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Section 1

Introduction

1.0 Introduction

1.1 This document contains the Ground Rules for the construction and management of the FTSE EDHEC-Risk Efficient Index Series ("FTSE EDHEC-Risk EIS"). The Index Series is calculated by FTSE International Limited ("FTSE") using an optimisation approach developed by EDHEC-Risk Institute ("EDHEC-Risk") referred to in these Ground Rules as the Efficient Weight Method. The Index Series aims to reflect equity market performance of securities weighted in an optimal manner.

1.2 Optimal security weightings result from maximisation of the expected Sharpe Ratio. Sharpe Ratio maximisation requires two inputs: the expected return of each stock and the covariance matrix of stock returns.

1.3 The FTSE EDHEC-Risk EIS is based on the eligible constituent securities of the FTSE All-World Index Series (See Section 4 for Eligible Securities). Constituent weightings result from the application of an optimisation process to maximise the reward-to-risk ratio of a broad market index. The "efficiency" of the resulting index may be measured by improvements in the Sharpe Ratio (relative to capitalisation weighted index). More detail of the Sharpe Ratio calculation used in this context can be found Appendix A.

1.4 The FTSE EDHEC-Risk EIS does not take account of ESG factors in its index design.
1.5 FTSE EDHEC-Risk Efficient Index Series (EIS) is composed of the following Reference Indexes:

<table>
<thead>
<tr>
<th>FTSE EDHEC Index</th>
<th>Universe</th>
<th>Currency</th>
<th>Reference Indexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTSE EDHEC-Risk Efficient All-World Index</td>
<td>FTSE All-World Index</td>
<td>US Dollar</td>
<td>USA, Canada, Developed Asia Pacific ex Japan, Japan, Emerging Asia Pacific, Developed Europe ex Eurozone ex UK, UK, Emerging Europe, Latin America, Israel, Middle East &amp; Africa ex Israel</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient All-World ex US Index</td>
<td>FTSE All-World ex US Index</td>
<td>US Dollar</td>
<td>Canada, Developed Asia Pacific ex Japan, Japan, Emerging Asia Pacific, Developed Eurozone, Developed Europe ex Eurozone ex UK, UK, Emerging Europe, Latin America, Israel, Middle East &amp; Africa ex Israel</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient All-World ex Japan Index</td>
<td>FTSE All-World ex Japan Index</td>
<td>US Dollar</td>
<td>USA, Canada, Developed Asia Pacific ex Japan, Japan, Emerging Asia Pacific, Developed Eurozone, Developed Europe ex Eurozone ex UK, UK, Emerging Europe, Latin America, Israel, Middle East &amp; Africa ex Israel</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient All-World ex UK Index</td>
<td>FTSE All-World ex UK Index</td>
<td>US Dollar</td>
<td>USA, Canada, Developed Asia Pacific ex Japan, Japan, Emerging Asia Pacific, Developed Eurozone, Developed Europe ex Eurozone ex UK, UK, Emerging Europe, Latin America, Israel, Middle East &amp; Africa ex Israel</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Developed Index</td>
<td>FTSE Developed Index</td>
<td>US Dollar</td>
<td>USA, Canada, Developed Asia Pacific ex Japan, Japan, Developed Eurozone, Developed Europe ex Eurozone ex UK, UK, Emerging Europe, Latin America, Israel, Middle East &amp; Africa ex Israel</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Emerging Index</td>
<td>FTSE Emerging Index</td>
<td>US Dollar</td>
<td>Emerging Asia Pacific, Emerging Europe, Latin America, Middle East &amp; Africa ex Israel</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Developed Europe Index</td>
<td>FTSE Developed Europe Index</td>
<td>US Dollar</td>
<td>Developed Eurozone, Developed Europe ex Eurozone ex UK, UK</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Developed Europe ex UK Index</td>
<td>FTSE Developed Europe ex UK Index</td>
<td>US Dollar</td>
<td>Developed Eurozone, Developed Europe ex Eurozone ex UK</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Developed Eurozone Index</td>
<td>FTSE Developed Eurozone Index</td>
<td>Euro</td>
<td>Developed Eurozone</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Asia Pacific Index</td>
<td>FTSE Asia Pacific Index</td>
<td>US Dollar</td>
<td>Developed Asia Pacific ex Japan, Japan, Emerging Asia Pacific</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Asia Pacific ex Japan Index</td>
<td>FTSE Asia Pacific ex Japan Index</td>
<td>US Dollar</td>
<td>Developed Asia Pacific ex Japan, Emerging Asia Pacific</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Developed Asia Pacific ex Japan Index</td>
<td>FTSE Developed Asia Pacific ex Japan Index</td>
<td>US Dollar</td>
<td>Developed Asia Pacific ex Japan</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Developed Asia Pacific ex Japan ex Korea Index</td>
<td>FTSE Developed Asia Pacific ex Japan ex Korea Index</td>
<td>US Dollar</td>
<td>Developed Asia Pacific ex Japan ex Korea</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient USA Index</td>
<td>FTSE US Index</td>
<td>US Dollar</td>
<td>USA</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient UK Index</td>
<td>FTSE UK Index</td>
<td>UK Pound Sterling</td>
<td>UK</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Japan Index</td>
<td>FTSE Japan Index</td>
<td>Japanese Yen</td>
<td>Japan</td>
</tr>
</tbody>
</table>
1.6 Each FTSE EDHEC-Risk Efficient Index comprises a set of Reference Indexes. Eligible securities within each Reference Index are weighted using an efficient weighting method. Reference Indexes are used as the building blocks to create each aggregate index by weighting each component Reference Index by investable market capitalisation. This approach permits the efficient weighting method (See Section 6) to be applied within countries and regions (i.e. at the Reference Index level), whilst ensuring that in aggregate each index reflects the regional and currency structure of the comparable market capitalisation weighted index.

1.7 These Ground Rules should be read in conjunction with the FTSE Global Equity Index Series Ground Rules and the Corporate Actions and Events Guide for Non Market Capitalisation Weighted Indexes which are available at www.ftserussell.com. Unless stated in these Ground Rules, the FTSE EDHEC-Risk EIS will follow the same process as the FTSE Global Equity Index Series.

1.8 Price and Total Return Indexes will be calculated on an end of day basis. The Total Return Indexes include income based on ex dividend adjustments.

1.9 The indexes may be calculated in real time (See Appendix E).

1.10 The base currency of the benchmark is USD. Index values may also be published in other currencies.

1.11 FTSE Russell hereby notifies users of the index series that it is possible that circumstances, including external events beyond the control of FTSE Russell, may necessitate changes to, or the cessation of, the index series and therefore, any financial contracts or other financial instruments that reference the index series should be able to withstand, or otherwise address the possibility of changes to, or cessation of, the index series.

1.12 FTSE Russell


1.13 Index users who choose to follow this index or to buy products that claim to follow this index should assess the merits of the index’s rules-based methodology and take independent investment advice before investing their own or client funds. No liability whether as a result of negligence or otherwise is accepted by FTSE Russell or EDHEC-Risk for any losses, damages, claims and expenses suffered by any person as a result of:

- any reliance on these Ground Rules, and/or
- any errors or inaccuracies in these Ground Rules, and/or
- any non-application or misapplication of the policies or procedures described in these Ground Rules, and/or
- any errors or inaccuracies in the compilation of the Index or any constituent data.
Section 2

Management Responsibilities

2.0  Management Responsibilities

2.1  FTSE International Limited (FTSE)

2.1.1  FTSE is the benchmark administrator of the index series.

2.1.2  FTSE is responsible for the daily calculation, production and operation of the FTSE EDHEC-Risk EIS and will:

- maintain records of the index weightings of all constituents;
- make changes to the constituents and their weightings in accordance with the Ground Rules;
- carry out the periodic index reviews of the index series and apply the changes resulting from the reviews as required by the Ground Rules;
- publicise changes to the constituent weightings resulting from their ongoing maintenance and the periodic reviews;
- disseminate the indexes.

2.1.3  The weightings of constituents in the real time indexes shall be used in the calculation of the end of day indexes.

2.1.4  FTSE is also responsible for monitoring the performance of the FTSE EDHEC-Risk EIS throughout the day and will determine whether the status of the Indexes should be Firm, Held or Indicative (see Appendix E).

2.2  EDHEC-Risk Institute

2.2.1  EDHEC-Risk is responsible for the calculation of the efficient weights. EDHEC-Risk will provide the efficient weighting for each stock in the FTSE EDHEC-Risk EIS at each periodic review.

2.3  Status of these Ground Rules

2.3.1  These Ground Rules set out the methodology and provide information about the publication of the FTSE EDHEC-Risk EIS.

2.4  Amendments to these Ground Rules

2.4.1  These Ground Rules shall be subject to regular review by FTSE Russell to ensure that they best reflect the aims of the index series. Any proposals for significant amendments to these Ground Rules will be subject to consultation with FTSE Russell advisory committees and other stakeholders.
if appropriate. The feedback from these consultations will be considered by the FTSE Russell Product Governance Board before approval is granted.

2.4.2 Where FTSE Russell determines that the Ground Rules are silent or do not specifically and unambiguously apply to the subject matter of any decision, any decision shall be based as far as practical on the Statement of Principles. After making any such determination, FTSE Russell shall advise the market of its decision at the earliest opportunity. Any such treatment will not be considered as an exception or change to the Ground Rules, or to set a precedent for future action, but FTSE Russell will consider whether the Rules should subsequently be updated to provide greater clarity.
Section 3
FTSE Russell Index Policies

3.0 FTSE Russell Index Policies

These Ground Rules should be read in conjunction with the following policy documents which can be accessed using the links below:

3.1 Queries and Complaints

FTSE Russell’s complaints procedure can be accessed using the following link:

[Benchmark_Determination_Complaints_Handling_Policy.pdf](mailto: Benchmark_Determination_Complaints_Handling_Policy.pdf)

3.2 Recalculation Policy and Guidelines

3.2.1 The FTSE EDHEC-Risk EIS is recalculated whenever errors or distortions occur that are deemed to be significant. Users of the FTSE EDHEC-Risk EIS are notified through appropriate media.

For further information please refer to the FTSE Russell Recalculation Policy and Guidelines document which is available from the FTSE Russell website using the link below or by contacting info@ftserussell.com.

[Equity_Index_Recalculation_Policy_and_Guidelines.pdf](mailto: Equity_Index_Recalculation_Policy_and_Guidelines.pdf)

3.3 FTSE Russell Policy for Benchmark Methodology Changes

3.3.1 Details of FTSE Russell’s policy for making benchmark methodology changes can be accessed using the following link:

[Policy_for_Benchmark_Methodology_Changes.pdf](mailto: Policy_for_Benchmark_Methodology_Changes.pdf)
Section 4

Eligible Securities

4.0 Eligible Securities

4.1 Constituents of the FTSE All-World Index Series will be eligible for inclusion in the FTSE EDHEC-Risk EIS. Please refer to the FTSE Global Equity Index Series Ground Rules at www.ftserussell.com for information on the construction of the FTSE All-World Index Series.

4.1.1 Saudi Arabia will be assigned Secondary Emerging market status in March 2019, Saudi Arabia securities included in the FTSE Global Equity Index Series will be eligible for the FTSE EDHEC-Risk Efficient Index Series from September 2019.

4.2 Ineligible Securities

4.2.1 China A Shares included in the FTSE Global Equity Index Series are ineligible for inclusion in the FTSE EDHEC Risk Efficient Index Series.

4.2.2 Companies whose business is that of holding equity and other investments (e.g. Investment Trusts) classified by the Industry Classification Benchmark¹ as Subsector Equity Investment Instruments (8985) (New ICB Closed End Investments (30204000)) will not be eligible for inclusion. For further details on the Industry Classification Benchmark (ICB), please visit the ICB website:

Industry Classification Benchmark

¹ FTSE indexes will migrate to the new ICB classification system in March 2021.
Section 5

Periodic Review of Constituents

5.0 Periodic Review of Constituents

5.1 The FTSE EDHEC-Risk EIS applies the weighting method described in Section 6 to the constituents of each Reference Index.

5.2 The FTSE EDHEC-Risk EIS will be reviewed quarterly using eligible constituents of the relevant Reference Indexes on the Monday following the third Friday of March, June, September and December.

5.3 The cut-off date for the calibration data (see Rule 5.2.1) is the close of business on the first Friday of March, June, September and December i.e. two weeks prior to the implementation date of each review.

5.4 The quarterly review will be implemented after the close of business on the third Friday (i.e. effective the following Monday) in March, June, September and December.
Section 6

Efficient Weighting Method

6.0 Efficient Weighting Method

6.1 Objective

6.1.1 The determination of the efficient index weights that maximise the expected Sharpe Ratio of each Reference Index requires estimates of the stock return covariance matrix $\Sigma$, and expected stock excess returns, $\mu$ for each constituent of the Reference Index (See Section 8 for a definition of the risk and return inputs).

6.1.2 The FTSE EDHEC-Risk EIS index weights are the set of weights that maximise the expected Sharpe Ratio, given the risk and return inputs and the constraints described in 5.3. These are the efficient weights $w^*$, obtained according to:

$$w^* = \arg \max_w \frac{w' \mu}{\sqrt{w' \Sigma w}}$$

where $\mu$ is the vector of expected returns in excess of the risk free rate and $\Sigma$ is the stock return covariance matrix.

6.1.3 The solution to this optimisation problem results in weights $w^*$:

$$w^* = m \Sigma^{-1} \mu$$

where $m$ is a scalar that ensures that weights sum to one. These optimal weights determine the final weight of constituents of the FTSE EDHEC-Risk EIS.

6.1.4 Appendix B contains a two stock example that details the determination of index weights.

6.2 Data

6.2.1 Weekly (Friday close to close) local total return data over the two year period to the data cut-off of each quarterly review (see Section 5) is used. This data is referred to as the calibration data and the time period as the calibration period.

6.2.2 Local currency returns are used in the optimisation. Securities that trade in currencies other than the local currency are converted to US Dollar returns using the WM/Reuters official closing spot exchange rate.
6.2.3 Efficient weights are determined only for securities with sufficient data; securities with insufficient data are allocated a minimum weight.

6.2.4 Securities with more than ten missing data points or an unchanged price (typically illiquid stocks) over more than ten weeks during the calibration period are classified as having insufficient return data and their weights are set to the minimum weight. This minimum weight is defined as the lower weighting bound applied to securities which have sufficient data (see Rule 6.3).

6.3 Weighting Constraints

6.3.1 An upper and lower bound; \( u_i \) and \( l_i \) respectively are imposed on the weight of each constituent security, where \( i = 1, \ldots, N \).

6.3.2 The following process is applied to the weightings derived according to Rule 6.1, to ensure that each security’s weight lies between the upper and lower bounds \( u_i \) and \( l_i \).

\[
l_i \leq w_i^* \leq u_i
\]

a) All negative weights are set to zero. The remaining positive weights are normalised such that they sum to \( 1 - 1/\lambda \).

b) The lower bound \( 1/(\lambda N) \) is added to all weights, such that the sum of all weights is one.

c) Security weightings in excess of the upper bound are set equal to the upper bound and the excess weight is reallocated to all stocks that have weightings below the upper and above the lower bounds, in proportion to the degree to which the weight exceeds the lower bound.

d) If this procedure leads to additional breaches of the upper bound, Rule 6.3.2(c) will be repeatedly applied until the upper bound is respected by all securities.

6.3.3 By construction, the aggregate weight of all \( N \) constituent weights equals one. This is achieved by setting the aggregate weight of the \( Z \) securities forming part of the optimisation equal to the proportion of total index weight that is not taken up by the \( M \) stocks with insufficient data. More precisely, the sum of efficient weights obtained from the optimisation is set equal to \( 1 - \sum_{j=1}^{M} l_j \), where \( M \) is the number of stocks with insufficient data.

6.3.4 The lower bound of each index in the FTSE EDHEC-Risk EIS is equal to \( 1/(\lambda N) \) and the upper bound is equal to \( \lambda/N \), where \( N \) is the number of constituents. \( \lambda \) is set equal to three.

6.4 Optimal Control Approach

6.4.1 In order to limit turnover, the weightings obtained from the quarterly optimisation are only applied to the FTSE EDHEC-Risk EIS if the change in index weights is above a specific threshold. Turnover arising from an update to the optimal weights is applied only if the impact of such weight changes is substantial, i.e. if sufficient new information has arrived since the last index review.

Consequently, the new weights obtained from the optimisation \( w^* \) at each quarterly review may not be applied.

6.4.2 Let \( D \) be the effective date of the quarterly review. The optimised weights \( w^* \) and minimum weights for stocks with insufficient data determine the set of optimal weights \( w^\text{Optimal} \) to be applied. The weights \( w^\text{Optimal} \) are compared to the current index weights \( w^\text{Current} \) at the close of business of the cut-off date. The sum of the prospective absolute weight changes \( \delta_D \) is calculated as:

\[
\delta_D = \sum_i |w_i^\text{Optimal} - w_i^\text{Current}|
\]
6.4.3 If $\delta_D$ is greater than or equal to the threshold value $\delta_I$, the new weights from the re-optimisation are applied following the procedure described in 5.1, 5.2 and 5.3. If the threshold value is not breached, only index constituents are updated following the procedure described in Rules 6.4.6 and 6.4.7.

6.4.4 The threshold used to determine whether the re-optimised weights are applied is set at 70% for Developed Indexes and 90% for Emerging Indexes. For example, a threshold of 70% implies that re-optimised weights are only applied if at least 35% one way turnover is required.

6.4.5 Re-optimised weights are applied at the quarterly review, if the index has not been rebalanced optimally for 7 consecutive quarters, irrespective of whether or not the threshold described in Rule 6.4.4 is breached. Consequently, the application of optimised weights will occur at least every two years.

6.4.6 If only the index constituents are to be updated at quarterly review date $D$ then this set constituents $C$ is compared to the constituents as of the cut-off date.

6.4.7 The procedure for updating constituents only is as follows:

a) The minimum weight $1/(\lambda N)$ is applied to all new stocks entering the Reference Indexes. This permits new constituents to be taken into account without including them in the optimisation. Let the number of new entrants be $E$.

b) Deleted stocks have their weights set to zero according to:

$$ w_i^{Current} = 0 \text{ if stock } i \text{ is not in } C. $$

c) The rebalance weights $w_i^D$ of constituents as of the cut-off date are now calculated as:

$$ w_i^D = \frac{w_i^{Current}}{\sum_{i=1}^{E} w_i^{Current}} \times \left[ 1 - E * 1/(\lambda N) \right] $$

6.5 Liquidity Rules

6.5.1 In order to facilitate replication of the index, two capping rules are applied to the index weights determined through the application of Rules 6.1 to 6.4.

6.5.2 The maximum multiple of the free-float market capitalisation weight is set at 10x. Note that the re-normalisation of index weights may result in some securities breaching the 10x market capitalisation weight.

6.5.3 The change in index weight at each quarterly review is limited to a security’s market capitalisation weight in the case of Developed Markets and to 50% of the market capitalisation weight Emerging Markets.

6.6 Weight Adjustment Factor

6.6.1 At the review date the efficient weights applied to constituents correspond to the weights obtained by the application of Rules 6.1 to 6.5.

6.6.2 FTSE computes a Weight Adjustment Factor for each constituent at the review date. This factor is computed by dividing the FTSE EDHEC-Risk Efficient Weight by the market capitalisation weight in
the relevant Reference Index. Multiplication of the free-float adjusted capitalisation weight of each constituent in the Reference Index by the Weight Adjustment Factor results in the FTSE EDHEC-Risk efficient index weight.

6.7 **Index Calculation Formula**

6.7.1 The Weight Adjustment Factor, $x_i$, is given by $x_i = w_i / c_i$, where $w_i$ is the efficient weight obtained for the $i$-th constituent ($i = 1, \ldots, N$) and $c_i$ is its (free-float adjusted market capitalisation) weight in the underlying FTSE Reference Index with: $c_i = c_i / \sum_{j=1}^{N} c_j$

6.7.2 The FTSE EDHEC-Risk EIS is calculated by adjusting the free float adjusted capitalisation weight in the underlying index using the Weight Adjustment Factor, i.e. $w_i = x_i c_i$

The index calculation formula is:

$$\sum_{i=1}^{N} \left( p_i \times e_i \times s_i \times f_i \times x_i \right) / d$$

where:

- $i = 1, 2, \ldots, N$
- $N$ is the number of securities in the FTSE EDHEC-Risk Efficient Index;
- $p_i$ is the price of the $i$-th security;
- $e_i$ denotes the relevant exchange rate;
- $s_i$ denotes the number of shares in issue;
- $f_i$ denotes the investability weight computed by FTSE based on the free float;
- $d$ is the index divisor, which represents the index-wide capitalisation at the initial date;
- $x_i$ denotes the Weight Adjustment Factor.
Section 7

Changes to Constituent Companies

7.0 Changes to Constituent Companies

7.1 New Issues

7.1.1 The FTSE EDHEC-Risk EIS will not have intra-review additions.

7.1.2 When a constituent is added to an underlying FTSE All-World Index, if eligible, the constituent will be included in the corresponding FTSE EDHEC-Risk EIS at the next quarterly review. New Issues if eligible are considered as additions.

7.2 Deletions

7.2.1 If a constituent is removed from the underlying FTSE All-World Index, the constituent will also be removed from the relevant FTSE EDHEC-Risk Efficient Index. The deletion will be concurrent with its deletion from the FTSE All-World Index.
Section 8

Corporate Actions and Events

8.0 Corporate Actions and Events

8.1 If a constituent in the underlying index has a stock split, stock consolidation, rights issue, bonus issue, a change in the number of shares in issue or a change in free float, the constituent’s weighting in the FTSE EDHEC-Risk EIS Index will remain unchanged pre and post such an event.

8.2 Full details of changes to constituent companies due to corporate actions and events can be accessed in the Corporate Actions and Events Guide for Non Market Cap Weighted Indexes using the following link:
Corporate_Actions_and_Events_Guide_for_Non_Market_Cap_Weighted_Indices.pdf

A Corporate ‘Action’ is an action on shareholders with a prescribed ex date. The share price will be subject to an adjustment on the ex date. The index will be adjusted in line with the ex date.

These include the following:
• Capital Repayments
• Rights Issues/Entitlement Offers
• Stock Conversion
• Splits (sub-division) / Reverse splits (consolidation)
• Scrip issues (Capitalisation or Bonus Issue)

A Corporate ‘Event’ is a reaction to company news (event) that may impact the index depending on the index rules. For example, a company announces a strategic shareholder is offering to sell their shares (secondary share offer) – this could result in a free float weighting change in the index.

Where an index adjustment is required FTSE will provide notice advising of the timing of the change.

8.3 Suspension of Dealing

Suspension of Dealing rules can be found within the Corporate Actions and Events Guide for Non Market Cap Weighted Indexes.

8.4 Takeovers, Mergers and Demergers

The treatment of takeovers, mergers and demergers can be found within the Corporate Actions and Events Guide for Non Market Cap Weighted Indexes.
Section 9

Definition of Optimisation Inputs

9.0 Definition of Optimisation Inputs

In order to compute the efficient index weights according to the formula in Rule 6.1.3, two inputs are required: the covariance matrix of returns of index constituents and the vector of expected excess returns. The following two subsections describe the estimation of each of these inputs.

9.1 Covariance Matrix

9.1.1 An estimate of the covariance matrix of securities in the underlying FTSE All-World Indexes is necessary to describe the interdependence of constituent returns. This interdependence is irrelevant in determining the expected return of the efficient index, however covariance is important for computing the volatility of the efficient index. Calculating the covariance matrix from past return observations leads to estimation error. Therefore some structure is imposed on the covariance matrix to reduce the dimensionality of the estimation problem. The approach to modelling the covariance matrix in the FTSE EDHEC-Risk EIS is described below.

9.1.2 A large number of stocks results in exponential growth in the number of parameters to be estimated; the majority of them pairwise correlations. To reduce the number of dimensions, a multifactor model is used to decompose the returns of an asset into the expected rewards from exposure to common risk factors. A factor model of the following form is used:

\[ r = \alpha + \beta F + \epsilon \]

Where \( i \) is column vector that contains the returns for the \( Z = N-M \) stocks that enter the optimisation. \( N \) is the number of constituents and \( M \) is the number of stocks with insufficient data. \( r \) depends linearly on the \( K \) random factors of column vector \( F \). The matrix \( \beta \) contains the loadings of the \( Z \) stocks on the \( K \) factors. \( \alpha \) is a vector of constants and \( \epsilon \) is a vector of random error terms.

9.1.3 Given the factors and the loadings of each stock on these factors, the covariance matrix may be estimated as:

\[ \Sigma = \beta \Sigma_F \beta' + \Sigma_\epsilon \]

where \( \Sigma_F \) is the \( K \times K \) factor covariance matrix and \( \Sigma_\epsilon \) is the \( Z \times Z \) covariance matrix of error terms. Modelling covariance in this way avoids the noise in the estimation of individual covariance terms. The covariance between two stocks is entirely driven by exposure to common risk factors.
9.1.4 To construct the covariance matrix, factors and factor loadings are required. A statistical factor model is used. Each factor is modelled as a linear combination of returns of individual index constituents. The first $K$ principal components are extracted. These principal components yield the best $K$-dimensional summary of the information contained in stock returns.

9.1.5 The exact procedure used to extract principal components and construct the covariance matrix is described in Appendix C. A comprehensive description of the approach can be found in Ruey Tsay, Analysis of Financial Time Series, Wiley, 2002, 1st ed., Chapter 8.7 and 8.8.

9.2 Expected Returns

9.2.1 Expected returns are difficult to estimate and present a problem in any portfolio optimisation problem. Financial theory indicates investors will be averse to holding securities with high total risk. Downside risk or semi-deviation of returns is used to estimate total risk. The total risk estimate provides a means to estimate expected returns; since, ceteris paribus investors wish to avoid holding high total risk stocks, these stocks will have a relatively low prices and thus relatively high expected returns.

9.2.2 Semi-deviation is a downside risk measure and a more meaningful definition of risk compared to volatility, since only deviations below the mean are considered. The semi-deviation of the returns of each constituent $SEM_i$ with respect to the average return $\mu_i$ is calculated as:

$$SEM_i = \sqrt{E[\min(r_{i,t} - \mu_i)^2]}$$

where $E(.)$ denotes the expectation operator computed as the arithmetic average, $\min(x,y)$ denotes the minimum of $x$ and $y$, and $r_{i,t}$ is the return of stock $i$ in week $t$.

9.2.3 Individual semi-deviation values of each stock are not used. Rather stocks are grouped by semi-deviation and the median semi-deviation of stocks within each group forms the expected return estimate for each stock in that group. More precisely, stocks are sorted into deciles based on semi-deviation. That is, the 10% of stocks with the highest semi-deviation form one group; the 10% of stocks with the next highest semi-deviations the next group and so forth. Within each group, the median semi-deviation of all stocks within the group forms the expected return of all stocks within that group.

---

2 If the index has less than 100 constituents, quintiles are used instead. If the index has less than 50 constituents, quartiles are used.
Appendix A: Sharpe Ratio Definition

The Sharpe Ratio of a portfolio is defined as the expected portfolio return in excess of the risk free rate divided by the risk of the same portfolio. Risk is measured in terms of the volatility or standard deviation of portfolio returns:

\[ S_p = \frac{\mu_p}{\sigma_p} \]

Where \( \mu_p = E(R_p) - R_f \) i.e. the expected excess return is computed as the difference between the expected portfolio return and the risk free interest rate.

Given a vector \( \mu \) of portfolio weights, the numerator of the Sharpe Ratio may be calculated from the vector \( \mu \) of constituent expected excess returns. The denominator of the Sharpe Ratio can be computed from the constituent return covariance matrix \( \Sigma \)

\[ \mu_p = \mu w \quad \sigma_p = \sqrt{w^T \Sigma w} \]
Appendix B: Example of Calculations

The weights of the maximum Sharpe Ratio portfolio are given by

\[ w^* = m \Sigma^{-1} \mu \]

With two stocks:

\[ \Sigma = \begin{pmatrix} \text{Var}_1 & \text{Cov} \\ \text{Cov} & \text{Var}_2 \end{pmatrix}; \quad \mu = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} \]

The optimal weights are obtained by inverting the covariance matrix and multiplying it by the vector of expected returns:

\[ w^* = m \frac{1}{\text{Var}_1 \text{Var}_2 - \text{Cov}^2} \begin{pmatrix} \text{Var}_2 & -\text{Cov} \\ -\text{Cov} & \text{Var}_1 \end{pmatrix} \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} \]

Since the first two terms are scalars, they are not relevant for the relative weightings of the two stocks. Only the multiplication of the matrix with the vector of expected returns is pertinent.

\[ \begin{pmatrix} \text{Var}_2 & -\text{Cov} \\ -\text{Cov} & \text{Var}_1 \end{pmatrix} \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} = \begin{pmatrix} \text{Var}_2 \mu_1 - \text{Cov}\mu_2 \\ \text{Var}_1 \mu_2 - \text{Cov}\mu_1 \end{pmatrix} \]

Hence the weight of the first stock is proportional to \( \text{Var}_2 \mu_1 - \text{Cov}\mu_2 \) and the weight of the second stock is proportional to \( \text{Var}_1 \mu_2 - \text{Cov}\mu_1 \).

Consider the following two stocks:

The expected excess return of stock 1 and 2 are 20% and 10% respectively. The volatilities (standard deviation) of returns are 20% and 10% respectively. The correlation between the two stocks’ returns is 0.5. Then the input parameters are

\[ \Sigma = \begin{pmatrix} 0.04 & 0.01 \\ 0.01 & 0.01 \end{pmatrix}; \quad \mu = \begin{pmatrix} 0.2 \\ 0.1 \end{pmatrix} \]

The weight of stock 1 is proportional to 0.01×0.2 – 0.01×0.1 = 0.001 and the weight of the second stock is proportional to 0.04×0.1 – 0.01×0.2 = 0.002. Normalising 0.001 and 0.002 yields weights of 1/3 and 2/3. This weighting yields the highest Sharpe Ratio for these two stocks.
Appendix C: Principal Component Analysis

1. Returns are standardised to have the same scale.
   For each stock $i$, compute the time series of weekly standardised returns:
   $$r_{i,t} = \frac{R_{i,t} - \mu_i}{\sigma_i} \text{ with } i = 1, \ldots, Z \text{ and } t = 1, \ldots, 104.$$
   where $Z$ is the number of stocks that enter the optimisation, $R_i$ is the return of stock $i$ in week $t$, $\mu_i$ is the average return of stock $i$, and $\sigma_i$ is its standard deviation.

2. Common factors are extracted through the application of a statistical procedure, Principle Component Analysis (PCA) on the sample correlation matrix $S$. The following factor model is used in matrix form for the $104 \times Z$ matrix $r$ of the time series of standardised returns over the calibration period:
   $$r = LF + \varepsilon$$
   Where the coefficients $l_{ij}$ of $L$ correspond to the loading on variable $i$ of factor $j$ and $F$ is the vector of unobserved factors.

3. $S$ denotes the sample covariance matrix of standardised returns, which is equivalent to the sample correlation matrix. The $Z$ principal components are computed. The $i$-th principal component is given by:
   $$f_i = l_i^T r = \sum l_{ai} r_a \quad i = 1, 2, \ldots Z$$
   For which variances and covariance are:
   $$\text{Var}[f_i] = l_i^T S l_i = \lambda_i \quad i = 1, 2, \ldots Z$$
   $$\text{Cov}[f_i, f_j] = l_i^T S l_j \quad i \neq j$$
   and $l_i^T l_i = 1, i = 1, 2, \ldots Z$ The loadings are determined by the eigenvectors of $S$ and their variances are equal to the corresponding eigenvalues $\lambda_i$.

4. The number of factors selected for retention in the factor model is determined by using only those $K$ factors associated with an eigenvalue greater or equal to:
   $$\lambda^{\text{max}} = 1 + \frac{N}{T} + 2\sqrt{\frac{N}{T}}$$
5. Construct the correlation matrix P based on the factor model focusing on the first K factors, that is \( f_1, \ldots, f_K \) obtained in Step 4.

Taking the eigenvalue-eigenvector pairs:

\((e_1, \lambda_1), (e_2, \lambda_2), \ldots, (e_K, \lambda_K)\) where \( \lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_K \geq 0 \) and \( e_j = [e_{1,j}, e_{2,j}, \ldots, e_{K,j}] \) of the correlation matrix P, the correlation matrix can be written as:

\[
P = \lambda_1 e_1 e_1^T + \lambda_2 e_2 e_2^T + \ldots + \lambda_K e_K e_K^T
\]

\[
= \begin{bmatrix}
e_1 & e_2 & \ldots & e_K
\end{bmatrix}
\begin{bmatrix}
\lambda_1 & 0 & 0 & 0 \\
0 & \lambda_2 & 0 & 0 \\
0 & 0 & \ldots & 0 \\
0 & 0 & 0 & \lambda_K
\end{bmatrix}
\begin{bmatrix}
e_1^T \\
e_2^T \\
\vdots \\
e_K^T
\end{bmatrix} = LL^T
\]

Where L is a \( N \times K \) matrix with \( K < N \), where \( K \) is chosen in Step 4 and enforcing the requirement that the diagonal elements of P equal one.

6. Construct Covariance matrix. For each element in P(i,j), compute the corresponding covariance term:

\[
\Sigma(i, j) = \sigma_i \sigma_j P(i, j)
\]
## Appendix D: Index Opening and Closing Hours

<table>
<thead>
<tr>
<th>Index</th>
<th>Open</th>
<th>Close</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTSE EDHEC-Risk Efficient Index Series</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient All-World Index</td>
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<td>21:10</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient All-World ex US Index</td>
<td>00:30</td>
<td>21:10</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient All-World ex UK Index</td>
<td>00:30</td>
<td>21:10</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Developed Index</td>
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<td>21:10</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Emerging Index</td>
<td>00:30</td>
<td>21:10</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Developed Europe Index</td>
<td>08:00</td>
<td>16:30</td>
</tr>
<tr>
<td>FTSE EDHEC-Risk Efficient Developed Europe ex UK Index</td>
<td>08:00</td>
<td>16:30</td>
</tr>
<tr>
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<td>09:00</td>
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<tr>
<td>FTSE EDHEC-Risk Efficient Japan Index</td>
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<td>06:45</td>
</tr>
</tbody>
</table>

### Notes:

Closing values at 21:10 will be disseminated at 21:30.  
Timings are UK hours.
Appendix E: Status of Index Series

The FTSE EDHEC-Risk EIS is calculated in the specified currency (see Rule 1.7) on a real time basis and may exist in the following states.

B) Firm
   a) The Index Series is being calculated during Official Market Hours (see Appendix D). No message will be displayed against the index value.
   b) The Official Closing Price for FTSE EDHEC-Risk EIS will be the Exchange Official Closing Price for the Index.

C) Closed
   The Index Series has ceased all calculations for the day. The message ‘CLOSE’ will be displayed against the index value calculated by FTSE Russell.

D) Held
   During Official Market Hours, the Index Series has exceeded pre-set operating parameters and the calculation has been suspended pending resolution of the problem. The message ‘HELD’ will be displayed against the last index value calculated by FTSE Russell.

E) Indicative
   If there is a system problem or situation in the market that is judged to affect the quality of the constituent prices at any time when the Index Series is being calculated, the index will be declared indicative (e.g. normally where a ‘fast market’ exists in the equity market). The message ‘IND’ will be displayed against the index value calculated by FTSE Russell.

The official opening and closing hours of the FTSE EDHEC-Risk EIS are set out in Appendix D. Variations to the official hours of the index will be published by FTSE Russell.

US Dollar, Euro, UK Pound Sterling and Japanese Yen values will be calculated on an end-of-day basis.
Appendix F: Further Information

A Glossary of Terms used in FTSE Russell’s Ground Rule documents can be found using the following link: [Glossary.pdf](#)

**FTSE**

For further information on the FTSE EDHEC-Risk Efficient Index Series visit [www.ftserussell.com](http://www.ftserussell.com) or e-mail info@ftserussell.com. Contact details can also be found on this website.

**EDHEC-Risk Institute**

Further Information on EDHEC-Risk Institute is available on [www.edhec-risk.com](http://www.edhec-risk.com). Contact details can also be found on this website.