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Are Market Capital Weighted Indices Suboptimal?

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Abstract

A vast amount of money is invested in funds trying to replicate different market capitalisation weighted benchmark indices, even though finance literature and scholars deny the mean-variance efficiency of these kinds of indices. This study investigates if market imperfections inherent in market capitalisation weighted indices can be mitigated by implementing weighting by fundamental metrics and growth adjusted fundamental metrics. The results from the analysis are inconclusive, but indicate, in line with previous studies made in the US, that fundamental indexation creates excess returns and displays lower volatility than the market capitalisation weighted benchmark index. Moreover, the growth adjusted fundamental indexation showed to significantly outperform the same benchmark in both a CAPM and Fama & French framework.

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Table of Contents

1. Introduction

Money under index management is a large and growing segment. In 2003 there were already more than 2.8 trillion dollars invested in index funds, of which 54 percent were invested in the US (O'Shaughnessy, 2005). This makes index fund management one of the most important segments in asset management and it presents a large set of opportunities for both investors and fund managers. The development is in line with what classical portfolio management has suggested ever since Markowitz (1952), Sharpe (1964) and Lintner (1965) drew the outlines of what has later grown into modern portfolio theory.

We will initially give an overview of the mechanisms behind why passive index management has not been as successful as the CAPM would have implied, discuss if these shortcomings are likely to prevail and foremost examine if there could be any improvements made to the capital weighted index portfolios most often used, in order to correct for these shortcomings making index portfolios the holy grail of investing that it was once made out to be.

Had the implications of the CAPM been fully accepted and adopted by investors we would have expected the amount invested in passive index management to be even more substantial. In more recent years alternative methods of defining a more efficient index have been put in use. In this paper we use an alternative approach for index creation, derived from Fundamental Indexation, a methodology developed by the American research firm Research Affiliates®. We have also expanded their methodology, from using solely company fundamentals, to also take into account the growth of the metric, in this case Net Income.

1.1 Purpose and contribution

We aim to examine whether or not one can obtain a more efficient portfolio over time than just holding a capital weighted benchmark index. While similar groundbreaking studies have been performed on the US market foremost by Research Affiliates®, there are no studies, to our knowledge, that take the growth factor of the fundamental metrics into account, neither in the US nor Europe. Previous published research primarily focuses on US markets. This study enables a comparison and investigates if taking growth of the fundamental data into consideration can create even more excess return than the classical fundamental indexation approach. We believe that exploring this fairly underdeveloped area of fund management can help develop new and more efficient fund management approaches.

1.2 Outline of the thesis

We will start with discussing the theory on which modern portfolio theory is built in *Chapter 2*, focusing on CAPM, its shortcomings and the implication of modern portfolio theory. Given that literature, we question whether or not the classical market capitalization weighted way is the best approach in defining an index, or if one by using another method can find a portfolio that is more efficient. The model used for building a new potentially improved index is defined in *Chapter 3,* followed by the hypotheses outline in *Chapter 4*. A presentation of the data and methodology is presented in *Chapter 5*. Finally, the results of the analyses are laid out and discussed in *Chapter 6* before the findings and discussions are concluded in *Chapter 7*.

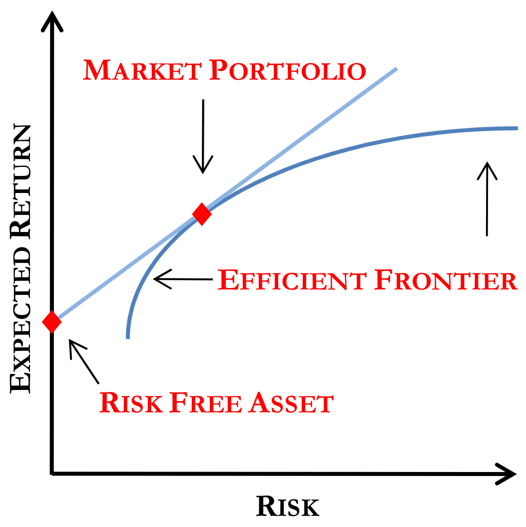
2. Theory and previous research

This section gives an overview of how the asset pricing models came about, what their strengths and weaknesses are and what these characteristics imply with regards to the capitalisation weighted indices as proxies for the market portfolio. In addition to this we summarise what has been uncovered in more recent research with regards to what can be done in order to improve on the market capitalisation weighted index portfolio as a proxy for the market portfolio.

2.1 Modern portfolio theory and mean variance efficiency

Modern Portfolio Theory (henceforth MPT) is primarily based on findings from the fifties and sixties. Markowitz (1952) was one of the pioneers and introduced mean-variance efficient portfolios as portfolios with minimised standard deviation given a specific rate of return. The findings were later on developed by Sharpe (1964) and Lintner (1965), who irrespectively of one another introduced the revolutionary Capital Asset Pricing Model (CAPM) (see *Graph I* for a graphical explanation).

Graph I



The model is built on the notion of mean-variance efficiency along with the assumptions *(i)* of no taxes, transaction costs or other illiquidities, *(ii)* that all investors are rational and have the same predictions about return, volatility and correlation with respect to the available securities, and *(iii)* that investors choose securities from the same statically set investment universe. In its first very elegant approach only long positions were considered and every investor could lend and borrow unlimited amounts at the risk-free rate. If this was true the market portfolio would consist of securities weighted by their market capitalisation and the market portfolio would be mean-variance efficient, i.e. we would not be able to find a portfolio that on average yielded a greater return without increasing the volatility of the portfolio. In fact, in the Sharpe-Linter approach, this market portfolio would be the only efficient portfolio and every investor would, given their level of risk aversion, hold a different composition of the risk-free assets and the market portfolio. One of the important conclusions that stem from the CAPM is that the cross-section of expected excess returns must have a linear relationship to the market betas with an intercept of zero. This allows us to price any available asset without having to dig very deep into its characteristics. However, what really makes the CAPM so attractive is the fact that if one can successfully identify the composition of the market portfolio, one has also identified a mean variance efficient portfolio.

2.2 CAPM critique

The CAPM model and its quantification of the risk-return relationship has led to it being empirically examined in a number of studies, which have rejected that the intercept of a regression of excess returns on the excess return of the market is zero, which would imply that the theory does not hold. The most famous critique put forward of the CAPM is that of Roll (1977), Ross (1977) and Roll and Ross (1980). The fact that the intercept in these studies is statistically different from zero led to a long and high profile academic debate about the accuracy and usefulness of the model. Another reaction to the CAPM was the development of multifactor asset pricing models such as the intertemporal capital asset pricing model (ICAPM) (Merton 1973) and the Arbitrage Pricing Theory (APT) (Ross 1976). The alternative asset pricing models although far from flawless, unveiled the shortcomings of the initial CAPM (see Fama (1993) for a thorough discussion of different multifactor asset pricing models). However, it is still frequently debated among academics what these additional factors in multifactor models really capture. As MacKinlay (1995) we divide the explanations in two categories in the upcoming discussion of our results; *(i)* the risk-based category, which assumes investor rationality and perfect markets, and the excess return (*alpha*), that is, the deviation from CAPM, is explained by either misidentifications of the market portfolio or that there are additional hidden risk factors not captured by the model (Roll 1977), and *(ii)* the non risk-based approach where the excess return is explained by the presence of irrational investors, market frictions or biases introduced in the empirical methodology. However, even the latter explanation contains some elements of risk, but they are different from those associated with perfect capital markets. In this thesis we will not take a stand on what is the source of the alpha, rather just state that it can be explained either by the risk-based category or the non risk-based category.

So, if CAPM does not have the ability to price securities correctly, is the market portfolio, constructed through market capitalisation weighting, really an efficient portfolio? Markowitz (2005) points out that by relaxing the assumption of unlimited lending and borrowing at the risk-free rate the market portfolio is not any more by definition mean-variance efficient, even though all other CAPM assumptions hold. Also, few academics would disagree on the fact that the market price of a security sometimes temporarily deviates from its true fundamental value. Black (1986) and Summers (1986) suggest that noise plays an important role in financial markets, even though it is hard to detect these temporary deviations. Black lists two explanations to why people are trading on noise, *(i)* either they think that they are trading on real information or *(ii)* they have some other incentive than getting high returns from trading, that is, they are obtaining a high utility from trading simply just because they like to trade. However, he argues that people trading on noise would be better off not trading at all. The noise created in trades of this kind will also introduce a problem for people trading on information, since it could be hard for them to tell the noise from true information. He also points out that noise trading can make the price of a security wander further and further away from its true value. This is likely to revert once information traders spot the large discrepancy. In case of smaller discrepancies, however, it is naturally harder to separate true information from noise, why reversion can not be guaranteed. Through this line of argument Black concludes, perhaps quite intuitively, that the volatility of price is higher than the volatility of value.

2.3 Advantages and disadvantages of capitalisation weighted indices

With mispricings present, the capitalization weighted market portfolio will by definition give additional weight to securities that are overvalued at the expense of undervalued ones. Thus, the portfolio manager of a passive index fund is forced to do exactly the opposite of what common sense would suggest; allocate relatively more of her portfolio to overvalued assets and relatively less to undervalued assets. As pointed out by Treynor (2005), Hsu (2006) and Hsu and Campollo (2006) this will lead to underperformance of the market capitalisation weighted portfolio even if the mispriced assets do not revert to their true values. However, the underperformance will of course be even more substantial should this reversion occur in the long run.

Despite these shortcomings, the advantages of capital weighted indices will always make them desirable to investors. First, and perhaps most important, the strategy is passive and will therefore give a broad market exposure incurring only very small trading costs. This is since rebalancing is taken care of automatically with the exception of stock repurchases, mergers and index entries and exits. The rebalancing that is needed is also very conveniently set up so that large trades will only have to take place in stocks with high liquidity since market capitalisation and liquidity are highly correlated. These characteristics are such that they allow for very large investments in index strategies, which is paramount for the strategy being successful.

2.4 Can the problem be easily fixed?

A number of different methods have been tried in order to mitigate the bias towards overvalued stocks. One of the most obvious methods is equal weighting (see for instance the Value Line Index). However, the downsides of this method are clear. Apart from incurring higher trading costs for rebalancing the index, one would also run into illiquidity problems when trading relatively large amounts in small stocks. Quite obviously one would also want larger exposure to large stocks not only to reduce trading costs, but also in order to replicate the overall market performance, i.e. not to deviate too much from the benchmark index.

2.5 Fundamental Indexation – the remedy?

A recent paper on the subject is Arnott, Hsu and Moore (2005) where the authors use another method to mitigate market imperfections. The method used is called fundamental indexation and it takes into consideration a number of different company fundamental metrics, in order to arrive at a more accurate market portfolio. The metrics studied are revenues, sales, gross dividend, book value, operating income, and total number of employers; all of these are assessed using five-year trailing averages. The strategy takes advantage of the fact that market inefficiencies make the capitalization weighted indices inefficient from a mean-variance perspective. It is built on the assumption that these inefficiencies are so large that an alternative approach of deriving the market portfolio can actually come closer to the optimal portfolio described in a CAPM setting.

However, the redefined index portfolio is clearly not the optimal market portfolio that CAPM describes. The question though is whether the market mispricing is so substantial that the new index will outperform the capitalization weighted index in a mean-variance setting, i.e. be *closer* to the true market portfolio. In their 2005 paper on the US market Arnott, Hsu and Moore show that the fundamental indices outperform the S&P500 by on average 1.65 percent annually over a 42 year period ranging from 1962 through 2003. The excess return is consistent over all time periods and macroeconomic environments for almost all of the fundamental portfolios. The results are also consistent in both bull and bear markets, even though the excess return in bear markets is significantly higher.

Evaluating the strategy it is obvious that it has a value stock bias. Thus, it is a question of whether or not one considers the excess returns to be a product of additional risk taking or if one considers it to be utilisation of market mispricing, i.e. pure alpha. It is a fact that the alpha found in a CAPM regression disappears in a Fama & French 3-factor regression. However, even though it is significantly negative, at -0.1 percent annually it is far smaller than what would be achieved with a straight forward Value-Growth strategy (Arnott, Hsu and Moore, 2005).

3. Model

In a perfectly efficient financial market price and value are always equal. However, as we have already seen there are additional factors and constraints involved in existing financial markets that interfere with this notion. It is therefore of great importance that information traders have adequate tools in order to derive proxies for the true value of firms from the information available. Examples of such valuation tools are for example multiple valuation and discounted cash flow valuation. In tools such as these fundamental values are used together with implicit or explicit assumptions about future cost structure development and the two value drivers, growth and risk, future cash flows of the firm, i.e. the growth of cash flows and the risk of these cash flows, in order to arrive at an estimated value of the firm (Koeller, Goedhart and Wessels, 2005). A lot of valuation techniques have been used over the years to create active trading strategies. In the case of redefining a passive index, building valuation models are out of the question since it would take us too close to active management. However, it is clear that the value bias created in fundamental indexation is a result of the methodology disregarding future growth and company risk, focusing only on today's fundamental metrics. We therefore introduce growth adjusted fundamental indexation, which combines fundamental indexation with the fact that growth is an important factor in value creation. We acknowledge the fact that capitalisation weighted indices introduces a mispricing bias, which severely harms overall performance. However, as already mentioned, completely neglecting the value of future growth introduces a substantial value-growth bias in the portfolio. The growth adjusted fundamental index should in theory adjust for this bias and would still not be affected by the capitalisation weighted indices' mispricing bias.

3.1 Fundamental Data

The concept of creating fundamental indices, which takes future growth and risk into account, in order to arrive at a more accurate market portfolio is tempting in theory. However, there are a number of issues, regarding the proxies for these metrics, when implementing the theory on a real data set. As previously mentioned, we focus solely on improving the index with regards to growth in this paper, since proxies for risk based on historical data are generally far from good. Still, there are a number of questions with regards to the index construction, which we will have to take a stand on.

First, have to decide on what fundamental metric to use in our calculations. We chose NI since it has proven to have the best risk-return relationship in terms of Sharpe ratio (Arnott, Hsu and Moore 2005). In addition to this, it also has a direct link to firm valuation (*Formula I*) as is not the case with for example number of employees. It has also been shown in previous studies that P/E is the multiple with the highest explanatory power with regards to future value of a security (Liu, Nissim and Thomas, 2002).

Formula I

$$P = \frac{DIV}{r_E - g} = \frac{Earnings \times (1-b)}{r_E - g} \Rightarrow P/E = \frac{1-b}{r_E - g} = \frac{1 - g/ROE}{r_E - g}$$

Second, we have to decide on a proxy for long term earnings growth. In this case we have chosen to use the earnings growth for the last five years. The time period generally covers a business cycle, why it should return a measure which is as unbiased by cyclical fluctuation as possible. We do not want to look at risk, i.e. cyclicality, why this approach is favourable. Rebalancing the index, shifting weights from cyclical to non cyclical companies and back again, over business cycles is not going to be profitable since we will be lagging both earnings and market reactions in both up and down turns.

Third, we will have to decide on how much weight we should give this factor. We chose to add a value to the fundamental metric equal to the implied incremental five year growth, based on the last five historical years. The period is once again enough to cover a business cycle. Therefore the growth adjusted fundamental index will not take into account any value generated more than five years from the index creation date. However, as past sales growth is a determinant of future sales growth for a relatively short period, i.e. growth converges quickly, (Koeller, Goedhart and Wessels, 2005) and we assume firms to be in steady state after five years, i.e. constant net margin, earnings growth will follow sales growth. Thus, any other growth measure that we could derive from historical figures at the time of the index creation, would not add any valuable information to the model. Instead one could say that judging solely from the historical growth figures, all companies' earnings in the index are expected to grow at a comparable pace, five years later, why the relative weights would remain the same as the ones we derive using our methodology.

3.2 Passive and Active Management

As a number of people are likely to question if the strategy put forward in this paper is indeed a passive strategy and not an active one, we find it necessary to address this issue when describing our model. We therefore give our view of passive and active fund management as it is clearly a subjective issue.

If we generalise fund managers there are typically two types; passive and active. Passive fund managers try to replicate the index and minimise tracking error. Active fund managers, on the other hand, try to beat a benchmark index. However, history has shown that a majority of active fund managers fail to create value through market timing and stock picking, which are the two value creators of active fund management (Malkiel, 1995), while other maintains the opposite (see for example Engström 2005). The inconclusive results introduce the question: *Why are they trying?* What it all comes down to is whether one believes in efficient markets or not. In an efficient market setting neither professionals nor small investors will, consistently, be able to separate winners from losers. Ever since MPT was created the question of whether or not markets are efficient has been a debatable subject. Given that the CAPM assumptions hold, the market portfolio is an optimal and passive portfolio. Of course, this is in line with what managers of index funds often claim; *"The only ones who believe that the market is not efficient are the Cubans, the North Koreans and the active fund managers"*.[2]

However, we have already argued that capital weighted portfolios are sub-optimal due to their construction. One could argue that the growth adjusted fundamental index is an active strategy since it differs from the market capitalization weighted index. The truth is that the difference between active and passive fund management is not a clear cut line. The index that we create is active in the sense that it does not rebalance itself, as would a true market portfolio have done. However, this is also the case for market capitalization weighted indices such as the S&P500 or the FTSE100, were active rebalancing is needed after certain events, such as mergers and acquisitions, share buy-backs and index entries or exits. Our index is on the other hand passive in another sense. It is not an attempt to beat the true market portfolio; it is an attempt to come closer to identifying it than the capitalization weighted index, why the intention is passive rather than active. This is also why we call the process redefining the index instead of trying to outperform it.

[2] Rex Sinquefield of Dimensional Fund Advisors

4. Hypotheses

We form our hypotheses based on the theoretical framework and previous studies presented in the earlier sections of this paper. Altogether we have a number of six hypotheses.

As we have already established, the market portfolio has shown not to be mean-variance efficient due to constraints imposed by the market structure (Markowitz, 2005) and the systematic error in constructing the market portfolio, which by definition overweights overvalued securities and reciprocally underweights undervalued securities, (Treynor, 2005 and Arnott, Hsu and Moore, 2005) due to the presence of mispricings such as noise (Black, 1986 and Summers, 1986). Previous research has shown that a portfolio based solely on fundamental indexation can create a more efficient portfolio from a mean variance perspective (Arnott, Hsu and Moore, 2005). However, these indices do not take the crucial factor growth into account. We therefore believe that we will be able to observe a performance superior to both a capital weighted index and a standard fundamental index in terms of Sharpe-ratio by introducing a growth factor into the equation. As it is considered stronger evidence for a theory if the issue requiring support is placed in the alternative hypothesis and the opposing result is placed in the null-hypothesis and then rejected, we therefore formed our hypothesis in a such a way that the null hypothesis would be that the difference in Sharpe ratios would be equal to zero, since this would emphasise the validity of the results to a larger extent than had we formed the hypothesis the other way around.

***H1**: A growth adjusted fundamental index will have a higher Sharpe-ratio than a capitalisation weighted benchmark index*

H_0: $Sharpe_{AFI} = Sharpe_{BM}$ H_1: $Sharpe_{AFI} > Sharpe_{BM}$

We expect the difference between the two Sharpe ratios to be statistically different from zero. The null hypothesis is therefore that the difference of the Sharpe ratios are equal to zero versus the alternative hypothesis of the growth adjusted fundamental index having a larger Sharpe ratio than the benchmark index.

***H2**: A growth adjusted fundamental index will have a higher Sharpe-ratio than a fundamental benchmark index*

H_0: $Sharpe_{AFI} = Sharpe_{FI}$ H_1: $Sharpe_{AFI} > Sharpe_{FI}$

Furthermore, fundamental indexation has proven to generate a positive alpha compared to capitalisation weighted indices in a CAPM setting (Arnott, Hsu and Moore 2005). We expect a growth adjusted fundamental index to return the same positive alpha as the fundamental index in a CAPM regression i.e. we expect the difference between the two Sharpe ratios to be statistically different from zero. The null hypothesis is that the difference in Sharpe ratios are equal to zero versus the alternative hypothesis of the growth adjusted index having a larger Sharpe ratio than the fundamental index.

***H3**: A growth adjusted fundamental index will create excess return*

***H4:** A fundamental index will create excess return*

$$H_0: \alpha_{AFI} = 0 \qquad H_1: \alpha_{AFI} > 0$$

$$H_0: \alpha_{FI} = 0 \qquad H_1: \alpha_{FI} > 0$$

Due to the composition of the indices, we expect that they will create a statistically significant alpha in a single factor CAPM regression. Furthermore, we also want to test if we can find an alpha in a multifactor setting when adding the SMB and HML factor. The null hypothesis is that the alphas are equal to zero versus the alternative hypothesis that the alphas are greater than zero.

***H5:** A growth adjusted index will on average create higher excess return over the benchmark index in bear markets than in bull markets*

***H6:** A fundamental index will on average create higher excess returns over the benchmark index in bear markets than in bull markets*

$$H_0: (\mu_{Bear\ AFI} - \mu_{Bear\ BM}) = (\mu_{Bull\ AFI} - \mu_{Bull\ BM}) \qquad H_1: (\mu_{Bear\ AFI} - \mu_{Bear\ BM}) > (\mu_{Bull\ AFI} - \mu_{Bull\ BM})$$

$$H_0: (\mu_{Bear\ FI} - \mu_{Bear\ BM}) = (\mu_{Bull\ FI} - \mu_{Bull\ BM}) \qquad H_1: (\mu_{Bear\ FI} - \mu_{Bear\ BM}) > (\mu_{Bull\ FI} - \mu_{Bull\ BM})$$

Since fundamental indices are less sensitive to temporary mispricings, i.e. are less likely to capture the upward and downward momentum of the stock market in case of a bubble, we expect the indices to have a higher excess return in recessionary than in expansionary markets. Thus, the null hypothesis is that excess returns in bear and bull markets are equal versus the alternative hypothesis of the excess return being greater in bear markets.

5. Methodology and Data

To be able to answer the hypotheses stated above we will create a growth adjusted fundamental index for the developed European markets ranging from 1979-2006. This index will then be evaluated against two different benchmark indices, a fundamental index and a capitalisation weighted index. The data needed to perform the study is supplied by MSCI.

5.1 Data Description

The data that we use is annual data for all constituents in the MSCI Europe index (See *Appendix B* for more information). We use annual Net Income (NI) data for all index constituents as a base for our index calculation. In addition to this we have yearly price data for the constituents of MSCI Europe as well as for the index itself and for the MSCI Europe Growth and MSCI Europe Value indices from 1979-2006. All share price data is net reported of dividends, but taking into account stock splits and reversed stock splits. The Value and Growth data is used to calculate a HML-factor for Europe. However, MSCI Europe Small Cap and MSCI Europe Large Cap indices were not available for our entire time period why we created an SMB-factor from the available constituents (see *Section 5.9*). We have also obtained GICS-codes (see *Section 5.11*) for the constituents in order to determine the sector belonging of the companies; this data is, however, only available from 1995 why we have limited any sector analysis to a shorter time period than for the other analyses. As the MSCI data is net of dividend reinvestment, we have used a dividend index for some of our analyses. The dividend proxy is derived from the FTSE100 index. Finally, we have used the German three months rate as a proxy for the European risk-free rate (the data for dividend yields and interest rate are shown in *Appendix E).*

5.2 Index Creation

When redefining a capitalisation weighted index it is not sufficient to look at the constituent list of an index and rearrange the constituents after different, in this case fundamental, measures. If this erroneous method is adopted a bias towards overvalued stocks would prevail since we would shift the weight within the index towards stocks with a higher fundamental values. Instead we will have to look at the entire relevant investment universe in order to include stocks with high fundamentals trading at a lower valuation than would otherwise have been left out of the index.

We define our investment universe as MSCI Europe. Should we have been completely stringent we should have included all publicly traded European securities in our investment universe. However, since the index includes the largest 432-649 constituents (differ from year to year) and covers about 60 percent of the European market capitalization it is highly unlikely that any assets outside it would have made it into our fundamental index or growth adjusted fundamental index. Should this, however, be the case the bias that we introduce is still small enough to be negligible.

5.3 The Indices

From the investment universe we create a market capitalisation weighted benchmark index, a fundamental index and a growth adjusted fundamental index, all consisting of 250 securities each. The number of securities to include is an important decision. On one hand we want a large number of constituents since this will make the index both well diversified and broad. On the other hand we want a number of securities which is substantially lower than the number of securities in our investment universe, since this limits the risk of omitting firms from the fundamental indices that should actually have been included (see previous section for explanation). All three indices are re-balanced on an annual basis on April 1 using Net Income data for the preceding year.

5.4 Market capitalisation weighted index

The market capitalisation weighted benchmark index is constructed through re-weighting of the top 250 securities in the MSCI Europe according to their market capitalisation weight in the index. This index is in our analysis used as a benchmark index for the other created indices described below.

5.5 Fundamental index

The metric that we will base our fundamental growth index and fundamental index calculations on is as previously discussed NI. We use rolling five-year averages for the NI data. This is done to minimise portfolio turnover since one-year data is more volatile. We have chosen five-year averages since we consider it a representative time period for a business cycle. Historically, using a business cycle average has shown not to dramatically affect returns, however, rendering a substantially lower portfolio turnover. (Arnott, Hsu and Moore 2005) The NI average calculated from the above methodology is then used to rank the firms and the top 250 are then given a weight according to their fraction of the total metric in order to create a fundamental benchmark index.

5.6 Growth adjusted fundamental index

To calculate the growth adjusted fundamental index we also need to take earnings growth rate of the firms into account. In order to do this we adjust the fundamental metric with respect to the growth rate over the last five years. It is done through a simple multiplication of the average fundamental value with the five-year growth factor. We recognise the fact that our exposure to either growth or value stocks is highly dependent on what weight we give the growth factor. In this case we have used a five year period to determine the growth factor, since it is coherent with our business cycle. All firms are thereafter ranked and the top 250 are given a weight according to their growth adjusted NI (for a more detailed description of the entire procedure of calculating the fundamental index and growth adjusted fundamental index see *Appendix A).*

5.7 Missing data

For cases where five years of NI data is not available we take the average of the data which is available. As previously mentioned this methodology does not severely affect returns but only portfolio turnover. With regards to the growth factor we have to be a bit more restrictive. Extrapolating a one-year growth rate to resemble a corresponding five-year rate could introduce major biases in our indices. Therefore, in such a case we use only the one year growth available. This introduces a bias towards firms that have existed for a longer period of time whereas firms with shorter track-record will be given a penalty.

Furthermore, if a company ceases to exist mid-year, due to either it being acquired or going bankrupt, it will be excluded from the analyses all together. This will introduce a number of biases in our indices compared to if this strategy was implemented in reality. However, as all indices are treated equally in this respect we conclude that the effects on the relative analyses will be minimal since: *(i)* We can not see any reason for why any of the three indices would weight acquisition or merger targets any differently than the other two, why comparison between them should not be affected. However, worth mentioning is that all three indices will lose out on any take-over premium paid to the target resulting in lower overall returns, making comparison to other indices more difficult. *(ii)* With regards to bankruptcies there could be a correlation between both low NI and low market cap and the risk of going bankrupt. Which one of these that is the strongest effect is difficult to say. However, the likelihood of any of the largest 250 companies in Europe going bankrupt is rather low.

5.8 Possible biases

The fact that all of our return data will not account for dividends will result in a lower overall return for the portfolios, the bias in-between the individual portfolios is, however, hard to determine. One could perhaps argue that mature companies often pay a higher dividend and that the fundamental index would weight these companies higher than the other two portfolios, why it would be treated unfairly by our methodology. We will use the FTSE100 annual dividend yield to proxy for dividends in the calculations where it is needed. The data series is presented in the *Appendix E*.

What could possibly introduce a shift would be the impact of different accounting rules, but as discussed earlier this will not have a material effect. However, as we use rolling five year averages this will not have a great impact on comparison over time, but may introduce a regional bias.

5.9 Risk adjusted performance

We evaluate the indices' performance by using the annually calculated weights compounded with annual price data for the securities. The risks and returns are compared both in terms of Sharpe-ratio (*Formula II*) and in CAPM-regressions (*Formula III*) where the market is defined by our 250 share benchmark index. In addition to this we also perform Fama and French 3-factor regressions (*Formula IV*) in order to add information about how much of an HML (*High-minus-Low*) and/or SMB (*Small-minus-Big*)-bias is created in the index construction.

The HML factor is derived from MSCI Europe Value and MSCI Europe Growth indices (*Formula V*). The SMB factor is in turn derived from the constituent data from the MSCI Europe Index. This procedure is used since the MSCI Europe Small Cap and MSCI Europe Large Cap did not exist for the entire time period. We therefore split the MSCI Europe in two equally large groups, with regards to market capitalisation. The cut-off point proved to almost consistently be after the 50 largest firms. We thereafter calculated the capitalisation weighted return of the two new indices and progress in the same fashion as with the HML factor (*Formula VI*).

Formula II

$$S = \frac{r_p - r_f}{\sigma_p}$$

Formula III

$$(r_p - r_f) = \alpha + \beta(r_m - r_f)$$

Formula IV

$$(r_p - r_f) = \alpha + \beta_1 (r_m - r_f) + \beta_2 SMB + \beta_3 HML$$

Formula V

$$HML = r_{MSCIEuropeValue} - r_{MSCIEuropeGrowth}$$

Formula VI

$$SMB = r_{MSCIEuropeSmall} - r_{MSCIEuropeBig}$$

5.10 Bull and Bear markets

We also evaluate the performance of the index compared to the capitalisation weighted benchmark index in both bull and bear markets. Bull market is defined as a larger than 20 percent increase on an annual basis in the MSCI Europe index, while the classification of a bear market is defined as a drop of more than ten percent, i.e. we have chosen individual years rather than periods when classifying bull and bear markets.

5.11 Sector weights

We also evaluate how the sector composition of the capitalisation weighted index differs from the growth adjusted fundamental index. Sectors have been defined according to the sector level of the GICS-system. This first level of the sector code system divides all companies in 10 different business areas. Sector weights for the different business areas are calculated annually based on market capitalisation. The different sectors are shown below in *Table I*.

Table I

Sectors	
Consumer Discretionary	Industrials
Consumer Staples	Information Technology
Energy	Materials
Financials	Telecommunication Services
Health Care	Utilities

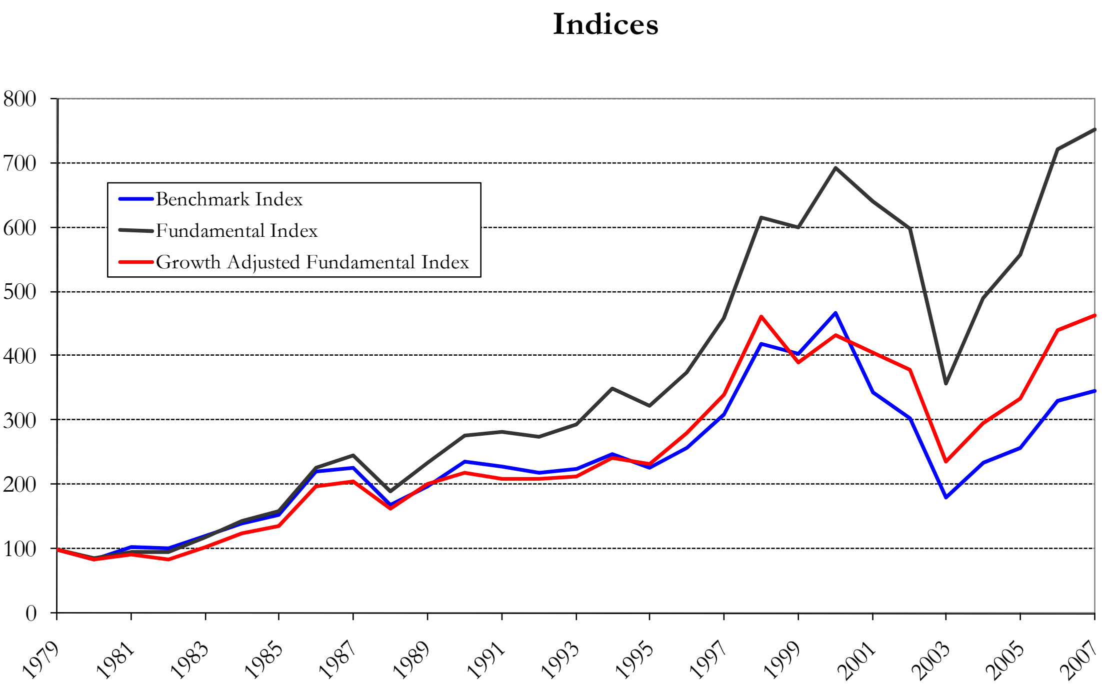
Source: MSCI

6. Results and discussion

We proceed to analyse our dataset by implementing the different analyses described in the previous section.

From a first ocular inspection of the time series in *Graph II* below, it becomes clear that both the fundamental index and the growth adjusted index on a non-risk adjusted basis outperform its benchmark over time. We can also observe that the drop around the time of the burst of the internet bubble is not as vast for the fundamental indices as for the benchmark index.

Graph II



Source: MSCI

6.1 Sharpe ratios

As mentioned above it is evident that the constructed indices have higher absolute returns than the benchmark index, but what is interesting is to see whether or not this persist when we adjust for risk, that is, if we get paid for the extra volatility we take on by holding potentially riskier assets, our indices, compared to the benchmark.

6.1.1 Sharpe ratio results

Just by looking at *Graph II* we cannot say anything about how to rank the different indices from a risk adjusted perspective. However, when comparing the return of respective indices over the risk-free rate, and divide this risk premium by the volatility of respective index we get a more comparable measure. As we see in *Table II* the fundamental index both have the lowest volatility and the highest excess return, why it also has the best Sharpe ratio. The growth adjusted index is second best and also has lower volatility and a higher excess return than the benchmark index. What this tells us basically is that, based solely on this analysis, any rational investor would choose to hold the fundamental index over any of the other indices.

When looking more closely at the data at hand, in *Table III*, we can conclude that the difference between the fundamental growth index and the benchmark index Sharpe quotes are not statistically different from zero at any viable significance level, with a t-stat of 0.22, resulting in a p-value of 0.83. The result with regards to the growth adjusted fundamental index compared to the fundamental portfolio is also inconclusive as the difference between the Sharpe ratios was not statistically different from zero at any viable level of statistical significance with a t-stat of -0.38, resulting in a p-value of 0.71 (see *Appendix D* for how to calculate the t-stats).

Table II

Number of Years	28
Risk free rate	5.5%

	Average Volatility	Average Excess Return	Average Sharpe
Benchmark Index	19.8%	5.1%	0.26
Fundamental Index	18.7%	7.8%	0.42
Fundamental Growth Adjusted Index	19.0%	5.9%	0.32

Source: MSCI

Table III

	df	S_1-S_2	σ (S_1-S_2)	T-stat (S_1-S_2)	p-value
AFI-BM	54	0.06	0.27	0.22	0.83
FI-BM	54	0.16	0.27	0.60	0.56
AFI-FI	54	-0.10	0.27	-0.38	0.71

Source: MSCI

6.1.2 Hypothesis outcome

***H1**: A growth adjusted fundamental index will have a higher Sharpe-ratio than a capitalisation weighted benchmark index*

Thus, the first hypothesis of the growth adjusted index outperforming the standard capitalisation weighted index on a risk adjusted basis was not proven correct, as we could not reject the null hypothesis of the Sharpe ratios being equal. However, the difference in Sharpe ratio (0.32 compared to 0.26) is an indication in line with our original thesis, although not statistically significant.

***H2**: A growth adjusted fundamental index will have a higher Sharpe-ratio than a fundamental benchmark index*

The regular fundamental index is the index with the highest Sharpe ratio, 0.42 compared to the Sharpe ratio of the growth adjusted index of 0.32 wherefore we have to reject the hypothesis of the growth adjusted index being superior to the fundamental index. Worth noticing is that the fundamental index has both lower volatility and higher return than the growth adjusted index, i.e. it is better both from an absolute and a risk adjusted perspective. The t-statistics of -0.38 confirms that we cannot reject the hypothesis of the Sharpe ratios being statistically different from zero at any viable significance level.

6.1.3 Sharpe ratio result discussion

Even though the evidence from this part of the study is inconclusive, we will try to analyse the indications that came out of the analysis of the absolute and risk adjusted returns, as we believe that the result of the analysis might have been another had we had a larger, monthly, data set. As concluded above our two constructed indices have both higher returns and displays lower volatility than the benchmark index, i.e. they both have higher Sharpe ratios. This was what we expected since by redefining the index we decreased the bias towards overvalued stocks. As the two indices turned out to be better than the benchmark index we therefore turn our attention to comparing the two indices to each other. It then becomes clear that both the absolute return and the Sharpe ratio are higher for the fundamental index, than for the growth adjusted fundamental index. This relationship is contrary to what we aimed at creating with the growth factor adjustment. It could however, be explained by a number of factors. If we start with the absolute returns, it is quite obvious that they are likely to be higher for an index, which takes on a higher amount of risk. This explanation would, however, not work for the Sharpe ratio, as it controls for risk in the form of the standard deviation of the returns. The argument in this case would be that the Sharpe ratio does not control for only market risk, i.e. non diversifiable risk, but also for idiosyncratic risk, i.e. diversifiable risk. To control for the relationship between the three indices in this context, we will have to analyse our regression data instead.

6.2 Regressions

In terms of regression analysis we will perform regressions in both a single factor CAPM and a multifactor Fama & French setting.

6.2.1 CAPM regressions

We will start by assessing our indices' returns using the single factor standard CAPM regression, as described in the preceding section.

6.2.1.1 Fundamental index

The results from the fundamental index are overall along the lines of expectations. The overall fit of the regression is relatively good with an adjusted R-square of 0.688, as can be seen below in *Table IV*. This should perhaps be expected since the underlying data for the two sample sets to a large extent are similar.

The beta-value is close to one (0.974) with a t-stat of 7.77, which tells us that the variable is significant at very high levels (>99.9%). The relatively broad 95% confidence interval [0.717-1.232] can be ascribed to the high standard error of 0.125, which is primarily explained by our limited number of observations (28). In this case performing the analysis on monthly data might have pinpointed our results a bit more, however due to the very limited data availability, this was not an option to us.

The alpha of 0.037 shows a t-stat of 1.58, which tells us that it is significant on an 85 percent level. That is, in a CAPM world the index is performing 3.7 percent better that the market weighted benchmark index per annum, or in other words, 3.7 percent of the excess return can not be explained by the explanatory variable in the regression. Once again the confidence interval is very wide ranging from a negative excess return of 1.1 percent to a positive excess return of 8.6 percent at a 95 percent level.

Table IV

Number of observations	28
Adj. R-square	0.6875
R-square	0.6991

Variable	Coeffcient	Std. Err	t	P > ItI	[95 % Conf. Interval]	
β	0.9742804	0.125359	7.77	0.000	0.7166012	1.23196
α	0.0374908	0.0237391	1.58	0.126	-0.0113057	0.0862873

Source: MSCI

6.2.1.2 Growth adjusted index

Regressing the growth adjusted index against the benchmark index results in an adjusted R-square of 0.599 implying a slightly less good fit than in the previous case but still relatively good (*see Table V*). The regression returns a beta-coefficient of 0.868 with a t-value of 6.43 implying a p-value of

0.000, which tells us that the coefficient is highly significant (>99.9%). The standard error is slightly higher than for the fundamental index at 0.135, but in the same range. The 95 percent confidence interval is therefore still very broad at [0.591-1.145].

The regression returns an alpha of 0.059 with a t-stat of 6.43, which implies that it is significant at a 97 percent level. This indicates that the index has outperformed the benchmark by on average 5.9 percent on a risk adjusted basis in the sample period. The confidence interval is even wider due to a higher standard error, but stays in the positive territory, due to the higher coefficient, ranging between [0.006-0.111] at a 95 percent level.

Table V

Number of observations	28
Adj. R-square	0.5993
R-square	0.6142

Variable	Coeffcient	Std. Err	t	P > ItI	[95 % Conf. Interval]	
β	0.8680263	0.1349238	6.43	0.000	0.5906864	1.145366
α	0.0585243	0.0255504	2.29	0.030	0.0060046	0.111044

Source: MSCI

6.2.2 *Fama and French regressions*

Following our first data analyses, we now add the SMB and HML factors previously described, to see if our indices somehow lever these risk factors to achieve the positive excess returns.

6.2.2.1 *Fundamental index*

When adding these two factors to our regression analysis of the fundamental index we can observe a decrease in the explanatory power of the model, returning an adjusted R-square of 0.426, compared to the previous 0.688 (*see Table VI*). Already from this analysis we could almost certainly rule out the possibility of any of the new variables being significant, however, we will look at some more indicators to see if we can draw any further conclusions from the results.

The beta coefficient increases slightly to 0.979 with a t-stat of 7.37 implying a somewhat higher significance (>99.9%). The standard error also increases to 0.133 resulting in a wider 95 percent confidence interval [0.705-1.254].

The SMB factor is negative with a very small coefficient at -0.017. The coefficient is also highly insignificant with a t-stat of -0.12 implying that it would not be significant even at a 10 percent level.

The HML factor that we previously argued should have an impact on the excess return of the fundamental index also shows a low and insignificant coefficient at 0.064 and a t-stat of 0.19 implying it would only be significant at a 15 percent level.

The alpha remains of approximately the same magnitude (0.037), only slightly down from the CAPM result. The result is, however, still insignificant with a t-stat of 1.46 implying the variable is only significant at levels below 84 percent. Also the confidence interval remains relatively the same at [-0.015-0.089].

Table VI

Number of observations	28
Adj. R-square	0.4256
R-square	0.6996

Variable	Coeffcient	Std. Err	t	P > Itl	[95 % Conf. Interval]	
β	0.9793116	0.1329288	7.37	0.000	0.70496	1.253663
α	0.0368389	0.0251785	1.46	0.156	-0.015127	0.0888048
SMB	-0.0174108	0.1479993	-0.12	0.907	-0.3228663	0.2880447
HML	0.0637602	0.3345636	0.19	0.85	-0.6267452	0.7542656

Source: MSCI

6.2.2.2 Growth adjusted index

The results are almost the same with regards to the growth adjusted fundamental index. The adjusted R-square falling to 0.309 from 0.599 *(see Table VII)*. The beta coefficient rises to 0.874 from 0.868 with the t-stat falling slightly to 6.16 from 6.43. The standard error increased slightly to 0.142 from 0.135 resulting in a broader 95 percent confidence interval of [0.581-1.167].

The alpha of 0.061 is significant at a 97 percent level and displays a 95 percent confidence interval of [0.005-0.116].

Both the SMB and the HML factor show the same pattern as for the fundamental index, with highly insignificant SMB and HML t-stats. Notable, however, is that the HML factor is negative with a magnitude of -0.016. The possible implications of this on our choice of model will be further discussed in the analysis section.

Table VII

Number of observations	28
Adj. R-square	0.3089
R-square	0.6211

Variable	Coeffcient	Std. Err	t	P > ItI	[95 % Conf. Interval]	
β	0.8741751	0.1419055	6.16	0.000	0.5812965	1.167054
α	0.0606502	0.0268788	2.26	0.033	0.005175	0.1161253
SMB	-0.0932549	0.1579937	-0.59	0.561	-0.4193378	0.2328281
HML	-0.0164549	0.3571568	-0.05	0.964	-0.7535902	0.7206804

Source: MSCI

6.2.3 *Hypothesis outcome*

***H3**: A growth adjusted fundamental index will create excess return*

It is clear that the regression results from the single factor CAPM regression creates excess return compared to the market capitalisation weighted benchmark index. The significant alpha allows us to reject our null hypothesis of the index yielding no excess return at significance levels as high as 97 percent. It has however, been argued that the CAPM model does not adequately capture the value growth bias and the potential risk factor associated with this. To control for this we performed a Fama & French multifactor regression where once again the outcome of the regression is that we can reject the null hypothesis of no excess return at a 97 percent level. We can therefore draw the conclusion that our third hypothesis, that the growth adjusted fundamental index will create excess return, is correct.

***H4:** A fundamental index will create excess return*

For the fundamental index we are not able to reject our null hypothesis of the returns being equal, neither in a CAPM nor a Fama & French model for all reasonable significance levels. This is surprising since it is contrary to what previous studies have concluded.

6.2.4 *Regression result discussion*

If we start by analysing the results from the CAPM regressions we can observe, in line with our hypotheses, a large alpha in both regressions of which one was statistically significant. We were, however, to some extent surprised by the regression results. This is due to the beta of the fundamental index being closer to that of the benchmark index than to that of the growth adjusted index. It would have been more in line with expectations to find that the relationship was the reverse. The rationale behind this is that the fundamental index is created in a way that normally limits the impact of cyclicality, or in other terms the index construction with five year rolling NI averages will more likely return a lower beta due to its more limited exposure to market mispricings. However, our suspicion beforehand was that the methodology underweighted growth stocks and levered on value stocks giving it too low returns compared to its market exposure. So when constructing the growth adjusted index we added the growth factor to counteract this bias. The intuition is therefore that the beta should not be lower for the growth adjusted fundamental index than for the fundamental index, nor should it normally be higher than for the benchmark index. As we give more weight to the growth factor the beta should, in theory, approach the benchmark index. We could, of course, end up with a higher beta than for the benchmark index, but that would only imply that we would have given more weight to the growth factor than was initially intended.

Looking at the alpha values for the indices it is also surprising to see that that the growth adjusted index has a much higher alpha. This since we are not at this stage controlling for a value stock bias. Fundamental growth indices have in previous studies shown to deliver excess returns, partially because of levering this “risk” factor. As we introduced the growth factor to counteract this bias it is perhaps somewhat surprising to see the index showing a larger alpha already in a single factor regression.

The lower beta and higher alpha implies a higher excess return at a lower risk. We are, however, still not convinced that the risk is lower in the growth adjusted index. The reason for this being the intuitive economic rationale mentioned above. We therefore remain a hesitant to draw to far reaching conclusions from the results on these rather basic regressions. The facts, however, still remain; even when we adjust for risk the outperformance compared to the benchmark index persist.

We found an alpha in the CAPM regression, but we also want to assess the indices exposure to potential additional risk factors why it is necessary to test these results further. When we expand the model we simply relax the constraint of a singe risk factor and look for other risk factors that might be influential. In this case we use factors describing book-to-market and size.

Starting off by looking at the fundamental index we expected to find a factor loading on the HML-factor, the so called value premium one obtain by investing in companies with high book-to-market values. If we compare it to the market capitalisation weighted index that is overexposed toward overvalued stocks, we have attempted to counteract this bias by taking the trailing average NI figures. Thus, we should have a smaller bias toward high book-to-market stocks than our benchmark index.

However, when examining the results from the three factor regression for the fundamental index we do find a loading on the HML-factor of about 6.4 percent per annum, but it is as mentioned earlier insignificant at all reasonable levels. Interestingly enough the factor loading on the SMB-factor is negative which indicates that one is punished for holding small cap over large cap. As our index is based on Net Income, it is not likely that we have a large exposure towards small cap. What one could argue though is that the way we constructed these factors omitted small caps for entering the index since we only are including the largest 250 firms in Europe each year. The interpretation should rather be that the smallest 50% are underperforming the largest 50% in our index. It should also be mentioned that neither the SMB-factor is significant at any reasonable level. Something that is significant though, and still persists in this extended model, is the alpha. As mentioned earlier these results could have been different had we had the possibility to obtain more frequently data than yearly observations.

For the growth adjusted index we expected a lower factor loading on the HML-factor since we are giving weight on growth, in this case companies with low, or at least lower, book-to-market. Again, the loading on the HML-factor is dependent on what weight we assign the growth factor. The larger weight we give growth, the lower the HML-factor will be. We would have hoped to see a stronger and more apparent relationship between the HML factor and the excess returns created by the fundamental index. However, in this case, our data set limits us substantially. Adding all three variables with only 28 observations will dramatically lower the probability of us finding a relationship if it actually exists. We will in this case take the negative outcome of the HML significance as a warning sign that the data used might be insufficient for the regression analysis performed, as previous studies on similar but monthly data has returned a positive and significant HML-factor loading. We still maintain though that the fundamental index counteracts a lot of the obvious flaws in market capitalisation weighted indices positive. Also there is a distinct possibility that the larger and more significant alpha shown by the growth adjusted fundamental index is due to the index building methodology mitigating one of the flaws in the fundamental methodology, i.e. the complete omission of growth as a value driver. We therefore believe that the overall results are intriguing, but do; however, recognise that there is still much work to be done in order to explain the phenomenon entirely, not the least the counter intuitive beta factors that we have still no viable explanation for.

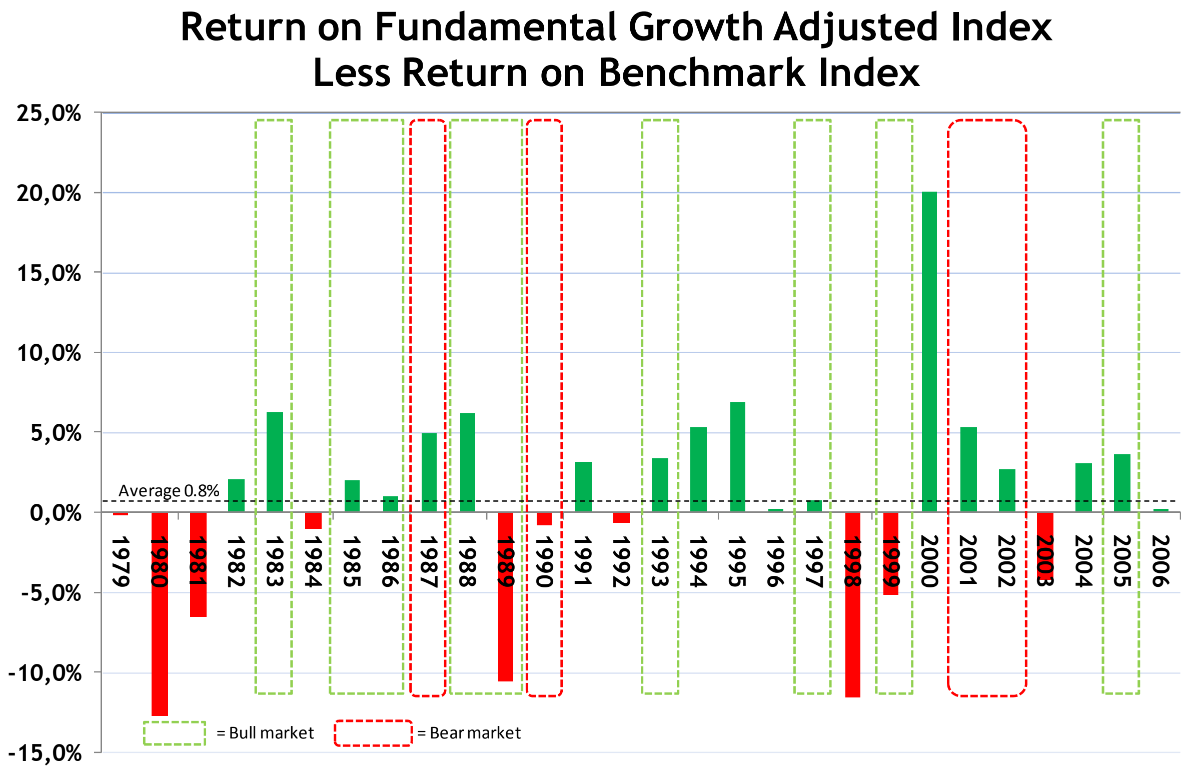
6.3 Bull and Bear markets

One of the things we wanted to test was how stable the indices were in bull and bear markets as the very idea of constructing the indices was that they were supposed to be less sensitive to large fluctuations in the market than market capitalisation weighted indices.

6.3.1 Fundamental growth index

The respective bull and bear periods are highlighted in *Graph III* where it becomes clear that the growth adjusted index outperform the benchmark index in all bearish years except for 1990. However, the results are the same for bullish periods except for 1989 where the benchmark index outperforms the growth adjusted index substantially. In *Table VIII* we quantify the results and from the results we can conclude that the average outperformance in bearish years is 3.0 percent, which is higher than both the bull years showing an average of 1.5 percent and the years not classified showing an average of 0.5 percent. Looking over the entire period the average excess return is 0.8 percent (*see Table VIII*), which is displayed by the dotted line in *Graph III*. Due to the limited number of years in the bull and bear samples it is difficult to get a good statistical precision in the estimates. When testing if the fundamental growth index' outperformance of the capitalisation weighted index is more significant in bear markets than in bull markets, we receive a t-value of 0.675. This returns a p-value of 0.52 for our 7 degrees of freedom *(see Table IX)*.

Graph III



Source: MSCI

Table VIII

Average excess return	
Bull market	1.5%
Bear market	3.0%
Not classified	0.2%
Total period	0.8%

Table IX

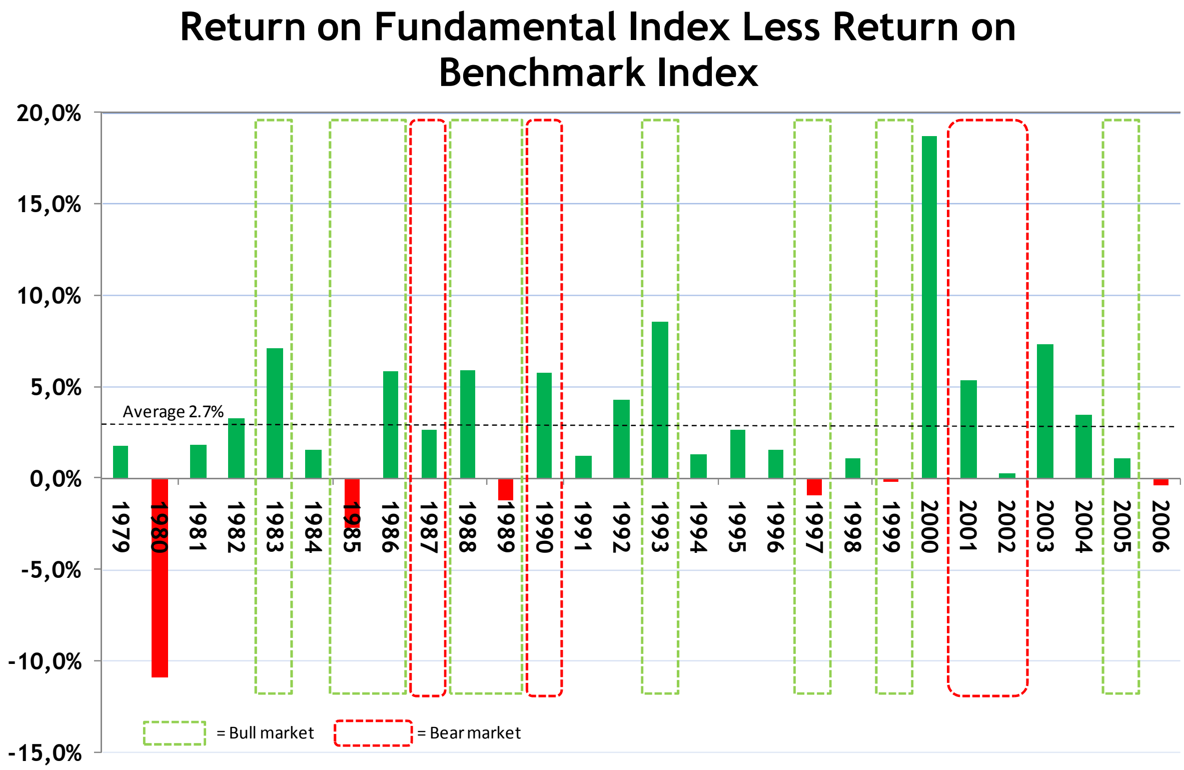
	Average excess return	Standard Deviation	t-stat	df	p-value
Bear-Bull	1.6%	2.3%	0.68	7	0.52

Source: MSCI

6.3.2 Fundamental index

In *Graph IV* below it is clear that the fundamental index outperforms the benchmark index in all bear markets resulting in an average annual excess return of 3.5 percent. The index, however, fails to create excess returns in almost half of all bull markets, but the average is still substantial at 2.4 percent. The average over the period is 2.7 percent and is shown in the graph below as a dotted line. In markets that are classified neither as bear nor bull markets the fundamental index creates an excess return of 2.6 percent on an annual basis (*see Table X*). When performing the t-test for this pair of indices we receive an even lower t-value at 0.441 which returns a p-value of 0.68 *(see Table XI)*.

Graph IV



Source: MSCI

Table X

Average excess return	
Bull market	2.4%
Bear market	3.5%
Not classified	2.6%
Total period	2.7%

Table XI

	Average excess return	Standard Deviation	t-stat	df	p-value
Bear-Bull	1.1%	2.6%	0.44	6	0.68

Source: MSCI

6.3.3 Hypothesis outcome

H5: *A growth adjusted index will on average create higher excess return over the benchmark index in bear markets than in bull markets*

The excess return over the benchmark index for the growth adjusted index in a bearish market proved to be twice as high as the return in a bullish market, which is in line with our hypothesis. However, due to the few number of years, 5 bull and 4 bear, in our sample we could not reject the null hypothesis of the returns being equal at any viable statistical significance level.

H6: *A fundamental index will on average create higher excess returns over the benchmark index in bear markets than in bull markets*

The fundamental index shows the same pattern as the growth adjusted fundamental index with higher, but insignificantly so, excess returns over the benchmark index in bear than bull markets. We can therefore not reject the null hypothesis of equal returns in this case either. What is worth noticing is that the t-value is lower for the fundamental index than for the growth adjusted index. This is a bit counter intuitive and will be further discussed below.

6.3.4 Bull and bear market discussion

The thesis of a fundamental index having a greater return than an ordinary market weighted index does not hold for our dataset. The index has and excess return of 3.5 percent in bear markets compared to the outperformance of 2.4 percent under more bullish conditions, but the results are not statistically significant (*see Table X*. Even though the results are not statistically significant we think that there is enough of an indication to discuss the difference in returns *(Table XI)*.

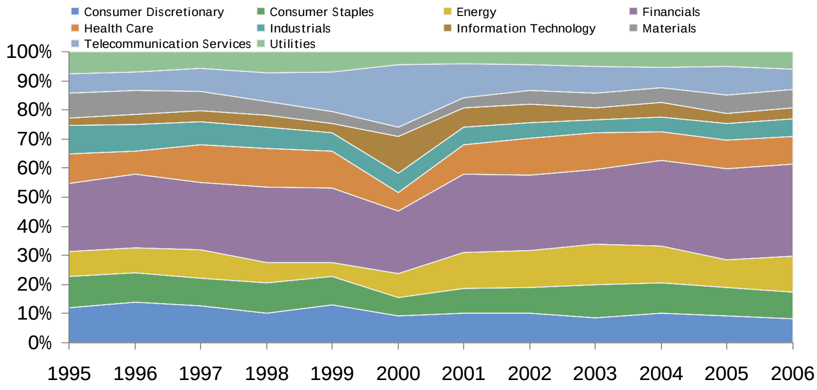
When a slump occurs it is often the case that overvalued stocks takes the hardest beating as many investors choose to realise their profits, i.e. market prices and underlying asset values are likely to converge in the long run. One of our main objectives was that we wanted to obtain an index that was more stable over time, i.e. did not drop as much in bear markets and implicitly did not gain as much in bull markets.

The fundamental index has been known to show these characteristics in earlier studies. Comparing *Graphs V-VII* we can see that the index displays a smoother sector weighting than the growth adjusted index and the market capitalisation weighted index, which is, therefore, in line with expectations. It is a fact that some years in the middle of the period studied on a sector basis, 1995-2006 showed a more rapid increase in market capitalisation than was motivated by underlying fundamentals. The absolute returns for the fundamental index is shown in *Graph VII* and summarised in *Table X*. It is a fact that the index outperforms on average in both bull and bear markets. It is, however, clear from the data that the fundamental index outperforms to a larger extent in bear markets than in neutral markets and that the excess returns of these two is larger on average than the bull market outperformance. It was our expectation that the index would outperform in bear markets as the mispricing bias of the fundamental index was not expected to be as severe.

For clarity of the underlying mechanism, we want to make a small case study, where we look at a certain period in time. As data for the different sectors is only available from 1995, the most apparent example of how the different index compositions differ is the burst of the internet bubble. In *Graph V* we can see the vast increase in the exposure towards Telecommunication and Information Technology in the benchmark index, starting around 1998 and beginning to decline dramatically around year 2000. With more frequent data points, these shifts might be even more evident. To compare this development we look closer at what happens with the composition of the growth adjusted index in the same period *(Graph VI)* it becomes apparent that the exposure towards these value inflated sectors do not occur to the same extent, why the drop in the index in retracting market conditions does not becomes as pronounced as for the benchmark index. In this aspect, we can only confirm, however not statistically significant, what previous studies of fundamental indices have found.

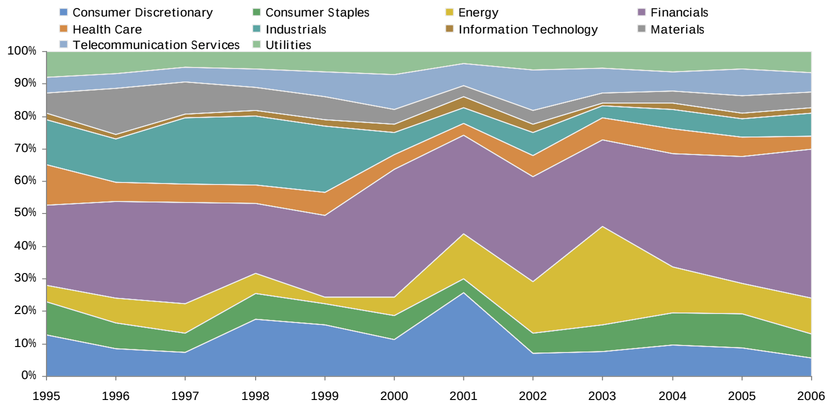
However, what is more interesting is the behaviour of the growth adjusted fundamental index under different market conditions. From *Graph III* and *Table VIII* we can conclude that the growth adjusted fundamental index alike the fundamental index on average outperforms the market capitalisation weighted benchmark in all market conditions. The outperformance in bear markets does not need a large analysis as the underlying factors are the same as for the fundamental index. The bull market outperformance is, however, more interesting and also more difficult to explain as two opposing factors that are difficult to quantify work in opposite directions; *(i)* the index will reward stocks with high growth potential, resulting in it singling out stocks that will perform well in positive market conditions and *(ii)* the methodology should, however, unlike the market capitalisation weighted benchmark index not have a tendency to ride the upside of the mispricing momentum, i.e. it should not give a lot of weight to stocks increasing in market capitalisation and subsequently diverging from their true value. Due to these opposing drivers of returns and the difficulty to quantify them, we will halt our analysis at acknowledging the existence of them and that the overall result in this case seems to weigh over in favour for the upside effect, rather than actually taking a stand on if this generally is the case.

Graph V, Benchmark index



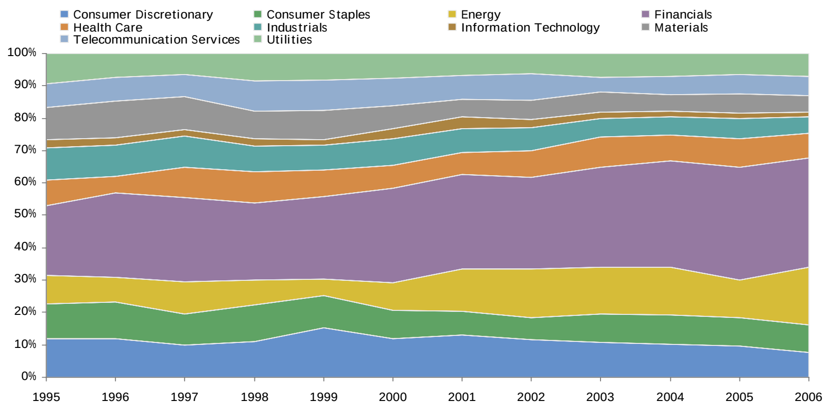
Source: MSCI

Graph VI, Fundamental Growth Adjusted Index



Source: MSCI

Graph VII, Fundamental Index



Source: MSCI

6.4 *Summary of hypothesis outcome*

Having assessed the hypothesis it becomes clear that only the third hypothesis is not rejected. That is, most of our initial beliefs cannot be confirmed by the results. Below in *Table XII* is a summary of the respective hypothesis and the outcomes.

Table XII

Hypotheses	Not Rejected	Rejected
H1 : A growth adjusted fundamental index will have a higher Sharpe-ratio than a capitalisation weighted benchmark index		✘
H2 : A growth adjusted fundamental index will have a higher Sharpe-ratio than a fundamental benchmark index		✘
H3 : A growth adjusted fundamental index will create excess return	✓	
H4: A fundamental index will create excess return		✘
H5: A growth adjusted index will on average create higher excess return over the benchmark index in bear markets than in bull markets		✘
H6: A fundamental index will on average create higher excess returns over the benchmark index in bear markets than in bull markets		✘

Source: MSCI

Note: 95% significance level, H3 and H4 consistent for both CAPM and Fama & French

7. Conclusions and final remarks

We have examined the shortcomings of the CAPM with regards to finding an optimal market portfolio and the subsequent potential underperformance of capitalization weighted indices. Previous research into the same area has found that systematic mispricings create a suboptimal weighting of constituents in these indices, and that a fundamental weighting will outperform the standard market portfolio because of these issues. Our findings cannot draw the same conclusions as our results with regards to both Sharpe ratio and regression analyses, although pointing in that direction, are not statistically significant at any viable level.

We also introduce a growth adjusted fundamental index to adjust for the value/growth bias that the fundamental indexation has been shown to introduce in previous literature. The growth adjusted index does not outperform the benchmark index at any reasonable statistical significance levels when evaluating from a Sharpe ratio perspective. It does, however, create a statistically significant excess return in both a CAPM and Fama & French setting.

It would have been truly interesting to compare the two fundamental indices and their individual performances more closely, but due to the insignificant result from the first index tests, this was not possible.

We also analysed the difference in returns in different market conditions. We found indications that the fundamental index and growth adjusted fundamental index performed better in bear markets than in bull markets, but once again the results were not statistically significant at any reasonable level.

All in all the results indicate that our initial suspicions were correct, but with proof only that the growth adjusted fundamental index performed better than the capitalization weighted benchmark index. We would like to see the results for the same tests based on monthly data instead of annual, but due to limited data availability, this was not possible. We do, however, believe that it would have at least cemented some of the indications that this study delivered.

7.1 Suggestions for further research

We have throughout the thesis pointed out that the results would have been different should we have had the opportunity with using monthly data, something that we did not have the possibility to do. Moreover, using other fundamental metrics and adjusting for growth and risk could be a way to get closer to the true market portfolio.

We have defined growth as the growth in Net Income over the trailing five year period, there are numerous different ways in defining growth, should anyone want to expand our study.

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Appendix A

Data description

The data used in this thesis is annual data for all MSCI Europe constituents as of April 1 every year, i.e. LTM Net Income and snapshot price data. For a more thorough description of the MSCI index methodology, please refer to *Appendix B*.

Index weight calculation

The index weights are calculated in three different ways. One, a normal capitalisation weighted index, one, the fundamental index as described by Arnott, Hsu and Moore (2005) and one, the growth adjusted fundamental indexation suggested in this paper.

Capitalisation weighted index

The capitalisation weighted index is created from the 250 largest constituents in the MSCI Europe index on April 1 every year. The constituents are weighted according to their free-float adjusted market capitalisation as reported by MSCI.

Fundamental index

The creation of the fundamental index is slightly more complicated. In this case the NI figures for the last twelve months, as reported by MSCI are compiled into five year rolling averages to determine each constituent's fundamental metric. The 250 largest companies with the largest fundamental metric are then singled out. Each constituent's individual weight is then decided according to its fundamental metric as a fraction of the total.

Growth adjusted fundamental index

The growth adjusted fundamental metric is derived from the previously descried fundamental metric. The difference is that every constituent's fundamental metric is adjusted with a growth multiplier. The growth multiplier is derived as the company's Net Income growth over the last five years. If this data is not available the constituent will get credit only for the growth that can be derived, i.e. if a company has only existed in the index for two years, its growth in prior years will not be taken into account. The top 250 companies with regards to their growth adjusted fundamental metric will then be included in the index and given weights according to their fundamental metric as a fraction of the total.

Constituent exclusion

Constituents have been excluded from the calculations if they for one reason or another leave the index in the year following the MSCI index creation.

Appendix B

MSCI Indices

The Morgan Stanley Capital International Inc. (MSCI) indices aspire to fulfill a number of objectives. They strive to maintain a broad and fair market representation, investability, replicability, consistency of approach, continuity, a disciplined approach towards principles, rules and guidelines, transparency, independence and objectivity. The purpose of these objectives is for the index to, amongst other things *(i)* serve as a gauge for measuring the performance of a market and serve as a benchmark in the measurement and attribution of the performance of an investment strategy and *(ii)* to be used as a research tool for a variety of purposes including in the strategic asset allocation process. The objectives and characteristics listed above in combination with MSCI's long history as an index provider makes the indices suitable benchmarks for geographical markets that are covered by the indices.

In general the indices strive to cover 85 percent of the free-float adjusted market capitalisation in each industry group and each country of the target market. The MSCI Europe covers approximately 60 percent of the total market capitalisation in the 15 European countries *(Table XIII)* that constitutes the core of European markets.

Table XIII

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

Source: MSCI

Appendix C

Fundamental Indexation Methodology

Fundamental Indexation attempts to derive a proxy for the true market index through the use of fundamental data instead of market capitalisation weights, which are assumed to be biased. The fundamental metrics are used as a gauge for the firms' true size. The metrics that have been used previously to perform this derivation are book value, trailing five-year average operating income, trailing five-year average revenues, trailing five-year average sales, trailing five year gross dividend and total employment (Arnott, Hsu, Moore 2005). In order to recreate a new improved index, all firms in the investment universe are ranked according to the different fundamental metrics. It is not sufficient to reweight the constituents of an index since this would omit firms with high fundamental metrics trading at a low valuation. With all firms in the universe arranged in the order defined by the fundamental values a new index can then be created. The largest N firms are given a weight according to their fraction of the total fundamental value. This is procedure is then conducted for each and every one of the fundamentals. In addition Arnott et al construct a composite index based on equal weighting of the fundamental weights. The rationale behind this is that no single one of the fundamental metrics will give a fair picture of the firms' fraction of the market. The most obvious bias is introduced if one solely constructs a dividend weighted index. That would introduce a substantial bias since not all firms pay dividends. However, Arnott et al maintains that the other metrics all have their individual weaknesses as well. However, all fundamental indices with the exception of the dividend index consistently outperform a market capitalisation weighted benchmark.

Appendix D

Descriptive statistics

In *Chapter VI* when performing t-tests we are using two different ways of calculating the statistics. For the Sharpe ratios we are using a paired t-test since we have equal sample sizes and different variances, where the denominator is the standard error of the difference between the two means.

Formula VII

$$t = \frac{\overline{Y}_1 - \overline{Y}_2}{s_{\bar{x}_1} - s_{\bar{x}_2}} \quad where \quad s_{\bar{x}_1} - s_{\bar{x}_2} = \sqrt{\frac{s_1^2 + s_2^2}{N}} \quad and \quad df = 2n - 2$$

Since we for the Bull and Bear analysis have unequal sample sizes and unequal variances we are using slightly different formulas for calculating the t-stat and degrees of freedom.

Formula VIII

$$t = \frac{\overline{Y}_1 - \overline{Y}_2}{s_{\bar{x}_1} - s_{\bar{x}_2}} \quad where \quad s_{\bar{x}_1} - s_{\bar{x}_2} = \sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}$$

and

Formula IX

$$df = \frac{(s_1^2 / N_1 + s_2^2 / N_2)^2}{(s_1^2 / N_1)^2 / (N_1 - 1) + (s_2^2 / N_2)^2 / (N_2 - 1)}$$

Appendix E

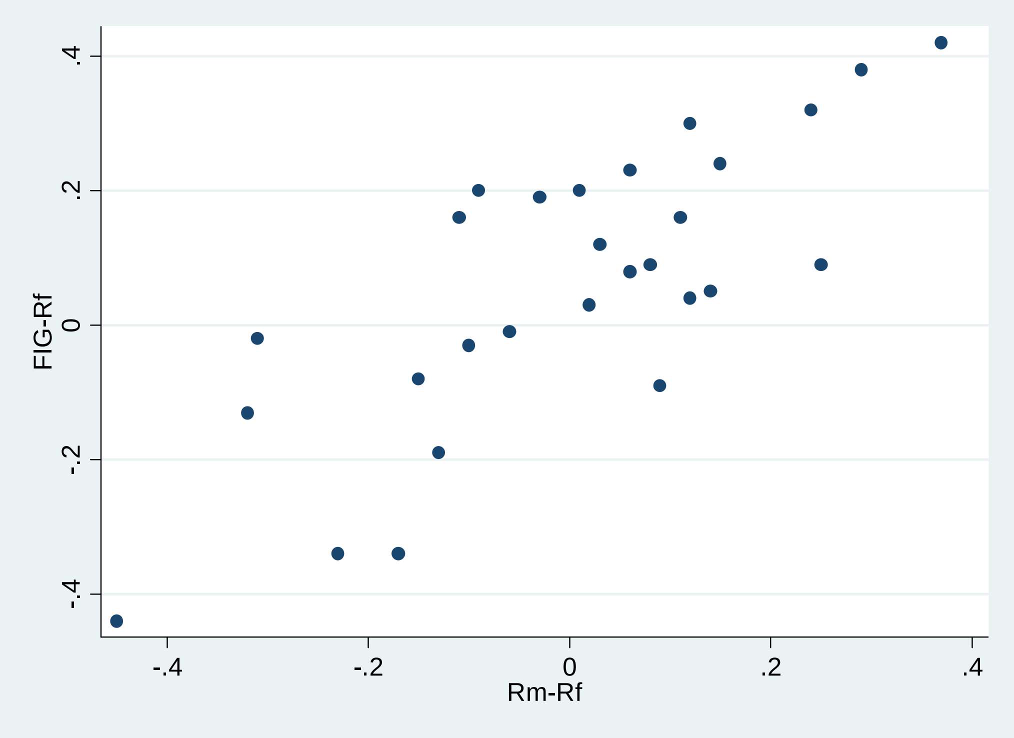
Table XIV, Data series

	MCap	Fund	GAFund	Dividend yield	Risk free rate	HML	SMB
1979	-16.1%	-14.3%	-16.3%	6.7%	9.1%	3.8%	-0.9%
1980	22.2%	11.3%	9.5%	6.2%	9.3%	-2.5%	-3.2%
1981	-1.4%	0.4%	-7.9%	6.0%	11.8%	-16.8%	-4.2%
1982	19.4%	22.7%	21.5%	5.3%	8.1%	6.1%	3.9%
1983	15.6%	22.7%	21.8%	4.7%	5.6%	-10.2%	-7.4%
1984	9.2%	10.8%	8.2%	4.5%	5.6%	13.0%	12.7%
1985	44.1%	41.5%	46.1%	4.5%	5.3%	1.7%	-2.0%
1986	3.2%	9.1%	4.2%	4.1%	4.7%	-0.8%	17.9%
1987	-25.6%	-23.0%	-20.7%	4.5%	3.9%	-3.4%	6.9%
1988	17.2%	23.1%	23.3%	4.8%	4.5%	8.4%	6.5%
1989	19.4%	18.2%	8.8%	4.3%	7.2%	5.3%	8.1%
1990	-3.7%	2.1%	-4.5%	5.4%	8.6%	0.4%	-6.1%
1991	-3.6%	-2.3%	-0.5%	5.0%	9.2%	-3.9%	-1.0%
1992	2.5%	6.8%	1.8%	4.5%	9.3%	-8.2%	-9.8%
1993	10.4%	18.9%	13.8%	3.6%	7.0%	-5.1%	3.4%
1994	-9.0%	-7.7%	-3.7%	4.1%	5.3%	18.2%	19.9%
1995	13.5%	16.2%	20.4%	3.8%	4.3%	1.6%	-6.7%
1996	20.9%	22.5%	21.1%	3.9%	3.2%	-6.6%	9.0%
1997	35.0%	34.0%	35.7%	3.3%	3.3%	-2.0%	-20.7%
1998	-3.6%	-2.6%	-15.2%	2.7%	3.4%	7.8%	-2.2%
1999	15.8%	15.6%	10.7%	2.2%	2.9%	-8.8%	-12.9%
2000	-26.4%	-7.6%	-6.3%	2.2%	4.5%	-0.3%	-51.5%
2001	-11.8%	-6.5%	-6.5%	2.7%	4.1%	16.7%	3.2%
2002	-40.4%	-40.1%	-37.8%	3.6%	3.2%	8.1%	1.4%
2003	29.4%	36.7%	25.1%	3.2%	2.2%	0.2%	-5.0%
2004	10.3%	13.8%	13.4%	3.1%	2.1%	12.0%	39.8%
2005	28.3%	29.3%	31.9%	3.0%	2.2%	6.1%	0.9%
2006	4.8%	4.4%	5.0%	2.9%	3.2%	2.9%	55.4%

Appendix F

Scatter plots

Graph VIII, Scatter plot fundamental growth index excess returns over Rf vs. Rm-Rf



Graph IX, Scatter plot fundamental index excess returns over Rf vs. Rm-Rf