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Improved Beta? A Comparison of Index-Weighting Schemes

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Table of Contents

About the Authors

Noël Amenc is professor of finance and director of EDHEC-Risk Institute. He has a masters in economics and a PhD in finance and has conducted active research in the fields of quantitative equity management, portfolio performance analysis, and active asset allocation, resulting in numerous academic and practitioner articles and books. He is a member of the editorial board of the *Journal of Portfolio Management*, associate editor of the *Journal of Alternative Investments* and a member of the scientific advisory council of the AMF (French financial regulatory authority).

Lionel Martellini is professor of finance at EDHEC Business School and scientific director of EDHEC-Risk Institute. He has graduate degrees in economics, statistics, and mathematics, as well as a PhD in finance from the University of California at Berkeley. Lionel is a member of the editorial board of the *Journal of Portfolio Management* and the *Journal of Alternative Investments*. An expert in quantitative asset management and derivatives valuation, Lionel has published widely in academic and practitioner journals and has co-authored textbooks on alternative investment strategies and fixed-income securities.

Felix Goltz is head of applied research at EDHEC-Risk Institute. He does research in empirical finance and asset allocation, with a focus on alternative investments and indexing strategies. His work has appeared in various international academic and practitioner journals and handbooks. He obtained a PhD in finance from the University of Nice Sophia-Antipolis after studying economics and business administration at the University of Bayreuth and EDHEC Business School.

Shuyang Ye is a quantitative equity analyst at EDHEC-Risk Institute. She has a Master in Management and Master in Finance double-degree from EDHEC Business School and worked as a financial analyst during the gap year. She also has a bachelor's in engineering, with first-class honors, from Communication University of China.

Executive Summary

Executive Summary

This paper analyses a set of equity indices whose aim is to improve on capitalisation weighting and thus to provide "improved beta". Four main weighting schemes are analysed: efficient indices, fundamental indices, minimum-volatility indices, and equal-weighted indices. Empirical results for US and Developed World data on these indices show that the average returns of all four alternative index construction methods are superior to those of cap-weighted equity indices in both universes and that, by several measures of risk-adjusted performance, they are likewise superior. We also analyse factor exposures of alternative weighting schemes. Only the fundamental index has a value exposure that is substantially greater than that of the equal-weighted index. Other non-cap-weighted indices such as efficient indexation and minimum volatility have value exposures that are comparable to that of equal weighting. Since the indices studied here are made up of large-cap stocks, none of these indices shows any economically meaningful bias towards small caps. Interestingly, the minimum-volatility index, similar to the cap-weighted indices, shows a negative small-cap exposure since it favours the largest stocks.

Introduction

Introduction

In recent years, many alternatives to cap-weighted equity indices have been launched. These indices are constructed using other weighting schemes, which are supposed to improve on capitalisation weighting and thus provide investors with "improved beta". The objective of this paper is to analyse the performance of a set of such indices. The results suggest that the improved beta approaches do provide benefits compared to the standard cap-weighted indices. Moreover, the weighting schemes achieve very different objectives, making good on their promise to alleviate specific problems inherent to cap-weighting.

Cap-weighted equity indices have come to dominate the market for equity index products. Standard & Poor's introduced its first cap-weighted stock index in 1923. Such indices were meant to provide information on the market's mood and direction and often serve as a bellwether for the economy. The leading economic indicator computed by the Conference Board, for example, has such a stock market index as one of its components. Stock market indices have also become a popular underlying for derivatives contracts. In 1982, the Chicago Mercantile Exchange introduced futures contracts on the S&P 500 index and, one year later, the Chicago Board of Options Exchange listed options on the same index. The predominance of cap-weighting in equity index construction is closely linked to these uses. Arguably, reflecting the performance of stocks in proportion to their market capitalisation allows a good representation of market movements. And, for the kind of short-term trading needed to replicate derivatives contracts, the liquidity inherent to cap-weighting is an advantage.

However, investors do not use equity indices only to obtain information and for short-term trading. Today, cap-weighted indices have become an integral part of the investment process of long-term investors such as pension funds, endowments, and insurance companies. The choice of an index will have a critical impact on both asset allocation and performance measurement. In particular, by creating a set of rules for selection of the asset universe, the weighting scheme of the selected assets, and periodic rebalancing, a particular index construction method will direct the risk exposures and performance of related passive investment vehicles and of active mandates managed with reference to the index.

To be useful in the investment process, an index must be more than a reliable indicator of short-term market movements. Bailey, Richard, and Tierney (1990) and Bailey (1992) point out that a chosen benchmark needs to be unambiguous, investable, measurable, appropriate, reflective of the investor's current investment views, and specified in advance. These criteria may of course be fulfilled by construction methods other than cap-weighting, leaving room for different weighting schemes.

Such alternatives have been developed in response to critiques of capitalisation weighting. About twenty years ago, papers by Ferson, Kandel, and Stambaugh (1987), Haugen and Baker (1991), and Grinold (1992) presented convincing empirical

Introduction

evidence that cap-weighted indices provide an inefficient risk/return trade-off. In addition, Ranaldo and Häberle (2007) point out that many capitalisation-weighted indices may be perceived as active investment strategies. In pursuit of a more representative weighting scheme, recently launched indices have proposed to weight stocks by firm characteristics such as earnings or book value (Arnott, Hsu and Moore, 2005; Siegel, Schwartz and Siracusano, 2007). Other indices weight stocks to achieve the highest risk/reward efficiency (Amenc *et al.*, 2010) or the lowest possible portfolio volatility (Nielsen and Aylursubramanian, 2008). Other approaches have focused on constructing maximum diversification benchmarks (Choueifaty and Coignard, 2008) or equal-risk contribution benchmarks (Maillard, Roncalli and Teiletche 2010). Rather than exploiting public information based on accounting data or risk/return computations, equal-weighted indices simply attribute an identical weight to all constituents (Dash and Loggie, 2008).

As a consequence of these developments, investors now have a wide range of weighting schemes at their disposal. A natural question is to ask how these schemes compare. In particular, these indices have very different objectives, ranging from minimising risk to improving the representation of the economy through a stock market index. They also use very different types of information to attribute weights, including risk/return data, accounting data, or even ignoring any information, as in the case of equal weighting. A detailed comparison will help investors decide which of these alternatives are most useful to them. This paper does such a comparison for both US and Developed World (henceforth *World*) equity indices that use the different weighting schemes. Among the aforementioned approaches, our analysis focuses on those approaches that have given rise to indices published by major index providers. In particular, we focus on the four following weighting schemes that have been used by the main index providers to propose alternatives to market-cap-weighted indices: efficient indices (FTSE), fundamental indices (FTSE), minimum-volatility indices (MSCI), and equal-weighted indices (S&P for US, MSCI for World). Our analysis is an update of Amenc *et al*. (2011), which analyses US indices. We analyse the same set of indices adding the more recent period and an analysis in a Developed World universe. Our performance analysis roughly covers the past decade, for which data a variety of indices is available. The paper proceeds as follows. Section one lists the indices that will be analysed and describes their construction principles. Section two reports risk and return statistics for these indices and compares them to cap-weighted indices. The third section assesses the factor exposures of the indices. The fourth reviews the turnover control methods used in indices. The final section provides the main conclusions.

Introduction

1. Available Weighting Schemes

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Investors may choose to use indices for information acquisition, for performance measurement, or as an investment vehicle. One of the key attractions of equity indexing is the transparency such indices provide. Indices are also sought for their purported ability to represent the equity market. Finally, but perhaps most importantly, equity indices are supposed to provide investors an attractive risk/reward ratio so that they can give useful guidance on investment choices.

There are a variety of systematic weighting approaches—other than weighting the stocks by their market capitalisation—that may fulfil the criteria of representativity and efficiency. It turns out, however, that the approaches usually have a focus that is on one of the two aspects. In addition, they exploit very different sources of information to reach their objectives. Cap-weighted indices and fundamental indices are mainly concerned with representativity by weighting stocks by firm characteristics, either market capitalisation or accounting characteristics. Minimum-volatility indices and efficient indices, on the other hand, exploit information in the returns data of constituent stocks, concerning either volatility and correlation (for minimum-volatility indices) or volatility, correlation, and expected returns (for efficient indexation). Equal-weighted indices are the extreme in the sense that they do not exploit any stock-specific information. Their weights can be computed simply from the number of constituent stocks in the index without any further knowledge of any characteristics of these stocks. We now turn to a detailed description of these weighting schemes and of the data sources we use to represent them.

1.1. Indices Focusing on Representativity

A focus on representativity naturally leads to indices that allocate greater weights to larger companies than to smaller companies. There are, however, two main approaches to measuring the size of a company. The cap-weighting scheme assumes that market capitalisation is the best measure for the size of a company, whereas the characteristic-based weighting scheme proposes to use more fundamental measures of company size.

Cap-weighted indices use a stock's market capitalisation (*i.e.*, the number of outstanding shares times the share price) as the weighting criterion. Each stock's weight in the index will correspond to its share of the overall market capitalisation of all stocks in the index. Such market-cap weighting is supposed to provide an accurate representation of the stock market, as more valuable firms will make up a larger share of the index. This weighting scheme is often justified by the CAPM and its central conclusion that the cap-weighted portfolio of all *available* assets in the economy will be mean-variance efficient. The major difference of cap-weighted equity indices from this theoretical market portfolio is that the available indices omit most of the assets available in the economy, as dividends on stocks account for only a small share of wealth compared to income and benefits derived from labour, non-listed businesses, social security, and private housing.

The cap-weighted indices we include in our empirical analysis are the S&P 500 index and the Russell 1000 index in the US universe, the MSCI World index and

1. Available Weighting Schemes

the FTSE All-World Developed index in the World universe. Those cap-weighted indices are made up of the largest stocks by market capitalisation. We chose these indices as they are the most widely used by investors. Rather than being weighted by market capitalisation, stocks are actually weighted by their free-float (*i.e.*, only the market capitalisation available to non-strategic investors is accounted for). This is the standard practice in cap-weighted construction of equity indices.

Fundamental-weighted indices attempt to be more representative than cap-weighted indices by introducing a different measure of firm size. Rather than being proportional to the stock's market capitalisation, the weights will be proportional to an accounting-based measure of size, such as the company's earnings or its book value. Such indices thus provide a better representation of stocks by their size as far as size can be captured by accounting measures. The idea behind such indices is not to optimise the risk/reward trade-off but to have measures of firm size more reliable than market capitalisation. Such indices may, however, improve returns compared to cap-weighted indices, since—compared to cap weighting—they will favour stocks with low price earnings ratios or high book-to-market ratios.

In our empirical analysis, we use the FTSE RAFI 1000 index and the FTSE RAFI Developed 1000 for US and World respectively. Both indices weight and select the one thousand largest stocks in their universe by a set of four characteristics measured over the past five years: dividends paid, book value, cash flows and company sales.

1.2. Indices Focusing on Efficiency

Portfolio theory suggests that when indices are used as investment benchmarks the focus should be not on representativity but on achieving the highest possible risk/reward ratio. As mentioned in the introduction, one of the key shortcomings of the cap-weighted indices is inefficiency resulting from poor diversification. Several indices have attempted to improve this dimension, while exploiting different approaches to building better diversified portfolios.

Equal-weighted indices simply attribute the same weight to each of their constituents. These indices may provide a fair representation of the stock market, as their return for a given day actually shows the average return of all stocks on this day. More importantly, perhaps, equal weighting may lead to favourable risk/reward properties, since it is a straightforward way to construct well-diversified portfolios. This diversification rule, known as naive diversification, has its origins in a recommendation, known as the one-third rule, more than fifteen hundred years old. This rule cited in the Talmud recommends dividing one's wealth into equal shares of land, business, and cash. In the case of stock market indices, it is called the 1/N rule. It recommends giving an equal weight to each of the N index constituents. However, equal weighting is an extreme view since it also means that we agree to give up deriving any form of useful information for weighting constituents, and that information on market capitalisation or other measures used to derive index weights is entirely useless.

1. Available Weighting Schemes

An equal-weighted version of the S&P 500 and the MSCI World index, which we use in our empirical analysis for US and World respectively, is computed by Standard & Poor's and MSCI. These indices are based on the same constituents as their relative cap-weighted versions but they attribute an equal weight to each of the N constituents. Each quarter, the weight of each constituent is set to 1/N.

Minimum-volatility weighting is an initial approach to building scientifically, rather than naively, diversified portfolios. The focus here is on finding the constituent weights that lead to the lowest possible portfolio volatility. To construct such an index, one need only estimate volatilities and correlations of index constituent stocks. No knowledge of expected returns is necessary.

Such a portfolio would be representative of the tangency portfolio if expected returns were identical for all stocks. It may thus represent the opportunity set of mean-variance investors in the absence of any information on differences in expected returns across stocks. In terms of risk/reward efficiency, the index focuses on lowering risk, without addressing its expected return properties.

The empirical analyses below draw on data for the MSCI Minimum Volatility Index in both universes. These indices are based on all constituents in its relative MSCI cap-weighted counterparts. The Barra portfolio optimiser is then used to find the minimum-volatility weights.

A concern with minimum variance portfolios is that they are typically heavily concentrated in the assets with the lowest volatility. The high concentration in GMV portfolios is a widely recognised issue (see Clarke, De Silva and Thorley, 2011; DeMiguel, Garlappi, Nogales and Uppal, 2009; Chan, Karceski and Lakonishok, 1999). In the end, for investors who have made the decision to move away from market-cap-weighted portfolios one could question whether replacing the concentration in the largest capitalisation stocks inherent in cap-weighting with concentration in the lowest volatility stocks addresses their concerns. A way of indirectly avoiding concentration in low volatility stocks is to penalise these stocks in the portfolio optimisation procedure.

Efficient-weighted indices aim to improve the Sharpe ratio compared to cap-weighted indices by weighting stocks by their impact on portfolio risk and reward. It can be argued that these indices provide higher welfare for investors in the mean-variance space and could thus be seen as more representative of the equity risk premium accessible in the stock market.

Efficient indices focus directly on risk/reward properties. Their greater efficiency thus results from the construction method, as long as robust parameter estimates for expected returns, correlations, and volatilities are used. These indices are different from cap-weighted, equal-weighted, or fundamentally weighted indices in that, to create an optimal portfolio, they weight constituents by quantitative information on expected returns, correlations, and volatilities.

Such a maximum Sharpe ratio approach avoids concentration in low-risk stocks

1. Available Weighting Schemes

and tries to more fully exploit the information available on correlations in the relevant equity universe.

In our empirical analysis, we use the FTSE EDHEC-Risk Efficient Index in both universes. The index weights stocks to maximise the index Sharpe ratio. To obtain parameter estimates for the stocks' return co-movements, an equity factor model is used to estimate common return drivers. To estimate the stocks' expected returns, downside risk is measured for each stock. The stock's riskiness is then used as an indicator of its expected returns. Portfolio optimisation is conducted on all mid- and large-cap stocks in the FTSE US index for US and on all constituent securities in the FTSE All-World Developed index for World.

1. Available Weighting Schemes

2. Comparing Risk and Return

2. Comparing Risk and Return

Over the period for which data is available, we first assess the return and risk properties of all the indices. We compute average returns, various risk measures, and risk-adjusted return ratios. Our concern is mainly with the four non-cap-weighted indices and their comparison with two cap-weighted indices in each universe, the S&P 500 index[1] and the Russell 1000 index in US and the MSCI World index and the FTSE All-World Developed index in World. For US portfolios, the paper looks at the period from 8 January 1999 to 26 August 2011, and for World portfolios from 20 December 2002 to 26 August 2011. This period is chosen so as to have official track records as published by the index providers for all four of the non-cap-weighted indices in each universe. Compared to Amenc et al. (2011) we update time period to include the recent crisis period and we add an analysis of the same indices in a Developed World universe. While it would be possible in principle to construct a longer dataset with simulated returns to these indices by applying the weighting scheme to a dataset of individual stocks in both universes, such an approach of simulating returns comes with the challenge of being able to account for all elements of the construction methodology of the respective index. Implementation of each approach, which may include various constraints and detailed protocols for rebalancing procedures, can have a significant impact on returns. To give a true and fair view of each method, we prefer to use official track records rather than making a potentially imperfect attempt of replicating the various methodologies.

Table 1 reports the results. Table 1 shows that all four alternatives to cap-weighting achieve higher returns in both datasets. While the cap-weighted indices return only about 1% (US data) and 7% (World data) per year, the efficient index and equal-weighted index have annual returns in excess of 6% (US) and 10% (World). The minimum-volatility index, with a return of 3.4% per year, yields considerably less than the other non-cap-weighted methods in the US universe. In the World data, the minimum volatility index has slower returns than efficient and equal-weighted indices but still has slightly higher returns than the fundamentals-based index.

In terms of risk, table 1 reports the standard deviation and downside risk (semi-deviation below zero) for all indices. In addition, the table shows both the tracking error volatility and the beta with respect to the cap-weighted indices. Minimum volatility stands out as it has the lowest volatility of all indices. The volatility of the efficient index is slightly lower than that of the cap-weighted indices, whereas that of fundamental and equal-weighted indices is slightly higher. Minimum volatility has a much lower beta with respect to the cap-weighted indices than any of the other non-cap-weighted indices. This result suggests that minimising volatility leads to a portfolio that loads up on the more defensive low-beta stocks. Equal-weighting and fundamental weighting lead to a beta of about one or higher than one, whereas efficient indexation, with a beta of 0.95 (US) and 0.98 (World), falls somewhat in between these two groups.

Interestingly, efficient indexation has the lowest tracking error volatility of the non-cap-weighted indices in both universes, suggesting that its outperformance of the

1 - We use S&P 500 as a reference cap-weighted index in the US universe. We have assessed that the annualised return difference between S&P 500 and the FTSE World USA Index or MSCI USA index is at most 0.2%, and the correlation of these indices with the S&P 500 is higher than 0.999.

2. Comparing Risk and Return

cap-weighted counterparts over the period analysed is more stable than that of the other three alternatives. On the contrary, the minimum volatility index has the highest tracking error, consistent with previous research findings (e.g. Bouchey, 2010).

Table 1 also shows risk-adjusted performance measures—the Sharpe, Sortino, information, and Treynor ratios—for all indices. The Sharpe ratio reflects the indices' risk/reward efficiency by adjusting excess returns over the risk-free interest rate by the volatility incurred by the index. The Sharpe ratio of all non-cap-weighted indices is positive and clearly more attractive than that of the cap-weighted indices. In US, efficient index has highest Sharpe Ratio attributed to its low volatility and high average return. Equal-weighted index and Fundamental index show slightly lower Sharpe Ratio than efficient index, coming from slightly lower returns but actually increase volatility compare to cap-weighted indices. Minimum volatility decreases volatility considerably but also has lower returns, resulting in lowest Sharpe Ratio among US non-cap-weighted indices.

For the World data, efficient index, minimum volatility and equal-weighted index have similar Sharpe Ratios. The equal-weighted index has the highest returns among the non-cap-weighted World indices

2 - Note that for World universe, efficient index is constructed on regional level and then aggregated by market capitalisation. See FTSE, 2011, "Ground rules for the management of the FTSE EDHEC-Risk Efficient index series".

Table 1: Performance statistics This table shows summary statistics for different equity indices in US and developed world universe. The construction principles of the indices are more fully described in section one. The statistics are based on over twelve years of weekly data from 8 January 1999 to 26 August 2011 for U.S and from 20 December 2002 to 26 August 2011 for World. All statistics are annualised and performance ratios that involve the average returns are based on the geometric average, which reliably reflects multiple holding period returns for investors. A Cornish-Fisher expansion was used to compute a Value-at-Risk estimate that takes into account the mean, volatility, skewness, and excess kurtosis of index returns.

	U.S. (08/01/1999 -26/08/2011)						World (20/12/2002 - 26/08/2011)					
	Non-capweight				Cap-weight		Non-capweight				Cap-weight	
	Efficient Index	Minimum Volatility	Fundamental Index	S&P 500 Equal-Weighted	S&P 500	Russell 1000	Efficient Index 2	Minimum Volatility	Fundamental Index	MSCI Equal-Weighted	MSCI World	FTSE All-World Developed
Average (geometric)	6.9%	3.4%	5.4%	6.0%	1.4%	1.9%	10.5%	8.8%	8.4%	11.2%	7.1%	7.2%
Std. Dev.	19.3%	16.1%	20.3%	21.2%	19.5%	19.7%	18.8%	14.2%	20.7%	19.9%	19.0%	18.9%
Semideviation (below 0)	13.8%	11.7%	14.4%	15.1%	14.1%	14.2%	13.8%	10.6%	15.1%	14.5%	14.0%	14.0%
Tracking error	5.5%	6.7%	6.2%	6.1%	0.0%	1.2%	2.8%	6.7%	4.0%	4.2%	0.0%	0.4%
Beta(w.r.t. cap-weighted references)	0.95	0.78	0.99	1.04	1.00	1.01	0.98	0.72	1.08	1.02	1.00	1.00
Sharpe ratio	0.22	0.05	0.14	0.16	-0.06	-0.04	0.46	0.49	0.31	0.47	0.27	0.28
Sortino ratio	0.50	0.29	0.38	0.40	0.10	0.13	0.76	0.83	0.56	0.77	0.50	0.52
Information ratio	0.99	0.29	0.64	0.75	NA	0.33	1.23	0.27	0.34	1.00	NA	0.40
Treynor ratio	0.05	0.01	0.03	0.03	-0.01	-0.01	0.09	0.10	0.06	0.09	0.05	0.05
5% VaR (Cornish Fisher)	4.4%	3.7%	4.4%	4.8%	4.5%	4.5%	4.4%	3.3%	4.7%	4.6%	4.4%	4.4%
1% VaR (Cornish Fisher)	10.5%	10.0%	11.4%	10.9%	10.1%	10.2%	12.2%	12.9%	13.7%	12.3%	12.7%	12.7%
Skewness	-0.62	-0.82	-0.39	-0.47	-0.50	-0.50	-1.19	-1.96	-0.97	-1.10	-1.13	-1.14
Kurtosis	8.84	10.88	9.57	8.01	7.97	7.98	11.89	21.53	12.14	11.02	12.47	12.46

2. Comparing Risk and Return

but also increases volatility with respect to cap-weighted indices. The Efficient Index increases returns and decreases volatility slightly, while minimum volatility has the lowest volatility but also lower returns than the efficient index and equal-weighted index. In the World universe, the fundamental index has lower Sharpe rations than the other non-cap-weighted indices but slightly higher Sharpe Ratio than the cap-weighted indices.

The results for the Sortino ratio (which uses downside risk instead of volatility to adjust for risk) and for the Treynor ratio (which uses the market beta to adjust for risk) are qualitatively similar to the results for the Sharpe ratio.

Table 1 also shows the indices' information ratios computed with respect to the cap-weighted index. This statistic reflects the average return difference with the cap-weight index when it is adjusted for the incurred tracking error. We see that all non-cap-weighted indices have rather high information ratios, meaning that they outperform the cap-weighted index fairly consistently. Efficient index has highest information ratios in both universes (0.99 in US and 1.23 in World) and minimum volatility the lowest (below 0.3) due to its high tracking error which was outlined above.

The minimum-volatility index, which effectively generates the lowest volatility of all indices, also has the highest kurtosis, i.e., the highest indicator of fat tails in the returns distribution (see table 1). In the World universe, its kurtosis is 21 versus at most 13 for all other indices. It also has most negative skewness. These findings are in line with evidence that low volatility stocks sometimes have very pronounced extreme risk (Boyer, Mitton and Vorkink 2010). Also, Andersen, Simonetti, and Sornette (2000) have shown that the focus on decreasing average risk (volatility) comes at the cost of an increase in tail risk.

Although the non-cap-weighted indices appear attractive overall in terms of risk and reward statistics, it is interesting to ask whether these differences are actually statistically significant. In fact, it would be possible that one would observe positive differences over a particular time period, even if the "true" performance of the underlying strategies were not better than that of the cap-weighting scheme. A statistical significance test allows us to assess whether we would be likely to observe such differences in the data if there were no true difference with respect to the cap-weighted index. Table 2 shows the results of significance tests for these three summary performance measures. All differences are computed with respect to the cap-weighted index and results that are significant at the 5% level are indicated in bold.

The results in table 2 show that, in both universes, the efficient index and the equal-weighted index have significantly higher average returns than the cap-weighted indices while the minimum-volatility index has significantly lower volatility but not significant higher Sharpe Ratio in any of the two universes. In terms of risk/reward efficiency, the efficient index and the equal-weighted index have significantly higher Sharpe ratios than the cap-weighted counterparts in both universes. As for the fundamental index, the outperformance of

2. Comparing Risk and Return

Table 2: Risk/reward difference compared to cap-weighted indices This table, based on over twelve years of weekly data, from 8 January 1999 to 26 August 2011 for U.S and from 20 December 2002 to 26 August 2011 for World, shows differences in average returns, in volatility, and in Sharpe ratios between each index and the relative cap-weighted index and the associated p-values. All differences are computed from annualised statistics and the average returns are a geometric average. The p-values for differences are computed using a paired t-test for the average returns, a Fisher test for the volatility, and a Jobson-Korkie test for the Sharpe ratio. Differences that are significantly different from zero at the 5% level are indicated in bold.

	U.S. (08/01/1999 -26/08/2011)				World (20/12/2002 - 26/08/2011)			
	Non-capweight				Non-capweight			
	Efficient Index	Minimum Volatility	Fundamental Index	S&P 500 Equal-Weighted	Efficient Index	Minimum Volatility	Fundamental Index	MSCI Equal-Weighted
Diff. in ann. average	**5.5%**	1.9%	**4.0%**	**4.6%**	**3.5%**	1.8%	1.4%	**4.2%**
p-value for difference	*0.1%*	*48.8%*	*2.1%*	*0.6%*	*0.1%*	*71.0%*	*22.9%*	*0.5%*
Diff. in ann. Volatility	-0.2%	**-3.4%**	0.9%	**1.7%**	-0.1%	**-4.8%**	1.8%	0.9%
p-value for vol. difference	*76.6%*	*0.0%*	*27.3%*	*3.4%*	*86.9%*	*0.0%*	*5.6%*	*32.6%*
Diff. in Sharpe ratio	**0.28**	0.11	**0.20**	**0.22**	**0.19**	0.22	0.04	**0.20**
p-value for Sharpe ratio diff.	*0.1%*	*32.6%*	*2.4%*	*0.6%*	*0.1%*	*6.4%*	*43.5%*	*1.0%*

the cap-weighted index in terms of Sharpe ratio as well as average returns is significant in the US data and insignificant in the World data.

It is useful to give some intuition on the statistical significance levels shown in table 2. For the Sharpe ratio, the efficient index has the most significant increase over the cap-weighted index, with a probability value of 0.1%. What this means is that, if there were no true difference in the Sharpe ratio with the cap-weighted index, we would expect to observe a difference as pronounced as the one we observed (*i.e.*, 0.28 in US and 0.19 in World) about one out of every 1,000 times we look at a dataset of over twelve years. The probability values for the equal-weighted index are on the order of one percent; hence it would also be highly unlikely to obtain such results if there were no true difference. To summarise the results that are statistically significant, we can conclude that—compared to the cap-weighted indices—minimum-volatility indices have lower volatility and the efficient index and the equal-weighted index have higher average returns and higher Sharpe ratios.

2. Comparing Risk and Return

3. Factor Exposures

3. Factor Exposures

The analysis of risk and return measures provides insight into how the indices behave, which is obviously important information for investors. However, it is also interesting to analyse where the return properties come from. The non-cap-weighted indices may take on exposures to common risk factors that are well known in the academic finance literature, such as value, momentum, and small-cap exposures.

Since the indices are broadly diversified across constituent stocks, one may in fact expect that the risk and return properties are largely driven by such factor exposures, leaving only a small fraction of returns that are completely specific to the method of index design. From the investor's perspective, such risk exposures matter. They are often implicit results of portfolio construction, but investors want to know how exposed they are to certain factors.

In this section, we use factor models to analyse exposure to the equity factors commonly used in the academic literature. The standard factor models in the empirical finance literature use a market risk factor, which is made up of all stocks that are traded on the market and additional factors that are long/short portfolios, rebalanced monthly, of stocks that have been selected from relative universe for their style characteristics. In our empirical analysis, we use the standard four-factor model (Carhart, 1997), in which we regress the returns in excess of the risk-free rate of the indices on the excess returns of the cap-weighted index, on the Fama-French (1992) factors for the value and small-cap premium, and on an additional factor representing a momentum strategy. The value factor is a portfolio that is long high book-to-price stocks (value stocks) and short low book-to-price stocks (growth stocks). The small-cap factor is a portfolio that is long low market-cap stocks (small stocks) and short high market-cap stocks (large stocks). The momentum factor goes long in stocks with high recent returns (winners) and short in stocks with low recent returns (losers).

In our empirical analysis, for the US universe, the four factors are taken from Kenneth French's data library, where the market factor is proxied by value-weighted CRSP total market index of all stocks listed on the NYSE, AMEX, and NASDAQ. For World universe, we use excess return of FTSE Developed All Cap Index over risk-free rate as market factor, and we construct the value and small cap factors from MSCI style and size indices. Because of data availability on the factors, the analysis period is slightly different from the full period used previously. The appendix contains details on the data. Table 3 shows the results of these four-factor regressions.

When the commonly used equity risk factors are adjusted for, only efficient index and minimum volatility index show *statistical* significance for alpha in the World universe and none of the indices shows a significant alpha in the US universe. Annual alpha is nevertheless *economically* significant for most of the non-cap-weighted indices in both datasets, with many values in the order of 2% annual.

We now turn to a detailed discussion of estimated factor exposures reported in Table 3.

3. Factor Exposures

Table 3: Factor exposures This table, based on over twelve years of weekly data, from 8 January 1999 to 29 July 2011 for US and from 3 October 2003 to 26 August 2011 for World, shows results for factor regressions of the excess returns of various equity indices on the market factor, value factor, small-cap factor, and momentum factor. The table shows R-squares, regression coefficients, and the p-values associated with the null hypothesis that the regression coefficients are zero. Coefficients that are significantly different from zero at the 5% level are indicated in bold.

	U.S. (08/01/1999 -29/07/2011)						World (03/10/2003 - 26/08/2011)					
	Non-capweight				Cap-weight		Non-capweight				Cap-weight	
	Efficient Index	Minimum Volatility	Fundamental Index	S&P 500 Equal-Weighted	S&P 500	Russell 1000	Efficient Index	Minimum Volatility	Fundamental Index	MSCI Equal-Weighted	MSCI World	FTSE All-World Developed
Adj, R-squared	0,93	0,89	0,95	0,93	0,97	0,97	0,99	0,93	0,99	0,98	1,00	1,00
Ann, Alpha	2,2%	0,2%	1,2%	1,9%	-1,0%	-0,8%	**1,9%**	**2,9%**	0,8%	1,4%	-0,2%	0,0%
p-value	*12,8%*	*87,0%*	*36,2%*	*21,9%*	*29,6%*	*36,5%*	*0,5%*	*3,1%*	*36,1%*	*14,7%*	*19,6%*	*97,8%*
Market Beta	**0,91**	**0,78**	**0,95**	**0,97**	**0,97**	**0,98**	**0,96**	**0,72**	**1,04**	**0,99**	**1,00**	**0,99**
p-value	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*
Small Cap Beta	-0,01	**-0,27**	**-0,11**	0,02	**-0,20**	**-0,15**	**0,21**	**-0,16**	0,02	**0,30**	**-0,10**	**-0,09**
p-value	*72,9%*	*0,0%*	*0,0%*	*52,6%*	*0,0%*	*0,0%*	*0,0%*	*1,5%*	*57,0%*	*0,0%*	*0,0%*	*0,0%*
Value Beta	**0,31**	**0,19**	**0,42**	**0,29**	0,00	0,00	0,03	**0,17**	**0,36**	0,05	0,00	**0,01**
p-value	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*71,2%*	*78,7%*	*18,9%*	*0,0%*	*0,0%*	*32,3%*	*35,7%*	*0,0%*
Momentum Beta	**-0,05**	**0,04**	**-0,08**	**-0,12**	-0,01	**-0,01**	**-0,18**	0,07	**-0,27**	**-0,16**	0,00	**-0,02**
p-value	*2,2%*	*4,2%*	*0,0%*	*0,0%*	*11,1%*	*2,3%*	*0,0%*	*26,1%*	*0,0%*	*0,6%*	*64,1%*	*0,0%*

Market Exposure

The results for the beta with the broad cap-weighted market proxy used here are qualitatively similar to what was obtained in table 2 when regressing the various indices on the cap-weighted index as a single market factor. The results confirm the low beta nature of the minimum-volatility index, whereas the other indices have beta reasonably close to one.

Value/Growth Exposure

It should first be noted that any reasonable definition of style neutrality would lead to the conclusion that equal weighting should be free of a value or growth bias. In fact, since no information whatsoever on valuation enters the determination of weights in an equal-weighted index, it is difficult to imagine that such an index would imply any choices in terms of value or growth exposure. That the equal-weighted index shows a value bias with respect to the cap-weighted index in the US universe indicates only the relativity of the reference point, and one could actually argue that the S&P 500 cap-weighted index has a growth bias relative to the equal-weighted reference. Furthermore, we can see that this value bias of equal-weighted index is eliminated when the World universe is analysed. If we take the equal-weighted index as a reference for value/growth neutrality, the direct implication is that indices whose factor exposure is not markedly different from that of the equal-weighted index do not include any value biases.

3. Factor Exposures

The results in table 3 show that only the fundamental index has a value exposure that is substantially greater than that of the equal-weighted index in both universes. Other non-cap-weighted indices such as efficient indexation and minimum volatility have value exposures that are closer to that of equal weighting. These results are consistent with economic intuition: the fundamental index method derives constituent weights from company characteristics such as the book value. Kaplan (2008) has shown that weighting stocks by their book value actually corresponds to an adjustment of the market-cap weight for the book-to-market ratio of each stock relative to the book-to-market ratio of the cap-weighted index. Thus, stocks with a high book-to-market ratio will be mechanically overweighted, whereas stocks with a low book-to-market ratio will be underweighted for their capitalisation weight. Similar arguments can be made concerning the additional firm characteristics used in the index method, notably dividends, cash-flows, and sales: stocks with a high dividend yield, high cash-flow-to-price ratio and high sales-to-price ratio will be overweighted for their capitalisation weight. As these are typical ratios used in value strategies, it is not surprising to find a substantial exposure to the value factor. Other weighting schemes considered in this analysis do not use fundamental information, and therefore do not lead to such a mechanical value bias. Compared to the equal-weighted reference, neither the efficient index nor the minimum-volatility index displays any value bias.

Small-cap Exposure

If one were to use an equal-weighted index that included a broad set of stocks covering all ranges of market capitalisation, one would ascertain a small-cap bias, as most of the stocks traded on exchange are small- or even micro-cap stocks. However, the equal-weighted index used in the US universe is composed of S&P 500 constituents (i.e., large-cap stocks), which may explain that the small-cap exposure in table 3 is insignificantly different from zero for the equal-weighted index. Moreover, the non-cap-weighted indices studied in the US universe are made up of large-cap stocks, so none of these indices should show any meaningful bias towards small caps. Interestingly, the fundamental index shows the opposite of a small-cap bias in the US universe. Table 3 shows a statistically significant negative exposure to the small-cap factor for fundamental index in US, as well as for the two cap-weighted indices in both universes. This can be explained by the fact that the cap-weighted market factor in these models is not the narrow S&P 500 or MSCI World index but the much broader index reflecting the entire stock universe, particularly for US. Compared to this market factor, the returns of cap-weighted and fundamental-weighted indices are driven largely by the largest stocks. This can be explained by the fact that their constituents are made up of the largest stocks and in addition their weighting mechanism depends on company size. The minimum-volatility index also has a significantly negative exposure to small caps, which perhaps can be explained by a concentration in low beta stocks that leads to a bias towards defensive industries such as telecoms and utilities, which are usually dominated by a few large companies. In

3. Factor Exposures

contrast, the efficient and equal-weighted indices have insignificant exposures to the small-cap factor in US. They appear to be the least biased towards large-cap stocks by virtue of their weighting mechanism in the US universe, which is made up of the most liquid and largest stocks. In the World universe, it should be noted that the market factor is much narrower compared to the CRSP total market index. The equal-weighted and efficient indices statistically speaking have a positive small cap exposure in this dataset which is explained by their comovement with the small cap factor. Of course, these two indices are made up of large and mid cap stocks, so that no small caps are actually contained in the indices. The minimum volatility index again has a negative small cap exposure confirming its tendency from the US analysis, while the fundamentals-weighted index has an insignificant small cap exposure.

Momentum Exposure

Of all the non-cap-weighted indices, momentum exposure is most negative for equal-weighted indices in the US universe. After all, compared to cap-weighting, equal-weighting mechanically rebalances away from stocks that increase in price. This mechanical rebalancing is also inherent to the fundamental index, which has the most pronounced negative momentum beta in the World universe. Momentum exposure is less pronounced for efficient indices and minimum volatility indices, this can perhaps be explained by the fact that they are rebalanced based on currently available quantitative information on risk and returns of the constituent stocks, so they do not necessarily have a mechanical rebalancing effect built into their weighting mechanism.

3. Factor Exposures

4. Turnover of Index-Weighting Methods

4. Turnover of Index-Weighting Methods

Turnover, which leads to transaction costs higher than those of buy-and-hold strategies and which may make it harder to replicate the index, is of concern to index investors. Cap-weighted indices are, in principle, a buy-and-hold strategy that involves no turnover. In practice, reconstitution of the index and changes in free-float adjustments mean that there will be turnover, but one-way annual turnover is usually no more than 5% to 10%.[3] Alternatively weighted indices such as equal-weighted indices, minimum-volatility indices, and so on, may have higher turnover as they involve some rebalancing of weights. In this section, we will explain how the approaches analysed above take into account concerns about turnover. We also report one-way annual turnover rates for the non-cap-weighted indices and the traditional cap-weighted indices. In the second subsection, we review the methods of controlling turnover.

4.1. Turnover Management and the Results of Improved Beta Strategies

Table 4 shows the one-way annual turnover rates across different indices. Since we use index-level data for the performance analysis, we have no information about actual portfolio composition. To indicate turnover, we thus provide the numbers reported by authors for each method for their backtests or the turnover objectives reported in index documentation.

It is not surprising that non-cap-weighted indices usually have higher turnover than the two commonly used cap-weighted indices, the S&P 500 and Russell 1000 in US and the MSCI World index and the FTSE All-World Developed index in World. The turnover of most of the non-cap-weighted indices is between 10% and 30%. The low turnover of the fundamentally weighted index, which uses trailing five-year average data, less volatile than annual or quarterly data, for most firm characteristics (Arnott, Hsu, and Moore, 2005), is understandable.[4] Moreover, this index rebalances annually, less frequently than the rest of the indices. The MSCI Minimum Volatility Index imposes an implicit 10% turnover constraint on the optimisation process at each semi-annual review, thus limiting annual turnover to 20%. But the index rules allow up to 30% turnover in a semester if there is no solution from the initial optimisation (MSCI Index Research, 2010). On the other hand, the S&P 500 Equal-Weighted Index does not have any turnover constraints and rebalances more frequently (quarterly) than the indices weighted by other methods.[5] Rather than merely reduce the frequency of rebalancing, the EDHEC-Risk Efficient Index takes an optimal control approach. This approach leads to rebalancing not in an automatic or periodic fashion but depending on whether the absolute change in weights exceeds a threshold. The idea behind this approach, which is inspired by optimal control techniques used in option replication, is to rebalance only when there is significant new information on optimal weights (Amenc *et al.*, 2010).

4.2. Managing Turnover: Methods

Turnover varies greatly from one index to another, and the methods of managing it are a complex problem in constructing indices. "Turnover constraints," as Scherer (2010, 224) puts it, "are implemented by practitioners to provide a heuristic safeguard against transaction costs". For all intents and purposes, then, turnover management is

3 - As reported by documents issued by Standard and Poor's (2011) and Russell Indexes (2010)
4 - Arnott, Hsu, and Moore (2005) test the effect when annual data is used. They argue that turnover will be substantially higher (more than 2%).
5 - As published by Standard and Poor's (2009) in the method document for the S&P 500 Equal-Weighted Index

4. Turnover of Index-Weighting Methods

6 - These turnover rates are the average values from 2003 to 2010, and the range is from 1.45% to 5.7% for the S&P 500 (S&P 2011) and 1.82% to 6.86% for the Russell 1000 (Russell Indexes 2010).
7 - The turnover rate is calculated based on the backtesting data (see FTSE EDHEC-Risk Efficient Index Series methodology 2011).
8 - MSCI has a semi-annual index review to limit the turnover to 10%, so we use 20% as the maximum annual turnover rate. However, the turnover limit may vary up to 30% per semester if there is no solution from the optimisation (MSCI Index Research 2010).
9 - The turnover rate depends on the period of analysis and the index is rebalanced annually (Hsu and Campollo 2005).
10 - The turnover rate is the average value from 01/2005 to 12/2009 and the index is quarterly rebalanced every quarter (Zeng, Dash, and Guarino 2010).
11 - As reported by BlackRock in "Alternative Equity Beta Indices" (August 2011)
12 - As reported by BlackRock in "Alternative Equity Beta Indices" (August 2011)
13 - As reported by BlackRock in "Alternative Equity Beta Indices" (August 2011)
14 - As reported by MSCI Index Research in "Update on MSCI Equal Weighted Indices"(December 2010)
15 - As reported by MSCI Index Research in "Update on MSCI Equal Weighted Indices"(December 2010)
16 - As reported by F&C Quantitative Equity Strategies Team in "Trouble in Quant Land Expect excellence"(February 2010)

Table 4: One-way annual turnover rates of several indices

	US						World					
	Non-cap-weighted				Cap-weighted[6]		Non-cap-weighted				Cap-weighted	
	Efficient Index[7]	Minimum Volatility[8]	Fundamental Index[9]	S&P 500 Equal-Weighted[10]	S&P 500	Russell 1000	Efficient Index[11]	Minimum Volatility[12]	Fundamental Index[13]	MSCI Equal-Weighted[14]	MSCI World[15]	FTSE All-World Developed[16]
One-way annual turnover	17-25%	20-60%	10-12%	28.1%	4.0%	3.9%	23.11%	19.89%	21.63%	31.8%	4.6%	5.0%

transaction cost management. Transaction costs come in many forms. They depend not only on the number of trades but also on the volume of each trade.

Scherer (2010) reviews methods of managing the transaction costs of portfolio construction. In general, there are either simple periodic rebalancing strategies or complex rules. There may also be explicit limits on turnover.

Periodic rebalancing

Calendar strategies rebalance the portfolio at certain pre-specified intervals: for instance, monthly, quarterly, yearly. The simplest method of keeping turnover under control is to adjust the rebalancing frequency. Buetow et al. (2002) have demonstrated that the higher the rebalancing frequency, the better the performance of the portfolio (and the higher the transaction costs, of course). So to keep these costs manageable, the rebalancing frequency must be adjusted. In general, lower frequency will lead to lower transaction cost (as well as to greater deviations from target weights). The Fundamental Index Series published by FTSE, for example, rebalances annually to reduce turnover, and the S&P 500 Equal-Weighted Index rebalances quarterly to strike a balance between equal weighting and investability. In addition, for non-cap-weighted indices, simply lowering the rebalancing frequency to adjust turnover will cause the performance of the index to depend on the market conditions around rebalancing dates, which may not represent the effect of a certain weighting strategy (Donohue and Yip, 2003). For their part, Blitz, van der Grient and van Vliet (2010) argue that the subjective choice of rebalancing dates may significantly affect index performance. For example, if one decides to rebalance once a year or once every two years, the choice of rebalancing date may alter performance. So, to attribute performance to strategies that rebalance at greater intervals, it may be necessary to take into account the impact of the choice of rebalancing date.

Optimal rebalancing conditions

The trigger approach activates rebalancing whenever the gap between the index and the target reaches a specific threshold (e.g. ±5% or ±10%). The trigger points could be set for individual stock weights as well as for their returns. Again, the wider the gap is, the lower turnover is (but the

4. Turnover of Index-Weighting Methods

greater deviation from the target weights is). Scherer (2010) shows that the trigger points may not be constant for all stocks. High transaction costs for certain stocks will lead to high trigger points, whereas high volatility could cause lower trigger points. So finding the proper trigger is hard, although index performance will depend on the performance of individual stocks (Donohue and Yip, 2003). In practice, however, trigger strategies—such as the capitalisation banding developed by Russell Investments (Agather and McCarthy, 2007)—are widely used, as they are easy to implement and monitor. Only stocks that exceed the capitalisation band are removed from the index when the index is reconstituted. In such a way, the number of stocks that need to be added to or removed from the index is greatly reduced, which results in lower turnover.

Trigger strategies essentially create a no-trade region for each asset in the portfolio. Such strategies may define no-trade regions for individual assets. However, the literature shows that the no-trade regions can also be defined depending on the overall weight changes in the portfolio (Atkinson, Pliska and Wilmott, 1997; Donohue and Yip, 2003; El Bied, Martellini and Priaulet, 2002; Leland, 1999). Such turnover control rules give rise to optimal control strategies. These strategies will rebalance the portfolio in accordance with the optimisation results only if a threshold of weight changes has been reached. In the quarterly review of the efficient index, for example, a new set of optimal weights is calculated. But application of the new weights depends on whether the absolute change in weights exceeds a threshold. This is consistent with insights from control techniques applied to portfolio optimisation to lower transaction costs. In short, only if a significant amount of new information has appeared since the previous rebalancing will the weights be updated. Such strategies are better for managing turnover than is merely widening the intervals between instances of rebalancing.

Imposing explicit turnover constraints

Imposing explicit turnover constraints is another means, relatively straightforward, of keeping turnover under control. In practice, the MSCI Minimum Volatility Index calculates its optimal weights during the semi-annual review with the maximum turnover at 10% in the optimisation model. So the maximum turnover of the index is implicitly 20% a year (10% in six months). There is, however, another problem, as these limits on turnover may make it hard to attain the optimal weights. So the limits on turnover are flexible; it can increase, in steps of 5%, to a maximum of 30%. In the worst case, the turnover of the index would be as high as 60% a year.

There are advantages to making limits on turnover an integral part of the portfolio construction process, but these limits will also make it harder for the index to obtain its optimal weights through optimisation.

Other strategies

Fundamentally weighted indices, constructed as part of other strategies for keeping turnover under control, adopt trailing five-year averaged data for the weighting criterion instead of annual or quarterly data. In this way, the weighting criterion will be smoothed. Smoothing may achieve more stable weights and less turnover. But it

4. Turnover of Index-Weighting Methods

is also harder for the five-year average data to reflect recent changes in the company than yearly or quarterly data. So, in spirit, smoothing weights is no different from other turnover control methods that reduce turnover but increase deviation from the target weights of the original strategy.

To conclude, turnover management is critical to index construction, as high turnover will make it difficult to replicate the index. It should be clear that, just as with weighting schemes themselves, there are many methods of rebalancing to keep turnover under control.

4. Turnover of Index-Weighting Methods

Conclusion

Conclusion

The analysis provided in this paper clearly shows that the non-cap-weighted indices beat the standard cap-weighted indices, such as the S&P 500 and the Russell 1000 in US as well as the MSCI World index and the FTSE All-World Developed index in World, in terms of risk-adjusted performance over twelve years for which data is available for all indices.

Moreover, the "improved beta" strategies achieve the main self-imposed objectives, which vary widely from one non-cap-weighted index to another. The efficient index, whose aim is higher risk/reward efficiency, does indeed obtain the highest Sharpe ratio of all the indices. The minimum-volatility index obtains the lowest volatility. Fundamental indices obtain higher average returns as a result of their value strategy. The differences among the indices are also reflected in quite different factor exposures. As minimum volatility favours low beta stocks, it clearly has the lowest market beta of all non-cap-weighted indices, while fundamental weighting leads to the highest value exposure, and equal weighting to the most pronounced anti-momentum exposure.

Efficient indices and equal-weighted indices are the only strategies which significantly increase the average return and Sharpe Ratio in both universes. In terms of Information Ratio, efficient indices obtain the best performance among the non-cap-weighted indices, while minimum volatility has the lowest Information Ratio due to high tracking error.

That the four weighting schemes have rather different risk and return properties also suggests that different investors may choose different alternatives, depending on which characteristic they value most. Moreover, combining these alternatives may add even more value, as different return properties may allow an investor who wants to move away from capitalisation weighting to diversify his exposure to non-cap-weighted schemes. This issue is left for further research.

Furthermore, our review of index turnover shows that, although the turnover management methods of one indexation method may well differ from those of another, all alternative weighting schemes achieve reasonably low turnover. Although turnover is higher than for cap-weighted indices, the turnover reported for alternatively weighted indices is not nearly high enough to incur transaction costs that would offset the superior performance of alternatively weighted indices.

Appendix

Appendix

A.1. Summary Statistics and Differences with Capitalisation Weighting in Sub-Periods

This section of the appendix contains an analysis of results for the two sub-periods of the sample. We chose the sub-periods so as to divide the sample into two halfs.

The analysis of sub-periods is provided for the information of the reader. On the whole, the results per sub-period confirm the conclusions drawn for the full period. The above results can thus be considered quite robust.

Table A.1: Performance statistics for sub-periods This table shows summary statistics for different equity indices. The construction principles of the indices are more fully described in section one. The statistics are based on weekly data. All statistics are annualised and performance ratios that involve the average returns are based on the geometric average, which reliably reflects multiple holding period returns for investors. A Cornish-Fisher expansion was used to compute a Value-at-Risk estimate that takes into account the mean, volatility, skewness, and excess kurtosis of index returns.

First sub-period	U.S. (08/01/1999 -29/04/2005)						World (20/12/2002 - 20/04/2007)					
	Non-capweight				Cap-weight		Non-capweight				Cap-weight	
	Efficient Index	Minimum Volatility	Fundamental Index	S&P 500 Equal-Weighted	S&P 500	Russell 1000	Efficient Index	Minimum Volatility	Fundamental Index	MSCI Equal-Weighted	MSCI World	FTSE All-World Developed
Average (geometric)	8,2%	3,3%	6,8%	7,3%	0,5%	1,0%	24,6%	19,4%	22,9%	27,8%	19,7%	19,9%
Std. Dev.	16,0%	14,7%	16,5%	18,1%	18,4%	18,5%	11,3%	8,7%	11,5%	12,2%	11,6%	11,6%
Semideviation (below 0)	11,4%	10,5%	11,6%	12,7%	13,2%	13,2%	6,7%	5,1%	7,0%	7,4%	7,2%	7,1%
Tracking error	6,9%	7,6%	6,8%	7,1%	0,0%	1,5%	2,3%	4,5%	1,7%	4,1%	0,0%	0,3%
Beta with S&P 500	0,81	0,73	0,83	0,91	1,00	1,00	0,95	0,70	0,98	0,99	1,00	1,00
Sharpe ratio	0,32	0,02	0,23	0,24	-0,14	-0,11	1,93	1,90	1,75	2,05	1,46	1,47
Sortino ratio	0,72	0,32	0,59	0,57	0,04	0,08	3,66	3,79	3,29	3,77	2,75	2,79
Information ratio	1,11	0,36	0,93	0,96	NA	0,32	2,10	-0,08	1,83	1,95	NA	0,58
Treynor ratio	0,06	0,00	0,05	0,05	-0,02	-0,02	0,23	0,24	0,21	0,25	0,17	0,17
5% VaR (Cornish Fisher)	3,8%	3,4%	3,8%	4,2%	4,3%	4,3%	2,2%	1,7%	2,3%	2,5%	2,3%	2,3%
1% VaR (Cornish Fisher)	7,0%	6,5%	7,4%	7,6%	7,7%	7,8%	3,6%	2,8%	3,7%	4,1%	3,9%	3,8%
Skewness	-0,67	-0,51	-0,49	-0,53	-0,35	-0,36	-0,23	-0,20	-0,20	-0,39	-0,15	-0,14
Kurtosis	5,50	5,64	5,92	5,09	5,19	5,25	3,53	3,50	3,58	3,55	3,81	3,77

Second sub-period	U.S. (06/05/2005 -26/08/2011)						World (27/04/2007 - 26/08/2011)					
Average (geometric)	5,6%	3,5%	4,0%	4,8%	2,4%	2,7%	-1,9%	-0,7%	-4,3%	-3,2%	-4,2%	-4,1%
Std. Dev.	22,0%	17,4%	23,6%	23,9%	20,5%	20,9%	24,0%	18,0%	26,9%	25,2%	24,1%	24,1%
Semideviation (below 0)	15,9%	12,8%	16,7%	17,1%	14,9%	15,2%	18,3%	14,1%	20,2%	19,2%	18,4%	18,4%
Tracking error	3,7%	5,5%	5,5%	5,0%	0,0%	0,9%	3,3%	8,3%	5,3%	4,2%	0,0%	0,5%
Beta with S&P 500	1,06	0,82	1,12	1,15	1,00	1,02	0,99	0,72	1,10	1,03	1,00	1,00
Sharpe ratio	0,16	0,08	0,08	0,11	0,01	0,03	-0,12	-0,10	-0,20	-0,17	-0,22	-0,21
Sortino ratio	0,35	0,27	0,24	0,28	0,16	0,18	-0,10	-0,05	-0,21	-0,16	-0,23	-0,22
Information ratio	0,88	0,20	0,30	0,48	NA	0,37	0,71	0,42	-0,02	0,26	NA	0,33
Treynor ratio	0,03	0,02	0,02	0,02	0,00	0,01	-0,03	-0,02	-0,05	-0,04	-0,05	-0,05
5% VaR (Cornish Fisher)	5,0%	4,0%	5,1%	5,3%	4,7%	4,8%	5,9%	4,5%	6,5%	6,2%	6,0%	6,0%
1% VaR (Cornish Fisher)	12,0%	12,1%	12,9%	12,4%	11,8%	11,9%	13,2%	13,7%	14,6%	13,5%	13,8%	13,8%
Skewness	-0,57	-1,00	-0,33	-0,42	-0,61	-0,60	-0,98	-1,74	-0,74	-0,87	-0,95	-0,96
Kurtosis	8,79	13,04	9,22	8,25	9,64	9,52	8,55	15,98	8,29	8,09	9,14	9,12

Appendix

Table A.2: Risk/reward difference compared to cap-weighted indices for sub-periods This table shows differences in average returns, in volatility, and in Sharpe ratios between each index and the cap-weighted indices and the associated p-values. All statistics are computed from weekly returns data. All differences are computed from annualised statistics and the average returns are a geometric average. The p-values for differences are computed using a paired t-test for the average returns, a Fisher test for the volatility, and a Jobson-Korkie test for the Sharpe ratio. Differences that are significantly different from zero at the 5% level are indicated in bold.

First sub-period	U.S. (08/01/1999 -29/04/2005)				World (20/12/2002 - 20/04/2007)			
	Non-capweight				Non-capweight			
	Efficient Index	Minimum Volatility	Fundamental Index	S&P 500 Equal-Weighted	Efficient Index	Minimum Volatility	Fundamental Index	MSCI Equal-Weighted
Diff. in ann. average	**7,7%**	2,8%	**6,3%**	**6,8%**	**4,8%**	-0,4%	**3,2%**	**8,1%**
p-value for difference	*1,2%*	*48,7%*	*3,4%*	*2,2%*	*0,0%*	*77,8%*	*0,2%*	*0,1%*
Diff. in ann. Volatility	**-2,4%**	**-3,8%**	**-1,9%**	-0,3%	-0,3%	**-2,9%**	-0,1%	0,6%
p-value for vol. difference	*1,2%*	*0,0%*	*5,0%*	*74,5%*	*65,8%*	*0,0%*	*88,1%*	*46,0%*
Diff. in Sharpe ratio	**0,46**	0,16	**0,37**	**0,37**	**0,47**	**0,44**	**0,29**	**0,59**
p-value for Sharpe ratio diff.	*0,5%*	*40,7%*	*2,1%*	*2,1%*	*0,0%*	*2,3%*	*0,1%*	*0,5%*

Second sub-period	U.S. (06/05/2005 -26/08/2011)				World (27/04/2007 - 26/08/2011)			
	Non-capweight				Non-capweight			
Diff. in ann. average	**3,3%**	1,1%	1,7%	2,4%	2,3%	3,5%	-0,1%	1,1%
p-value for difference	*1,9%*	*82,6%*	*30,0%*	*12,1%*	*12,9%*	*56,3%*	*80,8%*	*48,9%*
Diff. in ann. Volatility	1,5%	**-3,1%**	**3,0%**	**3,3%**	-0,1%	**-6,1%**	2,8%	1,1%
p-value for vol. difference	*19,4%*	*0,3%*	*1,2%*	*0,6%*	*95,9%*	*0,0%*	*9,8%*	*50,9%*
Diff. in Sharpe ratio	**0,15**	0,07	0,07	0,10	0,10	0,12	0,02	0,05
p-value for Sharpe ratio diff.	*1,8%*	*61,6%*	*32,7%*	*9,1%*	*12,9%*	*46,9%*	*69,2%*	*44,9%*

A.2. Additional Description of Data Sources

For the non-cap-weighted indices, the data for MSCI and S&P EW is obtained from Datastream. The information on fundamental indices is obtained from the data described in Amenc, Goltz, and Le Sourd (2009) and updated with returns from Datastream on the FTSE RAFI 1000 index. The data on efficient US index is obtained from the data in Amenc et al. (2010) and updated using the FTSE EDHEC-Risk Efficient Index for the US from Datastream.

The risk-free rate is the "Secondary Market US Treasury Bills (3M)" obtained from DataStream and is used as the risk-free rate for both universes. The US market factor in the factor regressions is taken from Kenneth French; this is the value-weighted CRSP total market index (NYSE, AMEX, and NASDAQ stocks). Since the factor data is updated to the end of July 2011 from Kenneth French, our factor analysis period is constrained by this date in the US universe.

For the World universe, we use the excess return of the MSCI World value index over the MSCI World growth index as a proxy

Appendix

for HML factor, the excess return of the MSCI World Small Cap index over the MSCI World Large Cap index as a proxy for SMB factor. The momentum factor is computed from a portfolio that goes long of an equally-weighted mix of MSCI Europe Barra Momentum Index and MSCI US Barra Momentum Index and short the equally-weighted mix of MSCI Europe Index and MSCI USA Index.[17]

17 - We only are able to assess momentum strategies on the major markets (US and Europe) but not in the entire World universe. We have assessed an alternative proxy that follows momentum in US and Europe and shorts the entire world index (including non US and non European components). This proxy is highly correlated to our proxy (correlation: 0.85) and difference in average returns and volatility is small (0.3% in returns and 0.21% in volatility)

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About EDHEC-Risk Institute

About EDHEC-Risk Institute

Founded in 1906, EDHEC is one of the foremost French business schools. Accredited by the three main international academic organisations, EQUIS, AACSB, and Association of MBAs, EDHEC has for a number of years been pursuing a strategy for international excellence that led it to set up EDHEC-Risk in 2001. With sixty-six professors, research engineers, and research associates, EDHEC-Risk has the largest asset management research team in Europe.

The Choice of Asset Allocation and Risk Management

EDHEC-Risk structures all of its research work around asset allocation and risk management. This issue corresponds to a genuine expectation from the market.

On the one hand, the prevailing stock market situation in recent years has shown the limitations of diversification alone as a risk management technique and the usefulness of approaches based on dynamic portfolio allocation.

On the other, the appearance of new asset classes (hedge funds, private equity, real assets), with risk profiles that are very different from those of the traditional investment universe, constitutes a new opportunity and challenge for the implementation of allocation in an asset management or asset-liability management context.

This strategic choice is applied to all of the Institute's research programmes, whether they involve proposing new methods of strategic allocation, which integrate the alternative class; taking extreme risks into account in portfolio construction; studying the usefulness of derivatives in implementing asset-liability management approaches; or orienting the concept of dynamic "core-satellite" investment management in the framework of absolute return or target-date funds.

An Applied Research Approach

In an attempt to ensure that the research it carries out is truly applicable, EDHEC has implemented a dual validation system for the work of EDHEC-Risk. All research work must be part of a research programme, the relevance and goals of which have been validated from both an academic and a business viewpoint by the Institute's advisory board. This board is made up of internationally recognised researchers, the Institute's business partners, and representatives of major international institutional investors. Management of the research programmes respects a rigorous validation process, which guarantees the scientific quality and the operational usefulness of the programmes.

Six research programmes have been conducted by the centre to date:

- Asset allocation and alternative diversification
- Style and performance analysis
- Indices and benchmarking
- Operational risks and performance
- Asset allocation and derivative instruments
- ALM and asset management

These programmes receive the support of a large number of financial companies. The results of the research programmes are disseminated through the EDHEC-Risk locations in London, Nice, and Singapore.

In addition, EDHEC-Risk has developed a close partnership with a small number of sponsors within the framework of research chairs or major research projects:

- Regulation and Institutional Investment, *in partnership with AXA Investment Managers*
- Asset-Liability Management and Institutional Investment Management, *in partnership with BNP Paribas Investment Partners*
- Risk and Regulation in the European Fund Management Industry, *in partnership with CACEIS*

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The philosophy of the Institute is to validate its work by publication in international journals, as well as to make it available to the sector through its position papers, published studies, and conferences.

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EDHEC-Risk Institute: Key Figures, 2009-2010

Nbr of permanent staff	66
Nbr of research associates	18
Nbr of affiliate professors	6
Overall budget	€9,600,000
External financing	€6,345,000
Nbr of conference delegates	2,300
Nbr of participants at EDHEC-Risk Indices & Benchmarks seminars	582
Nbr of participants at EDHEC-Risk Institute Risk Management seminars	512
Nbr of participants at EDHEC-Risk Institute Executive Education seminars	247

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Research for Business

The Institute's activities have also given rise to executive education and research service offshoots. EDHEC-Risk's executive education programmes help investment professionals to upgrade their skills with advanced risk and asset management training across traditional and alternative classes.

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www.edhec-risk.com/AIeducation/PhD_Finance

The EDHEC-Risk Institute PhD in Finance is designed for professionals who aspire to higher intellectual levels and aim to redefine the investment banking and asset management industries. It is offered in two tracks: a residential track for high-potential graduate students, who hold part-time positions at EDHEC, and an executive track for practitioners who keep their full-time jobs. Drawing its faculty from the world's best universities and enjoying the support of the research centre with the greatest impact on the financial industry, the EDHEC-Risk Institute PhD in Finance creates an extraordinary platform for professional development and industry innovation.

FTSE EDHEC-Risk Efficient Indices

www.edhec-risk.com/indexes/efficient

FTSE Group, the award winning global index provider, and EDHEC-Risk Institute launched the first set of FTSE EDHEC-Risk Efficient Indices at the beginning of 2010. Offered for a full global range, including All World, All World ex US, All World ex UK, Developed, Emerging, USA, UK, Eurobloc, Developed Europe, Developed Europe ex UK, Japan, Developed Asia Pacific ex Japan, Asia Pacific, Asia Pacific ex Japan, and Japan, the index series aims to capture equity market returns with an improved risk/reward efficiency compared to cap-weighted indices. The weighting of the portfolio of constituents achieves the highest possible return-to-risk efficiency by maximising the Sharpe ratio (the reward of an investment per unit of risk). These indices provide investors with an enhanced risk-adjusted strategy in comparison to cap-weighted indices, which have been the subject of numerous critiques, both theoretical and practical, over the last few years. The index series is based on all constituent securities in the FTSE All-World Index Series. Constituents are weighted in accordance with EDHEC-Risk's portfolio optimisation, reflecting their ability to maximise the reward-to-risk ratio for a broad market index. The index series is rebalanced quarterly at the same time as the review of the underlying FTSE All-World Index Series. The performances of the EDHEC-Risk Efficient Indices are published monthly on www.edhec-risk.com.

EDHEC-Risk Alternative Indexes

www.edhec-risk.com/indexes/pure_style

The different hedge fund indexes available on the market are computed from different data, according to diverse fund selection criteria and index construction methods; they unsurprisingly tell very different stories. Challenged by this heterogeneity, investors cannot rely on competing hedge fund indexes to obtain a "true and fair" view of performance and are at a loss when selecting benchmarks. To address this issue, EDHEC Risk was the first to launch composite hedge fund strategy indexes as early as 2003. The thirteen EDHEC-Risk Alternative Indexes are published monthly on **www.edhec-risk.com** and are freely available to managers and investors.

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For more information, please contact:
Carolyn Essid on +33 493 187 824
or by e-mail to: carolyn.essid@edhec-risk.com

EDHEC-Risk Institute
393 promenade des Anglais
BP 3116
06202 Nice Cedex 3 — France
Tel: +33 (0)4 93 18 78 24

EDHEC Risk Institute—Europe
10 Fleet Place - Ludgate
London EC4M 7RB - United Kingdom
Tel: +44 207 871 6740

EDHEC Risk Institute—Asia
1 George Street - #07-02
Singapore 049145
Tel.: +65 6438 0030

www.edhec-risk.com