**
Automobiles & Parts (J031)
Household Goods & Textiles (J034)

**5. Non-Cyclical Consumer Goods (J040)**
Beverages (J041)
Food Producers & Processors (J043)
Health (J044)
Personal Care & Household Products (J047)
Pharmaceuticals and Biotechnology (J048)
Tobacco (J049)

**6. Cyclical Services (J050)**
General Retailers (J052)
Leisure, Entertainment and Hotels (J053)
Media & Photography (J054)
Support Services (J058)
Transport (J059)

**7. Non-Cyclical Services (J060)**
Food & Drug Retailers (J063)
Telecommunication Services (J067)

**8. Utilities (J070)**
Electricity (J072)
Gas Distribution (J073)
Water (J078)

**9. Financials (J080)**

Banks (J081)
Insurance (J083)
Life Assurance (J084)
Investment Companies (J085)
Real Estate (J086)
Speciality and Other Finance (J087)
Investment Entities (J089)

**10. Information Technology (J090)**

Information Technology Hardware (J093)
Software and Computer Services (J097)

# APPENDIX B: DATA SAMPLE CONSTITUENTS

1a. Composition of the Share Data Sample

| Share | Economic Group | Sector |
|---|---|---|
| Anglo American PLC | Resources | Mining |
| Anglo American Platinum | Resources | Mining |
| AngloGold | Resources | Mining |
| Avgold | Resources | Mining |
| Barplats | Resources | Mining |
| Durban Rooderpoort Deep | Resources | Mining |
| Gold Fields | Resources | Mining |
| Harmony Gold | Resources | Mining |
| Impala Platinum | Resources | Mining |
| Northam Platinum | Resources | Mining |
| Palabora Mining | Resources | Mining |
| Sasol | Resources | Oil & Gas |
| Transhex | Resources | Mining |
| Western Areas Mines | Resources | Mining |
| AECI Limited | Basic Industries | Chemicals |
| Afrox Holdings | Basic Industries | Chemicals |
| Barloworld | Basic Industries | Chemicals |
| Chemical Services | Basic Industries | Diversified Industrials |
| Ceramic Industries | Basic Industries | Construction |
| Dorbyl | Basic Industries | Diversified Industrials |
| Group Five | Basic Industries | Construction |
| Highveld Steel | Basic Industries | Steel & Other Metals |
| Imperial Holdings | Basic Industries | Diversified Industrials |
| Murray & Roberts | Basic Industries | Construction |
| PPC Limited | Basic Industries | Construction |
| Sappi | Basic Industries | Forestry & Paper |
| Wilson Bayly | Basic Industries | Construction |

1b. Composition of the Share Data Sample

| Share | Economic Group | Sector |
|---|---|---|
| Allied Technologies | General Retailers | Electronic & Electrical |
| Bell Equipment | General Industrials | Engineering & Machinery |
| Delta Electronics | General Industrials | Electronic & Electrical |
| Hudaco Industries | General Industrials | Engineering & Machinery |
| Ozz Limited | General Industrials | Engineering & Machinery |
| Power Technologies | General Industrials | Electronic & Electrical |
| Reunert | General Industrials | Electronic & Electrical |
| | | |
| Richemont | Cyclical Consumer Goods | Household Goods |
| Tiger Wheels | Cyclical Consumer Goods | Automobiles |
| | | |
| ABI | Non-Cyc Consumer Goods | Beverages |
| Aspen Pharmacare | Non-Cyc Consumer Goods | Pharmaceuticals |
| Illovo | Non-Cyc Consumer Goods | Food Producers |
| Medi Clinic | Non-Cyc Consumer Goods | Health |
| Oceana Group SA Breweries | Non-Cyc Consumer Goods | Food Producers |
| Rainbow Chickens | Non-Cyc Consumer Goods | Beverages |
| Tiger Brands | Non-Cyc Consumer Goods | Food Producers |
| Aspen Pharmacare | Non-Cyc Consumer Goods | Food Producers |
| Tongaat-Hulett | Non-Cyc Consumer Goods | Food Producers |
| | | |
| Bidvest Group | Cyclical Services | Support Services |
| City Lodge Hotels | Cyclical Services | Leisure & Entertainment |
| CTP Holdings | Cyclical Services | Media & Photography |
| Edgars Consolidated | Cyclical Services | General Retailers |
| Ellerines | Cyclical Services | General Retailers |
| Foschini | Cyclical Services | General Retailers |
| JD Group | Cyclical Services | General Retailers |
| Kersaf Investments | Cyclical Services | Leisure & Entertainment |
| Metro Cash & Carry | Cyclical Services | General Retailers |
| MHH Holdings | Cyclical Services | Media & Photography |

1c. Composition of the Share Data Sample

| Share | Economic Group | Sector |
|---|---|---|
| Mr. Price | Cyclical Services | General Retailers |
| Nampak | Cyclical Services | Support Services |
| Naspers | Cyclical Services | Media & Photography |
| Primedia | Cyclical Services | Media & Photography |
| Profurn | Cyclical Services | General Retailers |
| Sun International | Cyclical Services | Leisure & Entertainment |
| United Service | Cyclical Services | Support Services |
| Unitrans | Cyclical Services | Transport |
| Johnnic Holdings | Non-Cyclical Services | Telecommunications |
| Pick 'n Pay | Non-Cyclical Services | Food & Drug Retailers |
| Shoprite | Non-Cyclical Services | Food & Drug Retailers |
| ABSA | Financials | Banks |
| African Life Assure | Financials | Life Assurance |
| Allan Gray Property | Financials | Real Estate |
| Capital Alliance | Financials | Life Assurance |
| Centrecity Property Fund | Financials | Real Estate |
| Coronation Holdings | Financials | Speciality Finance |
| Firstrand Limited | Financials | Banks |
| Genbel Group | Financials | Speciality Finance |
| Investec | Financials | Investment Banks |
| Nedcor | Financials | Banks |
| New Africa Capital | Financials | Life Assurance |
| PSG Investment Bank | Financials | Investment Banks |
| Rand Merchant Bank | Financials | Banks |
| Sage Group | Financials | Life Assurance |
| Santam | Financials | Insurance |
| Standard Bank | Financials | Banks |
| DataTech | Information Technology | Software & Comp Services |
| Dimension Data | Information Technology | Software & Comp Services |
| MGX Holdings | Information Technology | Software & Comp Services |

# APPENDIX C: CLUSTER ANALYSIS RESULTS

1. Cluster breakdown for the Complete Linkage Dendogram

| Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 |
|---|---|---|---|---|
| Computer Services | Food & Drug Retailers | Steel | Other Min. Extractors | Gold Mining |
| Information Tech | Speciality Finance | | Forestry & Paper | Platinum Mining |
| Media | Investment Companies | | Oil & Gas | Diamond Mining |
| Communication Services | Life Assurance | | | Mining |
| Non-Cyc. Services | Banks | | | Resources |
| Pharmaceuticals | Financials | | | |
| | Transport | | | |
| | General Retailers | | | |
| | Support Services | | | |
| | Cyclical Services | | | |
| | IT Hardware | | | |
| | Health | | | |
| | Automobiles | | | |
| | Household Goods | | | |
| | Cyc. Consumer Goods | | | |
| | Hotels | | | |
| | Engineering | | | |
| | Electrical Equipment | | | |
| | Real Estate | | | |
| | Insurance | | | |
| | Beverages | | | |
| | Non-Cyc. Consumer Goods | | | |
| | Food Producers | | | |
| | Diversified Industrials | | | |
| | General Industrials | | | |
| | Building Materials | | | |
| | Chemicals | | | |
| | Basic Industries | | | |

## 2. Cluster breakdown for the Ward Dendogram

| Cluster 1 | Cluster 2 | Cluster 3 |
|---|---|---|
| Computer Services | Communication Services | Steel |
| Information Tech | Non-Cyc. Services | Building Materials |
| | | Chemicals |
| | Media | Basic Industries |
| | IT Hardware | Other Min. Extractors |
| | Health | Forestry & Paper |
| | Pharmaceuticals | Oil & Gas |
| | Automobiles | |
| | | Household Goods |
| | Speciality Finance | Cyc. Consumer Goods |
| | Investment Companies | |
| | Life Assurance | Gold Mining |
| | Banks | Platinum Mining |
| | Financials | Diamond Mining |
| | Food & Drug Retailers | Mining Finance |
| | Transport | Mining |
| | General Retailers | Resources |
| | Support Services | |
| | Cyclical Services | |
| | Hotels | |
| | Engineering | |
| | Real Estate | |
| | Insurance | |
| | Electrical Equipment | |
| | Food Producers | |
| | Beverages | |
| | Non-Cyc. Consumer Goods | |
| | Diversified Industrials | |
| | General Industrials | |

# APPENDIX D: FACTOR ANALYSIS RESULTS

1a. FTSE/JSE Index Sample Factor Loadings (Two-factor model)

| **Index** | **Factor 1** | **Factor 2** |
|---|---|---|
| Resources | 0.17194 | **0.93293** |
| Mining | 0.17780 | **0.92199** |
| Oil & Gas | 0.10617 | **0.72265** |
| Basic Industries | 0.23664 | **0.79736** |
| Chemicals | **0.37054** | **0.55680** |
| Building Materials | **0.30536** | **0.39345** |
| Forestry & Paper | 0.18085 | **0.68952** |
| Steel | 0.13252 | **0.47217** |
| General Industrials | **0.73978** | **0.48113** |
| Diversified Industrials | **0.70939** | **0.46661** |
| Electrical Equipment | **0.64884** | **0.34685** |
| Engineering | **0.44281** | **0.42007** |
| Cyc. Consumer Goods | **0.38790** | **0.48121** |
| Automobiles | **0.49770** | **0.35169** |
| Household Goods | **0.36276** | **0.46241** |
| Non-Cyc. Consumer Goods | **0.73640** | **0.38031** |
| Beverages | **0.66781** | **0.37838** |
| Food Producers | **0.67425** | **0.31462** |
| Health | **0.60824** | 0.22040 |
| Pharmaceuticals | **0.41360** | 0.03909 |
| Cyclical Services | **0.88902** | 0.20717 |
| General Retailers | **0.75606** | 0.19270 |
| Hotels | **0.58776** | 0.24741 |
| Media | **0.71270** | 0.12029 |
| Support Services | **0.85187** | 0.19431 |
| Transport | **0.73517** | 0.22360 |
| Non-Cyc. Services | **0.74280** | 0.12399 |
| Food & Drug Retailers | **0.67349** | -0.02181 |
| Communication Services | **0.66439** | 0.16024 |

1b. FTSE/JSE Index Sample Factor Loadings (Two-factor model)

| Index | Factor 1 | Factor 2 |
|---|---|---|
| Financials | **0.87830** | 0.19593 |
| Banks | **0.82159** | 0.13541 |
| Insurance | **0.67824** | **0.34992** |
| Life Assurance | **0.82868** | 0.22616 |
| Investment Companies | **0.78585** | 0.26400 |
| Real Estate | **0.38216** | 0.28728 |
| Speciality Finance | **0.79193** | 0.14183 |
| Information Tech | **0.62989** | 0.16869 |
| IT Hardware | **0.60220** | 0.15034 |
| Computer Services | **0.61275** | 0.15962 |
| Gold Mining | -0.00320 | **0.56583** |
| Diamond Mining | 0.18596 | **0.68560** |
| Platinum Mining | 0.09346 | **0.65740** |
| Other Min. Extractors | 0.14488 | **0.62469** |
| Mining Finance | 0.25447 | **0.86019** |
| Top 40 | **0.61673** | **0.72818** |
| All Share Index | **0.67566** | **0.68316** |
| Industrial 25 | **0.76378** | **0.47959** |
| Financial Industrial 30 | **0.85794** | **0.38973** |
| Financial Industrials | **0.89424** | **0.36075** |

2a. FTSE/JSE Share Sample Factor Loadings (Two-factor model)

| Share | Factor 1 | Factor 2 |
|---|---|---|
| Anglo American PLC | 0.27091 | **0.799366** |
| Sasol | 0.17406 | **0.631000** |
| Gold Fields | -0.00271 | **0.481962** |
| Anglo Platinum | 0.01718 | **0.603239** |
| Anglo Gold | -0.03925 | **0.657795** |
| Impala Platinum | -0.01781 | **0.672062** |
| Harmony Gold | -0.08685 | **0.587533** |
| Durban Roodepoort Deep | -0.13631 | **0.465646** |
| Northam Platinum | -0.11147 | **0.558266** |
| Western Areas Mines | 0.04894 | **0.485081** |
| Avgold | -0.09793 | **0.328528** |
| Transhex | 0.19327 | **0.376604** |
| Palabora Mining | 0.14855 | **0.428537** |
| Barplats | -0.00390 | **0.397085** |
| Sappi | 0.25892 | **0.564393** |
| Barloworld | **0.64638** | **0.418414** |
| Imperial Holdings | **0.69724** | 0.191719 |
| Murray & Roberts | 0.29456 | **0.417395** |
| AECI Limited | 0.24454 | **0.436044** |
| African Oxygen | **0.45597** | **0.314427** |
| PPC Limited | **0.43766** | 0.244545 |
| Dorbyl | **0.48637** | 0.251231 |
| Chemical Services | **0.48778** | 0.293432 |
| Ceramic Industries | **0.47123** | -0.091730 |
| Highveld Steel | 0.16051 | **0.556407** |
| Wilson Bayly | **0.38740** | -0.103982 |
| Group Five | **0.37563** | 0.217003 |

2b. FTSE/JSE Share Sample Factor Loadings (Two-factor model)

| Share | Factor 1 | Factor 2 |
|---|---|---|
| Reunert | **0.46913** | **0.422434** |
| Delta Electronics | **0.43161** | 0.229776 |
| Power Technologies | **0.43776** | 0.145754 |
| Ozz Limited | **0.31085** | **0.419342** |
| Hudaco Industries | **0.50198** | 0.281550 |
| Bell Equipment | 0.03159 | **0.407025** |
| Richemont | **0.30663** | **0.413249** |
| Tiger Wheels | **0.43104** | 0.196711 |
| SA Breweries | **0.62384** | **0.371052** |
| Tiger Brands | **0.60969** | 0.160908 |
| Aspen Pharmacare | -0.10326 | -0.087875 |
| Illovo | **0.31679** | **0.432329** |
| Tongaat-Hulett | 0.27191 | **0.419360** |
| ABI | **0.50091** | 0.038139 |
| Medi Clinic | **0.54280** | 0.154073 |
| Oceana Group | **0.32446** | 0.185638 |
| Rainbow Chicken | 0.16240 | 0.271825 |
| Bidvest Group | **0.76735** | 0.184641 |
| Nampak | **0.61583** | 0.176726 |
| Metro Cash & Carry | **0.60842** | 0.143842 |
| Naspers | **0.60452** | 0.103618 |
| Kersaf Investments | **0.41897** | 0.204585 |
| Edgars Consolidated | **0.56144** | 0.040310 |
| JD Group | **0.67373** | 0.087145 |
| Foschini | **0.64487** | 0.205137 |
| Ellerines | **0.72401** | 0.192152 |
| Allied Technologies | **0.43116** | 0.191736 |
| Mr. Price | **0.50593** | 0.119908 |
| United Service Technologies | **0.38574** | 0.139941 |

2c. FTSE/JSE Share Sample Factor Loadings (Two-factor model)

| Share | Factor 1 | Factor 2 |
|---|---|---|
| Sun International | **0.44175** | 0.291337 |
| Unitrans | **0.38711** | 0.061761 |
| MHH Holdings | **0.48899** | 0.026955 |
| CTP Holdings | **0.31561** | -0.073558 |
| Profurn | **0.54207** | -0.072693 |
| City Lodge Hotels | **0.44536** | 0.182750 |
| Primedia | **0.51874** | 0.134720 |
| Johnnic Holdings | **0.61102** | 0.184217 |
| Shoprite | **0.57682** | 0.012665 |
| Pick 'n Pay | **0.67301** | -0.036418 |
| Standard Bank | **0.70827** | 0.065015 |
| Firstrand Limited | **0.72033** | 0.029735 |
| ABSA | **0.72891** | 0.077450 |
| Nedcor | **0.69980** | 0.052997 |
| Rand Merchant Bank | **0.68347** | 0.008660 |
| Investec | **0.73383** | 0.072406 |
| New Africa Capital | **0.72113** | -0.071455 |
| Santam | **0.56452** | 0.257844 |
| Allan Gray Property | **0.37195** | 0.060027 |
| Capital Alliance | -0.09564 | -0.253644 |
| African Life Assure | **0.52610** | 0.074794 |
| Coronation Holdings | **0.64291** | 0.118659 |
| Sage Group | **0.59768** | 0.148697 |
| PSG Investment Bank | **0.34229** | 0.185265 |
| Genbel Group | **0.77021** | 0.216560 |
| Centrecity Property Fund | 0.27597 | 0.018233 |
| Dimension Data | **0.48174** | 0.080655 |
| DataTech | **0.55261** | 0.075787 |
| MGX Holdings | **0.55257** | -0.021040 |
| Resources | 0.20690 | **0.882941** |
| Financial Industrials | **0.86581** | **0.341107** |

# APPENDIX E: MODEL COMPARISONS

1a. Results of the initial regressions for the Market Model on the Index Sample

| Index | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Resources | 65.69% | 159.92 |
| Mining | 65.62% | 159.41 |
| Oil & Gas | 34.95% | 45.60 |
| Basic Industries | 45.78% | 71.07 |
| Chemicals | 36.79% | 49.31 |
| Building Materials | 16.05% | 16.86 |
| Forestry & Paper | 33.86% | 43.49 |
| Steel | 16.44% | 17.33 |
| General Industrials | 69.20% | 187.50 |
| Diversified Industrials | 64.15% | 149.51 |
| Electrical Equipment | 45.43% | 70.10 |
| Engineering | 32.25% | 40.51 |
| Cyc. Consumer Goods | 41.94% | 60.96 |
| Automobiles | 33.80% | 43.37 |
| Household Goods | 38.24% | 52.39 |
| Non-Cyc. Consumer Goods | 60.46% | 127.93 |
| Beverages | 54.67% | 101.10 |
| Food Producers | 44.71% | 68.12 |
| Health | 31.87% | 39.82 |
| Pharmaceuticals | 7.12% | 7.36 |
| Cyclical Services | 58.03% | 115.74 |
| General Retailers | 42.58% | 62.54 |
| Hotels | 32.78% | 41.47 |
| Media | 33.65% | 43.10 |
| Support Services | 53.80% | 97.67 |
| Transport | 43.72% | 65.48 |
| Non-Cyc. Services | 36.51% | 48.74 |

1b. Results of the initial regressions for the Market Model on the Index Sample

| Index | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Food & Drug Retailers | 18.58% | 19.94 |
| Communication Services | 33.76% | 43.31 |
| Financials | 61.85% | 135.55 |
| Banks | 48.80% | 80.12 |
| Insurance | 49.94% | 83.82 |
| Life Assurance | 57.96% | 115.43 |
| Investment Companies | 60.58% | 128.53 |
| Real Estate | 24.66% | 28.17 |
| Speciality Finance | 48.01% | 77.66 |
| Information Tech | 37.27% | 50.32 |
| IT Hardware | 28.75% | 34.48 |
| Computer Services | 34.79% | 45.29 |
| Gold Mining | 18.42% | 19.74 |
| Diamond Mining | 38.92% | 53.88 |
| Platinum Mining | 34.42% | 44.56 |
| Other Min. Extractors | 26.14% | 30.38 |
| Mining Finance | 66.19% | 163.47 |

2a. Results of the initial regressions for the Two-Factor Model on the Index Sample

| Index | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Mining | 99.01% | 4143.03 |
| Oil & Gas | 56.14% | 54.11 |
| Basic Industries | 55.07% | 51.87 |
| Chemicals | 38.47% | 26.94 |
| Building Materials | 17.16% | 9.59 |
| Forestry & Paper | 42.03% | 31.08 |
| Steel | 18.59% | 10.48 |
| General Industrials | 75.43% | 128.39 |
| Diversified Industrials | 70.20% | 98.75 |
| Electrical Equipment | 49.97% | 42.46 |
| Engineering | 31.27% | 19.88 |
| Cyc. Consumer Goods | 40.39% | 29.11 |
| Automobiles | 34.70% | 23.05 |
| Household Goods | 36.65% | 25.01 |
| Non-Cyc. Consumer Goods | 66.01% | 81.59 |
| Beverages | 57.34% | 56.78 |
| Food Producers | 52.17% | 46.26 |
| Health | 36.23% | 24.57 |
| Pharmaceuticals | 15.30% | 8.49 |
| Cyclical Services | 80.28% | 169.90 |
| General Retailers | 58.24% | 58.88 |
| Hotels | 38.72% | 27.22 |
| Media | 48.69% | 40.38 |
| Support Services | 75.79% | 130.90 |
| Transport | 56.49% | 54.88 |
| Non-Cyc. Services | 54.34% | 50.38 |

2b. Results of the initial regressions for the Two-Factor Model on the Index Sample

| Index | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Food & Drug Retailers | 40.58% | 29.35 |
| Communication Services | 45.28% | 35.34 |
| Financials | 87.49% | 291.30 |
| Banks | 77.60% | 144.79 |
| Insurance | 55.10% | 51.92 |
| Life Assurance | 76.83% | 138.60 |
| Investment Companies | 75.71% | 130.36 |
| Real Estate | 23.48% | 13.73 |
| Speciality Finance | 68.13% | 89.70 |
| Information Tech | 45.54% | 35.70 |
| IT Hardware | 33.72% | 22.11 |
| Computer Services | 42.98% | 32.28 |
| Gold Mining | 35.62% | 23.96 |
| Diamond Mining | 56.97% | 55.95 |
| Platinum Mining | 51.66% | 45.34 |
| Other Min. Extractors | 34.75% | 23.10 |
| Mining Finance | 91.24% | 433.23 |

3a. Results of the secondary regressions for the Two-Factor Model against the Market Model residuals

| Index | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Mining | 96.10% | 1024.77 |
| Oil & Gas | 30.64% | 19.33 |
| Basic Industries | 14.30% | 7.93 |
| Chemicals | -2.18% | 0.11 |
| Building Materials | -2.38% | 0.036 |
| Forestry & Paper | 10.75% | 6 |
| Steel | 1.62% | 1.68 |
| General Industrials | 11.02% | 6.14 |
| Diversified Industrials | 8.37% | 4.79 |
| Electrical Equipment | 5.73% | 3.52 |
| Engineering | -2.30% | 0.067 |
| Cyc. Consumer Goods | -1.86% | 0.24 |
| Automobiles | -0.38% | 0.84 |
| Household Goods | -1.95% | 0.21 |
| Non-Cyc. Consumer Goods | 12.38% | 6.86 |
| Beverages | 5.99% | 3.64 |
| Food Producers | 9.44% | 5.33 |
| Health | 6.56% | 3.91 |
| Pharmaceuticals | 6.99% | 4.12 |
| Cyclical Services | 48.72% | 40.42 |
| General Retailers | 22.98% | 13.38 |
| Hotels | 8.54% | 4.88 |
| Media | 20.27% | 11.55 |
| Support Services | 43.76% | 33.30 |
| Transport | 19.81% | 11.25 |
| Non-Cyc. Services | 25.80% | 15.43 |

3b. Results of the secondary regressions for the Two-Factor Model against the Market Model residuals

| Index | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Food & Drug Retailers | 24.22% | 14.27 |
| Communication Services | 15.93% | 8.86 |
| Financials | 64.83% | 77.50 |
| Banks | 53.64% | 49.01 |
| Insurance | 5.75% | 3.53 |
| Life Assurance | 40.62% | 29.39 |
| Investment Companies | 40.18% | 28.87 |
| Real Estate | -1.26% | 0.48 |
| Speciality Finance | 35.84% | 24.18 |
| Information Tech | 11.51% | 6.40 |
| IT Hardware | 6.03% | 3.66 |
| Computer Services | 10.87% | 6.06 |
| Gold Mining | 20.98% | 12.02 |
| Diamond Mining | 25.80% | 15.43 |
| Platinum Mining | 25.29% | 15.05 |
| Other Min. Extractors | 10.30% | 5.77 |
| Mining Finance | 70.69% | 101.10 |

4a. Results of the secondary regressions for the Market Model against the Two-Factor Model residuals

| Index | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Mining | -1.21% | 0.00 |
| Oil & Gas | -1.22% | 0.00 |
| Basic Industries | -1.21% | 0.00 |
| Chemicals | -1.18% | 0.04 |
| Building Materials | -1.15% | 0.05 |
| Forestry & Paper | -1.22% | 0.00 |
| Steel | -1.22% | 0.00 |
| General Industrials | -1.16% | 0.05 |
| Diversified Industrials | -1.16% | 0.05 |
| Electrical Equipment | -1.22% | 0.00 |
| Engineering | -1.22% | 0.00 |
| Cyc. Consumer Goods | -1.20% | 0.02 |
| Automobiles | -1.22% | 0.00 |
| Household Goods | -1.20% | 0.02 |
| Non-Cyc. Consumer Goods | -1.22% | 0.00 |
| Beverages | -1.21% | 0.01 |
| Food Producers | -1.20% | 0.02 |
| Health | -1.21% | 0.01 |
| Pharmaceuticals | -1.21% | 0.01 |
| Cyclical Services | -1.19% | 0.02 |
| General Retailers | -1.18% | 0.03 |
| Hotels | -1.21% | 0.01 |
| Media | -1.21% | 0.01 |
| Support Services | -1.20% | 0.02 |
| Transport | -1.21% | 0.01 |
| Non-Cyc. Services | -1.21% | 0.00 |

4b. Results of the secondary regressions for the Market Model against the Two-Factor Model residuals

| Index | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Food & Drug Retailers | -1.18% | 0.03 |
| Communication Services | -1.22% | 0.00 |
| Financials | -1.22% | 0.00 |
| Banks | -1.21% | 0.01 |
| Insurance | -1.20% | 0.02 |
| Life Assurance | -1.20% | 0.02 |
| Investment Companies | -1.19% | 0.03 |
| Real Estate | -1.20% | 0.02 |
| Speciality Finance | -1.21% | 0.01 |
| Information Tech | -1.22% | 0.00 |
| IT Hardware | -1.22% | 0.00 |
| Computer Services | -1.22% | 0.00 |
| Gold Mining | -1.21% | 0.01 |
| Diamond Mining | -1.19% | 0.03 |
| Platinum Mining | -1.22% | 0.00 |
| Other Min. Extractors | -1.22% | 0.00 |
| Mining Finance | -1.21% | 0.01 |

5a. Results for the Wald Tests of the Index Sample using the Two-Factor Model

| Index | F-Statistic | P-Value |
|---|---|---|
| Mining | 1448.25 | 0.000 |
| Oil & Gas | 22.26 | 0.000 |
| Basic Industries | 5.40 | 0.023 |
| Chemicals | 0.76 | 0.385 |
| Building Materials | 0.47 | 0.494 |
| Forestry & Paper | 4.76 | 0.032 |
| Steel | 1.15 | 0.287 |
| General Industrials | 40.28 | 0.000 |
| Diversified Industrials | 30.78 | 0.000 |
| Electrical Equipment | 17.37 | 0.000 |
| Engineering | 2.16 | 0.145 |
| Cyc. Consumer Goods | 4.04 | 0.048 |
| Automobiles | 6.02 | 0.016 |
| Household Goods | 3.41 | 0.068 |
| Non-Cyc. Consumer Goods | 33.68 | 0.000 |
| Beverages | 19.75 | 0.000 |
| Food Producers | 23.47 | 0.000 |
| Health | 14.89 | 0.000 |
| Pharmaceuticals | 11.25 | 0.001 |
| Cyclical Services | 143.42 | 0.000 |
| General Retailers | 47.21 | 0.000 |
| Hotels | 17.95 | 0.000 |
| Media | 37.24 | 0.000 |
| Support Services | 114.31 | 0.000 |
| Transport | 40.44 | 0.000 |
| Non-Cyc. Services | 48.65 | 0.000 |

5b. Results for the Wald Tests of the Index Sample using the Two-Factor Model

| Index | F-Statistic | P-Value |
|---|---|---|
| Food & Drug Retailers | 39.23 | 0.000 |
| Communication Services | 29.50 | 0.000 |
| Financials | 261.74 | 0.000 |
| Banks | 153.19 | 0.000 |
| Insurance | 19.24 | 0.000 |
| Life Assurance | 107.15 | 0.000 |
| Investment Companies | 97.01 | 0.000 |
| Real Estate | 3.42 | 0.068 |
| Speciality Finance | 80.19 | 0.000 |
| Information Tech | 23.72 | 0.000 |
| IT Hardware | 13.87 | 0.000 |
| Computer Services | 22.16 | 0.000 |
| Gold Mining | 15.51 | 0.000 |
| Diamond Mining | 16.13 | 0.000 |
| Platinum Mining | 16.23 | 0.000 |
| Other Min. Extractors | 5.40 | 0.023 |
| Mining Finance | 107.88 | 0.000 |

6a. Results of the initial regressions for the Market Model on the Share Sample

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Anglo American PLC | 61.88% | 135.75 |
| Sasol | 34.82% | 45.33 |
| Gold Fields | 11.43% | 11.71 |
| Anglo Platinum | 25.60% | 29.56 |
| Anglo Gold | 16.78% | 17.73 |
| Impala Platinum | 24.05% | 27.29 |
| Harmony Gold | 8.75% | 8.96 |
| Durban Roodepoort Deep | 4.41% | 4.82 |
| Northam Platinum | 7.18% | 7.42 |
| Western Areas Mines | 11.05% | 11.31 |
| Avgold | 1.55% | 2.30 |
| Transhex | 14.05% | 14.57 |
| Palabora Mining | 13.66% | 14.13 |
| Barplats | 4.29% | 4.72 |
| Sappi | 33.83% | 43.44 |
| Barloworld | 47.91% | 77.33 |
| Imperial Holdings | 37.47% | 50.73 |
| Murray & Roberts | 17.21% | 18.25 |
| AECI Limited | 15.24% | 15.92 |
| African Oxygen | 24.50% | 27.94 |
| PPC Limited | 11.51% | 11.79 |
| Dorbyl | 18.61% | 19.98 |
| Chemical Services | 24.43% | 27.83 |
| Ceramic Industries | 6.48% | 6.75 |
| Highveld Steel | 21.69% | 23.99 |
| Wilson Bayly | 0.72% | 1.60 |
| Group Five | 8.03% | 8.25 |
| Reunert | 32.55% | 41.05 |
| Delta Electronics | 24.22% | 27.52 |
| Power Technologies | 8.75% | 8.96 |

6b. Results of the initial regressions for the Market Model on the Share Sample

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Ozz Limited | 16.86% | 17.83 |
| Hudaco Industries | 25.91% | 30.02 |
| Bell Equipment | 4.57% | 4.98 |
| Richemont | 37.06% | 49.87 |
| Tiger Wheels | 22.98% | 25.77 |
| SA Breweries | 52.37% | 92.25 |
| Tiger Brands | 25.55% | 29.48 |
| Aspen Pharmacare | -0.50% | 0.59 |
| Illovo | 23.85% | 26.99 |
| Tongaat-Hulett | 20.17% | 21.97 |
| ABI | 14.95% | 15.59 |
| Medi Clinic | 18.57% | 19.93 |
| Oceana Group | 6.22% | 6.50 |
| Rainbow Chicken | 5.87% | 6.18 |
| Bidvest Group | 43.40% | 64.65 |
| Nampak | 26.98% | 31.67 |
| Metro Cash & Carry | 24.59% | 28.06 |
| Naspers | 20.44% | 22.33 |
| Kersaf Investments | 19.84% | 21.54 |
| Edgars Consolidated | 12.13% | 12.45 |
| JD Group | 26.57% | 31.04 |
| Foschini | 31.22% | 38.68 |
| Ellerines | 37.14% | 50.03 |
| Allied Technologies | 14.85% | 15.48 |
| Mr. Price | 18.15% | 19.40 |
| United Service Technologies | 13.08% | 13.49 |
| Sun International | 23.33% | 26.26 |

6c. Results of the initial regressions for the Market Model on the Share Sample

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Unitrans | 5.73% | 6.04 |
| MHH Holdings | 12.33% | 12.67 |
| CTP Holdings | 0.62% | 1.52 |
| Profurn | 10.45% | 10.68 |
| City Lodge Hotels | 13.56% | 14.02 |
| Primedia | 25.74% | 29.77 |
| Johnnic Holdings | 32.16% | 40.35 |
| Shoprite | 14.30% | 14.85 |
| Pick 'n Pay | 17.02% | 18.02 |
| Standard Bank | 35.80% | 47.27 |
| Firstrand Limited | 32.78% | 41.48 |
| ABSA | 37.96% | 51.78 |
| Nedcor | 33.69% | 43.18 |
| Rand Merchant Bank | 29.41% | 35.58 |
| Investec | 37.22% | 50.21 |
| New Africa Capital | 22.73% | 25.42 |
| Santam | 29.22% | 35.27 |
| Allan Gray Property | 6.90% | 7.15 |
| Capital Alliance | 2.01% | 2.70 |
| African Life Assure | 19.75% | 21.43 |
| Coronation Holdings | 33.89% | 43.55 |
| Sage Group | 30.37% | 37.20 |
| PSG Investment Bank | 9.25% | 9.46 |
| Genbel Group | 49.11% | 81.11 |
| Centrecity Property Fund | 1.08% | 1.91 |
| Dimension Data | 23.25% | 26.14 |
| DataTech | 22.49% | 25.08 |
| MGX Holdings | 12.05% | 12.37 |

7a. Results of the initial regressions for the Two-Factor Model on the Share Sample

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Anglo American PLC | 88.80% | 330.06 |
| Sasol | 55.12% | 51.98 |
| Gold Fields | 15.14% | 8.40 |
| Anglo Platinum | 38.87% | 27.39 |
| Anglo Gold | 29.80% | 18.62 |
| Impala Platinum | 42.21% | 31.31 |
| Harmony Gold | 20.15% | 11.47 |
| Durban Roodepoort Deep | 12.53% | 6.95 |
| Northam Platinum | 23.16% | 13.51 |
| Western Areas Mines | 13.70% | 7.59 |
| Avgold | 4.63% | 3.01 |
| Transhex | 14.88% | 8.25 |
| Palabora Mining | 25.52% | 15.22 |
| Barplats | 6.29% | 3.78 |
| Sappi | 42.02% | 31.08 |
| Barloworld | 51.04% | 44.26 |
| Imperial Holdings | 47.65% | 38.78 |
| Murray & Roberts | 19.07% | 10.78 |
| AECI Limited | 17.12% | 9.57 |
| African Oxygen | 26.22% | 15.75 |
| PPC Limited | 12.58% | 6.97 |
| Dorbyl | 20.39% | 11.63 |
| Chemical Services | 24.81% | 14.69 |
| Ceramic Industries | 16.57% | 9.24 |
| Highveld Steel | 26.57% | 16.02 |
| Wilson Bayly | 4.65% | 3.02 |
| Group Five | 8.00% | 4.61 |

7b. Results of the initial regressions for the Two-Factor Model on the Share Sample

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Reunert | 33.69% | 22.08 |
| Delta Electronics | 23.49% | 13.74 |
| Power Technologies | 12.42% | 6.89 |
| Ozz Limited | 17.37% | 9.73 |
| Hudaco Industries | 24.92% | 14.77 |
| Bell Equipment | 6.02% | 3.66 |
| Richemont | 35.41% | 23.75 |
| Tiger Wheels | 22.91% | 13.33 |
| SA Breweries | 54.63% | 50.98 |
| Tiger Brands | 42.20% | 31.30 |
| Aspen Pharmacare | -1.80% | 0.27 |
| Illovo | 22.03% | 12.72 |
| Tongaat-Hulett | 21.41% | 12.31 |
| ABI | 21.62% | 12.45 |
| Medi Clinic | 23.58% | 13.80 |
| Oceana Group | 5.85% | 3.58 |
| Rainbow Chicken | 7.28% | 4.26 |
| Bidvest Group | 63.02% | 71.73 |
| Nampak | 32.29% | 20.79 |
| Metro Cash & Carry | 33.35% | 21.76 |
| Naspers | 30.85% | 19.52 |
| Kersaf Investments | 22.17% | 12.82 |
| Edgars Consolidated | 16.95% | 9.47 |
| JD Group | 44.64% | 34.47 |
| Foschini | 37.01% | 25.38 |
| Ellerines | 43.55% | 33.02 |
| Allied Technologies | 17.06% | 9.54 |
| Mr. Price | 23.08% | 13.45 |

7c. Results of the initial regressions for the Two-Factor Model on the Share Sample

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| United Service Technologies | 12.76% | 7.07 |
| Sun International | 24.42% | 14.41 |
| Unitrans | 7.54% | 4.38 |
| MHH Holdings | 18.66% | 10.52 |
| CTP Holdings | 5.46% | 3.40 |
| Profurn | 25.79% | 15.42 |
| City Lodge Hotels | 13.33% | 7.38 |
| Primedia | 31.44% | 20.04 |
| Johnnic Holdings | 42.97% | 32.27 |
| Shoprite | 26.89% | 16.27 |
| Pick 'n Pay | 34.51% | 22.87 |
| Standard Bank | 57.52% | 57.19 |
| Firstrand Limited | 54.96% | 51.64 |
| ABSA | 56.77% | 55.49 |
| Nedcor | 57.56% | 57.27 |
| Rand Merchant Bank | 50.78% | 43.82 |
| Investec | 57.56% | 57.28 |
| New Africa Capital | 45.21% | 35.25 |
| Santam | 31.35% | 19.95 |
| Allan Gray Property | 11.95% | 6.63 |
| Capital Alliance | 1.77% | 1.75 |
| African Life Assure | 29.08% | 18.02 |
| Coronation Holdings | 46.19% | 36.62 |
| Sage Group | 40.43% | 29.17 |
| PSG Investment Bank | 9.56% | 5.39 |
| Genbel Group | 66.84% | 84.66 |
| Centrecity Property Fund | 1.71% | 1.72 |
| Dimension Data | 31.90% | 20.44 |
| DataTech | 33.09% | 21.52 |
| MGX Holdings | 29.35% | 18.24 |

8a. Results of the secondary regressions for the Two-Factor Model against the Market Model residuals

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Anglo American PLC | 66.74% | 84.27 |
| Sasol | 29.34% | 18.24 |
| Gold Fields | 4.76% | 3.07 |
| Anglo Platinum | 17.60% | 9.87 |
| Anglo Gold | 15.16% | 8.41 |
| Impala Platinum | 22.69% | 13.18 |
| Harmony Gold | 11.19% | 6.23 |
| Durban Roodepoort Deep | 7.65% | 4.44 |
| Northam Platinum | 15.88% | 8.84 |
| Western Areas Mines | 1.81% | 1.77 |
| Avgold | 2.21% | 1.94 |
| Transhex | -0.46% | 0.81 |
| Palabora Mining | 12.35% | 6.85 |
| Barplats | 0.56% | 1.24 |
| Sappi | 10.78% | 6.01 |
| Barloworld | 0.97% | 1.40 |
| Imperial Holdings | 11.35% | 6.31 |
| Murray & Roberts | -0.89% | 0.64 |
| AECI Limited | -0.10% | 0.96 |
| African Oxygen | -0.78% | 0.68 |
| PPC Limited | -1.92% | 0.22 |
| Dorbyl | 0.56% | 1.23 |
| Chemical Services | -2.06% | 0.16 |
| Ceramic Industries | 9.85% | 5.53 |
| Highveld Steel | 4.25% | 2.84 |
| Wilson Bayly | 2.65% | 2.13 |
| Group Five | -2.42% | 0.02 |
| Reunert | -1.01% | 0.58 |

8b. Results of the secondary regressions for the Two-Factor Model against the Market Model residuals

| **Share** | **Adjusted $R^2$** | **F-Statistic** |
|---|---|---|
| Delta Electronics | -1.59% | 0.35 |
| Power Technologies | 2.87% | 2.23 |
| Ozz Limited | -1.37% | 0.44 |
| Hudaco Industries | -1.68% | 0.31 |
| Bell Equipment | -0.43% | 0.82 |
| Richemont | -2.06% | 0.16 |
| Tiger Wheels | -0.17% | 0.93 |
| SA Breweries | 4.75% | 3.07 |
| Tiger Brands | 19.39% | 10.98 |
| Aspen Pharmacare | -2.47% | 0.00 |
| Illovo | -2.43% | 0.01 |
| Tongaat-Hulett | -0.88% | 0.64 |
| ABI | 7.13% | 4.19 |
| Medi Clinic | 5.32% | 3.33 |
| Oceana Group | -1.19% | 0.51 |
| Rainbow Chicken | -1.24% | 0.49 |
| Bidvest Group | 31.86% | 20.40 |
| Nampak | 4.77% | 3.08 |
| Metro Cash & Carry | 8.76% | 4.98 |
| Naspers | 9.65% | 5.43 |
| Kersaf Investments | 1.99% | 1.84 |
| Edgars Consolidated | 3.54% | 2.52 |
| JD Group | 20.97% | 12.01 |
| Foschini | 5.64% | 3.48 |
| Ellerines | 7.55% | 4.39 |
| Allied Technologies | -0.48% | 0.80 |
| Mr. Price | 3.76% | 2.62 |
| United Service Technologies | -0.66% | 0.73 |

8c. Results of the secondary regressions for the Two-Factor Model against the Market Model residuals

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Sun International | -0.44% | 0.82 |
| Unitrans | 0.31% | 1.13 |
| MHH Holdings | 5.23% | 3.29 |
| CTP Holdings | 3.54% | 2.52 |
| Profurn | 14.50% | 8.04 |
| City Lodge Hotels | -2.13% | 0.13 |
| Primedia | 7.17% | 4.21 |
| Johnnic Holdings | 13.90% | 7.70 |
| Shoprite | 12.68% | 7.03 |
| Pick 'n Pay | 18.25% | 10.26 |
| Standard Bank | 32.91% | 21.35 |
| Firstrand Limited | 32.63% | 21.10 |
| ABSA | 27.39% | 16.65 |
| Nedcor | 33.16% | 21.59 |
| Rand Merchant Bank | 30.26% | 19.01 |
| Investec | 29.76% | 18.58 |
| New Africa Capital | 27.10% | 16.42 |
| Santam | 1.26% | 1.53 |
| Allan Gray Property | 3.46% | 2.49 |
| Capital Alliance | -1.99% | 0.19 |
| African Life Assure | 9.07% | 5.14 |
| Coronation Holdings | 16.68% | 9.31 |
| Sage Group | 12.98% | 7.19 |
| PSG Investment Bank | -1.04% | 0.57 |
| Genbel Group | 31.12% | 19.75 |
| Centrecity Property Fund | -1.05% | 0.57 |
| Dimension Data | 9.86% | 5.54 |
| DataTech | 12.36% | 6.85 |
| MGX Holdings | 17.44% | 9.77 |

9a. Results of the secondary regressions for the Market Model against the Two-Factor Model residuals

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Anglo American PLC | -1.19% | 0.02 |
| Sasol | -1.22% | 0.00 |
| Gold Fields | -1.16% | 0.05 |
| Anglo Platinum | -1.21% | 0.01 |
| Anglo Gold | -1.21% | 0.01 |
| Impala Platinum | -1.22% | 0.00 |
| Harmony Gold | -1.22% | 0.00 |
| Durban Roodepoort Deep | -1.22% | 0.00 |
| Northam Platinum | -1.22% | 0.00 |
| Western Areas Mines | -1.22% | 0.00 |
| Avgold | -1.21% | 0.01 |
| Transhex | -1.22% | 0.00 |
| Palabora Mining | -1.22% | 0.00 |
| Barplats | -1.22% | 0.00 |
| Sappi | -1.22% | 0.00 |
| Barloworld | -1.19% | 0.02 |
| Imperial Holdings | -1.16% | 0.05 |
| Murray & Roberts | -1.18% | 0.03 |
| AECI Limited | -1.21% | 0.01 |
| African Oxygen | -1.20% | 0.02 |
| PPC Limited | -1.16% | 0.05 |
| Dorbyl | -1.22% | 0.00 |
| Chemical Services | -1.21% | 0.01 |
| Ceramic Industries | -1.22% | 0.00 |
| Highveld Steel | -1.22% | 0.00 |
| Wilson Bayly | -1.22% | 0.00 |
| Group Five | -1.19% | 0.02 |
| Reunert | -1.21% | 0.01 |
| Delta Electronics | -1.21% | 0.00 |

9b. Results of the secondary regressions for the Market Model against the Two-Factor Model residuals

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Power Technologies | -1.22% | 0.00 |
| Ozz Limited | -1.21% | 0.00 |
| Hudaco Industries | -1.21% | 0.01 |
| Bell Equipment | -1.20% | 0.02 |
| Richemont | -1.20% | 0.02 |
| Tiger Wheels | -1.21% | 0.01 |
| SA Breweries | -1.21% | 0.01 |
| Tiger Brands | -1.19% | 0.02 |
| Aspen Pharmacare | -1.22% | 0.00 |
| Illovo | -1.20% | 0.01 |
| Tongaat-Hulett | -1.21% | 0.01 |
| ABI | -1.22% | 0.00 |
| Medi Clinic | -1.22% | 0.00 |
| Oceana Group | -1.21% | 0.01 |
| Rainbow Chicken | -1.15% | 0.06 |
| Bidvest Group | -1.21% | 0.01 |
| Nampak | -1.21% | 0.01 |
| Metro Cash & Carry | -1.20% | 0.02 |
| Naspers | -1.17% | 0.04 |
| Kersaf Investments | -1.22% | 0.00 |
| Edgars Consolidated | -1.21% | 0.01 |
| JD Group | -1.17% | 0.04 |
| Foschini | -1.21% | 0.01 |
| Ellerines | -1.21% | 0.00 |
| Allied Technologies | -1.18% | 0.03 |
| Mr. Price | -1.21% | 0.01 |
| United Service Technologies | -1.20% | 0.01 |

9c. Results of the secondary regressions for the Market Model against the Two-Factor Model residuals

| Share | Adjusted $R^2$ | F-Statistic |
|---|---|---|
| Sun International | -1.22% | 0.00 |
| Unitrans | -1.21% | 0.00 |
| MHH Holdings | -1.21% | 0.01 |
| CTP Holdings | -1.22% | 0.00 |
| Profurn | -1.17% | 0.04 |
| City Lodge Hotels | -1.22% | 0.00 |
| Primedia | -1.21% | 0.00 |
| Johnnic Holdings | -1.22% | 0.00 |
| Shoprite | -1.21% | 0.01 |
| Pick 'n Pay | -1.18% | 0.03 |
| Standard Bank | -1.22% | 0.00 |
| Firstrand Limited | -1.21% | 0.00 |
| ABSA | -1.20% | 0.01 |
| Nedcor | -1.20% | 0.02 |
| Rand Merchant Bank | -1.21% | 0.01 |
| Investec | -1.21% | 0.01 |
| New Africa Capital | -1.21% | 0.01 |
| Santam | -1.22% | 0.00 |
| Allan Gray Property | -1.20% | 0.01 |
| Capital Alliance | -1.20% | 0.02 |
| African Life Assure | -1.20% | 0.01 |
| Coronation Holdings | -1.22% | 0.00 |
| Sage Group | -1.22% | 0.00 |
| PSG Investment Bank | -1.22% | 0.00 |
| Genbel Group | -1.20% | 0.02 |
| Centrecity Property Fund | -1.20% | 0.02 |
| Dimension Data | -1.22% | 0.00 |
| DataTech | -1.22% | 0.00 |
| MGX Holdings | -1.19% | 0.02 |

10a. Results for the Wald Tests of the Share Sample using the Two-Factor Model

| Share | F-Statistic | P-Value |
|---|---|---|
| Anglo American PLC | 94.33 | 0.000 |
| Sasol | 20.75 | 0.000 |
| Gold Fields | 3.36 | 0.070 |
| Anglo Platinum | 10.94 | 0.001 |
| Anglo Gold | 10.41 | 0.002 |
| Impala Platinum | 16.01 | 0.000 |
| Harmony Gold | 8.46 | 0.005 |
| Durban Roodepoort Deep | 6.40 | 0.013 |
| Northam Platinum | 13.02 | 0.001 |
| Western Areas Mines | 1.57 | 0.214 |
| Avgold | 2.79 | 0.098 |
| Transhex | 0.34 | 0.564 |
| Palabora Mining | 8.59 | 0.004 |
| Barplats | 1.32 | 0.254 |
| Sappi | 4.78 | 0.032 |
| Barloworld | 10.83 | 0.001 |
| Imperial Holdings | 24.76 | 0.000 |
| Murray & Roberts | 0.10 | 0.757 |
| AECI Limited | 0.41 | 0.525 |
| African Oxygen | 4.47 | 0.038 |
| PPC Limited | 1.58 | 0.212 |
| Dorbyl | 5.51 | 0.021 |
| Chemical Services | 2.27 | 0.136 |
| Ceramic Industries | 14.04 | 0.000 |
| Highveld Steel | 2.12 | 0.150 |
| Wilson Bayly | 5.14 | 0.026 |
| Group Five | 0.19 | 0.665 |
| Reunert | 4.90 | 0.030 |
| Delta Electronics | 2.97 | 0.089 |

10b. Results for the Wald Tests of the Share Sample using the Two-Factor Model

| Share | F-Statistic | P-Value |
|---|---|---|
| Power Technologies | 6.83 | 0.011 |
| Ozz Limited | 0.03 | 0.869 |
| Hudaco Industries | 2.95 | 0.089 |
| Bell Equipment | 0.71 | 0.403 |
| Richemont | 3.09 | 0.083 |
| Tiger Wheels | 4.89 | 0.030 |
| SA Breweries | 17.16 | 0.000 |
| Tiger Brands | 33.36 | 0.000 |
| Aspen Pharmacare | 0.01 | 0.920 |
| Illovo | 1.08 | 0.302 |
| Tongaat-Hulett | 0.07 | 0.787 |
| ABI | 12.63 | 0.001 |
| Medi Clinic | 11.10 | 0.001 |
| Oceana Group | 2.03 | 0.158 |
| Rainbow Chicken | 0.22 | 0.642 |
| Bidvest Group | 66.40 | 0.000 |
| Nampak | 12.24 | 0.001 |
| Metro Cash & Carry | 17.24 | 0.000 |
| Naspers | 17.71 | 0.000 |
| Kersaf Investments | 7.37 | 0.008 |
| Edgars Consolidated | 8.25 | 0.005 |
| JD Group | 36.86 | 0.000 |
| Foschini | 14.31 | 0.000 |
| Ellerines | 18.18 | 0.000 |
| Allied Technologies | 3.88 | 0.052 |
| Mr. Price | 9.53 | 0.003 |
| United Service Technologies | 3.27 | 0.074 |

10c. Results for the Wald Tests of the Share Sample using the Two-Factor Model

| Share | F-Statistic | P-Value |
|---|---|---|
| Sun International | 4.73 | 0.033 |
| Unitrans | 3.71 | 0.057 |
| MHH Holdings | 10.26 | 0.002 |
| CTP Holdings | 5.99 | 0.017 |
| Profurn | 21.62 | 0.000 |
| City Lodge Hotels | 1.37 | 0.245 |
| Primedia | 14.66 | 0.000 |
| Johnnic Holdings | 26.10 | 0.000 |
| Shoprite | 19.84 | 0.000 |
| Pick 'n Pay | 28.88 | 0.000 |
| Standard Bank | 62.73 | 0.000 |
| Firstrand Limited | 60.02 | 0.000 |
| ABSA | 53.31 | 0.000 |
| Nedcor | 64.50 | 0.000 |
| Rand Merchant Bank | 52.96 | 0.000 |
| Investec | 57.98 | 0.000 |
| New Africa Capital | 45.61 | 0.000 |
| Santam | 7.81 | 0.006 |
| Allan Gray Property | 7.33 | 0.008 |
| Capital Alliance | 0.09 | 0.771 |
| African Life Assure | 16.53 | 0.000 |
| Coronation Holdings | 30.97 | 0.000 |
| Sage Group | 24.06 | 0.000 |
| PSG Investment Bank | 2.56 | 0.113 |
| Genbel Group | 69.12 | 0.000 |
| Centrecity Property Fund | 1.73 | 0.192 |
| Dimension Data | 17.97 | 0.000 |
| DataTech | 21.18 | 0.000 |
| MGX Holdings | 26.07 | 0.000 |

# APPENDIX F: BENCHMARK CONSTITUENTS

1a. Constituents for the All-Share Index as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Anglo American | 17.86% | Dimension Data | 0.59% |
| BHP Billiton | 8.77% | Durban Roodepoort | 0.54% |
| Richemont | 8.39% | Liberty Group | 0.54% |
| Sasol | 5.17% | ISCOR | 0.52% |
| South African Breweries | 4.85% | BOE | 0.52% |
| Gold Fields | 4.04% | Investec Group | 0.52% |
| Old Mutual | 3.83% | Nampak | 0.49% |
| Anglo Platinum Corp. | 3.10% | Johnnic Holdings | 0.49% |
| Standard Bank Group | 3.00% | Steinhoff International | 0.40% |
| Sappi | 2.45% | Alexander Forbes | 0.39% |
| Remgro | 2.39% | Network Healthcare | 0.34% |
| Firstrand Limited | 2.21% | Anglovaal Inds. | 0.33% |
| Anglogold | 2.15% | Metro Cash & Carry | 0.30% |
| Impala Platinum Hlds | 2.01% | New Africa Capital | 0.30% |
| Liberty International | 1.86% | Shoprite | 0.29% |
| Harmony | 1.69% | Woolworths Holdings | 0.28% |
| Sanlam | 1.61% | Reunert | 0.27% |
| Absa Group | 1.12% | Coronation N | 0.25% |
| Nedcor | 1.07% | Pick N Pay Stores | 0.23% |
| Bidvest Group | 1.01% | Aveng | 0.22% |
| Kumba | 0.99% | Anglovaal Mining | 0.22% |
| Barloworld | 0.96% | Murray & Roberts | 0.22% |
| Imperial Holdings | 0.85% | African Bank Invest | 0.21% |
| Tiger Brands | 0.82% | Naspers | 0.21% |
| RMB Holdings | 0.68% | Northam Platinum | 0.20% |
| M-Cell | 0.68% | Western Areas | 0.20% |
| Venfin | 0.60% | Truworths International | 0.20% |

1b. Constituents for the All-Share Index as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Aspen Pharmacare | 0.19% | Mr Price Group | 0.08% |
| Illovo Sugar | 0.19% | United Service | 0.08% |
| Kersaf Investments | 0.18% | Avis Southern Africa | 0.07% |
| Tongaat-Hulett Group | 0.18% | Martprop Property Fund | 0.07% |
| Delta Electrical | 0.17% | Mvelaphanda Resources Ltd | 0.07% |
| Super Group | 0.17% | Rebserve Holdings | 0.07% |
| Comparex Holdings | 0.16% | Brait SA | 0.07% |
| New Clicks Holdings | 0.16% | Tradehold | 0.06% |
| Datatec | 0.16% | Pepkor | 0.06% |
| Amalgamated Beverages | 0.16% | Discovery Holdings | 0.06% |
| AECI | 0.16% | South African Chrome | 0.06% |
| African Oxygen | 0.15% | Coronation Holdings | 0.06% |
| Santam | 0.15% | Sun International | 0.05% |
| Edgars Consolidated | 0.15% | Palabora Mining | 0.05% |
| Allan Gray Property | 0.14% | AMB Holdings | 0.05% |
| Massmart Holdings | 0.14% | Net 1 Applied Tech | 0.05% |
| JD Group | 0.14% | Real Africa Holdings | 0.05% |
| Energy Africa | 0.13% | Unitrans | 0.05% |
| OTK Holdings | 0.13% | MIH Holdings | 0.04% |
| PPC | 0.12% | Sage Group | 0.04% |
| Avgold | 0.11% | Tiger Wheels | 0.04% |
| Foschini | 0.11% | Oceana Group | 0.04% |
| Medi-Clinicrp | 0.10% | PSG Group | 0.04% |
| Capital Alliance Holdings | 0.09% | CTP Holdings | 0.04% |
| Nedcor Investment Bank | 0.09% | MGX Holdings | 0.04% |
| African Life Assur | 0.09% | Dorbyl | 0.04% |
| Ellerine Holdings | 0.09% | Investment Solutions | 0.04% |
| Trans HEX Group | 0.09% | Chemical Services | 0.04% |
| Allied Technologies | 0.08% | Johnnic Communications | 0.04% |
| Malbak | 0.08% | Power Technologies | 0.04% |

1c. Constituents for the All-Share Index as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Caxton Publishers & Printers | 0.04% | AST Group | 0.02% |
| Metboard Properties | 0.04% | Rainbow Chicken | 0.02% |
| JCI Gold | 0.04% | PSG Investment Bank Holdings | 0.02% |
| Ceramic Industries | 0.04% | Profurn | 0.02% |
| Primedia Limited N | 0.04% | Barplats Investments. | 0.02% |
| Highveld Steel | 0.03% | Hudaco Industries | 0.01% |
| Glenrand MIB | 0.03% | Sa Retail Properties | 0.01% |
| Corpcapital | 0.03% | Bell Equipment | 0.01% |
| Redefine Income Find | 0.03% | Global Technology | 0.01% |
| Genbel Invsts. | 0.03% | Acucap Properties Limited | 0.01% |
| Tourism Investment Corp | 0.03% | Africa Glass Industries | 0.01% |
| Adcorp Holdings | 0.03% | Gold Reef Casino Resorts | 0.01% |
| Softline. | 0.03% | Wetherlys Investment Holdings | 0.01% |
| Mustek | 0.03% | City Lodge Hotels | 0.01% |
| OZZ | 0.03% | Grindrod | 0.01% |
| Centrecity Property Fund | 0.02% | Primedia Limited | 0.01% |
| Grindrod N | 0.02% | Comair | 0.01% |
| Bytes Technology Group | 0.02% | Clientele Life Assurance. | 0.01% |
| Wilson Bayly Holmes-Ovcon | 0.02% | Cadiz Holdings | 0.01% |
| Grintek | 0.02% | Wooltru N | 0.01% |
| MB Technologies | 0.02% | Wooltru | 0.00% |
| African Harvest | 0.02% | Intervid | 0.00% |
| Group Five/South Africa | 0.02% | Capitec Bank Hldgs Ltd | 0.00% |
| Peregrine Holdings | 0.02% | | |

## 2a. Constituents for the CAPI as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Anglo American | 10.00% | Dimension Data | 0.65% |
| BHP Billiton | 9.61% | Durban Roodepoort | 0.59% |
| Richemont | 9.19% | Liberty Group | 0.59% |
| Sasol | 5.67% | ISCOR | 0.57% |
| South African Breweries | 5.31% | BOE | 0.57% |
| Gold Fields | 4.43% | Investec Group | 0.57% |
| Old Mutual | 4.20% | Nampak | 0.54% |
| Anglo Platinum Corp. | 3.40% | Johnnic Holdings | 0.54% |
| Standard Bank Group | 3.29% | Steinhoff International | 0.44% |
| Sappi | 2.69% | Alexander Forbes | 0.42% |
| Remgro | 2.62% | Network Healthcare | 0.37% |
| Firstrand Limited | 2.42% | Anglovaal Inds. | 0.36% |
| Anglogold | 2.36% | Metro Cash & Carry | 0.33% |
| Impala Platinum Hlds | 2.20% | New Africa Capital | 0.33% |
| Liberty International | 2.04% | Shoprite | 0.32% |
| Harmony | 1.85% | Woolworths Holdings | 0.31% |
| Sanlam | 1.77% | Reunert | 0.30% |
| Absa Group | 1.22% | Coronation N | 0.27% |
| Nedcor | 1.17% | Pick N Pay Stores | 0.25% |
| Bidvest Group | 1.11% | Aveng | 0.25% |
| Kumba | 1.09% | Anglovaal Mining | 0.24% |
| Barloworld | 1.05% | Murray & Roberts | 0.24% |
| Imperial Holdings | 0.93% | African Bank Invest | 0.23% |
| Tiger Brands | 0.90% | Naspers | 0.23% |
| RMB Holdings | 0.75% | Northam Platinum | 0.22% |
| M-Cell | 0.74% | Western Areas | 0.21% |
| Venfin | 0.66% | Truworths International | 0.21% |

2b. Constituents for the CAPI as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Aspen Pharmacare | 0.21% | Mr Price Group | 0.08% |
| Illovo Sugar | 0.21% | United Service | 0.08% |
| Kersaf Investments | 0.20% | Avis Southern Africa | 0.08% |
| Tongaat-Hulett Group | 0.19% | Martprop Property Fund | 0.08% |
| Delta Electrical | 0.19% | Mvelaphanda Resources Ltd | 0.08% |
| Super Group | 0.18% | Rebserve Holdings | 0.08% |
| Comparex Holdings | 0.18% | Brait SA | 0.07% |
| New Clicks Holdings | 0.18% | Tradehold | 0.07% |
| Datatec | 0.17% | Pepkor | 0.07% |
| Amalgamated Beverages | 0.17% | Discovery Holdings | 0.06% |
| AECI | 0.17% | South African Chrome | 0.06% |
| African Oxygen | 0.17% | Coronation Holdings | 0.06% |
| Santam | 0.16% | Sun International | 0.06% |
| Edgars Consolidated | 0.16% | Palabora Mining | 0.06% |
| Allan Gray Property | 0.16% | AMB Holdings | 0.06% |
| Massmart Holdings | 0.15% | Net 1 Applied Tech | 0.05% |
| JD Group | 0.15% | Real Africa Holdings | 0.05% |
| Energy Africa | 0.15% | Unitrans | 0.05% |
| OTK Holdings | 0.14% | MIH Holdings | 0.05% |
| PPC | 0.13% | Sage Group | 0.05% |
| Avgold | 0.12% | Tiger Wheels | 0.05% |
| Foschini | 0.12% | Oceana Group | 0.05% |
| Medi-Clinicrp | 0.11% | PSG Group | 0.05% |
| Capital Alliance Holdings | 0.10% | CTP Holdings | 0.04% |
| Nedcor Investment Bank | 0.10% | MGX Holdings | 0.04% |
| African Life Assur | 0.10% | Dorbyl | 0.04% |
| Ellerine Holdings | 0.10% | Investment Solutions | 0.04% |
| Trans HEX Group | 0.09% | Chemical Services | 0.04% |
| Allied Technologies | 0.09% | Johnnic Communications | 0.04% |
| Malbak | 0.09% | Power Technologies | 0.04% |

2c. Constituents for the CAPI as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Caxton Publishers & Printers | 0.04% | AST Group | 0.02% |
| Metboard Properties | 0.04% | Rainbow Chicken | 0.02% |
| JCI Gold | 0.04% | PSG Investment Bank Holdings | 0.02% |
| Ceramic Industries | 0.04% | Profurn | 0.02% |
| Primedia Limited N | 0.04% | Barplats Investments. | 0.02% |
| Highveld Steel | 0.04% | Hudaco Industries | 0.02% |
| Glenrand MIB | 0.04% | Sa Retail Properties | 0.02% |
| Corpcapital | 0.04% | Bell Equipment | 0.02% |
| Redefine Income Find | 0.04% | Global Technology | 0.01% |
| Genbel Invsts. | 0.03% | Acucap Properties Limited | 0.01% |
| Tourism Investment Corp | 0.03% | Africa Glass Industries | 0.01% |
| Adcorp Holdings | 0.03% | Gold Reef Casino Resorts | 0.01% |
| Softline. | 0.03% | Wetherlys Investment Holdings | 0.01% |
| Mustek | 0.03% | City Lodge Hotels | 0.01% |
| OZZ | 0.03% | Grindrod | 0.01% |
| Centrecity Property Fund | 0.03% | Primedia Limited | 0.01% |
| Grindrod N | 0.03% | Comair | 0.01% |
| Bytes Technology Group | 0.02% | Clientele Life Assurance. | 0.01% |
| Wilson Bayly Holmes-Ovcon | 0.02% | Cadiz Holdings | 0.01% |
| Grintek | 0.02% | Wooltru N | 0.01% |
| MB Technologies | 0.02% | Wooltru | 0.00% |
| African Harvest | 0.02% | Intervid | 0.00% |
| Group Five/South Africa | 0.02% | Capitec Bank Hldgs Ltd | 0.00% |
| Peregrine Holdings | 0.02% | | |

3a. Constituents for the SWIX as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Sasol | 8.63% | BOE | 0.87% |
| Anglo American | 8.05% | Investec Group | 0.87% |
| Standard Bank Group | 5.00% | Harmony | 0.85% |
| Richemont AG | 4.76% | Nampak | 0.82% |
| Anglo American Platinum Corp. | 4.50% | Johnnic Holding Limited | 0.81% |
| Remgro | 3.99% | Steinhoff International Holdings | 0.66% |
| Firstrand Limited | 3.69% | Alexander Forbes | 0.65% |
| Gold Fields | 3.37% | Network Healthcare Holdings | 0.56% |
| Old Mutual | 3.26% | Anglovaal Inds. | 0.54% |
| BHP Billiton | 3.07% | Metro Cash & Carry | 0.50% |
| Sanlam | 2.69% | New Africa Capital | 0.50% |
| South African Breweries | 2.51% | Shoprite | 0.48% |
| Anglogold | 2.37% | Reunert | 0.45% |
| Impala Platinum Hlds | 2.28% | Woolworths Holdings | 0.42% |
| Absa Group | 1.87% | Coronation Holdings N | 0.41% |
| Sappi | 1.80% | Pick N Pay Stores | 0.38% |
| Nedcor | 1.78% | Dimension Data Holdings | 0.38% |
| Bidvest Group | 1.69% | Aveng | 0.37% |
| Kumba | 1.66% | Murray & Roberts | 0.36% |
| Imperial Holdings | 1.41% | African Bank Invest | 0.35% |
| Barloworld | 1.26% | Naspers | 0.35% |
| Tiger Brands | 1.15% | Northam Platinum | 0.34% |
| RMB Holdings | 1.14% | Western Areas | 0.33% |
| M-Cell | 1.13% | Truworths International | 0.33% |
| Liberty International | 1.02% | Aspen Pharmacare Holdings | 0.32% |
| Venfin | 1.01% | Illovo Sugar | 0.31% |
| ISCOR | 0.87% | Liberty Group | 0.31% |

3b. Constituents for the SWIX as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Kersaf Investments | 0.31% | Avis Southern Africa | 0.12% |
| Anglovaal Mining | 0.30% | Martprop Property Fund | 0.12% |
| Delta Electrical Industries | 0.29% | Mvelaphanda Resources Ltd | 0.12% |
| Super Group | 0.28% | Rebserve Holdings | 0.11% |
| Comparex Holdings | 0.27% | Tradehold | 0.11% |
| New Clicks Holdings | 0.27% | Pepkor | 0.10% |
| Tongaat-Hulett Group | 0.27% | Discovery Holdings | 0.10% |
| Datatec | 0.27% | South African Chrome & Alloys | 0.10% |
| Amalgamated Beverage Industries | 0.26% | Coronation Holdings | 0.10% |
| AECI | 0.26% | Sun International South Africa | 0.09% |
| African Oxygen | 0.26% | Palabora Mining | 0.09% |
| Santam | 0.25% | Brait SA | 0.09% |
| Edgars Consolidated Stores | 0.25% | AMB Holdings | 0.09% |
| Allan Gray Property Trust | 0.24% | Net 1 Applied Tech Holdings | 0.08% |
| Massmart Holdings | 0.24% | Real Africa Holdings | 0.08% |
| JD Group | 0.23% | Unitrans | 0.08% |
| OTK Holdings | 0.22% | MIH Holdings | 0.08% |
| Pretoria Portland Cement | 0.19% | Sage Group | 0.07% |
| Avgold | 0.19% | Tiger Wheels | 0.07% |
| Foschini | 0.19% | Durban Roodepoort Deep | 0.07% |
| Medi-Clinicrp | 0.17% | Oceana Group | 0.07% |
| Capital Alliance Holdings | 0.16% | PSG Group | 0.07% |
| Nedcor Investment Bank Holdings | 0.15% | CTP Holdings | 0.07% |
| African Life Assur | 0.15% | MGX Holdings | 0.07% |
| Ellerine Holdings | 0.15% | Dorbyl | 0.07% |
| Trans HEX Group | 0.14% | Investment Solutions Holdings | 0.07% |
| Allied Technologies | 0.14% | Chemical Services | 0.07% |
| Malbak | 0.13% | Johnnic Communications | 0.07% |
| Mr Price Group | 0.13% | Power Technologies | 0.06% |
| United Service Technologies | 0.13% | Caxton Publishers & Printers | 0.06% |

3c. Constituents for the SWIX as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Metboard Properties | 0.06% | AST Group | 0.03% |
| JCI Gold | 0.06% | Rainbow Chicken | 0.03% |
| Ceramic Industries | 0.06% | PSG Investment Bank Holdings | 0.03% |
| Primedia Limited N | 0.06% | Profurn | 0.03% |
| Highveld Steel | 0.06% | Barplats Investments. | 0.03% |
| Glenrand MIB | 0.06% | Hudaco Industries | 0.02% |
| Corpcapital | 0.05% | Sa Retail Properties | 0.02% |
| Redefine Income Find | 0.05% | Bell Equipment | 0.02% |
| Genbel Invsts. | 0.05% | Global Technology | 0.02% |
| Energy Africa | 0.05% | Acucap Properties Limited | 0.02% |
| Tourism Investment Corp | 0.05% | Africa Glass Industries | 0.02% |
| Adcorp Holdings | 0.05% | Gold Reef Casino Resorts | 0.02% |
| Softline. | 0.05% | Wetherlys Investment Holdings | 0.02% |
| Mustek | 0.04% | City Lodge Hotels | 0.02% |
| OZZ | 0.04% | Grindrod | 0.01% |
| Centrecity Property Fund | 0.04% | Primedia Limited | 0.01% |
| Grindrod N | 0.04% | Comair | 0.01% |
| Bytes Technology Group | 0.04% | Clientele Life Assurance. | 0.01% |
| Wilson Bayly Holmes-Ovcon | 0.04% | Cadiz Holdings | 0.01% |
| Grintek | 0.03% | Wooltru N | 0.01% |
| MB Technologies | 0.03% | Wooltru | 0.01% |
| African Harvest | 0.03% | Intervid | 0.01% |
| Group Five/South Africa | 0.03% | Capitec Bank Hldgs Ltd | 0.00% |
| Peregrine Holdings | 0.03% | | |

4a. Constituents for the 50% RESI as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Richemont AG | 12.18% | Liberty Group | 0.78% |
| Anglo American | 8.93% | ISCOR | 0.76% |
| South African Breweries | 7.04% | BOE | 0.76% |
| Old Mutual | 5.56% | Investec Group | 0.75% |
| BHP Billiton | 4.38% | Nampak | 0.72% |
| Standard Bank Group | 4.36% | Johnnic Holding Limited | 0.71% |
| Sappi | 3.56% | Steinhoff International Holdings | 0.58% |
| Remgro | 3.47% | Alexander Forbes | 0.56% |
| Firstrand Limited | 3.21% | Kumba | 0.50% |
| Liberty International | 2.70% | Network Healthcare Holdings | 0.49% |
| Sasol | 2.59% | Anglovaal Inds. | 0.47% |
| Sanlam | 2.34% | Metro Cash & Carry | 0.44% |
| Gold Fields | 2.02% | New Africa Capital | 0.44% |
| Absa Group | 1.62% | Shoprite | 0.42% |
| Anglo American Platinum Corp. | 1.55% | Woolworths Holdings | 0.41% |
| Nedcor | 1.55% | Reunert | 0.39% |
| Bidvest Group | 1.47% | Coronation Holdings N | 0.36% |
| Barloworld | 1.39% | Pick N Pay Stores | 0.33% |
| Imperial Holdings | 1.23% | Aveng | 0.33% |
| Tiger Brands | 1.19% | Murray & Roberts | 0.32% |
| Anglogold | 1.08% | African Bank Invest | 0.31% |
| Impala Platinum Hlds | 1.00% | Naspers | 0.30% |
| RMB Holdings | 0.99% | Truworths International | 0.28% |
| M-Cell | 0.99% | Aspen Pharmacare Holdings | 0.28% |
| Venfin | 0.88% | Illovo Sugar | 0.27% |
| Dimension Data Holdings | 0.86% | Durban Roodepoort Deep | 0.27% |
| Harmony | 0.84% | Kersaf Investments | 0.27% |

4b. Constituents for the 50% RESI as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Tongaat-Hulett Group | 0.26% | Rebserve Holdings | 0.10% |
| Delta Electrical Industries | 0.25% | Brait SA | 0.10% |
| Super Group | 0.24% | Western Areas | 0.10% |
| Comparex Holdings | 0.24% | Tradehold | 0.09% |
| New Clicks Holdings | 0.24% | Pepkor | 0.09% |
| Datatec | 0.23% | Discovery Holdings | 0.09% |
| Amalgamated Beverage Industries | 0.23% | Coronation Holdings | 0.08% |
| AECI | 0.23% | Sun International South Africa | 0.08% |
| African Oxygen | 0.22% | AMB Holdings | 0.07% |
| Santam | 0.22% | Net 1 Applied Tech Holdings | 0.07% |
| Edgars Consolidated Stores | 0.21% | Real Africa Holdings | 0.07% |
| Allan Gray Property Trust | 0.21% | Energy Africa | 0.07% |
| Massmart Holdings | 0.21% | Unitrans | 0.07% |
| JD Group | 0.20% | MIH Holdings | 0.07% |
| OTK Holdings | 0.19% | Sage Group | 0.06% |
| Pretoria Portland Cement | 0.17% | Tiger Wheels | 0.06% |
| Foschini | 0.16% | Oceana Group | 0.06% |
| Medi-Clinicrp | 0.14% | PSG Group | 0.06% |
| Capital Alliance Holdings | 0.14% | CTP Holdings | 0.06% |
| Nedcor Investment Bank Holdings | 0.13% | MGX Holdings | 0.06% |
| African Life Assur | 0.13% | Dorbyl | 0.06% |
| Ellerine Holdings | 0.13% | Investment Solutions Holdings | 0.06% |
| Allied Technologies | 0.12% | Chemical Services | 0.06% |
| Malbak | 0.12% | Avgold | 0.06% |
| Mr Price Group | 0.11% | Johnnic Communications | 0.06% |
| United Service Technologies | 0.11% | Power Technologies | 0.06% |
| Anglovaal Mining | 0.11% | Caxton Publishers & Printers | 0.06% |
| Avis Southern Africa | 0.11% | Metboard Properties | 0.06% |
| Martprop Property Fund | 0.11% | Ceramic Industries | 0.05% |
| Northam Platinum | 0.10% | Primedia Limited N | 0.05% |

4c. Constituents for the 50% RESI as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Highveld Steel | 0.05% | Rainbow Chicken | 0.02% |
| Glenrand MIB | 0.05% | PSG Investment Bank Holdings | 0.02% |
| Corpcapital | 0.05% | Profurn | 0.02% |
| Redefine Income Find | 0.05% | Hudaco Industries | 0.02% |
| Genbel Invsts. | 0.05% | Sa Retail Properties | 0.02% |
| Trans HEX Group | 0.04% | Bell Equipment | 0.02% |
| Tourism Investment Corp | 0.04% | Global Technology | 0.02% |
| Adcorp Holdings | 0.04% | Acucap Properties Limited | 0.02% |
| Softline. | 0.04% | JCI Gold | 0.02% |
| Mustek | 0.04% | Africa Glass Industries | 0.02% |
| OZZ | 0.04% | Gold Reef Casino Resorts | 0.02% |
| Mvelaphanda Resources Ltd | 0.04% | Wetherlys Investment Holdings | 0.02% |
| Centrecity Property Fund | 0.03% | City Lodge Hotels | 0.02% |
| Grindrod N | 0.03% | Grindrod | 0.01% |
| Bytes Technology Group | 0.03% | Primedia Limited | 0.01% |
| Wilson Bayly Holmes-Ovcon | 0.03% | Comair | 0.01% |
| South African Chrome & Alloys | 0.03% | Clientele Life Assurance. | 0.01% |
| Grintek | 0.03% | Cadiz Holdings | 0.01% |
| MB Technologies | 0.03% | Wooltru N | 0.01% |
| African Harvest | 0.03% | Barplats Investments. | 0.01% |
| Group Five/South Africa | 0.03% | Wooltru | 0.01% |
| Palabora Mining | 0.03% | Intervid | 0.00% |
| Peregrine Holdings | 0.03% | Capitec Bank Hldgs Ltd | 0.00% |
| AST Group | 0.02% | | |

5a. Constituents for the 80% RESI as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Anglo American | 14.29% | Dimension Data Holdings | 0.70% |
| Richemont AG | 9.91% | Liberty Group | 0.63% |
| BHP Billiton | 7.02% | ISCOR | 0.61% |
| South African Breweries | 5.73% | BOE | 0.61% |
| Old Mutual | 4.52% | Investec Group | 0.61% |
| Sasol | 4.14% | Nampak | 0.58% |
| Standard Bank Group | 3.54% | Johnnic Holding Limited | 0.58% |
| Gold Fields | 3.23% | Steinhoff International Holdings | 0.47% |
| Sappi | 2.90% | Alexander Forbes | 0.46% |
| Remgro | 2.82% | Durban Roodepoort Deep | 0.43% |
| Firstrand Limited | 2.61% | Network Healthcare Holdings | 0.40% |
| Anglo American Platinum Corp. | 2.48% | Anglovaal Inds. | 0.38% |
| Liberty International | 2.20% | Metro Cash & Carry | 0.36% |
| Sanlam | 1.91% | New Africa Capital | 0.36% |
| Anglogold | 1.72% | Shoprite | 0.34% |
| Impala Platinum Hlds | 1.60% | Woolworths Holdings | 0.34% |
| Harmony | 1.35% | Reunert | 0.32% |
| Absa Group | 1.32% | Coronation Holdings N | 0.29% |
| Nedcor | 1.26% | Pick N Pay Stores | 0.27% |
| Bidvest Group | 1.20% | Aveng | 0.26% |
| Barloworld | 1.13% | Murray & Roberts | 0.26% |
| Imperial Holdings | 1.00% | African Bank Invest | 0.25% |
| Tiger Brands | 0.97% | Naspers | 0.25% |
| RMB Holdings | 0.81% | Truworths International | 0.23% |
| M-Cell | 0.80% | Aspen Pharmacare Holdings | 0.23% |
| Kumba | 0.79% | Illovo Sugar | 0.22% |
| Venfin | 0.71% | Kersaf Investments | 0.22% |

5b. Constituents for the 80% RESI as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Tongaat-Hulett Group | 0.21% | United Service Technologies | 0.09% |
| Delta Electrical Industries | 0.20% | Avis Southern Africa | 0.09% |
| Super Group | 0.20% | Martprop Property Fund | 0.09% |
| Comparex Holdings | 0.19% | Rebserve Holdings | 0.08% |
| New Clicks Holdings | 0.19% | Brait SA | 0.08% |
| Datatec | 0.19% | Tradehold | 0.08% |
| Amalgamated Beverage Industries | 0.19% | Pepkor | 0.07% |
| AECI | 0.18% | Discovery Holdings | 0.07% |
| African Oxygen | 0.18% | Trans HEX Group | 0.07% |
| Santam | 0.18% | Coronation Holdings | 0.07% |
| Anglovaal Mining | 0.17% | Sun International South Africa | 0.06% |
| Edgars Consolidated Stores | 0.17% | AMB Holdings | 0.06% |
| Allan Gray Property Trust | 0.17% | Mvelaphanda Resources Ltd | 0.06% |
| Massmart Holdings | 0.17% | Net 1 Applied Tech Holdings | 0.06% |
| Northam Platinum | 0.16% | Real Africa Holdings | 0.06% |
| JD Group | 0.16% | Unitrans | 0.05% |
| Western Areas | 0.16% | MIH Holdings | 0.05% |
| OTK Holdings | 0.15% | Sage Group | 0.05% |
| Pretoria Portland Cement | 0.14% | Tiger Wheels | 0.05% |
| Foschini | 0.13% | Oceana Group | 0.05% |
| Medi-Clinicrp | 0.12% | PSG Group | 0.05% |
| Capital Alliance Holdings | 0.11% | CTP Holdings | 0.05% |
| Nedcor Investment Bank Holdings | 0.11% | MGX Holdings | 0.05% |
| Energy Africa | 0.11% | Dorbyl | 0.05% |
| African Life Assur | 0.11% | Investment Solutions Holdings | 0.05% |
| Ellerine Holdings | 0.10% | South African Chrome & Alloys | 0.05% |
| Allied Technologies | 0.10% | Chemical Services | 0.05% |
| Malbak | 0.10% | Johnnic Communications | 0.05% |
| Avgold | 0.09% | Power Technologies | 0.05% |
| Mr Price Group | 0.09% | Caxton Publishers & Printers | 0.05% |

5c. Constituents for the 50% RESI as at 30 June 2002

| Share | Weight | Share | Weight |
|---|---|---|---|
| Metboard Properties | 0.04% | AST Group | 0.02% |
| Ceramic Industries | 0.04% | Rainbow Chicken | 0.02% |
| Primedia Limited N | 0.04% | PSG Investment Bank Holdings | 0.02% |
| Palabora Mining | 0.04% | Profurn | 0.02% |
| Highveld Steel | 0.04% | Hudaco Industries | 0.02% |
| Glenrand MIB | 0.04% | Sa Retail Properties | 0.02% |
| Corpcapital | 0.04% | Bell Equipment | 0.02% |
| Redefine Income Find | 0.04% | Global Technology | 0.02% |
| Genbel Invsts. | 0.04% | Acucap Properties Limited | 0.02% |
| Tourism Investment Corp | 0.03% | Africa Glass Industries | 0.02% |
| Adcorp Holdings | 0.03% | Gold Reef Casino Resorts | 0.02% |
| Softline. | 0.03% | Wetherlys Investment Holdings | 0.01% |
| Mustek | 0.03% | City Lodge Hotels | 0.01% |
| OZZ | 0.03% | Barplats Investments. | 0.01% |
| JCI Gold | 0.03% | Grindrod | 0.01% |
| Centrecity Property Fund | 0.03% | Primedia Limited | 0.01% |
| Grindrod N | 0.03% | Comair | 0.01% |
| Bytes Technology Group | 0.03% | Clientele Life Assurance. | 0.01% |
| Wilson Bayly Holmes-Ovcon | 0.03% | Cadiz Holdings | 0.01% |
| Grintek | 0.02% | Wooltru N | 0.01% |
| MB Technologies | 0.02% | Wooltru | 0.00% |
| African Harvest | 0.02% | Intervid | 0.00% |
| Group Five/South Africa | 0.02% | Capitec Bank Hldgs Ltd | 0.00% |
| Peregrine Holdings | 0.02% | | |

# APPENDIX G: OPTIMAL BENCHMARK FINDINGS

1. Findings for the optimal ALSI analysis

| Fund Size | ñ | FINDI Weight | RESI Weight | Max Leeway | Std Dev |
|---|---|---|---|---|---|
| 1,000,000 | 161.00 | 77.02% | 22.98% | 166.46% | 17.41% |
| 10,000,000 | 160.68 | 76.94% | 23.06% | 165.09% | 17.47% |
| 100,000,000 | 151.86 | 76.09% | 23.91% | 157.13% | 17.61% |
| 500,000,000 | 104.11 | 72.24% | 27.76% | 150.26% | 17.92% |
| 1,000,000,000 | 75.83 | 68.72% | 31.28% | 128.49% | 18.56% |
| 1,500,000,000 | 58.85 | 64.53% | 35.47% | 115.39% | 18.71% |
| 2,000,000,000 | 47.68 | 61.62% | 38.38% | 87.99% | 18.77% |
| 2,500,000,000 | 40.27 | 58.58% | 41.42% | 66.58% | 18.88% |
| 3,000,000,000 | 34.42 | 53.00% | 47.00% | 36.81% | 19.33% |
| 3,500,000,000 | 29.34 | 47.27% | 52.73% | 15.67% | 19.87% |
| 4,000,000,000 | 23.14 | 41.36% | 58.64% | - | 20.44% |

2. Findings for the optimal ALSI analysis constrained by the 80%-20% FINDI-RESI allocation

| Fund Size | ñ | Standard Deviation | E(R) | Sharpe Ratio |
|---|---|---|---|---|
| 1,000,000 | 160.20 | 17.67% | 15.11% | 0.22 |
| 10,000,000 | 159.83 | 17.74% | 14.99% | 0.21 |
| 100,000,000 | 150.71 | 17.95% | 14.55% | 0.18 |
| 500,000,000 | 100.46 | 18.55% | 17.12% | 0.32 |
| 1,000,000,000 | 69.58 | 19.22% | 17.56% | 0.33 |
| 1,500,000,000 | 49.64 | 19.28% | 18.57% | 0.38 |
| 2,000,000,000 | 36.03 | 18.91% | 19.88% | 0.46 |
| 2,100,000,000 | 32.80 | 18.75% | 20.38% | 0.49 |

3. Findings for the optimal ALSI analysis constrained by the 66%-34% FINDI-RESI allocation

| Fund Size | ñ | Standard Deviation | E(R) | Sharpe Ratio |
|---|---|---|---|---|
| 1,000,000 | 150.67 | 16.66% | 20.66% | 0.57 |
| 10,000,000 | 150.51 | 16.71% | 20.57% | 0.56 |
| 100,000,000 | 140.92 | 16.83% | 20.50% | 0.55 |
| 500,000,000 | 99.91 | 17.45% | 22.31% | 0.63 |
| 1,000,000,000 | 74.57 | 18.44% | 23.16% | 0.65 |
| 1,500,000,000 | 58.84 | 18.71% | 23.89% | 0.68 |
| 2,000,000,000 | 47.24 | 18.71% | 24.83% | 0.73 |
| 2,500,000,000 | 37.70 | 18.54% | 26.10% | 0.80 |

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