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Fundamental Indexation - A European Investigation

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Abstract

Traditional capitalized-weighted index portfolios aim to capture the market performance, and can be considered as a viable investment option for passive investors. However, research suggest that cap-weighted indices are sub-optimal as they overweight overpriced stocks and underweight underpriced stocks. This Master Thesis examines whether the fundamental indexation strategy is superior relative to cap-weighted indexation, covering 15 developed countries in Europe between 1986-2016. The fundamental indices are equally weighted between four non-price based metrics; Book Value, Net Income, Cash Flow and Dividends. The study finds that fundamental indexation generates excess returns adjusted for several risk factors, which is in accordance to comparable research papers. In addition, the findings indicate that the fundamental indices perform better in bear markets relative to the cap-weighted indices' outperformance in bull markets. The results are persistent through time, which substantiates that fundamental indexation has the features of being a superior indexation method.

1. Introduction

The main objective of this master thesis is to develop a fundamental index and assess its performance relative to a set of both commercial and self-constructed benchmarks in Europe, among them the MSCI Europe Index. We compare the fundamental indexation method against the traditional market capital-weighted approach, and our objective is to carefully consider if fundamental indexation creates excess returns.

1.1 - Background

Fundamental indexation is a relatively new concept that presents an alternative approach of asset composition compared to the cap-weighted index framework.

According to the study of Arnott, Hsu & West (2008), a central aspect in the development of the fundamental indexation strategy is the financial theory that stock prices should converge towards “fair price” in the long-run. Their view supports the “noisy market hypothesis”, which is in opposition to the “efficient market hypothesis”, emphasizing that the market price can be an unsuitable estimator for true underlying value (Siegel, 2006). Hence, a cap-weighted index might suffer from an inefficient return drag as it will rebalance itself with an overweight in overpriced stocks and an underweight in underpriced stocks. This creates an imbalance between stocks that are expected to over-/underperform according to the theory.

To overcome the inefficiency, Arnott et al. (2008) propose to create indices using “market-value-indifferent-measures”, which focus on firm-specific fundamentals instead, such as; Cash Flow, Sales, Revenues, Book Value and Number of Employees. According to Arnott et al. (2008), weighting by these metrics will reflect the economic state rather than the market state, distancing the fundamental index from market opinions and reducing its exposure towards mispricing and irrational behavior. In recent years, the concept is often recognized as a “Smart Beta”-strategy, which is an umbrella term comprising all portfolio strategies that do not take market price into account when assigning index weights.

That being said, there are no universal agreements regarding the economic theory the fundamental index is built upon, resulting in both admiration and critique. Some admires its superiority while others claim that the outperformance is just a result of its tilt towards value stocks relative to the cap-weighted indices, which exposes the index to another risk scheme.

1.2 - Motivation

A motivation for this field of study is that several academic papers worldwide rejects the concept that cap-weighted indices are good proxies for the market portfolio, which consequently rejects the theory that cap-weighted indices are mean-variance optimal. Furthermore, consensus is that it should be possible to create more efficient portfolios.

New forms of indexation are experiencing an increase in popularity among investors. Smart Beta index strategies rapidly gain market shares, and recently passed the $1tn milestone for assets under management[1]. The increasing popularity triggered our motivation to assess whether the concept outperforms the traditional cap-weighted indices.

1.3 - Research question

Our main target with this master thesis is to answer the following research question:

- Does fundamental indexation create superior risk-adjusted returns compared to a traditional cap-weighted index portfolio for the passive investor?

As a sub-question, we want to assess the following:

- How does index composition affect the gains/losses in bull- and bear markets?

[1] Thompson, Jennifer. 2017. URL:
https://www.ft.com/content/bb0d1830-e56b-11e7-8b99-0191e45377ec

1.4 - Contribution

The original study by Arnott, Hsu & Moore (2005) covers the U.S stock market. As of this, we believe that it would be interesting to conduct an equivalent test on the European stock market to assess whether we find similar patterns. Such an outcome could make their conclusion more generalizable across countries, whereas the opposite would make us question the theory’s validity. As far as we know, existing research in Europe concerns a slightly different set of participating countries, using different benchmarks, as well as being dated back by roughly a decade. Thus, our research provides complementary insight for the fundamental indexation concept.

1.5 - Expected findings

Arnott et al. (2005) find that their portfolios risk-adjusted return outperforms the S&P500 over the 43 year testing period. This implies that fundamental indexation in general has the features to be more mean-variance efficient than standard cap-weighted indices. Hence, we target our hypothesis and expectations to find similar results in Europe. Although, we expect deviating findings as the research is conducted on another market with a different set of characteristics.

That being said, we emphasize that the goal of this thesis is to challenge the established theories that substantiates cap-weighted indexation as superior. Hence, we do not neglect that there might be alternative ways to construct a superior passive index strategy.

2. Literature review

2.1 - Market efficiency and the mean-variance efficient portfolio

A commonly established theory states that under the efficient market hypothesis and Capital Asset Pricing Model (CAPM) framework, the market portfolio is mean-variance efficient due to the fact that investors are assumed to be risk-averse (Fama & French, 2004). As of this, all investors are expected to choose the portfolio that maximizes returns while minimizing the risk. When investors fully agree upon the distribution of returns according to CAPM, the portfolio consisting of risky assets are equal across all investors. Hence, it will be the mean-variance optimal market portfolio. The weight of each asset in the portfolio will conform with the total market value of the asset divided by the market value of all risky assets, hence a cap-weighted portfolio (Fama & French, 2004).

The credibility of CAPM has been debated for the last four decades, and recent empirical studies reveal that much of the variety in expected returns are not captured by the market beta. Hence, they seem to be unrelated, meaning that a large proportion of assets yield deviating returns compared to the CAPM suggestion. Evidence indicates that there are other relevant measures to determine returns, such as P/E-ratio, debt/equity-ratio, excess return from small stocks and book-to-market ratio. Furthermore, if the market-beta does not explain expected returns in a sufficient manner, CAPM does not hold.

However, constructing the true market portfolio is rather infeasible in real life. This is because it is theoretically unclear which assets that can be excluded from the market portfolio, such as human capital. As of this, one cannot actually test the CAPM, as the real life market portfolio is only a proxy for the true market portfolio. So, an explanation for the weak relation between expected returns and estimated betas might be that the market portfolio proxies are mean-variance inefficient (Roll & Ross. 1994). According to Ross & Ross (1994), the market portfolio proxy is 22 basis points below the efficient frontier. This questions whether cap-weighted indices are optimal and if fundamental indices are one of the superior options in terms of risk-adjusted return.

2.2 - Fundamental Indexation

Fundamental indexation can be considered an alternative way to construct indices and it deviates from the traditional market-cap indexation method. The market-cap indexation is based on the market value of companies, whereas the fundamental indexation method is so-called "non-price-based" (Arnott et al., 2008). The fundamental values are for example; Dividends, Sales, Net Income, Number of Employees etc. (Arnott et al., 2005). A common conception is that the stock markets are not fully efficient. This in turn can lead to an overweight of overpriced stocks and an underweight of underpriced stocks when applying a market capitalization weighting scheme (Mar, Bird, Casavecchia & Yeung, 2009). Therefore, it might be possible to construct a portfolio with higher mean-return and comparable risk to the market (Chen, Chen & Bassett, 2007).

Even though Arnott et al. (2005) points out flaws with the market-cap indexation, they also highlight the benefits a passive investor can achieve by tracking these indices. They consider the cost aspect to be the most important, and they emphasize that it is extremely hard for active funds to outperform the market consistently net of costs. Hence, an investment in a passive fund that tracks the market should be a better investment for the average investor (Arnott et al., 2008). Other benefits in which contributes to the attractiveness of index funds are; liquidity and capacity, built-in diversification, low turnover and taxes, and that it is easy to use (Arnott et al., 2008). These factors revolve around that the index-firms are large with a high trading volume, which provides sufficient liquidity. It is also automatically rebalanced, reducing the transaction costs and management fees. Furthermore, the cap-weighted indices let the investors participate in a broad equity market, which increases the diversification. Lastly, the market-cap indices rarely realize gains, which makes the taxes lower relative to the active managers, whom are trying to buy low and sell high.

Arnott et al. (2005) constructs a fundamental index in which the portfolio outperforms the S&P 500 with an average of 197 basis points over a 43-year time period. The results are robust through time, business cycles, bull- and bear markets and through different interest rate regimes (Arnott et al., 2005). They believe that there might be several reasons for the outperformance, such as better portfolio construction, inefficiency in the stock prices, that their portfolios have additional exposure to distress risk or a combination of the mentioned (Arnott et al., 2005).

2.3 - Performance measures

2.3.1 - Jensen's Alpha

To compute the excess returns provided by the fundamental index relative to the benchmark, Arnott et al. (2005) calculate the average CAPM-betas to obtain the alpha. This performance measure is known as Jensen's Alpha, initially used to assess mutual fund performance in the context of managerial skills (Jensen, 1968). Hence, it aims to test the ability to predict excess returns compared to the market expectations adjusted for the systematic risk. Thus, if a portfolio manager has the ability to forecast returns, the alpha is positive (Jensen, 1968).

Jensen's Alpha is closely related to CAPM, implying that the market portfolio is mean-variance optimal. Hence, one should not be able to beat the market, meaning that alpha should be smaller than or equal to zero.

2.3.2 - Fama French Three-Factor Model

Arnott et al. (2005) use the Fama & French Three-Factor Model. This model takes into consideration both the size of the companies (SMB) and the relationship between the book-value and the market-value of a company's equity (HML), in addition to the market risk stated by CAPM. Both factors tend to be positive.

These two additional firm-specific components are believed to be good proxies for usual risk factors in stock returns as well as directly related to economic fundamentals. Hence, SML and HML will typically capture a substantial amount of variations in stock returns that is left unexplained by the market risk factor (Fama & French, 1992). In that manner, the mentioned are relevant variables when accessing the excess return from fundamental indexation. Applying the model to the fundamental index concept, the portfolio earns an alpha of 30 basis points over the period 1979 to 2006 (Arnott et al., 2008).

Further explanations on size (SMB)

Banz (1979) finds that the common stocks of small firms on average yields a higher risk-adjusted return compared to the common stocks of large firms. The same implications also appear in a study by Chen & Chan (1991), proposing that the additional returns are due to the fact that small firms tend to be riskier than large firms. Thus, risk premiums increase.

Further explanations on value (HML)

This factor is also commonly referred to as the Book-to-Market value of equity, typically denoted as BE/ME. Fama & French (1982) find that the firm's value, similar to the firm size, has explanatory power on stock returns. They discover that high BE/ME stocks tend to have higher returns than low BE/ME stocks (Fama French, 1996). Their evidence suggest that high BE/ME is associated with persistently lower earnings compared to firms with low BE/ME. Hence, the average HML return is a result of the additional state-variable risk of distress.

Lakonishok, Shleifer & Vishny (1994) find that value stocks yield greater returns due to suboptimal behavior, emphasizing that value investing strategies are not fundamentally riskier. They propose that the pattern persists because the future growth expectations among investors are closely related to past performance, even though stock returns are rather mean-reverting. This causes investor overreactions to good and bad news. Hence, firms with high BE/ME tend to be irrationally underpriced, in terms of the true intrinsic value, compared to popular growth stocks.

2.3.3 - Carhart Four-Factor Model

Carhart (1997) adds an additional factor to the three-factor model; Jegadeesh & Titman’s one-year momentum anomaly. The momentum factor represents the return one obtains by selling (shorting) the bottom-quantile and buying the top-quantile based on stock returns from the previous year. He finds that the four-factor model improves the average pricing error compared to the standard CAPM and the three-factor model.

Amenc, Goltz & Le Sourd (2009) argue that using the model leads to an incorporation of an equity portfolio's investment style. This cause a significantly reduction in the alpha compared to the single factor model CAPM-alpha.

2.3.4 - Sharpe Ratio

The Sharpe Ratio is a performance metric with the purpose of measuring the expected return per unit of risk for a zero-investment strategy (Sharpe, 1994). By subtracting the risk-free rate from the mean-return of the portfolio, the effect of undertaking risk can be isolated. As with other single-number performance prediction measures, the Sharpe Ratio requires a substantial set of assumptions, which at its best holds approximately. Additionally, the Sharpe Ratio does not consider correlations among other assets, which can be considered a limitation. However, it can provide valuable insights when it comes to investment-making decisions, especially among funds that represent particular markets sectors (Sharpe, 1994).

2.4 - Other relevant studies

2.4.1 - The noisy market hypothesis

The "noisy market hypothesis" is supposed to explain size-and value anomalies (Siegel, 2006). The hypothesis implies that stocks with a declining (inclining) price tends to yield greater (lower) than normal returns for no fundamental reason. In the context of a cap-weighted index, this effect will lead to an overweight in overpriced stocks and an underweight in underpriced stocks in relative terms. This will cause a return drag (Amenc et al., 2009), leaving cap-weighted indices suboptimal. Amenc et al. (2009) conclude that all characteristic-based indices, such as the fundamental index, yield greater returns than the cap-weighted S&P500 index.

2.5 - Possible shortcomings and critique

Even though Amenc et al. (2009) find that characteristic-based indices outperform the cap-weighted indices, the majority of the results are not statistically significant. Furthermore, compared to the equally-weighted index concept, most other characteristic-based indices have lower returns. Hence, Amenc et al. (2009) remain critical regarding the superiority of the fundamental index concept, as Arnott et al. (2005) state.

Jun & Malkiel (2008) argue that the recent outperformance of the fundamental indices is not a result of the strategy's ability to exploit the inefficiency in the market, but rather a reward from loading on factor tilts. This is done by increasing the exposure in Fama-French's "value" and "size" risk factors. Further, they point out that value stocks have enjoyed a significantly larger return than "growth" stocks during the past decades. It is not certain that this trend will prevail in the future as value-and growth stocks historically outperform one another (Jun & Malkiel, 2008).

Perold (2007) has a critical view on the "Noisy market hypothesis". He argues that cap-weighted indices do not skew investments towards overvalued stocks, and that the likelihood for over-/undervaluation is equal when using cap-weighting. Hence, he claims that the "return drag"-statement is wrong. Since value stocks historically yield documented higher-than-index returns, he questions whether this is due to mispricing or simply because they are riskier. In his opinion, the theory seeks to implement an active management form into a passive management framework (Perold, 2007).

Blitz & Swinkels (2008) question the active/passive management framework. A fundamental index, in contrast to a cap-weighted index, cannot be held in equilibrium by every investor. This is simply because everyone cannot over-/underweight the same stocks as the fundamental index layout proposes. Thus, some investors must actively contra trade against these stocks (Blitz & Swinkels, 2008).

Secondly, Blitz & Swinkels (2008) argue that fundamental indexation, in its nature, does not follow a passive buy-and-hold strategy as the stock weights continuously will change and require rebalancing. Reducing the rebalancing frequency is not a solution, as the resulting portfolio will deviate from its theoretical ideal (Blitz & Swinkels, 2008).

2.6 - Normal distribution and stock returns

The consensus in research is that stock returns in general do not follow a normal distribution. The distributions have “fat tails” relative to a normal distribution (Officer, 1972). However, results indicate that stock returns bear resemblance of following a normal distribution due to for example; reasonably stable stock returns on a monthly basis, and well-behaved variances (Officer, 1972). Therefore, a common assumption in modern portfolio theory is that stock returns are normally distributed (Rom & Ferguson, 1994).

3. Methodology

3.1 - Specifying data input

Arnott et al. (2005) state that creating fundamental indices requires a different set-up than simply changing the weights of a market-cap index. The rationale is that it will create an index in which weights its constituents on fundamental values, given that the constituents are the top-ranked firms in terms of market values. Thus, the result will be an index that is heavily concentrated both in fundamentals and market cap, which might leave asset-heavy companies trading at a high book-to-market ratio outside the index.

3.1.1 - Covering Europe

For comparison reasons, we choose the same 15 European countries as the MSCI Europe Index, which they believe to be a good proxy for the European market (see **Table 1** for the country constituent list).

Table 1 - List of constituents in the MSCI Europe Index Portfolio

Countries				
Austria	Finland	Ireland	Norway	Sweden
Belgium	France	Italy	Portugal	Switzerland
Denmark	Germany	Netherlands	Spain	United Kingdom

Source: https://www.msci.com/europe

3.1.2 - Stock picking

To avoid a survival bias, we include all companies in which have been present on any of the related stock exchanges during the time period. In addition, we correct for overlapping stock exchanges to remove the risk of accounting for the same company twice, which reduces the credibility of the output.

3.1.3 – The fundamental values

Arnott et al. (2005) use the following fundamental values: Book value, Cash flow, Revenues, Sales, Dividends and Total Number of Employees. In line with Arnott et al. (2005), retrieving reliable data for the latter is difficult as this is information companies do not necessarily publish. Furthermore, we change Revenues and Sales with Net Income for two reasons;

Firstly, sales and revenues typically covary in a positive manner, which might result in double effects in both directions in terms of index weighting. These figures are also easy targets for managers searching for opportunities to manipulate financial statements to paint a glossier picture of the company and to trigger bonuses etc. Hence, these factors will have a negative impact on the reliability of the numbers as well as on the index turnover. Consequently, a fair amount of a company's total index weight is dependent on a factor that might fluctuate a lot.

Secondly, sales and revenues do not actually provide the complete picture of the economic prospect. Without analyzing the measures in light of its respective costs, high figures are of limited worth if the bottom line is continuously red. On the contrary, Net Income subtracted for dividends on preferred stocks will provide a solid idea of earnings in which accrues to common shareholders.

3.2 – Modeling

3.2.1 - Fundamental index construction

Following Arnott et al. (2005), we use five year trailing averages for all fundamentals expect for Book Value, which we keep as a single-year metric. The rationale for using five-year trailing averages is to smoothen out yearly fluctuations to keep the stock weights at a steadier level, reducing the magnitude of index rebalancing. As a five-year data history for certain periods are unobtainable, we average the maximum coherent number of observations.

Furthermore, we add these four fundamental values together using equal weights, subject to a couple of conditions to qualify for being an index constituent. Firstly, all companies are required to obtain values on all fundamentals except for dividends. Arnott et al. (2005) find that being a non-dividend-paying firm does not imply weak output in the other fundamentals, and that dividend payout policy can deviate solely for tax reasons. Hence, the fundamentals are included by equal proportions, 0.25 and 0.33, per fundamental for dividend-payers and non-dividend-payers respectively. To decide upon the index weight for each stock, we use the following formula:

$$w_i = \frac{FV_i}{\sum_{i=1}^{N} FV_i}$$

Where:
w_i = the weight of the single firm, i, in the index
FV_i = the fundamental value of the single firm, i

As for the second condition, all companies incorporated into the index have to be tradable. Thus, we only include companies that have both start- and end year prices to calculate returns. We implement this condition mainly because Datastream does not always differentiates between companies that goes off listing, bankrupt or simply that the prices are not available. It is left unclear how Arnott et al. (2005) deal with this aspect, and our results can potentially suffer from the survival bias on an annual basis in which is a consequence of the condition. However, our data indicate that the missing prices mainly is an issue among companies of low significance for our indices. Hence, we reckon that the issue is of limited magnitude.

3.2.2 - Index Performance

To determine company returns, we use the differences in the Total Return Index for each company for the respective year. We calculate the index return by multiplying the company’s index weight with its return the respective year.

An important notation regarding the index returns is that they are quoted in U.S. dollars, although Euros as a base currency is preferable. The rationale is that our benchmark, MSCI Europe, only has returns quoted in Euro from 1998, while returns quoted in USD are obtainable for an additional decade. Furthermore, the Fama & French factors are also quoted in USD. Hence, the returns are affected by exchange rate development and fluctuations.

3.2.3 - Rebalancing and Transaction costs

In line with the fundamental indexation method by Arnott et al. (2005), we opt for annual rebalancing at the end of each year. Arnott et al. (2005) find that more frequent rebalancing, such as monthly, quarterly or semiannually, only increase turnover without providing sufficient value added. Our own tests show that the fundamental values in general are quoted on a yearly basis, which substantiates that more frequent rebalancing seems pointless.

Passive investing typically conforms with low management fees, but it is still relevant to include transaction costs in a real life perspective. This will provide more accurate return outputs as these fees will accumulate and become more significant over time. Arnott et al. (2005) suggest to leave them out of the equation, as it is common practice among commercial cap-weighted indices, as well as within research. Thus, including transaction costs seem counterintuitive as we compare our indices against other commercial indices, whereas transaction costs create noise in the output. In addition, to determine transaction costs with any precision might be difficult as the index constituents are exposed to different spread costs, as well as the impact costs when buying and selling.

3.3 - Reference portfolios

3.3.1 – The benchmark index

The MSCI Europe Index aims to cover approximately 85% of the free float-adjusted market capitalization in the developed part of Europe (MSCI, 2018). Furthermore, the index focuses on liquidity, investability and replicability and it is re-weighted quarterly; February, May, August and November. As of that, we suggest that it is rational to use the same strategy on an annual basis when deciding the number of participating constituents in our fundamental index. Hence, we include the top 85% companies, weighted by fundamentals, to be a part of the index each year. Complementary information from 2015 and 2016 for the MSCI Europe Index reveals only minor deviations in number of constituents between the indices.

3.3.2 - Cap-weighted reference indices

For benchmarking purposes, we use a cap-weighted reference portfolio with the same framework as the MSCI Europe Index. By creating a reference portfolio, it is possible to make direct comparisons unaffected by float, subjective selection or market impact (Arnott et al., 2005). Implementing fundamental values change the data output as these values are not obtainable for all tradable and listed companies. Thus, some companies cannot be considered as a part of the total population when we construct the fundamental indices. By using the exact same population sample when constructing the reference portfolio, we bypass the potential problem of a population difference between the MSCI Europe Index and the fundamental indices. Therefore, the differences in performance will be exclusively attributable to differences in their weighting schemes.

Furthermore, we create both a cap-weighted- and a fundamental-weighted index consisting of 1,000 companies. The rationale is that adding more companies to the index will provide additional diversification by accentuating a larger set of sectors and companies.

We construct the reference portfolios using the following formula:

$$Index\ Weight\ Firm_i = \frac{Market\ Value\ Firm_i}{\sum_{i=1}^{N} Market\ Value\ Firm_i}$$

Where,

$$Market\ Value\ Firm_i = Common\ Shares\ Firm_i \times Share\ Price\ Firm_i$$

3.3.3 - Equal weighted index

We construct an equal-weighted index, assigning all the companies in our market-cap reference portfolio the same weights in the given period. An equal-weighted index reference portfolio can provide useful information whether fundamental indexation can be considered a superior alternative indexation method amongst other alternative methods.

3.4 - Performance testing

3.4.1 - Sharpe Ratio

The Sharpe Ratio measures the risk reward trade-off for portfolios (Sharpe, 1994). By using this ratio, we can easily make comparisons of the risk adjusted performance between the index portfolios. We use the following formula to calculate the Sharpe Ratios:

$$Sharpe\ Ratio = \frac{R_p - R_f}{\sigma_p}$$

In addition, we want to compare the Sharpe Ratio in selected sub-periods, which can be considered to represent bull- and bear markets. We define bull-and bear states to be periods in which the index returns deviate from the previous year, both positive and negative. The consensus among financial analysts seem to be that a 20% rise or decline in the stock market classifies as bull- and bear states respectively (Jansen & Tsai, 2010). To capture the full effect of the sudden drops and spikes, we include the prior- and following year in the calculations.

3.4.2 - Tracking Error

The Tracking Error is commonly used to assess if and how much a given portfolio consistently deviates from a benchmark portfolio. Hence, applying this measure throughout the research period can provide valuable insight about the fundamental indexation's over-or underperformance relative to the reference portfolios. A Tracking Error different from zero will imply that the indices take on different "bets". We calculate the Tracking Error using the following formula:

$$Tracking\ Error = \sqrt{\frac{\sum_{i=1}^{N}(R_{Portfolio} - R_{Reference})^2}{N-1}}$$

We split the overall Tracking Error period into bull and bear sub-periods. To obtain the sub-period Tracking Errors, we calculate the standard deviation of the excess return/loss in the specified time interval.

To search for generalizable patterns through different market states, we average the bull-and bear sub-periods separately for both Sharpe Ratios and Tracking Errors.

3.4.3 - Preparing data for empirical analysis

To run empirical tests on the performance of the indices, we need to check certain properties of the data. See **Exhibit 2** for the actual results.

Stationarity

If a process is non-stationary, it can potentially influence behavior and properties. For example, the persistence of shocks might be infinite, and a non-stationary series will potentially provide "t-ratios" in which do not follow a t-distribution. Hence, hypothesis tests of the regression parameters might be invalid. We run the Augmented Dickey-Fuller test, which checks if a unit-root is present in a time series. The full hypothesis test is as follows:

H_0: A unit root is present, the series is nonstationary

H_A: The series is stationary

Issues of independence

Issues of independence, such as autocorrelation, occurs when the error term of the series correlate with each other over different time periods. To check for autocorrelation, we run a Durbin-Watson test and a Breusch-Godfrey test, both with the "small option" in Stata as we have a limited number of observations. The hypothesis in both tests is as follows:

H_0: No serial correlation

H_A: Serial correlation

Heteroscedasticity

Ordinary Least Squares (OLS) assumes that the error terms are independently and identically distributed. The regression analysis assumes that the variances do not vary with the effect of being modeled, and it will break the OLS criterions if they do. To test for heteroscedasticity, we run a White test in which is a test that determines whether the variance is constant or not. The hypothesis is as follows:

H_0: Homoscedasticity

H_A: Unrestricted hetroscedasticity

Using robust standard errors will relax the assumptions and the results will be more trustworthy.

Multicollinearity

Multicollinearity issues occur when the explanatory variables highly correlate with each other. When the degree of multicollinearity,

increases, the regression model estimates of the coefficients become unstable with highly inflated standard deviation. To test for this, we apply the "Variance Inflation Factor" (VIF) in Stata. The general rule of thumb is that variables with a VIF higher than 10 shows a strong indication of being a linear combination of other independent variables (O'Brien, 2007).

3.4.4 - Empirical tests

Jensen's Alpha

In the literature review, we define Jensen's Alpha as the excess return a portfolio generates relative to a benchmark portfolio, adjusted for systematic risk. Arnott et al. (2005) apply the framework as an empirical measure, and the model is written as follows:

$$\alpha = R_p - \left[R_f + (R_m - R_f)\beta_p\right]$$

From the regression we conduct the following hypothesis test:

H_0: $\alpha = 0$

H_A: $\alpha \neq 0$

An alpha that is not equal to zero indicates that the portfolio performs either better or worse than the benchmark. Since we exclusively care about excess returns, we only consider positive values as relevant.

Carhart Four-Factor Model

By using the Carhart Four-Factor Model, additional variation in stock returns that is unexplained by the market risk factor will be taken into consideration (Fama & French, 1992). The regression model can be written as follows:

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_{M,t}\left(R_{M,t} - R_{f,t}\right) + \beta_{SMB,t}SMB + \beta_{HML,t}HML + \beta_{MOM,t}MOM + \varepsilon_{i,t}$$

From the regression we conduct the following hypothesis test:

H_0: $\alpha = 0$

H_A: $\alpha \neq 0$

The interpretation is equivalent to what is outlined in the Jensen's Alpha section.

4. Data

4.1 - Source of data

We use Thomson Reuters Datastream to obtain the data, which is a comprehensive data retrieval service containing data for all relevant countries over the 35-year time span.

4.2 - Selection of data

4.2.1 - Datastream

To construct the indices, we retrieve the following fundamental values including their respective Datastream retrieval code (all denoted in Euro);

- Net income available to common (WC01751)
- Cash flow per share, fiscal (WC05502)
- Dividends per share (WC05101)
- Book value per share (WC05476)
- Common shares outstanding (WC05301)

We retrieve Common shares outstanding as all fundamental data, except for Net income, are quoted on a "per share"-basis. Further, we opt for the "Dividends per share"-measure in which displays the actual dividends for common shareholders the past year, both ordinary and extraordinary.

To create our own reference portfolio as well as calculating the returns for all indices, we retrieve the following data (denoted in USD):

- End of year price, unpadded (P#T)
- Return Index (RI)

The "End of year price, unpadded" provides the same output as "Adjusted price, Default", except that the "unpadded" function makes sure that a company's price is only displayed as long as it is listed and tradable. This is of importance for the reliability, as the standard padded output can distort the results. According to Thomson Reuters, the price measure is the official closing price adjusted for subsequent capital actions, which becomes the default price offered on all research programs.

Thomson Reuters suggests to use the Total Return Index (RI) to measure the performance of the indices. The Return Index is adjusted for dividends received during the year in addition to other capital actions. Thus, this measure displays the actual returns obtained by holding a given stock.

4.2.2 – The Fama-French & Carhart factors

The risk factors we use to describe the returns of the indices are the excess market returns (given by the ordinary CAPM), Small minus Big market capitalization (SMB) and High book-to-market ratio Minus Low (HML). To calculate the excess returns, we use the US 1-month treasury-bill as the risk-free rate. We retrieve all factors from Kenneth R. French's data library on the homepage of Tuck School of Business at Dartmouth College.

4.2.3 - MSCI data

We retrieve the historical index returns from MSCI Europe through their own website. To ensure data reliability, we cross-check the equivalent output from

Datastream against the data published by MSCI. However, the annual lists of index portfolio constituents are unfortunately unobtainable for the time period.

4.3 - Descriptive statistics

Table 2 shows a selection of descriptive statistics for all of the indices including the actual benchmark. All the indices have higher returns than the MSCI Europe benchmark, and the non-cap weighted indices have marginally better returns than the cap-weighted reference portfolios. However, the standard deviations of the non-price based indices are slightly larger than the price-based indices.

Table 2 - Descriptive Statistics

N=31	Mean	Max	Min	Std. Dev.	Skewness	Kurosis
MSCI Europe	0.078	0.403	-0.482	0.195	-0.670	3.435
Cap. 85%	0.111	0.395	-0.432	0.191	-0.678	3.255
Cap. 1000	0.114	0.405	-0.437	0.193	-0.653	3.330
Fundamental 85%	0.125	0.469	-0.459	0.210	-0.498	3.224
Fundamental 1000	0.129	0.482	-0.459	0.212	-0.432	3.249
Equal 85%	0.124	0.483	-0.450	0.208	-0.449	3.238

The table reports descriptive statistics for the yearly observations of the indices. The sample period is from December 1986 through December 2016.

Both the skewness and the kurtosis indicates a slight deviation from being normally distributed, as skewness is supposed to be zero and kurtosis equal to three. However, the negative skewness is in accordance to expectations, because the European economies represented in the indices have experienced steady economic growth as well as some years of significant setbacks during the last decades. The leptokurtic tendencies indicate that extreme outcomes occurs more than one might expect in a normal distribution. This is normal in the world of stock returns as they occasionally experience extreme shocks.

Despite of the deviations from normality, we choose to assume that our data follow a normal distribution for two reasons;

Firstly, the common assumption in modern portfolio theory is that stock returns follow a normal distribution (Rom & Ferguson, 1994). Secondly, the First Known

Property of the Normal Distribution states that if the population is normally distributed, then any sample regardless of size, will be normally distributed[2].

Table 3 shows the correlation in returns between the indices. They seem to correlate almost perfectly, which is intuitive as the sample populations are close to identical.

Table 3 - Correlation Matrix Between Indices

	MSCI Europe	Cap. 1000	Cap. 85%	Fund. 1000	Fund. 85%	Equal 85%
MSCI Europe	1					
Cap. 1000	0.996	1				
Cap. 85%	0.996	0.999	1			
Fund. 1000	0.979	0.985	0.979	1		
Fund. 85%	0.983	0.987	0.983	0.999	1	
Equal 85%	0.982	0.989	0.981	0.986	0.982	1

The table reports the correlations between the indices over the entire sample period, 1986-2016

5. Empirical findings

In this part, we present and describe the different empirical findings in the light of our research questions. In the first sub-section, we determine the most suitable reference portfolio. The following sub-sections present the findings with supporting theoretical explanations.

5.1 - Reference portfolio as a proxy

To give our results validity, generating a reference portfolio that works as a good proxy for the MSCI Index is of importance.

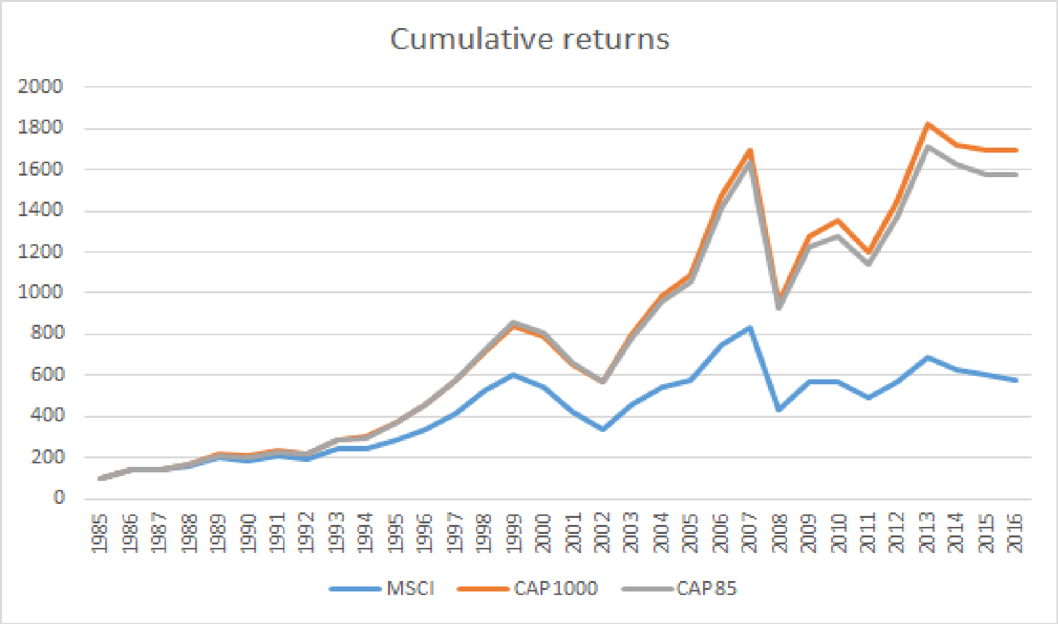
In **Table 3**, we find that both reference portfolios achieve almost perfect positive correlation with the MSCI Europe Index. This indicates that the reference portfolios have the features to be suitable proxies for the benchmark.

Figure 1 displays the cumulative returns for holding the different index portfolios for an initial investment of USD 100 in 1986. The figure shows that the reference

[2] Mordkoff, J. Toby. 2018. URL: http://www2.psychology.uiowa.edu/faculty/mordkoff/GradStats/part%201/I.07%20normal.pdf

portfolios follow the same pattern as the benchmark portfolio, although with different impact as the reference portfolios project a higher cumulative return throughout the period.

Figure 1 - Cumulative Returns 1986-2016



Emphasizing the CAP85 index as our main reference portfolio, we compare the returns to assess whether this portfolio shows similar characteristics as the benchmark portfolio during the period **(Exhibit 1)**. We find that CAP85 significantly outperforms the MSCI Europe Index by ~3,7% on an annual basis.

Moreover, the findings are useful; As in our case, if the fundamental index outperforms the cap-weighted index, this implies that it outperforms the benchmark and the results will be rather conclusive. On the opposite, if the benchmark beats the reference portfolios, the potential excess returns for the fundamental index will generate inconclusive results.

With these underlying aspects, in addition to what we discussed in **subsection 3.2.2**, we conclude that our reference portfolios are appropriate to use as proxies for the commercial and tradable benchmark, the MSCI Europe Index.

5.2 - Sharpe Ratios & Tracking Error

Table 4 - Sharpe Ratios & Tracking Errors

Portfolio/Index	Overall Sharpe Ratio	Sharpe Ratio Bull Markets	Sharpe Ratio Bear Markets	Overall Tracking Error (%)	Tracking Error Bull Markets (%)	Tracking Error Bear Markets (%)
Cap. 1000	0.386	1.828	-1.321	1.84	1.63	1.50
Cap. 85%	0.380	1.856	-1.428	1.69	1.51	1.93
Fund. 1000	0.403	1.559	-0.785	3.99	2.94	4.65
Fund. 85%	0.396	1.580	-0.781	4.15	2.98	4.99

The table reports the Sharpe Ratios and Tracking Errors over the entire sample period as well as in bull- and bear markets separately. We measure the Tracking Errors for the cap-weighted reference portfolios against the MSCI Europe benchmark, and the fundamental indices against their respective reference portfolios.

Table 4 displays the overall Sharpe Ratios for the 26-year period**.** The results indicate that the risk-adjusted returns for both fundamental indices are greater than their respective reference portfolios. These Sharpe Ratios are slightly smaller than the ones that Hemminki & Puttonen (2008) achieve in their European study. However, the study covers the period between 1996 and 2006, so they do not experience the impact of for instance the financial crisis in 2008 and the collapse of the oil price in 2015. Moreover, they use Dow Jones Euro Stoxx 50 as their benchmark (Hemminki & Puttonen, 2008). This can be significant explanatory factors for the differences in Sharpe Ratios.

Furthermore, we want to assess the Sharpe Ratios in bull- and bear markets. The Sharpe Ratio in bull-periods between 1991-2016 indicates that cap-weighted indices perform slightly better. The results change in bear-periods, as the fundamental portfolios provide significantly better results relative to its counterparts (**Table 4**).

The results present an intuitive output that is in accordance to economic theory and our expectations; The fundamental indices are in general expected to hold a value tilt relative to the cap-weighted indices, which are typically more tilted towards growth stocks. Value stocks in general are perceived to generate a greater earnings stability as well as a majority are dividend payers, which is valuable in bear markets (downturns). In bull-markets it is the other way around; Growth stocks are typically based on a rich valuation of future prospects, and these are often expected to generate returns above the market average. Hence, it is likely that these stocks perform better in periods of optimism, while value stocks often stay underrated.

Furthermore, an interesting notation regarding the Sharpe Ratios is that the fundamental indices closely follow the cap-weighted indices in upturns, while indicating a tendency of outperformance in terms of risk-adjusted returns in downturns.

Table 4 presents the overall Tracking Error of the fundamental indices versus the reference indices, and the cap-weighted indices against the MSCI Europe Index. We find that the fundamental index portfolios overall generate a significantly positive Tracking Error, implying that there is a consistent difference in excess returns. There is a tendency that the Tracking Error is significantly higher in bear states relative to bull states, indicating that the fundamental index weighting deviates more in bear states.

Arnott, Hsu & West (2008) suggest a rationale for this pattern. When growth stocks are trending upwards, cap-weighted indices have to pay a continuously increasing premium for the future growth prospect of these stocks. In that manner, cap-weighted indices undertake large “bets” on a sample of growth companies. Since the fundamental indexation method is non-price based, its weighting will be based on each company’s economic state. Given that the economic variables do not increase proportionally, the weightings between the fundamental index and the reference index will deviate more and more as the fundamental index will contra-trade the reference index’ ever larger bets in relative terms. Hence, when market corrections/crashes occur after periods of optimism, the opposing trades will be at its top level. This will result in deviating amounts of losses as the indices have different risk profiles. The results are promising, as we want our fundamental indices to perform differently when stock prices turn south, while at the same time matching the upside gains.

5.3 - Risk-adjusted regression models

We implement factor-specific regression models, which aim to capture the features that affect differences in portfolio returns.

5.3.1 - Jensen's Alpha

We run the regressions for the two fundamental indices with their respective reference portfolios as explanatory variables, both in excess of the risk free rate. **Table 5** displays the results. The alphas are positive in both regressions, but show no clear signs of statistical significance. However, there is consensus in financial academics that the "simple" one-factor model has limitations in capturing the cross-section of expected stock returns (Amenc et al., 2009). To overcome this problem, we include additional explanatory variables.

Table 5 - Jensen's Alpha Regression Output

Fundamental Indices	α	β_{MKT}	t_{α}	t_{MKT}	R^2
Fund. 85%	0.004	1.087	0.53	25.30	0.964
Fund. 1000	0.005	1.081	0.60	26.54	0.969

The table reports the output for the Jensen's Alpha Regressions for the two fundamental indices. The sample period is from December 1991 through December 2016. The market (MKT) is the excess return of the fundamental indices' respective cap-weighted reference portfolio.

5.3.2 – Fama-French & Carhart

The Fama-French & Carhart model adds three explanatory variables, in addition to the normal one-factor model. We find that both fundamental indices generate a positive alpha in the range of 1-2%, meaning that the fundamental indices obtain ~ 1-2% yearly excess return relative to the reference portfolios from 1991-2016 **(Table 6)**. In contrast to the insignificant alphas in the one-factor model, the alphas of the four-factor model show a substantially larger statistical significance; Both alphas for the fundamental indices are significant at a 90% confidence interval (C.I.), indicating that the results are somewhat strong.

The beta coefficients indicate that the fundamental indices have a positive exposure to both HML and SMB, which is in accordance with the findings of Arnott et al. (2005). The positive HML-coefficient suggests the presence of a value tilt, while a positive SMB-coefficient indicates a tilt towards small-cap stocks. Hence, there is evidence that the fundamental index portfolios undertake additional systematic risk relative to the cap-weighted index portfolios.

Further, the slightly negative exposure towards the WML suggests that the fundamental indices trades opposite to momentum strategies. The fundamental portfolios will rather "sell" winners if the firm's economic development does not grow proportionally with the share price relative to the cap-weighted indices (Arnott et al., 2008).

Table 6 - Fama-French-Carhart Four-Factor Model Regression Output

Indices	α	β_{MKT}	β_{HML}	β_{SMB}	β_{WML}	t_α	t_{MKT}	t_{HML}	t_{SMB}	t_{WML}	R^2
Fund. 85%	0.010	1.042	0.177	0.125	-0.096	1.87	55.64	4.84	2.28	-4.39	0.991
Fund. 1000	0.011	1.032	0.168	0.121	-0.092	1.98	57.06	4.57	2.26	-3.87	0.992
Equal 85%	0.011	1.015	0.069	0.276	-0.059	2.32	33.44	1.67	3.30	-2.73	0.985

The table reports the output for the Fama-French-Carhart Regression for the two fundamental indices and the equal-weighted index. The sample period is from December 1991 through December 2016. The market (MKT) is the excess return of the fundamental indices' respective cap-weighted reference portfolios, and the Cap. 85% is the refernence portfolio for the Equal 85% portfolio.

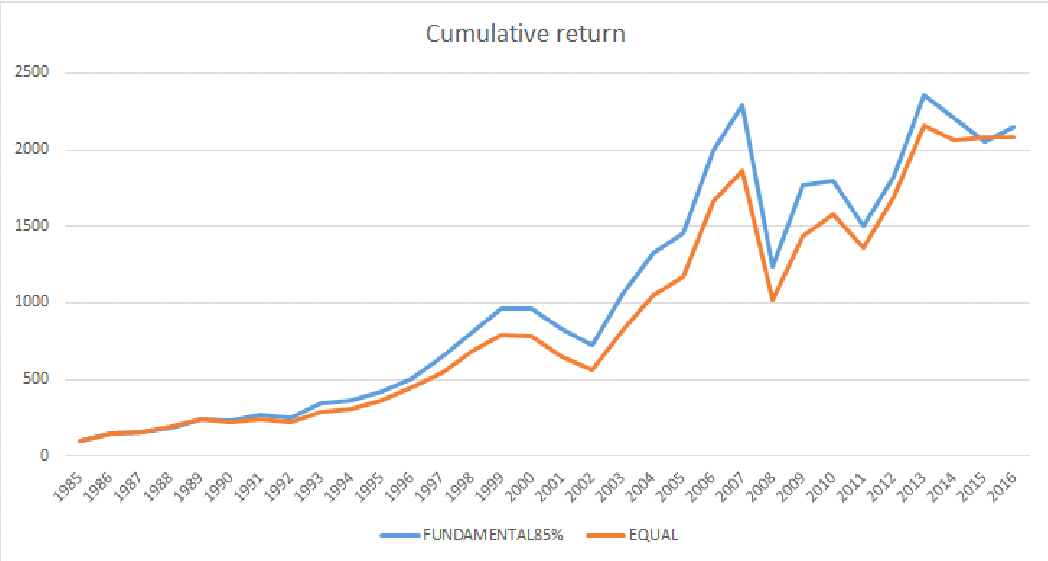
Amenc et al. (2009) suggest that by using the Fama-French & Carhart model, the additional risk-factors will capture more of the effects in which the single-factor model fails to explain. Hence, using the more comprehensive four-factor model enhances trustworthiness of the alphas. In their study, the alphas converge towards values insignificantly different from zero when they use a multi-factor model (Amenc et al., 2009). Our findings do not support this, as the alphas of both the fundamental indices increase when we apply the multi-factor model. As the four-factor model is more accurate when measuring systematic risk, it could indicate that implementing additional risk factors have limited explanatory power on the fundamental indices' performance.

5.4 - Equal Weighted Index

For comparison reasons, we create an equal weighted index, which is an already common index weighting methodology. As for the fundamental indices, the equal weighted index generates a positive alpha of ~1.1% over the time period **(Table 6)**. The alpha is statistically significant at a 95% C.I., which is an improvement when we compare it to the fundamental indices. The index has only a modest exposure towards the beta coefficients, WML and HML. However, the positive exposure towards the SMB factor deviates from the rest. This is in accordance to our expectations as the index assigns an equal weight to all the companies, which increase the weights of smaller companies in the index.

Overall, the equal weighted index provides a superior alpha relative to the Fundamental 85% Index, although slightly smaller than the Fundamental 1000 Index. The cumulative return follows the same pattern over the entire sample period, while being marginally lower **(Figure 2).**

Figure 2 - Cumulative Returns Fundamental 85% and Equal 85%, 1986-2016



However, as the indexation methodology provides an equal weight to all stocks, it is reasonable to believe that transaction costs will be significantly larger than the two other indexation methodologies. Further, there are possible issues regarding the feasibility due to increasing exposure towards liquidity issues as the loading in smaller stocks increase. Hence, applying this method in a real-life setting might dilute some of the actual benefits.

6. Conclusion

In this Master Thesis, we examine alternatives to the traditional cap-weighted index portfolio framework, with the objective to enhance risk-adjusted returns for the passive investor. The market price is essential in cap-weighted indices, but it is not necessarily the best estimator for true underlying value due to “noise”, such as irrational behavior and market inefficiencies (Siegel, 2006). Hence, we propose the non-price based fundamental indexation methodology as a viable substitute.

We construct two fundamental index portfolios using the four fundamental values; Book Value, Net Income, Cash Flow and Dividends. Further, we create comparable cap-weighted reference portfolios, Cap 85% and Cap 1000, which we determine to be good proxies for the MSCI Europe Index.

We find that both fundamental indices, Fundamental 85% and Fundamental 1000, outperform their respective reference portfolios by ~1.03% and ~1.1% respectively. Both results are statistically significant at a 90% C.I., which imply that the findings are somewhat strong. Additionally, the economic significance is in line with the findings of both Arnott et al. (2005) and Hemminki & Puttonen (2007), whose studies cover the US-and European market respectively. The results can be attributable to:

1. The potential price inefficiencies in which create return drags for the cap-weighted indices. This is in line with the Noise Market Hypothesis.
2. A superior index construction method that reflects the economic state rather than the market state.
3. Undertaking additional risk, which our performance measures do not take into account.
4. A combination of the above mentioned

We find that the Sharpe Ratios of the fundamental indices outperform the reference portfolios on an overall basis. Furthermore, our results indicate that the fundamental indices yield greater risk-adjusted returns in bear markets, but not in bull markets. These findings are in line with our initial expectations, as cap-weighted indices tend to have a growth tilt, whereas fundamental indices usually have a value tilt (Arnott et al., 2008). According to financial theory, growth stocks tend to outperform value stocks in bull markets, while the opposite occurs in bear markets. The spread in bear markets is significantly larger than in bull markets, which suggest an overall better performance of the fundamental indices in the two market states. This is supported by the Tracking Error in which indicates that the fundamental indices achieve a positive deviation in both market states, with a substantially larger spread in bear states. The significant spread in bear markets suggests that the fundamental indices takes on different weights relative to the market-cap.

For comparison purposes, we also construct an equally-weighted index. The results are in accordance with Amenc et al. (2009), which propose that fundamental indexation does not provide significant returns over the equal-weighted index. Additionally, the equal-weighted index generates roughly the same amount of excess returns, whereas the results are statistically significant at a 95% C.I. Therefore, this indexation method seems to be a good alternative to the fundamental index, and contributes to increase the doubt that the market cap-weighting is mean-variance optimal.

To summarize, we find that fundamental indexation generates consistent excess returns relative to cap-weighted indices. Due to the fact that our research period covers three decades of European stock returns subject to booms, bubbles, crashes and years of economic growth, we believe that the results cannot be considered as coincidental. Thus, we find it likely that these patterns will persist in the future.

However, we are careful about not being too confident in our conclusions. The rationale is mainly that there is a clear distinction between a theoretical approach and a real life application, meaning that the findings should not be interpreted uncritically. Hence, we believe it is rather unwise to promote the fundamental index methodology as superior in absolute terms. We rather emphasize that the concept has the features to be one of the mean-variance superior options relative to the cap-weighted index methodology.

7. Further research

For further research, it might be preferable to increase the number of observations. Extending the time span can reduce the impact of exposure towards short-term biases and extreme single-observations. For instance, on average, value stocks have experienced greater returns than growth stocks during recent decades (Jun & Malkiel. 2008).

Furthermore, it can be interesting to implement the fundamental indices as a tradable index fund to obtain actual performance output. As we discuss, the fundamental indices might be subject to different costs and possibly liquidity issues relative to cap-weighted indices. Hence, it is reasonable to assume that the findings in this thesis can deviate in a real-life application.

8. Bibliography

- Amenc, N., Goltz, F. & Le Sourd, V. (2009). “The performance of characteristics-based indices”. *European Financial Management*, *15(2)*, 241-278
- Arnott D. R., Hsu, J. C. & Moore, P. (2005). “Fundamental Indexation”. *Financial Analysts Journal, 61(2),* 83-99.
- Arnott, R. D., Hsu, J. C. & West, J. M. (2008). *The fundamental index - a better way to invest*. Hoboken, New Jersey: John Wiley & Sons, Inc.
- Blitz, D. & Swinkels, L. (2008). “Fundamental Indexation: An active value strategy in disguise”. *Journal of Asset Management*, *9(4)*, 264-269.
- Bodie, Z., Kane, A., Marcus, A. (2014). *Investments* (10th Edition). McGraw- Hill Education.
- Carhart, M. M. (1997). “On persistence in mutual fund performance”. *The Journal of Finance*, *52(1)*, 57-82
- Chan, K.C. & Chen, N. (1991). “Structural and Return Characteristics of Small and Large Firms”. *The Journal of Finance*, *46(4)*, 1467-1484
- Chen, C., Chen, R. & Bassett, G. W. (2007). "Fundamental indexation via smoothed cap weights.". *Journal of Banking & Finance*, *31(11),* 3486-3502.
- Fama, E. F. & French, K. R. (1992). “Common risk factors in the returns on stocks and bonds”. *The Journal of Financial Economics*, *33(1)*, 3-56.
- Fama, E. F. & French, K. R. (1996). “Multifactor Explanations of Asset Pricing Anomalies “. *The Journal of Finance, 51(1)*, 55-84.
- Fama, E. F. & French, K. R. (2004). "The Capital Asset Pricing Model: Theory and Evidence". *Journal of Economic Perspectives*, *18(3)*, 25-46.
- Hemminki, J. & Puttonen, V. (2008). ”Fundamental indexation in Europe”. *Journal of Asset Management*, *8(6),* 401-405.
- Hsu, J. (2005). “Cap-Weighted Portfolios are Sub-Optimal Portfolios”. *Journal of Investment Management*, *4(3)*.
- Hsu. J., Kalensnik, V., Little, B. (2011) “A Survey of Alternative Equity Index Strategies”. *Financial Analysts Journal*, *67(5)*.
- Jansen, D. W. (2010). “Monetary Policy and Stock Returns: Financing Constraints and Asymmetries in Bull and Bear Markets”. *Journal of Empirical Finance, 17(5),* 981-990.

- Jensen, M. C. (1968). “The Performance of Mutual Funds in the period 1945-1964”. *The journal of Finance*, *23(2),* 389-416.
- Jun, D. & Malkiel, B. G. (2008). “New paradigms in stock market indexing”. *European Financial Management*, *14(1),* 118-126.
- Lakonishok, J., Shleifer, A. & Vishny, R.W. (1994). “Contrarian Investment, Extrapolation, and Risk”. *The Journal of Finance, 49(5),* 1541-1578.
- Litzenberger, R. H. & Ramaswamy, K. (1979). “The effect of personal taxes and dividends on capital asset prices: Theory and empirical evidence”. *Journal of Financial Economics, 7(2),* 163-195.
- Malkiel, B. G. (2003). “The Efficient Market Hypothesis and its Critics”. *Journal of Economic Perspectives, 17(1),* 59-82.
- Mar, J. Bird, R., Casavecchia, L. & Yeung, D. (2009). “Fundamental Indexation: An Australian Investigation”. *Australian Journal of Management, 34(1),* 1-20.
- Mohanram, P. S. (2005). “Separating Winners from Losers among Low Book-to-Market Stocks using Financial Statement Analysis”. *Review of Accounting Studies, 10(2),* 133-170.
- Mordkoff, J. Toby. Last visited 2018. The Assumption(s) of Normality. URL: http://www2.psychology.uiowa.edu/faculty/mordkoff/GradStats/part%201/I.07%20normal.pdf
- MSCI. (2018). MSCI Europe Index. URL: https://www.msci.com/europe
- O’Brien, R. M. (2007). “A Caution Regarding Rules of Thumb for Variance Inflation Factors”. *Quality & Quantity – International Journal of Methodology, 41(5),* 673–690.
- Officer, R. R. (1972). “The Distribution of Stock Returns “. *Journal of the American Statistical Association, 67(340),* 807-812
- Perold, A. F. (2007) “Fundamentally Flawed Indexing”. *Financial Analyst Journal, 63(6),* 31-37.
- Roll, R. & Ross, S. A. (1994) “On the cross-sectional relation between expected returns and betas”. *The journal of Finance, 49(1),* 101-121.
- Rom, B. M. & Ferguson, K. W. (1994). “Post-Modern Portfolio Theory Comes of Age”. *Journal of Investing, 3(3),* 11-17.
- Siegel, J. J. (2006, Jun. 14). The noisy market hypothesis. *The Wall Street Journal*, p, A.14.

- Sharpe, W. F. (1994). "The Sharpe Ratio". *The Journal of Portfolio Management, 21(1)*, 49-58.
- Thompson, J. (2017, Dec. 27). Smart beta funds pass $1tn in assets. *Financial Times*. URL: https://www.ft.com/content/bb0d1830-e56b-11e7-8b99-0191e45377ec
- UCLA, Institute for Digital Research and Education. Last visited: 2018. Regression with Stata Chapter 2 - Regression Diagnostics. URL: https://stats.idre.ucla.edu/stata/webbooks/reg/chapter2/stata-webbooksregressionwith-statachapter-2-regression-diagnostics/
- Williams, R. (2015). Heteroskedasticity. URL: https://www3.nd.edu/~rwilliam/stats2/l25.pdf

9. Appendix

Exhibit 1 - Regression of Cap. 85% Output

Index	α	$\beta_{MSCI\ Europe}$	t_{α}	$t_{MSCI\ Europe}$	R^2
Cap. 85%	0.037	0.987	13.80	64.42	0.9941

The table reports a linear regression for the reference portfolio using MSCI Europe as the market.

Exhibit 2 - Interpretation of the Data Preparation

Stationary

The Fundamental 85% Index shows clear signs of being stationary as we reject the hypothesis for the Augmented Dickey Fuller test at any level of significance. Hence, there is no unit root present using zero lags. The reason for using zero lags is that we assume our dataset to approximately follow a normal distribution. Therefore, the observations of the dependent variable shall not be dependent on previously observations. Furthermore, to incorporate lagged variables the already quite small dataset will be shaved even more, which is not ideal.

Issues of independence

Both the Durbin-Watson and Breusch-Godfrey test results cannot reject the null given the common statistical significance level of a 95% C.I. Thus, we conclude that no autocorrelation is present.

Heteroscedasticity

We run White's test for heteroscedasticity and cannot reject the null. Thus, we conclude that the variance terms in the Fundamental 85% Index regression are heteroscedastic. To overcome the problem, we use the robust standard errors in Stata, as previously mentioned.

Multicollinearity

The results we get from the "Variance Inflation Factor"-test is that the Fama-French & Carhart factors vary between 1.07 and 1.12. The rule of thumb states that a VIF less than 10 indicates no signs of multicollinearity.

Both fundamental indices follow a similar pattern, and the differences in the tests is not enough to change the results. Therefore, the same conclusions hold for the Fundamental 1000 Index.

Regression diagnostics

By visualizing the regression data from all the different regressions in a scatter plot we can see the presence of extreme observations in which potentially can contribute to increase the skewness of the regression lines **(Exhibit 3).** As the residuals of the regression slightly follows a normal distribution as seen in the Q-Q Plot and the P-P Plot, we decide to leave the outliers in the regression **(Exhibit 4 & Exhibit 5)**.

Exhibit 3 - Scatter Plot of Indices

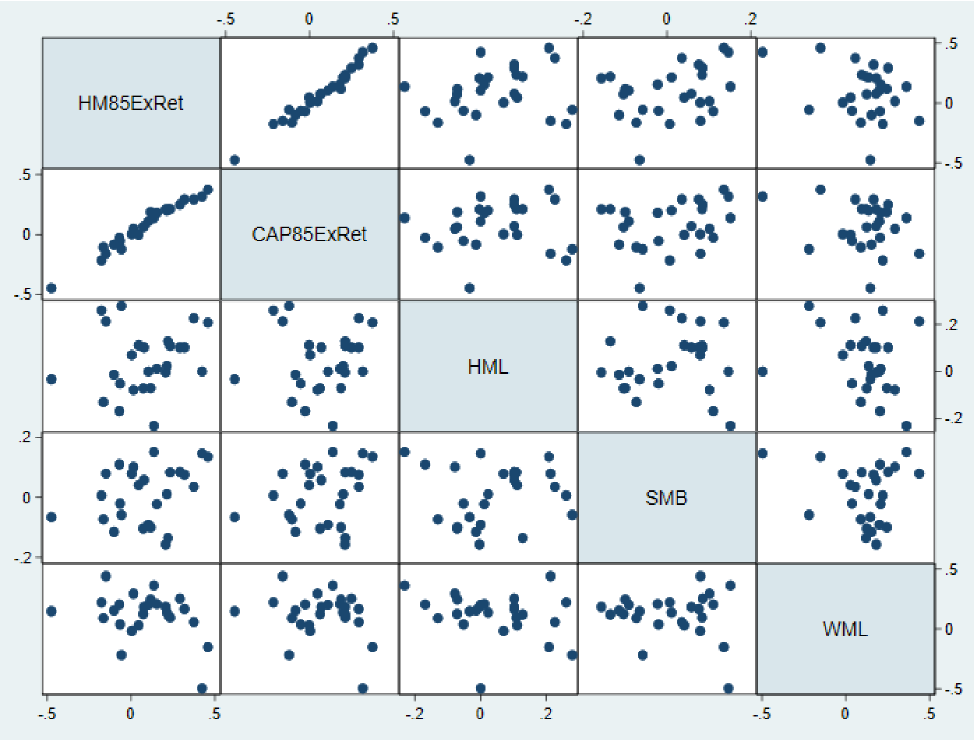


Exhibit 4 - Q-Q Plot on Residuals Fundamental85%

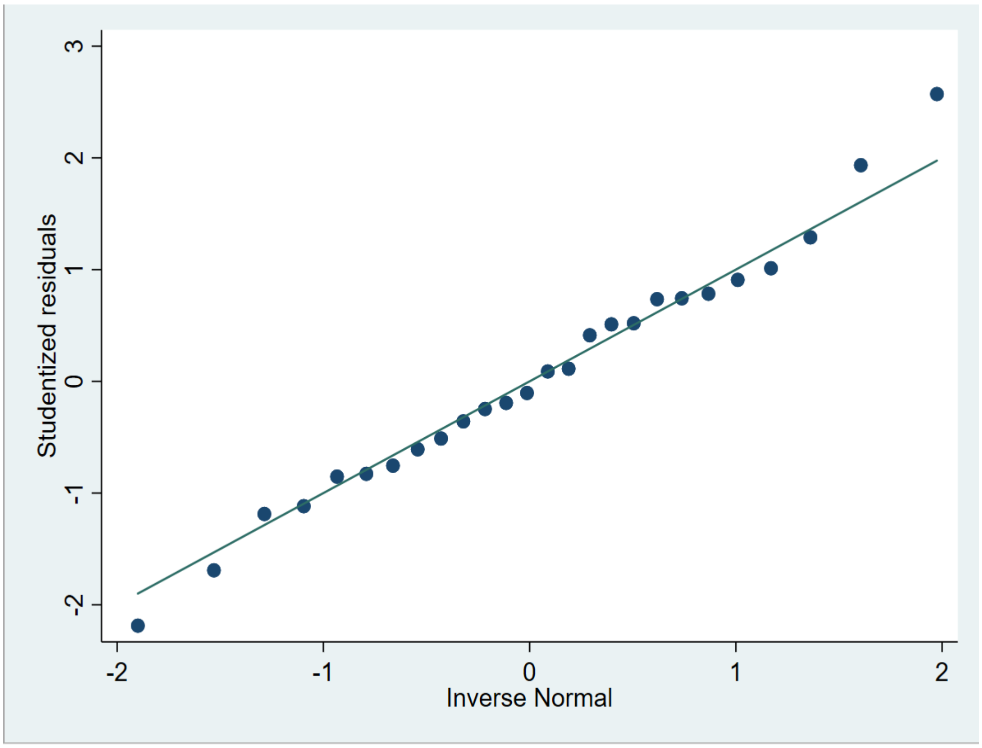


Exhibit 5 - P-P Plot on Residuals Fundamental85%