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Performance evaluation of equal-weighted and value-weighted portfolios on the JSE

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Abstract

The 1/N rule of equal equity weightings for portfolios was found by previous studies to be a simple way to not only achieve portfolio diversification but also to outperform more sophisticated approaches of portfolio optimisation. This study compared quarterly rebalanced equal- and value-weighted portfolios constructed of large-, mid-, and small-caps on the JSE during the holding period of December 1987 to November 2018. The portfolios were constructed following the rolling window approach (quarterly), different holding periods (12, 36, 60 and 120 months) and before transaction costs. Multi-variate and t-tests were performed to test for differences in total mean return, volatility, maximum drawdown, performance success ratio, Sharpe ratio, Treynor ratio, Jensen's alpha, and Information ratio. This study found that large- and mid-cap equal-weighted portfolios significantly outperformed their value-weighted counterparts regarding the total mean return, volatility, Sharpe and Treynor ratio for longer investment periods. Small-cap equal-weighted portfolios underperformed across all investment periods and performance metrics.

Keywords

Portfolio performance, portfolio weightings, equal-weighted portfolio, value-weighted portfolio, 1/N rule, rolling window

Declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

Jakob Leander Schleu

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List of abbreviations

ALSI	-	JSE All Share Index
CAL	-	Capital Asset Line
CAPM	-	Capital Asset Pricing Model
CML	-	Capital Market Line
HHI	-	Herfindahl-Hirschman Index
JSE	-	Johannesburg Stock Exchange
MDD	-	Average Maximum Drawdown
MPT	-	Modern Portfolio Theory
SML	-	Security Market Line
SR	-	Sharpe Ratio
TR	-	Treynor Ratio
US	-	United States of America
WACC	-	Weighted Average Cost of Capital

Chapter 1: Introduction to research problem

1.1 Research title

Performance evaluation of equal-weighted and value-weighted portfolios on the JSE.

1.2 Research introduction

The asset allocation (or security allocation) of portfolios has always been one of the most crucial investing decisions and can be traced far back in history. The words of Rabbi Isaac in the fourth century bears testimony, “one should always divide his [sic] wealth into three parts: a third in land, a third in merchandise, and a third ready to hand” (Talmud, 1986). However, the last 1600 years has seen substantial improvements made on this rule of thumb. Most notably, in 1952, Markowitz (1952) created the modern portfolio theory (MPT) for portfolio selection. Markowitz established that investors were not only genuinely risk-averse, but also expected higher returns for bearing additional units of risk. The MPT has often been referred to as one of the most important economic theories in the field of finance and investment, and, subsequently, Harry Markowitz was awarded the Nobel Prize in Economics in 1990, together with Merton Miller and William Sharpe (“All Prizes in Economic Sciences”, 2018).

Building on Markowitz, multiple theories have been established, such as the Bayesian-Stein estimator (Barillas & Shanken, 2018; Barry, 1974; Frost & Savarino, 1986; Jagannathan & Ma, 2003; Jorion, 1985, 1986). In contrast to the Bayesian-Stein estimator, non-Bayesian estimators were utilised to develop “robust” portfolio allocation rules (Soliman, Ellah & Sultan, 2006; Garlappi, Uppal & Wang, 2006). Non-Bayesian, refers to the statistical inference of: stating a belief, determining the probability of observing the belief and observing of the belief to determine the correctness of the original belief.

As Markowitz (1952) demonstrated, assets inherently bear risk. Assets are subject to idiosyncratic risk and market risk. Idiosyncratic risk of stock refers to microeconomic risks of the underlying entity (company) and has little to no correlation with market risk (Panousi & Papanikolaou, 2012). Because idiosyncratic risk is company specific it can be substantially mitigated by appropriate diversification, and has proved to be a bigger contributor to portfolio risk than market risk (Campbell, Lettau, Malkiel & Xu, 2001). Systematic risk or market risk on the other hand, cannot be substantially mitigated or eliminated by diversification.

Despite the clear advantages of diversification, observed investment behaviour of households differ greatly from optimum (or efficient) portfolio construction, which considers not only asset classes but also asset-allocation (Barber & Odean, 2013; Campbell, 2006). Preliminary research has found that the majority of individual investors, whether households or professional investors were diversifying enough (de Dreu & Bikker, 2017; Ibbotson & Kaplan, 2000; Robinson & Sensoy, 2013; Tang, Mitchell, Mottola & Utkus, 2010).

The Capital Asset Pricing Model (CAPM) was based on the findings of Markowitz and through empirical checks was considered to be largely successful (Jensen, Black & Scholes, 1972; Fama & MacBeth, 1973). The value-weighted portfolio (sometimes referred to as the capitalisation-weighted, cap-weighted, or market portfolio) has played a critical role in asset-allocation as well as pricing, most prominently in the CAPM (Sharpe, 1964, 1994). Sharpe (1964) and Lintner's (1965) core finding was that the value-weighted portfolio was, in fact, an optimal portfolio and could only be beaten by luck or chance. Therefore, the value-weighted portfolio is essential to CAPM, since rational investors should only hold a combination of the market portfolio and risk-free investment. Academic research is predominantly concerned with the model by Markowitz (1952) and Sharpe (1964); this study will examine a "naive" approach to diversification – equal-weighted portfolios.

In stark contrast to the CAPM, the theory of equal-weighted portfolio is a naive type of asset-allocation utilising the N/1 rule. Naive portfolio selection refers to rule of thumb asset-allocation, such as 1/N, where N is the number of investments making up the equal-weighted portfolio (DeMiguel, Garlappi & Uppal, 2007). They are easier to implement compared to Markowitz´s models, as they do not rely on the estimation of asset returns of portfolio optimisation. The ease of implementing naive rules is the reason its wide use by investors, despite the advances made in the last 60 years in portfolio selection (de Dreu & Bikker, 2017; Huberman & Jiang 2006).

DeMiguel et al. (2007) sparked the recent academic discussion on the performance of equal-weighted portfolios. They compared equal-weighted to mean-variance efficient portfolios and found that none of their mean-variance portfolios could consistently outperform the equal-weighted portfolio rule concerning Sharpe ratios, certainty-equivalent returns, or turnover. Therefore, DeMiguel et al. (2007) concluded that additional gains from optimal portfolio diversification were more than cancelled out by the estimation error.

Fletcher (2011) replicated the experiment by DeMiguel et al. (2007) and reached a contrary conclusion that many optimal portfolio strategies significantly outperformed equal-weighted portfolios. The reason for these contrary findings was that the data DeMiguel et al. (2007) used were market- and sample-specific and, six out of the seven datasets were from the US market.

In the context of South Africa and the JSE, mean-variance portfolios (with ex-ante data from 1997 to 2008) were proved to significantly outperform the market (Du Plessis & Ward, 2009). The CAPM was tested by Ward and Muller (2012) on data, spanning 1986 to 2011, and showed an inverse correlation between risk and returns in the last seven years of their study. Pearson and du Toit (2013) created minimum-variance, mean-variance and diversity and risk parity portfolios. They tested these against traditionally-weighted indices, like the JSE All Share Index (ALSI), and found that the newly created portfolios outperformed the traditional ones. Pearson and du Toit (2013) also found evidence of a negative relationship between risk and return of equal-weighted portfolios.

1.3 Research problem and motivation

Even though the performance of equal-weighted portfolios on international equity markets have been discussed in academic literature over the years, none of the research has been focussed on the South African market and the JSE.

This study was motivated by the findings of DeMiguel et al. (2007) who observed significant excess total mean returns of equal-weighted over value-weighted portfolios and by Jacobs, Müller and Weber (2014) as well as Plyakha, Uppal and Vilkov (2012), who replicated their findings with more comprehensive datasets. Plyakha et al. (2012) found that excess returns of equal-weighted portfolios was based substantially on bearing higher systematic risk as well as a higher alpha. Further, Maillard, Roncalli and Teïletche (2008) found that equal-weighted portfolios are a good alternative regarding absolute diversification, the level of risk, and risk budgeting. Jacobs et al. (2014), building on an early study of Farinelli, Ferreira, Rossello, Thoeny and Tibiletti (2008) investigated multiple different portfolio strategies and found that, as long as a portfolio is overly invested in one asset class, naive asset-allocation rules are achieving diversification.

Simple heuristic allocation produces similar diversification results compared to more sophisticated allocation rules.

However, the lack of robustness of DeMiguel's et al. (2007) study, proven by Fletcher (2011) and Guo, Boyle, Weng and Wirijanto (2018a) meant that the performance of equal-weighted portfolios is market-specific. This pervasiveness of an absolute answer regarding the performance of equal-weighted portfolios has motivated this study to investigate the performance of equal-weighted portfolios in the South African context.

1.4 Research purpose and objectives

The research purpose of this study is to contribute towards the understanding of the performance of equal-weighted portfolios in the context of the main board of the JSE by using the work from Plyakha et al. (2012) as a reference model.

The following objective was compiled in support of this purpose:

1. Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding the attributes: total mean return, volatility, maximum drawdown and performance success ratio (Hypothesis 1a-d, and stated in Chapter 3).
2. Determine whether equal-weighted portfolios and value-weighted portfolios on the JSE differ statistically regarding the Sharpe ratio (Hypothesis 2, and stated in Chapter 3).
3. Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding the Treynor ratio (Hypothesis 3, and stated in Chapter 3).
4. Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding Jensen's alpha (Hypothesis 4, and stated in Chapter 3).
5. Determine the Sortino ratio of the equal-weighted portfolio benchmarked over the value-weighted portfolios on the JSE (Hypothesis 5, and stated in Chapter 3).
6. Determine the Information ratio of equal-weighted portfolios on the JSE and in what of Grinold and Kahn's (1995) category it falls (Hypothesis 6, and stated in Chapter 3).

This study contributes towards a better understanding of equal-weighted portfolios on the JSE utilising an extended and improved dataset by Muller and Ward (2013) from 1987 to 2018. It further contributes towards academic research in South African as it examines whether the equal-weighted portfolios outperform value-weighted portfolios on the JSE market.

1.5 Importance and contribution of the study

This study's main contribution is towards a better understanding of equal-weighted portfolios on the JSE. Unlike in developed markets, financial research for South Africa is often incomplete. Despite Muller and Ward (2013) who tested whether 30 investment styles could beat the market, the current body of literature presents a gap in performance evaluations of equal-weighted portfolios on the JSE.

Furthermore, academic literature continues to produce mixed results about the market efficiency of the JSE (Afego, 2015; Jefferis & Smith, 2004, 2005; Strebel, 1977; Ward & Muller, 2012). Despite the lack of liquidity which Chordia, Roll and Subrahmanyam (2008a, 2008b) blamed for much of the inefficiency, Afego (2015) found strong evidence for information inefficiency and behavioural biases. Thus, this study contributes to the current literature regarding both of these problems and plays a role in widening the scope of financial research in South Africa.

The final contribution of this study is to evaluate the appropriateness of equal-weighted portfolios as a benchmark for portfolio managers invested in South African JSE.

1.6 Research scope and delimitations

This study investigated the performance of equal-weighted and value-weighted portfolios in South Africa, more specifically of the top 160 shares respectively, of market share on the JSE during 1987 to present. The study subdivides the portfolios small-, mid-, and large-caps and investigates the performance of these separately. Due to the highly concentrated nature of the JSE, the top 160 shares represent more than 99% of the market capitalisation, and any smaller shares (micro-caps) are not deemed investment grade. The study will utilise the extended and previously published dataset by Muller and Ward (2013).

This study was subject to a number of delimitations. The scope of the study was limited to the largest 160 companies listed on the JSE between December 1987 and November 2018. Hence, no generalisation regarding unlisted companies and micro-caps in South Africa should be made. The period investigated was, however, not chosen at random but dictated by the availability of data. 160 shares were only listed in December 1987 for the first time. Since South Africa's financial market data was often incomplete, the study is based on a reconstructed ALSI Top 160 share index.

This study utilised the rolling window approach with quarterly rebalancing but did not consider transaction costs. Other studies rebalanced monthly (Maillard et al. 2008; Plyakha et al., 2012; Roncalli & Weisang, 2016). More frequent rebalancing, however, was found by Guo et al. (2018), to not have a substantial effect, since additional transaction costs marginalise eventual gains.

1.7 Outline

This chapter provided context, defined the research problem and stated the research purpose. It further showed the significance for the business need of this study. The remaining document is organised as follows:

- Chapter 2 reviews seminal and recent academic literature regarding Markowitz and equity market efficiency, the CAPM and its criticism, equal-weighted portfolios and the performance of such a portfolio strategy. It further illustrates the background of the above-stated research objectives
- Chapter 3 states the research hypotheses based on the research objectives stated in this chapter and expanded on in Chapter 2
- Chapter 4 states the methodology for testing the outlined hypotheses
- Chapter 5 presents the results of the analyses based on the methodology in Chapter 4
- Chapter 6 discusses and places the results of Chapter 5 in the academic literature
- Chapter 7, to conclude the study, summarises the discussion and proposes future research

Chapter 2: Literature review

2.1 Introduction

The following literature review highlighted the position of this research, from the seminal work of Markowitz to current academic literature. This section outlined the theoretical underpinnings of the study's focus and provided background to the research problem and objectives and built towards the research hypotheses in the next chapter.

2.2 Modern portfolio theory by Markowitz

Long before economic science was concerned with the topic of portfolio optimisation, the diversification of investments was a common practice. King Solomon wrote in the book of preachers around 1000 B.C. (Ecclesiastes 11:2): "Divide your possessions among seven or eight; you do not know what misfortune may come upon the land."

William Shakespeare wrote around 1600 in the Merchant of Venice: “Believe me, not; I thank my happiness: My advance is not familiar to a ship, nor to another place; nor does my whole fortune hang on the happiness of this present year; Therefore, my trade does not make me sad” (Shakespeare, 1600, 1.1.43-46). The merchant in Shakespeare's play understood the concept of diversification and the principle of asset covariance as Markowitz (1999) pointed out.

Based on the observation of real investor behaviour, Markowitz (1952) gave scientific research a new basis and changed practical portfolio management significantly. Markowitz jointly received the Nobel Prize in Economics (for his work on MPT in 1990 (“All Prizes in Economic Sciences”, 2018)) together with Miller (for his contribution towards the understanding of the capital structure) and Sharpe (for his Capital Asset Pricing Model theory).

The MPT by Markowitz (1952) was revolutionary at the time of its publication and regarded as the beginning of MPT. One of the core statements was that all market participants hold a part of the market portfolio (Sharpe 1964) and that all market participants should have their assets invested only in well-diversified portfolios. Based on his theory, he later developed algorithms – also with more complex constraints – to determine efficient or optimal portfolios.

The core finding of Markowitz (1952) was: The risk of securities of a specific portfolio was by no means the average risk of its respective assets. He, thus, reduced the classic selection and the decision-making problem, in the selection of securities for various assets, to the first two statistical distribution parameters – risk and return. In particular, the correlation, which quantified the equilibrium/ unbalance of preselected individual investment returns among themselves, proved to be particularly significant.

Markowitz (1952, 1999) further proposed that criteria for portfolio selection should not only be only the expected return but also the risk or variance of a portfolio. Expected portfolio returns were proportionally composed of the respective asset returns. The volatility (or variance) of portfolios was comprised of individual asset variances, their covariances and their weight in a particular portfolio. The mean-variance analysis presumed that investors take rational decisions to increase returns and minimise risk, under the condition of complete information. While “mean” referred to the mean return, “variance” referred to the risk (standard deviation) of the underlying investment. Therefore, Markowitz (1952) concluded that the mean-variance paradigm was a satisfactory statistical measurement to characterise an investment portfolio.

The concept of portfolio optimisation inherently implied that there must be efficient and inefficient portfolios (Markowitz, 1952). Efficient portfolios were located on the “efficient frontier” and constructed from estimated returns, variances, and covariances. The graphical display of the efficient frontier is displayed in Figure 1 (p. 11).

However, the MPT was not without criticism for practical problems such as the mean-variance problem, which was covered by vast academic literature (Best & Grauer, 1991; Li & Ng, 2000; Michaud,1989; Steinbach, 2001). Further, the mean-variance analysis assumed perfectly liquid assets (Markowitz, 1959), which was not realistic. This problem was addressed by Markowitz and van Dijk (2003) and they presented the “quadratic surrogate” heuristic to deal with illiquidity and altering probability distributions. Kritzman, Myrgren and Page (2007) tested and supported Markowitz and van Dijk (2003) as they found that the heuristic worked remarkably well. Criticism of the “classical” MPT did not discount the fact that MPT continues to be valuable and valid in general. MPT formed the theoretical basis of CAPM.

To follow the discussion of this study, it is vital that specific terms are understood, such as risk and return, diversification, portfolio, portfolio weightings (equal-weighted and value-weighted), the differences between the two portfolio types, and the theoretical underpinnings of the performance metrics. The researcher, therefore, explained the constructs in the sections following.

2.3 The Capital Asset Pricing Model

Building on earlier work by Markowitz, the CAPM was separately conceived by Lintner (1965, 1975), Mossin (1966), Sharpe (1964), and Treynor (1961). The theoretical universe of the CAPM had six defining properties: (i) investors are rational, meaning risk averse and profit maximisation driven; (ii) investors cannot influence prices but are consistent in their anticipation of expected returns of normally distributed securities; (iii) investors can, without limitation, borrow and lend at a risk-free rate; (iv) investors are not subject to buying or selling restrictions of assets; (v) perfect information exists; and (vi) there are no taxes on investors.

Sharpe (1964) and Lintner (1965), utilising the above CAPM properties, found that the market portfolio is, in fact, the optimised mean-variance and as such, an efficient portfolio. They further found a positive linear relationship between excess returns and the beta of a security. However, Markowitz (2005) found that the positive relationship between excess return and beta, had to be broken down if there were to be restrictions regarding lending at the risk-free rate or short-selling securities.

The CAPM formulated an equation between the expected return and the underlying risk (or beta) of a security (the CAPM referred to individual assets as securities):

Equation 1: The Capital Asset Pricing Model

$$E(r_i) = r_f + \beta_i \, (E(r_m) - r_f)$$

Where:

$E(r_i)$	=	Expected return
r_f	=	Risk-free rate
$E(r_m)$	=	Expected market return
β_i	=	Beta of the underlying security

Therefore, CAPM directly linked the expected return to risk, which arose from unexpected events. Markowitz (1952) stated that the risk of one security could be cancelled out by another (the paradox of umbrella and ice cream sales), which is generally known as diversification. The risk of the portfolio could, therefore, be reduced by holding more securities. The risk of a security, however, was comprised of two factors, idiosyncratic risk (diversifiable-risk) and market risk (non-diversifiable-risk).

The portfolio risk, on the other hand, was defined as the weighted average of the variance of each security in the portfolio as well as the weighted covariances between the securities (Sharpe, 1964). The following calculation defined the standard deviation of a portfolio:

Equation 2: Portfolio Standard Deviation

$$\sigma_p = \sqrt{w_1^2\sigma_1^2 + w_1^2\sigma_1^2 + 2w_1w_2\sigma_{1,2}}$$

Where:

σ_p	=	Portfolio standard deviation
w_i	=	Portfolio weight
σ_i^2	=	Variance of security
$\sigma_{i,j}$	=	Covariance between two securities

For N securities in a portfolio, there had to be n variances as well as (n2-n) covariances. The market portfolio was defined as a portfolio of an infinite number of securities in a specific market.

Each investment opportunity could be plotted on a Capital Asset Line (CAL), illustrating all possible combinations of the expected return and the risk-free rate (Mossin, 1966). The Capital Market Line (CML) was defined as the CAL of the market portfolio and had the highest slope, or unit of return, per unit of volatility. Sharpe (1964) coined the slope reward-to-variability ratio, and yet today it is known as the Sharpe ratio.

Investors demanded higher returns for additional units of risk, and therefore, chose the tangency portfolio, where the CML and the efficient frontier touch. Owing to the unique characteristics of the world of CAPM, the investor's capability of lending and borrowing at the risk-free rate, the model arrived at the CML. The CML (or efficient market line) was displayed in the figure below:

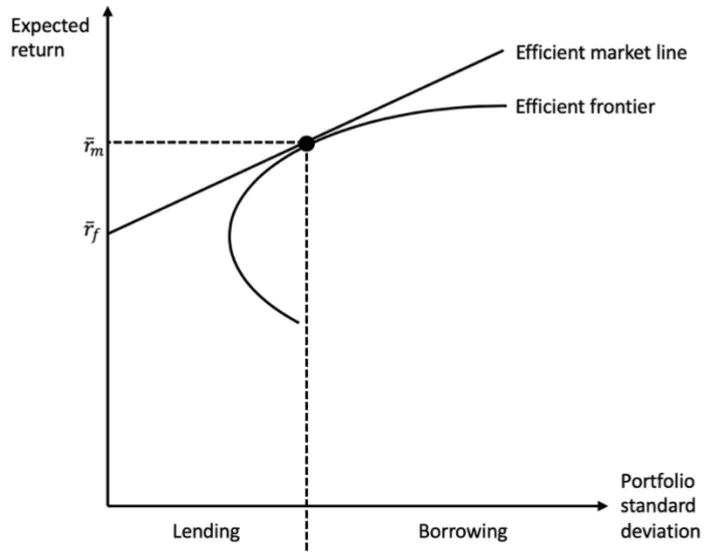

Figure 1: Graphical representation of the capital market line (CML)

Source: Own research

The Security Market Line (SML) quantified, for a specific security, the risk-return trade-off and allowed the graphical depiction of the market risk premium. The market risk premium (calculated by $\bar{r}_m - \bar{r}_f$) mirrored the slope of the line with expected returns and beta:

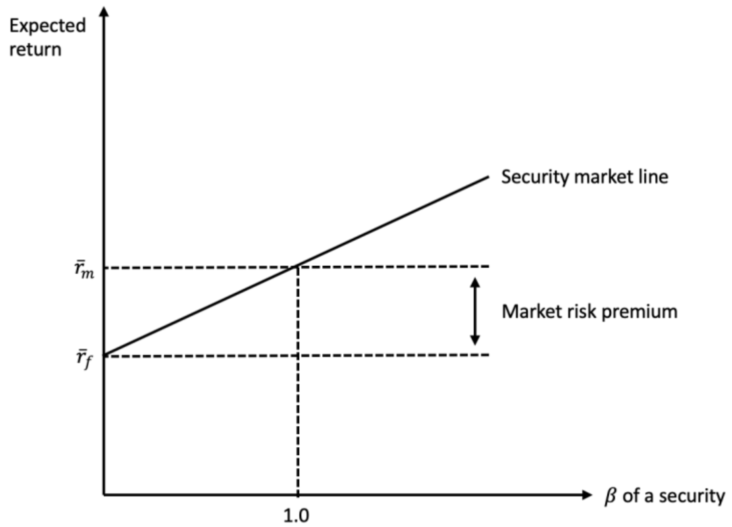

Figure 2: The market risk premium trade-off

Source: Own research

The SML was derived from the CML and related the expected total return of a security to the market portfolio return:

Equation 3: The Security Market Line

$$E(r_i) = r_f + \beta_i(E(r_m) - r_f)$$

Where:

$E(r_i)$ = Expected portfolio return

r_f = Risk-free rate

$E(r_m)$ = Expected market return

β_i = Beta of the underlying security

Unlike the CML, which quantified expected returns per total risk, the SML risk measured systematic risk (consecutively referred to as beta). The beta of the underlying security was denoted as the following:

Equation 4: The SML Beta

$$\beta_i = \frac{cov(r_i, r_m)}{\sigma^2(r_m)}$$

Where:

$E(r_i)$ = Expected portfolio return

r_f = Risk-free rate

$E(r_m)$ = Expected market return

β_i = Beta of the underlying security

The equilibrium of the SML corresponded to the CAPM market model:

Equation 5: The CAPM equilibrium

$$r_{i,t} = \alpha_i + \beta_i(r_{mt} - r_f) + \varepsilon_{it}$$

Where:

β_i = Beta of the underlying security

ε_{it} = Error term

If the CAPM theory held it implied that the market was efficient and, thus, α should be statically not different from zero. When the CAPM held true, securities were priced on the CML or the SML. If they were plotted above (or under), they were under-priced (or over-priced), therefore generating returns that were too high (or low).

The CAPM was not without criticism, as it was a test of expected returns but could only be empirically examined with ex-ante data of actual returns (Roll, 1977). Most notable alternatives to the CAPM were the Black CAPM (Jensen et al., 1972), who tested the CAPM empirically in a world without risk-free security, and the Arbitrage Pricing Theory devised by Ross (2013).

However, the CAPM continues to be the most commonly practised financial theory today, laying the foundations for the widely accepted and widely used Weighted Average Cost of Capital (WACC). A firm's cost of capital is defined as the average rate a company has to pay its equity and non-equity holders (Modigliani & Miller, 1958) and was proven generally correct (Miles & Ezzell, 1980). The WACC displayed the minimum return a firm had to generate, to repay an existing asset base, and thus, was not determined by management, but by the external market. Although often criticised in academic literature, the CAPM had surpassed its origins in academia and is now widely used by practitioners in business.

2.4 Portfolio weights

2.4.1 Value-weighted portfolios

This study adopted Bhattacharya and Galpin's (2011) definition of market value-weighted portfolios: "The weight of stock (i) in a value-weighted portfolio is, by definition, proportional to the market capitalization of stock (i)" (p. 2). Value-weighted portfolios, therefore, were based on the work by Markowitz (1952) and the principles of MPT and CAPM. Bhattacharya and Galpin (2011) also found that the popularity of value-weighted portfolios had expanded substantially in the investigated timeframe (1995 to 2007) in the 35 of 43 countries tested. Value-weighted portfolios, as they replicated the performance of a specific market, were generally used as a benchmark for other portfolios (Admati & Pfleiderer, 1997). Thus, value-weighted portfolios were also used by Plyakha, Uppal and Vilkov (2015) as well as Guo et al. (2018) to test the performance of equal-weighted portfolios.

2.4.2 Equal-weighted portfolios

This study adopted the generally practised definition of equal-weighted portfolio: the 1/N rule (DeMiguel et al., 2007). An equal-weighted portfolio is a portfolio of N securities held with equal weightings or an equal share of wealth per security of 1/N. Equal-weighted portfolios were regarded as a passive and naive investment strategy.

As already stated, equal-weighted portfolios were a “naive” form of portfolio selection and were not more advanced than, a rule of thumb. Therefore, it was found to be simpler to implement than Markowitz’s optimised portfolios, as they did not rely on the estimation of asset returns of portfolio optimisation. The ease of implementing naive rules is the reason why they have been widely used by investors (Benartzi & Thaler, 2001), despite the advances made in the last 60 years in portfolio selection (de Dreu & Bikker, 2017; Huberman & Jiang, 2006). Benartzi and Thaler (2001) even found an inherent cognitive bias of participants faced with different investment choices, to adopt the 1/N rule independent of the fund type and return, proving an irrational investor behaviour regarding portfolio weight allocation. However, if investors faced fundamental uncertainty regarding the distribution of returns, also known as ambiguity, Pflug, Pichler and Wozabal (2012) argued that the adoption of the equal-weighted portfolio strategy was “perfectly rational”.

Thus, equal-weighted portfolios seemed to conflict with the more advanced models of portfolio optimisation and had therefore not been extensively covered before DeMiguel et al. (2007) by academic literature, which had focused more on the MPT by Markowitz and the variation thereof. Equal-weighted portfolios have been established as another benchmark for other portfolios in recent history (Blitzer, 2016) as advocated by DeMiguel et al. (2007).

2.5 Performance evaluations of equal-weighted and value-weighted portfolios in the academic literature

Academic literature was mostly concerned with variations of the MPT by Markowitz (1952, 1959) and Sharpe (1964, 1970). However, more recently, equal-weighted portfolios were afforded more attention in academic literature, since the research of DeMiguel et al. (2007). Additional findings of other crucial academic literature discussing the performance of equal-weighted and value-weighted portfolios, were outlined in the paragraphs below.

Equal-weighted and value-weighted portfolios were both exposed to flaws originating in the weightings of the equities. Whereas value-weighted portfolios were overly exposed to large-caps, the opposite is true for equal-weighted portfolios, where micro-caps (often illiquid and subject to high volatility) dominate, due to the large percentage of the total number of shares in the market (Fama & French, 2008). Markets in which the concentration is high, value-weighted portfolios are subject (to an even greater extend) to the fate of the largest stocks (see Table 1: Market concentration of the JSE). The more concentrated a market is, the more value-weighted portfolios differ from equal-weighted portfolios.

Table 1: Market concentration of the JSE

Top 10 shares	% of ALSI
Anglo American	17.90%
Billiton	8.80%
Richemont	8.40%
Sasol	5.20%
SAB	4.80%
Gold Fields	4.00%
Old Mutual	3.80%
Amplats	3.10%
Standard Bank	3.00%
Sappi	2.50%
Total	61.50%

Source: Adapted from Kruger & Van Rensburg (2008).

Atchison, Butler and Simonds (1987), Breen, Glosten and Jagannathan (1989), Canina, Michaely, Thaler and Womack (1998), Lessard (1976), Grinblatt and Titman (1989), Ohlson and Rosenberg (1982) and Roll (1981) all conducted empirical tests and found that equal-weighted portfolios bear higher return and volatility. These findings were later confirmed by Whited and Wu (2006), DeMiguel, Garlappi, Nogales and Uppal (2009) as well as Pae and Sabbaghi (2010). They proposed three origins: lack of market efficiency (Perold, 2007), lack of market liquidity (Blume & Stambaugh, 1983; Bali, Cakici, Yan & Zhang, 2005) and autocorrelation (Roll, 1981; Atchison et al., 1987). However, Pae and Sabbaghi (2010, 2015) findings were limited to the context of a positive market premium and no bankruptcy costs, but with tax-shields.

DeMiguel et al. (2007) revived attention to more naive portfolio selection methods and compared 14 different portfolio allocation methods to equal-weighted portfolios, concerning total mean return, Sharpe ratio, and turnover amongst others of US stock-market data. The constructed portfolios utilised five different approaches; naive, the Bayesian approach (to estimate error), moment restrictions (value-weighted and mean-variance portfolios – amongst others), portfolio constraints and combinations of optimal portfolios (equal-weighted and mean-variance portfolios – amongst others). DeMiguel et al. (2007) found that none of the constructed optimised portfolios had consistently outperformed equal-weighted portfolios pertaining to Sharpe ratio, certainty-equivalent return, or turnover. Most importantly, "the estimation period needed before the sample-based mean-variance strategy could be expected to achieve a higher certainty-equivalent return (…) for a portfolio with only 25 assets; the estimation window needed was more than 3000 months, and for a portfolio with 50 assets, it was more than 6000 months" (DeMiguel et al., 2007, p. 1948). DeMiguel's et al. (2007) study was based on the findings of Grinblatt and Titman (1989) and Jegadeesh and Titman (1993). Furthermore, for long-term globally diversified investments, Goetzmann, Li and Rouwenhorst (2005) had found a diversification benefit of equal-weight over value-weighted portfolios. Windcliff and Boyle (2004) and DeMiguel et al. (2007) explained the excess returns of equal-weighted over optimal portfolios to the severity of estimation errors in the input variables and the methods created to mitigate for these estimation errors could not compensate.

Using market data from the United Kingdom, Fletcher (2011) replicated the experiment DeMiguel et al. (2007) and reached a directly contrary conclusion, as many optimal portfolio strategies significantly outperformed equal-weighted portfolios. Therefore, Fletcher's study was seen as a defence of optimal portfolios. The reason for these contrary findings was that the data DeMiguel et al. (2007) used were market specific and, six out of the seven datasets were from the US market.

Maillard et al. (2008) compared equally risk-contributing portfolios to equal-weighted portfolios, again highlighting that the popularity of these portfolios was based on the simplicity of execution of the investment strategy. The portfolios tested had a unique characteristic; the risk contribution from each security was equal, which in turn maximised diversification. Equally risk contributing and equal-weighted portfolios were found to be a good alternative regarding absolute diversification, the level of risk, and risk budgeting.

Other researchers explained the superiority of equal-weighted portfolios from perspectives other than estimation error. Plyakha et al. (2012) benchmarked equal-weighted against value-weighted and price-weighted portfolios (rebalanced monthly). Utilising Patton and Timmermann (2010) non-parametric monotonicity tests, Plyakha et al. (2012), motivated by DeMiguel et al. (2009), investigated these portfolios regarding the total mean return, Sharpe ratio, Carhart's (1997) four-factor alpha, and certainty-equivalent return. They further found evidence indicating that equal-weighted portfolios significantly outperform concerning total mean return, which was found to be based substantially on bearing higher systematic risk and higher alpha. The higher alpha solely resulted from the monthly rebalancing. Due to the frequent rebalancing, the resulting portfolio was contrary to the market portfolio (to maintain equal weights monthly rebalancing resulted in selling last period's winners and buying last period's losers). Patton and Timmermann (2010) also attributed the excess mean returns to the frequent rebalancing.

Plyakha et al. (2012) decomposed the total returns utilising the four-factor alpha model by Fama and French (1993) and Carhart (1997) to differentiate between an excess systematic component (factor exposure) and alpha. Plyakha et al. (2012) found that 96% of out-of-sample returns resulted from higher alpha and just 4% was attributable to the excess of systematic exposure.

Jacobs, Müller and Weber (2010, 2014) extended the findings by DeMiguel et al. (2009) to other datasets and equities. Jacobs et al. (2014) investigated eleven different portfolio optimisation models (scientific and heuristic stock weighting allocation, international market diversification and different asset-allocation methods), building on an early study of Farinelli et al. (2008). The equal-weighted portfolio model outperformed the other optimisation models regarding the total mean return, standard deviation and Sharpe ratio. They further found that as long as a portfolio was not over-invested in one asset class, naive asset-allocation rules were achieving diversification. Simple heuristic allocation achieved similar diversification results compared to more sophisticated allocation rules.

Other academic research strived to create more sophisticated portfolio strategies to outperform the equal-weighted portfolio. By combining multiple portfolio optimisation approaches by Jorion (1986), Kan, Wang and Zhou (2016), Craig MacKinlay and Pástor (2000), Makrowitz (1952) and Tu and Zhou (2011) succeeded in beating equal-weighted portfolio strategy in nearly all scenarios. Thus, Tu and Zhou's (2011) paper provided additional support in defence of the optimal portfolios and the utility of the Markowitz portfolio theory.

Kan et al. (2016) utilised two and three-fund suggestion rules from earlier research by Kan and Zhou (2007) and found that the excess returns of equal-weighted portfolios could be partly explained, since the constructed optimised portfolios were not invested in risk-free assets, despite being designed to do so. To mitigate this optimal portfolio problem, they recreated the DeMiguel et al. (2009) experiment solely with risky assets and mitigated for estimation error. The resulting optimised portfolio supported the utility of the Markowitz portfolio theory again.

Malladi and Fabozzi (2017) created a theoretical framework and found why equal-weighted portfolios outperformed value-weighted portfolios with financial data set from 1926 to 2014. They, again, found that a significant component of the excess total mean return (even after transaction costs) of equal-weighted portfolios arose from rebalancing and a correlation with a positive market risk premium. Malladi and Fabozzi (2017) found that most of the excess total mean return of equal-weighted portfolios arose from the rebalancing which implied that the yearly rebalancing approach was inferior.

Guo et al. (2018) investigated the performance of equal-weighted portfolios in other equity markets and found that equal-weighted portfolios outperformed more sophisticated allocation approaches in only two (US and Japan markets) out of seven equity markets during the holding period from 1999 to 2016 for annually rebalanced portfolios. Thus, Guo et al. (2018) show that the outperformance of equal-weighted portfolios was market- and sample-specific. Therefore, previous studies (DeMiguel et al., 2007) lacked robustness. Besides, Guo et al. (2018) found that outperformance was not only due to the estimation error of optimal portfolios but that equal-weighted portfolios were inherently close to optimality, which showed that the equal-weighted portfolio strategy, was less naive as initially perceived.

Since the equal-weighted portfolio strategy was market- and sample-specific, Guo et al. (2018) found a measure indicating when equal-weighted portfolios had excess returns compared to optimal portfolios that were simple and intuitive. Two market attributes were found to have a positive correlation with the outperformance of naive strategies: market performance overall as well as how close the maximum Sharpe ratio portfolio was to the equal-weighted portfolio, mainly if the Sharpe ratio maximising portfolio was, in fact, the equal-weighted portfolio. Although the positive correlation of excess returns with the Sharpe ratio was not surprising, the observed correlation between the excess returns of equal-weighted portfolios and the degree of market prosperity were of particular interest for this study.

Hwang, Xu and In (2018) proposed an alternative explanation of why equal-weighted portfolios outperform optimal portfolios, but those naive strategies bear higher tail risks. Therefore, the resulting portfolio returns took a more concave shape (especially portfolios with a large number of equities) while maintaining excess returns. Thus, Hwang et al. (2018) explained the excess returns as compensation for bearing increased tail risk as well as the concavity of the returns.

Table 2 shows a summary of the evidence of outperformance of equal- over value-weighted portfolios found in the literature reviewed.

Table 2: Summary of evidence in literature

Findings	**Evidence in literature**
Higher Total mean return	Atchison et al., 1987; Breen et al., 1989; Canina et al., 1998; Grinblatt & Titman, 1989; Hwang et al., 2018; Lessard, 1976; Ohlson & Rosenberg, 1982; Roll, 1981
Lower Total mean return	Fletcher, 2011
Higher Volatility	Atchison et al., 1987; Breen et al., 1989; Canina et al., 1998; Grinblatt & Titman, 1989; Hwang et al., 2018; Lessard, 1976; Ohlson & Rosenberg, 1982; Roll, 1981
Higher Maximum drawdown	Plyakha et al., 2014, 2015
Higher Sharpe ratio	DeMiguel et al., 2009; Farinelli et al., 2008; Guo et al., 2018; Hwang et al., 2018; Jacobs et al., 2014; Jiang et al., 2018; Malladi and Fabozzi, 2017; Plyakha et al., 2012
Higher Treynor ratio	Brown et al., 2013; Hwang et al., 2018; Plyakha et al., 2015
Higher Jensen's alpha	Jacobs et al., 2014; Plyakha et al., 2015
Higher Sortino ratio	Plyakha et al., 2015; Post et al., 2018
Higher Information ratio	No research found

Source: Own research

2.6 Theoretical background of research hypotheses

In the following section, the theoretical background of the performance measures was illustrated.

First, the research compared total mean return, volatility, maximum drawdown and performance success ratio (number of positive versus negative quarters) with descriptive statistics such as the test of two means of equal-weighted and value-weighted portfolios (pursuant to hypothesis 1).

Second, the study measured the risk-return tread-off utilising the Sharpe ratio (Sharpe, 1964), Treynor ratio (Treynor, 1966), Jensen's alpha (Jensen, 1968), Sortino ratio (Sortino, 1981) and Information ratio (Treynor & Black, 1973). A table highlighting all mentioned performance metrics (pursuant to hypotheses 2, 3, 4, 5, 6) and the unit of measure were listed below:

Table 3: Tested performance metrics

Performance metric	Subject of measurement:	References
Sharpe ratio	Portfolio excess return divided by the standard deviation of the excess returns	Goetzmann et al., 2002; Guo et al., 2018a, 2018b; Ledoit and Wolf, 2008; Memmel, 2003; Plyakha et al., 2015; Sharpe, 1964, 1970, 1975
Treynor ratio	Portfolio excess return divided by the covariance of the portfolio and market return	Bauman & Miller, 1994; Elton & Gruber, 1997; Goel, Sharma & Mehra, 2019; Hübner, 2005; Plyakha et al., 2015; Treynor, 1966; Treynor & Black, 1973; Treynor & Mazuy, 1966
Jensen's alpha	Average portfolio return less the sum of risk-free rate and the product of beta and the excess market return.	Elton, Gruber & Blake, 1996; Fama, 1991, 1998; Grinblatt & Titman, 1987, 1989, 1992; Lehmann, 1990; Ledoit & Wolf, 2008; Jensen, 1968, 1972; Plyakha et al., 2015
Sortino ratio	Average portfolio return less the desired target return divided by the Target downside deviation	Markowitz, 1952; Plyakha et al., 2015; Rollinger & Hoffman, 2013; Sortino, 1981; Sortino & Price, 1994; Sortino & Van Der Meer, 1991
Information ratio	Average excess return over benchmark divided by the standard deviation of the excess return	Goodwin, 1998; Grinold, 1989; Grinold & Kahn, 1995; Huij & Derwall, 2011; Ledoit & Wolf, 2008; Treynor & Black, 1973

Source: Own research

These performance measures, while computed utilising historical data, predicted relationships. For theoretical discussions, ex-ante data could be utilised, whereas for practical implementations academia was focussed on ex-post data. This study was focussed on ex-post results to calculate the performance measures.

2.6.1 Sharpe ratio (pursuant to hypothesis 2)

More than half a century ago, Sharpe (1964, 1975) created a performance measure of the desirability of an investment. The Sharpe ratio had been a well-researched performance measure in academic literature and was widely used as the performance measurement in business (Horowitz, 1966; Treynor & Black, 1973; Hodges, Taylor & Yoder, 1997; Goetzmann, Ingersoll, Spiegel & Welch, 2002; Ledoit & Wolf, 2008; Guo et al. 2018). The Sharpe ratio was calculated by dividing the excess of the average period return over the risk-free rate by the standard deviation of the risky investment or portfolio. Thus, the Sharpe ratio compounded the total risk of an investment and, therefore, was employable to illustrate the risk if an investor were to place all (or most) of her or his wealth in one investment or portfolio (Sharpe, 1975). When comparing risky investment opportunities, all else equal, a higher Sharpe ratio was found to be better.

The calculation of the ex-post Sharpe ratio was defined as the division of the excess return over the standard deviation ($SD(XR_t)$) of that return of that portfolio. The excess return (XR_t) was the difference of the period return (one month) of that portfolio and the risk-free rate. Usually, the 10-year government bond expiring at the end of the period (month) is utilised as the risk-free rate.

Thus, the Sharpe ratio was denoted like this:

Equation 6: The Sharpe ratio

$$\text{Ex-post Sharpe ratio} = \frac{\frac{1}{T}\sum_{t=1}^{T} XR_t}{SD(XR_t)}$$

Where:

XR_t	=	$r_i - r_f$ = total mean-return of portfolio (i) – risk-free rate
$SD(XR_t)$	=	Standard deviation of portfolio excess returns (i)

The ex-post Sharpe ratios had two clear advantages (Sharpe, 1975): first, the ease of calculation. Second, it was backwards-looking and, therefore, suitable to evaluate past investment performance. However, this meant the ex-post Sharpe ratio had only limited predictability of the future, since it was based on historical averages.

Furthermore, there were also more general flaws associated with the Sharpe ratio, as it could not discriminate between upward and downward volatility (Rollinger & Hoffman, 2013). Hence, it could not distinguish between good or bad news (no investor would complain about high upside volatility but low downside volatility, since this is what most investors were striving for (Markowitz, 1952). This return pattern was also known as a positively skewed return distribution. Higher upside volatility would increase the denominator of the ratio, thus, lowering the ratio. The Sharpe ratio could, therefore, be increased by removing the most significant return contributing investments, which were fallacious (Dowd, 2000).

Compounding the above findings, Memmel (2003) found that the above-described flaw of the Sharpe ratio implied that if the return distribution was non-normal, the performance metric was not adequate. The Sharpe ratio, as such, was as a consequence a poor performance measure to evaluate positively skewed distributions of return (Ledoit &

Wolf, 2008), as positively skewed returns, could be realised with less risk to what the Sharpe ratio suggested. Rollinger and Hoffman (2013) argued that this conversely implies that negatively skewed return distributions are riskier than the Sharpe ratio predicts.

Finally, ex-post Sharpe ratios utilised average returns and volatilities, and, thus, were constant over time. Ledoit and Wolf (2008), as well as Rollinger and Hoffman (2013), found that Sharpe ratios did not provide information regarding the origin of time-varying risk premiums. Goetzmann et al. (2002) found that long-term investment portfolios typically had Sharpe ratios between 0.50 and 0.90.

Since Sharpe ratios incorporated the total risk or composite risk, the following section discussed the Treynor ratio, a performance metric for systematic risk.

2.6.2 Treynor ratio (pursuant to hypothesis 3)

Treynor and Mazuy (1966) created another risk-adjusted measure to evaluate portfolio performance as a significant extension of the CAPM utilising the SML. The Treynor ratio, similar to the Sharpe ratio was a risk-adjusted measurement of return. The significant difference between the two ratios was that unlike the Sharpe ratio which utilised the standard deviation, or total risk, the Treynor ratio used the beta, or market risk (Treynor, 1966). The Treynor ratio just like the Sharpe ratio was an equally recognised performance metric for portfolio performance in literature and practice (Elton & Gruber, 1997; Bauman & Miller, 1994; Goel et al., 2019). The systematic risk was found to be a significant source of risk for portfolios and had played a significant role in portfolio construction (Chen & Brown, 1983; Statman, 1987). When comparing risky investment opportunities, all else equal, a higher Treynor ratio was found to be better.

The Treynor ratio utilised the SML, and hence, could be calculated by dividing the total excess return of the portfolio by beta:

Equation 7: The Treynor ratio

$$TR_i = \frac{\bar{r}_i - \bar{r}_f}{\beta_i}$$

Where:

$\bar{r}_i$ = Average total mean return of the portfolio

$\bar{r}_f$ = Average risk-free rate

β_i = Beta of the portfolio

Treynor ratios, just like the Sharpe ratios, had the same two advantages (Sharpe, 1975; Treynor & Black, 1973; Hübner, 2005): first, was the ease of calculation. Second, that it was backwards-looking and, therefore, adequate to evaluate past investment performance. However, this meant the that Treynor ratio had only limited predictability of the future based on historical averages (Treynor & Black, 1973).

Hübner (2005) listed a wide array of flaws of the Treynor ratio, most notably the high dependency of the ratio on the appropriate benchmark to derive beta. Further, it was merely a ranking tool regarding the systematic risk, but not total-risk. Therefore, portfolios with the same systematic risk, but differing total risk, were ranked equally. Thus, the less diversified portfolio or the portfolio with the higher total risk could, erroneously, be priced identical.

2.6.3 Jensen's Alpha (pursuant to hypothesis 4)

The Jensen's Alpha performance metric (or Jensen's performance index to evaluate mutual fund performance) was first developed by Jensen (1968). It described the excess portfolio return over the theoretical expected return. Therefore, similar to the Sharpe ratio and Treynor ratio, Jensen's Alpha was a risk-adjusted measurement of return but outlined the residual risk of an investment (Lehmann, 1990). A fairly priced security, according to CAPM, was defined as having an alpha of zero (Jensen, 1968). A positive alpha indicated the presence of abnormal returns and, hence, the asset's return was higher than the risk-adjusted return and was therefore priced too low (Jensen, 1972). Conversely, a negative alpha indicated that an asset was priced too high and had not earned the expected return. Thus, investors, in order to maximise their returns, were seeking investments that bear higher positive alpha.

However, the concept of investments repeatedly earning higher alphas had been criticised by many researchers in the financial field, most notably Fama (1998). Fama (1991, 1998) argued that financial markets were too efficient, which in turn prohibits earning positive alpha continually, except for by chance. Despite criticism, Jensen's Alpha, in conjunction with the Sharpe ratio and Treynor ratio, were used as a widespread performance metric to evaluate portfolios (Jobson & Korkie, 1981; Grinblatt & Titman, 1987, 1989; Hübner, 2005; Ledoit & Wolf, 2008).

Jensen's alpha stands solely for the alpha in the Treynor ratio equation for the ex-post measure of excess return:

Equation 8: Jensen's alpha

$$\bar{r}_i = \alpha_i + \beta_i \bar{r}_m$$

Rearranged the equation resulted in the following formula:

$$\alpha_i = \bar{r}_i - (r_f + \beta_i(\bar{r}_m - \bar{r}_f))$$

Where:

α_i	=	Jensen's alpha
$\bar{r}_i$	=	Average return
$\bar{r}_f$	=	Average risk-free rate
$\bar{r}_m$	=	Average market return
β_i	=	Beta of the underlying security

The Jensen's alpha was roughly equivalent to the Treynor ratio, but admittedly easier to interpret as it quantified the additional return above the SML (Hübner, 2005). Therefore, the Treynor ratio denotes nothing different than Jensen's alpha per unit of systematic risk, which was the original performance metric devised by Treynor and Mazuy (1966).

As indicated above, Jensen's alpha was not without criticism, since the efficient market hypothesis stated that excess returns, and hence alpha, could solely be derived from chance or luck (Malkiel, 2003; Lo, 2017). Additionally, there was more focussed criticism such as the dependence of alpha on beta, since the cogency of the hypothesis was determined by a perpetual beta in the portfolio (Grinblatt & Titman, 1989, 1992). A perpetual beta meant that the portfolio weights were not changed according to the expectation of the future.

Finally, since Jensen's alpha was an absolute measure, a riskier fund was likely to have a higher alpha than a less risky fund. Thus, alpha did not show the total risk of the fund (Elton et al., 1996).

2.6.4 Sortino ratio (pursuant to hypothesis 5)

The Sortino ratio, developed by Sortino (1981) and later refined by Sortino and Van Der Meer (1991), was created to address the shortcomings of the Sharpe ratios. To recap, the Sharpe ratio had two glaring flaws: the inability to differentiate between upside or downside volatility and the inability to analyse non-normal distributed returns for both negatively and positively skewed returns (Rollinger & Hoffman, 2013). The Sortino ratio was created to address the first problem and isolated the downside volatility from total volatility (Sortino & Price, 1994). The Sortino ratio was defined as the excess return over a specific benchmark divided by the downside deviation. Therefore, the Sortino ratio allowed investors to analyse portfolio returns for a pre-defined level of risk; this is linked back to Markowitz's (1952) MPT which argued that only downside deviation and not standard deviation was the relevant measure of risk. Nevertheless, at this point, Markowitz used variance instead of downside deviation, because of the lack of computational capacity at the time.

The Sortino ratio was defined as the average period return, less the target (benchmark) return (or minimum acceptable return) divided by the target downside deviation:

Equation 9: The Sortino ratio

$$S = \frac{\bar{r} - t}{TDD}$$

Where:

$\bar{r}$ = Average portfolio period return

t = Desired target return

TDD = Target downside deviation

The target downside deviation, as indicated above, was calculated by the root-mean-square of the portfolio return less the target benchmark return:

Equation 10: Target downside deviation

$$TDD = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Min(0, r_i - t)^2)}$$

Where:

N = Total number of returns

r_i = Portfolio return in period i

t = Desired target return

2.6.5 Information ratio (pursuant to hypothesis 6)

The Information ratio was yet another performance metric created by Treynor and Black (1973) to address the flaws of the Sharpe ratio (Sharpe, 1966). While the Sharpe ratio related excess returns to total risk, the Information ratio eliminated market risk, since it only considered the actual risk taken by investors (Goodwin, 1998; Hallerbach, 2005). The ratio was recognised as the most relevant ratio to evaluate portfolio performance (Grinold, 1989; Goodwin, 1998). The Information ratio was defined as the excess return (portfolio return less benchmark return) per unit of volatility in excess return of a portfolio:

Equation 11: The Information ratio

$$IR = \frac{\overline{XR}}{\sigma_{ER}}$$

Where:

$\overline{XR}$ = Average excess portfolio return over benchmark return

σ_{ER} = Standard deviation of excess return

Building on Markowitz's mean-variance paradigm, the Information ratio was created to summarise the mean-variance properties in a single measure. Since the excess return standard deviation could not be negative, positive excess returns translated into a positive Information ratio. Grinold and Kahn (1995) stated the following ratio categories without empirical basis:

Table 4: Information ratio categories

Information ratio	Verdict	Percentile
1.0	Exceptional	90
0.5	Good	75
0	Above average	50
-0.5	Below Average	25

Source: Adapted from Grinold and Kahn (1995)

Later these categories were challenged by Goodwin (1998), since maintaining a high Information ratio over a prolonged time period was indeed difficult, as two of the examined active investment styles (core, value, growth, small-cap, international and bonds) would not be rated as “good” by Grinold and Kahn (1995).

2.7 Financial research in South Africa

The JSE is the 19th largest stock exchange in the world and largest in Africa according to market capitalisation (Atherfold, 2019). The companies of the stocks listed on the JSE fall in three main categories: resource, financial and industrial. Initially, resource companies made up more the largest share of the JSE, however, this changed during the period of this study. Currently, resource companies make up less than 15% of market capitalisation on the JSE. Unfortunately, emerging markets stock exchanges were often under-researched, since stocks listed are usually fewer in number and smaller in market capitalisation than on developed markets. Additionally, conventions and standards tend to be inferior, the market overall less liquid and more concentrated than more developed ones. The resulting markets tend to be subject to market inefficiency. The JSE is subject to this predicament (Dittberner, 2016) and the largest ten stocks make-up over 56% of the entire market (Pearson & du Toit, 2013). The active share on the JSE had been declining, just like in more developed markets, from 50% to under 15% in the last 20 years (Muller & Ward, 2011).

The general applicability of the CAPM was tested by Ward and Muller (2013) on data spanning 1986 to 2011. They found an inverse correlation between risk and return, or with other words, assets were not priced efficiently on the JSE, rendering the CAPM inapplicable. However, the general applicability and superiority of the MPT were proven by Du Plessis and Ward (2009), who tested mean-variance optimised portfolios (from 1997 to 2008) and found that they significantly outperform the market. Pearson and du Toit (2013) created minimum-variance, mean-variance as well as diversity and risk parity portfolios; they tested these against traditionally weighted indices such as the JSE ALSI and found that the newly created portfolios were outperforming the traditional ones.

2.8 Conclusion

Despite the advances in MPT, many empirical studies found that equal-weighted portfolios were an excellent method for diversification and consistently outperformed value-weighted portfolios. The naive diversifications rule of the 1/N strategy did not detract from its performance, despite a higher turnover and therefore greater transaction costs (to maintain equal weights). However, Fletcher (2011) found that the much-praised research by DeMiguel et al. (2007) was in fact market specific and lacked robustness. Despite the valid criticism and repeated challenges to the strategy, researchers found that in markets with generally high returns, the performance of equal-weighted portfolios continued to challenge modern portfolio optimisation.

Chapter 3: Research Hypotheses

After positioning this study in the academic literature, the researcher will state the research hypotheses in this chapter, followed by the methodology for testing these hypotheses in the ensuing chapter.

3.1 Hypothesis 1

The first objective of this research was to determine whether equal-weighted portfolios and value-weighted portfolios differ, regarding total mean return and volatility (Pae & Sabbaghi, 2010; Plyakha et al., 2015), maximum drawdown and performance success ratio. The objective was stated as follows:

- Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding the attributes: total return, volatility, maximum drawdown and performance success ratio.

Thus, the first hypothesis was subdivided into five parts and presented in the next sections.

3.1.1 Hypothesis 1a: Total mean return

The null and alternative hypotheses for testing the statistical difference between equal-weighted and value-weighted portfolios, regarding total mean return on the JSE domestic context were stated as follows:

Null hypothesis one (a) (**$H1a_0$**): Up to a 95% confidence level, equal-weighted portfolios had the same total mean return as value-weighted portfolios.

Alternate hypothesis one (a) (**$H1a_1$**): Beyond a 95% confidence level, equal-weighted portfolios did not have the same total mean return as value-weighted portfolios.

3.1.2 Hypothesis 1b: Volatility

The null and alternative hypotheses for testing the statistical difference between equal-weighted portfolios and value-weighted portfolios, regarding volatility on the JSE domestic context, were as follows:

Null hypothesis one (b) (**$H1b_0$**): Up to a 95% confidence level, equal-weighted portfolios did bear the same volatility than value-weighted portfolios.

Alternate hypothesis one (b) (**$H1b_1$**): Beyond a 95% confidence level, equal-weighted portfolios did not bear the same volatility than value-weighted portfolios.

3.1.3 Hypothesis 1c: Maximum drawdown

The null and alternative hypotheses for testing the statistical difference between equal-weighted and value-weighted portfolios, regarding maximum drawdown on the JSE domestic context were as follows:

Null hypothesis one (c) (**$H1c_0$**): Equal-weighted portfolios did not have a greater maximum drawdown compared to value-weighted portfolios.

Alternate hypothesis one (c) (**$H1c_1$**): Equal-weighted portfolios did have a greater maximum drawdown compared to value-weighted portfolios.

3.1.4 Hypothesis 1d: Performance success ratio

The null and alternative hypotheses for testing the statistical difference between equal-weighted and value-weighted portfolios, regarding performance success ratio on the JSE domestic context were as follows:

Null hypothesis one (d) (**$H1d_0$**): Equal-weighted portfolios did not have a higher performance success ratio compared to value-weighted portfolios.

Alternate hypothesis one (d) (**$H1d_1$**): Equal-weighted portfolios did have a higher performance success ratio compared to value-weighted portfolios.

3.2 Hypothesis 2: Sharpe ratio

The study´s second objective was to determine whether the findings regarding higher Sharpe ratio by DeMiguel et al. (2009), Jacobs et al. (2014), Plyakha et al. (2015) and Hwang et al. (2018) could be replicated on the JSE. Their research found a statistically significant higher Sharpe ratio of equal-weighted than value-weighted portfolios. The objective was stated as follows:

- Determine whether equal-weighted portfolios and value-weighted portfolios on the JSE differ statistically regarding the Sharpe ratio.

The null and alternative hypotheses for testing the findings of DeMiguel et al. (2009), Jacobs et al. (2014), Plyakha et al. (2015) and Hwang et al. 2018 regarding Sharpe ratios on the JSE were as follows:

Null hypothesis three ($\mathbf{H2a_0}$): Up to a 95% confidence level, equal-weighted portfolios did not have a higher Sharpe ratio compared to value-weighted portfolios.

Alternate hypothesis three ($\mathbf{H2a_1}$): Beyond a 95% confidence level, equal-weighted portfolios did have a higher Sharpe ratio compared to value-weighted portfolios.

3.3 Hypothesis 3: Treynor ratio

The study's third objective was to determine whether the findings by DeMiguel et al. (2009), Brown et al. (2013), Plyakha et al. (2015) and Jiang et al. (2018) could be replicated on the JSE regarding whether equal-weighted portfolios statically significant outperformed value-weighted portfolios regarding the Treynor ratio. The objective was stated as follows:

- Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding the Treynor ratio.

The null and alternative hypotheses for testing the findings of DeMiguel et al. (2009), Brown et al. (2013), Plyakha et al. (2015) and Jiang et al. (2018) regarding Treynor ratios on the JSE were as follows:

Null hypothesis two ($\mathbf{H3_0}$): Up to a 95% confidence level, equal-weighted portfolios did not have a higher Treynor ratio compared to value-weighted portfolios.

Alternate hypothesis two (**$H3_1$**): Beyond a 95% confidence level, equal-weighted portfolios did have a higher Treynor ratio compared to value-weighted portfolios.

3.4 Hypothesis 4: Jensen's alpha

The study's fourth objective was to determine whether the findings by Jacobs et al. (2014) could be replicated on the JSE regarding whether there was a statistically higher performance of equal-weighted portfolios compared to value-weighted portfolios regarding the Jensen's alpha. The objective was stated as follows:

- Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding Jensen's alpha

The null and alternative hypotheses for testing the findings of Jacobs et al. (2014) regarding Jensen's alpha on the JSE, were as follows:

Null hypothesis two (**$H4_0$**): Up to a 95% confidence level, equal-weighted portfolios did not have a higher Jensen's alpha compared to value-weighted portfolios.

Alternate hypothesis two (**$H4_1$**): Beyond a 95% confidence level, equal-weighted portfolios did have a higher Jensen's alpha compared to value-weighted portfolios.

3.5 Hypothesis 5: Sortino ratio

The study's fifth objective was to determine whether the findings by Plyakha et al. (2015) and Post et al. (2018) could be replicated on the JSE, whether equal-weighted have a statistically significant higher Sortino ratio than 1.0 benchmarked by their value-weighted portfolio pair. The objective was stated as follows:

- Determine the Sortino ratio of the equal-weighted portfolio benchmarked over the value-weighted portfolios on the JSE

The null and alternative hypotheses for testing the findings of Plyakha et al. (2015) and Post et al. (2018) regarding the Sortino ratio on the JSE, were as follows:

Null hypothesis two (**$H5_0$**): Up to a 95% confidence level, equal-weighted portfolios did not have a higher Sortino ratio of 2.0 or above.

Alternate hypothesis two (**$H5_1$**): Beyond a 95% confidence level, equal-weighted portfolios did have a higher Sortino ratio of 2.0 or above.

3.6 Hypothesis 6: Information ratio

The study's final objective was to determine in which of Grinold and Kahn's (1995) Information ratio categories, the individual equal-weighted portfolios fall. The objective was stated as follows:

- Determine in which of Grinold and Kahn's (1995) Information ratio categories the individual equal-weighted portfolios fall

The null and alternative hypotheses for testing in which of Grinold and Kahn's (1995) category the individual equal-weighted portfolio falls were as follows:

Null hypothesis six (**$H6_0$**): Up to a 95% confidence level, equal-weighted portfolios do not differ regarding information ratio from "1.0", "0.0" or "-0.5" respectively.

Alternate hypothesis two (**$H6_1$**): Beyond a 95% confidence level, equal-weighted portfolios do differ regarding information ratio from "1.0", "0.0" or "-0.5" respectively.

Chapter 4: Research methodology and design

4.1 Introduction to the research methodology

Chapter 4 states the research methodology for obtaining the data and details the models for testing the stated hypotheses expounded in Chapter 3. Chapter 4 is arranged as follows:

- Section 4.1 describes the research design, time horizon, unit of analysis and measurement instrument
- Section 4.2 outlines the statistical tools utilised for the hypotheses testing and assumptions made with statistical tests
- Section 4.3 states the data gathering, preparation and transformation;
- Section 4.4 shows the followed methodological research process
- Section 4.5 discuss the data analysis
- Moreover, the remainder of the section states the research limitations and concludes the methodology.

4.1.1 Philosophy, approach, strategy and methodological choices

The performance evaluation of equal-weighted and value-weighted portfolios adopted a positivist philosophy, as all observations were conducted from data in a highly structured manner (DeMiguel et al., 2009; Guo et al., 2018).

The positivistic research approach ensured a law-like generalisation when utilised in combination with the deductive approach to test of hypotheses (Saunders & Lewis, 2012). As opposed to establishing a new theory, this research aspired to test a theory (Saunders & Lewis, 2009).

Robson and McCartan (2016) defined the ontological view of a researcher as the researcher´s opinion of the environment in which he or she is conducting research. According to Hofer and Bendixen (2012), the epistemological view of the researcher is his or her opinion of what is known and unknown in the field of study. Wahyuni (2012) defines axiology as the view of the researcher on the importance of values in the field of study.

The literature reviewed by the researcher, on which this study builds, advocated for a philosophical stance for positivism in a value-free method (DeMiguel et al., 2007; Plyakha et al., 2012; Guo et al., 2018). Their research was conducted in an objective, independent manner, analysing only observable and credible data. Achinstein and Barker (1971), Healy and Perry (2000) and Bernard (2017) pointed out that the enduring theory should be used to develop the researcher's hypothesis. Once the hypotheses were formed, they were tested and proven or disproven, in part or whole, ensuring a high validity and replicability.

The research approach reflected the philosophy of positivism, as this study conducted statistical analyses on observable data from the JSE. This study statistically analysed equal-weighted and value-weighted portfolios utilising a strongly structured methodology. The objective, independent and value-free method ensured the replicability of this study on the observable and credible data. Finally, the study tested the hypotheses on the basis of the data obtained.

In nature this was a deductive study. The deductive research approach, according to Bryman and Bell (2015), referred to theoretical hypotheses with the means of a research strategy intended purely to prove or disprove. This study analysed financial data to find empirical evidence to proof or disproof of the hypotheses stated in Chapter 3. The deductive test of financial models had a long history of explaining archival financial data (Goel et al., 2019; Jobson & Korkie, 1980; Lo, 2017; Malkiel & Fama, 1970; Pilbeam, 2018; Roll, 1981).

The quantitative nature of the data allowed this study to test the hypotheses utilised statistical analyses. In accordance with Dane (2011), this study adopted a single-data collection method and, the corresponding analysis is the mono-method approach. Even though multi-methods "promise deeper and richer data", according to Saunders and Lewis (2012), no additional information could be obtained outside the mono-method approach.

The positivistic research approach, coupled with the deductive research approach ensured the ability to draw law-like generalisations (Saunders & Lewis, 2012) and, therefore, ensured high validity and replicability.

4.1.2 Time horizon

The study's time horizon was dictated by the availability of accurate and reliable historical data. Even though the JSE was founded by Benjamin Wollan in November 1887 ("History and Company Overview - Johannesburg Stock Exchange", 2016), the study covered the period from December 1987 to November 2018. As shown below in Figure 3, the population of JSE listed shares reached 160 only in December 1987. According to Neuman (2013), a time period was the characteristic, not of a cross-sectional, but a longitudinal study.

This study investigated secondary data from a single source and time series data. The JSE data was categorised as a financial market database, containing comparable variables collected at different times.

4.1.3 Data universe, population and sampling

The data universe in which this study was located were the share prices listed on the JSE as displayed below in Figure 3.

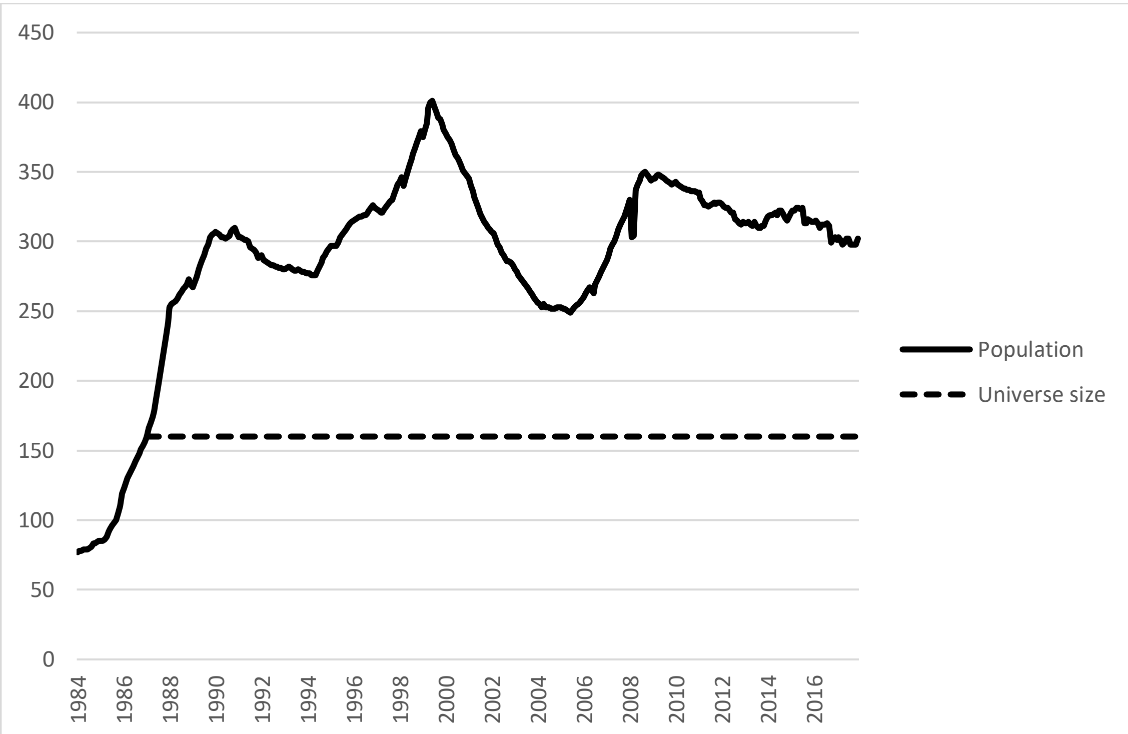

Figure 3: The population of JSE listed shares

Source: Adapted from Muller and Ward (2013)

This study utilised a non-probability, purposive and typical case-sampling approach. According to Saunders and Lewis (2012), the above-stated sampling approach required the researcher's judgement to identify representable cases, enabling the researcher to test his or her hypotheses in the best method. This study sampled the largest 160 shares according to market capitalisation. From the largest 160 companies, the monthly closing share prices for the stated time horizon were sampled. The number of companies listed had been steadily declining from 401 since September 2000 ("Number of Listed Companies: JSE", 2018) and the average number of companies listed was estimated to be 278 companies since 1984.

302 companies were listed on the main board of the JSE at the time of this study. However, this study sampled only the 160 largest shares according to market capitalisation, as they were deemed investment grade (Muller & Ward, 2013). Due to the highly concentrated nature of the JSE, the remaining shares were often illiquid and not of interest to investors and, hence, not subject to academic research (Pillay, Muller & Ward, 2010; Ratshikuni, 2009; Semnarayan, Ward & Muller, 2018)

Despite the population size being known, this study will sample only the monthly closing share prices, since a holistic approach would not be manageable in size. The researcher was limited to time and budget constraints to analyse the data. This approach was suggested by Zikmund, Babin, Carr and Griffin (2013) for large quantitative data sets. The sample in this study will represent a vast majority (99.5%) of the market capitalisation (Raubenheimer, 2011), ensuring a high validity and reliability.

From the largest 160 shares listed on the JSE, this study created different portfolios that differ mainly in the weightings of the equities. The shares were ranked according to market capitalisation (in descending order; one to 160) and then classified into the categories large-, mid-, and small-caps: the largest 40 shares, according to market capitalisation, classified as large-caps, the middle 60 classified as mid-caps and the smallest 60 were classified as small-caps, adopting the general accept categories (Bhana, 2007; Hsieh, 2015; Muller & Ward, 2013). Then the researcher constructed equal-weighted and value-weighted portfolios from the individual shares, with the weightings corresponding either to the market-capitalisation (value-weighted) or equal weights (equal-weighted).

4.1.4 Unit of analysis

While this study evaluated the performance of equal-weighted portfolios and value-weighted portfolios, the unit of analysis varied according to the individual research hypothesis. According to Pinsonneault and Kraemer (1993), the unit of analysis is the unit selected to test the research hypotheses. This study's goal was to evaluate the performance of equal-weighted and value-weighted portfolios on the JSE with multiple performance metrics, with multiple and corresponding, unit of analysis (Wegner, 2017). The unit of analysis corresponding to each hypothesis could be found in the table below:

Table 5: Unit of analysis

Hypothesis	Research test	Unit of analysis
H1a	Hypothesis t-test to determine if there is a significant difference between the mean returns of the two portfolio strategies	The total mean returns of equal- and value-weighted portfolios
H1b	Hypothesis t-test to determine if there is a significant difference between the volatility of the two portfolio strategies	The volatility of equal- and value-weighted portfolios
H1c	Comparison of the maximum drawdown of the two portfolio strategies	The maximum drawdown (before a new monotonically upwards trend in total portfolio prices) of equal- and value-weighted portfolios until the losses were recovered
H1d	Comparison of performance success ratio of the two portfolio strategies	The number of positive and negative months of equal- and value-weighted portfolios
H2	Hypothesis t-test to determine if there is a significant difference between the Sharpe ratio of the two portfolio strategies	The Sharpe ratio of equal- and value-weighted portfolios
H3	Hypothesis t-test to determine if there is a significant difference between the Treynor ratio of the two portfolio strategies	The Treynor ratio of equal- and value-weighted portfolios
H4	Hypothesis t-test to determine if there is a significant difference between Jensen's alpha of the two portfolio strategies	Jensen's alpha of equal- and value-weighted portfolios
H5	Hypothesis t-test to determine if the Sortino ratio for equal-weighted portfolios is significantly greater than 2.0	The Sortino ratio of equal- and value-weighted portfolios
H6	Hypothesis t-test to determine in which of Grinolds and Kahn's Information ratio categories the portfolios fall	The Information ratio of equal- and value-weighted portfolios

Source: Own research

4.1.5 Measurement instrument

The data analysed is quantitative numerical and continuous secondary data. According to Newman and Benz (1998), numerical data can be analysed by a broader range of statistics. They further stated that continuous data can take any value, which is sometimes restricted to a certain range. This is true for portfolio returns; however, portfolios returns are limited at the lower end to -100%, or total loss of capital. On the upper end there is, theoretically, no limit, yet usually double the average total mean return was rarely observed on the JSE (15%) per year (Small & Hsieh, 2017).

The continuous data were processed with Microsoft® Excel (version 16) and STATA® (version 15). The researcher did not influence the data with coding; the JSE had already coded the secondary data. Saunders and Lewis (2012) suggested that data cleaning or data scrubbing should be used to find outliers, illegitimate codes, illogical relationships, and if the right filter is applied. The high-quality secondary data eliminated the necessity for this process.

4.1.6 Research ethics

The secondary data utilised in this study consists of portfolio values of underlying asset prices and the South African government's ten-year bond rate, therefore, it could be obtained from public sources. No human data had been utilised in this study and, hence, ethical concerns linked to human data gathering were not of concern. However, data sources required that the data may not be used for commercial purposes.

Finally, the scope of this study was at no point concerned with any human factors such as race, gender, or other such factors.

4.2 Statistical models

4.2.1 Student T-test

This study used the traditional approach of most equivalent studies to test for significant differences in the unit of analysis: the student t-test (Corrado, 1989; Fletcher, 2011; Gibbons et al., 1989; Malladi & Fabozzi, 2017; Pae & Sabbaghi, 2010). The student t-test was developed by Gosset who published his work on the probable error of a mean under the pseudonym "Student" (Student, 1908). The statistical test provided researchers with a method to test hypotheses regarding the mean of a sample even if the standard deviation is not known. The test compared the two averages, identified if they were different from one another and quantified the significance of the differences. The test enabled so by assuming the standard normal (Gaussian) distribution of the sample distributions. The t distributions, could be displayed by a family of curves according to the number of degrees of freedom. The number of degrees of freedom of a sample were defined as independent observations – less one. The t-distribution approached the shape of the normal standard distribution bell curve when the sample size and, therefore, the degrees of freedom, increased.

The procedure of testing was as followed:

First, the null and alternative hypotheses had to be formulated;

- Generally, the null hypothesis (H_0) stated: "Any differences, discrepancies, or suspiciously outlying results are purely due to random and not systematic errors".
- The alternative hypothesis (H_1) always stated the exact opposite

The test could be two-tailed (the two sample means were not equivalent), or one-tailed (sample mean was larger/smaller than the hypothesised population mean). Further, the level of significance was chosen to be p = 0.05, and then the t-test value was calculated as followed:

Equation 12: Student's T-test

$$t = \frac{\mu_a - \mu_b}{\sqrt{\frac{S^2}{df_a} + \frac{S^2}{df_b}}}$$

Where:

μ = mean of sample or population respectively

df = degrees of freedom of sample or population respectively

S^2 represented the estimators of the common variance of the two samples and could be calculated as followed:

Equation 13: Estimator of the pooled standard deviation

$$S^2 = \frac{\sum x - \mu_a + \sum x - \mu_b}{df_a + df_b - 2}$$

The p-value was the counterpart to the t-value and was a predefined confidence level, since the p-value indicated the probability of the results occurring by luck or chance. Therefore, p-values could range from 0.0 to 1.0 (0% to 100%), and the lower, the observed p-value was, the lower the chance that the results of the experiment were a coincidence. In academic literature, p-values of 0.05 were an accepted level of significance.

Therefore, if the observed t-test value was larger (or more extreme) than the critical value ($p = 0.05$), the null hypothesis had to be rejected.

4.2.2 Testing for errors

According to Wegner (2017), two errors were recognised with testing any hypothesis;

- **Type I error** denotes the incorrect rejection of a true null hypothesis (H_0); and
- **Type II error** denotes the incorrect acceptance of a false null hypothesis (H_0).

Unfortunately, the two errors were inversely correlated: by reducing the probability of the type I error, the probability of sustaining a type II error increases. This study controlled the probability for incurring a type I error by setting the critical limits for areas of rejection and acceptance to a, generally considered a fair compromise between the two different risks at a 95% level confidence.

4.3 Data gathering, preparation and transformation

4.3.1 Data gathering process

The researcher obtained the long-term government bond rate (OECD descriptor ID: IRLTLT01) from Tlotliso Phakisi, Investment Analyst at Cannon Asset Managers.

The researcher obtained the JSE data from Chris Muller and Mike Ward – both respected scholars in the field of finance and financial modelling. The researcher collaborated with them to obtain the required data set for this study from their larger data set. Multiple studies based on this dataset have been published (Muller & Ward, 2013; Taljaard, Ward & Muller, 2012, 2015).

The data collection was uncomplicated, and despite JSE data being publicly available, the study benefitted immensely from Muller and Ward's cleaned and comprehensive dataset. Their data cleaning methodology was described in the section below.

4.3.2 Data preparation

The dataset included companies, listed and delisted on the JSE, over the course of 1987 to 2018. Shares that were delisted within a quarter were thereafter treated with a zero return. Following the same reasoning, delisted shares were dropped at the end of the quarter with their final trading price, while newly listed shares (IPOs) were included at the beginning of the next quarter. Name changes were tracked and backwards adjusted for.

Further, the dataset was adjusted backwards in the time series data for changes in share prices resulting from share splits or consolidations. Company spinoffs were also taken into consideration and adjusted for (returns from them were included in the parents return for the quarter of the spinoff and treated individually from there onwards).

Since this study investigates total return, cash pay-out, scrip and stock dividends were added to the share price.

However, the dataset was not adjusted to accommodate for

- share buybacks as those affect only devesting investors and
- stock compensations granted to managers.

Finally, data errors were accommodated by treating any daily return, which was greater than ±40%, as a zero daily return, and only on the day those occurred.

4.3.3 Data transformations

The portfolios were constructed in the following manner: The J203T (the value-weighted index of the top 160 companies) was first created in June 2002 and, hence, it had to be recreated as the portfolios under investigation were based on it. Figure 4 displayed the J203T monthly total returns over the period 1987 to present, the reconstruction as well as the relative difference. The red coloured relative difference displayed a slightly higher return for the period of 2003 to 2006 indicating a small discrepancy of the reconstruction to the J203T. However, these gradually declined over the remaining period and, thus showed the accuracy of the reconstruction.

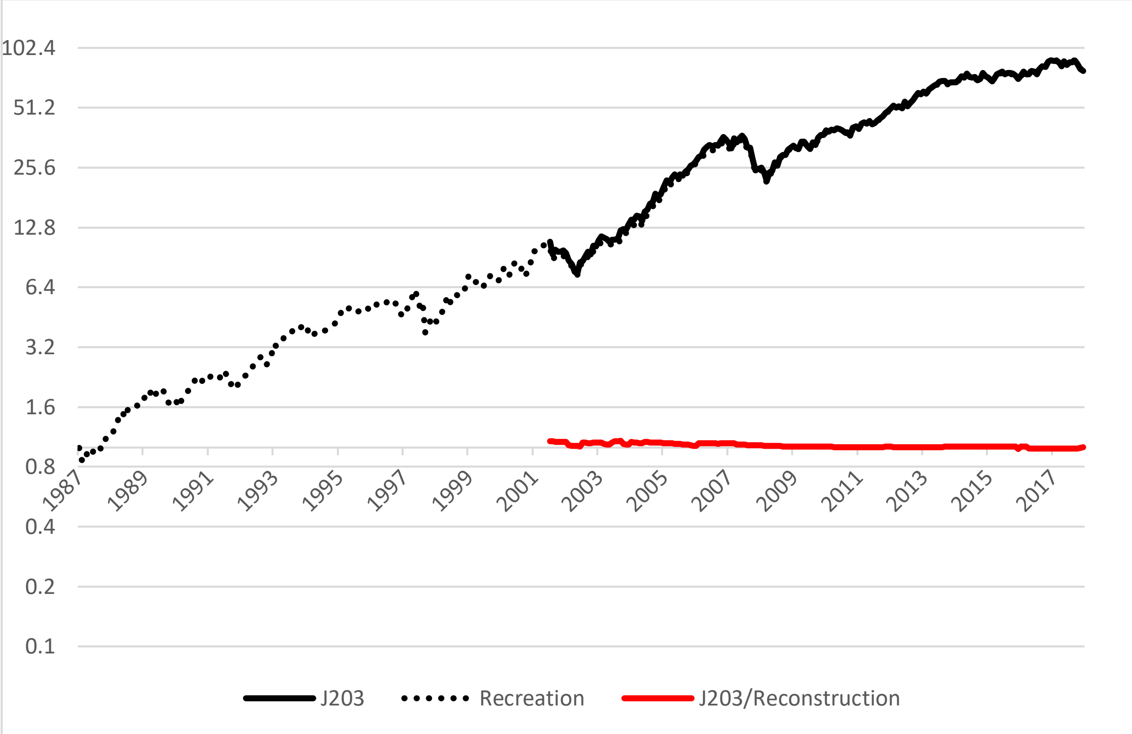

Figure 4: J203T vs reconstruction

Source: Adapted from Muller and Ward (2013)

The reconstructed J203T was then subdivided into three commonly used categories: large-, mid-, and small-cap shares. Large-caps consisted of the largest 40 companies, mid-caps, of the remaining 60 largest companies and small-caps, of the 60 smallest companies.

Equal-weighted portfolios were constructed from the large-, mid-, and small-cap shares utilising the 1/N rule. Further, the J203T also formed the basis of the value-weighted portfolios creating portfolio pairs regarding the categories mentioned above. Hence, a total of six portfolio types were created.

The portfolios were constructed on a “rolling-sample” (or “rolling-window”), which was a widely adopted approach to access the performance of security markets (DeMiguel et al., 2007). The investment window length was chosen to be 12, 36, 60, and 120 months. This most accurately represents different investors´ behaviour with different investment horizons. The portfolios were quarterly rebalanced.

Equal-weighted portfolios will be constructed to beat the market in terms of a benchmark, the value-weighted portfolios. The overarching research question arises as to whether there are any misjudgements of prices on the capital market of the JSE and equal-weighted portfolios can consistently beat the benchmark. The benchmark is the value-weighted portfolio pair (the same investment period with the same investment and divestment point in time).

Finally, the total monthly total mean returns were calculated from total portfolio prices.

4.4 The methodological process

This study followed Muller and Ward’s (2013) and DeMiguel’s et al. (2007) approach and compared the cumulative total return (H1a), volatility (H1b), maximum drawdown (H1c) and performance success ratio (H1d), over the period from 1987 to 2018. The cumulative returns comparison (thus, total price movements), despite being a simple visual approach, was found to be superior, compared to average monthly/quarterly returns (Muller & Ward, 2013).

Additionally, this study followed the traditional approach of most researchers to evaluate the portfolio performance (Gibbons, Ross & Shanken, 1989; Malladi & Fabozzi, 2017; Pae & Sabbaghi, 2010) and utilised the multi-variate and t-test to test for significant difference in the results on all rolling window portfolio pairs. This allowed testing the portfolio’s significant differences, not only of total mean returns (H1a) and volatility (H1b), but also the ratios mentioned, regarding (H2 to H5).

Table 6: Overview of analysis

Testing approach	DeMiguel's et al. (2007) approach	Traditional portfolio analysis
H1a	✓	✓
H1b		✓
H1c	✓	
H1d	✓	
H2		✓
H3		✓
H4		✓
H5		✓
H6		✓

Source: Own research

4.5 Testing hypotheses

4.5.1 Testing hypothesis 1

4.5.1.1 Testing hypothesis 1a: Total returns

STATA 15 was used to generate descriptive statistics for each of the six cumulative portfolio total mean returns.

STATA 15 was used to perform a multi-variate and t-test for a significant difference in total mean return of all three portfolio pairs and each investment period (12, 36, 60, and 120 months).

This study will follow Plyakha et al. (2012) closely to compare total returns.

4.5.2.2 Testing hypothesis 1b: volatility

STATA 15 was used to generate descriptive statistics of the volatility for each of the six cumulative portfolio returns.

STATA 15 was used to perform a multi-variate and t-test for a significant difference in mean volatility of all three portfolio pairs and each investment period (12, 36, 60, and 120 months).

This study will follow Plyakha et al. (2012) closely to compare volatility.

4.5.2.3 Testing hypothesis 1c: Maximum drawdown

Excel 16 was used to calculate the maximum drawdown of each portfolio strategy and compared visually. This study will follow Plyakha et al. (2012) closely to compare maximum drawdown.

4.5.2.4 Testing hypothesis 1d: Performance success ratio

Excel 16 was used to calculate the performance success ratios of each portfolio strategy and then compared visually.

4.5.3 Testing hypothesis 2: Sharpe ratio

STATA 15 was used to perform a multi-variate and t-test for a significant difference in mean Sharpe ratios of all three portfolio pairs for each investment period (12, 36, 60, and 120 months).

This study will follow closely Malladi and Fabozzi (2017) as well as Ledoit and Wolf (2008) to test for excess Sharpe ratios of equal-weighted over value-weighted portfolios.

4.5.4 Testing hypothesis 3: Treynor ratio

STATA 15 was used to perform a multi-variate and t-test for a significant difference in mean Treynor ratio of all three portfolio pairs for each investment period (12, 36, 60, and 120 months).

This study will follow closely Plyakha et al. (2012) as well as Van Dyk, Van Vuuren and Styger (2012) to test for excess Treynor ratios of equal-weighted over value-weighted portfolios.

4.5.5 Testing hypothesis 4: Jensen's alpha

STATA 15 was used to perform a multi-variate and t-test for a significant difference in mean Jensen's alphas of all three portfolio pairs for each investment period (12, 36, 60, and 120 months).

4.5.6 Testing hypothesis 5: Sortino ratio

STATA 15 was used to perform a multi-variate and t-test for a significant difference in mean Sortino ratios of all three portfolio pairs for each investment period (12, 36, 60, and 120 months).

4.5.7 Testing hypothesis 6: Information ratio

STATA 15 was used to perform a t-test in which Information ratio category the six portfolios would fall for each investment period (12, 36, 60, and 120 months).

4.6 Research limitations apparent prior to analysis

This study was limited to the largest 160 companies listed on the JSE for the duration of December 1987 until November 2018; hence, no generalisation to unlisted companies in South Africa could be made. Also, generalisations about micro-caps listed on the JSE were not be made, since those shares were not investment grade and therefore illiquid and subject to considerable volatility. Finally, since the success of the equal-weighted portfolio strategy was proven to be market- and data-specific (DeMiguel et al., 2007; Fletcher, 2011) no generalisations were be made for other equity markets.

The second limitation this study encountered was the problem, especially common for financial researchers in emerging markets, of the lack of accurate, reliable as well as comprehensive data. South Africa's financial market data was often incomplete, limiting the time horizon of the study.

The study utilised the rolling window approach with quarterly rebalancing but not transaction costs. Other studies have rebalanced monthly (Maillard et al., 2008; Plyakha et al., 2012; Roncalli & Weisang, 2016). Rebalancing, however, was found by Guo et al. (2018), not to have a substantial effect, since additional transaction costs marginalise eventual gains.

The choice of testing, the t-test, is known to statistically weak, yet it is the traditional and preferred method of researchers to test for differences of portfolios.

Since no formal explanation was presented with regards to the reasons for the performance success of the equal-weighted portfolio strategy, the explanation was hypothesised.

4.7 Conclusion of the methodology

This chapter elaborated on the research methodology to test the hypotheses stated in Chapter 3. The hypotheses have been researched in other international equity markets. This research adopted the research methodology from previous studies but acknowledges of the limitations of the study design. The following chapter outlines the statistical results of this study.

Chapter 5: Results

5.1 Introduction to results

Chapter 5 was arranged according to the methodology discussed in Chapter 4.

For the remainder of the chapter, the results were generated in the following way, unless otherwise stated. First, the descriptive statistics were generated, followed by a table of the confidence intervals. Then a multivariate inferential analysis was conducted to indicate differences between each variable and finally a t-test of which portfolio performed significantly better on average was conducted. The descriptive statistics for all hypotheses were arranged according to hypothesis in Appendix III: Descriptive statistics.

The general convention of codes used to describe the variables in this chapter can be explained by the following example "H1a_L_EqW_1yr":

- The first part "H1a" described the unit of analysis (in this instance total mean returns)
- Second, the portfolio category was denoted as follows:
  - "L" for large-caps
  - "M" for mid-caps
  - "S" for small-caps
  - "X" for the ALSI index recreation
- Third, the code indicated if it was an equal-weighted or value-weighted portfolio (EqW or CapW)
- Finally, the investment length was stated (1yr, 3yr, 5yr, and 10yr).

The following Chapter 6 discussed the results presented in this chapter.

5.2 Results for testing hypothesis 1

The first objective of this research was to determine whether equal-weighted and value-weighted portfolios differ, regarding total mean return, volatility (Pae & Sabbaghi, 2010; Plyakha et al., 2015), maximum drawdown and performance success ratio. The objective was stated as follows:

- Determine whether equal-weighted and value-weighted portfolios on the JSE differ regarding the attributes: total return, volatility, maximum drawdown and performance success ratio.

Thus, the first hypothesis was subdivided into five parts and presented in the next sections.

5.2.1 Results for testing H1a: Total mean returns

Figure 5 displayed the cumulative returns for each of the eight different portfolio strategies on a logarithmic scale. The first observation was that all portfolios are closely aligned and follow the same trends. Out of the six equal-weighted and value-weighted portfolio strategies, only the mid-cap equal-weighted ones could consistently beat the market, while all other strategies failed.

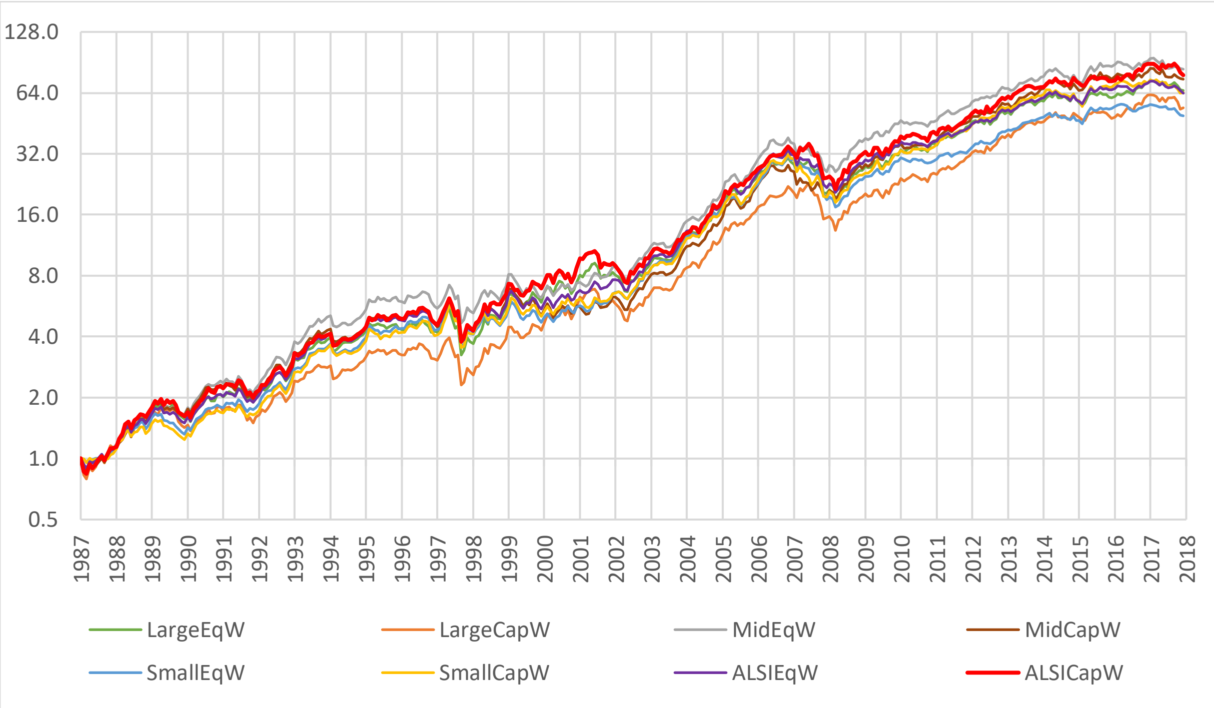

Figure 5: Log returns of all portfolios

Source: Own research

A clearer picture of the performance of each portfolio strategy could be formed from observing Figure 6.

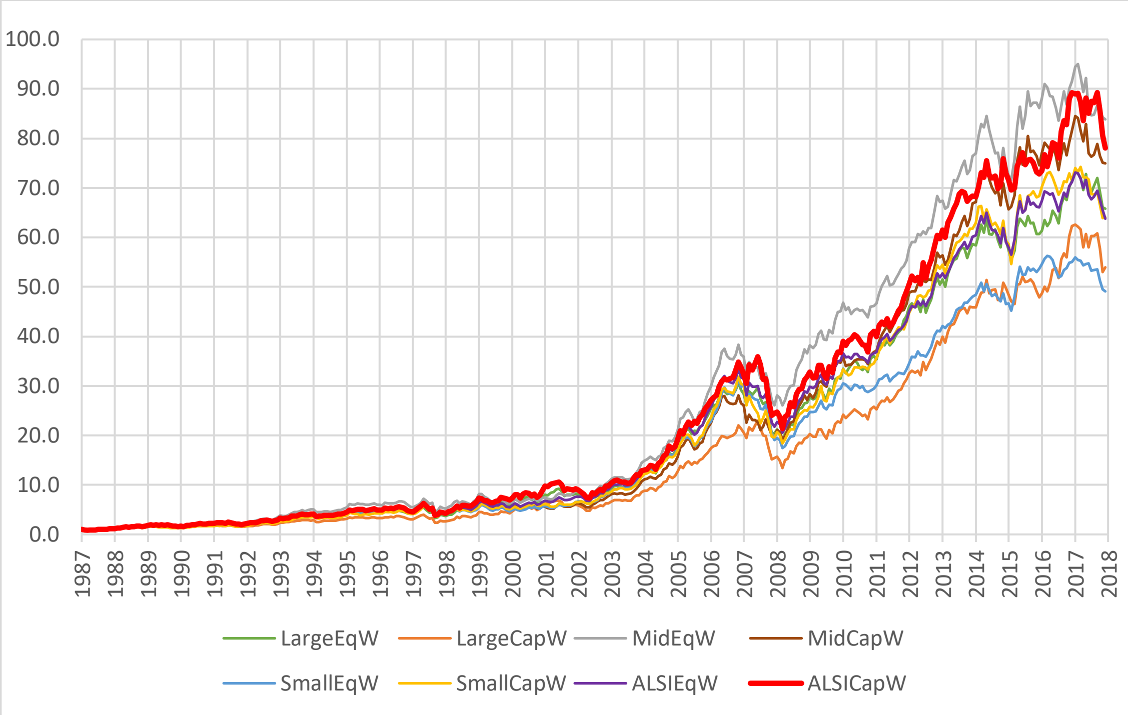

Figure 6: Returns of all portfolio strategies

Source: Own research

The above figure indicated the following;

- the large-cap equal-weighted portfolio strategy outperformed the large-cap value-weighted portfolio strategy;
- the mid-cap equal-weighted portfolio strategy outperformed the mid-cap value-weighted portfolio strategy;
- the small-cap equal-weighted portfolio strategy did not outperform the small-cap value-weighted portfolio strategy; and
- the ALSI equal-weighted portfolio strategy did not outperform the ALSI value-weighted portfolio strategy.

A more detailed, preliminary analysis was conducted in the next section.

5.2.1.1 Descriptive statistics

STATA 15 was used to generate descriptive statistics for each of the six cumulative portfolio strategies, total returns, as well as the ALSI recreation and the ALSI equal-weighted. Table 7 presented these results.

Table 7: Descriptive statistics of all portfolio returns

	H1_L_EqW	*H1_L_CapW*	*H1_M_EqW*	*H1_M_CapW*	*H1_S_EqW*	*H1_S_CapW*	*H1_X_EqW*	*H1_X_CapW*
Mean	0.038	0.037	0.04	0.039	0.036	0.038	0.037	0.039
Standard Error	0.008	0.008	0.008	0.008	0.008	0.008	0.007	0.008
Skewness	-1.053	-1.09	-0.762	-0.637	-1.056	-0.872	-1.121	-1.122
Range	0.543	0.603	0.543	0.551	0.569	0.563	0.552	0.586
Minimum	-0.346	-0.353	-0.317	-0.314	-0.364	-0.355	-0.345	-0.341
Maximum	0.198	0.25	0.226	0.237	0.205	0.208	0.206	0.244

Source: Own research

The descriptive statistics reaffirmed the visual findings of the diagrams described above. The following section tested whether these findings were statistically significant.

5.2.1.2 Hypothesis for testing portfolios

The null and alternative hypotheses for testing the statistical difference between equal-weighted and value-weighted portfolios regarding total mean return on the JSE domestic context were stated as follows:

Null hypothesis one (a) (**H1a$_0$**): Up to a 95% confidence level, equal-weighted portfolios had the same total mean return as value-weighted portfolios.

Alternate hypothesis one (a) (**H1a$_1$**): Beyond a 95% confidence level, equal-weighted portfolios did not have the same total mean return as value-weighted portfolios.

5.2.1.3 Results for H1a_1yr

A summary of whether the acceptance or rejection of the specific null hypothesis was concluded at the end of this section (p. 57).

Table 8: Confidence intervals of H1a_1yr

Variable	**N**	**Mean**	**SD**	**[95% Conf.**	**Interval]**
H1a_L_EqW_1yr	121	0.1703	0.0179	0.1350	0.2057
H1a_L_Cap_1yr	121	0.1657	0.0181	0.1298	0.2016
H1a_M_EqW_1yr	121	0.1775	0.0180	0.1419	0.2132
H1a_M_Cap_1yr	121	0.1749	0.0183	0.1386	0.2112
H1a_S_EqW_1yr	121	0.1574	0.0174	0.1229	0.1919
H1a_S_Cap_1yr	121	0.1670	0.0171	0.1332	0.2008

Source: Own research

Table 8 indicated that from all one year investment period portfolios, the mid-cap equal-weighted portfolios had the highest mean score (M=0.178; SD=0.02), followed by mid-cap value-weighted portfolios (M=0.175), and the large-cap equal-weighted portfolio (m=0.170). The small-cap equal-weighted portfolios had the least mean score (M=0.157).

Table 9: Multi-variate test for H1a_1yr

Hotelling T2	14.72
Hotelling F(5,116)	2.85
Prob > F	0.0184

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is large (14.7) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the one-year investment length.

Table 10: T-test summary for H1a_1yr

Variable	**N**	**Mean**	**t statistics**	**Pr(|T| > |t|)**
H1a_L_EqW_1yr	121	0.170	0.972	0.337
H1a_L_CapW_1yr	121	0.166		
diff	121	0.005		
H1a_M_EqW_1yr	121	0.178	0.642	0.739
H1a_M_CapW_1yr	121	0.175		
diff	121	0.003		
H1a_S_EqW_1yr	121	0.157	-2.3049	0.0229
H1a_S_CapW_1yr	121	0.167		
diff	121	-0.010		

Source: Own research

Table 10 provided statistically significant evidence that small-cap equal-weighted portfolios performed worse (0.01) than their value-weighted portfolio pair. The t statistics is large (-2.3) while the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected. The outperformance regarding total mean return of the large-cap equal-weighted (0.005) and of the mid-cap equal-weighted (0.003) was not statistically significant, hence the null hypothesis (H0: an(diff) = 0) was accepted.

5.2.1.4 Results for H1a_3yr

Table 11: Confidence intervals of H1a_3yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H1a_L_EqW_3yr	113	0.1537	0.0100	0.1340	0.1734
H1a_L_Cap_3yr	113	0.1473	0.0099	0.1277	0.1668
H1a_M_EqW_3yr	113	0.1649	0.0107	0.1436	0.1861
H1a_M_Cap_3yr	113	0.1616	0.0110	0.1398	0.1834
H1a_S_EqW_3yr	113	0.1476	0.0110	0.1257	0.1695
H1a_S_CapW_3yr	113	0.1591	0.0107	0.1380	0.180

Source: Own research

Table 11 indicated that from all three year investment period portfolios, the mid-cap equal-weighted portfolios had the highest mean score (M=0.165; SD=0.01), followed by mid-cap value-weighted portfolios (M=0.162), and the small-cap value-weighted portfolio (m=0.159). The large-cap value-weighted portfolios had the least mean score(M=0.147).

Table 12: Multi-variate test for H1a_3yr

Hotelling T2	63.33
Hotelling F(5,108)	12.21
Prob > F	0.000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics was overwhelmingly large (63.33) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the three-year investment length.

Table 13: T-test summary for H1a_3yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H1a_L_EqW_3yr	113	0.1537	2.1564	0.0332
H1a_L_CapW_3yr	113	0.1472		
diff	113	0.0064		
H1a_M_EqW_3yr	113	0.1648	1.1617	0.2478
H1a_M_CapW_3yr	113	0.1616		
diff	113	0.0032		
H1a_S_EqW_3yr	113	0.1476	-4.2174	0.0001
H1a_S_CapW_3yr	113	0.1591		
diff	113	-0.0115		

Source: Own research

Table 13 provided statistically significant evidence of the outperformance regarding total mean return of large-cap equal-weighted portfolios (0.006). Hence, the null hypothesis (H0: an(diff) = 0) was accepted at a 95% level of confidence.

There was no significant evidence of the outperformance mid-cap equal-weighted portfolios to reject the null hypothesis; hence the null hypothesis (H0: an(diff) = 0) was accepted at a 95% level of confidence.

The small-cap equal-weighted portfolios performed worse (-0.012) than their value-weighted portfolio pair. The t statistics is large (-4.2) while the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) is rejected.

5.2.1.5 Results for H1a_5yr

Table 14: Confidence intervals of H1a_5yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H1a_L_EqW_5yr	105	0.1539	0.0059	0.1421	0.1657
H1a_L_CapW_5yr	105	-0.0127	0.0107	-0.0340	0.0085
H1a_M_EqW_5yr	105	0.1644	0.0081	0.1483	0.1806
H1a_M_CapW_5yr	105	-0.0143	0.0201	-0.0542	0.0256
H1a_S_EqW_5yr	105	0.1493	0.0084	0.1327	0.1659
H1a_S_CapW_5yr	105	0.0070	0.0127	-0.0182	0.0322

Source: Own research

Table 14 indicated that from all five year investment period portfolios, the mid-cap equal-weighted portfolios had the highest mean score (M=0.164; SD=0.01), followed by large-cap value-weighted portfolios (M=0.154), and the small-cap equal-weighted portfolio (M=0.149). The mid-cap value-weighted portfolio had the least mean score (M=-0.014).

Table 15: Multi-variate test for H1a_5yr

Hotelling T2	1234.90
Hotelling F(5,100)	237.48
Prob > F	0.000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is overwhelmingly large (1234.90) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the three-year investment length.

Table 16: T-test summary for H1a_5yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H1a_L_EqW_5yr	105	0.1539	27.4842	0.0000
H1a_L_CapW_5yr	105	-0.0127		
diff	105	0.1666		

H1a_M_EqW_5yr	105	0.1644	12.3767	0.0000
H1a_M_CapW_5yr	105	-0.0143		
diff	105	0.1788		
H1a_S_EqW_5yr	113	0.1476	26.8468	0.0000
H1a_S_CapW_5yr)	113	0.1591		
diff	113	-0.0115		

Source: Own research

Table 16 provided statistically significant evidence of the outperformance regarding total mean return of large-cap equal-weighted portfolios (0.167) and of mid-cap equal-weighted portfolios (0.179). Hence, the null hypothesis (H0: an(diff) = 0) was rejected at a 95% level of confidence.

The small-cap equal-weighted portfolios performed worse (-0.012) than their value-weighted portfolio pair. The t statistics is large (26.9) while the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) is rejected.

5.2.1.6 Results for H1a_10yr

Table 17: Confidence intervals of H1a_10yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H1a_L_EqW_10yr	85	0.1515	0.0036	0.1443	0.1586
H1a_L_CapW_10yr	85	0.1469	0.0040	0.1389	0.1548
H1a_M_EqW_10yr	85	0.1586	0.0041	0.1504	0.1668
H1a_M_CapW_10yr	85	0.1540	0.0047	0.1446	0.1634
H1a_S_EqW_10yr	85	0.1450	0.0040	0.1370	0.1530
H1a_S_CapW_10yr	85	0.1584	0.0037	0.1509	0.1658

Source: Own research

Table 17 indicated that for all ten-year investment period portfolios, the mid-cap equal-weighted portfolios had the highest mean score (M=0.159; SD=0.004), followed by small-cap value-weighted portfolios (M=0.158), and the mid-cap value-weighted portfolio (M=0.154). The small-cap equal-weighted portfolio had the least mean score (M=0.145).

Table 18: Multi-variate test for H1a_10yr

Hotelling T2	731.07
Hotelling F(5,80)	139.25
Prob > F	0.000

Source: Own research

Multivariate inferential analysis indicated that there were differences within subject means. The Hotelling statistics was overwhelmingly large (731.07) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the three-year investment length.

Table 19: T-test summary for H1a_10yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H1a_L_EqW_10yr	85	0.1515	2.5713	0.0119
H1a_L_CapW_10yr	85	0.1469		
diff	85	0.0046		
H1a_M_EqW_10yr	85	0.1586	2.2721	0.0256
H1a_M_CapW_10yr	85	0.1540		
diff	85	0.0045		
H1a_S_EqW_10yr	85	0.1450	-9.7818	0.0000
H1a_S_CapW_10yr	85	0.1584		
diff	85	-0.0134		

Source: Own research

Table 19 provided statistically significant evidence of the outperformance regarding total mean return of the large-cap equal-weighted portfolios (0.005) and of mid-cap equal-weighted portfolios (0.005). Hence, the null hypothesis (H0: an(diff) = 0) was rejected at a 95% level of confidence.

The small-cap equal-weighted portfolios performed worse (-0.013) than their value-weighted portfolio pair. The t statistics is large (-9.782) while the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) is rejected.

5.2.1.7 Conclusion of testing H1a

Table 20 indicates that the majority of equal-weighted portfolios performed differently to value-weighted portfolios at a 95% level of confidence regarding the total mean return.

Table 20: Conclusion of testing H1a

Hypothesis H0: mean(diff) = 0	Accepting H0	Accepting H1
mean(diff) = mean(H1_L_EqW_1yr - H1_L_CapW_1yr)	Yes	No
mean(diff) = mean(H1_M_EqW_1yr - H1_M_CapW_1yr)	Yes	No
mean(diff) = mean(H1_S_EqW_1yr - H1_S_CapW_1yr)	No	Yes (negative)
mean(diff) = mean(H1_L_EqW_3yr - H1_L_CapW_3yr)	No	Yes (positive)
mean(diff) = mean(H1_M_EqW_3yr - H1_M_CapW_3yr)	Yes	No
mean(diff) = mean(H1_S_EqW_3yr - H1_S_CapW_3yr)	No	Yes (negative)
mean(diff) = mean(H1_L_EqW_5yr - H1_L_CapW_5yr)	No	Yes (positive)
mean(diff) = mean(H1_M_EqW_5yr - H1_M_CapW_5yr)	No	Yes (positive)
mean(diff) = mean(H1_S_EqW_5yr - H1_S_CapW_5yr)	No	Yes (negative)
mean(diff) = mean(H1_L_EqW_10yr - H1_L_CapW_10yr)	No	Yes (positive)

mean(diff) = mean(H1_M_EqW_10yr - H1_M_CapW_10yr)	No	Yes (positive)
mean(diff) = mean(H1_S_EqW_10yr - H1_S_CapW_10yr)	No	Yes (negative)

Source: Own research

Table 21 showed that all small-cap equal-weighted portfolios performed significantly worse regarding total mean return. The study failed to find evidence for the outperformance of large-cap and mid-cap equal-weighted portfolios for investment periods of under one year. However, once the investment period was five or ten years, large and mid-cap equal weighted portfolios performed significantly better regarding total mean return. Every small-cap equal-weighted portfolio (1, 3, 5 and 10 year) performed worse than their value-weighted portfolio pair.

Table 21: Outperformance of H1a_EqW vs H1a_CapW

Return of EqW over CapW	Underperform	NS	Outperform
H1_L_EqW_1yr - H1_L_CapW_1yr		NS	
H1_M_EqW_1yr - H1_M_CapW_1yr		NS	
H1_S_EqW_1yr - H1_S_CapW_1yr	Underperform		
H1_L_EqW_3yr - H1_L_CapW_3yr			Outperform
H1_M_EqW_3yr - H1_M_CapW_3yr		NS	
H1_S_EqW_3yr - H1_S_CapW_3yr	Underperform		
H1_L_EqW_5yr - H1_L_CapW_5yr			Outperform
H1_M_EqW_5yr - H1_M_CapW_5yr			Outperform
H1_S_EqW_5yr - H1_S_CapW_5yr	Underperform		
H1_L_EqW_10yr - H1_L_CapW_10yr			Outperform
H1_M_EqW_10yr - H1_M_CapW_10yr			Outperform
H1_S_EqW_10yr - H1_S_CapW_10yr	Underperform		

Source: Own research

5.2.2. Results for testing H1b: Volatility

5.2.2.1 Hypothesis for testing

The null and alternative hypotheses for testing the statistical difference between equal-weighted portfolios and value-weighted portfolios regarding volatility on the JSE domestic context were as follows:

Null hypothesis one (b) (**$H1b_0$**): Up to a 95% confidence level, equal-weighted portfolios did bear the same volatility than value-weighted portfolios.

Alternate hypothesis one (b) (**$H1b_1$**): Beyond a 95% confidence level, equal-weighted portfolios did not bear the same volatility than value-weighted portfolios.

5.2.2.2 Results for H1b_1yr

Table 22: Confidence intervals of H1b_1yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H1b_L_EqW_1yr	121	0.0659	0.0035	0.0590	0.0728
H1b_L_CapW_1yr	121	0.0685	0.0037	0.0612	0.0758
H1b_M_EqW_1yr	121	0.0691	0.0030	0.0631	0.0750
H1b_M_CapW_1yr	121	0.0714	0.0031	0.0654	0.0775
H1b_S_EqW_1yr	121	0.0692	0.0035	0.0623	0.0761
H1b_S_CapW_1yr	121	0.0712	0.0034	0.0645	0.0779

Source: Own research

Table 22 indicated that from all one year investment period portfolios, the mid-cap value-weighted portfolios had the highest mean score (M=0.071; SD=0.003), followed by small-cap value-weighted portfolios (M=0.071), and the mid-cap equal-weighted portfolio (m=0.069). The large-cap equal-weighted portfolios had the least mean score (M=0.066).

Table 23: Multi-variate test for H1b_1yr

Hotelling T2	311.01
Hotelling F(5,116)	42.21
Prob > F	0.0000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is large (311.0) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the one-year investment length.

Table 24: T-test summary for H1b_1yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H1b_L_EqW_1yr	121	0.0658	-2.5027	0.0137
H1b_L_CapW_1yr	121	0.0685		
diff	121	-0.0026		
H1b_M_EqW_1yr	121	0.0690	-3.8532	0.0002
H1b_M_CapW_1yr	121	0.0714		
diff	121	-0.0023		
H1b_S_EqW_1yr	121	0.0692	-3.3009	0.0013
H1b_S_CapW_1yr	121	0.0712		
diff	121	-0.0019		

Source: Own research

Table 24 provided statistically significant evidence that all large-cap (-0.003), mid-cap (--0.002) and small-cap (-0.002) equal-weighted portfolios were subject to lower volatility than their value-weighted portfolio pair. The t statistics were large (-2.5, -3.9, -3.3) while the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) is rejected.

5.2.2.3 Results for H1b_3yr

Table 25: Confidence intervals of H1b_3yr

Variable	Obs	Mean	SD	[95% Conf.	Interval]
H1b_L_EqW_3yr	113	0.0767	0.003	0.0708	0.0826
H1b_L_CapW_3yr	113	0.0800	0.003	0.0741	0.0859
H1b_M_EqW_3yr	113	0.0788	0.0025	0.0738	0.0838
H1b_M_CapW_3yr	113	0.0811	0.0027	0.0758	0.0863
H1b_S_EqW_3yr	113	0.0795	0.003	0.0735	0.0856
H1b_S_CapW_3yr	113	0.0811	0.003	0.0751	0.0871

Source: Own research

Table 25 indicated that from all three-year investment period portfolios, the small-cap value-weighted portfolios had the highest mean score (M=0.081; SD=0.003), followed by mid-cap value-weighted portfolios (M=0.081), and the large-cap value-weighted portfolios (m=0.080). The least mean score had the large-cap value-weighted portfolios (M=0.077).

Table 26: Multi-variate test for H1b_3yr

Hotelling T2	879.88
Hotelling F(5,108)	118.96
Prob > F	0.000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is large (879.9) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the three-year investment length.

Table 27: T-test summary for H1b_3yr

Variable	Obs	Mean	t statistics	Pr(|T| > |t|)
H1b_L_EqW_3yr	121	0.0767	-4.6026	0.0000
H1b_L_CapW_3yr	121	0.0780		
diff	121	-0.0032		
H1b_M_EqW_3yr	121	0.0787	-4.8616	0.0000
H1b_M_CapW_3yr	121	0.0811		

diff	121	-0.0023		
H1b_S_EqW_3yr	121	0.0795	-3.7270	0.0003
H1b_S_CapW_3yr	121	0.0811		
diff	121	-0.0016		

Source: Own research

Table 27 provided statistically significant evidence that all large-cap (-0.003), mid-cap (--0.002) and small-cap (-0.002) equal-weighted portfolios were subject to lower volatility than their value-weighted portfolio pair. The t statistics were large (-4.6, -4.9, -3.7) while the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) is rejected.

5.2.2.4 Results for H1b_5yr

Table 28: Confidence intervals of H1b_5yr

Variable	**Obs**	**Mean**	**SD**	**[95% Conf.**	**Interval]**
H1b_L_EqW_5yr	105	0.0815	0.0026	0.0763	0.0867
H1b_L_CapW_5yr	105	0.0849	0.0024	0.0801	0.0897
H1b_M_EqW_5yr	105	0.0826	0.0023	0.0781	0.0871
H1b_M_CapW_5yr	105	0.0851	0.0024	0.0803	0.0899
H1b_S_EqW_5yr	105	0.0844	0.0027	0.079	0.0898
H1b_S_CapW_5yr	105	0.0860	0.0027	0.0806	0.0914

Source: Own research

Table 28 indicated that from all five year investment period portfolios, the small-cap value-weighted portfolios had the highest mean score (M=0.086 SD=0.003), followed by mid-cap value-weighted portfolios (M=0.085), and the large-cap value-weighted portfolio (M=0.085). The least mean score had the large-cap equal-weighted portfolios (M=0.082).

Table 29: Multi-variate test for H1b_5yr

Hotelling T2	1831.67
Hotelling F(5,100)	246.57
Prob > F	0.0000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is overwhelmingly large (1234.90) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the five-year investment length.

Table 30: T-test summary for H1b_5yr

Variable	Obs	Mean	t statistics	Pr(|T| > |t|)
H1b_L_EqW_5yr	105	0.0814	-6.6711	0.0000
H1b_L_CapW_5yr	105	0.0849		
diff	105	-0.0034		
H1b_M_EqW_5yr	105	0.0825	-5.9028	0.0000
H1b_M_CapW_5yr	105	0.0850		
diff	105	-0.0025		
H1b_S_EqW_5yr	105	0.0843	-4.4386	0.0000
H1b_S_CapW_5yr	105	0.0860		
diff	105	-0.0016		

Source: Own research

Table 30 provided statistically significant evidence that all large-cap (-0.003), mid-cap (--0.003) and small-cap (-0.002) equal-weighted portfolios were subject to lower volatility than their value-weighted portfolio pair as the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) is rejected.

5.2.2.5 Results for H1b_10yr

Table 31: Confidence intervals of H1b_10yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H1b_L_EqW_10yr	85	0.0900	0.0015	0.0871	0.0929
H1b_L_CapW_0yr	85	0.0925	0.0011	0.0903	0.0948
H1b_M_EqW_10yr	85	0.0897	0.0015	0.0867	0.0928
H1b_M_CaW_10yr	85	0.0927	0.0017	0.0893	0.0961
H1b_S_EqW_10yr	85	0.0944	0.0014	0.0917	0.0972
H1b_S_CapW_10yr	85	0.0953	0.0016	0.0922	0.0984

Source: Own research

Table 31 indicated that from all ten year investment period portfolios, the small-cap value-weighted portfolios had the highest mean score (M=0.0953; SD=0.002), followed by small-cap equal-weighted portfolios (M=0.094), and the mid-cap value-weighted portfolios (M=0.093). The large-cap equal-weighted portfolios had the least mean score (M=0.090).

Table 32: Multi-variate test for H1b_10yr

Hotelling T2	23270.89
Hotelling F(5,80)	3086.95
Prob > F	0.000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is overwhelmingly large (23370.9) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the ten-year investment length.

Table 33: T-test summary for H1b_10yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H1b_L_EqW_10yr	85	0.08999	-6.7240	0.0000
H1b_L_CapW_10yr	85	0.0925		
diff	85	-0.0025		
H1b_M_EqW_10yr	85	0.0897	-9.758	0.0000
H1b_M_CapW_10yr	85	0.0927		
diff	85	-0.0029		
H1b_S_EqW_10yr	85	0.0944	-3.484	0.0008
H1b_S_CapW_10yr	85	0.0953		
diff	85	-0.0008		

Source: Own research

Table 33 provided statistically significant evidence of the outperformance regarding total mean return of the large-cap equal-weighted portfolios (0.005) and of mid-cap equal-weighted portfolios (0.005). Hence, the null hypothesis (H0: an(diff) = 0) was accepted at a 95% level of confidence.

The small-cap equal-weighted portfolios performed worse (-0.013) than their value-weighted portfolio pair. The t statistics is large (26.9) while the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) is rejected.

5.2.2.6 Conclusion of testing H1b

Table 34 clearly indicates that the majority of equal-weighted portfolios had a significantly different mean to value-weighted portfolios at a 95% level of confidence regarding total mean return.

Table 34: Conclusion of testing H1b

Hypothesis H0: mean(diff) = 0	Accepting H0	Accepting H1
mean(diff) = mean(H1b_L_EqW_1yr - H1b_L_CapW_1yr)	No	Yes (negative)
mean(diff) = mean(H1b_M_EqW_1yr - H1b_M_CapW_1yr)	No	Yes (negative)
mean(diff) = mean(H1b_S_EqW_1yr - H1b_S_CapW_1yr)	No	Yes (negative)
mean(diff) = mean(H1b_L_EqW_3yr - H1b_L_CapW_3yr)	No	Yes (negative)
mean(diff) = mean(H1b_M_EqW_3yr - H1b_M_CapW_3yr)	No	Yes (negative)
mean(diff) = mean(H1b_S_EqW_3yr - H1b_S_CapW_3yr)	No	Yes (negative)

mean(diff) = mean(H1b_L_EqW_5yr - H1b_L_CapW_5yr)	No	Yes (negative)
mean(diff) = mean(H1b_M_EqW_5yr - H1b_M_CapW_5yr)	No	Yes (negative)
mean(diff) = mean(H1b_S_EqW_5yr - H1b_S_CapW_5yr)	No	Yes (negative)
mean(diff) = mean(H1b_L_EqW_10yr - H1b_L_CapW_10yr)	No	Yes (negative)
mean(diff) = mean(H1b_M_EqW_10yr - H1b_M_CapW_10yr)	No	Yes (negative)
mean(diff) = mean(H1b_S_EqW_10yr - H1b_S_CapW_10yr)	No	Yes (negative)

Source: Own research

Table 35 showed that all equal-weighted portfolios experienced significantly lower volatility than their value-weighted portfolio pair regardless of the investment period length.

Table 35: Outperformance of H1b_EqW vs H1b_CapW

Performance of EqW over CapW	Underperform	NS	Outperform
H1b_L_EqW_1yr - H1b_L_CapW_1yr			Outperform
H1b_M_EqW_1yr - H1b_M_CapW_1yr			Outperform
H1b_S_EqW_1yr - H1b_S_CapW_1yr			Outperform
H1b_L_EqW_3yr - H1b_L_CapW_3yr			Outperform
H1b_M_EqW_3yr - H1b_M_CapW_3yr			Outperform
H1b_S_EqW_3yr - H1b_S_CapW_3yr			Outperform
H1b_L_EqW_5yr - H1b_L_CapW_5yr			Outperform
H1b_M_EqW_5yr - H1b_M_CapW_5yr			Outperform
H1b_S_EqW_5yr - H1b_S_CapW_5yr			Outperform
H1b_L_EqW_10yr - H1b_L_CapW_10yr			Outperform
H1b_M_EqW_10yr - H1b_M_CapW_10yr			Outperform
H1b_S_EqW_10yr - H1b_S_CapW_10yr			Outperform

Source: Own research

5.2.3 Results for testing H1c: Maximum drawdown

The null and alternative hypotheses for testing the statistical difference between equal-weighted and value-weighted portfolios regarding maximum drawdown on the JSE domestic context were as follows:

Null hypothesis one (c) (**$H1c_0$**): Equal-weighted portfolios did not have a greater maximum drawdown compared to value-weighted portfolios.

Alternate hypothesis one (c) (**$H1c_1$**): Equal-weighted portfolios did have a greater maximum drawdown compared to value-weighted portfolios.

Figure 7 displayed the drawdown for each portfolio strategy below as well as the market portfolio:

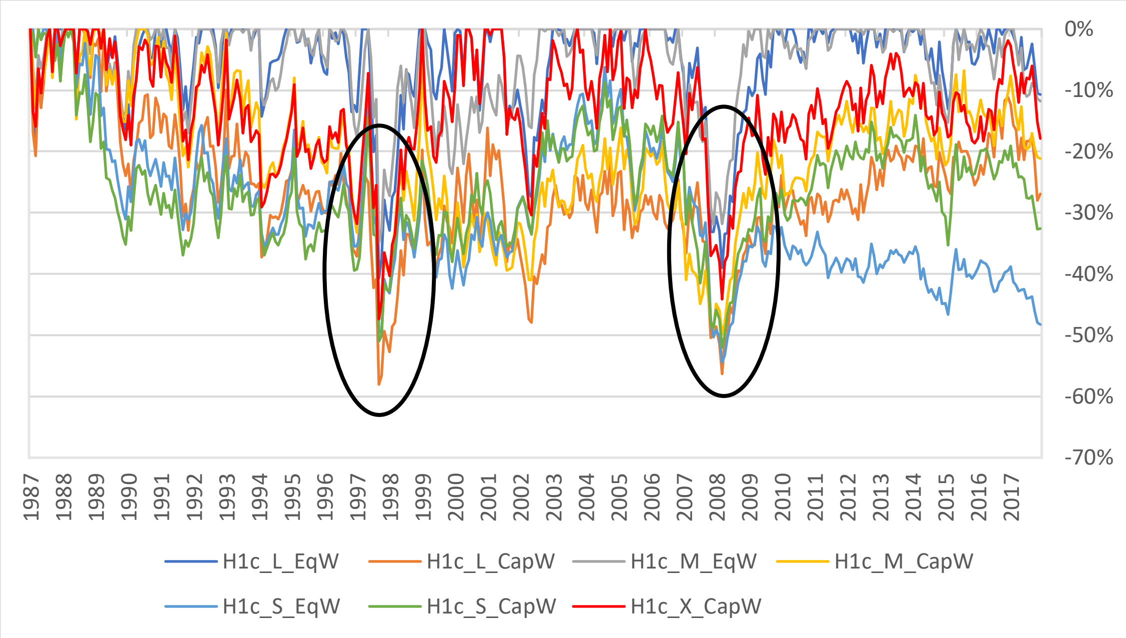

Figure 7: Drawdown of all portfolio strategies

Source: Own research

It was evident from the above-displayed figure that all portfolio strategies were, at times, subject to severe drawdown. Especially the large-cap value-weighted and the small-cap equal-weighted experienced the greatest drawdown. The following section quantified the maximum drawdown.

5.2.3.1 Descriptive statistics

Table 36 showed the maximum drawdown of each portfolio strategy. As mentioned above, the large-cap value-weighted portfolio strategy was subject to the most substantial continuous drawdown (-58.0%). The small-cap equal-weighted strategy performed second worst with a second consecutive drawdown of -54.4%

Table 36: Descriptive statistics of the drawdown of all portfolio strategies

	H1c_L_ EqW	***H1c_L_ CapW***	***H1c_M_ EqW***	***H1c_M_ CapW***	***H1c_S_ EqW***	***H1c_S_ CapW***	***H1c_X_ EqW***	***H1c_X_ CapW***
Mean	-0.054	-0.260	-0.057	-0.203	-0.293	-0.257	-0.196	-0.131
Standard Error	0.004	0.005	0.004	0.006	0.006	0.005	0.005	0.005
Median	-0.022	-0.265	-0.030	-0.195	-0.317	-0.265	-0.206	-0.126
Minimum	**-0.407**	**-0.580**	**-0.349**	**-0.498**	**-0.544**	**-0.520**	**-0.478**	**-0.474**
Count	372	372	372	372	372	372	372	372

Source: Own research

A summary of the conclusion of testing H1c can be found in the following section.

5.2.3.2 Conclusion of testing H1c

Over the period investigated, the large-cap equal-weighted and mid-cap equal-weighted portfolio strategy was subject to a smaller maximum drawdown than the respective value-weighted portfolio strategy. However, the small-cap equal-weighted portfolio strategy was subject to slightly higher maximum drawdown. The summary of the hypothesis 1c can be found in Table 37 below.

Table 37: Conclusion of testing H1c

Hypothesis H0: CapW - EqW >= 0	Accepting H0	Accepting H1
H1c_L_CapW - H1c_L_EqW >= 0	No	Yes
H1c_M_CapW - H1c_M_EqW >= 0	No	Yes
H1c_L_CapW - H1c_L_EqW >= 0	Yes	No

Source: Own research

5.2.4 Results for testing H1d: Performance success ratio

The null and alternative hypotheses for testing the statistical difference between equal-weighted and value-weighted portfolios regarding performance success ratio on the JSE domestic context were as follows:

Null hypothesis one (d) (**H1d$_0$**): Equal-weighted portfolios did not have a higher performance success ratio compared to value-weighted portfolios.

Alternate hypothesis one (d) (**H1d$_1$**): Equal-weighted portfolios did have a higher performance success ratio compared to value-weighted portfolios.

5.2.4.1 Results for H1d

Table 38 shows the performance success ratio of each portfolio strategy.

Table 38: The performance success ratio of all portfolio strategies

	H1d_L_ EqW	H1d_L_ CapW	H1d_M_ EqW	H1d_M_ CapW	H1d_S_ EqW	H1d_S_ CapW
Number of positive quarters	93	93	91	88	91	92

Performance success ratio	74.40%	74.40%	72.80%	70.40%	72.80%	73.60%

Source: Own research

A summary of the conclusion of testing H1d can be found in the following section.

5.2.4.2 Conclusion of testing H1d

Over the period investigated, the large-cap value-weighted and small-cap value-weighted portfolio strategy had a large or equal number of positive quarters and hence a better or equal performance success ratio. However, the mid-cap equal-weighted portfolio strategy experienced three more positive quarters than its portfolio pair. The summary of the hypothesis 1d can be found in Table 39 below.

Table 39: Conclusion of testing H1d

Hypothesis H0: CapW - EqW >= 0	Accepting H0	Accepting H1
H1d_L_EqW < H1d_L_CapW	Yes	No
H1d_M_EqW < H1d_M_CapW	No	Yes
H1d_L_EqW < H1d_L_CapW	Yes	No

Source: Own research

5.3 Results for testing H2: Sharpe ratio

The study´s second objective was to determine whether the findings regarding higher Sharpe ratio by DeMiguel et al. (2009), Jacobs et al. (2014), Plyakha et al. (2015) and Hwang et al. (2018) could be replicated on the JSE. Their research found a statistically significant higher Sharpe ratio of equal-weighted than value-weighted portfolios. The objective was stated as follows:

- Determine whether equal-weighted portfolios and value-weighted portfolios on the JSE differ statistically regarding the Sharpe ratio.

5.3.1 Hypothesis for testing

The null and alternative hypotheses for testing the findings of DeMiguel et al. (2009), Jacobs et al. (2014), Plyakha et al. (2015) and Hwang et al. 2018 regarding Sharpe ratios on the JSE were as follows:

Null hypothesis three (**H2a₀**): Up to a 95% confidence level, equal-weighted portfolios did not have a higher Sharpe ratio compared to value-weighted portfolios.

Alternate hypothesis three (**H2a₁**): Beyond a 95% confidence level, equal-weighted portfolios did have a higher Sharpe ratio compared to value-weighted portfolios.

5.3.2 Results for testing

5.3.2.1 Results for H2_1yr

Table 40: Confidence intervals of H2_1yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H2_L_EqW_1yr	120	1.71	0.32	1.07	2.35
H2_L_CapW_1yr	120	2.03	0.37	1.31	2.76
H2_M_EqW_1yr	120	1.34	0.29	0.78	1.91
H2_S_EqW_1yr	120	1.13	0.28	0.57	1.69
H2_S_CapW_1yr	120	1.26	0.27	0.72	1.8

Source: Own research

Table 40 indicated that from all one year investment period portfolios, the large-cap value-weighted portfolios had the highest mean score (M=2.03; SD=0.37), followed by large-cap equal-weighted portfolios (M=1.71), and the mid-cap equal-weighted portfolios (M=1.34). The small-cap equal-weighted portfolios had the least mean score (M=1.13).

Table 41: Multi-variate test for H2_1yr

Hotelling T2	13.12
Hotelling F(5,116)	2.54
Prob > F	0.0324

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is large (13.12) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the one-year investment length.

Table 42: T-test summary for H2_1yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H2_L_EqW_1yr	120	1.7127	-2.7954	0.0060
H2_L_CapW_1yr	120	2.0342		
diff		-0.3215		
H2_M_EqW_1yr	120	1.3449	0.6446	0.5204

H2_M_CapW_1yr	120	1.2932			
diff		0.0517			
H2_S_EqW_1yr	120	1.1332	1.274		0.2051
H2_S_CapW_1yr	120	1.2601			
diff		-0.1269			

Source: Own research

Table 42 displayed statistically significant evidence that large-cap equal-weighted portfolios performed worse (-0.32) than their value-weighted portfolio pair. The t statistics is large (-2.8) while the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) had to be rejected.

The study did not find statistically significant evidence that mid-cap equal-weighted portfolios performed better (P-value > 0.05) and that small-cap equal weighted portfolios performed worse (-0.13) than their value-weighted portfolio pair regarding the Sharpe ratio. Hence, the null hypothesis (H0: an(diff) = 0) was accepted.

5.3.2.2 Results for H2_3yr

Table 43: Confidence intervals of H2_3yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H2_L_EqW_3yr	112	0.9184	0.1825	0.5569	1.2800
H2_L_Cap_3yr	112	1.0108	0.2175	0.5798	1.4419
H2_M_EqW_3yr	112	0.8622	0.1492	0.5666	1.1578
H2_M_Cap_3yr	112	0.8896	0.1648	0.5629	1.2162
H2_S_EqW_3yr	112	0.7239	0.1632	0.4004	1.0474
H2_S_CapW_3yr	112	0.9276	0.1739	0.5828	1.2724

Source: Own research

Table 40 indicated that from all one year investment period portfolios, the large-cap value-weighted portfolios had the highest mean score (M=1.01; SD=0.22), followed by small-cap value-weighted portfolios (M=0.93), and the large-cap equal-weighted portfolios (M=0.92). The small-cap equal-weighted portfolios had the least mean score (M=0.72).

Table 44: Multi-variate test for H2_3yr

Hotelling T2	27.08
Hotelling F(5,107)	5.22
Prob > F	0.0003

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is large (27.08) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the three-year investment length.

Table 45: T-test summary for H2_3yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H2_L_EqW_3yr	112	0.0918	-1.4484	0.1503
H2_L_CapW_3yr	112	1.0108		
Diff	112	-0.0924		
H2_M_EqW_3yr	112	0.8622	-0.5745	0.5668
H2_M_CapW_3yr	112	0.8896		
diff	112	-0.0274		
H2_S_EqW_3yr	112	0.7239	-3.2306	0.0016
H2_S_CapW_3yr	112	0.9276		
diff	112	-0.0274		

Source: Own research

Table 45 provided statistically significant evidence that small-cap equal-weighted portfolios had lower Sharpe ratios (-0.027) than their value-weighted portfolio pair as the p-value was smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected at a 95% level of confidence.

There was not enough evidence to reject the null hypothesis for large-cap and mid-cap portfolios since the p-value was above 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was accepted.

5.3.2.3 Results for H2_5yr

Table 46 Confidence intervals of H2_5yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H2_L_EqW_5yr	105	0.71	0.11	0.50	0.92
H2_L_CapW_5yr	105	-1.31	0.13	-1.58	-1.05
H2_M_EqW_5yr	105	0.77	0.11	0.55	0.98
H2_M_CapW_5yr	105	-1.35	0.2	-1.74	-0.96
H2_S_EqW_5yr	105	0.63	0.12	0.39	0.86
H2_S_CapW_5yr	105	-1.14	0.15	-1.44	-0.83

Source: Own research

Table 46 indicated that from all five year investment period portfolios, the mid-cap equal-weighted portfolios had the highest mean score (M=0.77; SD=0.11), followed by large-cap equal-weighted portfolios (M=0.71), and the small-cap equal-weighted portfolios (M=0.63). The mid-cap value-weighted portfolio had the least mean score (M=-1.14).

Table 47: Multi-variate test for H1a_5yr

Hotelling T2	1105.00
Hotelling F(5,100)	212.50
Prob > F	0.0000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is overwhelmingly large (1105.0) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the five-year investment length.

Table 48: T-test summary for H2_5yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H2_L_EqW_1yr	105	0.7076	30.1281	0.0000
H2_L_CapW_1yr	105	-1.3144		
diff		2.0221		
H2_M_EqW_1yr	105	0.7687	17.845	0.0000
H2_M_CapW_1yr	105	-1.3474		
diff		2.1161		
H2_S_EqW_1yr	105	0.6256	21.3716	0.0000
H2_S_CapW_1yr	105	-1.1375		
diff		1.7631		

Source: Own research

Table 48 provided statistically significant evidence of the outperformance regarding the Sharpe ratio of large-cap equal-weighted portfolios (2.02), of mid-cap equal-weighted portfolios (2.11) and of small-cap equal-weighted portfolios (1.76) as the p-value was below 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected at a 95% level of confidence.

5.3.2.4 Results for H2_10yr

Table 49: Confidence intervals of H2_10yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H2_L_EqW_10yr	84	0.46	0.06	0.34	0.58
H2_L_CapW_10yr	84	0.41	0.07	0.27	0.55
H2_M_EqW_10yr	84	0.56	0.07	0.42	0.69
H2_M_CapW_5yr	84	0.52	0.08	0.36	0.68
H2_S_EqW_10yr	84	0.35	0.06	0.24	0.47
H2_S_Cap_10yr	84	0.52	0.06	0.39	0.64

Source: Own research

Table 49 indicated that from all ten year investment period portfolios, the mid-cap equal-weighted portfolios had the highest mean score (M=0.56; SD=0.07), followed by mid-cap value-weighted portfolios (M=0.52), and the small-cap equal-weighted portfolios (M=0.52). The small-cap equal-weighted portfolios had the least mean score (M=0.35).

Table 50: Multi-variate test for H2_10yr

Hotelling T2	551.92
Hotelling F(5,79)	105.06
Prob > F	0.0000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is overwhelmingly large (551.92) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the ten-year investment length.

Table 51: T-test summary for H2_10yr

Variable	**N**	**Mean**	**t statistics**	**Pr(|T| > |t|)**
H2_L_EqW_10yr	84	0.4634	2.8537	0.0055
H2_L_CapW_10yr	84	0.4098		
diff	84	0.0536		
H2_M_EqW_10yr	84	0.5554	1.5127	0.1341
H2_M_CapW_10yr	84	0.5183		
diff	84	0.0371		
H2_S_EqW_10yr	84	0.3534	-8.5437	0.0000
H2_S_CapW_10yr	84	0.5171		
diff	84	-0.1637		

Source: Own research

Table 51 provided statistically significant evidence of the outperformance regarding the Sharpe ratios of the large-cap equal-weighted portfolios (0.054) as the p-value was below 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected at a 95% level of confidence.

There was not enough statistical evidence regarding the outperformance of mid-cap equal-weighted portfolios regarding the Sharpe ratio to reject the null hypothesis.

The small-cap equal-weighted portfolios performed significantly worse (-0.164) than their value-weighted portfolio pair as the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected.

5.3.3 Conclusion of testing H2

Table 52 indicated that the majority of equal-weighted portfolios had significantly different Sharpe ratios than value-weighted portfolios at a 95% level of confidence.

Table 52: Conclusion of testing H2

Hypothesis H0: mean(diff) = 0	Accepting H0	Accepting H1
mean(diff) = mean(H2_L_EqW_1yr - H2_L_CapW_1yr)	No	Yes (negative)
mean(diff) = mean(H2_M_EqW_1yr - H2_M_CapW_1yr)	Yes	No
mean(diff) = mean(H2_S_EqW_1yr - H2_S_CapW_1yr)	Yes	No
mean(diff) = mean(H2_L_EqW_3yr - H2_L_CapW_3yr)	Yes	No
mean(diff) = mean(H2_M_EqW_3yr - H1_M_CapW_3yr)	Yes	No
mean(diff) = mean(H2_S_EqW_3yr - H2_S_CapW_3yr)	No	Yes (negative)
mean(diff) = mean(H2_L_EqW_5yr - H2_L_CapW_5yr)	NO	Yes (positive)
mean(diff) = mean(H2_M_EqW_5yr - H2_M_CapW_5yr)	No	Yes (positive)
mean(diff) = mean(H2_S_EqW_5yr - H2_S_CapW_5yr)	No	Yes (positive)
mean(diff) = mean(H2_L_EqW_10yr - H2_L_CapW_10yr)	No	Yes (positive)
mean(diff) = mean(H2_M_EqW_10yr - H2_M_CapW_10yr)	Yes	No
mean(diff) = mean(H2_S_EqW_10yr - H2_S_CapW_10yr)	No	Yes (negative)

Source: Own research

Table 53 showed that the majority of equal-weighted portfolios performed the same or worse than the value-weighted portfolios regarding Sharpe ratios. However, all equal-weighted portfolios with a five year investment period performed significantly better than value-weighted portfolios regarding the Sharpe ratio.

Table 53: Outperformance of H2_EqW vs H2_CapW

Performance of EqW over CapW	Underperform	NS	Outperform
H2_L_EqW_1yr - H2_L_CapW_1yr	Underperform		
H2_M_EqW_1yr - H2_M_CapW_1yr		NS	
H2_S_EqW_1yr - H2_S_CapW_1yr		NS	
H2_L_EqW_3yr - H2_L_CapW_3yr		NS	
H2_M_EqW_3yr - H2_M_CapW_3yr		NS	
H2_S_EqW_3yr - H2_S_CapW_3yr	Underperform		
H2_L_EqW_5yr - H2_L_CapW_5yr			Outperform
H2_M_EqW_5yr - H2_M_CapW_5yr			Outperform
H2_S_EqW_5yr - H2_S_CapW_5yr			Outperform
H2_L_EqW_10yr - H2_L_CapW_10yr			Outperform
H2_M_EqW_10yr - H2_M_CapW_10yr		NS	
H2_S_EqW_10yr - H2_S_CapW_10yr	Underperform		

Source: Own research

5.4 Results for testing H3: Treynor ratio

The study's third objective was to determine whether the findings by DeMiguel et al. (2009), Brown et al. (2013), Plyakha et al. (2015) and Jiang et al. (2018) could be replicated on the JSE regarding whether equal-weighted portfolios did statistically significant outperform value-weighted portfolios regarding the Treynor ratio. The objective was stated as follows:

- Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding the Treynor ratio.

5.4.1 Hypothesis for testing

The null and alternative hypotheses for testing the findings of DeMiguel et al. (2009), Brown et al. (2013), Plyakha et al. (2015) and Jiang et al. (2018) regarding Treynor ratios on the JSE were as follows:

Null hypothesis two (**$H3_0$**): Up to a 95% confidence level, equal-weighted portfolios did not have a higher Treynor ratio compared to value-weighted portfolios.

Alternate hypothesis two (**$H3_1$**): Beyond a 95% confidence level, equal-weighted portfolios did have a higher Treynor ratio compared to value-weighted portfolios.

5.4.2 Results for testing

5.4.2.1 Results for H3_1yr

Table 54: Confidence intervals of H3_1yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H3_L_EqW_1yr	119	0.0772	0.02	0.03	0.12
H3_L_CapW_1yr	119	0.0591	0.02	0.02	0.1
H3_M_EqW_1yr	119	0.0555	0.02	0.02	0.09
H3_M_CapW_1yr	119	0.0752	0.04	-0.00	0.15
H3_S_EqW_1yr	119	0.0446	0.02	0.01	0.08
H3_S_CapW_1yr	119	0.1874	0.09	0.01	0.37

Source: Own research

Table 54 indicated that for one year investment period portfolios, the small-cap value-weighted portfolios had the highest mean score (M=0.19; SD=0.09), followed by large-cap equal-weighted portfolios (M=0.08), and the mid-cap value-weighted portfolios (M=0.08). The small-cap equal-weighted portfolios had the least mean score (M=0.04).

Table 55: Multi-variate test for H3_1yr

Hotelling T2	6.38
Hotelling F(5,116)	1.33
Prob > F	0.2567

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics was large (6.38) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the one-year investment length.

Table 56: T-test summary for H3_1yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H3_L_EqW_1yr	119	0.0772	1.4241	0.1571
H3_L_CapW_1yr	119	0.0591		
diff	119	0.0181		
H3_M_EqW_1yr	119	0.0555	-0.6370	0.5254
H3_M_CapW_1yr	119	0.0752		
diff	119	-0.0196		
H3_S_EqW_1yr	119	0.0446	-0.6017	0.1119
H3_S_CapW_1yr	119	0.1874		
diff	119	-0.1428		

Source: Own research

Table 56 displayed that there was enough statistically significant evidence to reject any of the null hypothesis (H0: an(diff) = 0) since the p-value was greater than 0.05. Hence, the null hypothesis was accepted.

5.4.2.2 Results for H3_3yr

Table 57: Confidence intervals of H3_3yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H3_L_EqW_3yr	112	0.0506	0.01	0.02	0.08
H3_L_CapW_3yr	112	0.0361	0.01	0.01	0.06
H3_M_EqW_3yr	112	0.0441	0.01	0.02	0.07
H3_M_CapW_3yr	112	0.0527	0.01	0.03	0.08
H3_S_EqW_3yr	112	0.0357	0.01	0.01	0.06
H3_S_CapW_3yr	112	0.0717	0.02	0.04	0.11

Source: Own research

Table 57 indicated that from all three year investment period portfolios, the small-cap value-weighted portfolios had the highest mean score (M=0.072; SD=0.01), followed by mid-cap value-weighted portfolios (M=0.053), and the large-cap equal-weighted portfolios (M=0.051). The small-cap equal-weighted had the least mean score (M=0.036).

Table 58: Multi-variate test for H3_3yr

Hotelling T2	34.22
Hotelling F(5,108)	6.60
Prob > F	0.000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is large (34.2) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the three-year investment length.

Table 59: T-test summary for H3_3yr

Variable	**N**	**Mean**	**t statistics**	**Pr(|T| > |t|)**
H3_L_EqW_3yr	112	0.0506	3.7059	0.0003
H3_L_CapW_3yr	112	0.0361		
diff	112	0.0145		
H3_M_EqW_3yr	112	0.0441	-1.0997	0.2739
H3_M_CapW_3yr	112	0.0527		
diff	112	-0.0086		
H3_S_EqW_3yr	112	0.0357	-2.9970	0.0034
H3_S_CapW_3yr	112	0.0717		
diff	112	-0.0360		

Source: Own research

Table 59 provided statistically significant evidence that the large-cap equal-weighted portfolios had a greater Treynor ratio (0.014) than their value-weighted portfolio pair since the p-value was smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected at a 95% level of confidence.

There was not enough evidence to reject the null hypothesis for mid-cap equal-weighted portfolios since the p-value was above 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was accepted.

However, there was significant evidence that small-cap equal-weighted portfolios had a lower Treynor ratio (-0.036) than their value-weighted portfolio pairs since the p-value was smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected at a 95% level of confidence.

5.4.2.3 Results for H3_5yr

Table 60 Confidence intervals of H3_5yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H3_L_EqW_5yr	104	0.0468	0.01	0.03	0.06
H3_L_CapW_5yr	104	-0.1260	0.01	-0.15	-0.1
H3_M_EqW_5yr	104	0.0470	0.01	0.03	0.06
H3_M_CapW_3yr	112	-0.1639	0.01	0.03	0.08
H3_S_EqW_5yr	104	0.0370	0.01	0.02	0.06
H3_S_CapW_5yr	104	-0.1410	0.02	-0.18	-0.1

Source: Own research

Table 61 indicated that from all five year investment period portfolios, the mid-cap equal-weighted portfolios had the highest mean score (M=0.047; SD=0.01), followed by large-cap equal-weighted portfolios (M=0.047), and the small-cap equal-weighted portfolios (M=0.037). The mid-cap value-weighted portfolios had the least mean score (M=-0.164).

Table 61: Multi-variate test for H3_5yr

Hotelling T2	1130.27
Hotelling F(5,100)	217.28
Prob > F	0.0000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is overwhelmingly large (1130.3) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the five-year investment length.

Table 62: T-test summary for H3_5yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H3_L_EqW_5yr	104	0.0500	29.6351	0.0000
H3_L_CapW_5yr	104	-0.1260		
diff	104	0.1729		
H3_M_EqW_5yr	104	0.0470	10.8610	0.0000
H3_M_CapW_5yr	104	-0.1639		
diff	104	0.2109		
H3_S_EqW_5yr	104	0.0037	15.6439	0.0000
H3_S_CapW_5yr	104	-0.1410		
diff	104	0.1781		

Source: Own research

Table 62 provided statistically significant evidence of the outperformance regarding the Treynor ratio of large-cap, equal-weighted portfolios (0.173), of mid-cap equal-weighted portfolios (0.211) and of small-cap equal-weighted portfolios (0.178) as the p-value was below 0.05. Hence, the null hypotheses (H0: an(diff) = 0) were rejected at a 95% level of confidence.

5.4.2.4 Results for H3_10yr

Table 63: Confidence intervals of H3_10yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H3_L_EqW_10yr	84	0.0420	0.01	0.03	0.05
H3_L_CapW_10yr	84	0.0339	0.01	0.02	0.05
H3_M_EqW_10yr	84	0.0462	0.01	0.03	0.06
H3_M_CapW_10yr	84	0.0618	0.01	0.04	0.08
H3_S_EqW_10yr	84	0.0306	0.00	0.02	0.04
H3_S_CapW_10yr	84	0.0641	0.01	0.05	0.08

Source: Own research

Table 63 indicated that from all ten year investment period portfolios, the small-cap value-weighted portfolios had the highest mean score (M=0.064; SD=0.01), followed by mid-cap value-weighted portfolios (M=0.062), and the mid-cap equal-weighted portfolios (M=0.046). The small-cap equal-weighted portfolio had the least mean (M=0.031).

Table 64: Multi-variate test for H3_10yr

Hotelling T2	666.41
Hotelling F(5,80)	126.86
Prob > F	0.0000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is extremely large (666.4) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the ten-year investment length.

Table 65: T-test summary for H3_10yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H3_L_EqW_10yr	84	0.0420	4.6834	0.0000
H3_L_CapW_10yr	84	0.0340		
diff	84	0.0080		
H3_M_EqW_10yr	84	0.0462	-3.5931	0.0006
H3_M_CapW_10yr	84	0.06186		

diff	84	-0.0156		
H3_S_EqW_10yr	84	0.0307	-11.1387	0.0000
H3_S_CapW_10yr	84	0.0642		
diff	84	-0.0335		

Source: Own research

Table 65 provided statistically significant evidence of the outperformance regarding the Treynor ratio of the large-cap equal-weighted portfolios (0.008) as the p-value was below 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected at a 95% level of confidence.

The mid-cap equal-weighted portfolios (-0.016) and the small-cap equal-weighted portfolios (-0.034) performed significantly worse than their value-weighted portfolio pairs as the p-value is smaller than 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected.

5.4.3 Conclusion of testing H3

Table 66 indicated that the majority of equal-weighted portfolios had significantly different Treynor ratios than value-weighted portfolios at a 95% level of confidence.

Table 66: Conclusion of testing H3

Hypothesis H0: mean(diff) = 0	Accepting H0	Accepting H1
mean(diff) = mean(H3_L_EqW_1yr - H3_L_CapW_1yr)	Yes	No
mean(diff) = mean(H3_M_EqW_1yr - H3_M_CapW_1yr)	Yes	No
mean(diff) = mean(H3_S_EqW_1yr - H3_S_CapW_1yr)	Yes	No
mean(diff) = mean(H3_L_EqW_3yr - H3_L_CapW_3yr)	No	Yes (positive)
mean(diff) = mean(H3_M_EqW_3yr - H3_M_CapW_3yr)	Yes	No
mean(diff) = mean(H3_S_EqW_3yr - H3_S_CapW_3yr)	No	Yes (negative)
mean(diff) = mean(H3_L_EqW_5yr - H3_L_CapW_5yr)	No	Yes (positive)
mean(diff) = mean(H3_M_EqW_5yr - H3_M_CapW_5yr)	No	Yes (positive)
mean(diff) = mean(H3_S_EqW_5yr - H3_S_CapW_5yr)	No	Yes (positive)
mean(diff) = mean(H3_L_EqW_10yr - H3_L_CapW_10yr)	No	Yes (positive)
mean(diff) = mean(H3_M_EqW_10yr - H3_M_CapW_10yr)	No	Yes (negative)
mean(diff) = mean(H3_S_EqW_10yr - H3_S_CapW_10yr)	No	Yes (negative)

Source: Own research

Table 67 showed that the majority of equal-weighted portfolios performed the same or worse than the value-weighted portfolios regarding Treynor ratios. However, all equal-weighted portfolios with a five year investment period performed significantly better than value-weighted portfolios regarding the Treynor ratio.

Table 67: Outperformance of H3_EqW vs H3_CapW

Performance of EqW over CapW	Underperform	NS	Outperform
H3_L_EqW_1yr - H3_L_CapW_1yr		NS	
H3_M_EqW_1yr - H3_M_CapW_1yr		NS	
H3_S_EqW_1yr - H3_S_CapW_1yr		NS	
H3_L_EqW_3yr - H3_L_CapW_3yr			Outperform
H3_M_EqW_3yr - H3_M_CapW_3yr		NS	
H3_S_EqW_3yr - H3_S_CapW_3yr	Underperform		
H3_L_EqW_5yr - H3_L_CapW_5yr			Outperform
H3_M_EqW_5yr - H3_M_CapW_5yr			Outperform
H3_S_EqW_5yr - H3_S_CapW_5yr			Outperform
H3_L_EqW_10yr - H3_L_CapW_10yr			Outperform
H3_M_EqW_10yr - H3_M_CapW_10yr	Underperform		
H3_S_EqW_10yr - H3_S_CapW_10yr	Underperform		

Source: Own research

5.5 Results for testing H4: Jensen's alpha

The study's fourth objective was to determine whether the findings by Jacobs et al. (2014) could be replicated on the JSE in terms of whether there was a statistically higher performance of equal-weighted portfolios compared to value-weighted portfolios regarding Jensen's alpha. The objective was stated as follows:

- Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding Jensen's alpha

5.5.1 Hypothesis for testing

The null and alternative hypotheses for testing the findings of Jacobs et al. (2014) regarding Jensen's alpha on the JSE were as follows:

Null hypothesis two (**$H4_0$**): Up to a 95% confidence level, equal-weighted portfolios had a higher Jensen's alpha compared to value-weighted portfolios.

Alternate hypothesis two (**$H4_1$**): Beyond a 95% confidence level, equal-weighted portfolios did not have a higher Jensen's alpha compared to value-weighted portfolios.

5.5.2 Results for testing

5.5.2.1 Results for H4_1yr

Table 68: Confidence intervals of H4_1yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H4_L_EqW_1yr	120	0.010	0.010	0.000	0.020
H4_L_CapW_1yr	120	0.109	0.004	0.101	0.118
H4_M_EqW_1yr	120	-0.010	0.010	-0.030	0.010
H4_M_CapW_1yr	120	0.732	0.018	0.374	0.019
H4_S_EqW_1yr	120	-0.030	0.010	-0.050	0.000
H4_S_CapW_1yr	120	0.088	0.019	0.051	0.125

Source: Own research

Table 68 indicated that from all one year investment period portfolios, the mid-cap value-weighted portfolios had the highest mean score (M=0.732; SD=0.18), followed by large-cap value-weighted portfolios (M=0.109), and the small-cap value-weighted portfolios (M=0.088). The small-cap equal-weighted portfolios had the least mean score (M=-0.030).

Table 69: Multi-variate test for H4_1yr

Hotelling T2	238.68
Hotelling F(5,115)	46.13
Prob > F	0

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is large (238.68) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the one-year investment length.

Table 70: T-test summary for H4_1yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H4_L_EqW_1yr	120	0.0129	-14.0009	0.0000
H4_L_CapW_1yr	120	0.1095		
diff	120	-0.0966		
H4_M_EqW_1yr	120	-0.0136	-5.5146	0.0000
H4_M_CapW_1yr	120	0.0731		
diff	120	-0.0868		
H4_S_EqW_1yr	120	-0.0272	-6.7219	0.0000
H4_S_CapW_1yr	120	0.0883		
diff	120	-0.1155		

Source: Own research

Table 70 displayed statistically significant evidence that large-cap equal-weighted portfolios (-0.097), mid-cap equal-weighted portfolios (-0.087) and small equal-weighted portfolios (-0.116) performed worse than their value-weighted portfolio pair regarding the Treynor ratio . The t statistics were large while the p-values were smaller than 0.05. Hence, each null hypotheses (H0: an(diff) = 0) had to be rejected.

5.5.2.2 Results for H4_3yr

Table 71: Confidence intervals of H4_3yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H4_L_EqW_3yr	112	-0.0300	0.000	-0.040	-0.030
H4_L_CapW_3yr	112	0.0665	0.005	0.057	0.076
H4_M_EqW_3yr	112	-0.0500	0.010	-0.060	-0.030
H4_M_CapW_3yr	112	0.0624	0.014	0.034	0.091
H4_S_EqW_3yr	112	-0.0500	0.010	-0.070	-0.040
H4_S_CapW_3yr	112	0.0774	0.012	0.053	0.102

Source: Own research

Table 71 indicated that from all one year investment period portfolios, the small-cap value-weighted portfolios had the highest mean score (M=0.077; SD=0.012), followed by large-cap value-weighted portfolios (M=0.067), and the mid-cap value-weighted portfolios (M=0.062). The small-cap equal-weighted portfolios had the least mean score (M=-0.05).

Table 72: Multi-variate test for H4_3yr

Hotelling T2	715.40
Hotelling F(5,107)	137.92
Prob > F	0.000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is large (715.4) and significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the three-year investment length.

Table 73: T-test summary for H4_3yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H4_L_EqW_3yr	112	-0.0316	-23.0569	0.0000
H4_L_CapW_3yr	112	0.0668		
diff	112	-0.0984		
H4_M_EqW_3yr	112	-0.0451	-10.8919	0.0000

H4_M_CapW_3yr	112	0.0627		
diff	112	-0.1078		
H4_S_EqW_3yr	112	-0.0537	-14.7626	0.0000
H4_S_CapW_3yr	112	0.0778		
diff	112	-0.1315		

Source: Own research

Table 73 displayed statistically significant evidence that large-cap equal-weighted portfolios (-0.098), mid-cap equal-weighted portfolios (-0.108) and small equal-weighted portfolios (-0.131) performed worse than their value-weighted portfolio pair regarding Jensen's alpha. The t statistics were large while the p-values were smaller than 0.05. Hence, each null hypotheses (H0: an(diff) = 0) had to be rejected.

5.5.2.3 Results for H4_5yr

Table 74 Confidence intervals of H4_5yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H4_L_EqW_5yr	104	-0.0600	0.000	-0.070	-0.060
H4_L_CapW_5yr	104	-0.1242	0.005	-0.134	-0.114
H4_M_EqW_5yr	104	-0.0700	0.010	-0.090	-0.060
H4_M_CapW_5yr	104	-0.1084	0.017	-0.141	-0.075
H4_S_EqW_5yr	104	-0.0800	0.010	-0.100	-0.070
H4_S_CapW_5yr	104	-0.0761	0.009	-0.095	-0.057

Source: Own research

Table 74 indicated that from all five year investment period portfolios, the large-cap equal-weighted portfolios had the highest mean score (M=-0.06), followed by mid-cap equal-weighted portfolios (M=-0.07), and the small-cap equal-weighted portfolios (M=0.-0.08). The large-cap value-weighted portfolio had the least mean score(M=-0.12).

Table 75: Multi-variate test for H4_5yr

Hotelling T2	547.08
Hotelling F(5,99)	105.17
Prob > F	0.000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is overwhelmingly large (547.1) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the five-year investment length.

Table 76: T-test summary for H4_5yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H4_L_EqW_5yr	104	-0.0642	14.7504	0.0000
H4_L_CapW_5yr	104	-0.1262		
diff	104	0.0619		
H4_M_EqW_5yr	104	-0.0749	2.2460	0.0268
H4_M_CapW_5yr	104	-0.1092		
diff	104	0.0343		
H4_S_EqW_5yr	104	-0.0837	-1.1161	0.2670
H4_S_CapW_5yr	104	-0.0754		
diff	104	-0.0083		

Source: Own research

Table 76 provided statistically significant evidence of the outperformance regarding the Treynor ratio of large-cap equal-weighted portfolios (0.062) and of the mid-cap equal-weighted portfolios (0.034) as the p-value was below 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was rejected at a 95% level of confidence.

However, there was not enough statistically significant evidence to reject the null hypothesis for small-cap equal-weighted portfolios as the p-value was above 0.05. Hence, the null hypothesis (H0: an(diff) = 0) was accepted at a 95% level of confidence.

5.5.2.4 Results for H4_10yr

Table 77: Confidence intervals of H4_10yr

Variable	N	Mean	SD	[95% Conf.	Interval]
H4_L_EqW_10yr	85	-0.1800	0.010	-0.190	-0.160
H4_L_CapW_10yr	85	-0.0823	0.010	-0.102	-0.062
H4_M_EqW_10yr	85	-0.1900	0.010	-0.210	-0.170
H4_M_CapW_10yr	85	-0.0242	0.008	-0.041	-0.008
H4_S_EqW_10yr	85	-0.2100	0.010	-0.230	-0.190
H4_S_CapW_10yr	85	-0.0180	0.008	-0.033	-0.003

Source: Own research

Table 77 indicated that from all ten year investment period portfolios, the small-cap value-weighted portfolios had the highest mean score (M=-0.018; SD=0.008), followed by mid-cap value-weighted portfolios (M=-0.024), and the large-cap value-weighted portfolios (M=-0.08). The small-cap equal-weighted portfolios had the least mean score (M=-0.210).

Table 78: Multi-variate test for H4_10yr

Hotelling T2	25617.99
Hotelling F(5,80)	4879.62

Prob > F	0.000

Source: Own research

Multivariate inferential analysis indicated that there are differences within subject means. The Hotelling statistics is extremely large (25618.0) and highly significant at 5% level. This was evidence to conclude that there were significant differences in the means of the portfolios for the ten-year investment length.

Table 79: T-test summary for H4_10yr

Variable	N	Mean	t statistics	Pr(|T| > |t|)
H4_L_EqW_10yr	85	-0.1752	-39.1715	0.0000
H4_L_CapW_10yr	85	-0.0823		
diff	85	-0.0929		
H4_M_EqW_10yr	85	-0.1852	-50.5453	0.0000
H4_M_CapW_10yr	85	-0.0242		
diff	85	-0.1609		
H4_S_EqW_10yr	85	-0.2104	-51.3256	0.0000
H4_S_CapW_10yr	85	-0.0180		
diff	85	-0.1923		

Source: Own research

Table 79 provided statistically significant evidence that large-cap equal-weighted portfolios (-0.093), mid-cap equal-weighted portfolios (-0.016) and small-cap equal-weighted portfolios had a lower Treynor ratio than their portfolio pairs as the p-value was below 0.05. Hence, the null hypotheses (H0: an(diff) = 0) was rejected at a 95% level of confidence.

5.5.3 Conclusion of testing H4

Table 80 clearly indicates that the majority of equal-weighted portfolios had significantly different Jensen's alpha than value-weighted portfolios at a 95% level of confidence.

Table 80: Conclusion of testing H4

Hypothesis H0: mean(diff) = 0	Accepting H0	Accepting H1
mean(diff) = mean(H4_L_EqW_1yr - H4_L_CapW_1yr)	No	Yes (negative)
mean(diff) = mean(H4_M_EqW_1yr - H4_M_CapW_1yr)	No	Yes (negative)
mean(diff) = mean(H4_S_EqW_1yr - H4_S_CapW_1yr)	No	Yes (negative)
mean(diff) = mean(H4_L_EqW_3yr - H4_L_CapW_3yr)	No	Yes (negative)
mean(diff) = mean(H4_M_EqW_3yr - H4_M_CapW_3yr)	No	Yes (negative)
mean(diff) = mean(H4_S_EqW_3yr - H4_S_CapW_3yr)	No	Yes (negative)
mean(diff) = mean(H4_L_EqW_5yr - H4_L_CapW_5yr)	No	Yes (positive)

mean(diff) = mean(H4_M_EqW_5yr - H4_M_CapW_5yr)	No	Yes (positive)
mean(diff) = mean(H4_S_EqW_5yr - H4_S_CapW_5yr)	Yes	No
mean(diff) = mean(H4_L_EqW_10yr - H4_L_CapW_10yr)	No	Yes (negative)
mean(diff) = mean(H4_M_EqW_10yr - H4_M_CapW_10yr)	No	Yes (negative)
mean(diff) = mean(H4_S_EqW_10yr - H4_S_CapW_10yr)	No	Yes (negative)

Source: Own research

Table 81 showed that the all equal-weighted portfolios performed worse than the value-weighted portfolios regarding, Jensen's alpha.

Table 81: Outperformance of H4_EqW vs H4_CapW

Performance of EqW over CapW	Underperform	NS	Outperform
H4_L_EqW_1yr - H4_L_CapW_1yr	Underperform		
H4_M_EqW_1yr - H4_M_CapW_1yr	Underperform		
H4_S_EqW_1yr - H4_S_CapW_1yr	Underperform		
H4_L_EqW_3yr - H4_L_CapW_3yr	Underperform		
H4_M_EqW_3yr - H4_M_CapW_3yr	Underperform		
H4_S_EqW_3yr - H4_S_CapW_3yr	Underperform		
H4_L_EqW_5yr - H4_L_CapW_5yr			Outperform
H4_M_EqW_5yr - H4_M_CapW_5yr			Outperform
H4_S_EqW_5yr - H4_S_CapW_5yr		NS	
H4_L_EqW_10yr - H4_L_CapW_10yr	Underperform		
H4_M_EqW_10yr - H4_M_CapW_10yr	Underperform		
H4_S_EqW_10yr - H4_S_CapW_10yr	Underperform		

Source: Own research

5.6 Results for testing H5: Sortino ratio

The study's fifth objective was to determine whether the findings by Plyakha et al. (2015) and Post et al. (2018) could be replicated on the JSE whether equal-weighted portfolios had a statistically significant higher Sortino ratio than 1.0 – benchmarked by their value-weighted portfolio pairs. The objective was stated as follows:

- Determine the Sortino ratio of the equal-weighted portfolio benchmarked over the value-weighted portfolios on the JSE

5.6.1 Hypothesis for testing

The null and alternative hypotheses for testing the findings of Plyakha et al. (2015) and Post et al. (2018) regarding the Sortino ratio on the JSE were as follows:

Null hypothesis two (**H5**$_{0}$): Up to a 95% confidence level, equal-weighted portfolios did not have a higher Sortino ratio of 2.0 or above.

Alternate hypothesis two (**H5**$_{1}$): Beyond a 95% confidence level, equal-weighted portfolios did have a higher Sortino ratio of 2.0 or above.

5.6.2 Problems experienced testing the Sortino ratio

Regarding the Sortino ratios, testing hypothesis five was unsuccessful, due to the nature of the performance metric. The Sortino ratio measured the excess portfolio returns against a benchmark over the TDD of that benchmark. Due to the highly similar nature of each of the portfolio pairs, the TDD turned out to be extremely small, so that the resulting Sortino ratios were either extremely large or zero. Hence, the performance metric was not adequate to test the portfolio performance of equal-weighted and value-weighted portfolio pairs as it had lost its effectiveness.

5.7 Results for testing H6: Information ratio

The study's final objective was to determine in which of Grinold and Kahn's (1995) Information ratio categories the individual equal-weighted portfolios fall. The objective was stated as follows:

- Determine in which of Grinold and Kahn's (1995) Information ratio categories the individual equal-weighted portfolios fall

5.7.1 Hypothesis for testing

The null and alternative hypotheses for testing in which of Grinold and Kahn's (1995) category, the individual equal-weighted portfolio falls, were as follows:

Null hypothesis six (**H6**$_{0}$): At a 95% confidence level, equal-weighted portfolios did not differ regarding information ratio from "1.0", "0.0" or "-0.5" respectively.

Alternate hypothesis two (**H6**$_{1}$): At a 95% confidence level, equal-weighted portfolios did differ regarding information ratio from "1.0", "0.0" or "-0.5" respectively.

5.7.2 Results for testing hypothesis

5.7.2.1 Results for H6

Table 82: T-test summary for H6

Variable = 0	N	Mean	t statistics	Pr(|T| > |t|)
H6_L_EqW_3yr	112	0.3861447	2.3973	0.0182
H6_L_EqW_10yr	84	0.2429726	2.9169	0.0045
H6_M_EqW_1yr	119	0.4514894	1.3516	0.1791
H6_M_EqW_3yr	112	0.4653148	2.1052	0.0375
H6_M_EqW_10yr	84	0.4132651	3.5027	0.0007
Variable > 1.0				
H6_L_EqW_1yr	120	-0.004959	-2.8783	0.0047
H6_L_EqW_5yr	104	8.308097	18.8346	0.0000
H6_M_EqW_5yr	104	11.92837	12.3170	0.0000
H6_S_EqW_5yr	104	8.497683	19.4838	0.0000
Variable > -0.5				
H6_S_EqW_1yr	115	-0.587227	3.5027	0.8103
H6_S_EqW_3yr	112	-0.5647365	-0.3605	0.7191
H6_S_EqW_10yr	84	-0.6241017	-2.0620	0.0423

Source: Own research

Table 82 displayed the summary of the statistical t-test conducted. In the following section conclusion of the hypotheses was displayed.

5.7.3 Conclusion of testing H6

Table 83: Conclusion of testing H6

Hypothesis H0: mean() = 0	Accepting H0	Accepting H1
0 = mean(H6_L_EqW_1yr)	Yes	No
0 = mean(H6_L_EqW_3yr)	Yes	No
0 = mean(H6_M_EqW_1yr)	No	Yes (negative)
0 = mean(H6_M_EqW_3yr)	No	Yes (positive)
0 = mean(H6_M_EqW_10yr)	No	Yes (positive)
Hypothesis H0: mean() = 1.0		
1.0 = mean(H6_L_EqW_1yr)	No	Yes (negative)
1.0 = mean(H6_L_EqW_5yr)	No	Yes (positive)
1.0 = mean(H6_M_EqW_5yr)	No	Yes (positive)
1.0 = mean(H6_S_EqW_5yr)	No	Yes (positive)
Hypothesis H0: mean() = -0.5		
-0.5 = mean(H6_S_EqW_1yr)	Yes	No
-0.5 = mean(H6_S_EqW_3yr)	Yes	No
-0.5 = mean(H6_S_EqW_10yr)	No	Yes (negative)

Source: Own research

Table 84 showed that the majority of equal-weighted portfolios performed “Exceptional”, “good” or “Above average” regarding Information ratio. However, all small-cap equal-weighted portfolios had a significantly “Below average” Information ratio according to Grinold and Kahn (1995).

Table 84: Outperformance of H6_EqW vs H6_CapW

Performance of EqW	Exceptional	Good	Above average	Below average
H6_L_EqW_3yr			Above average	
H6_L_EqW_10yr			Above average	
H6_M_EqW_1yr		Good		
H6_M_EqW_3yr		Good		
H6_M_EqW_10yr			Above average	
H6_L_EqW_1yr				Below average
H6_L_EqW_5yr	Exceptional			
H6_M_EqW_5yr	Exceptional			
H6_S_EqW_5yr	Exceptional			
H6_S_EqW_1yr				Below average
H6_S_EqW_3yr				Below average
H6_S_EqW_10yr				Below average

Source: Own research

Chapter 6: Discussion of results

6.1 Introduction

This chapter comprises of an overarching discussion of the results displayed in Chapter 5 with the literature reviewed in Chapter 2. The objective of this chapter is to highlight the consensuses and differences of this study and literature reviewed, establish to elaborate if hypotheses formulated for this study were accepted, and to whether equal-weighted portfolios do perform significantly better value-weighted portfolios in the context of the JSE.

The variables of this study included: the total mean return, volatility, maximum drawdown, performance success ratio, Sharpe, Treynor, Sortino, Information ratio as well as Jensen's alpha of both equal-weighted and value-weighted portfolios on a quarterly adjusted rolling window approach for investment periods of 12, 36, 60, and 120 months.

6.2 Expected results based on literature reviewed

Table 85 shows the expected results from evidence in literature reviewed in Chapter 2. Despite the performance of equal-weighted portfolios to be known to be data- and market specific, there is compelling evidence to expect: *higher* total mean returns, *higher* volatility, *higher* maximum drawdown, *higher* Sharpe ratios, *higher* Treynor ratios, *higher* Jensen's alpha as well as *higher* Sortino ratios. No conclusive expectations were made with regards to *highe*r Information ratios of equal-weighted portfolios.

Table 85: Expected results from evidence in literature

Unit of analysis	Evidence in literature
Higher Total mean return	Atchison et al., 1987; Breen et al., 1989; Canina, et al., 1998; Grinblatt & Titman, 1989; Hwang et al., 2018; Lessard, 1976; Ohlson & Rosenberg, 1982; Roll, 1981
Lower Total mean return	Fletcher, 2011

Higher Volatility	Atchison et al., 1987; Breen et al., 1989; Canina et al., 1998; Grinblatt & Titman, 1989; Hwang et al., 2018; Lessard, 1976; Ohlson & Rosenberg, 1982; Roll, 1981
Higher Maximum drawdown	Plyakha et al., 2015
Higher Sharpe ratio	DeMiguel et al., 2009; Farinelli et al., 2008; Guo et al., 2018; Hwang et al., 2018; Jacobs et al., 2014; Jiang et al., 2018; Malladi and Fabozzi, 2017; Plyakha et al,. 2012
Higher Treynor ratio	Brown et al., 2013; Hwang et al., 2018; Plyakha et al., 2015
Higher Jensen's alpha	Jacobs et al., 2014; Plyakha et al., 2015
Higher Sortino ratio	Plyakha et al., 2015; Post et al., 2018
Higher Information ratio	No research found

Source: Own research

6.3 Discussion of Hypothesis 1

Hypothesis 1 focussed on determining whether equal-weighted portfolios and value-weighted portfolios differ, regarding total mean return and volatility, maximum drawdown and performance success ratio (Pae & Sabbaghi, 2010; Plyakha et al., 2015).

6.3.1 Discussion of Hypothesis 1a

Hypothesis 1a focussed on whether equal-weighted portfolios differ from value-weighted portfolios regarding the total mean return throughout the period of the study for the JSE. First, the cumulative returns were compared for each portfolio strategy and, second, a t-test was performed to test for difference in means of all portfolios generated with the rolling window approach.

Figure 8 graphically depicts the total cumulative returns for 1987 to 2018 for each portfolio strategy and showed that both large-cap and mid-cap equal-weighted strategies, held over the entire period, outperformed their respective value-weighted strategy. However, the small-cap equal-weighted strategy underperformed with regards to the small-cap value-weighted strategy.

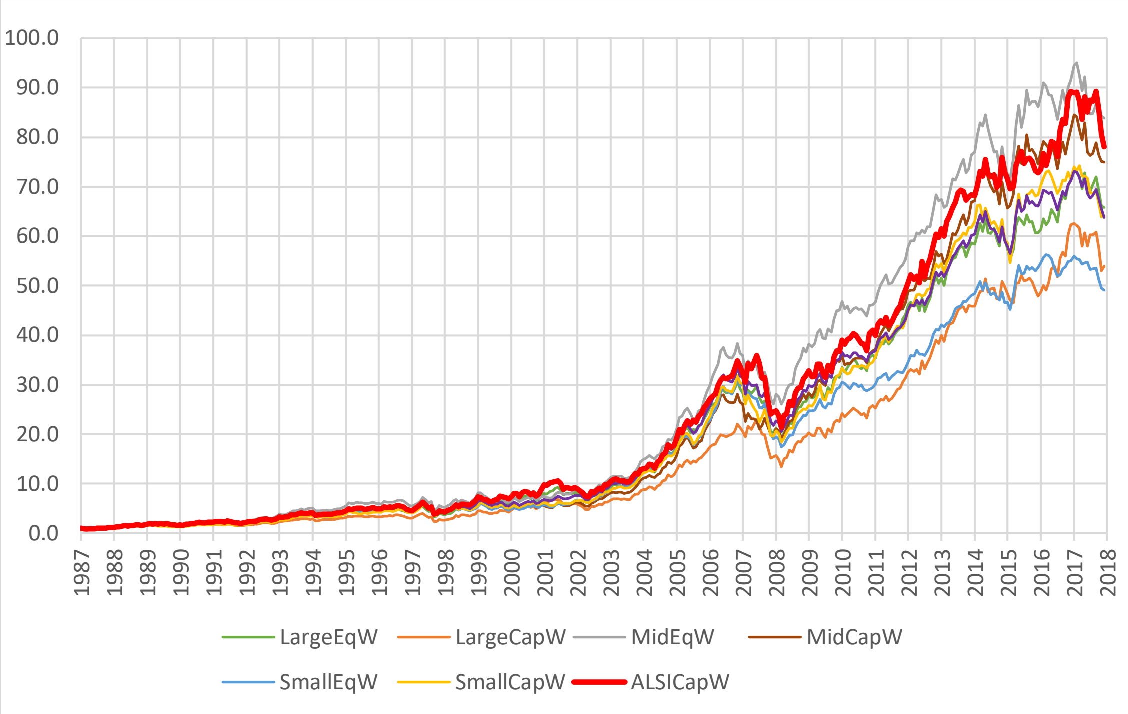

Figure 8 Total returns for all portfolio strategies

Source: Own research

Table 86 showed that all small-cap equal-weighted portfolios performed significantly worse regarding the total mean return. Also, there was not statistically significant for the outperformance of large-cap and mid-cap equal-weighted portfolios for investment periods of under one year. However, once the investment period was greater or equal to five years, all large-cap and mid-cap equal weighted portfolios performed significantly better regarding the total mean return.

Table 86: Implications of H1a

Total mean return of EqW over CapW	Underperform	NS	Outperform
H1a_L_EqW_1yr - H1a_L_CapW_1yr		NS	
H1a_M_EqW_1yr - H1a_M_CapW_1yr		NS	
H1a_S_EqW_1yr - H1a_S_CapW_1yr	Underperform		
H1a_L_EqW_3yr - H1a_L_CapW_3yr			Outperform
H1a_M_EqW_3yr - H1a_M_CapW_3yr		NS	
H1a_S_EqW_3yr - H1a_S_CapW_3yr	Underperform		
H1a_L_EqW_5yr - H1a_L_CapW_5yr			Outperform
H1a_M_EqW_5yr - H1a_M_CapW_5yr			Outperform
H1a_S_EqW_5yr - H1a_S_CapW_5yr	Underperform		
H1a_L_EqW_10yr - H1a_L_CapW_10yr			Outperform
H1a_M_EqW_10yr - H1a_M_CapW_10yr			Outperform
H1a_S_EqW_10yr - H1a_S_CapW_10yr	Underperform		

Source: Own research

The literature regarding the outperformance of equal-weighted portfolios in relation to the total mean return is mixed and found the performance of equal-weighted portfolios to be market- and data-specific Fletcher (2011). DeMiguel et al. (2007), who had jump-started the academic discussion about the benefits of equal-weighted portfolios, found that equal-weighted portfolios significantly outperformed value-weighted portfolios (mainly in the US and Japanese equity markets). Before DeMiguel et al. (2007), had confirmed the findings of Grinblatt and Titman (1989) as well as Jegadeesh and Titman (1993), many other researchers had found excess returns of equal-weighted portfolios (Atchison et al., 1987; Breen et al., 1989; Canina et al., 1998; Grinblatt & Titman, 1989; Lessard, 1976; Ohlson & Rosenberg, 1982; Roll, 1981). This study overall reaches the same conclusion: the majority of investigated equal-weighted portfolios performed significantly better at 95% confidence level or better; however, they were not statistically significant.

It is important to note that the small-cap equal weighted portfolios performed significantly worse regarding the total mean return. Hence the results confirmed two of the suggested origins of total excess return (DeMiguel et al., 2009; Pae & Sabbaghi (2010) since the small-caps on the JSE are known to be less liquid and not as efficient as the large- and the mid-caps. Perold (2007) found a lack of market efficiency and Blume and Stambaugh (1983) and Bali et al. (2005) found a lack of market liquidity to be the source of excess returns. This study also confirmed the findings of Goetzmann et al. (2005) of excess returns on long-term equal-weighted portfolios, as all equal-weighted large-cap and mid-cap portfolios performed significantly better than their value-weighted counterparts once the investment period was longer than three years (except for M_EqW_3yr).

This study did not investigate the effectiveness of different rebalancing frequencies since Malladi and Fabozzi (2017) had found that quarterly rebalancing to be the optimum. This study did not take into account transaction costs for rebalancing as there are now an array of equal-weighted ETFs listed on the JSE for large- and mid-caps at negligibly low costs.

In conclusion, this study confirmed the above-noted literature and listed the South African JSE as an equity market where large- and mid-cap equal-weighted portfolios did outperform value-weighted portfolios for more extended investment periods than three-years. The findings cannot be generalised for other equity markets outside of South Africa and non-listed shares in South Africa.

Summary of findings Hypothesis 1a

Hypothesis 1a focussed on whether equal-weighted portfolios differ from value-weighted portfolios regarding the total mean return over the period of the study for the JSE.

Equal-weighted portfolios did differ from value-weighted portfolios regarding the total mean return. Generally, large- and mid-cap equal-weighted portfolios performed better for investment periods more extended than three-years, while small-cap equal-weighted portfolios performed worse than their value-weighted counterparts.

6.3.2 Discussion of Hypothesis 1b

Hypothesis 1b focussed on whether equal-weighted portfolios differ from value-weighted portfolios regarding the volatility over the period of the study for the JSE. A t-test was performed to test for difference in means.

Figure 9 graphically depicts the volatility of each portfolio strategy and showed that all equal-weighted (large-, mid- & small-cap) portfolios had lower volatilities on average than their value-weighted counterparts for 1987 to 2018. All lower volatilities were statistically significant at a 95% level of confidence.

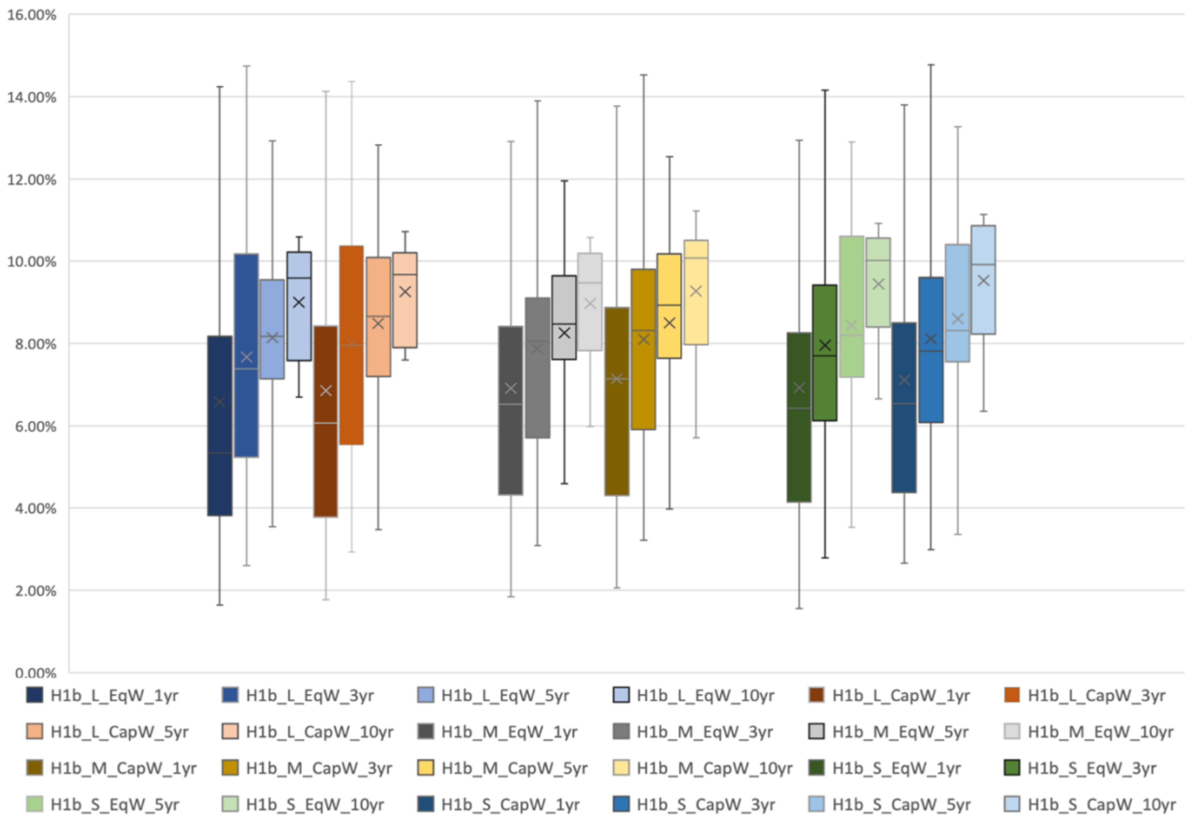

Figure 9: Boxplot of volatilities of each portfolio

Source: Own research

Table 87 showed that all equal-weighted portfolios experienced significantly lower volatility than their value-weighted portfolio pair regardless of the investment period length.

Table 87: Outperformance of H1b_EqW vs H1b_CapW

Performance of EqW over CapW	Underperform	NS	Outperform
H1b_L_EqW_1yr - H1b_L_CapW_1yr			Outperform
H1b_M_EqW_1yr - H1b_M_CapW_1yr			Outperform
H1b_S_EqW_1yr - H1b_S_CapW_1yr			Outperform
H1b_L_EqW_3yr - H1b_L_CapW_3yr			Outperform
H1b_M_EqW_3yr - H1b_M_CapW_3yr			Outperform
H1b_S_EqW_3yr - H1b_S_CapW_3yr			Outperform
H1b_L_EqW_5yr - H1b_L_CapW_5yr			Outperform
H1b_M_EqW_5yr - H1b_M_CapW_5yr			Outperform
H1b_S_EqW_5yr - H1b_S_CapW_5yr			Outperform
H1b_L_EqW_10yr - H1b_L_CapW_10yr			Outperform
H1b_M_EqW_10yr - H1b_M_CapW_10yr			Outperform
H1b_S_EqW_10yr - H1b_S_CapW_10yr			Outperform

Source: Own research

The literature reviewed regarding the volatility of equal-weighted portfolios was uniform; equal-weighted portfolios do bear higher volatility than value-weighted portfolios (Atchison et al., 1987; Breen et al., 1989; Canina et al., 1998; Grinblatt & Titman, 1989; Lessard, 1976; Ohlson & Rosenberg, 1982; Roll, 1981). Hwang et al. (2018) associated the excess returns of equal-weighted portfolios directly to bearing higher volatility, in accordance with the efficient market theory.

The findings of this study were entirely contrarian to current literature: all equal-weighted portfolios for all investment periods did bear lower volatility than their value-weighted counterparts despite some realising higher returns. This study is, therefore, also contrarian to Hwang et al. (2018).

Equal-weighted portfolios are in nature contrarian to the market portfolio, since shares that drop in price are allocated more weight and other shares are allocated less weight at the quarterly rebalancing date (the opposite being true for value-weighted portfolios). Hence, volatility for equal-weighted portfolios should be greater in markets, with positive momentum effects. Another explanation could be the unusually high market concentration of the JSE compared to other markets, and that larger stocks, according to market capitalisation, were subject to higher volatility than smaller shares. However, this must only be true within their respective category as the volatility decreased monotonously from small- to large-cap. Another possible explanation could be the limitation of this study of only investigating the volatility of the portfolio prices of the quarterly closing prices and not daily or monthly volatility.

In conclusion, this study disproved the above-noted literature in the context of the South African JSE equity market. The findings cannot be generalised to other equity markets outside of South Africa and non-listed shares in South Africa; the findings can also not be generalised for any other, than the investigated quarterly closing prices such as daily or monthly closing prices.

Summary of findings Hypothesis 1b

Hypothesis 1b focussed on whether equal-weighted portfolios differ from value-weighted portfolios regarding the volatility over the period of the study for the JSE.

The investigated equal-weighted portfolios differed from their value-weighted portfolios regarding volatility. All equal-weighted portfolios did bear significantly less volatility than their value-weighted counterparts at a 95% level of confidence. Further, findings were that the longer the investment period, the higher the volatility on average, but the smaller the range of volatility for the portfolios investigated.

6.3.4 Discussion of Hypothesis 1c

Hypothesis 1c focussed on whether equal-weighted strategies had greater maximum drawdown than value-weighted strategies. The drawdowns were calculated, and then the maximums were compared.

Figure 10 graphically depicted the drawdown of each portfolio strategy and showed that all portfolio strategies were, at times, subject to severe drawdown. Especially the large-cap value-weighted and the small-cap equal-weighted experienced the most substantial drawdowns.

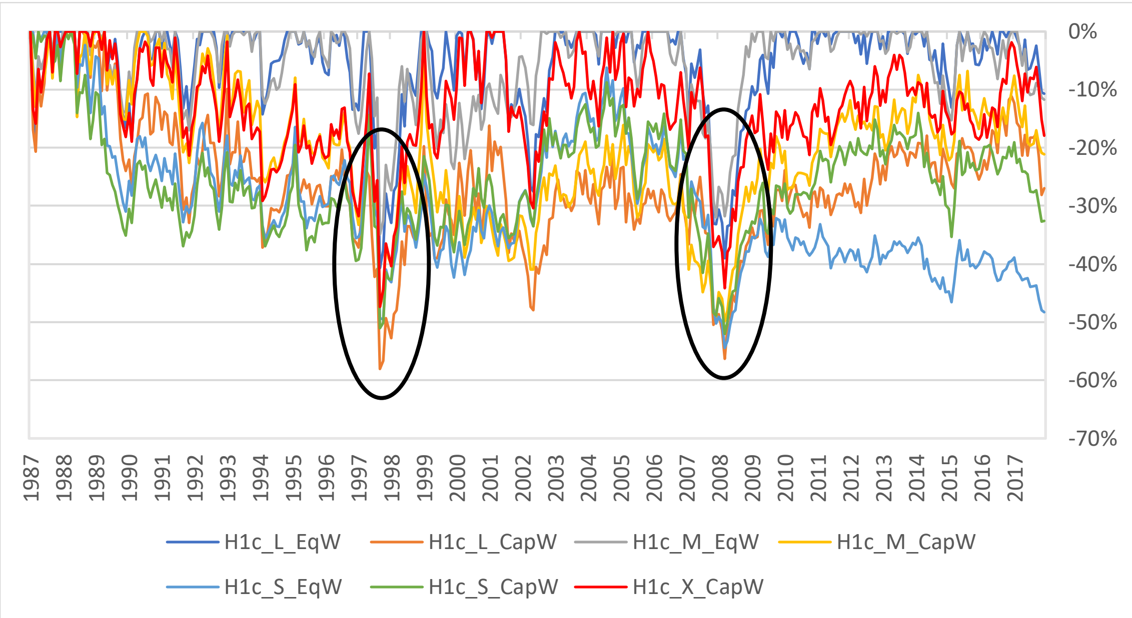

Figure 10: Drawdown of each portfolio strategy

Source: Own research

Table 88 showed the maximum drawdown of each portfolio strategy. The maximum drawdown of the large-cap equal-weighted portfolio strategy was significantly less severe (17.3%) than the value-weighted portfolio strategy (with the same being true for the mid-cap equal-weighted portfolio strategy (14.9%). The small-cap equal-weighted strategy was subject to a slightly higher drawdown (2.4%) than its counterpart. Only the large- and mid-cap equal-weighted strategies had a lower maximum drawdown than the market (6.7% and 12.5% respectively). The lowest maximum drawdown overall experienced the mid-cap equal-weighted strategy (-34.9%). Therefore, with exception to the small-cap equal-weighted strategy, the equal-weighted strategy performs significantly better at the worst of times.

Table 88: Maximum drawdown of all portfolio strategies

	H1c_L_ EqW	***H1c_L_ CapW***	***H1c_M_ EqW***	***H1c_M_ CapW***	***H1c_S_ EqW***	***H1c_S_ CapW***	***H1c_X _CapW***
Median	-0.022	-0.265	-0.030	-0.195	-0.317	-0.265	-0.126
Minimum	**-0.407**	**-0.580**	**-0.349**	**-0.498**	**-0.544**	**-0.520**	**-0.474**
Count	372	372	372	372	372	372	372

Source: Own research

Plyakha et al. (2012, 2015) investigated the average yearly maximum drawdown of equal-weighted and value-weighted portfolios and found that the former was subject to significantly greater maximum drawdown. The study utilised a different methodology as it investigated the total maximum drawdown, for each of the portfolio strategies, over the entire period, rather than the average maximum drawdown for portfolios, of the rolling window approach. The researcher deemed Plyakha et al.'s (2015) methodology to lack rigour with regard to testing the maximum drawdown as investors are interested in the worst case scenario regarding drawdown.

However, the contrarian nature of equal-weighted portfolios to value-weighted portfolios (described in the previous section above) and the inverse correlation of performance and momentum strategies are in cohesion with Plyakha et al. (2012, 2015) findings. They found evidence of higher volatility and greater maximum drawdown (the opposite of this study), for other equity markets, reaffirming the market-specific nature of the performance of equal-weighted portfolios (Fletcher, 2011).

In conclusion, this study found substantially lower maximum drawdowns for large- and mid-caps in the context of the South African JSE equity market. The findings cannot be generalised for other equity markets outside of South Africa and non-listed shares in South Africa.

Summary of findings hypothesis 1c

Hypothesis 1c focussed on whether equal-weighted strategies had greater maximum drawdown than value-weighted strategies.

Equal-weighted strategies differed from value-weighted strategies regarding maximum drawdown. The large- and mid-cap equal-weighted portfolio strategies were subject to substantially small maximum drawdown than their respective value-weighted strategy.

The small-cap equal-weighted portfolio strategy was subject to slightly higher maximum drawdown.

6.3.5 Discussion of Hypothesis 1d

Hypothesis 1d focussed on whether equal-weighted portfolio strategies had a greater performance success ratio than value-weighted portfolios. The number of positive quarters were then divided by the total number of quarters (125).

Figure 11 graphically depicted the performance success ratio of each portfolio strategy and showed that all strategies had positive returns for more than 70% of the quarters. While there was no difference between large-caps, mid-cap equal-weighted portfolios had a slightly higher and small-cap equal-weighted portfolios had a slightly lower performance success ratios than their counterpart.

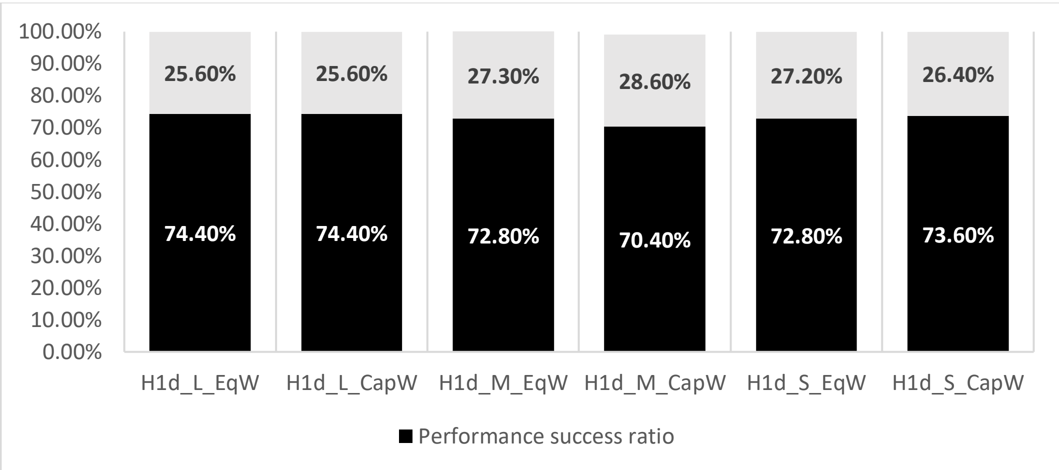

Figure 11: Performance success ratio

Source: Own research

Summary of findings hypothesis 1d

Hypothesis 1c focussed on whether equal-weighted portfolio strategies had greater performance success ratio than value-weighted portfolios.

The large-cap equal-weighted portfolio strategy did not differ regarding the quarterly performance success ratio from value-weighted, while mid-caps performed slightly better and small-caps performed slightly worse.

6.4 Discussion of Hypothesis 2

Hypothesis 2 focussed on whether the findings regarding a higher Sharpe ratio by DeMiguel et al. (2009), Jacobs et al. (2014), Plyakha et al. (2015) and Hwang et al. (2018) for equal-weighted and value-weighted portfolios, could be replicated for the JSE. First, the Sharpe ratios were compounded for each of the portfolios generated with the rolling window approach and then a t-test was performed to test for difference in means between portfolio pairs.

Figure 12 graphically depicts the Sharpe ratios of each portfolio strategy and showed that the large-cap value-weighted (1yr) portfolios had the largest Sharpe ratio on average (2.03) followed by the large-cap (1yr) equal-weighted portfolios (1.71) and the mid-cap equal-weighted (1yr) portfolios (1.34). The lowest Sharpe ratios had the mid-cap value-weighted (5yr) portfolios (-1.35), while the large-cap value-weighted (5yr) portfolios had achieved second worst (-1.31) and the small-cap value-weighted (5yr) portfolios scored third worst (-1.14).

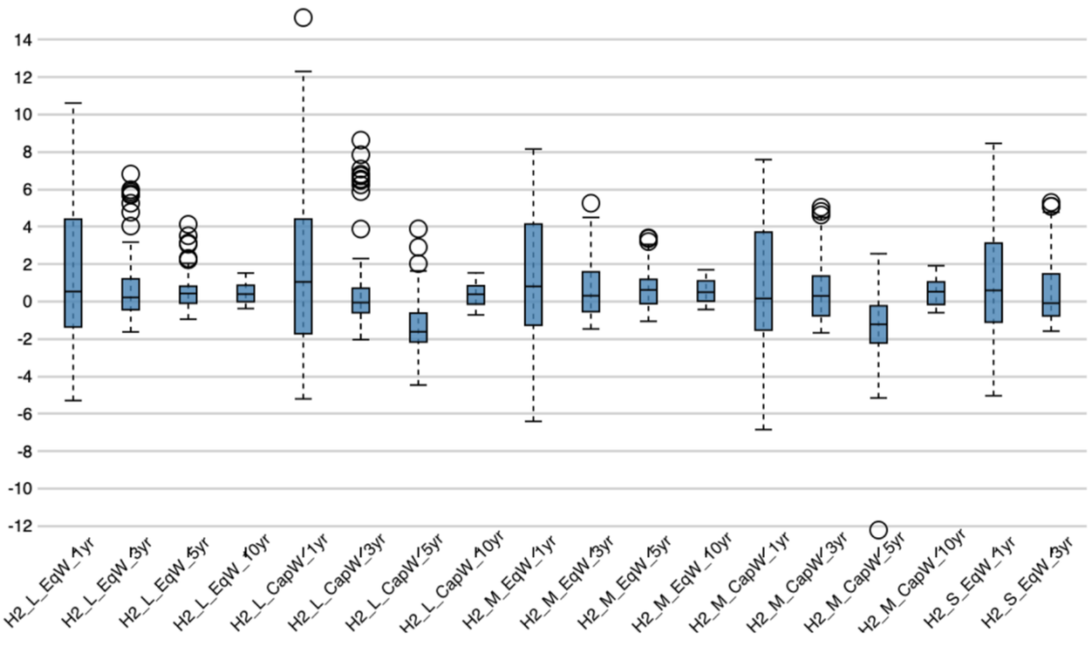

Figure 12: Sharpe ratios of each portfolio

Source: Own research

Table 89 showed that the majority of equal-weighted portfolios performed better or the same as the value-weighted portfolios regarding Sharpe ratio. Notably, the five-year investment period led to better the Sharpe ratios of equal- and value-weighted portfolios. However, three equal-weighted portfolios performed significantly worse on average than their value-weighted counterpart, the large-cap (1yr), the small-cap (3yr) and the small-cap (10yr).

Table 89: Hypothesis 2 Sharpe ratio

Performance of EqW over CapW	Underperform	NS	Outperform
H2_L_EqW_1yr - H2_L_CapW_1yr	Underperform		
H2_M_EqW_1yr - H2_M_CapW_1yr		NS	
H2_S_EqW_1yr - H2_S_CapW_1yr		NS	
H2_L_EqW_3yr - H2_L_CapW_3yr		NS	
H2_M_EqW_3yr - H2_M_CapW_3yr		NS	
H2_S_EqW_3yr - H2_S_CapW_3yr	Underperform		
H2_L_EqW_5yr - H2_L_CapW_5yr			Outperform
H2_M_EqW_5yr - H2_M_CapW_5yr			Outperform
H2_S_EqW_5yr - H2_S_CapW_5yr			Outperform
H2_L_EqW_10yr - H2_L_CapW_10yr			Outperform
H2_M_EqW_10yr - H2_M_CapW_10yr		NS	
H2_S_EqW_10yr - H2_S_CapW_10yr	Underperform		

Source: Own research

DeMiguel et al. (2007) tested 14 different common portfolio strategies and found that none could consistently outperform the equal-weighted portfolio strategy regarding the Sharpe ratio. These findings were confirmed by Farinelli et al. (2008), Guo et al. (2018), Hwang et al. (2018), Jacobs et al. (2014), Jiang et al. (2018), Malladi and Fabozzi (2017) as well as Plyakha et al. (2012). The naive portfolio strategy of equal weights achieved the same or better levels of diversification as more sophisticated allocation rules – as long as the portfolio was not overly invested in one asset class (Jacobs et al., 2014). Jacobs et al. (2014) further found that equal-weighted portfolios were naturally Sharpe ratio maximising portfolios. Sharpe ratios of equal-weighted portfolios have thus far not been investigated in the South African context.

This study mostly correlated with these findings as nine out of the 12 different equal-weighted portfolios significantly outperformed or at least achieved the same standards of diversification as their respective value-weighted portfolio pairs regarding the Sharpe ratio. Therefore, equal-weighted portfolios generated the same or higher excess returns per unit of total portfolio risk. Again, it was observed that the trend of underperformance of small-cap equal-weighted portfolios continued regarding the Sharpe ratios as two out of three underperforming portfolios were small-caps.

In conclusion, this study was confirming the above-noted literature that equal-weighted portfolios are naturally Sharpe ratio optimising portfolios, proven in the context of the South African JSE equity market. The findings cannot be generalised for other equity markets outside of South Africa and non-listed shares in South Africa.

Summary of findings hypothesis 2

Hypothesis 2 focussed on whether the findings regarding a higher Sharpe ratio by DeMiguel et al. (2009), Jacobs et al. (2014), Plyakha et al. (2015) and Hwang et al. (2018) for equal-weighted and value-weighted portfolios could be replicated for the JSE.

Four equal-weighted portfolios had significantly higher Sharpe ratios, and five equal-weighted portfolios had statistically no different Sharpe ratios than their value-weighted portfolio pairs at a 95% level of confidence. Three equal-weighted portfolios had significantly lower Sharpe ratios.

6.5 Discussion of Hypothesis 3

Hypothesis 3 focussed on whether the findings regarding a higher Treynor ratio by Brown et al. (2013), Hwang et al. (2018), Plyakha et al. (2015) for equal-weighted and value-weighted portfolios could be replicated for the JSE. First, the Treynor ratios were compounded for each of the portfolios generated with the rolling window approach and then a t-test was performed to test for difference in means between portfolio pairs.

Table 90 showed that the majority of equal-weighted portfolios performed the same or better than their respective value-weighted portfolio pairs regarding the Treynor ratio. Notably, the five-year investment period led to better Treynor ratios of equal-weighted portfolios. However, three equal-weighted portfolios performed significantly worse on average than their value-weighted counterpart, the small-cap (3yr), the mid-cap (10yr) and the small-cap (10yr).

Table 90: Hypothesis 3 Treynor ratio

Performance of EqW over CapW	Underperform	NS	Outperform
H3_L_EqW_1yr - H3_L_CapW_1yr		NS	
H3_M_EqW_1yr - H3_M_CapW_1yr		NS	
H3_S_EqW_1yr - H3_S_CapW_1yr		NS	
H3_L_EqW_3yr - H3_L_CapW_3yr			Outperform
H3_M_EqW_3yr - H3_M_CapW_3yr		NS	
H3_S_EqW_3yr - H3_S_CapW_3yr	Underperform		
H3_L_EqW_5yr - H3_L_CapW_5yr			Outperform
H3_M_EqW_5yr - H3_M_CapW_5yr			Outperform
H3_S_EqW_5yr - H3_S_CapW_5yr			Outperform
H3_L_EqW_10yr - H3_L_CapW_10yr			Outperform
H3_M_EqW_10yr - H3_M_CapW_10yr	Underperform		
H3_S_EqW_10yr - H3_S_CapW_10yr	Underperform		

Source: Own research

Despite many researchers investigating the Sharpe ratios of equal-weighted portfolios, the Treynor ratios of equal-weighted portfolios have only been tested by a few studies, namely by Brown et al. (2013), Hwang et al. (2018) and Plyakha et al. (2015). These studies found equal-weighted portfolios to significantly outperform value-weighted portfolios regarding the Treynor ratio, thus, equal-weighted portfolios have higher excess returns per unit of systematic risk.

This study mostly confirmed these findings as nine out of the 12 different equal-weighted portfolios significantly outperformed or at least achieved the same level of excess return per unit of market risk. Again, it was observed that the trend of underperformance of small-cap equal-weighted portfolios continued with regards to Treynor ratios as two out of three underperforming portfolios were small-caps.

In conclusion, this study confirmed the above-noted literature that equal-weighted portfolios achieved higher Treynor ratios, proven in the context of the South African JSE equity market. The findings cannot be generalised for other equity markets outside of South Africa and non-listed shares in South Africa.

Summary of findings hypothesis 3

Hypothesis 3 focussed on whether the findings regarding a higher Treynor ratio by Brown et al. (2013), Hwang et al. (2018), Plyakha et al. (2015) for equal-weighted and value-weighted portfolios could be replicated for the JSE.

Five equal-weighted portfolios had significantly higher Treynor ratios, and four equal-weighted portfolios had statistically no different Sharpe ratios than their value-weighted portfolio pairs at a 95% level of confidence. Three equal-weighted portfolios had significantly lower Treynor ratios.

6.6 Discussion of Hypothesis 4

Hypothesis 4 focussed on whether the findings by Jacobs et al. (2014) and Plyakha et al. (2015) could be replicated on the JSE regarding whether there was a statistically higher performance of equal-weighted portfolios compared to value-weighted portfolios in terms of the Jensen's alpha. First, the alphas were compounded for each of the *portfolios generated with the rolling window approach and then a t-test was performed to test for difference in means between portfolio pairs.*

Table 89 showed that the majority of equal-weighted portfolios performed significantly worse on average than the value-weighted portfolios regarding Jensen's alpha. However, the five-year investment period portfolios led to better or equal alphas of equal-weighted portfolios on average.

Table 91: Hypothesis 4 Jensen's alpha

Performance of EqW over CapW	Underperform	NS	Outperform
H4_L_EqW_1yr - H4_L_CapW_1yr	Underperform		
H4_M_EqW_1yr - H4_M_CapW_1yr	Underperform		
H4_S_EqW_1yr - H4_S_CapW_1yr	Underperform		
H4_L_EqW_3yr - H4_L_CapW_3yr	Underperform		
H4_M_EqW_3yr - H4_M_CapW_3yr	Underperform		
H4_S_EqW_3yr - H4_S_CapW_3yr	Underperform		
H4_L_EqW_5yr - H4_L_CapW_5yr			Outperform
H4_M_EqW_5yr - H4_M_CapW_5yr			Outperform
H4_S_EqW_5yr - H4_S_CapW_5yr		NS	
H4_L_EqW_10yr - H4_L_CapW_10yr	Underperform		
H4_M_EqW_10yr - H4_M_CapW_10yr	Underperform		
H4_S_EqW_10yr - H4_S_CapW_10yr	Underperform		

Source: Own research

The efficient market theory predicts that no share or portfolio can consistently outperform the market unless by luck or chance. However, Plyakha et al. (2015) found an alpha for equal weighted portfolios of 2.71% that resulted from monthly rebalancing. Jacobs et al. (2014) tested these findings with a much more comprehensive dataset including the regions emerging markets, Europe, North America, as well as Pacific and found an excess alpha of 0.13% for equal-weighted portfolios. This study found an average alpha of **-7.93%** across all equal-weighted portfolios whilst the value-weighted average was **+0.37%**. Thus, the equal-weighted portfolio did not outperform the market supporting the efficient market theory.

Summary of findings hypothesis 4

Hypothesis 4 focussed on whether the findings by Jacobs et al. (2014) and Plyakha et al. (2015) could be replicated on the JSE regarding whether there was a statistically higher performance of equal-weighted portfolios compared to value-weighted portfolios in terms of the Jensen's alpha.

Nine equal-weighted portfolios performed worse than their value-weighted counterparts, two better and one statistically no different on average at 95% level of confidence.

6.7 Discussion of Hypothesis 5

Hypothesis 5 focussed on whether the findings by Plyakha et al. (2015) and Post et al. (2018) could be replicated on the JSE whether equal-weighted portfolios have a statistically significantly higher Sortino ratio than 1.0 benchmarked by their value-weighted portfolio pairs.

Problems experienced testing the Sortino ratio

Testing hypothesis 5 regarding the Sortino ratio turned out to be unsuccessful, due to the nature of the performance metric and the portfolios investigated. The Sortino ratio measured the excess portfolio returns against a benchmark over the TDD of that benchmark. Due to the highly similar nature of each of the portfolio pairs, the TDD turned out to be extremely small, so that the resulting Sortino ratio was either extremely large or zero. Hence, the performance metric was not adequate and lost its efficiency to test the portfolio performance of equal-weighted and value-weighted portfolio pairs as it lost its effectiveness. Researchers that did investigate Sortino ratios in the context of equal-weighted portfolios did so with randomised stock selection (Plyakha et al., 2015).

Summary of findings hypothesis 5

Hypothesis 5 focussed on whether the findings by Plyakha et al. (2015) and Post et al. (2018) could be replicated on the JSE in terms of whether equal-weighted portfolios have a statistically significantly higher Sortino ratio than 1.0 benchmarked by their value-weighted portfolio pairs.

The study did not investigate the Sortino ratio due to the loss efficiency of the performance metric to test the two portfolio types.

6.8 Discussion of Hypothesis 6

The sixth and final hypothesis was to determine in which of Grinold and Kahn's (1995) Information ratio categories the individual equal-weighted portfolios fall. First, the Information ratios were compounded for each of the portfolios generated with the rolling *window approach and then a t-test was performed to test for difference in means between portfolio pairs.*

Table 92 showed that the majority of equal-weighted portfolios performed "exceptional" "good" or "above average" against the benchmark of their value-weighted portfolio pairs regarding the Information ratio (Grinold & Kahn, 1995). Again, a trend can be observed that all five-year equal-weighted portfolios performed "exceptional". However, four equal-weighted portfolios performed significantly below average: the large-cap one-year as well as the small-cap three-year, five-year and 10-year.

Table 92: Hypothesis 6 Information ratio

Performance of EqW	Exceptional	Good	Above average	Below average
H6_L_EqW_3yr			Above average	
H6_L_EqW_10yr			Above average	
H6_M_EqW_1yr		Good		
H6_M_EqW_3yr		Good		
H6_M_EqW_10yr			Above average	
H6_L_EqW_1yr				Below average
H6_L_EqW_5yr	Exceptional			
H6_M_EqW_5yr	Exceptional			
H6_S_EqW_5yr	Exceptional			
H6_S_EqW_1yr				Below average
H6_S_EqW_3yr				Below average
H6_S_EqW_10yr				Below average

Source: Own research

The Information ratio is the excess return of equal-weighted over value-weighted portfolios divided by the standard deviation of those returns for the underlying period. Whilst the metric is popular for evaluating portfolio performance and their portfolio managers (Goodwin, 1998; Grinold & Kahn, 1995) it has not been to investigate the performance of equal-weighted portfolios thus far. However, the widespread use of the Information ratio as well as its similarity to the popular Sharpe ratio warrants for its robustness.

In conclusion, eight out the 12 investigated portfolio pairs scored "above average" and three even attained the "exceptional" verdict in the context of the South African JSE equity market. The findings cannot be generalised for other equity markets outside of South Africa and non-listed shares in South Africa.

Summary of findings Hypothesis 6

The sixth and final hypothesis was to determine in which of Grinold and Kahn's (1995) Information ratio categories the individual equal-weighted portfolios fall.

Three equal-weighted portfolios attained the "exceptional" verdict, two scored "good", and a further three came "above average" whilst four scored "below average" at a 95% level of confidence.

6.9 Summary of overall portfolio performance

Table 93 provides an overview of the statically significant implications of all individual portfolio performances. Four trends can be observed regarding the performance of equal-weighted and value-weighted portfolios on the JSE;

- the performance of equal-weighted portfolio tended to improve with the investment period length;
- all equal-weighted portfolios had lower volatilities than their value-weighted portfolio pairs and could be a good alternative for value-weighted portfolios for investors that seek to reduce overall portfolio volatility yet diversify investments across large-, mid- and small-caps;
- the five year large- and mid-cap equal-weighted portfolios significantly performed statistically better than their value-weighted portfolio pairs throughout all hypotheses; and
- any small-cap equal-weighted portfolios did not perform as well as their value-weighted pairs regarding the total mean return.

Table 93: Implications of overall portfolio performance

Portfolio	H1a: Mean return	H1b: Volatility	H2: Sharpe ratio	H3: Treynor ratio	H4: Jensen's alpha	H6: Information ratio
L_EqW_1yr - L_CapW_1yr	NS	Outperform	Underperform	NS	Underperform	Above average
M_EqW_1yr - M_CapW_1yr	NS	Outperform	NS	NS	Underperform	Above average
S_EqW_1yr -S_CapW_1yr	Underperform	Outperform	NS	NS	Underperform	Good
L_EqW_3yr - L_CapW_3yr	Outperform	Outperform	NS	Better	Underperform	Good
M_EqW_3yr - M_CapW_3yr	NS	Outperform	NS	Underperform	Underperform	Above average
S_EqW_3yr -S_CapW_3yr	Underperform	Outperform	Underperform	Underperform	Underperform	Below average
L_EqW_5yr - L_CapW_5yr	Outperform	Outperform	Outperform	Outperform	Outperform	Exceptional
M_EqW_5yr - M_CapW_5yr	Outperform	Outperform	Outperform	Outperform	Outperform	Exceptional
S_EqW_5yr -S_CapW_5yr	Underperform	Outperform	Outperform	Outperform	NS	Exceptional
L_EqW_10yr - L_CapW_10yr	Outperform	Outperform	Outperform	Outperform	Underperform	Below average
M_EqW_10yr - M_CapW_10yr	Outperform	Outperform	NS	Underperform	Underperform	Below average
S_EqW_10yr - S_CapW_10yr	Underperform	Outperform	Underperform	Underperform	Underperform	Below average

Source: Own research

Chapter 7: Conclusion

7.1 Introduction

Chapter 7 summarises the key findings of this research which sought to understand the performance of equal-weighted and value-weighted portfolios. This chapter draws implications from these findings for academic theory and management. The chapter further reflects on the limitations of this study and proposes avenues for further research.

7.2 Principal findings

The principal findings of this study were that equal-weighted portfolios constructed from large- and mid-caps perform at least as well as value-weighted portfolios in the short-term (one and three years) but significantly outperform in the long-term with regards to mean return. The performance of the total mean return of equal-weighted portfolios tended to improve with the investment period length. However, equal-weighted portfolios constructed from small-caps failed to beat their value-weighted counterparts.

The other main findings are summarised below:

1. The volatility of all equal-weighted portfolios was lower: all equal-weighted portfolios had statistically significant lower volatilities than their value-weighted portfolio pairs. As such, equal-weighted portfolios could be a good alternative value-weighted portfolios for investors that seek to reduce overall portfolio volatility yet diversify investments across large-, mid- and small-caps.
2. Equal-weighted portfolios are adequate and statistically significant measures to diversify against total risk (Sharpe ratio) and market risk (Treynor ratio) since they scored, in majority, higher or equal ratios than their value-weighted counterparts.
3. Only the two five years large- and mid-cap equal-weighted portfolios could outperform value-weighted portfolios with regards to Jensen's alpha. All other equal-weighted portfolios performed statistically significantly worse than their counterparts.
4. Majority of equal-weighted portfolios performed above average regarding Information ratio including three which obtained the "exceptional" verdict

Table 94 reports all performance metrics for the equal- and value-weighted portfolios constructed in the three categories of large-, mid- and small-caps on the JSE from individual tables in Chapter 5. The results contain the summary of the 848 quarterly rebalanced portfolios from monthly returns ranging from 1987 to 2018 (372 months) with the rolling window approach. The portfolio returns are before transactions costs.

Table 94: Summary of all portfolio performance metrics

	Mean return (per annum)	Std. dev.	Volatility	Sharpe ratio	Treynor ratio	Jensen's alpha	Information ratio
L_EqW_1yr	17.03%	19.65%	0.06586	1.713	0.076	1.29%	-0.009
L_CapW_1yr	16.57%	19.93%	0.06851	2.034	0.058	10.95%	
M_EqW_1yr	17.75%	19.82%	0.06909	1.735	0.054	-1.36%	0.430
M_CapW_1yr	17.49%	20.18%	0.07142	2.311	0.073	7.31%	
S_EqW_1yr	15.74%	19.15%	0.06921	1.133	0.043	-4.51%	-0.571
S_CapW_1yr	16.70%	18.79%	0.07117	1.260	0.182	8.83%	
L_EqW_3yr	15.37%	10.59%	0.07670	0.918	0.051	-3.16%	0.386
L_CapW_3yr	14.73%	10.48%	0.07997	1.011	0.036	6.65%	
M_EqW_3yr	16.49%	10.59%	0.07877	0.710	0.044	-7.49%	0.465
M_CapW_3yr	16.16%	10.48%	0.08106	0.695	0.053	6.24%	
S_EqW_3yr	14.76%	11.73%	0.07953	0.724	0.036	-18.52%	-0.565
S_CapW_3yr	15.91%	11.32%	0.08113	0.928	0.072	7.74%	
L_EqW_5yr	15.39%	6.09%	0.08150	0.714	0.047	-6.42%	8.308
L_CapW_5yr	-1.27%	10.99%	0.08491	-1.327	-0.126	-12.42%	
M_EqW_5yr	16.44%	8.34%	0.08256	1.300	0.047	-2.72%	11.928
M_CapW_5yr	-1.43%	20.62%	0.08508	0.022	-0.164	-10.84%	
S_EqW_5yr	14.76%	8.60%	0.08439	0.632	0.037	-5.37%	8.498
S_CapW_5yr	15.91%	13.01%	0.08597	-1.148	-0.141	-7.61%	
L_EqW_10yr	15.15%	3.32%	0.08998	0.463	0.042	-17.52%	0.243
L_CapW_10yr	14.69%	3.67%	0.09254	0.410	0.034	-8.23%	
M_EqW_10yr	15.86%	3.80%	0.08972	0.109	0.046	-8.37%	0.413
M_CapW_10yr	15.40%	4.35%	0.09269	-0.039	0.062	-2.42%	
S_EqW_10yr	14.50%	3.72%	0.09445	0.353	0.031	-21.04%	-0.624
S_CapW_10yr	15.84%	3.46%	0.09531	0.517	0.064	-1.80%	

Source: Own research

Table 95 reports the summarised results for the equal- and value-weighted strategy for large-, mid-, and small-caps. The 1/N strategy realised higher returns and lower maximum drawdowns for large- and mid-caps held over the entire period with the opposite being the case for small-caps and ALSI index.

Table 95: Summary of all strategy metrics

	Mean return (per annum)	Std. dev.	Maximum Drawdown	Performance success ratio
L_EqW	3.82%	8.63%	-40.70%	74.4%
L_CapW	3.69%	9.00%	-58.04%	74.4%
M_EqW	4.01%	8.57%	-34.90%	72.8%
M_CapW	3.94%	8.84%	-49.83%	70.4%
S_EqW	3.59%	8.73%	-54.42%	72.8%
S_CapW	3.81%	8.83%	-52.02%	73.6%
X_EqW	3.77%	8.28%	-47.77%	73.6%
X_CapW	3.98%	8.77%	-47.36%	73.6%

Source: Own research

7.3 Implications for academic theory

The implications for academic theory are as follows:

The outperformance of equal- over value-weighted portfolios were found across portfolio categories and investment periods. The study further contributed towards the understanding of equal- and value-weighted portfolios on the JSE and widened the scope of financial research in South Africa. The reasons for the different performance of equal-weighted portfolios were not investigated and remain unclear.

The source of the outperformance, in general, and across international equity markets remains unclear and under-researched.

7.4 Implications for investors

The following implications were identified as substantive for management to consider for investment in equal- and value-weighted portfolios in the categories of large-, mid- and small-caps on the JSE. The study drew different implications for short- and long-term investment. The short-term implications were as follows:

1. The excess of the total mean of equal- over value-weighted portfolios tended to increase with the investment length. For shorter investment horizons of one or three years, the study found equal-weighted portfolios from large- and mid-caps to perform at least as well while being subject to lower volatility.
2. Equal-weighted portfolios created from small-caps underperformed statistically significant with regards to total mean return for one and three-year investment horizons.
3. The predictability of future performance of equal- and value-weighted portfolios is limited as the study was based on historical data.

The long-term implications were as follows:

1. The excess of the total mean returns of equal-weighted over value-weighted portfolios were positive and statistically significant for large- and mid-caps for both the five and ten year investment period. Most notably, investors with a five-year investment horizon would find that equal weighted portfolios produce "exceptional" results for determining the weightings of the portfolio investment strategy. However, equal-weighted portfolios constructed from small-caps significantly underperformed regarding total mean return for both the five and ten-year horizon.
2. The volatility of all equal-weighted portfolios was significantly lower than their value-weighted counterparts, which, combined with higher mean returns (L_EqW/ M_EqW) resulted in higher Sharpe ratios. Also, equal-weighted portfolios constructed from large- and mid-caps performed significantly better regarding Treynor ratios in the long-term.
3. Since equal-weighted portfolios had significantly lower volatility as well as maximum drawdown it was found to be an excellent tool during times of crises.
4. The equal-weighted portfolio strategy could be implemented as a new standard to measure the performance of portfolio managers.

7.5 Limitations of the research

This study investigated the performance of equal-weighted and value-weighted portfolios from large-, mid-, and small-caps in the JSE in South Africa, and, thus, was limited to the top 160 shares respectively, of market share on the JSE. The study utilised the extended and previously published dataset by Muller and Ward (2013): the dataset is considered to be one of the most complete and correct dataset of the JSE.

The major limitations of this study were that no other rebalancing frequencies were tested and the prices were before transaction costs. Further, the study did not construct the individual portfolios from randomly sampled shares but instead tested for differences in each of the large-, mid-, and small-cap categories. Therefore, no generalisations should be drawn for the general performance of equal-weighted portfolios in the context of the JSE, but rather for the 1/N strategy within these specific categories. The results, therefore, should also not be generalised non-listed shares and micro-caps in the South-African context or for other equity markets

In addition, the methodology utilised for testing of differences in means, the t-test, is known to be statistically weak, yet the traditional approach for testing portfolio performance. The study was confined with regards to the methodology, to the scope of the research, as it did not test for relationships or other phenomena.

7.6 Suggestions for future academic research

The study did not seek to understand the reasons for the difference in performance of equal- and value-weighted portfolios but instead tested if differences of performance did exist and where it was most pronounced. Thus, further academic research should investigate the reasons for an eventual outperformance and test for relationships with other known share price influencing factors such as size, price, book-to-market, momentum (3, 6 or 12-month momentum), reversal-of-return, liquidity or idiosyncratic volatility following Fama and MacBeth (1973) regression analysis.

Second, this study wants to motivate for further research following Hwang et al.'s (2018) study design testing for higher tail-risk or a more concave portfolio return distribution. The study design of Hwang et al. (2018) also allows to test for the optimal number of equities of equal-weighted portfolios and how the distribution of returns differs with additional equities.

Third, since this study found lower volatilities for all equal-weighted portfolios, additional research to discover the reason for the occurrence should be undertaken. Lower volatility is contrary to all literature reviewed in Chapter 2.

The final suggestion for research would be to determine if Guo et al.'s (2018) "1/N favourability index" is applicable to the South African context. The measure is based on the simple measure of the distance between equal-weighted and the maximum Sharpe ratio portfolio.

7.7 Conclusion

This study contributes towards a better understanding of equal-weighted and value-weighted portfolios on the JSE utilising an extended and improved dataset by Muller and Ward (2013) from 1987 to 2018. It further contributes towards academic financial research in South Africa.

Additionally, this study will assist institutional as well as private investors with investment decision on the JSE. Finally, this study motivated for future research regarding the factors of outperformance of equal-weighted portfolios.

Chapter 8: Reference list

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Appendices

Appendix I: Consistency matrix

Table 96: Consistency matrix

Hypotheses		Description	Literature review	Data collection tool	Analysis
1		Determine whether equal-weighted and value-weighted portfolios on the JSE differ regarding the attributes: total return, volatility, maximum drawdown and performance success ratio for investment periods of 12, 36, 60 and 120 months. Thus, the first hypothesis was subdivided into five parts and presented in the next sections.	DeMiguel et al. (2007), Guo et al. 2018, Kazak and Pohlmeier (2019), Malladi and Fabozzi (2017), Plyakha et al. (2015)	Secondary data sourced from Muller and Ward (2012) (improved and extended) as well as public sources	See below
	a	Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding the total mean return	DeMiguel et al. (2007), Guo et al. (2018), Malladi and Fabozzi (2017), Plyakha et al. (2015),	Secondary data sourced from Muller and Ward (2012) (improved and extended) as well as public sources	First, the descriptive statistics were generated, followed by a table of the confidence interval, then a multivariate inferential analysis was conducted to indicate differences between each variable, and finally, a t-test of which portfolio performed significantly better on average.
	b	Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding volatility.	Brown et al. (2013), DeMiguel et al. (2007), Guo et al. (2018), Hwang et al. (2018) Malladi and Fabozzi (2017), Plyakha et al. (2015),	Secondary data sourced from Muller and Ward (2012) (improved and extended) as well as public sources	First, the descriptive statistics were generated, followed by a table of the confidence interval, then a multivariate inferential analysis was conducted to indicate differences between each variable, and finally, a t-test of which portfolio performed significantly better on average.
	c	Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding the maximum drawdown.	Guo et al. (2018), Malladi and Fabozzi (2017), Plyakha et al. (2015),	Secondary data sourced from Muller and Ward (2012) (improved and extended) as well as public sources	Visual comparison of the total maximum drawdown.
	d	Determine whether equal-weighted and value-weighted portfolios on the JSE differ statistically regarding the performance success ratio.	Guo et al. (2018), Malladi and Fabozzi (2017), Plyakha et al. (2015),	Secondary data sourced from Muller and Ward (2012) (improved and	Visual comparison of the performance success ratio.

			extended) as well as public sources	
2	Determine whether equal-weighted portfolios and value-weighted portfolios on the JSE differ statistically regarding the Sharpe ratio.	Ledoit and Wolf (2008), Goetzmann et al. (2002), Guo et al. (2018), Ledoit and Wolf (2008), Memmel (2003), Plyakha et al. (2015), Rollinger and Hoffman (2013), Sharpe (1964, 1975), Van Dyk et al. (2012)	Secondary data sourced from Muller and Ward (2012) (improved and extended) as well as public sources	First, the descriptive statistics were generated, followed by a table of the confidence interval, then a multivariate inferential analysis was conducted to indicate differences between each variable, and finally, a t-test of which portfolio performed significantly better on average.
3	Determine whether equal-weighted portfolios and value-weighted portfolios on the JSE differ statistically regarding the Treynor ratio.	Brown et al. (2013), Hwang et al. (2018), Elton and Gruber (1997), Hübner (2005), Plyakha et al. (2015), Treynor (1966). Treynor and Black (1973), Treynor and Mazuy (1966)	Secondary data sourced from Muller and Ward (2012) (improved and extended) as well as public sources	First, the descriptive statistics were generated, followed by a table of the confidence interval, then a multivariate inferential analysis was conducted to indicate differences between each variable, and finally, a t-test of which portfolio performed significantly better on average.
4	Determine whether equal-weighted portfolios and value-weighted portfolios on the JSE differ statistically regarding the Jensen's alpha.	Elton, Gruber and Blake (1996) Fama (1991, 1998), Grinblatt and Titman (1987, 1989, 1992), Lehmann (1990), Ledoit and Wolf (2008), Jensen (1968, 1972), Plyakha et al. (2015)	Secondary data sourced from Muller and Ward (2012) (improved and extended) as well as public sources	First, the descriptive statistics were generated, followed by a table of the confidence interval, then a multivariate inferential analysis was conducted to indicate differences between each variable, and finally, a t-test of which portfolio performed significantly better on average.
5	Determine the Sortino ratio of the equal-weighted portfolio benchmarked over the value-weighted portfolios on the JSE	Markowitz (1952), Plyakha et al. (2015), Rollinger and Hoffman (2013), Sortino (1981), Sortino and Price (1994), Sortino and Van Der Meer (1991)	Secondary data sourced from Muller and Ward (2012) (improved and extended) as well as public sources	Failed to test the hypothesis
6	Determine in which of Grinold and Kahn's (1995) Information ratio categories the individual equal-weighted portfolios fall	Goodwin (1998), Grinold, 1989), Grinold and Kahn (1995), Huij and Derwall (2011), Ledoit and Wolf (2008), Plyakha et al. (2015)Treynor and Black (1973)	Secondary data sourced from Muller and Ward (2012) (improved and extended) as well as public sources	T-test was used to determine in which of Grinold and Kahn's (1995) Information ratio categories the individual equal-weighted portfolios fall

Source: Adapted from GIBS (2018)

Appendix II: Ethical clearance letter

Gordon Institute of Business Science
University of Pretoria

8 November 2018

Schleu Jakob

Dear Jakob

Please be advised that your application for Ethical Clearance has been approved.

You are therefore allowed to continue collecting your data.

Please note that approval is granted based on the methodology and research instruments provided in the application. If there is any deviation change or addition to the research method or tools, a supplementary application for approval must be obtained

We wish you everything of the best for the rest of the project.

Kind Regards

GIBS MBA Research Ethical Clearance Committee

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Appendix III: Descriptive statistics

Descriptive statistics H1a

Table 97: Descriptive statistics H1a_L

	H1a_L_EqW _1yr	H1a_L_EqW _3yr	H1a_L_EqW _5yr	H1a_L_EqW _10yr	H1a_L_CapW _1yr	H1a_L_CapW _3yr	H1a_L_CapW _5yr	H1a_L_CapW _10yr
Mean	0.170	0.154	0.154	0.151	0.166	0.147	-0.013	0.147
Standard Error	0.018	0.010	0.006	0.004	0.018	0.010	0.011	0.004
Median	0.156	0.143	0.157	0.153	0.195	0.132	-0.009	0.146
Standard Deviation	0.196	0.106	0.061	0.033	0.199	0.105	0.110	0.037
Sample Variance	0.039	0.011	0.004	0.001	0.040	0.011	0.012	0.001
Kurtosis	-0.061	-0.064	-0.249	-0.611	-0.109	-0.041	0.724	-0.860
Skewness	-0.046	0.527	0.400	-0.067	-0.300	0.552	-0.317	0.141
Range	1.009	0.493	0.267	0.151	0.990	0.479	0.613	0.157
Minimum	-0.354	-0.050	0.047	0.083	-0.382	-0.059	-0.352	0.084
Maximum	0.655	0.444	0.314	0.234	0.609	0.420	0.260	0.241
Sum	20.611	17.369	16.159	12.874	20.047	16.640	-1.338	12.483
Count	121	113	105	85	121	113	105	85
Confidence Level(95.0%)	0.035	0.020	0.012	0.007	0.036	0.020	0.021	0.008

Source: Own research

Table 98: Descriptive statistics H1a_M

	H1a_M_EqW _1yr	H1a_M_EqW _3yr	H1a_M_EqW _5yr	H1a_M_EqW _10yr	H1a_M_CapW _1yr	H1a_M_CapW _3yr	H1a_M_CapW _5yr	H1a_M_CapW _10yr
Mean	0.178	0.165	0.164	0.159	0.175	0.162	-0.014	0.154
Standard Error	0.018	0.011	0.008	0.004	0.018	0.011	0.020	0.005
Median	0.178	0.148	0.157	0.158	0.156	0.154	0.022	0.150
Standard Deviation	0.198	0.114	0.083	0.038	0.202	0.117	0.206	0.044
Sample Variance	0.039	0.013	0.007	0.001	0.041	0.014	0.043	0.002
Kurtosis	-0.505	-0.180	-0.604	-1.194	-0.672	0.227	16.613	-0.962
Skewness	0.141	0.662	0.308	-0.062	0.095	0.705	-2.936	0.162
Range	0.924	0.505	0.337	0.132	0.936	0.548	1.664	0.165
Minimum	-0.293	-0.003	0.022	0.087	-0.304	-0.037	-1.360	0.074
Maximum	0.631	0.502	0.359	0.219	0.631	0.511	0.305	0.239
Sum	21.482	18.630	17.266	13.478	21.164	18.263	-1.506	13.093
Count	121	113	105	85	121	113	105	85
Confidence Level(95.0%)	0.036	0.021	0.016	0.008	0.036	0.022	0.040	0.009

Source: Own research

Table 99: Descriptive statistics H1a_S

	H1a_S_EqW_1yr	H1a_S_EqW_3yr	H1a_S_EqW_5yr	H1a_S_EqW_10yr	H1a_S_CapW_1yr	H1a_S_CapW_3yr	H1a_S_CapW_5yr	H1a_S_CapW_10yr
Mean	0.157	0.148	0.149	0.145	0.167	0.159	0.007	0.158
Standard Error	0.017	0.011	0.008	0.004	0.017	0.011	0.013	0.004
Median	0.167	0.129	0.145	0.147	0.178	0.140	0.009	0.151
Standard Deviation	0.191	0.117	0.086	0.037	0.188	0.113	0.130	0.035
Sample Variance	0.037	0.014	0.007	0.001	0.035	0.013	0.017	0.001
Kurtosis	0.058	0.037	0.232	-0.473	-0.074	0.079	-0.162	-0.944
Skewness	-0.187	0.734	0.738	-0.338	-0.178	0.744	0.085	0.081
Range	0.954	0.521	0.367	0.158	0.930	0.512	0.585	0.134
Minimum	-0.386	-0.048	0.008	0.060	-0.356	-0.029	-0.281	0.089
Maximum	0.568	0.473	0.376	0.218	0.574	0.483	0.304	0.223
Sum	19.047	16.679	15.677	12.325	20.204	17.982	0.738	13.463
Count	121	113	105	85	121	113	105	85
Confidence Level(95.0%)	0.034	0.022	0.017	0.008	0.034	0.021	0.025	0.007

Source: Own research

Descriptive statistics H1b

Table 100: Descriptive statistics H1b_L

	H1b_L_EqW_1yr	*H1b_L_EqW_3yr*	*H1b_L_EqW_5yr*	*H1b_L_EqW_10yr*	*H1b_L_CapW_1yr*	*H1b_L_CapW_3yr*	*H1b_L_CapW_5yr*	*H1b_L_CapW_10yr*
Mean	0.066	0.077	0.081	0.090	0.069	0.080	0.085	0.093
Standard Error	0.003	0.003	0.003	0.001	0.004	0.003	0.002	0.001
Median	0.053	0.074	0.082	0.096	0.061	0.080	0.087	0.097
Standard Deviation	0.038	0.031	0.027	0.013	0.041	0.032	0.025	0.011
Sample Variance	0.001	0.001	0.001	0.000	0.002	0.001	0.001	0.000
Kurtosis	2.261	-0.598	-0.567	-1.361	1.876	-0.882	-0.634	-1.511
Skewness	1.492	0.363	-0.239	-0.496	1.434	0.265	-0.290	-0.413
Range	0.175	0.121	0.100	0.039	0.175	0.114	0.094	0.031
Minimum	0.016	0.026	0.029	0.067	0.018	0.029	0.035	0.076
Maximum	0.191	0.147	0.129	0.106	0.193	0.144	0.128	0.107
Count	121	113	105	85	121	113	105	85
Confidence Level(95.0%)	0.007	0.006	0.005	0.003	0.007	0.006	0.005	0.002

Source: Own research

Table 101: Descriptive statistics H1b_M

	H1b_M_EqW_1yr	H1b_M_EqW_3yr	H1b_M_EqW_5yr	H1b_M_EqW_10yr	H1b_M_CapW_1yr	H1b_M_CapW_3yr	H1b_M_CapW_5yr	H1b_M_CapW_10yr
Mean	0.069	0.079	0.083	0.090	0.071	0.081	0.085	0.093
Standard Error	0.003	0.003	0.002	0.002	0.003	0.003	0.002	0.002
Median	0.065	0.081	0.085	0.095	0.071	0.083	0.089	0.101
Standard Deviation	0.033	0.027	0.023	0.014	0.034	0.028	0.025	0.016
Sample Variance	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.000
Kurtosis	2.089	-0.380	-0.438	-0.759	1.284	-0.495	-0.456	-0.626
Skewness	1.251	0.071	-0.566	-0.731	1.013	-0.069	-0.610	-0.782
Range	0.162	0.108	0.085	0.046	0.159	0.113	0.092	0.055
Minimum	0.018	0.031	0.034	0.060	0.021	0.032	0.033	0.057
Maximum	0.180	0.139	0.120	0.106	0.180	0.145	0.125	0.112
Count	121	113	105	85	121	113	105	85
Confidence Level(95.0%)	0.006	0.005	0.005	0.003	0.006	0.005	0.005	0.003

Source: Own research

Table 102: Descriptive statistics H1b_S

	H1b_S_EqW_1yr	H1b_S_EqW_3yr	H1b_S_EqW_5yr	H1b_S_EqW_10yr	H1b_S_CapW_1yr	H1b_S_CapW_3yr	H1b_S_CapW_5yr	H1b_S_CapW_10yr
Mean	0.069	0.080	0.084	0.094	0.071	0.081	0.086	0.095
Standard Error	0.003	0.003	0.003	0.001	0.003	0.003	0.003	0.002
Median	0.064	0.077	0.082	0.100	0.065	0.078	0.083	0.099
Standard Deviation	0.038	0.032	0.028	0.013	0.037	0.032	0.028	0.015
Sample Variance	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.000
Kurtosis	3.330	-0.388	-0.783	-0.820	4.311	-0.055	-0.714	-1.130
Skewness	1.618	0.494	-0.221	-0.699	1.808	0.609	-0.048	-0.528
Range	0.192	0.126	0.094	0.043	0.188	0.129	0.099	0.048
Minimum	0.016	0.028	0.035	0.067	0.027	0.030	0.034	0.064
Maximum	0.208	0.154	0.129	0.109	0.215	0.159	0.133	0.111
Count	121	113	105	85	121	113	105	85
Confidence Level(95.0%)	0.007	0.006	0.005	0.003	0.007	0.006	0.005	0.003

Source: Own research

Descriptive statistics H2

Table 103: Descriptive statistics H2_L

	H2_L_EqW_1yr	H2_L_EqW_3yr	H2_L_EqW_5yr	H2_L_EqW_10yr	H2_L_CapW_1yr	H2_L_CapW_3yr	H2_L_CapW_5yr	H2_L_CapW_10yr
Mean	1.699	0.91	0.701	0.458	2.017	1.002	-1.302	0.405
Standard Error	0.32	0.181	0.105	0.059	0.365	0.216	0.134	0.069
Median	1.555	0.328	0.493	0.401	1.441	0.151	-1.5	0.365
Standard Deviation	3.517	1.924	1.083	0.547	4.011	2.294	1.381	0.636
Sample Variance	12.37	3.703	1.173	0.299	16.09	5.262	1.907	0.405
Kurtosis	-0.431	0.823	0.95	-1.136	0.248	1.674	1.74	-1.036
Skewness	0.431	1.16	1.141	0.291	0.743	1.474	0.83	0.005
Range	15.9	8.437	5.076	1.901	20.38	10.66	8.356	2.244
Minimum	-5.29	-1.621	-0.942	-0.367	-5.199	-2.029	-4.464	-0.709
Maximum	10.61	6.816	4.135	1.535	15.18	8.635	3.892	1.536
Sum	205.5	102.9	74.3	38.93	244.1	113.2	-138	34.42
Count	121	113	106	85	121	113	106	85
Confidence Level(95.0%)	0.633	0.359	0.209	0.118	0.722	0.428	0.266	0.137

Source: Own research

Table 104: Descriptive statistics H2_M

	H2_M_EqW_1yr	H2_M_EqW_3yr	H2_M_EqW_5yr	H2_M_EqW_10yr	H2_M_CapW_1yr	H2_M_CapW_3yr	H2_M_CapW_5yr	H2_M_CapW_10yr
Mean	1.334	0.847	0.761	0.549	1.282	0.882	-1.335	0.512
Standard Error	0.286	0.147	0.107	0.067	0.29	0.164	0.194	0.08
Median	1.066	0.532	0.665	0.498	1.131	0.513	-1.219	0.519
Standard Deviation	3.142	1.569	1.106	0.622	3.194	1.739	1.999	0.739
Sample Variance	9.869	2.461	1.222	0.386	10.2	3.023	3.998	0.547
Kurtosis	-0.764	-0.198	-0.279	-1.214	-0.856	-0.581	7.19	-1.096
Skewness	0.136	0.664	0.445	0.314	0.066	0.643	-1.48	0.274
Range	14.56	6.911	4.458	2.121	14.44	6.71	14.77	2.511
Minimum	-6.4	-1.646	-1.052	-0.425	-6.842	-1.666	-12.21	-0.59
Maximum	8.157	5.265	3.405	1.696	7.595	5.043	2.563	1.921
Sum	161.4	96.57	80.72	46.65	155.2	99.63	-141.5	43.53
Count	121	114	106	85	121	113	106	85
Confidence Level(95.0%)	0.565	0.291	0.213	0.134	0.575	0.324	0.385	0.159

Source: Own research

Table 105: Descriptive statistics H2_S

	H2_S_EqW _1yr	*H2_S_EqW _3yr*	*H2_S_EqW _5yr*	*H2_S_EqW _10yr*	*H2_S_CapW _1yr*	*H2_S_CapW _3yr*	*H2_S_CapW _5yr*	*H2_S_CapW _10yr*
Mean	1.13322	0.72390	0.62557	0.35335	1.26017	0.92761	-1.13748	0.51713
Standard Error	0.28268	0.16326	0.11648	0.05680	0.27090	0.17399	0.15471	0.06168
Median	0.77475	0.29463	0.45530	0.32495	0.96136	0.28772	-1.20432	0.45856
Standard Deviation	3.09664	1.72780	1.19359	0.52059	2.96752	1.84139	1.58531	0.56531
Sample Variance	9.58918	2.98529	1.42465	0.27101	8.80615	3.39072	2.51321	0.31957
Kurtosis	-0.60423	0.25662	0.64149	-1.44179	-0.90632	-0.57993	0.58873	-1.15624
Skewness	0.34238	0.98172	1.06510	0.22271	0.11322	0.81005	0.41698	0.38434
Range	13.95037	6.92461	4.94308	1.57872	13.66093	6.91949	8.28691	1.84442
Minimum	-5.02707	-1.62216	-0.98882	-0.35599	-5.67694	-1.61602	-5.20984	-0.23882
Maximum	8.92330	5.30245	3.95426	1.22273	7.98399	5.30348	3.07707	1.60560
Sum	135.98699	81.07642	65.68530	29.68141	151.22069	103.89259	-119.43514	43.43895
Count	120	112	105	84	120	112	105	84
Confidence Level(95.0%)	0.55974	0.32351	0.23099	0.11297	0.53640	0.34478	0.30680	0.12268

Source: Own research

Descriptive statistics H3

Table 106: Descriptive statistics H3_L

	H3_L_EqW _1yr	*H3_L_EqW _3yr*	*H3_L_EqW _5yr*	*H3_L_EqW_ 10yr*	*H3_L_CapW _1yr*	*H3_L_CapW _3yr*	*H3_L_CapW _5yr*	*H3_L_CapW _10yr*
Mean	0.077	0.051	0.047	0.042	0.059	0.036	-0.126	0.034
Standard Error	0.024	0.013	0.008	0.006	0.020	0.012	0.013	0.006
Median	0.074	0.026	0.038	0.035	0.101	0.015	-0.129	0.033
Standard Deviation	0.262	0.138	0.081	0.050	0.213	0.123	0.129	0.057
Sample Variance	0.069	0.019	0.007	0.003	0.045	0.015	0.017	0.003
Kurtosis	1.391	1.515	1.150	-1.353	-0.393	0.054	0.631	-1.106
Skewness	-0.288	1.063	0.712	0.097	-0.352	0.524	-0.311	-0.211
Range	1.629	0.726	0.429	0.180	1.011	0.548	0.695	0.208
Minimum	-0.983	-0.218	-0.114	-0.038	-0.504	-0.215	-0.515	-0.072
Maximum	0.645	0.508	0.315	0.142	0.507	0.332	0.181	0.136
Count	119	112	104	84	119	112	104	84
Confidence Level(95.0%)	0.048	0.026	0.016	0.011	0.039	0.023	0.025	0.012

Source: Own research

Table 107: Descriptive statistics H3_M

	H3_M_EqW_1yr	*H3_M_EqW_3yr*	*H3_M_EqW_5yr*	*H3_M_EqW_10yr*	*H3_M_CapW_1yr*	*H3_M_CapW_3yr*	*H3_M_CapW_5yr*	*H3_M_CapW_10yr*
Mean	0.056	0.044	0.047	0.046	0.075	0.053	-0.164	0.062
Standard Error	0.018	0.011	0.009	0.006	0.038	0.014	0.026	0.010
Median	0.055	0.038	0.050	0.038	0.089	0.062	-0.116	0.065
Standard Deviation	0.195	0.112	0.087	0.053	0.415	0.147	0.265	0.087
Sample Variance	0.038	0.012	0.008	0.003	0.172	0.022	0.070	0.008
Kurtosis	-0.226	0.151	-0.160	-1.334	22.938	-0.832	14.175	-1.249
Skewness	-0.104	0.443	0.027	0.149	-2.642	-0.047	-2.638	0.158
Range	0.920	0.537	0.369	0.178	4.281	0.661	2.079	0.286
Minimum	-0.472	-0.163	-0.124	-0.041	-2.907	-0.320	-1.830	-0.074
Maximum	0.448	0.374	0.245	0.136	1.374	0.341	0.249	0.211
Count	119	112	104	84	119	112	104	84
Confidence Level(95.0%)	0.035	0.021	0.017	0.011	0.075	0.028	0.052	0.019

Source: Own research

Table 108: Descriptive statistics H3_S

	H3_S_EqW_1yr	*H3_S_EqW_3yr*	*H3_S_EqW_5yr*	*H3_S_EqW_10yr*	*H3_S_CapW_1yr*	*H3_S_CapW_3yr*	*H3_S_CapW_5yr*	*H3_S_CapW_10yr*
Mean	0.045	0.036	0.037	0.031	0.187	0.072	-0.141	0.064
Standard Error	0.018	0.012	0.009	0.005	0.092	0.018	0.019	0.008
Median	0.050	0.021	0.033	0.029	0.105	0.028	-0.145	0.050
Standard Deviation	0.195	0.125	0.093	0.046	1.000	0.192	0.192	0.069
Sample Variance	0.038	0.016	0.009	0.002	1.000	0.037	0.037	0.005
Kurtosis	-0.136	0.369	0.853	-1.516	64.165	0.557	-0.042	-1.383
Skewness	-0.041	0.902	0.913	0.151	6.661	0.826	0.356	0.263
Range	0.992	0.544	0.415	0.140	12.199	1.001	0.861	0.220
Minimum	-0.458	-0.176	-0.117	-0.032	-2.730	-0.306	-0.565	-0.032
Maximum	0.534	0.368	0.298	0.108	9.469	0.695	0.296	0.188
Count	119	112	104	84	119	112	104	84
Confidence Level(95.0%)	0.035	0.023	0.018	0.010	0.182	0.036	0.037	0.015

Source: Own research

Descriptive statistics H4

Table 109: Descriptive statistics H4_L

	H4_L_EqW _1yr	H4_L_CapW _1yr	H4_L_EqW _3yr	H4_L_CapW _3yr	H4_L_EqW _5yr	H4_L_CapW _5yr	H4_L_EqW _10yr	H4_L_CapW _10yr
Mean	0.013	0.109	-0.032	0.067	-0.065	-0.127	-0.175	-0.083
Standard Error	0.005	0.004	0.003	0.005	0.004	0.005	0.008	0.01
Median	0.01	0.11	-0.03	0.08	-0.05	-0.13	-0.17	-0.06
Mode	0.01	0.09	-0.02	0.08	-0.05	-0.15	-0.17	-0.01
Standard Deviation	0.058	0.048	0.03	0.053	0.041	0.047	0.077	0.093
Sample Variance	0.003	0.002	9E-04	0.003	0.002	0.002	0.006	0.009
Kurtosis	-0.091	2.632	1.306	4.921	2.514	1.533	0.641	0.1
Skewness	0.137	-0.557	-0.674	-1.971	-1.367	-0.967	-0.782	-0.73
Range	0.26	0.32	0.17	0.32	0.23	0.24	0.39	0.43
Minimum	-0.11	-0.08	-0.14	-0.17	-0.23	-0.29	-0.44	-0.38
Maximum	0.15	0.24	0.03	0.15	0	-0.05	-0.05	0.05
Sum	1.55	13.12	-3.54	7.47	-6.71	-13.18	-14.88	-7.04
Count	120	120	112	112	104	104	85	85
Confidence Level(95.0%)	0.01	0.009	0.006	0.01	0.008	0.009	0.017	0.02

Source: Own research

Table 110: Descriptive statistics H4_M

	H4_M_EqW _1yr	H4_M_CapW _1yr	H4_M_EqW _3yr	H4_M_CapW _3yr	H4_M_EqW _5yr	H4_M_CapW _5yr	H4_M_EqW _10yr	H4_M_CapW _10yr
Mean	-0.013	0.074	-0.045	0.063	-0.075	-0.109	-0.185	-0.024
Standard Error	0.01	0.018	0.008	0.015	0.006	0.017	0.01	0.008
Median	-0.01	0.115	-0.03	0.1	-0.065	-0.07	-0.17	-0.02
Mode	0.01	0.15	-0.01	0.14	-0.06	-0.07	-0.17	0.02
Standard Deviation	0.11	0.197	0.087	0.155	0.065	0.173	0.093	0.077
Sample Variance	0.012	0.039	0.008	0.024	0.004	0.03	0.009	0.006
Kurtosis	1.817	9.819	1.047	11.15	8.164	30.69	1.239	0.83
Skewness	0.327	-2.5	-0.862	-3.133	-2.265	-4.653	-0.914	-0.935
Range	0.71	1.38	0.5	0.95	0.41	1.48	0.49	0.36
Minimum	-0.29	-0.92	-0.32	-0.66	-0.39	-1.4	-0.53	-0.26
Maximum	0.42	0.46	0.18	0.29	0.02	0.08	-0.04	0.1
Sum	-1.6	8.82	-5.03	7.06	-7.82	-11.34	-15.74	-2.03
Count	120	120	112	112	104	104	85	85
Confidence Level(95.0%)	0.02	0.036	0.016	0.029	0.013	0.034	0.02	0.017

Source: Own research

Table 111: Descriptive statistics H4_S

	H4_S_EqW _1yr	H4_S_CapW _1yr	H4_S_EqW _3yr	H4_S_CapW _3yr	H4_S_EqW _5yr	H4_S_CapW _5yr	H4_S_EqW _10yr	H4_S_CapW _10yr
Mean	-0.028	0.088	-0.054	0.078	-0.084	-0.075	-0.21	-0.018
Standard Error	0.012	0.019	0.009	0.012	0.006	0.009	0.011	0.008
Median	-0.02	0.11	-0.04	0.11	-0.07	-0.065	-0.2	0
Mode	0.07	0.11	-0.04	0.15	-0.05	-0.14	-0.22	0.04
Standard Deviation	0.13	0.205	0.094	0.13	0.064	0.096	0.099	0.07
Sample Variance	0.017	0.042	0.009	0.017	0.004	0.009	0.01	0.005
Kurtosis	0.707	9.66	0.949	8.575	4.095	6.089	0.35	-0.178
Skewness	-0.169	-2.078	-0.142	-2.526	-1.423	-1.303	-0.85	-0.866
Range	0.77	1.7	0.55	0.8	0.38	0.7	0.47	0.28
Minimum	-0.41	-0.95	-0.33	-0.5	-0.35	-0.57	-0.54	-0.2
Maximum	0.36	0.75	0.22	0.3	0.03	0.13	-0.07	0.08
Sum	-3.33	10.59	-6.02	8.71	-8.69	-7.85	-17.87	-1.53
Count	120	120	112	112	104	104	85	85
Confidence Level(95.0%)	0.023	0.037	0.018	0.024	0.012	0.019	0.021	0.015

Source: Own research

Descriptive statistics H6

Table 112: Descriptive statistics H6_L

	H6_L_EqW_1yr	H6_L_EqW_3yr	H6_L_EqW_5yr	H6_L_EqW_10yr
Mean	-0.005	0.386	8.308	0.243
Standard Error	0.349	0.161	0.388	0.083
Median	0.519	0.514	7.538	0.227
Standard Deviation	3.809	1.705	3.957	0.763
Sample Variance	14.507	2.906	15.658	0.583
Kurtosis	3.042	-0.179	5.392	-0.410
Skewness	-1.415	-0.078	2.029	0.572
Range	21.988	8.295	23.157	2.840
Minimum	-14.515	-4.012	2.629	-0.922
Maximum	7.473	4.283	25.787	1.918
Sum	-0.590	43.248	864.042	20.410
Count	119	112	104	84
Confidence Level(95.0%)	0.691	0.319	0.770	0.166

Source: Own research

Table 113: Descriptive statistics H6_M

	H6_M_EqW_1yr	H6_M_EqW_3yr	H6_M_EqW_5yr	H6_M_EqW_10yr
Mean	0.451	0.465	11.928	0.413
Standard Error	0.334	0.221	0.887	0.118
Median	-0.037	0.032	8.785	0.625
Standard Deviation	3.644	2.339	9.048	1.081
Sample Variance	13.279	5.472	81.872	1.169
Kurtosis	-0.789	-0.636	13.125	-1.306
Skewness	-0.022	0.556	2.691	-0.265
Range	15.918	9.187	64.354	3.700
Minimum	-7.817	-3.308	3.657	-1.717
Maximum	8.101	5.879	68.011	1.982
Sum	53.727	52.115	1240.550	34.714
Count	119	112	104	84
Confidence Level(95.0%)	0.662	0.438	1.760	0.235

Source: Own research

Table 114: Descriptive statistics H6_S

	H6_S_EqW_1yr	H6_S_EqW_3yr	H6_S_EqW_5yr	H6_S_EqW_10yr
Mean	-0.587	-0.565	8.498	-0.624
Standard Error	0.363	0.180	0.385	0.060
Median	-0.266	-0.458	8.809	-0.596
Standard Deviation	3.956	1.900	3.924	0.552
Sample Variance	15.651	3.611	15.401	0.304
Kurtosis	1.772	0.070	0.542	-0.832
Skewness	-0.142	-0.381	0.694	0.103
Range	25.124	9.234	19.968	2.489
Minimum	-13.804	-5.571	2.760	-1.866
Maximum	11.320	3.663	22.728	0.624
Sum	-69.880	-63.250	883.759	-52.425
Count	119	112	104	84
Confidence Level(95.0%)	0.718	0.356	0.763	0.120

Source: Own research