Diversification and the Inefficiency of the Market Cap Portfolio

Equity indexation using Market Cap-weighted portfolios appears so natural to investors today that it is easy to forget that indices have not always been considered as central to the investment process. The size of asset under management which are benchmarked to Market Cap Weighted indices has grown enormously over the last thirty years, but concerns about the efficiency of using such benchmarks have been raised both in the finance industry and in the academic world.
In this article we consider the efficiency of the Market Cap-weighted portfolios and compare the latter with some alternatives.

We first place the Market Cap-weighted indexing in its historical context and then consider what support the Capital Asset Pricing Model (CAPM) appears to give to this investment approach. We review the evidence for the efficiency of the Market Cap-weighted portfolios and examine the Market Cap-weighted portfolio and its alternatives from the perspective of diversification. We present an illustrative example drawn from the UK equity market to highlight the relative merits of the different portfolio constructions. The empirical results presented may cause some investors to revaluate their belief in the rela-

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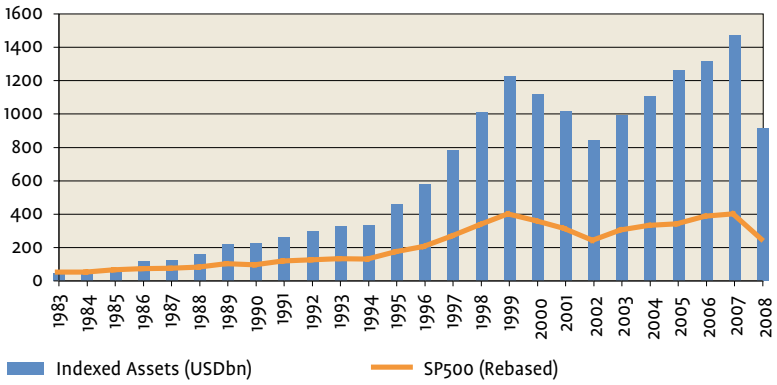
tive efficiency of the Market Cap-weighted portfolio for obtaining core equity exposure.

Historical Context

In the US the price-weighted Dow Jones Industrial Average dates back to 1884, while Standard and Poors introduced their market weighted index in 1923, expanding it to form the S&P500 index in 1957. Wells Fargo introduced an equally weighted institutional equity fund in 1971 but this did not catch on, one reason being that the cost of rebalancing was particularly high at the time with commissions at around 2% of the trade value. Then, in 1975, Vanguard introduced the first retail Market Cap weighted fund and Market Cap-weighted investment began to grow into a multi-trillion dollar set of investments globally. Siegel (2005) provides a more comprehensive history on the early days of indexing.

The decade of the 1950's also saw the introduction by Markowitz of mean variance portfolio theory, and the 1960's saw the introduction of the Capital Asset Pricing Model (CAPM) in its various forms. The Capital Asset Pricing Model (CAPM), introduced independently by Treynor (1961 unpublished), Sharpe (1964), Lintner (1965) and Mossin (1966), gave a special position to the Market Portfolio, suggesting that under some conditions the Market Portfolio should be the portfolio that maximizes the Sharpe Ratio (tangency portfolio) and be held, suitably leveraged or de-leveraged to allow for risk tolerance, by all investors.

Figure 1: Source: Blitzer & Macchia, Standards & Poors, Annual Survey of S&P Indexed Assets, July 2009. The Indexed Assets include Indexed and Enhanced Index Products. The SP500 has been rebased to the same levels as the Indexed Assets in 1983 and demonstrates that the amount of indexed assets has grown faster than the SP500 index itself.



The Market Cap-weighted portfolio has been broadly considered to be a good proxy for the Market Portfolio.

The US market is one of the most developed index markets and Standard and Poors estimated that in 2008 that USD3.51tr was benchmarked to the S&P500 Market Cap-weighted index, with approximately USD915bn of this directly in indexed assets. These figures do not take into account other US indices. Blitzer and Macchia at Standard and Poors presented results showing the phenomenal growth of the purely indexed S&P500 indices from the early 1980's.

Figure 1 shows that, over the period 1983 to 2008, the index grew by just 7.0% CAGR while the assets being indexed grew by 12.9% CAGR. Exchange traded funds and the availability of derivatives on indices have accelerated this trend.

Why have Market Cap Weighted indices become so popular? There are a number of possibilities which include (in no special order):

- Widely reported in financial markets and general media;
- Broadly accepted as a measure of market performance;
- Easily calculated;
- Apparent theoretical support from CAPM;
- Self-rebalancing buy-and-hold strategy;
- Most competitors use it;
- Sum of all (equity) portfolios.

It is clear that market cap-weighted indices are popular, but are they efficient *ex-post*? And if not, what are the reasons for this and what are the alternatives?

CAPM and the Market Portfolio

The Capital Asset Pricing Model is a very elegant model that has been scrutinized since it was first introduced in the 1960's. Built upon the Mean-Variance framework of Markowitz, the CAPM has been challenged in terms of its assumptions, its testability and its implications.
Some of these challenges include the Critique of Roll (1977) discussed further below, and the difficulties relating discreet and continuous time models raised by Rosenberg and Ohlson (1976) and by Fernholz and Shay (1982). In one sense, the model is just that – a

Figure 2: US Return/Risk comparison from Aug-1963 to Apr-2008. The Market-Cap Weighted (MC) index is the SP500; Equally Weighted (EQ); Minimum Variance (MV); Anti-Benchmark (AB); r_f is the risk free return. The dotted efficient frontier is illustrative only.

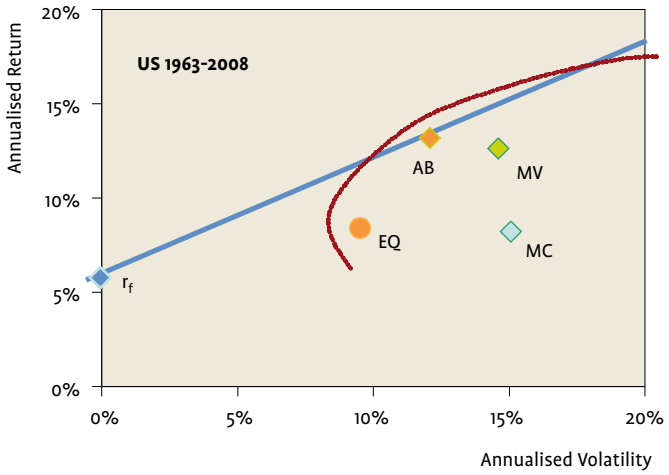
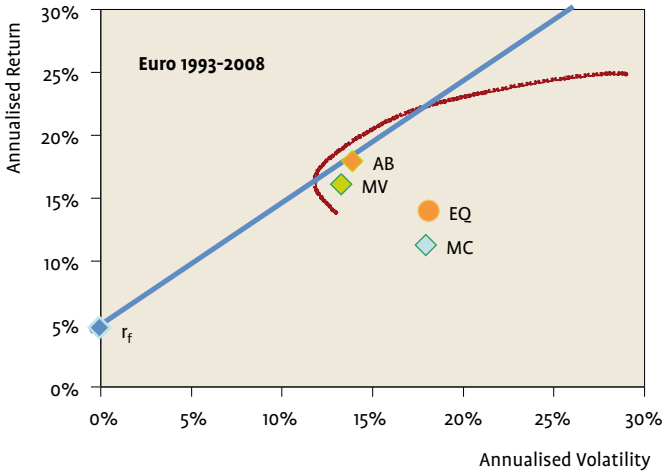


Figure 3: Eurozone Return/Risk comparison from Jan-1992 to Feb-2008. The Market-Cap Weighted (MC) index is the DJ EuroStoxx Large Cap Index; Equally Weighted (EQ); Minimum Variance (MV); Anti-Benchmark (AB); r_f is the risk free return. The dotted efficient frontier is illustrative only.



model; we should not expect the real world to be correctly represented by the CAPM.

The essence of CAPM is the following: with homogeneous investment views, all investors hold a portfolio that contains an amount of the risk free asset and an amount of the same optimal tangential portfolio of risk assets, where the weighting (amount) is dependent upon the risk tolerance of each investor; in order to clear the market, the net lending and borrowing should be zero and so the sum of the risky portfolios (which are all identical) should be the market portfolio.

In summary, the Roll Critique of the CAPM (Roll 1977) asserts that as the Market Portfolio is unobservable, as it should comprise not only all financial assets, but also any investable asset such as real estate, human capital etc.; an implication of this is that the CAPM is not directly testable using commonly available empirical data. For example, suppose one proved that equities' cross sectional returns are unrelated to their betas to a proposed market proxy such as a Market Cap-weighted equity index. It would be impossible to decide whether the CAPM does not hold, or instead the market proxy is not a good one.

The Market Cap-weighted portfolio is the most obvious proxy for the Market Portfolio.

It has been assumed by many investors that the differences between the Market Cap-weighted portfolio and the Market Portfolio are small enough to be ignored. This view, coupled with the theoretical support of CAPM, has encouraged the adoption of the Market Cap-weighted equity portfolio as the portfolio of choice for passive equity investors and as a reasonable benchmark for active equity investors. However, empirical studies of ex-post efficiency have called this assumption into question.

Empirical Results

Here we compare the market cap-weighted (MC) benchmark in the US and the Eurozone with the corresponding equally weighted (EQ), minimum variance (MV) and Anti-Benchmark (AB) portfolios. The Anti-Benchmark portfolio is designed to maximize the diversification within a given stock universe (Choueifaty 2006, 2008). No forecast is made of expected return and only the covariance information is used to construct the Anti-Benchmark weightings.

Figures 2 and 3 show the return to risk frontier diagrams respectively for the US (Aug-1963 to Apr-2008) and Eurozone (Dec-1992 to Feb-2008) for which we have common data for all the strategies we present. The results in both regions over this period clearly demonstrate that the Market Cap-Weighted portfolio has the lowest Sharpe Ratio, lower than any of the

other three strategies presented. This is in accord in the results of Haugen and Baker (1991) which span the period 1972-1989 in the US, where a low volatility portfolio would have beaten the Market Cap-weighted portfolio. A similar pattern of return/risk can be obtained in the UK and Japan.

The picture that emerges is that, from an *ex-post* perspective, the Market Cap-weighted portfolios appear to consistently underperform other systematic portfolios for long periods of time. Taken together, the studies suggest that, in the US at least, the Market Cap-weighted portfolio has been inefficient since 1963, before 1972 when the Market Cap-weighted index products were first marketed.

These results are somewhat shocking and must make investors sit up and think hard about their core equity investments. The portfolios strategies which have been used to compare to Market Cap-weighted are systematic, non-discretionary portfolio constructions. If the Market-Cap weighted portfolio is a relatively poor way of representing equity exposure, then two questions follow; "Why?" and "What other approaches might be better?".

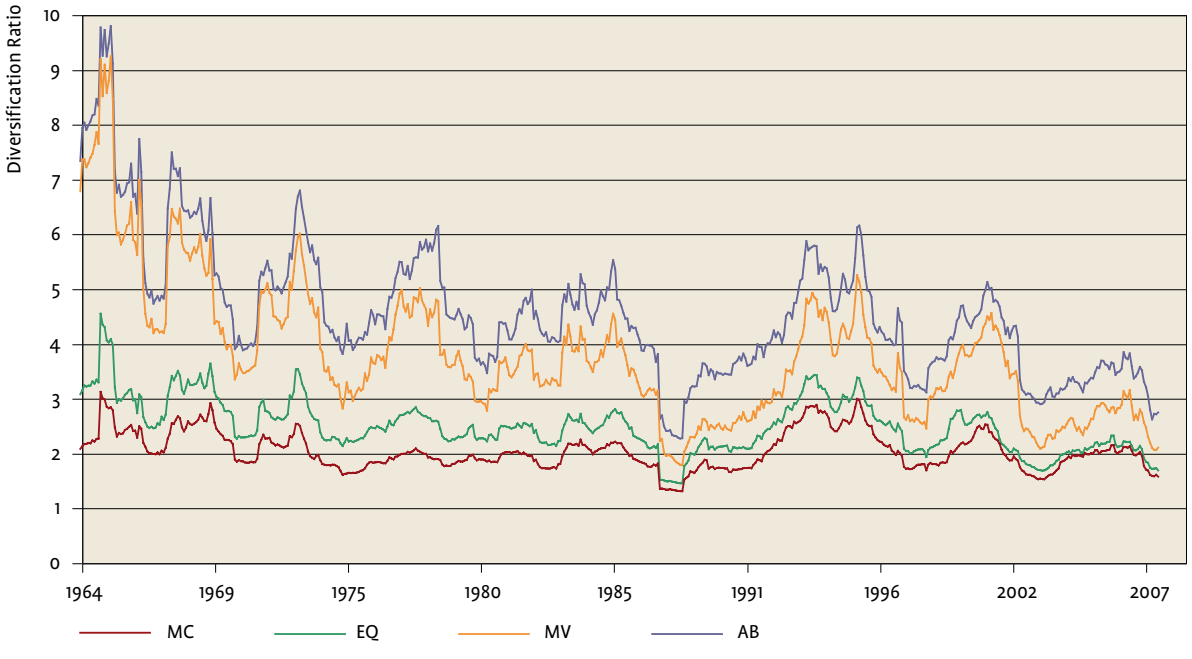
Diversification in Equity Markets

One claim often made concerning market cap-weighted indices is that they are diversified. However, without a metric for diversification such claims are qualitative only. Choueifaty (2006) introduced the Diversification Ratio, the weight averaged asset volatility divided by the portfolio volatility. This quantity is dimensionless because volatility is effectively found both in the numerator and denominator, so that if all asset volatilities doubled, there would be no change in the Diversification Ratio. The lowest value of Diversification Ratio in a long-only portfolio is 1, while the largest Diversification Ratio possible would be the square root of the number of assets in the portfolio.

Diversification is intuitively understood by many investors. Two simple examples serve to demonstrate this.

First, let us consider two stocks, A and B, where the expected volatility of stock A is twice that of stock B. Suppose that an investor has no views on expected returns. If the investor wants to diversify the budget risk in this two stock portfolio, she will hold twice as much of stock B as she does of stock A so that the

Figure 4: US Diversification Ratio from 1964 to 2008. The Market-Cap Weighted (MC) index is the SP500; Equally Weighted (EQ); Minimum Variance (MV); Anti-Benchmark (AB). Source TOBAM.



holdings of A and B will be in the proportion 33.3% to 66.7% respectively.

Next, consider a three stock portfolio of X, Y and Z, all stocks have the same expected volatility, and there are no views on expected return. If X and Y are highly correlated at 95% and Z has a low correlation of 5% with the two other stocks, then the most diversified portfolio will hold 25.3% of each of X and Y and 49.3% of Z. This gives us confidence that the Diversification Ratio is a useful measure of diversification, and that maximising it give us a method to generate the most diversified portfolio.

Figure 4 compares the Diversification Ratio of the Market Cap-Weighted, Equally Weighted, Minimum Variance and Anti-Benchmark Portfolios for the SP500 universe of US stocks. The most obvious aspect is that the Market Cap-weighed portfolio has a lower diversification Ratio than the other strategies over the full period 1964-2008. The Anti-Benchmark, by construction, will always have the highest *ex-ante* Diversification Ratio.
It is clear that, as measured by the Diversification Ratio metric, the Market Cap-weighted portfolio is poorly diversified.

The Market Cap-weighted portfolio has an implied strategy. Typically a Market Cap-weighting follows a power law-like distribution, effectively the well-known 80-20 heuristic where the top 20% of the stock ordered by market cap-weighting account for around 80% of the total market weight. For the S&P500 the heuristic is closer to being a 75-25 rule but the analogy is still useful. If one examines the strategy of such a Market Cap-weighted strategy, as a first approximation, the asset implied returns are proportional to the market weighting of a given asset (this actually being the case when the volatilities and correlations are identical for all assets). If an investor holds the Market Cap-weighted portfolio, as a first approximation, the implied expectation is that larger stocks will have a higher return than smaller ones. This means that the most concentrated stocks will become even more concentrated if these implied returns are realised, and the resulting implied returns in the next period will be even greater for the larger cap-weighted stocks relative to the smaller cap-weighted ones. Iterated to its absurd limit, there will be only one significant asset in the portfolio.

The Market Cap-weighted portfolios have strong biases and these biases change over time. Examples of these periodic biases are the Consumer Discretionary concentration at the beginning of the seventies, the Energy bubble which started to build in the late 1970s and the Technology bubble in the late 1990's. Figure 5 clearly identifies these periods where concentration has grown and diminished in the sector weightings in the SP500 since 1962. The

Figure 5: SP500 Sector Weights according to the GICS classification of Sectors. A bubble is seen in the Consumer Discretionary sector in 1972, in the Energy sector in 1981 and in Info Tech in 2000. More recently a smaller bubble in Financials deflated. There is a discontinuity in July 1976 when the SP500 was restructured.

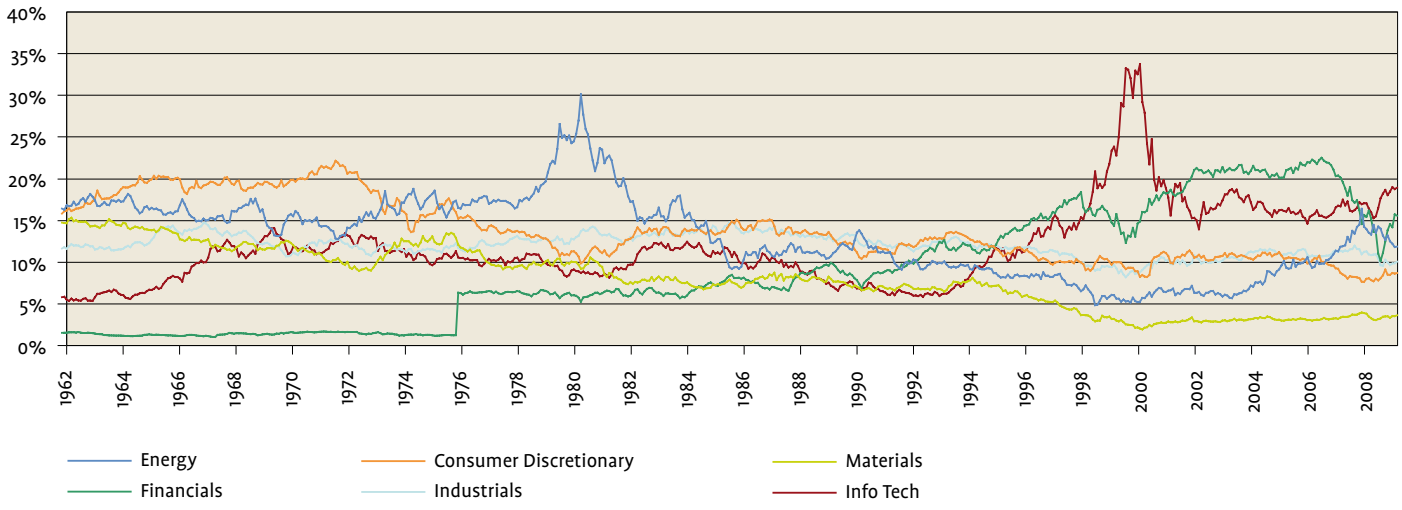
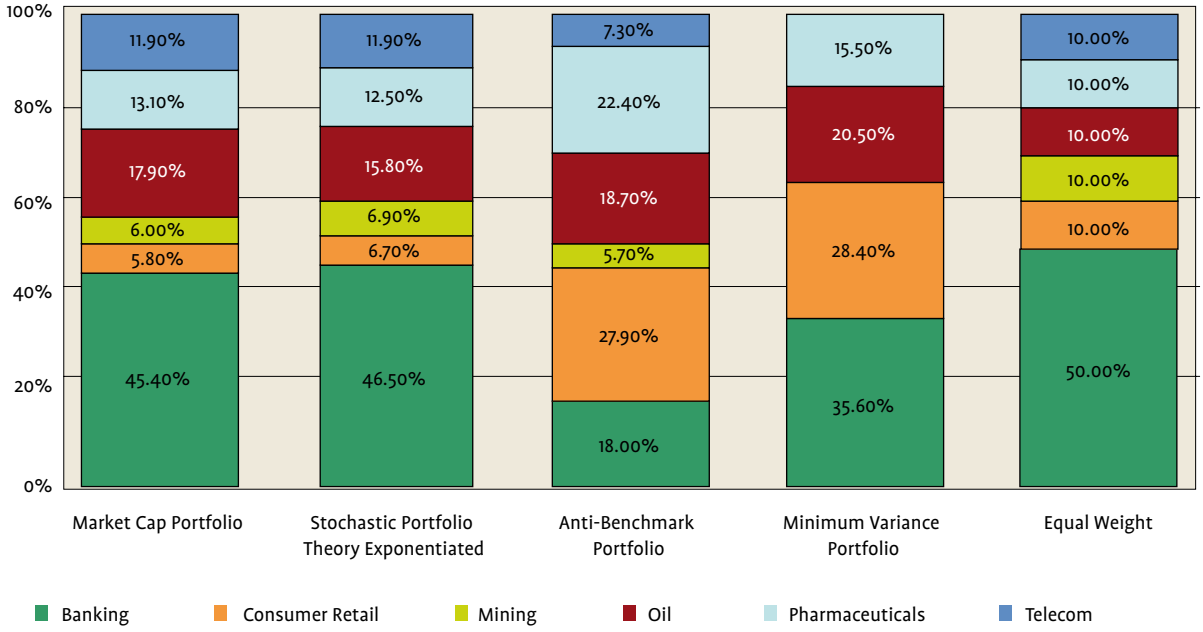


Figure 6: Industry Weightings for the UK Portfolio Construction Example.



appearance of these bubbles and, especially, their subsequent disappearance is a strong indication that the implied strategy of Market Cap-weighted portfolio has not worked in the past; the market has not continued to concentrate.

Approaches like Fundamental Indexation (Arnott et al. 2005) will typically produce portfolios with different weightings from the Market Cap- and Equally weighted portfolios; such approaches might reduce concentration. Unconstrained Minimum Variance portfolios are biased towards low volatility stocks or sectors.

The Anti-Benchmark approach of Choueifaty et al. (2006) by construction comes closest to creating a fully diversified portfolio within a set of operating constraints (e.g. Long-only equity). In the next section we present an illustration of how diversification affects both the distribution of assets and other characteristics when different methods of portfolio construction are employed.

Illustration Comparing Portfolio Construction in a Sub-universe of the UK Equity Market

For this illustration we use a universe of ten companies selected from the largest capitalised names of the MSCI UK Index in 2007. These companies represent six industries, of which banking is the dominant sector as is the case in UK market cap indices.

We first constructed five sample strategy portfolios:

1. Market Cap-Weighting;
2. Stochastic Portfolio Theory (SPT);
3. Equally Weighted;
4. Minimum Variance;
5. Anti-Benchmark.

Table 1 presents the Diversification Ratios, volatilities and tracking error information with respect to the Market Cap-Weighted portfolio. Both the Anti-Benchmark and Minimum Variance statistics are very different from the market cap portfolio, as demonstrated by having higher tracking errors to a market cap weighting scheme. The equally weighted basket is the highest absolute risk portfolio as measured by the portfolio volatility. The SPT portfolio is less different from the market cap weights than the other alternatives. In terms of diversification, as measured by the Diversification Ratio, the greatest is the Anti-Benchmark Portfolio (by construction), followed by the Minimum Variance portfolio.

Looking more closely at the stock weightings in Table 2, presented along with their industrial sector classification and stock volatility, a number of nota-

Table 1: Comparison of Portfolio Diversification Ratios, Annualised Volatility, Tracking Error to Market Cap-weighted portfolio for the UK Portfolio Construction Example.

	Market Cap Portfolio	SPT Portfolio	Equal Weight	Minimum Variance Portfolio	Anti-Benchmark Portfolio
Diversification Ratio	1.398	1.399	1.394	1.445	1.5
Portfolio Volatility	13.07%	13.25%	13.85%	10.67%	11.78%
Tracking Error to Market	–	0.46%	1.92%	5.63%	4.56%

Table 2: Portfolio Weightings for Different Construction Methods for the UK Portfolio Construction Example.

		Portfolio Weightings					
Company Name	Industry	Stock Volatility	Market Cap Portfolio	SPT Portfolio	Equal Weight Portfolio	Minimum Variance Portfolio	Anti-Bench-mark Portfolio
HSBC Holdings	Banking	13.48%	16.90%	15.10%	10.00%	25.90%	3.20%
RBS Group	Banking	17.42%	9.60%	9.90%	10.00%	–	1.90%
Barclays	Banking	22.24%	7.40%	8.10%	10.00%	–	–
HBOS	Banking	17.59%	6.40%	7.20%	10.00%	–	2.60%
Lloyds TSB GROUP	Banking	16.13%	5.10%	6.10%	10.00%	9.70%	10.30%
TESCO	Consumer Retail	15.73%	5.80%	6.70%	10.00%	28.40%	27.90%
Anglo American	Mining	35.32%	6.00%	6.90%	10.00%	–	5.70%
Royal Dutch Shell	Oil	16.04%	17.90%	15.80%	10.00%	20.50%	18.70%
GlaxoSmithKline	Pharmaceuticals	16.86%	13.10%	12.50%	10.00%	15.50%	22.40%
Vodafone Group	Telecom	22.18%	11.90%	11.60%	10.00%	–	7.30%

ble points arise. First, the Minimum Variance Portfolio has a definite bias towards the lower volatility stocks, selecting only five from the possible ten stocks. Next, the SPT portfolio has weights which are, by construction, always intermediate between the Market Cap Portfolio and the Equally Weighted Portfolio; in this example, the SPT weightings are not very different from the Market Cap Weightings and contain very similar biases.

Anti-Benchmark and Minimum Variance both have lower volatility than the other approaches, and higher tracking error than SPT or Equally Weighted. The higher tracking error reflects the poor diversification of the Market Cap-weighted example. Although the Anti-Benchmark is the most diversified, it has a lower tracking error than the Minimum Variance Portfolio. While some diversification benefit is evident in Minimum Variance, the benefit is offset by replacing the market cap bias with a low volatility bias, which actually increases its tracking error versus the market cap index. This can be observed in the concentration of low volatility stocks in the minimum variance approach in Table 2.

Now we consider the industry allocation in the UK Portfolio Construction example. To within some approximation the industries can be considered to represent different risk factors in the market. Figure 6 shows the weights aggregated into industrial sectors for each of the portfolios. The bias towards Banking is clear in the Market Cap Portfolio and Equally Weighted Portfolios and, thus, by extension, it is also for the SPT Portfolio. The Minimum Variance Portfolio contains biases driven only by which stocks have the lower volatility and so the industry weighting likely to be a side-effect; the Anti-Benchmark Portfolio, on the other hand, shows a good coverage over the different industries, with all of them being represented in the Portfolio, but also without the huge bias to Banking found in all the other portfolios.

Conclusion

The long-term results presented here show that the Market Cap-weighted portfolio has had the lowest return to risk ratios for the strategies compared in the US equity market over the period 1963-2008 and Eurozone equity markets over the period 1992 to

2008. These results are in accord with the earlier results of Haugen and Baker for the US.

We believe that the lower diversification in the concentrated Market Cap-Weighted portfolios can account for the poor risk adjusted performance relative to other portfolio constructions. Credible alternatives to Market Cap-weighted exposure have been already developed and the latter have been empirically shown to provide better absolute returns as well as better risk adjusted returns.

For investors the choice is clear; the default position of obtaining core equity risk exposure through the Market Cap-weighted portfolio must not be taken for granted. The Market Cap-weighted portfolio is not supported empirically and is a relatively inefficient way of creating Beta exposure. With other more efficient and diversified approaches available, the onus on fiduciary managers to consider alternatives will increase.

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