Alternative Index Weighting Strategies on
the Swedish Stock Market

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Abstract
The Market-Capitalization index reweighting has since long had the role as the conventional tool for passive investments through its simplicity and CAPM framework conformance. Nowadays, alternative index reweightings are getting increased traction in the light of market-capitalization criticism and suggested risk-return improvements and possibilities of desired characteristics. This study sets to examine four alternative index reweightings; the Minimum Variance, the Equal Weights, the Equal Risk Contribution and the Risk-Weighted Alpha reweighting methods, as well as compare these indices to the benchmark Market-Capitalization weighted index over a number of quantitative measures. The stock universe chosen is the OMXS30 constituents of the NASDAQ OMX Stockholm Stock Exchange and the study also discusses the feasibility of introducing the alternative methods to the exchange. The study shows that all computed alternative methods beat the benchmark in terms of risk-adjusted return, as well as return in absolute measures. Index weight characteristics over time, especially as an effect of short-selling constraints, do however impact the weightings significantly and with regards to feasibility do not all alternative indices show on definite prevalence over the Market-Capitalization index for the examined data set and time period. Possible improvements of the data collection, method decisions and tools for analysis are also discussed as a reference for further studies. The findings of the study conclude in not being able to reject the proposal of an alternative index launch on the Swedish stock market.

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Contents

1 Introduction 3
   1.1 Background .................................................. 3
   1.2 The study .................................................. 3
   1.3 Purpose and contribution .................................... 4
   1.4 Research questions ......................................... 4
   1.5 Structure .................................................. 4

2 Literature review 5
   2.1 Index weightings ............................................ 5
      2.1.1 The Market Capitalization Index ....................... 5
      2.1.2 The Minimum Variance Index .......................... 6
      2.1.3 The Equal Weight Index ............................... 7
      2.1.4 The Equal Risk Contribution Index ................. 8
      2.1.5 Risk-Weighted Alpha Index .......................... 8
   2.2 Measuring index performance and characteristics ........ 9

3 Data 11
   3.1 The OMXS30 constituents .................................. 11
      3.1.1 The OMXS30 stock selection methodology ........... 11
   3.2 Data collection ............................................ 11

4 Methodology 13
   4.1 Constructing the indices ................................... 13
      4.1.1 The Market Capitalization Index ....................... 14
      4.1.2 The Minimum Variance Index .......................... 14
      4.1.3 The Equal Weight Index ............................... 15
      4.1.4 The Equal Risk Contribution Index ................. 15
      4.1.5 The Risk-Weighted Alpha Index .......................... 15
   4.2 Index measurements ........................................ 16

5 Results 20
   5.1 Index constituents .......................................... 20
   5.2 Index performance ......................................... 22
      5.2.1 Performance measures ................................ 22
      5.2.2 Annual returns ...................................... 24
      5.2.3 Correlations ........................................ 25
   5.3 Index weights ............................................. 25
      5.3.1 Weight characteristics ................................ 25
      5.3.2 Stock concentration .................................. 27
      5.3.3 Index turnover ....................................... 28
6 Discussion

6.1 Index Performance and characteristics
   6.1.1 The Market Capitalization Index
   6.1.2 The Minimum Variance Index
   6.1.3 The Equally Weighted Index
   6.1.4 The Equal Risk Contribution Index
   6.1.5 The Risk-Weighted Alpha Index

6.2 Index feasibility and the suitability of the Swedish stock market

6.3 Problematization
   6.3.1 Data selection
   6.3.2 Methodology
   6.3.3 Tools for analysis

7 Conclusion

8 References
1 Introduction

1.1 Background

Ever since the launch of the Dow Jones Industrial Average, the world’s first stock market index, indices have played an important role as both indicators and bellwethers to the global financial markets. Over time, their role has developed significantly from being merely market signallers to today appeal as an instrument for passive investment from investors seeking capital gains. Historically, the long-standing and by convention standard market capitalization-based weighting scheme, manifested by pillars such as the S&P 500, the FTSE 100 and the Russell 2000 indices, has formed the single most popular weighting framework. The market capitalization-based methodology has however become a fiery topic across the academic finance field, having been a target for academic evaluation and criticism for some time.

In parallel with the market capitalization methodology being put under review, alternative index weighting schemes have been shed light on and are gaining increased traction, mainly following some criticism of the performance efficiency of the market-cap based indices. Although research has stressed beneficial characteristics of these alternative approaches, there appeared to be a tangible shyness in turning too much capital towards non-cap weighted indices. In a survey by Amenc, Goltz, Tang and Vaidyanathan (2011) on North American equity investors’ index preferences, only a third of the respondents had implemented one or more of the alternative weighting methods, even though the satisfaction rate for the traditional market-cap weighted index was at similarly low figures. Today, the alternative index strategies are increasingly common on a global scale but still remain to become a standard investable product on the Swedish stock market.

1.2 The study

Based on the above background, this study sets out to research how a selected range of alternative indices perform when applied to the Swedish stock market, benchmarking both their performance and practical feasibility against the more conventional capitalization weighted index. Namely, four different alternative weighting methods are examined and evaluated; the Minimum Variance, the Equal Weight, the Equal Risk Contribution and the Risk-weighted Alpha methods. These four alternative methodologies each implement a different weighting strategy aimed at optimizing the level of risk, diversification or risk-adjusted return through their respective distribution of weights amongst the index constituents. The Minimum Variance index weighs its inherent stocks to minimize the overall variance of the portfolio, while the Equally Weighted methodology simply applies the same weight to all constituents, thus forming a rationale independent from any estimations, however fundamentally biased because of the selection of included stocks in the index. In a related manner, the Equal Risk Contribution index sets its constituent weights so that each single stock’s contribution to the portfolio volatility is equal, thus spreading risk evenly across its assets. Lastly, the Risk-weighted alpha approach incorporates a risk-adjusted modified Jensen’s alpha measure, allocating higher weights to assets with higher risk-adjusted excess return.
The Swedish NASDAQ OMXS30 stock index is utilized as a source of Swedish stocks and constitute the data foundation for the study. The OMXS30 comprises the most traded stocks present at the Stockholm stock exchange and sets its constituent weights relative to each respective stock’s market capitalization, thus forming a suitable representation of the traditional capitalization-weighted index methodology. Each alternative index is constructed using the 30 stocks of the OMXS30 at the first date of January respectively July each year as decided by the Nasdaq OMX and OMXS30 market-cap weighting scheme and rules of stock selection, further described in section 3.1. The study follows data across an 11 year time period between 01/01/2003 and 03/18/2014, evaluating each index’ performance in absolute values as well as in relation to the benchmark of the cap-weighted counterpart.

To evaluate each index’ performance and feasibility and conduct the test, a range of standard performance measures and characteristics evaluations are applied to the data set, including conventional observations of risk, return and correlations along with risk-adjusted ratio analyses. In addition, each index’ practical feasibility is evaluated by computing its respective turnover and stock concentration levels.

1.3 Purpose and contribution

This study aims to evaluate the attractiveness of the Swedish stock market as a base for creating and launching alternative indices, by assessing how risk-return efficient each index is and if they are economically justifiable. The study’s main contribution lies in providing a scientific test of how suitable the Swedish stock market is for these alternative weighting strategies, along with a comparative presentation of the indices’ respective performances.

1.4 Research questions

The research questions aimed to be answered throughout the paper are thus:

i. How do the alternative index weightings compare against the market-cap index weighting for the Stockholm stock exchange’s most traded stocks in terms of performance and feasibility, and how do their weighting behaviors and dynamics differ over the studied time period?

ii. Does the Swedish stock market provide an attractive foundation for a potential launch of alternative indices?

1.5 Structure

The structure for answering the outlined research questions is as follows. Firstly, section two comprises a review of previous literature on the subject of alternative index weightings, laying groundwork for further discussion. Section three poses as the explanatory chapter for the data used and section four follows by presenting the methodology on how each index was quantitatively constructed and how the indices are evaluated and measured. The results are exhibited in section five and are discussed and analyzed in section six. The conclusions of the study are drawn in section seven. All references used are listed in section eight.
2 Literature review

2.1 Index weightings

2.1.1 The Market Capitalization Index

The standard practice for determining asset allocation within benchmark or market-wide equity indices has since long been the market capitalization weighting scheme (henceforth abbreviated MC). The MC allocates weight to a stock within the index proportional to the company market value’s share of the total market. An early fundament to the MC methodology was set by Markowitz (1952), who introduced the concept of a mean-variance framework based on a risk-return relationship where the investor, with a set volatility level, sought to maximize the expected return. Sharpe (1964) took this further by developing the Capital Asset Pricing Model framework (CAPM), today a pillar within financial theory, stating that investors own the mean-variance optimal pool of risky assets by holding the market portfolio. Ultimately, the CAPM model implies that an investor cannot hold a more efficient portfolio than one based on market capitalization. Hsu (2006) listed the primary benefits of the market-cap based portfolio as the fact that it is a passive strategy whereby management costs can be limited, that rebalancing costs can be kept down thanks to smaller-sized rebalancings and higher liquidity in the higher market capitalized companies with larger index weights and foremost its implication of theoretically being the mean-variance optimal portfolio with the highest Sharpe ratio in the CAPM framework.

The criticism against the MC being the most efficient passive investment strategy has in recent years evolved from theoretical arenas to play a large role for the industry. In theory, the complete diversified asset CAPM market portfolio would have to include all assets in positive net supply globally, implying the inclusion of stocks, commodities, corporate bonds, real estate and human capital (Arnott, Hsu and Moore (2005)). Thus, the MC portfolio theoretically fails to proxy the true market portfolio, punctuating one of the model’s fundamental benefits. Ferson, Kandel and Stambaugh (1987) also showed on these poor proxy properties, along with the references mentioned in the literature review by Goltz and Le Sourd (2010).

The market-cap weighted index has also empirically been proved performance suboptimal to other portfolio strategies. Studies show a number of explanations, but the primary flaw of the price-driven MC lies in overvalued stocks being weighted higher while undervalued stocks have less weight allocation, leading to an underperformance relative to other, non-capitalization based indices with similar risk (Arnott et al. (2005), Hsu (2006), Arnott and Hsu (2008)). Related to this value bias lies the problem of the MC weighing some of its larger constituents so heavily that its composition of assets becomes highly concentrated, which was shown by Malevergne, Santa-Clara and Sornette (2009). In their study, the MC methodology exhibited tendency to overexpose investors to firm-specific risk.

Despite this criticism, Amenc, Goltz, Tang and Vaidyanathan (2011) in their survey on North American investors showed that in fact, a majority of their respondents regarded alternative indices as a mere complement to the conventional MC, suggesting investors do tread with caution.
when approached by new investment innovations. Further, they produced data indicating that the slow adoption rate of the new indices was mainly based on four rigid facts: the longstanding market-cap’s popularity, the convenient access of track records and through its property of representing the average investment decisions of the market.

It should be mentioned that in opposition of the critique, there has been substantial defense of the MC methodology, discussing and disentangling this “shown” underperformance of the market cap weighting. In his test of the S&P 500 and the FTSE 100 capitalization weighted indices against equally weighted counterparts, Tabner (2012) numerically showed that the MC could not be proven to be underperforming its FTSE 100 equally weighted counterpart, but the S&P 500 MC did exhibit a lower risk-return ratio. When controlling for size, style and momentum factors, the S&P 500 however did not underperform. Being performance optimal or not, Tabner and others (Kaplan (2008), DeMiguel, Garlappi and Uppal (2009), Amenc, Goultz and Le Sourd (2009)) address the MC’s properties as a benchmark by arguing that rejecting the MC as a benchmark for the market’s overall performance today is too early, in the absence of plausible theoretical proof of it not being the best alternative.

However, as a consequence of the criticism against the market capitalization weighted index there have been numerous alternative weighting schemes intending to deliver returns to the passive investor in a more efficient risk-return framework, some of which will be discussed and tested in this thesis paper. A theoretical background of a selection of index reweighting schemes follows.

### 2.1.2 The Minimum Variance Index

The Minimum Variance approach (henceforth abbreviated MV) formalizes the idea of weighting to minimize the risk-exposure of the portfolio as a whole without having expected portfolio return as an input. Introducing the “low volatility anomaly” almost four decades ago, Haugen and Heins (1975) refuted the longstanding financial dogma of the high risk-high return relationship suggested by the CAPM framework by showing on higher returns from a low-volatility portfolio. This lay the foundation for the MV reweighting, which has gained multitudes in popularity in the aftermath of the Global Financial Crisis in 2008, with both MSCI and the S&P 500 launching a series of variance-focusing indices.¹

By not integrating the expected return in its construction, the MV portfolio stands out through its independence from expected and forecasted return, two of which’s estimations require several simplifying market assumptions, most illustrious the premise of the market’s efficient access to security price information.

The option to keep negative weights for some constituents, i.e. to demand for short-selling to be employed in order for the MV producer to follow its reweighting method, has been topic for some academic discussion. It is known that the shortsale-allowed MV implies lower exposure to risk (Clarke, De Silva and Thorley (2006)), but Jagannathan and Ma (2002) advocated that a long-only constraint provides weight stability and an overall gain for the MV portfolio perfor-

Examining the mean-variance performance of the MV portfolio, Clarke et al. (2006) benchmarked it against a corresponding market cap index. Their study revealed a stronger risk-efficient performance of the MV, displayed by a higher attained Sharpe ratio and a lower portfolio volatility than the MC counterpart, confirming previous results shown by Haugen and Baker (1991). They further presented proof of MV portfolios possessing both value and small-size biases due to the more volatile nature of small-cap stocks, which favors the index return when value stocks outperform growth stocks, but becomes a drag when conditions are the opposite. These biases are conventionally controlled through imposing weighting constraints on factor neutrality and sensitivities on factor return and Clarke et al. showed that limiting the weights did not significantly affect the high Sharpe ratios obtained (2006).

2.1.3 The Equal Weight Index

The Equal Weight index weighting (“EW”) does through its characteristic uniformly distributed weights ignore available market information completely in its weighting. Being the oldest and most time-tested index methodology next to its MC relative, the heuristic approach of setting all portfolio weights equal is referred to as naive but effective and sometimes advantageous in terms of performance. It has shown to outperform a number of alternative rebalancings as well as delivering a distinct robustness unparalleled by e.g. the MC, partly explained by its elimination of large-cap bias and its reduction of large stock concentration found in e.g. the market cap index (DeMiguel et al. (2009), Windcliff and Boyle (2004)). Its independence to stock size also imposes some liquidity constraints.

Chow, Hsu, Kalesnik and Little (2011) emphasize the EW’s sensitivity to the total number of stocks included in the constructed portfolio, with the mean-variance performance being affected significantly depending on the portfolio size. By comparing an EW of the S&P 500 with one of the Russell 1000 index, they found a higher volatility in the latter, explaining the difference originating from the Russell’s larger exposure to more volatile small-cap stocks. In critique of this “dependence” on an investor’s arbitrary choice of stock pool to choose constituents from, an extension of the EW, the Risk Clustered Equal Weighting (RCEW) concept was developed. The RCEW extends the EW through creating equally weighted clusters based on the risk of the combined assets in the cluster.

Windcliff and Boyle (2004) pointed out the EW’s beneficial property of being freed from any estimation procedures, which often possess large risks and factors of error, and stated its independence of estimation errors provides solid robustness to the EW model. Amenc, Goltz and Lod (2012) followed on this, stressing the EW portfolio’s importance of being the most robust weighting alternative not aiming at diversification of portfolio risk - i.e. controlling intra-portfolio correlations which stands as a recurring mantra within the Modern Portfolio Theory\(^2\) - but rather on portfolio deconcentration. The concept of deconcentration laid the groundwork for the more recent Equal Risk Contribution index which focuses on deconcentrating on a risk-basis, rather

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\(^2\)Markowitz, M. “Portfolio Selection: Efficient Diversification of Investments, 2nd Edition”
than on the equal weighting’s money-basis, further discussed below in 2.1.4.

2.1.4 The Equal Risk Contribution Index

The Equal Risk Contribution (“ERC”) weighting forms the concept of spreading the overall risk of the portfolio equally among its constituents, maximizing the risk diversification of the index on at least an ex ante-basis. In this composed blend of a Minimum Variance portfolio and an equally weighted ditto, each constituent is weighted so that their respective contribution to overall risk is equal throughout the resulting portfolio. Thus it possesses a high level of diversification while still exhibiting the convenience of being a passive strategy.

Studying the properties of the ERC, Maillard, Roncalli and Teiletche (2008) constructed such an index and described it as a Minimum Variance-portfolio with diversification constraints on the constituent weights. They showed that their created portfolio’s volatility both in theory and empirically roughly lied in between the one of the EW and MV portfolios, while at the same time giving higher returns than the cap index. Thus, they concluded that it composes an attractive alternative to an investor seeking a middle ground on risk-taking, diversification and risk budgeting. The same mean-variance outperformance of the conventional market cap-approach was also found by Neukirch (2008).

2.1.5 Risk-Weighted Alpha Index

The risk-weighted alpha index methodology (“RWA”) was recently academically introduced by Agarwal (2013; 2014), and bases its rationale on an augmentation of a risk-weighted volatility method by weighting according to each portfolio constituent’s risk-weighted Jensen’s alpha measure, which is determined by both the stock volatility and excess return factors to expectation. In practice, stocks with higher risk-adjusted alphas are allocated a heavier weighting within the portfolio. The risk-adjusted Jensen’s alpha measures a stock’s realized return compared to its expected return and divides this by its historical volatility. The stock’s systematic risk, the stock beta, is incorporated in the expected return and derived by e.g. the CAPM model. Through incorporating the CAPM-beta in the alpha-weighting, Agarwal’s method stands out amongst the chosen indices as a CAPM theory-derived alternative weighting approach.

Agarwal further stresses that it is the risk-return ratio of the alpha that is utilized, implying that for an example a high-return stock with relatively high historical price volatility is unlikely to have allocated an above-average weight in the portfolio due to its high variance. The character of the Risk-weighted alpha weighting thus aims at creating an optimization of return and reduction of variance. Agarwal further discusses the RWA’s beneficial properties by shedding light on the single advantages of the two current other major alternative index strategies, mentioning increasing alpha through the fundamentals-approach and reducing risk through risk-based indices, suggesting that the RWA aims for both.

Applying the RWA to the capitalization weighted Heng Seng 50 Hong Kong Stock Exchange Index and the S&P’s ASX 50 Australian Stock Exchange Index indices, Agarwal found his constructions to outperform their MC parent indices. In fact, his study showed the respective RWA
provided nearly five times the return of the ASX 50 and three times the return of the Heng Seng 50, over a time period of 10 years (January 2, 2002 to December 31, 2012), whilst both indices were exposed to roughly the same systematic risk as their respective parent indices. Agarwal further suggests the fundamental reason to this being the RWA over time weights stocks with stable and increasing returns.

However, an important aspect of the RWA to consider is that Agarwal in his study allows for negative weights on poor-performing stocks, with negative alphas, thus allowing for short-selling, an aspect needing consideration when comparing indices. There has not yet been summoned any academic responses to Agarwal’s RWA up to this study’s release date, implying his findings stand relatively academically unacknowledged due to its lack of proper further investigation.

With the RWA currently being in comparison unchallenged on an academic basis, this study aims to further investigate the dynamics and properties of the RWA applied on the Swedish stock market, benchmarking it against the conventional market-cap index as well as the other mentioned alternative weighting methods.

2.2 Measuring index performance and characteristics

In order to assess and evaluate the performance of the constructed indices and compare them with the capital weighted benchmark, a range of common performance measures are utilized such as annualized realized return, annualized volatility, the Return/Volatility ratio (henceforth Ret/Vol), correlations and the Treynor ratio. These are all regarded conventional, standard measures of performance and are thoroughly defined in section 4.2.

In addition to performance, previous literature has stressed that indices should also be examined for practical feasibility and whether they are subject to economic reason, i.e. if the costs associated with maintaining the index are kept manageable (Kamp (2008), Arnott, Hsu and West (2008), Amenc, Goltz and Tang (2011)). As such an assessment virtually knows no limits in terms of extensiveness, this study has delimited this review to two major index characteristics; index weight turnover, a proxy for transaction costs, and concentration, linked to firm and market-specific risk.

Index turnover

Transactions and their accompanying costs occur if new constituents are added to or excluded from an index or when market changes force new weights on the inherent stocks. That is, transaction costs are a byproduct of index reconstitution and reweighting, i.e. a turnover of inherent assets. The total turnover of inherent constituents forms an important characteristic to evaluate in determining an index’ attractiveness and economic justifiability. As computing the actual transaction costs could be practically difficult and limited in accuracy e.g. since trading costs differ for different types of investors (Arnott et al. (2005)), such a computation was not executed in this study. Inspired by previous studies, a qualitative discussion of the transaction costs was carried out instead (Arnott et al. (2005), Amenc et al. (2010)).
Stock concentration
As stated initially by Markowitz (1952), any holder of a portfolio gains benefit from holding a diversified selection of assets, thus spreading market risk across the inherent assets. Following this statement, which later has gained traction as somewhat of a financial dogma, comes the problem of mainly the capitalization weighted index which by construction is often overly concentrated in a few large firms as it weights constituents by size, implying a higher exposure to firm-specific risk (Malevergne et al. (2009)). Hence the study evaluates each index’ concentration, here measuring the concentration through the effective number of constituents as suggested by Strongin, Petsch & Sharenow (2000). This method is further described in section 4.2.
3 Data

3.1 The OMXS30 constituents

The OMXS30 index comprises the 30 most frequently traded stocks on the Stockholm Stock Exchange, utilizing a Market-capitalization based weighting scheme for the construction of the index. These stocks constitute the stock universe utilized for this study with the stock selection methodology as per subsection 3.1.1. By having a limit on 30 stocks instead of incorporating every listed stock in Sweden provides a focused and liquid universe of stocks to the alternative weightings that are tested. Moreover, being the most prominent market-cap index available in Sweden, the OMXS30 acts as a summarizing indicator of the Swedish market’s overall movements.

3.1.1 The OMXS30 stock selection methodology

The OMXS30 applies the following eligibility methodology in its selection of stocks and reconstitutes its index constituents semi-annually:

i. If an included index share is not among the 45 most traded shares on NASDAQ OMX Stockholm for the past six months, that share is replaced by the non-index share with the highest traded volume for the same period

ii. If a share listed on NASDAQ OMX Stockholm is among the 15 most traded shares on NASDAQ OMX Stockholm for the past six months but is not yet included in the OMXS30, that share replaces the index share with the lowest traded volume.

The high liquidity of the OMXS30 assures investability, i.e. index reproducibility, and thus its constituents form suitable candidates for any hypothetically launched alternative index in the Swedish market. Also, it is relatively protected from survivorship bias. Consequently, it provides an adequate data foundation for the study at hand, while a more extensive data assessment would undoubtedly be of large interest.

3.2 Data collection

The data for the OMXS30 in this study was collected through the Thomson Reuters Datastream database, assessing 11 years of past performance of the inherent stocks. Lists of OMXS30 constituents were shared by the NASDAQ OMX Global Index Group. Share price, market value and trading volume were extracted for each stock where pricings were defined as daily closing prices and adjusted for dividends and splits in order to avoid sudden price jump or dip anomalies. The 11 year time period from 01/01/2003 to 03/18/2014 (2817 recorded trading days) was chosen to ascertain that the data extracted formed a complete set of prices and market values for all the 30 OMXS30 index constituents.

When faced with incomplete time series data, data was collected from other databases and in the case of prices in other currencies, daily recalculations of the share price was conducted at the prevalent mid rate of the exchange rate closing price. As the study focuses on the Swedish stock market, the general case did not require any exchange conversions.
Figures for the short-term risk-free interest rate, collected as the rate of the 6 month Svenska Stadsskuldväxlar (SSVX 6M) because of the reweighting periods, were retrieved from the Sveriges Riksbank webpage.\(^3\)

\(^3\)www.riksbank.se/sv/Rantor-och-valutakurser/Sok-rantor-och-valutakurser/
4 Methodology

The study aims to test our hypothesis of the Swedish stock market’s suitability and therefore attractiveness to alternatively weighted indices. This is done by constructing the four alternative index strategies discussed earlier applied to the OMXS30 stock universe, and back testing their performance against the capitalization weighted OMXS30 index over a 11 year period. The evaluation is conducted through benchmarking each index’ performance through measurements common to the trade, further described in detail under section 4.2.

The programming of the index reweightings, the multiple linear regressions and data handling were conducted in MATLAB, Microsoft Excel and STATA.

4.1 Constructing the indices

The indices were created according to the procedures following in the coming subchapters. In order to enable a fair comparison between the indices, short-selling was disallowed for all index weightings. This would facilitate for the index weightings to be implemented since there are investment vehicles that are regulatory restricted to not using short-selling, as well as the possibly higher costs of utilizing short-selling instruments. The short-selling constraints had to be implemented for the Minimum Variance (MV) as well as Risk-Weighted Alpha (RWA) weighting methods, while the other rebalancing methods managed without these constraints because of the reweightings being dependent on non-negative volatility and market-capitalization measures. The market capitalization based benchmark was created using the above methodology and stocks rather than taken as the historical true levels for the index in order for consistent comparisons to be conducted.

To make the constructed indices comparable to the MC benchmark, they were semi-annually reconstituted on January 1 and July 1 each year respectively, to only incorporate and weigh stocks that were present in the true OMXS30 index during the time periods. In other words, any stocks that were added or excluded from the real world OMXS30 were also added to or excluded from the study’s constructed indices. Thus, although posing a restriction on the index construction, this implies an investment pattern in allowing for only the most liquid stocks available each year and provides comparability, replicability and relevance for the study, assuring plausibility in the comparisons of the indices. Keeping the stock universe the same for all indices adds validity and robustness to the study’s results, as a comparison of indices constructed using dissimilar stock universes would in large imply invalidity to any conclusions.

The index weighting approaches were rebalanced on a six month basis where the reweighting parameters were either taken as spot values on the rebalancing dates or as trailing averages over the past rebalancing period. This methodology of rebalancing weights dependent on solely backward-looking measures ensures of realistic rebalancings and does mean that the techniques demonstrated in this report could be applied to the index constituents with a probability of similar results on a forward-looking basis - although no foretells of course could be done on these premises. The rebalancing periods were chosen as semi-annual, each six months, because of the
fact that the OMXS30, as well as many other indices, are reweighted similarly. This is since six
months are considered sufficiently often to account for the desired effects of the index weightings
as well as since transaction costs of reweightings possibly could be kept to a sustainable level.
The new weights and prevalent market prices of the assets were made sure to add up to the total
capital available before the reweighting.

The daily returns at time \( t \) of the assets or indices, indexation \( i \), were calculated with the
following formula, where \( P_{i,t} \) is the price level of asset \( i \) at time \( t \):

\[
r_{i,t} = \frac{P_{i,t}}{P_{i,t-1}} - 1
\]

Each daily index level \( I_t \) for the different index reweightings was then calculated as the sum of the
products of the respective weight, \( w_j \), and daily return, \( r_j \), of each underlying index component
\( j \), as per the following formula:

\[
I_t = \sum_{j=1}^{n=30} r_{j,t} w_j
\]

The construction and computation of each index reweighting method is described in more detail
in the following sections.

4.1.1 The Market Capitalization Index
The Market-cap weighting approach allocates weights to its constituents based on their stock’s
market capitalization, weighted as a proportion of the total market cap sum by the index con-
stituents as a whole. Accordingly, larger companies are weighted heavier, implying larger impact
on the daily index value in total. The individual weights of each stock \( i \) can thus be represented
in the following way:

\[
w_i = \frac{MV_i}{\sum_{j=1}^{n=30} MV_j}
\]

where \( MV_i \) is the market value of asset \( i \). The values for each rebalancing of the market capital-
ization weighted index are taken as the market values for the day of the rebalancing.

4.1.2 The Minimum Variance Index
Aiming at keeping the portfolio overall volatility to a minimum, the MV weighting approach
adjusts its weights to optimize that achievement. In its construction here, short-selling is not
allowed because of the aim of comparing indices with the same prerequisites. The optimization
problem is thus:

\[
\begin{align*}
\text{minimize} & \quad \frac{1}{2} w^T \Sigma w \\
\text{subject to} & \quad w^T \mu \geq \mu_0 V_0 \\
w^T 1 & = V_0
\end{align*}
\]

where \( w \), and its transpose \( w^T \), is the vector of weights for the 30 constituents. \( \Sigma \) is the covariance
matrix of the returns of the constituents. The vector \( \mu \) and the scalar \( \mu_0 \) are the constituents
expected return respectively a set minimum return in order for the optimization problem to
yield a positive expected return whilst minimizing the variance. The last constraint ensures that
the weights all combine to equal the start capital $V_0$. Solving this problem yields the vector of weights as:

$$ w = V_0 \sum_{i}^{-1} \frac{1}{\Sigma_i} $$

In the case of negative weight components of the weight vector these were put to 0, and the remaining weights rebalanced proportionally according to the initial minimum variance weights, with the sum of the weights again equal to $V_0$. Limitations of this approach are further discussed in the Discussion section.

4.1.3 The Equal Weight Index

The Equal Weight method simply applies an equal weight to each index constituent, with all weights summing up to 1, hence it’s nickname “1/N” index. In its construction here, the 30 inherent stocks within the OMXS30 receive equal weights based on capital allocation, i.e. each stock allocates the same amount of capital within the portfolio, to the ratio of 1/30 of available weight respectively, excessively as per the formula:

$$ w_i = \frac{1}{\sum_{j=1}^{30} 1} $$

Important to notice is however that the index rebalancings are made every six months rather than continuously, whereby the capital allocated to each stock at any point between the reweighting times will not necessarily be 1/30, but rather depend on how the individual stock has performed since its 1/30-allocation at the previous reweighting time.

4.1.4 The Equal Risk Contribution Index

Weighing to set each portfolio constituent’s respective risk contribution equal, the ERC weights depends on the stock’s historical volatility and its correlation with the other portfolio assets. Decomposing the combined portfolio’s total volatility into parts originating from each portfolio constituent, one can write the portfolio volatility as follows.

$$ \sigma(w) = \sum_{i=1}^{30} w_i \frac{\partial \sigma(w)}{\partial w_i} $$

Here, the sum adds each weighted risk contribution of the $i$:th asset to the total volatility of the portfolio. The ERC then refers to every risk contribution of each individual asset being equal, that is:

$$ w_i \frac{\partial \sigma(w)}{\partial w_i} = w_j \frac{\partial \sigma(w)}{\partial w_j} \text{ for every asset } i, j $$

This problem is then simplified in order for the weights to be calculated more straight-forwardly, through assuming a uniform pairwise correlation between the assets. This results in the following solution of the problem:

$$ w_i = \frac{1}{\sum_{n=1}^{30} \frac{1}{\sigma_n}} $$

4.1.5 The Risk-Weighted Alpha Index

The RWA utilizes the concept of attributing heavier weights to stocks with higher historical Jensen’s risk-adjusted alpha. Jensen’s risk-adjusted alpha is calculated as Jensen’s alpha divided
by volatility, as per the following formula:

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

$$\sigma_i$$

$r_i$ is here the stock or index $i$'s average return over the past six months, $r_f$ the average six month Swedish treasury bond, $\beta_i$ the stock or index $i$'s beta as solved when regressing the asset’s excess return on the market risk premium. $r_m$ is the market average return over the past six months and $\sigma_i$, $i$’s volatility for the past six months.

The index weights are then formed through dividing the risk-adjusted alpha for each stock with the sum of all alphas for that reweighting time. The framework incorporates both historical volatility and return and premieres stocks with a wider positive gap between realized risk-return payoff and each respective expected return. Its calculation requires the determination of each stock’s market beta, which in this study’s RWA construction is based on the CAPM model. Each index constituents’ risk premium above the risk-free rate, as determined by the annual six month Swedish treasury bonds, is here regressed on the market risk premium as per the following equation with variables as introduced above. Additionally, $\epsilon_i$ is the error term for the regressions.

$$r_i - r_f = \alpha_i + \beta_i(r_m - r_f) + \epsilon_i$$

Because of the characteristics of the resulting RWA weights, some alterations to the method were made. Originally, the RWA in its theoretical execution would allow for negative weights as some stocks probably would likely be delivering negative alphas and thus also negative risk-adjusted alphas. However the short-selling possibilities are deprived the indices in this study in order to achieve more homogeneous prerequisites and enable comparisons under the same conditions. Instead of allowing short-selling, an alternative approach to eliminating negative weights was employed in that the negative weights were set to 0, and new relative weights calculated in order to attain the combined asset weight equal to the previous day’s portfolio value. The results and implications of this tweak to the RWA weights are further presented and discussed under the Results respectively Discussion sections.

### 4.2 Index measurements

To estimate the potential gains of creating alternative indices applied to the Swedish stock market, an array of performance measures known to the trade were assessed in the comparison between the indices. These include:

i. Annualized average return

ii. Annualized standard deviation

iii. Return/Volatility ratio

iv. Pairwise correlations

v. Tracking error

vi. Treynor ratio

vii. Annual one-way turnover
viii. Efficient Number of Constituents

ix. Relative Deconcentration

The **annualized average return** is defined by:

$$AR_i = \left( \frac{P_{i,T}}{P_{i,t}} \right) \frac{252}{T-t-1} - 1$$

Where $P_{i,t}$ and $P_{i,T}$ are the stock or index $i$'s price at time $t$ respectively $T$, where these are set to the start respectively end trading points of the examined period. The division between the prices, or the relative return over the entire time period, is then annualized on a compounded basis through raising it to the inverse of the number of years. The number of years is the number of trading points divided by the average number of trading dates in one year, 252 on average.

The **annualized volatility** is constructed using the standard deviation of the daily returns over the chosen time period as per:

$$\sigma_{i,\text{Annual}} = \sqrt{252} \sigma_{i,\text{Daily}}$$

where the daily historical volatility of asset $i$ on time $t$, $\sigma_{i,t,\text{Daily}}$, is calculated as:

$$\sigma_{i,t,\text{Daily}} = \sqrt{\frac{1}{n-1} \sum_{j=0}^{n-1} (r_{i,t-j} - \bar{r}_i)^2}$$

where $\bar{r}_i = \frac{1}{n} \sum_{j=0}^{n-1} r_{i,t-j}$ and $r_{i,j}$ the daily returns for the asset $i$ at time $j$ as per the formula stated earlier. $n$ is the number of days in the previous back-tracking period and thus varies depending on the number of actual trading days in the past half year period. For the general performance measures which include the entire back testing period is $n$ the total number of trading dates. As volatility is the chosen measurement of risk throughout the study, the annualized standard deviation is a useful reference for risk exposure and performance in a risk-return perspective.

The **Return per Volatility ratio (Ret/Vol)** is a modification of the Sharpe ratio, one of the most conventionally used measures for risk-adjusted performance. By excluding the risk-free rate from the Sharpe ratios original formula, the study hedges against any biased values due to a quickly changing risk-free rate over time that would otherwise deteriorate the measure. The Vol/Ret provides a good reference for this study’s examination of each index risk-return performance. The measure is utilized to evaluate each asset’s excess return against its undertaken risk, as well as the measure for the indices, quantifying the portfolio’s level of risk compensation. The Ret/Vol can, for an example, thereby clarify whether a portfolio strategy’s strong returns in a given period is relatively smart as compared to the risk exposure, or whether it is a direct result of a bold exposure to risk. The Ret/Vol is calculated by:

$$\text{Ret/Vol}_i = \frac{r_{\text{Ann},i}}{\sigma_{\text{Ann},i}}$$

where $r_{\text{Ann},i}$ is the stock or index annualized return and $\sigma_{\text{Ann},i}$ the stock or index annualized standard deviation.
Correlations are also analyzed. This since pairwise correlations between different stocks can help analyze how the index constituents of the OMXS30 have an impact on the different index weighting schemes applied in this report. Correlations of the different indices are also looked at since these can be utilized in order to see how the index weightings co-move to attain the true variation of the index weightings. The pairwise correlation between asset or index weighting $A$ and $B$ is calculated as:

$$
\rho_{A,B} = \frac{\text{cov}_{A,B}}{\sigma_A \sigma_B}
$$

where $\text{cov}_{A,B}$ is the covariance between the variables and $\sigma_A$ and $\sigma_B$ respectively are the standard deviations of the respective assets. The standard deviations are calculated as per previously stated formula and the covariance is calculated with the formula:

$$
\text{cov}_{A,B} = \frac{\sum_{j=0}^{n-1} (r_{A,t-j} - \bar{r}_A)(r_{B,t-j} - \bar{r}_B)}{n - 1}
$$

where $\bar{r}_A$ and $\bar{r}_B$ are the average daily returns of asset $A$ respectively $B$ as previously defined and $n$ the number of trading days in the previous period.

The ex-post or realized tracking error measures how close a portfolio follows its benchmark index using historical data, essentially determining the average deviation between the different portfolios’ returns. Hence, it assesses by which degree the alternative index at hand differs from the MC in performance. The tracking error is calculated as the standard deviation in the difference of the chosen index to the benchmark index, thus with the following formula:

$$
\sigma_{i,TE} = \sqrt{\frac{1}{n - 1} \sum_{j=0}^{n-1} (r_{i,t-j} - r_{\text{Benchmark},t-j})^2}
$$

The Treynor ratio is also computed for each index. It establishes the risk-return payoff of the index in the same way as the Ret/Vol ratio, however exchanging the individual standard deviation for the systematic risk to the CAPM market portfolio, beta. The formula is thus:

$$
\text{Treynor}_i = \frac{r_i - r_f}{\beta_i}
$$

$\text{Treynor}_i$ is the Treynor ratio of asset $i$, $r_i$ the annualized return of asset $i$, $r_f$ the annualized risk free rate over the period and $\beta_i$ is calculated through regressing the asset risk premium on the market risk premium.

In determining whether launching an alternative index based on the Swedish stock market would be an attractive investment, only assessing measures in terms of risk-return figures and risk-adjusted performance observed in isolation does not completely answer if a given index actually forms a financially justifiable platform for investment. Factors such as the asset turnover and stock concentration in an index relates to the costs of both investing in and running the index, along with the overall risk-profile of the index. Hence, both turnover and concentration are evaluated and discussed for each of the constructed indices.

In assessing the overall attractiveness and practical feasibility of the constructed indices as they relate to transaction costs, the turnover of constituents within each index is calculated using the average annual one-way turnover measure as defined by the U.S. Securities and Exchange
Commission, computed as the total amount of new securities acquired or amount of new securities sold, whichever is lesser over the year, divided by the total average net value of the index that same year.\(^4\) An evaluation of how the turnover levels relates to transaction costs incurred to the indices is conducted in the Discussion section.

As stated initially by Markowitz (1952), any holder of a portfolio gains benefit from holding a diversified selection of assets, thus spreading risk across the market. Following this statement, which later has gained traction as somewhat of a financial dogma, comes the problem of mainly the capital weighted index often being overconcentrated in a few large firms, implying a higher exposure to firm-specific risk as noted above in section 2.1. Hence the study evaluates each index’ concentration, here measuring the concentration variable through the Effective Number of Constituents (\(ENC_i\)) for index \(i\) as suggested by Strongin, Petsch & Sharenow (2000), computed as

\[
ENC_i = \frac{1}{\sum_{j=1}^{N} w_{ij}^2}
\]

Here, \(N\) is the number of stocks in the index, 30, and \(w_{ij}\) the weight of each respective index components. The \(ENC_i\) is for each constructed index set in relation to the corresponding figure for the MC benchmark through the Relative Deconcentration (\(RD_i\)) for index \(i\) with respect to the market capitalization benchmark, which determines a relative figure on the index deconcentration compared to the MC. Averaged yearly over the entire studied period, it is computed through

\[
RD_i = \frac{\bar{ENC}_i}{ENC_{Benchmark}}
\]

where \(\bar{ENC}_i\) is the arithmetic average Effective Number of Constituents for the index \(i\) and \(ENC_{Benchmark}\) the Effective Number of Constituents for the benchmark MC index.

Another way of depicting the different weight characteristics of the index weightings is by assessing the relative sizes of the weights of the individual stocks. The Lorenz curve, which plots the cumulative weights of the smallest to the largest stock weights as a function of the number of accumulated stocks, is utilized to compare how unbalanced the weightings are. As an example, the EW forms a straight line across the accumulated 30 stocks of the x-axis up to the accumulated weight of 1 on the y-axis because of the 1/30 weight of each individual stock in the index.

Complementary to the Lorenz curve, the Gini coefficient \(G_i\) of the graph measures the difference to the perfectly equally balanced portfolio. This is thus calculated with the integral of the Lorenz curve, \(I_{L,i}\), and integral of the equally balanced portfolio, \(I_{EW}\), in the following formula:

\[
\frac{I_{EW} - I_{L,i}}{I_{EW}}
\]

\(^4\)http://www.sec.gov/about/forms/formn-3.pdf, p. 10
5 Results

The results are structured in order to systematically examine whether the different aspects of the index weighting methods support the research question of in what ways the weightings differ and whether the OMXS30 index is suitable for alternative index weightings. Thus, summary statistics and measures about the OMXS30 underlying stocks are initially presented and form a foundation for the further discussion. This follows with a presentation and examination of the performance measures of the alternative index weightings, including a yearly comparison of how these perform against the market-cap weighted index. In addition, a display of each index’ turnover and concentration is presented. Concluding the result section, the different weighting dynamics of the indices’ are reviewed by plotting each index’ weighting behavior and assessing the characteristics of particularly favored or low-weighted stocks.

5.1 Index constituents

Indices with the same underlying assets will logically share a number of characteristics depending on the properties of their common underlyings. However, when the weighting schemes differ depending on e.g. desired minimization of total variance or a historical alpha dependence, the weightings will be biased when determining what constituents to include and give a higher weight. This can influence the index attractiveness as an investment tool, hedge or market indicator and is therefore important to map out as well as helpful when investigating reweighting results. The OMXS30 index constituents over the studied time period are therefore mapped out in Table 5.1 including some characteristic measures for their respective examined periods, i.e. measures for their time included in the index.

From Table 5.1 it can be noted that for the studied time period 01/01/2003 to 03/18/2014, seven reconstitutions were made in the MC OMXS30 index due to market changes. Over time, seven stocks are excluded from the index. In order of exclusion: SDIA SEK, FABG, STE R, HOLM B, VGAS, ALIV and ENRO. In their stead, the following stocks entered the index, replacing each excluded stock in the same order: BOL, VGAS, SCV B, SSAB A, LUPE, MTG B and GETI.

The annualized return over the 11 year period ranges between the relatively extreme -43.0% and 21.6%, produced by ENRO and FABG respectively. They are however somewhat outlying constituent returns as most of the other stock returns are close to the return average of 4.2%. The median is at the close value of 5.7% and approximately two thirds of the observed returns were within the 5%-10% interval, implying an absence of significant skewness of the annualized return distributions.

The market capitalization of the companies range between 4.78 bSEK for Fabege (FABG) and 821.2 bSEK for AstraZeneca (AZN) at the start of the study period 01/01/2003, and between 11.65 bSEK for SSAB and 526.1 bSEK for AstraZeneca at the end of the study period 03/18/2014. Notably, by the beginning of the study AZN’s market capitalization were 173 times larger than the smallest stock, FABG, hinting on the relative tangible size difference amongst the OMXS30 constituents.
<table>
<thead>
<tr>
<th>Stock</th>
<th>Ticker</th>
<th>Date included in index</th>
<th>Date excluded from index</th>
<th>Annualized return</th>
<th>Annualized volatility</th>
<th>Return/ Market cap at end (mSEK)</th>
<th>Market cap at start (mSEK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABB</td>
<td>ABB</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>8.5%</td>
<td>47.7%</td>
<td>0.18</td>
<td>115,801</td>
</tr>
<tr>
<td>ALFA</td>
<td>ALFA</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>18.9%</td>
<td>37.0%</td>
<td>0.51</td>
<td>9,967</td>
</tr>
<tr>
<td>AUTOLIV</td>
<td>ALIV</td>
<td>01/01/2003</td>
<td>01/01/2008</td>
<td>12.8%</td>
<td>27.4%</td>
<td>0.47</td>
<td>18,694</td>
</tr>
<tr>
<td>ASSA ABLOY 'B'</td>
<td>ASSA B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>9.0%</td>
<td>34.4%</td>
<td>0.26</td>
<td>45,180</td>
</tr>
<tr>
<td>ATLAS COPCO 'A'</td>
<td>ATCO A</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>17.6%</td>
<td>36.7%</td>
<td>0.48</td>
<td>34,765</td>
</tr>
<tr>
<td>ATLAS COPCO 'B'</td>
<td>ATCO B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>17.8%</td>
<td>38.4%</td>
<td>0.46</td>
<td>16,589</td>
</tr>
<tr>
<td>ASTRazeneca</td>
<td>AZN</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>0.8%</td>
<td>25.3%</td>
<td>0.03</td>
<td>821,171</td>
</tr>
<tr>
<td>BOLIDEN</td>
<td>BOL</td>
<td>07/01/2006</td>
<td>03/18/2014</td>
<td>-2.4%</td>
<td>31.1%</td>
<td>-0.05</td>
<td>38,643</td>
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<tr>
<td>ELECTROLUX 'B'</td>
<td>ELUX B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>4.2%</td>
<td>28.2%</td>
<td>0.11</td>
<td>58,839</td>
</tr>
<tr>
<td>ENHIRO</td>
<td>ENRO</td>
<td>01/01/2003</td>
<td>03/18/2009</td>
<td>-43.0%</td>
<td>38.3%</td>
<td>-1.12</td>
<td>9,954</td>
</tr>
<tr>
<td>ERICSSON 'B'</td>
<td>ERIC B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>3.6%</td>
<td>45.2%</td>
<td>0.08</td>
<td>195,605</td>
</tr>
<tr>
<td>FABEGE</td>
<td>FABG</td>
<td>01/01/2003</td>
<td>07/01/2006</td>
<td>21.6%</td>
<td>34.6%</td>
<td>0.62</td>
<td>4,775</td>
</tr>
<tr>
<td>GETINGE</td>
<td>GETI B</td>
<td>07/01/2009</td>
<td>03/18/2014</td>
<td>5.3%</td>
<td>26.8%</td>
<td>0.20</td>
<td>22,350</td>
</tr>
<tr>
<td>HENNES &amp; MAURITZ 'B'</td>
<td>HM B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>10.0%</td>
<td>26.7%</td>
<td>0.38</td>
<td>446,067</td>
</tr>
<tr>
<td>HOLMEN 'B'</td>
<td>HOLM B</td>
<td>01/01/2003</td>
<td>01/01/2007</td>
<td>5.5%</td>
<td>24.1%</td>
<td>0.23</td>
<td>12,330</td>
</tr>
<tr>
<td>INVESTOR 'B'</td>
<td>INVE B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>9.2%</td>
<td>28.8%</td>
<td>0.32</td>
<td>47,143</td>
</tr>
<tr>
<td>LUNDIN PETROLEUM</td>
<td>LUPE</td>
<td>01/01/2008</td>
<td>03/18/2014</td>
<td>8.1%</td>
<td>49.0%</td>
<td>0.17</td>
<td>21,054</td>
</tr>
<tr>
<td>MODERN TIMES GP. 'B'</td>
<td>MTG B</td>
<td>01/01/2009</td>
<td>03/18/2014</td>
<td>5.2%</td>
<td>38.4%</td>
<td>0.13</td>
<td>11,857</td>
</tr>
<tr>
<td>NORDEA BANK</td>
<td>NDA SEK</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>7.3%</td>
<td>35.3%</td>
<td>0.21</td>
<td>169,276</td>
</tr>
<tr>
<td>NOKIA</td>
<td>NOKI SEK</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>-4.9%</td>
<td>48.0%</td>
<td>-0.10</td>
<td>592,228</td>
</tr>
<tr>
<td>SANDVIK</td>
<td>SAND</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>6.5%</td>
<td>35.5%</td>
<td>0.18</td>
<td>62,476</td>
</tr>
<tr>
<td>SCA 'B'</td>
<td>SCA B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>4.8%</td>
<td>26.4%</td>
<td>0.18</td>
<td>66,008</td>
</tr>
<tr>
<td>SCANIA 'B'</td>
<td>SCV B</td>
<td>01/01/2007</td>
<td>03/18/2014</td>
<td>5.3%</td>
<td>41.3%</td>
<td>0.13</td>
<td>47,950</td>
</tr>
<tr>
<td>SKANDIA FORSÄKRINGS</td>
<td>SDIA SEK</td>
<td>01/01/2003</td>
<td>07/01/2006</td>
<td>3.2%</td>
<td>25.7%</td>
<td>0.06</td>
<td>24,463</td>
</tr>
<tr>
<td>SEH 'A'</td>
<td>SEH A</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>5.1%</td>
<td>42.5%</td>
<td>0.12</td>
<td>71,084</td>
</tr>
<tr>
<td>SECRITAS 'B'</td>
<td>SECU B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>-3.2%</td>
<td>32.4%</td>
<td>-0.10</td>
<td>65,913</td>
</tr>
<tr>
<td>SVENSKA HANDELSBIANKEN 'A'</td>
<td>SHB A</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>7.7%</td>
<td>30.5%</td>
<td>0.25</td>
<td>102,042</td>
</tr>
<tr>
<td>SKANSKA 'B'</td>
<td>SKA B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>7.5%</td>
<td>31.3%</td>
<td>0.24</td>
<td>27,756</td>
</tr>
<tr>
<td>SKF 'B'</td>
<td>SKF B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>11.2%</td>
<td>34.0%</td>
<td>0.33</td>
<td>16,791</td>
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<tr>
<td>SSAB 'B'</td>
<td>SSAB A</td>
<td>01/01/2007</td>
<td>03/18/2014</td>
<td>-5.6%</td>
<td>45.9%</td>
<td>-0.20</td>
<td>31,588</td>
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<tr>
<td>STORA ENSO 'B'</td>
<td>STE R</td>
<td>01/01/2003</td>
<td>01/01/2007</td>
<td>-4.6%</td>
<td>40.2%</td>
<td>-0.15</td>
<td>69,358</td>
</tr>
<tr>
<td>SWEDBANK 'A'</td>
<td>SWED A</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>5.7%</td>
<td>40.2%</td>
<td>0.14</td>
<td>68,879</td>
</tr>
<tr>
<td>SWEDISH MATCH</td>
<td>SWMA</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>8.6%</td>
<td>25.4%</td>
<td>0.34</td>
<td>29,356</td>
</tr>
<tr>
<td>TELIG 'B'</td>
<td>TELIG B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>5.4%</td>
<td>33.5%</td>
<td>0.16</td>
<td>24,506</td>
</tr>
<tr>
<td>TELIASONERA</td>
<td>TLSN</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>5.8%</td>
<td>39.0%</td>
<td>0.19</td>
<td>87,635</td>
</tr>
<tr>
<td>VOSTOK GAS</td>
<td>GAS</td>
<td>07/01/2006</td>
<td>01/01/2009</td>
<td>-27.7%</td>
<td>41.1%</td>
<td>-0.64</td>
<td>23,550</td>
</tr>
<tr>
<td>VOLVO 'B'</td>
<td>VOLV B</td>
<td>01/01/2003</td>
<td>03/18/2014</td>
<td>9.6%</td>
<td>46.2%</td>
<td>0.26</td>
<td>59,220</td>
</tr>
</tbody>
</table>

Table 5.1: Descriptive statistics for the OMXS30 constituents
5.2 Index performance

The trajectories of the different index weightings are shown in Figure 5.1. The index values are plotted over time from the first index weighting 6 months into the study period, 01/01/2003, until the final date 03/18/2014. All indices are set to start at the value 100 at the first reweighting time to facilitate the comparison.

![Figure 5.1: Performance trajectories of the constructed indices](image)

5.2.1 Performance measures

Performance measures for each alternative index and the MC benchmark are presented in Table 5.2.

<table>
<thead>
<tr>
<th></th>
<th>MC</th>
<th>MV</th>
<th>EW</th>
<th>ERC</th>
<th>RWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ann Ret</td>
<td>6.9%</td>
<td>11.0%</td>
<td>11.1%</td>
<td>10.1%</td>
<td>10.7%</td>
</tr>
<tr>
<td>Ann Vol</td>
<td>21.7%</td>
<td>20.5%</td>
<td>24.0%</td>
<td>22.8%</td>
<td>27.1%</td>
</tr>
<tr>
<td>Ret/Vol</td>
<td>0.32</td>
<td>0.54</td>
<td>0.46</td>
<td>0.44</td>
<td>0.39</td>
</tr>
<tr>
<td>Beta</td>
<td>1.00</td>
<td>0.88</td>
<td>1.05</td>
<td>1.00</td>
<td>1.07</td>
</tr>
<tr>
<td>Ret/Syst risk</td>
<td>6.9%</td>
<td>12.6%</td>
<td>10.5%</td>
<td>10.1%</td>
<td>9.9%</td>
</tr>
<tr>
<td>Tracking Error</td>
<td>-</td>
<td>8.2%</td>
<td>7.6%</td>
<td>7.1%</td>
<td>14.1%</td>
</tr>
<tr>
<td>Correlation with MC</td>
<td>1.00</td>
<td>0.93</td>
<td>0.95</td>
<td>0.95</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Table 5.2: Performance measures of the constructed indices

Table 5.2 interestingly shows a tangible disparity in each index’ respective performance measure. The annualized return spans between 6.9% to a 11.1% return for the observed indices, while the annualized volatility ranges from 20.5% up to 27.1%. The alternative indices’ tracking error, measuring their relative divergence to the MC benchmark, differs between a 7.1% level for the ERC to a figure of 14.1% for the RWA. The Ret/Vol ratio shows a risk-return discrepancy span-
ning from a 0.32 value to a 0.54 maximum.

The benchmark MC, exhibited in Table 5.2’s second column, produced the lowest annualized return of all observed indices (6.9%), although keeping somewhat more stable levels of those returns through its volatility being relatively lower in comparison (21.7%). Its Ret/Vol and Treynor ratios of 0.32 and 6.9% respectively stand as the weakest measured risk-return performance of all studied, signalling on a relatively poor risk reward ability for the MC benchmark.

The third column presents the EW’s performance, which shows on strong return properties for the assessed time period and data by delivering the highest annualized return of all indices. The return figure of 11.1% is c. 61% stronger than the benchmark’s ditto, while contrastingly having the highest realized value of correlation to the MC of 0.95. Its 24.0% annualized volatility is though the second highest observed value, suggesting its higher return may be a result of higher risk taken. These figures imply The EW Ret/Vol ratio of 0.46 and the related but systematic risk dependent Treynor measure is 10.5%.

The Equal Risk Contribution index, which approaches risk by spreading it evenly across its portfolio, performs well in terms of annualized return (10.1%) but notably displays a relatively high level of volatility (22.8%), contradicting its name suggesting otherwise. Its Ret/Vol ratio of 0.44 and Treynor ratio of 10.1% indicates an in comparison strong risk-return reward ability, clearly beating the benchmark despite their high inter-correlation.

The variance optimization-based MV delivered the lowest level of annualized volatility across the study’s time period. Mentionably, its 11.0% return is 59% higher than the MC, while withholding relatively lower volatility levels. The MV exhibited Ret/Vol ratio of 0.54 and a Treynor ratio of 12.6%, beating all other indices observed. In addition, the MV’s returns deviate the second most from the benchmark out of all observed indices with a correlation of 0.926 and a 8.18% tracking error, suggesting a tangible differentiation in its weightings of constituents compared with the MC.

The RWA, exhibited in column seven, presents data suggesting a relatively unstable pattern of returns, showing the highest volatility observed (27.1%) along with an in comparison poor Ret/Vol ratio of 0.39. However to its favor, its 10.7% annualized return together with a Treynor ratio of 9.9% displays a moderate capability of utilizing the systematic risk it exposes itself to through its choice of constituents and weights, thus enabling a competitive risk-return ability. Its correlation with the MC is the lowest observed.

Overall collecting Table 5.2’s results, it stands clear that all of the alternative weighting strategies exhibit higher annualized returns and risk-adjusted Ret/Vol and Treynor ratios over the MC benchmark. These findings support that in this study, the alternative indices do outperform the conventional market cap index from a risk-return perspective. In order to ascertain the weighting dynamics and factors underpinning the results, the study does below follow up on the measure review by analyzing each index’ performance on a yearly basis along with a breakdown of the indices’ weighting specifics, stock by stock, across time.
Table 5.3: Yearly annual returns of the constructed indices

<table>
<thead>
<tr>
<th>Year</th>
<th>MC</th>
<th>MV</th>
<th>EW</th>
<th>ERC</th>
<th>RWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>17.0%</td>
<td>23.4%</td>
<td>27%</td>
<td>24.4%</td>
<td>35.3%</td>
</tr>
<tr>
<td>2004</td>
<td>2.7%</td>
<td>8.5%</td>
<td>13.1%</td>
<td>11.5%</td>
<td>12.6%</td>
</tr>
<tr>
<td>2005</td>
<td>37.4%</td>
<td>29.4%</td>
<td>36.7%</td>
<td>35.3%</td>
<td>32.2%</td>
</tr>
<tr>
<td>2006</td>
<td>14.1%</td>
<td>18.7%</td>
<td>21.7%</td>
<td>21.1%</td>
<td>31.1%</td>
</tr>
<tr>
<td>2007</td>
<td>4.3%</td>
<td>2.9%</td>
<td>-2.0%</td>
<td>-2.6%</td>
<td>1.9%</td>
</tr>
<tr>
<td>2008</td>
<td>-36.2%</td>
<td>-27.3%</td>
<td>-43.0%</td>
<td>-41.9%</td>
<td>-48.6%</td>
</tr>
<tr>
<td>2009</td>
<td>30.0%</td>
<td>45.4%</td>
<td>63.9%</td>
<td>56.4%</td>
<td>70.0%</td>
</tr>
<tr>
<td>2010</td>
<td>12.8%</td>
<td>16.1%</td>
<td>27.1%</td>
<td>25.0%</td>
<td>22.8%</td>
</tr>
<tr>
<td>2011</td>
<td>-15.4%</td>
<td>-7.8%</td>
<td>-13.4%</td>
<td>-12.5%</td>
<td>-9.3%</td>
</tr>
<tr>
<td>2012</td>
<td>7.8%</td>
<td>9.4%</td>
<td>12.4%</td>
<td>11.4%</td>
<td>2.6%</td>
</tr>
<tr>
<td>2013</td>
<td>23.7%</td>
<td>18.8%</td>
<td>17.4%</td>
<td>17.5%</td>
<td>17.5%</td>
</tr>
<tr>
<td>2014*</td>
<td>1.8%</td>
<td>3.6%</td>
<td>2.1%</td>
<td>2.3%</td>
<td>-1.6%</td>
</tr>
</tbody>
</table>

* Refers to 01/01/2014 - 03/18/2014

5.2.2 Annual returns

Reviewing the indices’ performance on a yearly basis sheds light on their responsive as well as defensive properties to drastic changes in the market. Namely, the years of the crising 2008 and the consecutive recovery in 2009 constitute sudden unforeseen events around which some characteristics differentiated stock weight reactions are observable. Table 5.3 outlines the yearly returns for each constructed index. Notably, the financial crisis in 2008 implied significant losses for all indices and some noteworthy observations can be made around this event. The MV shows on possessing a trait of strong financial damage control as its loss in 2008, -27.3%, is by far the lowest drop, compared to the losses of -48.6% for the RWA and -36.2% for the MC. In addition, the MV proved itself resilient to loss for a second time in 2011 by again showing the smallest loss in return at -7.8%, along with being one of only two indices yielding positive returns during 2007. These limits in downside performance and aims of minimization of variance result in the top return/volatility value of 0.54 amongst the indices.

The MC benchmark again provides results supporting its feature of being relatively stable and non-volatile, as its response to the 2008’s crisis resulted in a -36.2% value drop, the second lowest level of loss observed. On the other hand, it does again not show on the strongest profit reaping abilities as its recovery in 2009 and 2010 was in the very bottom of the studied indices. The EW once more shows proof of its volatile nature, as its loss (-43.0%) is the second most severe in 2008, while its gain in 2009 (63.9%) was the second largest observed.

As for the RWA, the data suggests it performs best in “stable”, uneventful circumstances as its losses during 2008 is the greatest observed (-48.6%), while its recovery in 2009 is the study’s strongest (70.0%). This is aligned with the RWA’s previously remarked high annualized volatility.
5.2.3 Correlations

In order to assess how much the indices’ returns deviate from each other and specifically from the MC benchmark, Table 5.4 outlines the correlations between the returns of each index. The

<table>
<thead>
<tr>
<th></th>
<th>MC</th>
<th>MV</th>
<th>EW</th>
<th>ERC</th>
<th>RWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC</td>
<td>1.000</td>
<td>0.926</td>
<td>0.950</td>
<td>0.950</td>
<td>0.570</td>
</tr>
<tr>
<td>EW</td>
<td>0.926</td>
<td>1.000</td>
<td>0.961</td>
<td>0.971</td>
<td>0.579</td>
</tr>
<tr>
<td>ERC</td>
<td>0.950</td>
<td>0.961</td>
<td>1.000</td>
<td>0.998</td>
<td>0.602</td>
</tr>
<tr>
<td>MV</td>
<td>0.950</td>
<td>0.971</td>
<td>0.998</td>
<td>1.000</td>
<td>0.600</td>
</tr>
<tr>
<td>RWA</td>
<td>0.570</td>
<td>0.579</td>
<td>0.602</td>
<td>0.600</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Table 5.4: Index correlations

EW and ERC indices show a correlation of approximately 0.95, indicating a somewhat similar pattern in returns to the MC. The two highest correlations are shown to be between the ERC and the EW, with a correlation of 0.998 in both cases. Interestingly, in the case of the ERC - EW correlation, the historical six month volatilities that the ERC was constructed with were similar across all assets, making the ERC similar to the EW in that each stock got a fairly similar weight. The RWA shows the lowest correlation with the other indices, substantially lower than the other indices with correlations spanning between 0.570 and 0.602.

5.3 Index weights

The above presentation of the historical performance of the OMXS30 constituents and the display of each index’ performance provide a useful exhibit on the constructed indices’ competitiveness. However, to examine what factors in each index methodology that produce significant impact on the performance demands a further dissecting of the index subjects. More specifically, it is of large interest to decompose the indices’ different weight treatments of their inherent constituents over time to assess what behavior under what circumstances that pertains to a specific outcome, strong or weak.

5.3.1 Weight characteristics

<table>
<thead>
<tr>
<th></th>
<th>MC</th>
<th>MV</th>
<th>EW</th>
<th>ERC</th>
<th>RWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of weights &gt;10%</td>
<td>7.1%</td>
<td>9.6%</td>
<td>n.a.</td>
<td>0.0%</td>
<td>9.7 %</td>
</tr>
<tr>
<td>Proportion of weights &gt; 5%</td>
<td>20.6 %</td>
<td>26.7%</td>
<td>n.a.</td>
<td>3.9%</td>
<td>25.4%</td>
</tr>
</tbody>
</table>

Table 5.5: Aggregated weight proportions

A general weight assessment can be observed in table 5.5, showing that the MC, MV and RWA indices exhibited the highest propensity to put relatively large weights to single stocks: 7.1%, 9.6% and 9.7% of the total aggregated weights calculated were larger than 10% for each respective index. Similar overweight-indicative figures are displayed for the >5% weight limit.

The market capitalization reweighting scheme does in its construction present heavy size bias
by allocating significantly larger weights to the the largest company stocks. Constituents like AZN and NOKI SEK have average weights of 15.2% and 12.2% respectively over the entire study period, with as much as 25.3% respectively 17.0% for each stock at the first reweighting time. Other remarkable notations are the ABB, ERIC and HM stocks with on average 7.5% weights within the MC portfolio.

The MV sets higher weights to low volatility stocks; its average weight on the five stocks included over the entire period with the lowest annualized volatilities, SWMA, AZN, HM B, SCAB and SECU B, were the largest or second largest out of all indices. The MV was only outweighed on the AZN and HM B stocks by the MC; an expected result as their market capitalization is of significantly larger size relative to the remaining constituents. In addition, these five low-volatility stocks also exhibited the market betas closest to 1, implying the MV’s active limitation of its market exposure. In addition, its weights on the highest-beta stocks SEB, ATCO B, ERIC, NOKI and VOLV, only including full time span constituents, were the lowest observed except for one (NOKI). The EW by definition sets and maintains its weights equal to 1/30 at the start of each reweighting period.

As for the risk-diversifying ERC, its most obvious weight behavior shown is it mainly keeping the weights more or less equal - its yearly average weights on the constituents span between a max-min range of 4.6% to 2.3%. Compared with the respective figures for the MC and MV, 15.2% to 0.3% and 11.% to 0.1%, the ERC thus exhibit a relatively stable weighting behavior. In fact, only 3.9% of all the ERC’s observed stock weights throughout the period is larger than 5%, indicating an in comparison uniform weight allocation across time.

By assigning weights proportional to each stock’s six month historical volatility-weighted excess return, the RWA methodology operates a momentum strategy by setting larger weights to past unexpectedly strong performers. The imposed no short-selling constriction caused poor performing stocks to be excluded from its total asset constitution, i.e. having the weight 0. In the studied dataset, NOKI SEK and SSAB were continuously poor performers and were only included 8 out of 23 reweighting times in the RWA. As e.g. NOKI SEK had a downwards going return trend, excluding it was to RWA’s gain. This behavior would not be as beneficial for highly cyclical stocks as a downturn period would imply a low weighting for such a stock, limiting the potential gains from its cyclical upturn. The data’s worst performers, ENRO and VGAS, were moderately excluded by the RWA by having weights of zero 9 out of 14 respective 1 out of 4 reweighting times. On the contrary, FABG, ATCO A and B and ABB, which historically proved strong alphas, were incorporated 5 out of 8 respectively 15, 16 and 16 times out of 23 within the RWA. Notably, as few as merely three stocks were included in the RWA in the wake of the beginning of 2000’s financial crisis, when the data set’s first reweighting period was conducted. Overall, the RWA’s maximum and minimum number of included stocks were 26 and 3 respectively, with a stock count average of 16 incorporated stocks.
5.3.2 Stock concentration

The results of the stock concentration evaluation is presented by first displaying the relative deconcentration of each index compared to the MC, followed by an exhibit of the Lorenz curves and Gini coefficients for respective index.

<table>
<thead>
<tr>
<th></th>
<th>Average effective components</th>
<th>Ratio of effective to nominal components</th>
<th>Relative deconcentration compared with the MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC</td>
<td>13.2</td>
<td>44%</td>
<td>-</td>
</tr>
<tr>
<td>MV</td>
<td>10.8</td>
<td>36%</td>
<td>0.8</td>
</tr>
<tr>
<td>EW</td>
<td>30.0</td>
<td>100%</td>
<td>2.3</td>
</tr>
<tr>
<td>ERC</td>
<td>28.3</td>
<td>94%</td>
<td>2.1</td>
</tr>
<tr>
<td>RWA</td>
<td>9.7</td>
<td>32%</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Table 5.6: Stock deconcentration

Column four in Table 5.7 displays the relative deconcentration of each index compared to the MC benchmark. As expected, the zero-concentration EW weighting exhibits the highest rate of deconcentration compared with the MC. As the ERC as previously mentioned maintained relatively equal weights and thus fairly replicating the EW, its deconcentration is in similar high figures. Interestingly, the MV and RWA indices show more concentrated portfolios than the MC benchmark, with deconcentration figures lower than 1. Figure 5.2 presents the Lorenz curves for each index.

![Figure 5.2: Lorenz curves with average accumulated weights for the constructed indices](image)

By the definition of the Lorenz curve, the EW forms a straight line as its assigned weights to all index components are equal. The MC is the most unevenly distributed index in terms of individual stock weightings, indicated by its curve displaying the largest skewness. In fact, 20 of the 30 stocks included account for just about 30% of the total weights, implying a high level of concentration. Next to the MC, the MV’s bended Lorenz curve signals a high stock concentration. The ERC instead follows the EW closely with a balanced distribution of weights.
over the stocks, forming an expected result as its deconcentration levels were in similar figures. The RWA weight distribution characteristics are insignificant when looking at the average as depicted in the Lorenz graph, whereas the Gini coefficient of the stock concentration over time displays a more varying result, found in Figure 5.3.

As a measure quantifying the concentration of the index weightings, the Gini coefficient assigns a higher value to more unevenly balanced indices. In the graph one sees that the MC Gini coefficient is high (0.6-0.7) throughout the study period, in line with the results from the Lorenz graph of average concentration. The EW, ERC and MV indices also have limited deviating Gini coefficients over time. The RWA on the other hand shows an over time heavily varying concentration, explaining its high returns and exhibited low correlation values to the remaining indices’ returns. In whole, the above display of each index’ performance and outperformance of the MC benchmark utilizing stocks from the OMXS30 universe, hints on the Swedish stock market in fact providing a good foundation for the launch of alternative indices, in terms of returns and risk-return rewards. However, in order to determine the actual attractiveness of launching an index on the Swedish market, a separate analysis of the actual economic feasibility in terms of practical maintenance costs, for both the index provider and investor, is called for. The following section thus presents an evaluation of each index’ turnover, which provides an indicative measure on potential transaction costs associated with both running and investing in the indices.

5.3.3 Index turnover
Unsurprisingly, the MC, EW and ERC indices perform the least amount of reweightings, showed by their low turnover ratios. In contrast the MV and RWA display higher turnover figures of 0.82% and 1.22% respectively, indicating fairly high rates of reweightings and reconstitutions following a holding of their suggested portfolios. These turnover results reflect the previously reported highly differing weight distributions of the MV and RWA, implying larger changes to capital allocation within the index including any inclusions or exclusions of assets.

<table>
<thead>
<tr>
<th></th>
<th>Average one-way turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC</td>
<td>0.16 %</td>
</tr>
<tr>
<td>EW</td>
<td>0.05 %</td>
</tr>
<tr>
<td>ERC</td>
<td>0.17 %</td>
</tr>
<tr>
<td>MV</td>
<td>0.82 %</td>
</tr>
<tr>
<td>RWA</td>
<td>1.22 %</td>
</tr>
</tbody>
</table>

Table 5.7: Average one-way turnover
6 Discussion

6.1 Index Performance and characteristics

With results on performance, correlations and weighting dynamics presented for each index, the study follows up on the exhibited results by discussing the potential sources of each index’ displayed characteristics found in the data.

6.1.1 The Market Capitalization Index

The MC demonstrated the lowest observed values for both plain annualized and risk-adjusted return. With its aforementioned high concentration of stocks, its returns are highly dependent on the performance of these few stocks, tangential on the MC methodology’s flaw of turning too much capital towards large-cap assets. As the comparatively cap-heavy AZN and NOKI SEK stocks with respective average allocated weights of 15.2% and 12.2% throughout the period delivered annualized returns of 0.8% and -4.9% respectively, they formed a heavy drag on the MC’ total returns, likely in large contributing to the relative risk-return underperformance of the MC benchmark. This unfavorable dynamic of stock concentration was also found by Malevergne et al. (2009). In addition, the MC by construction suffers from its inability to reap larger parts of potential profits coming from newly added, smaller stocks within its index as it weighs these smaller, potentially undervalued stocks low, limiting prospective returns. This finding was shared by Arnott et al. (2005), Hsu (2006) and Arnott and Hsu (2008). On the other hand, its heavy weighting of larger, less volatile stocks does limit its movements in returns, thus creating a more stable index than some of the alternatives.

The MC’s observed underperformance in terms of risk-return reward is aligned with the conclusions drawn by Chow, Hsu and Kalesnik (2011), resulting in this study’s data supporting the critics of the market capitalization scheme. In addition, the results of the MC displaying non-diversified risk properties through its high stock concentration are consistent with the findings of previous studies evaluating the similar (DeMiguel et al. (2009), Windcliff and Boyle (2004)).

6.1.2 The Minimum Variance Index

The MV displayed noteworthy strong performance in the studied data set and its clear outperformance of the MC benchmark was consistent with the conclusions drawn by Clarke, De Silva and Thorley (2006). The comparatively low correlation with the MC benchmark as well as higher tracking error are in line with the observations made by Amenc et al. (2011) and Chow et al. (2011). These contribute to disconnecting the MV with the overall market and diminishes its market exposure, thus stepping away from the optimal portfolio suggestions made by the CAPM model discussed under section 2.1.1. The lower systematic risk exposure compared to the market can further help explain the MV’s relatively good outcome during the 2008 crisis, its limited market exposure mitigating losses through diversified risk.

The MV’s relatively loss-resilient returns in downtrend markets suggest an attribution of defensive characteristics to its methodology, as it exhibited an ability to mitigate losses under
market distress within this data set. This is accredited the MV’s solution to the optimization problem of minimizing variance; the back-looking feature of assessing historical volatility acts as a defensive measure to changes, although crippled in responsiveness as the reweightings are made semi-annually.

The MV notably showed high levels of concentration despite the diversifying benefits of allocating capital across the assets. This was due to the short-selling constraint superimposed on the minimum variance optimization problem in that weights with negative values were set to zero. Along the reweighting times the MV with short-selling constraints excluded as many as 11 stocks on average and some characteristics of the original method are thus overshadowed by what stocks were included. According to the theory, the MV assesses the characteristics of the stocks with a pattern of premiering stocks with low historical volatility and low correlation with other stocks in order to minimize the total portfolio variance. The low-correlation stocks of AZN and SWMA are thus e.g. assigned relatively high variance. The short-selling constraint however also biases the inclusion and stocks expected to be more heavily weighted are at times excluded from the index as compared to having a negative weight.

6.1.3 The Equally Weighted Index

The unconventional EW approach delivered the study’s highest annualized return (11.1%), while still being the second most volatile index of all (24.0%). Its in comparison strong ability to capitalize on undertaken risk by providing competitive returns, as supported by the high values of Ret/Vol and the Treynor ratios is consistent with what DeMiguel et al. (2009) found in their EW’s outperformance of the benchmark.

The EW’s performance may be explained by the fact that its methodology’s greatest advantage is also the reason for its severe losses; by distributing weights equally, the index diversifies firm-specific risk and realizes gains in return uniformly across its assets, while simultaneously forming a wide exposure to overall market risk as supported by its relatively high beta.

Compared to the MC benchmark the EW has a property of allocating larger weights to smaller stocks, opening up for both gains and losses in these. As such, the EW distributes more exposure to growth stocks than potentially slower-moving value stocks, enabling a potential reap of higher small-stock returns, partly serving as an explanation for its strong performance. In fact, the three smallest stocks by the beginning of the period ALFA, ATCO B and SKF B also delivered amongst the highest annualized returns.

Overall, as the EW once again presents strong figures of performance, its methodology’s simplicity puts further pressure on the advocators and engineers of more sophisticated weighting approaches.

6.1.4 The Equal Risk Contribution Index

In comparison to the minimization of total portfolio variance as per the MV methodology, the ERC solely looks at the historic volatility of the last six months, assigning weights inversely
thereafter. Because of fairly similar past volatilities across the study period, the ERC has a low variation across its constituent weights, thus making the ERC fairly similar to the EW with regards to weights and performance. Hence, its return properties in this study likely build on the same dynamics underpinning the EW’s strong performance. The results showed returns less volatile than the related EW, hinting on a somewhat effective outcome of its risk-diversifying purpose and construction. Aligned with Maillard et al. (2008), this study finds the ERC’s annualized volatility to lie between the EW and MV indices’ respective figures, although not sharing the outcome of the ERC outperforming the EW.

As Maillard et al. conclude, the ERC does demand a large computational effort for larger portfolios. This has for long stalled further and more extensive academic analysis. As a result, applying its methodology on a larger data set and a greater time span is of great importance to further shed light on the ERC’s risk-return properties and practical use.

6.1.5 The Risk-Weighted Alpha Index

As somewhat of a joker among the constructed indices, the RWA exhibits results that stand out from the other alternative weighting schemes with regards to correlations, tracking error and an interchanging concentration along the reweighting times. Contradictory to Agarwal’s (2014) findings, where his constructed RWA provided stronger returns relative to his benchmarks as well as to other reweighting schemes, the RWA does for our examined period and data set not show on these outstanding results. The overperformance of the RWA in the up-trending market of 2007 as well as the following underperformance in the financial crisis of 2008 show on the RWA’s inability to adapt to the current market situation. This diverges from the expectations as the RWA in theory aims at assigning weights according to stocks with past high risk-weighted excess returns. Poorly performing stocks should thus be assigned small weights.

The lower correlation of the RWA to the other indices can partly be understood by looking at the varying Gini coefficient of the RWA as well as the realized weights of the index over time. The Gini coefficient shows that the concentration of the weights varies much and assigns high weights to a few number of stocks meaning that the index will be more dependent on specific stock performance, explaining the low correlation with the other indices. To this should be added that the RWA excludes stocks on a more random basis compared with the systematic exclusion of specific stocks as per the MV method, limiting some of the stock selection bias.

6.2 Index feasibility and the suitability of the Swedish stock market

The turnover and concentration results presented above form an array of data suitable for the discussion of each constructed index’ actual economic feasibility; that is, how appealing the different indices are for an actual potential launch or as a target of investment. The evaluation of index feasibility bases on three factors that define the incentives for any potential investor to run or invest in the index: i) the potential gains of investing; ii) the risk-profile and iii) costs associated with investment in or maintenance of the index. According to these, each index is examined individually and given an overall feasibility assessment.
The MC, as expected, displayed the lowest asset turnover of the studied indices. This was hardly surprising as the market capitalization approach by definition automatically reweights its constituents as their respective market prices go up or down. This result correspond to the similar findings by Hsu (2006) in his study, stating one of the MC index’ main benefits being its low operational costs associated with its low turnover. This makes the MC an attractive passive investment strategy for the average investor looking to invest passively in the market. However, with its concentration being relatively large - in this study in particular - the MC’s exposure to firm-specific risk becomes significant. This may not suit all type of investors, e.g. one with an inclination to spread risk by diversification. Having assessed a rather stable level of volatility offset by an in comparison low risk-return reward, the MC does not appear as the most attractive index investment opportunity among the ones constructed in this study.

The MV exhibited the strongest ability to deliver return upon taken risk along with a defensive characteristic of damage control capabilities when faced by financial distress, forming an incentive to invest for the somewhat risk-averse return seeking investor. Although with a considerably high level of turnover arising from numerous reconstitutions and a high stock concentration within the index, the MV appears to be a costly and non-diversified investment which erodes its feasibility significantly.

Suitable for the bullish and moderately aggressive investor, the EW constructed in this study forms an appealing subject of investment through its displayed high return performance in an upturning market, while taking on considerable levels of loss in greater downturns, making it less desirable by the risk-averse. As both turnover and concentration per definition practically is zero, there is a considerable economic incentive to hold an EW portfolio as the associated running costs are close to none and its exposure to firm-specific risk minimized. With these characteristics suggested by the results, an educated, return-seeking investment in the EW would imply a relatively positive bet on the market with an in comparison rewarding return on capital invested.

As the ERC, in rough terms, more or less replicated the EW weightings by having its weights hovering around an equal value, it showed turnover and concentration in similar levels. However, by in addition to incurring low holding costs, the ERC presented a more return-stable, less volatile performance throughout the study period. Assessing that the ERC in summary delivered both annualized as well as risk-adjusted returns clearly beating the MC benchmark, virtually close to zero operational costs and an attractive, diversified risk profile, the ERC constitute the perhaps most attractive index for the average investor seeking relatively risk-hedged returns. Although being computation-heavy for the larger market, it remains an interesting subject to further evaluation and examination, both on an academic and practical level.

Agarwal’s RWA methodology forced a significant high level of stock exclusion and a large variance in its weights, driving the index’ high rate of stock concentration and constituent turnover. Alongside with the costly implications of the above, the RWA was highly volatile and produced the second weakest risk-adjusted performance observed, implying a tangible disincentive to invest for an index provider as well as the general investor, diminishing its practical justification. Thus, its feasibility is not in the RWA’s favor within this study’s framework, however it should...
Concludingly, as for the Swedish stock market as a foundation for the potential launch of alternative indices’, the data’s attractive levels of turnover and concentration among foremost the EW and ERC indices imply relatively low maintenance and running costs for holding the index portfolio. Along with the actual outperformance of the MC benchmark by the alternative indices, this study presents a profit-gain incentive for both the index creator and the individual investor to invest in the Swedish stock market with an alternative weighting approach - they all beat the conventional MC index.

6.3 Problematization

The aim of the study does in its selection of examined data, methodology and tools for analysis inherent and create biases and limiting implications to the aim of the study. These are discussed in more detail in the following subchapters together with some suggestions for improvement and angles of approach for further research within the area.

6.3.1 Data selection

The data chosen for the study was an ultimately complete set of the OMXS30 constituents over the 01/01/2003 - 03/18/2014 time period. The fact that only 30 stocks were chosen for the index could be considered limiting to the index weightings as well as dangerously dependent on individual stock performances and characteristics. This can in part be confirmed for this study in that some of the weightings at times were unrealistically composed of fewer than acceptable index components. The idea of looking at the OMXS30 components as a proxy for the Swedish stock exchange in order to attain results to discuss alternative index weightings for the stock exchange can however be considered a sound decision. Since the OMXS30 itself is commonly used and since other stock market indices are utilizing similarly created indices, such as the Swiss SMI as well as the Belgian and Portuguese BEL20 respectively PSI20 - all including just 20 stocks. The liquidity and combined market capitalization of the stocks are furthermore equally or even more important aspects as the reweightings need to be practically plausible at the market bid-offer prices and to the correct volumes in order for the index reweighting schemes to be sufficiently efficient.

6.3.2 Methodology

In reweighting the indices over the study period a number of assumptions with regards to back-tracking periods and at times needed modifications were made, many of which have been stated in section four. This study has narrowed its research scope to the evaluation of the above four alternative indices, compared with the MC benchmark. Other available alternative strategies, such as the fundamental weighting approach, risk-cluster equal weighting, volatility weighted and the maximum diversification scheme, have been intentionally excluded to maintain focus and sharpness throughout the study in terms of number of evaluated subjects, as well as to provide a range of indices with more differentiated methodologies. For further research into these alternatives, Chow, Hsu and Kalesnik (2011) and their literature and references present an informative account on the currently most prominent alternative index strategies. As regards to
the fundamental weighting scheme, which has been subject of rigorous discussion lately, it differs from the others through basing its weighting criterias on the different constituent’s fundamental stock values. The fundamental index and its properties have been thoroughly examined by a number of studies - see e.g. Arnott, Hsu and Moore (2005), Arnott, Hsu and West (2008), Kaplan (2008) for exhaustive introductions to the methodology and deeper analyses.

Short-selling constraints were imposed in order for negative weights to be excluded from the weightings and thus produce results which did not discriminate across the possible set of investors and index creators which could use the results for alternative reweighting methods tested. The implications of this were that the MV and RWA weightings excluded on average 11 respectively 14 stocks per six month period, an in retrospect high value considering the desired index characteristics of the combination of stocks. The MV approach with short-selling constraints superimposed on the result of the initial optimization problem result did also lose its absolute minimization of variance characteristic. Instead the methodology enabled a modification to the theory because of the aim of making the results of the study applicable to a wider range of market participants.

Another decision regarding the weights which was also amplified because of the short-selling constraints was the fact that no weight limitations were imposed on the reweighting schemes. This led to at times abnormally high weights in individual stocks which meant that the index reweightings to a large extent inherited the specific stock characteristics. This is considered and discussed throughout the weightings and the remedy of limiting the individual stock weights to e.g. a 5% or 10% level would have caused other problems such as a divergence of the weight allocations to the original reweighting scheme.

6.3.3 Tools for analysis

The measures used for studying the performance and characteristics of the reweightings were selected in order to provide a broad and at times more in-depth base for the study. However, an extensive filtering of possible measures had to be made, considering relevance and additional contribution of the measure. The information and Sortino ratios are examples of measures commonly used when comparing indices but which have been excluded from this report. As regards the information ratio, the active risk of the alternative weighting as compared with the benchmark divided by the tracking error, does not contribute with any additional insights into the characteristics or performance of the weightings than the annualized return and tracking error measures individually. The Sortino ratio builds on the methodology behind the aforementioned Sharpe ratio, but separates a given stock’s volatility measure by only considering the standard deviation of the negative returns (downside deviation). Thus, the Sortino would have provided an insightful measure on how each index tends to handle loss when approached with a bearish market. This study has however concluded that if a more in-depth performance evaluation of the indices’ behavior around a disruptive event - e.g. the financial crisis 2008 - would have been conducted, the Sortino would have a better fit. In addition, with the relatively short 10 year time frame, a more extensive data collection would provide more reason to utilize the Sortino ratio.
The performances of the indices have been analyzed on a comparative basis with the aim of looking at how the alternative indices have performed rather than on why they have performed in this way. The reason behind the performance is an interesting aspect which could have been analyzed more, through e.g. attributing the overperformance of the alternative weightings to different factors. Commonly used factors are e.g. the market, value and size factors of the Fama-French three-factor model. The data could have been regressed on these factors, as well as on the fourth factor of momentum as in the Carhart model, in order to establish whether the returns can be attributed to the reweightings or any more universal data and market characteristics.
7 Conclusion

The first research question this study set out to evaluate:

i. How do the alternative index weightings compare against the market-cap index weighting for the Stockholm stock exchange’s most traded stocks in terms of performance and feasibility, and how do their weighting behaviors and dynamics differ over the studied time period?

The results of this study show that alternative reweighting methods of the OMXS30 stock universe outperform the traditional market-capitalization weighted index on a risk-return as well as absolute return basis. The return per risk is for the examined period shown to be 22%-68% larger for the alternative weightings and the absolute returns of the indices are even higher showing on favorable aspects of the alternative indices. The alternative indices furthermore track the benchmark to 7%-14% and the pairwise correlation to the MC is in most cases around 95%. These reaffirming results of creating and investing in alternative indices of the OMXS30 stocks are extended with another perspective through the characteristics of the weights of the alternative indices. The modified MV and RWA indices constructed in this study, which in their original formation allow for short-selling possibilities, assign a weight of zero to the otherwise negatively weighted stocks and this results in heavily a reduced number of stocks in these indices. This bias is hard to ignore when considering indices with a set goal of market-wide exposure. The ERC and EW indices do on the other hand show on more diversifying properties in the weights of the stocks than the unevenly balanced OMXS30 MC benchmark. Finding that the ERC and EW relatively closely track the benchmark’s returns but with a substantially stronger performance and a more diversified portfolio of included stocks can in conclusion be considered value-adding approaches to reweighting the stocks.

Again, this study set out to also answer the second research question:

ii. Does the Swedish stock market provide an attractive foundation for a hypothetical launch of alternative indices?

Assessing the observed measures on the three previously stated index feasibility factors: the potential gains of investing, the index’ risk-profile and lastly the costs associated with investment in or maintenance of the index, the results of the alternative indices applied on the Swedish OMXS30 presented in this study express an interesting contribution: The alternatives clearly outperform the capitalization weighted benchmark, host an attractive risk-profile except the EW and RWA, as well as an appealing take on risk by mainly the MV and ERC indices. In terms of returns, they all beat the benchmark, and thus form an attractive concept while observing pure capital gains in isolation. As regards to practical feasibility and economic justification, the EW and ERC pose as investment portfolios worthy both risk and costs associated with their creation.

In whole, the study cannot reject the proposal of an alternative index launch on the Swedish stock market being a commendable investment based on assessed data and results. As mentioned, investors have historically shown hesitance towards turning their capital to alternative weightings, but as academics push forward with suggestive evidence of a performance inferiority
of the conventional capitalization weighted index, the walls of convention and practice are taken
down brick by brick.
8 References


39


