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FTSE RESEARCH WHITE PAPER

FTSE Global Equal Risk Contribution Index Series

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1. Introduction

Capitalisation-weighted equity market indices play a crucial role in financial markets as a benchmark, and provide the anchor for portfolio construction, performance attribution and risk management.

Capitalisation-weighted indices, representing the equity market opportunity set, combine desirable properties such as high levels of capacity, liquidity and low turnover. Index tracking funds represent one financial product designed to benefit from these properties.

Concentration, where a small number of stocks represent a disproportionately large percentage of an index, is a manifestation of market outcomes. Concentration may manifest itself not only at stock level, but also at industry and country levels. Individual countries with developed financial markets typically represent a sizable proportion of a global index. Industry concentration may arise as a consequence of investors' collective enthusiasm for particular industries. Price momentum may coincide with an increase in corporate earnings resulting in the over-valuation of stocks with specific characteristics culminating in valuation risk. Concentration is not confined to one dimension and may arise in many forms.

Diversification is the key to avoiding concentration and is the premise on which many risk-based indices are constructed. An equally weighted index represents the simplest weighting scheme and yields the least concentrated outcome in terms of index weights. However, such an approach typically exhibits limited investment capacity and high turnover (and naturally leads to a small cap bias). Consequently, the implementation of an equally weighted index is not straight forward.

Diversification is at the heart of the Equal Risk Contribution methodology, striking a balance between equal and capitalisation weighting and representing the most diversified outcome in terms of risk contribution. Equal weighting can be viewed as a special case of the Equal Risk Contribution approach to index construction where the market beta of all assets is assumed equal. If the correlations between all assets are assumed equal to zero, the Equal Risk Contribution approach is equivalent to an inverse volatility weighted index. In contrast, applying a zero correlation assumption to a Minimum Variance approach results an inverse variance weighted index.

The ERC methodology has strong parallels with and has evolved from the concept of Risk Parity (see for example, Bruder and Roncalli (2012)). The Risk Parity approach is commonly applied across asset classes and requires each asset class to contribute equally to risk. Typically, leverage is employed to maintain performance and target improvements in Sharpe Ratios. The drawback is that leverage applied to low risk asset classes involves timing risk and may not result in anticipated performance levels being realised.

This paper is structured as follows: Section 2 introduces the concept of risk contribution and the advantages of such an approach to index construction. The specifics of the FTSE Equal Risk Contribution index methodology are discussed in Section 3. Subsequently, in Section 4, we present the simulated performance and liquidity characteristics of the FTSE Equal Risk Contribution indices. In section 5, we examine the factor tilts, performance drivers and robustness of the indices. Finally, section 6 concludes.

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2. Equal Risk Contribution

2.1 The Importance of Risk Contribution

Risk Contribution (RC), or percentage risk contribution, is calculated as the product of Marginal Risk Contribution (MRC) and constituent portfolio weighting, normalised by portfolio risk. MRC is the sensitivity of portfolio level risk to a small change in the weighting of a portfolio constituent and is similar to the familiar concept of beta[1]. Mathematically, under the condition that total portfolio risk is one, MRC and beta are identical [2]. Stocks with zero or negative MRC are uncorrelated with other portfolio constituents and are natural candidates for reducing risk. In other words, the weighting of stocks with negative MRC can be increased in order to reduce portfolio total risk.

A financial interpretation of RC was developed by Qian (2006). He shows that RC is closely linked to the expected contribution to losses, a concept that is crucial to modern risk management. The implication is that the magnitude of portfolio draw-downs can be attributed to RC and are not solely related to the magnitude of portfolio weightings.

A risk budgeting approach represents a particular allocation of portfolio risk. Maillard et al (2010) argue that risk budgeting is the analysis of a portfolio in terms of risk contribution rather than in terms of portfolio weights. The Equal Risk Contribution (ERC) approach is a special form of risk budgeting where the risk budget is allocated equally to each asset. Sharpe (2002) suggests a monitoring system where RC is consistent with expected contribution to total expected returns. For example, if the relative contribution to expected return of large and small capitalisation stocks segments is 60/40, then the RC allocated to each segment should also be in the ratio of 60/40.

2.2 Risk Contribution and Index Construction: A Flexible Approach

The close link between RC and return contribution suggests that the RC approach can be usefully applied to index construction. A RC index refers to a collection of assets that achieves a predetermined profile of RCs.

The RC approach may be applied at security, industry, country or asset class level, reflecting investors' beliefs regarding the appropriate level of construction. Within a single asset class such as equities, the RC approach may be implemented at the security, industry, country or factor level. An ERC index at the industry level, for example, treats each industry as a distinct asset. Correlations below the industry level are ignored. We choose to implement the ERC methodology at stock level. Examples of RC indices are not limited to equities; the approach is applicable to fixed income, commodities, real estate and other asset classes.[3]

1 Formally, the MRC of a stock is the partial derivative of portfolio volatility with respect to stock weight.

2 MRC is the ratio of stock and portfolio covariance to portfolio volatility. Beta is the ratio of stock and portfolio covariance to portfolio volatility squared (variance). Hence, when portfolio variance is one, beta equals MRC.

3 The Neuberger Berman Risk Balanced Commodity Strategy Fund applies an ERC approach to 25-30 individual commodities to achieve diversified outcomes.

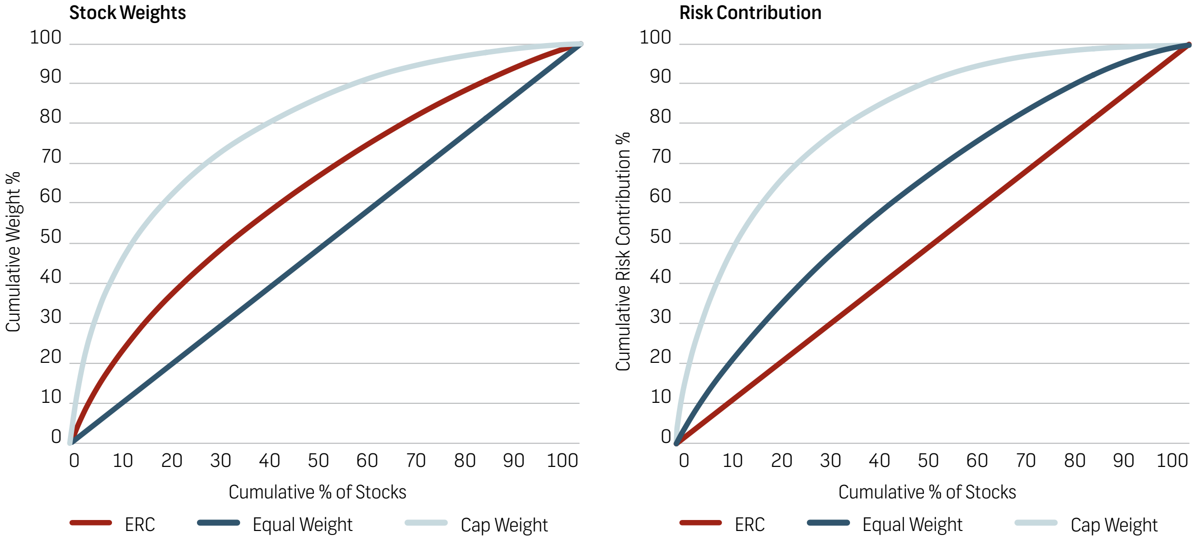
2.3 Risk Diversification

An equally weighted index represents the most diversified index outcome in terms of the distribution of index weights. Analogous to an equally weighted index, the ERC methodology ensures that all constituent securities contribute equally to the total risk of the index.

Figure 1 illustrates the concentration profiles of capitalisation-weighted, equally-weighted and ERC indices in terms of stock weights and RCs in the form of Lorenz curves. The y-axis represents the cumulative index weight or contribution to index risk for a given proportion of index constituents. The 45 degree line represents the least concentrated outcome. The capitalisation weighted index exhibits the highest levels of concentration, both in terms of index weights and RCs. The equally-weighted index does not offer equivalent RC diversification, implying that certain stocks contribute disproportionally to risk. The ERC index is less concentrated in weight terms than the capitalisation-weighted index and more importantly, less concentrated in terms of RC than the equally-weighted index.

Equally weighted indices are constrained by relatively low investment capacity and potentially higher turnover whilst offering less risk diversification under these assumptions.

Figure 1 Concentration — Weight and RC: FTSE Developed Large Cap Index (Dec 2012)



Source: FTSE
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2.4 ERC: Number of Constraints

The ERC methodology offers an alternative solution to equal weighting; diversified RCs.

The ERC index is a minimum variance index subject to long only and full investment constraints and the equilibrium condition that the RC of all stocks is equal. The ERC approach achieves the desired outcomes through both the overweighting of low volatility stocks and those that exhibit relatively low correlation to other stocks, resulting in naturally diversified outcomes. Compared to other risk based weighting schemes, the ERC approach naturally results in diversified outcomes, limiting the number of constraints that are in practice required and increasing index transparency.

An important implication of imposing fewer constraints during the construction of an ERC index is that ERC delivers what it is designed to do: each underlying constituent contributes equally to index risk. The resulting ERC index will be close to the theoretical outcome. As the number of constraints increases, any optimization process will tend to be dominated by the constraints, which in turn tend to dictate the solution.

The ERC approach to diversification warrants fewer constraints, but may also reduce index volatility. Since risk is additive when the underlying assets are perfectly correlated, volatility reduction is a natural result of diversification. Millard et al. (2010) proves that theoretically, the volatility of an ERC index lies between the equally-weighted and Minimum Variance indices:

Volatility (Min Variance) ≤ Volatility (ERC)
Volatility (ERC) ≤ Volatility (Equal Weight)

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3. FTSE Global ERC Indices

3.1 Definition of the FTSE Global ERC Indices

Let w_i be the weight of the i^{th} stock and define $C_{ij,T}$ to be the covariance between stocks *i* and *j* based on information available at time T. Assume N stocks. Let RC_i be the RC of the i^{th} stock. The ERC objective is to determine stocks weights in order to equalize the RC of each stock in the index. One approach is to design the objective function to ensure that RCs between any stocks *i* and *j* are equal, provided that the index is long only and fully invested.

$$w^* = \underset{w}{argmin} \sum_{i=1}^{N}\sum_{j=1}^{N}(RC_i - RC_j)^2$$

Subject to:

$$w_i \geq 0, \forall i \text{ and } \sum_{i=1}^{N} w_i = 1 \qquad \text{(Eq 1)}$$

Maillard et al. (2010) suggests an alternative implementation where the objective is to minimize total risk provided that the index is long only and satisfies the ERC property.

(Eq 2)

$$w^* = \underset{w}{argmin}\ \sigma = \sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N} w_i C_{ij,T}\, w_j}$$

Subject to:

$$w_i \geq 0, \forall i \qquad \text{(long-only constraint)}$$

$$\sum_{i=1}^{N} ln(w_i) \geq \left(\tfrac{1}{N}\right) \qquad \text{(log constraint)}$$

The objective function in (Eq2), together with the two constraints ensures the ERC property holds across all stocks. The weights from the optimization are normalized such that weights sum to one, $w_i^* = w_i / \sum_{i=1}^{N} w_i$. For each index comprising the FTSE Global Equal Risk Contribution Index Series, the optimisation algorithm defined in (Eq2) is used to determine the weighting scheme applied to large capitalisation constituents of the corresponding underlying FTSE universe. Mid-capitalisation constituents and stocks with an insufficiently long trading history are included in the ERC index at their investable market capitalisation weight. To ensure the index remains replicable, index weights are constrained to 20 times the investable market capitalisation weights post optimization. We discuss the rationale and effect of these practical considerations in section 3.3.

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3.2 Covariance Matrix Estimation

The composition of risk-based indices is solely determined by the estimated covariance matrix.[4] This has several advantages; firstly, there is no requirement to estimate expected returns – a notoriously difficult task; secondly, empirical estimates of the covariance matrix are relatively stable and hence a reasonable proxy for the future: Thirdly, the optimisation process is less sensitive to errors in estimates of the covariance matrix than to errors in forecasts of expected returns (for example, DeMiguel et al. (2008)).

The construction of an ERC index does not require forecasts of expected returns or equivalently expected returns are assumed to be identical for all assets. Estimates of the covariance matrix rely on historical return data, since covariance and volatility are relatively persistent in contrast to expected returns. The simplest approach is to compute the empirical covariance matrix from historical stock return information. However, this results in a sample covariance matrix of high dimensionality that is not ideal for a mean-variance optimization framework. For example, the sample covariance matrix for a 100-stock index requires 5050 estimates.

FTSE employs a statistical factor model to estimate the covariance matrix, $C_{ij,T}$ in Eq2. In essence, each factor in the PCA factor model represents a distinct dimension explaining a significant amount of asset level variation whilst each estimate in an empirical covariance matrix represents a factor however insignificant and correlated. The factor model reduces the number of dimensions and noise in the individual risk estimates and ensures the resulting covariance matrix is positive semi-definite. This property not only ensures that the covariance matrix can be inverted but also facilitates the solution to the mean-variance optimization problem. The additional stability of the covariance matrix from employing a factor model and the relatively long estimation window (two years of daily returns) has a beneficial impact on turnover.

Formally, the volatility and correlation estimation period is defined by the number of business days in the two years prior to each review date.

Volatility: $$\delta_{i,T} = \sqrt{\frac{1}{T_\delta - 1} \sum_{t=T-T_\delta+1}^{T} (r_{i,t} - \bar{r}_i)^2}$$

where T_δ = volatility estimation period (approx 500 to 520 days), $\bar{r}_i$ is the average return.

Correlation

$$\rho_{ij,T} = \left[\frac{1}{(T_\rho - 1)} \sum_{t=T-T_\rho+1}^{T} (r_{i,t} - \bar{r}_i)(r_{j,t} - \bar{r}_j)\right] / (\delta_{i,T}\delta_{j,T})$$

where T_ρ = correlation estimation period (approx 500 to 520 days).

Empirical Covariance Matrix: $\Omega_{ij,T} = \delta_{i,T}\,\delta_{j,T}\,\rho_{ij,T}$

A covariance matrix based on a Principle Component Analysis (PCA) of the $N \times N$ empirical covariance matrix is used. Let $\lambda_1, .., \lambda_K$ be the K eigenvalues of the empirical correlation matrix $\rho_{ij,T}$ that are bigger than $1 + N/T_\delta + 2\sqrt{N/T_\delta}$ and let $\bar{\Lambda}_1, ..., \bar{\Lambda}_K$ be their associated eigenvectors each with N elements. Let D_{nm} be the $K \times K$ diagonal matrix with $D_{nn} = \lambda_n$ and ρ_{nj} be the $K \times N$ matrix whose n^{th} row is given by $\bar{\Lambda}_n$. One then constructs the $N \times N$ PCA correlation matrix as $\phi = P^T DP$. The diagonal elements of ϕ are additionally constrained to be equal to one. The PCA covariance matrix is then defined by:

$$C_{ij,T} = \delta_{i,T}\,\delta_{j,T}\,\phi_{ij,T}$$

4 In real-world implementations, weights are also determined by additional constraints set by practitioners e.g. capacity constraints.

Table 1 compares the turnover of ERC indices using an empirical or sample covariance matrix derived from daily data with the turnover of indices employing the described factor model. The indices derived from the factor model approach consistently exhibit lower levels of turnover across all regions, with no deterioration in risk adjusted performance (Sharpe Ratio).

Table 1
Annualised Average Two-Way Turnover (%) and Sharpe Ratio of Semi-Annual Rebalanced ERC Indices (Sep 2003 – Jun 2013)

Turnover/ Sharpe Ratio	1-Year Sample Covariance T.O. / S.R.		2-Year Sample Covariance T.O. /S.R.		2-Year Factor Model T.O. /S.R.	
Developed	55.4	0.57	44.8	0.61	40.6	0.62
USA	42.2	0.38	35.0	0.40	34.5	0.38
Developed Europe	43.6	0.36	36.8	0.35	36.0	0.35
Developed Asia Pacific	53.2	0.44	43.7	0.43	41.5	0.43

Source: FTSE
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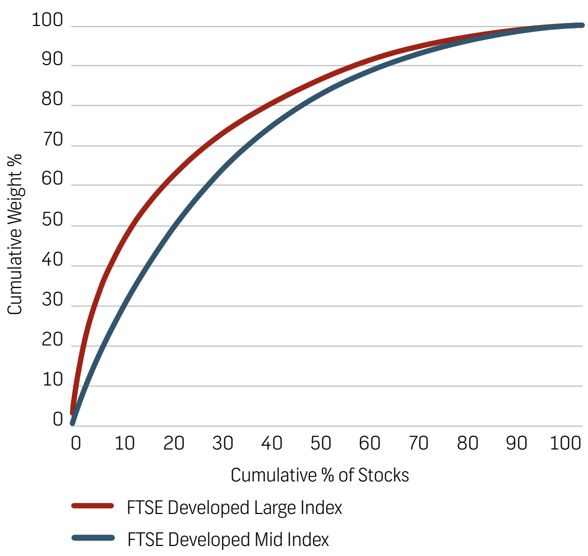
3.3 Tradability and Market Representation

The flexible nature of the RC approach allows ERC to be implemented within the large-capitalisation segment where there is both scope for diversification and capacity limits are less restrictive. The FTSE Developed Large Cap Index, due to its regional selection process, has a broad representation from super large capitalisation constituents to large capitalisation stocks. The resulting level of concentration provides a greater opportunity for diversification than in the FTSE Developed Mid Cap Index where stock weights are more evenly distributed. Figure 2 Diversification Opportunity (December 2012) visualizes the diversification opportunity within large and mid-capitalisation stocks. In particular, 12% of large capitalisation stocks account for half the FTSE Large Cap Index by weight in contrast to 20% for mid-capitalisation stocks.

Figure 2 Diversification Opportunity (December 2012)



Source: FTSE
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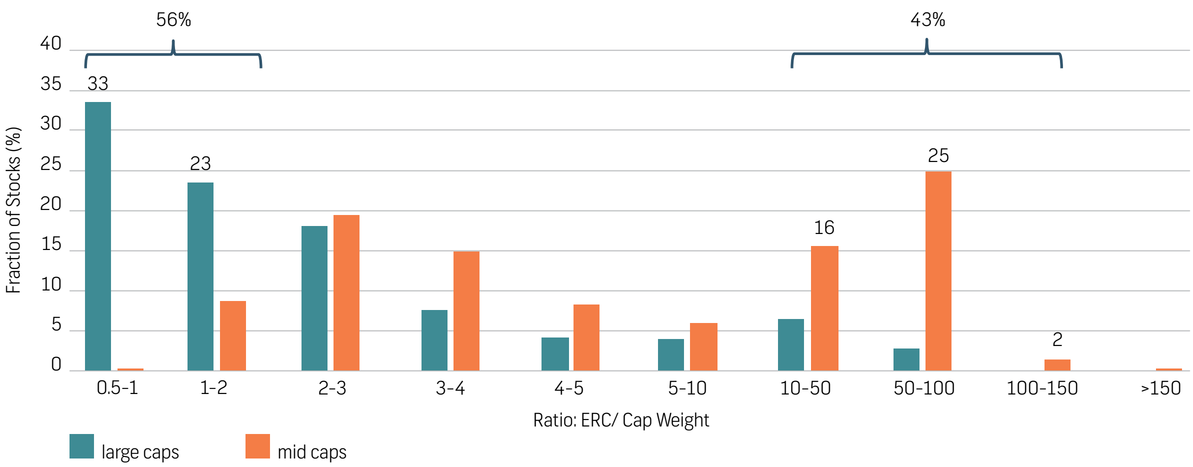
The objective of achieving a broad market representation prompts us to include mid-capitalisation stocks in the FTSE ERC indices. However, ease of replication and investment capacity pose a greater challenge for mid-capitalisation stocks and the ERC approach. Figure 3 plots the ratio of ERC to market capitalisation weights after applying the ERC approach to all stocks in the FTSE Developed Index (i.e. both large and mid-capitalisation segments). The distribution is evidently different for large and mid-capitalisation stocks. Note that, more than half (56%) of large capitalisation stocks exhibit an ERC weight that is similar to the capitalisation weight (0.5-2 times), whilst nearly half (43%) of mid- capitalisation stocks exhibit an ERC weight at least 10 times the capitalisation weight.

Figure 3 Diversification Opportunity vs. Tradability, FTSE Developed (Dec 2012)



Source: FTSE

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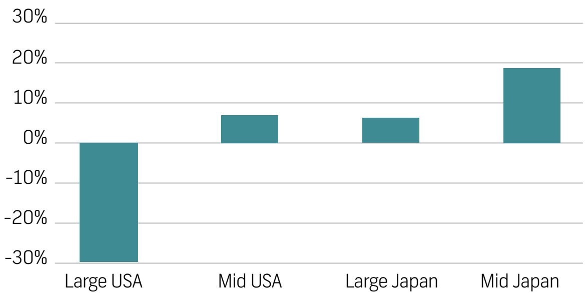
Investment capacity concerns pose a challenge if ERC is to be applied to all stocks in the underlying index. Furthermore the make-up of the large and mid-capitalisation segments differs significantly across countries and industries. For example, large capitalisation US and mid-capitalisation Japanese stocks constitute 42% and 1% of the FTSE Developed Index respectively. Additionally, we observe twice as many mid-capitalisation Industrial, Basic Material and Consumer Services stocks as large capitalisation stocks. The application of the ERC approach to mid-capitalisation stocks therefore results in larger active country and industrial weights relative to the underlying capitalisation weighted index than if applied to large capitalisation stocks in isolation culminating in higher tracking error. Figure 4 illustrates the ERC geographic size segment weights relative to the underlying segments in the capitalisation weighted index. We observe a significant underweight position in the large capitalisation US segment. Equally, the mid-capitalisation Japan segment is heavily overweight.

Figure 4 Active Country Weights, FTSE Developed (Dec 2012)



Source: FTSE

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A possible solution to the capacity concerns that arise from the application of ERC to mid-capitalisation stocks is to apply a capacity constraint to mid-capitalisation stocks, limiting the weight of such stocks in the ERC index to a multiple of their market capitalisation weights e,g. 20 times. Such an approach can be implemented post optimisation or as part of the optimisation process. The drawback to a capacity constraint is that it effectively breaks the ERC property of the index. A pragmatic approach is to assess whether the loss of this property is significant. In section 5.3 we show the effect of a post-optimisation constraint to large capitalisation stocks is trival. In contrast, Figure 3 suggests that the effect on mid-capitalisation stocks would be substantial.

Consequently, the different geographic and industrial make-up of the large and mid-capitalisation segments, capacity and tradability considerations and the requirement for a broad market representation lead us to include mid-capitalisation stocks at their investable market capitalisation weights.

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4. Simulation Results

4.1 Performance

Table 2 shows performance metrics of the FTSE Global Equal Risk Contribution and underlying market capitalisation weighted indices. The FTSE ERC indices have historically produced two-way turnover in the region of 30-40% p.a. Compared to the capitalisation weighted equivalent, turnover of the FTSE ERC indices has been substantially higher, reflecting the additional turnover required to adjust index weightings for reversals in volatility and correlation.

As a form of variance-minimization, the ERC indices have historically reduced volatility by 16% (FTSE Developed ERC Index). One observation is that volatility reductions tend to go hand in hand with lower draw-downs. Volatility reduction is a natural consequence of risk diversification. As such, risk diversification is particularly useful during market downturns when volatility and uncertainty is abundant.

The FTSE ERC indices have historically been defensive, exhibiting betas with respect to capitalisation weighted indices that are below one.

Table 2 Performance of FTSE ERC Indices (Sep 2003 - Oct 2013)

	Developed		USA		Developed Europe		Developed Asia Pacific	
	ERC	Developed Index	ERC	USA Index	ERC	Developed Europe Index	ERC	Developed Asia Pacific Index
Returns (%p.a.)	9.84	7.95	8.77	7.21	10.76	8.86	9.96	7.50
Volatility (%p.a.)	14.34	17.11	19.08	20.00	22.21	23.70	17.70	20.53
Sharpe Ratio	0.69	0.46	0.46	0.36	0.48	0.37	0.56	0.37
Vol. Reduction (%)	16.20		4.61		6.27		13.77	
Max DD (%)	-52.52	-57.37	-52.95	-54.73	-61.38	-62.65	-49.32	-55.32
Two Way Turnover (%p.a.) *	40.10	12.50	34.51	12.82	35.15	12.07	41.26	13.95
Excess Returns (%p.a.)	1.76		1.46		1.74		2.29	
Tracking Error (%p.a.)	5.36		2.19		2.77		4.31	
Information Ratio	0.33		0.67		0.63		0.53	
Alpha (%p.a.)	3.11		1.73		2.16		3.13	
Alpha T-Stat	2.42		2.85		3.09		3.36	
Beta**	0.80		0.95		0.93		0.85	

Source: FTSE

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Total Returns in USD

* Review turnover

** Geometric relative returns

*** statistically significant at the 5% level

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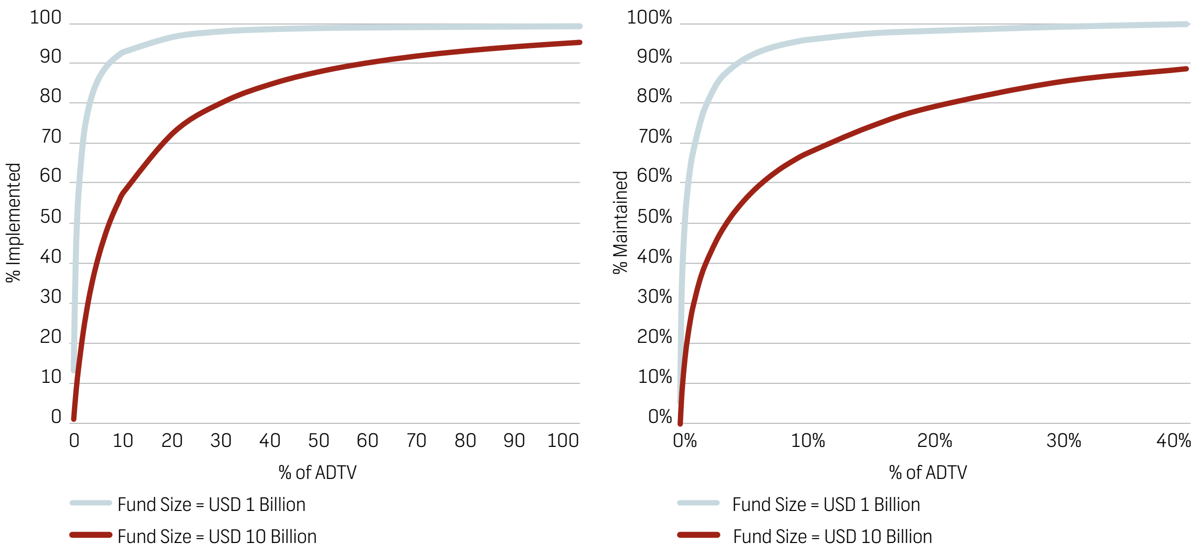
4.2 Implementation: Liquidity

Liquidity profiles can be used to gauge potential implementation issues regarding the capacity of indices. Specifically, the liquidity profile shows the proportion of a notional index that can be implemented or rebalanced (maintained) at various levels of Average Daily Traded Value (ADTV). Figure 5 shows such a liquidity profile for the FTSE Developed ERC Index. A hypothetical fund of USD 1 Billion would absorb approximately 40% of ADTV in order to implement the index. Approximately 98% of the index –could be replicated at around 30% of ADTV. The same 1 Billion USD fund would require less than 5% of the ADTV to maintain 90% of the index. In contrast roughly 90% of a hypothetical fund of USD 10 Billion would require 60% of the ADTV to implement and 40% ADTV to maintain.

Figure 5 Implementation and Maintenance, FTSE Developed ERC Index (Mar 2013)



Source: FTSE

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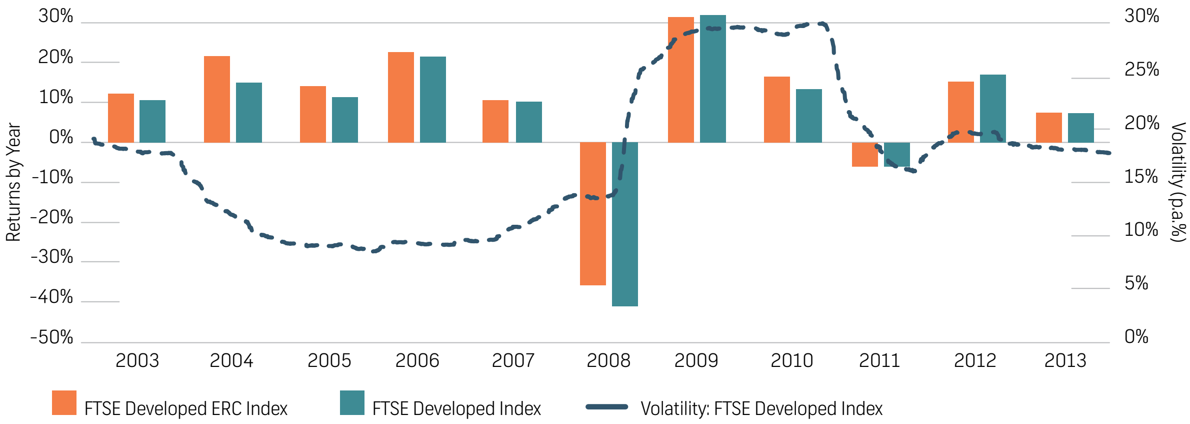
5. Robustness and Sources of Performance

5.1 Consistency of Performance

Figure 6 (chart below) shows the historic performance of the FTSE Developed ERC Index and the FTSE Developed Index by calendar year along with the rolling 2-year volatility of the FTSE Developed Index.

Figure 6 Performance by Calendar Year (2003– 2013)*



*2003: since September. 2013: til June

Source: FTSE

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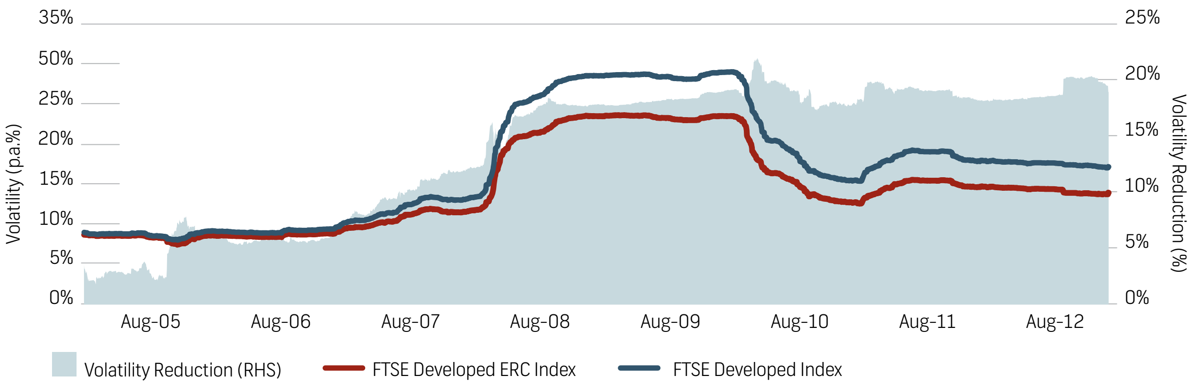
Theoretically, diversification should result in volatility reduction. With diversification at the heart of its construction, the ERC indices have historically exhibited a persistent pattern of volatility reduction, as shown in Figure 7. Volatility reductions have varied between 3%, during the less eventful periods, to 20% during more recent times. During the global financial crisis, the volatility of the FTSE Developed Index reached approximately 30% per annum. Over the same period, the FTSE ERC index exhibited volatility of 23% per annum.

Figure 7 FTSE Developed: 2-year Rolling Volatility and Volatility Reduction (Aug 2005 – Jun 2013)



Source: FTSE

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5.2 Robustness: Ex-post RC

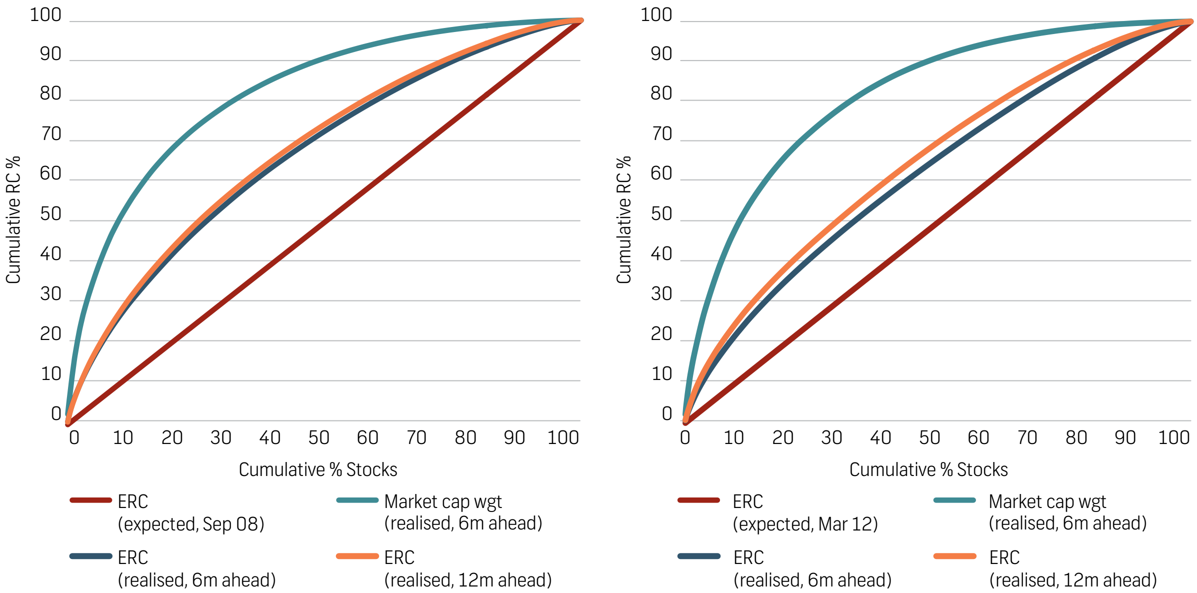
The FTSE ERC indices are a practical implementation of a theoretical model in which each stock is expected to exhibit an equal contribution to index risk. In reality expected and realised contributions to risk are likely to differ. Figure 8 compares the expected and realised RCs of an ERC and market capitalisation index based on the FTSE Large Cap Developed Index. Specifically, realised RCs are calculated using the sample covariance[5] matrix 6-months and 12-months after an index review using a two year data window – the same length as is used by the factor model in the construction of the ERC index. Therefore constituents included at their ERC weights in September 2008 have been assessed in terms of their actual contribution to risk using data over the relatively volatile period from March 2007 to March 2009 (6m ahead) and September 2007 to September 2009 (12m ahead). Additionally, we also show a comparable analysis of constituents from the March 2012 review with realised RCs calculated over the relatively benign periods of September 2010 to September 2012 and March 2011 to March 2013.

The 45° line in Figure 8 represents the expected RC of each stock, since each contributes equally to total index risk by construction. The capitalisation weighted index is concentrated in terms of realised RC; half of the capitalisation-weighted index by weight contributes approximately 90% of total risk. Half of the ERC index by weight contributes up to 75% and 70% of realised total risk as of the September 2008 and March 2012 reviews respectively.

To assess the magnitude of the drift in RCs, Figure 9 plots the distribution of index weight versus the ratio of realised (6-months after the review) to expected RCs. A reading of 0.9 to 1 on the X-axis indicates an overestimation of the RC of up to 10%. Conversely, a reading of greater than one indicates an underestimation. For the September 2008 review, approximately 80% of index has a realised to expected RC ratio in the region of 0.5 to 3 times. During the less volatile period (March 2012 review), approximately 92% of the index achieved this ratio.

5 The sample covariance matrix is used as it is straight forward to replicate.

Figure 8 Expected and Realised RC: FTSE Developed Large Cap (Sept 2008 and Mar 2012 Index Review)



Source: FTSE

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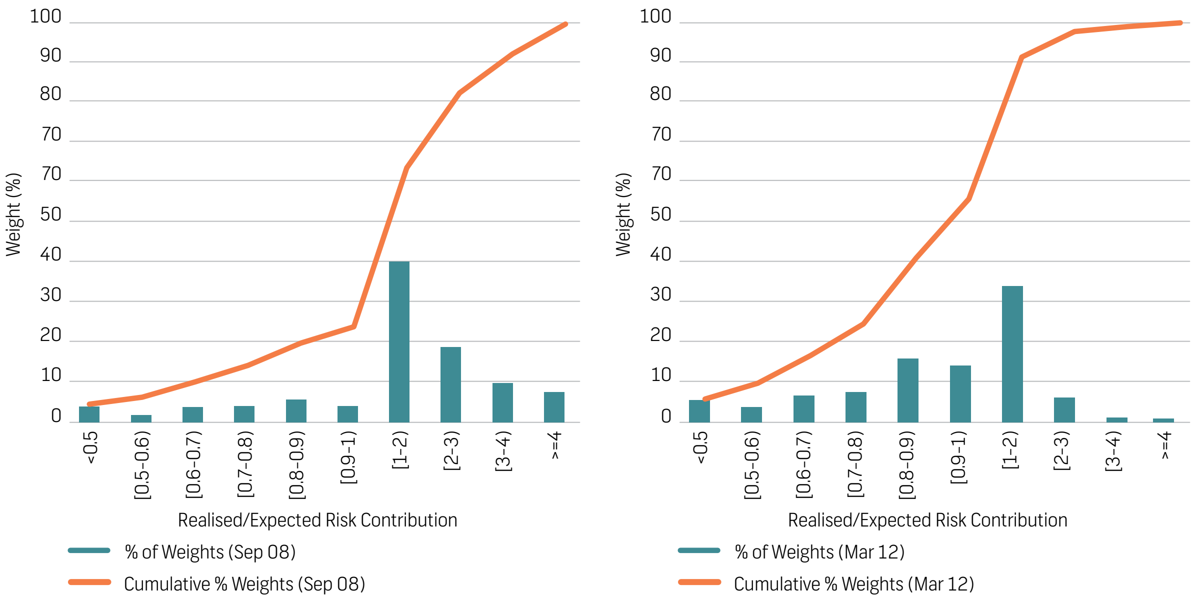
Figure 9: Expected and Realised RC: FTSE Developed ERC Index (Sept 2008 and Mar 2012 review)



Source: FTSE

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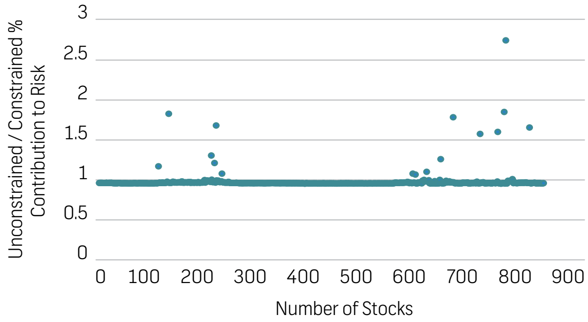
5.3 Robustness: Capacity Constraint

The application of the ERC approach to large capitalisation stocks does not ensure the resulting index is practical. A capacity constraint (see section 3.3) is applied post-optimization to facilitate replication whilst approximately retaining the ERC property.

Figure 10 illustrates the magnitude of the change in RC after the application of a capacity constraint that limits the ERC index weight to 20 times the market capitalisation index weight as of March 2013. Specifically the ratio of unconstrained and constrained contribution to risk is plotted. The majority of stocks (around 830) have retained the ERC property, whilst a handful of stocks have exhibited a larger RC. The magnitude of the drift in RCs is small (around 1 bps).

Figure 10 Impact of Capacity Constraint on ERC Property (FTSE Developed ERC – Large Cap, Mar 2013)



Source: FTSE

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5.4 Robustness: Performance of Large Cap ERC versus Large Caps

Section 2.2 highlights the flexibility of the ERC approach, whilst Table 2 in section 4.1 illustrates the past performance characteristics of the FTSE Global ERC indices, where the index includes both large and mid-capitalisation stocks, but the ERC approach is applied only to the former. Table 3 illustrates the past performance metrics of a set of large capitalisation only ERC indices compared to the relevant capitalisation-weighted FTSE Large Cap indices. One observation from comparing Table 3 with Table 2 concerns volatility reductions. A Developed Large capitalisation only ERC index exhibits a 18% reduction in volatility, 2% greater than that of the FTSE Developed ERC index. We expect to observe a greater reduction in volatility within the large capitalisation only ERC index because of the greater diversification opportunity that exists within this size segment. The tracking error of the FTSE ERC indices is lower than that of a large capitalisation only ERC index, since the FTSE ERC indices weight mid-capitalisation stocks by market capitalisation. Importantly, the past performance metrics in Table 2 are comparable to those in Table 3, where mid-capitalisation stocks are excluded, suggesting the inclusion of mid-capitalisation serves to increase index capacity and permit diversification across size categories.

Table 3 Performance of Large Cap ERC (Sep 2003 – Oct 2013)

	Developed		All World		Emerging	
	ERC Large Cap	Developed Large Cap Index	ERC Large Cap	World Large Cap Index	ERC Large Cap	Emerging Large Cap Index
Returns (%p.a.)	9.80	7.49	10.97	7.72	15.01	12.64
Volatility (%p.a.)	13.91	17.01	14.01	17.10	17.76	21.64
Sharpe Ratio	0.70	0.44	0.78	0.45	0.85	0.58
Vol. Reduction (%)	18.24		18.07		17.95	
Max DD (%)	-51.51	-57.12	-51.99	-57.32	-57.09	-64.65
Two Way Turnover (%p.a.) *	47.75		52.18		64.93	
Excess Returns (%p.a.)	2.15		3.02		2.11	
Tracking Error (%p.a.)	6.42		6.82		5.70	
Information Ratio	0.33		0.44		0.37	
Alpha (%p.a.)	3.70		4.66		4.14	
Alpha T-Stat	2.40		2.80		3.57	
Beta**	0.76		0.76		0.80	

Source: FTSE

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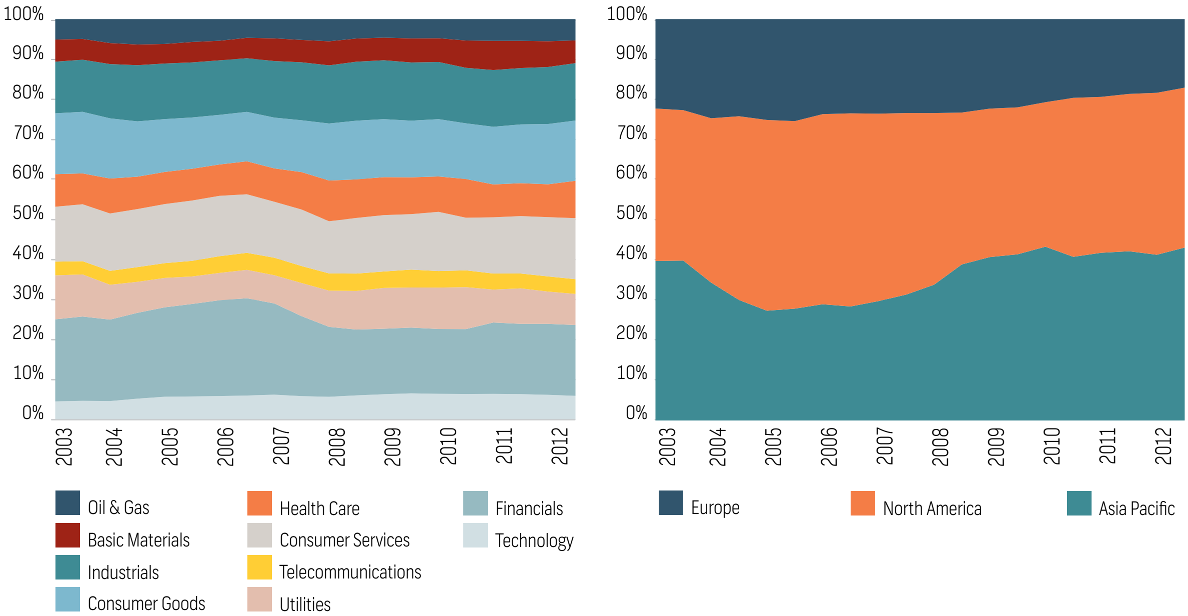
5.5 Diversification across Industries and Countries

At the core of the ERC methodology is diversification. Figure 11 shows the ICB industry and regional weights through time. Diversification is observed at the industry and regional level. Industry weights are balanced and stable through time.

Figure 11 Industry and Country/Regional Weights through Time (FTSE Developed ERC Index)



Source: FTSE
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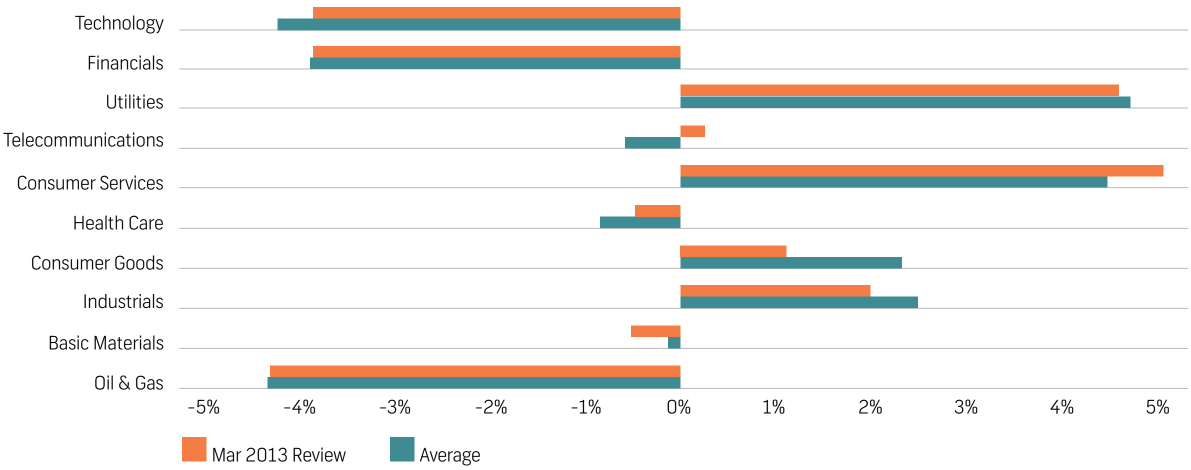
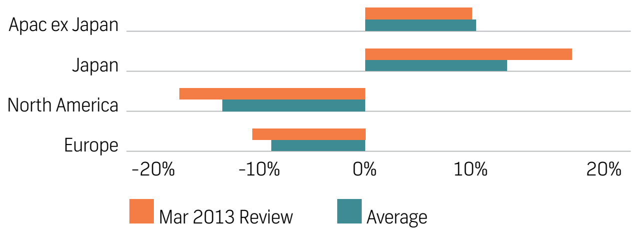
To understand the industry and regional allocations further, in Figure 12 we show the active weights associated with the FTSE Developed ERC index relative to the FTSE Developed Index as of March 2013. On average, the ERC index over-weights Utilities and Consumer Services whilst underweighting Financials, Technology and Oil & Gas. At a country/regional level, the ERC index tends to overweight Japan and under-weight the US.

Figure 12 Active Weights (FTSE Developed ERC Index, Mar 2013)





Source: FTSE

Past performance is no guarantee of future results. Returns shown may not reflect hypothetical historical performance.

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5.6 Robustness: Varying the Base Currency and Return Frequency

The covariance matrix of the FTSE Developed ERC Index is estimated from a USD perspective. We show that the results are not sensitive to the choice of base currency. Furthermore, our results are also robust to the frequency of returns used to estimate the covariance matrix. Table 4 presents performance metrics where the covariance matrix is constructed from either daily or weekly USD and Euro denominated currency returns with a 2-year data window, using both the sample covariance matrix and factor model approaches. Weekly returns are Wednesday to Wednesday non-overlapping returns. For completeness, Table A1 (see Appendix) presents comparable results utilising a covariance matrix denominated in JPY and local currency.

The risk-adjusted performance of ERC indices using daily or weekly EUR and USD returns are comparable, leading us to conclude that our results are robust to the choice of base currency and return frequency. Significantly the sample covariance matrix results in greater turnover than when a factor model approach is applied to the determination of the covariance matrix. This reinforces our conclusions on the usage of the factor model presented in Table 1. Additionally, turnover derived from the use of daily returns is lower than when weekly returns are used.

Table 4 Annualised Average Two-Way Turnover (%) and Sharpe Ratio: Semi-Annual Rebalance, FTSE Developed (Sep 2003 – Jun 2013)

Turnover / Sharpe Ratio	Sample Covariance				Factor Model			
	USD		EUR		USD		EUR	
	T.O.	S.R.	T.O.	S.R.	T.O.	S.R.	T.O.	S.R.
Daily Returns	44.8	0.61	43.8	0.59	40.6	0.62	39.7	0.60
Weekly Returns	63.9	0.60	65.1	0.60	45.1	0.62	46.3	0.62

Source: FTSE

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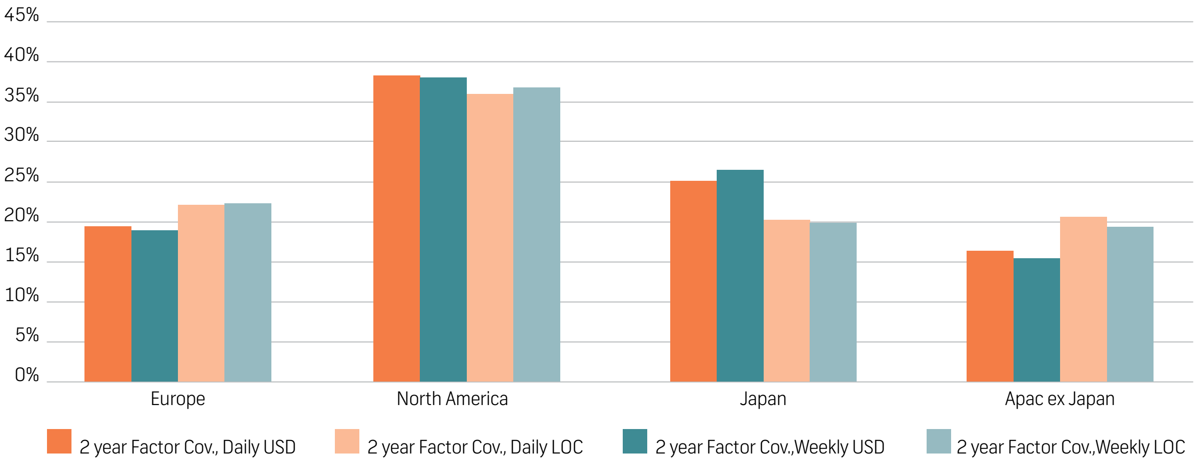
Furthermore, the distribution of industry and country weights is not affected significantly by the choice of base currency and return frequency. Figure 13 shows the regional and country weights of ERC indices based on daily and weekly USD and local currency returns.

Several observations are noteworthy from a reading of Table 4 and Figure 13. Firstly, the estimation of the covariance matrix from weekly returns results in slightly higher turnover than when daily returns are used. Secondly, the factor model approach results in lower turnover than the sample covariance matrix approach and this is more evident when using weekly returns than daily returns. Thirdly, the use of weekly returns results in a comparable weighting of Japan relative to the use of daily returns.

Weekly returns are less noisy than daily returns, resulting in larger covariance terms. However correlations rarely persist in the market for six months (a review period). Higher covariance coupled with non-persistency results in higher turnover in an ERC index derived using weekly returns. Furthermore, the transient component of covariance will not be captured by the factor model, implying lower levels of turnover in general from the application of a factor model.

Generally speaking, the ERC approach will over weight stocks that exhibit relatively low levels of correlation with other stocks. The Japanese market is closed when the US is open, suggesting one possible cause of the overweighting of Japan is artificially low correlations arising as a result of such non-synchronous trading. However, our empirical results indicate that daily returns and non-synchronous trading are not the source of the over-weighting of Japan, since the use of weekly returns results in similar outcomes. Perhaps the main reason is more fundamental: Japanese stocks have exhibited relatively low levels of correlation with the rest of the world in recent periods. This hypothesis is consistent with the results in Figure 13.

Figure 13 Average Regional/Country Weights: Varying Return Frequency – FTSE Developed ERC (Mar 2009-Mar 2013)



Source: FTSE

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5.7 Factor Exposures

Country and industry factors are traditionally important risk factors in explaining variations in asset returns. A market factor in conjunction with a set of style factors is typically able to explain a significant proportion of index or portfolio excess returns. Following Fama (1992), we run OLS regressions of monthly excess returns against a market factor and a set of style factors namely size, value and momentum. Table 5 documents the factor loadings from four regressions; the first compares index excess returns to a market factor; subsequently we add size, value and momentum factors to the regression.

The factor regressions indicate that annualized alphas, adjusted for market and style tilts are around 2% per annum historically. A consequence of risk reduction and diversification is that ERC indices are expected to have a smaller correlation with the market factor. Hence, the loading of excess returns on the market factor is expected to be negative. The loading on size premium is positive i.e. a small-cap tilt. The ERC indices exhibit a small insignificant growth tilt and a small yet significant negative loading on momentum.

Table 5 Factor Exposures of FTSE Developed ERC Index (Sep 2003 – Jun 2013)

	Regression 1	Regression 2	Regression 3	Regression4
Alpha (p.a.%)	2.1%	2.0%	2.0%	2.4%
Market	-0.09 (*)	-0.10 (*)	-0.10 (*)	-0.11 (*)
Size Premium		0.23 (*)	0.23 (*)	0.24 (*)
Value Premium			0.00	-0.03
Momentum				-0.05 (*)
R^2	24%	40%	40%	45%

Source: FTSE Fama / French Website

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* Statistically significant at the 5% level

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6. Conclusion

Risk reduction through diversification suggests that the RC approach can be usefully applied to index construction. Analogous to an equally weighted index, the ERC methodology ensures that all constituent securities contribute equally to the total risk of the index.

The ERC approach naturally results in diversified outcomes, limiting the number of constraints that are in practice required and increasing index transparency. The ERC approach to diversification warrants fewer constraints, but has also historically reduced index volatility (compared to an equivalent cap-weighted index). Volatility reduction is a natural consequence of risk diversification. As such, risk diversification is particularly useful during market downturns when volatility and uncertainty is abundant. The construction of an ERC index does not require forecasts of expected returns or equivalently assumes expected returns are identical for all assets. FTSE employs a statistical factor model to estimate the covariance matrix. The additional stability from employing a factor model and the relatively long estimation window (two years of daily returns) has a beneficial impact on turnover. We show the application of a factor model to the determination of the covariance matrix results in comparable performance and lower turnover to the sample covariance matrix approach. Moreover, index characteristics and outcomes are insensitive to the choice of return frequency and base currency used to construct the covariance matrix.

The flexible nature of the RC approach allows ERC to be implemented within the large-capitalisation segment where there is both scope for diversification and capacity limits are less restrictive. Investment capacity concerns pose a challenge if ERC is to be applied to all stocks in the underlying index. Differences in the geographic and industrial make-up of the large and mid-capitalisation segments, capacity and tradability considerations and the requirement for a broad market representation lead us to include mid-capitalisation stocks at their investable market capitalisation weights.

The application of the ERC approach to large capitalisation stocks and imposing a capacity constraint ensures the resulting index is both practical and approximately retains the important ERC property. We show that the magnitude of the change in RCs resulting from a capacity constraint is negligible. The main effect of limiting ERC to large capitalisation stocks and capitalisation weighting mid-capitalisation stocks is on improvements to investment capacity and diversification in size bands.

In summary, the FTSE Global ERC indices offer:

√ A Transparent Approach

√ Naturally Results in Diversified Outcomes

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Appendix

Table A 1: Annualised Average Two-Way Turnover (%) and Sharpe Ratio: Semi-Annual Rebalanced FTSE Developed (Sep 2003 – Jun 2013)

Turnover / Sharpe Ratio	Sample Covariance				Factor Model			
	JPY		LOC		JPY		LOC	
	T.O.	S.R.	T.O.	S.R.	T.O.	S.R.	T.O.	S.R.
Daily Returns	40.8	0.57	46.70	0.60	38.1	0.59	41.8	0.62
Weekly Returns	55.8	0.56	74.7	0.59	42.4	0.58	49.1	0.62

Table A 2: FTSE Global ERC Index Series Product Suite

FTSE Index	Base Currency
FTSE All-World Equal Risk Contribution Index	USD
FTSE Developed Equal Risk Contribution Index	USD
FTSE Developed ex Japan Equal Risk Contribution Index	JPY
FTSE Developed Asia Pacific Equal Risk Contribution Index	USD
FTSE Developed Asia Pacific ex Japan Equal Risk Contribution Index	USD
FTSE Developed Europe Equal Risk Contribution Index	EUR
FTSE Developed Europe ex UK Equal Risk Contribution Index	GBP
FTSE Eurobloc Equal Risk Contribution Index	EUR
FTSE North America Equal Risk Contribution Index	USD
FTSE Emerging Equal Risk Contribution Index	USD
FTSE Japan Equal Risk Contribution Index	JPY
FTSE USA Equal Risk Contribution Index	USD

For further information, please contact

Beijing	+86 10 5833 2202	**New York**	+1 888 747 FTSE (3873)
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