A. Appendix to the Index Guideline of Solactive Global Real Estate 2-Factor Index

A.1. Weighting

The weights as of a business day t are implied from the solution of following system:

$$\sigma^2 = w_{1,t}^2 \cdot \sigma_{1,t-2}^2 + w_{2,t}^2 \cdot \sigma_{2,t-2}^2 + 2 \cdot w_{1,t} \cdot w_{2,t} \cdot \rho_{t-2} \cdot \sigma_{1,t-2} \cdot \sigma_{2,t-2} \tag{1}$$

$$w_{1,t} + w_{2,t} = X_t \tag{2}$$

whereas

- $\sigma_{i,t}$ Standard Deviation of Constituent i as of t according to section A.2.
- σ^2 Target portfolio variance of 0.0081, which is the target portfolio volatility $\sigma = 0.09$ to the power of 2.
- X_t Aggregate weight as of t. Initially set equal to 1 on each business day t.
- $w_{i,t}$ Weight of Constituent i as of t.
- ρ_t Correlation of constituent 1 and 2 as of t according to section A.3.

We define

$$a_t := \sigma_{1,t-2}^2 + \sigma_{2,t-2}^2 - 2\rho_{t-2} \cdot \sigma_{1,t-2} \cdot \sigma_{2,t-2} \tag{3}$$

$$b_t := 2X_t \cdot (\rho_{t-2} \cdot \sigma_{1,t-2} \cdot \sigma_{2,t-2} - \sigma_{2,t-2}^2) \tag{4}$$

$$c_t := X_t^2 \cdot \sigma_{2,t-2}^2 - \sigma^2 \tag{5}$$

$$D_t := b_t^2 - 4a_t \cdot c_t \tag{6}$$

(Case 1) If $D_t > 0$, we choose:

$$w_{1,t} = max\left(0, min\left(X_t, \frac{-b_t \pm \sqrt{D_t}}{2a_t}\right)\right) \tag{7}$$

$$w_{2,t} = X_t - w_{1,t} \tag{8}$$

If equation 7 is returning two possible solutions, the greater is taken. If either $w_{1,t}$ or $w_{2,t}$ is equal to zero, we set

$$w_{1,t} = max\left(0, min\left(1, \frac{\sigma}{\sigma_{1,t-2}}\right)\right) \tag{9}$$

$$w_{2,t} = 0 \tag{10}$$

(Case 2) Else, if $D_t = 0$, we set

$$w_{1,t} = max\left(0, min\left(1, \frac{\sigma}{\sigma_{1,t-2}}\right)\right) \tag{11}$$

$$w_{2,t} = 0 \tag{12}$$

(Case 3) Else, if $D_t < 0$, we iteratively decrease X_t by 0.001 until $D_t > 0$ and determine the weights according to (Case 1).

If

$$\left|w_{1,t} - w_{1,t-1}\right| + \left|w_{2,t} - w_{2,t-1}\right| \leq 0.05 \tag{13}$$

the weights will not change: $w_{i,t} := w_{i,t-1}$.

A.2. Standard Deviation

We are evaluating the standard deviation of a constituent based on two volatility measures. The *short*-term volatility measure of the daily returns (r_{short}) and the *long*-term volatility measure of the weekly returns (r_{long}) of the preceding business days up to (and including) t.

$$r_{short,i,t} = \ln\left(\frac{p_{i,t}}{p_{i,t-1}}\right) \tag{14}$$

$$r_{long,i,t} = \ln\left(\frac{p_{i,t}}{p_{i,t-5}}\right) \tag{15}$$

$$\sigma^2_{short,i,t} = \lambda_{short} \cdot \sigma^2_{short,i,t-1} + 252 \cdot (1 - \lambda_{short}) \cdot r^2_{short,i,t} \tag{16}$$

$$\sigma^2_{long,i,t} = \lambda_{long} \cdot \sigma^2_{long,i,t-1} + \frac{252}{5} \cdot (1 - \lambda_{long}) \cdot r^2_{long,i,t} \tag{17}$$

$$\sigma_{i,t} = max(\sigma_{short,i,t}, \sigma_{long,i,t}) \tag{18}$$

whereas

- $m = 3$, whereas $t = -m$ shall be the business day that is m business days prior to $t = 0$.
- $\sigma_{short,i,-m} = 0$
- $\sigma_{long,i,-m} = 0$
- $p_{i,t}$ Closing level of the constituent as of t.
- $r_{short,i,t}$ Daily return as of t of constituent i.
- $r_{long,i,t}$ Weekly return as of t of constituent i.
- $\lambda_{short} = 0.930685282$
- $\lambda_{long} = 0.98267132$
- $\sigma_{short,i,t}$ *Short*-term standard deviation of a constituent i.
- $\sigma_{long,i,t}$ *Long*-term standard deviation of a constituent i.
- $\sigma_{i,t}$ Standard Deviation of a constituent i.

A.3. Correlation

We are evaluating the correlation of constituent 1 and 2 based on the *short* and *long*-term standard deviation and returns.

$$Cov_{short,t} = \lambda_{short} \cdot Cov_{short,t-1} + 252 \cdot (1 - \lambda_{short}) \cdot r_{short,1,t} \cdot r_{short,2,t} \tag{19}$$

$$Cov_{long,t} = \lambda_{long} \cdot Cov_{long,t-1} + \frac{252}{5} \cdot (1 - \lambda_{long}) \cdot r_{long,1,t} \cdot r_{long,2,t} \tag{20}$$

$$\rho_{short,t} = \frac{Cov_{short,t}}{\sigma_{short,1,t} \cdot \sigma_{short,2,t}} \tag{21}$$

$$\rho_{long,t} = \frac{Cov_{long,t}}{\sigma_{long,1,t} \cdot \sigma_{long,2,t}} \tag{22}$$

$$\rho_t = max(\rho_{short,t}, \rho_{long,t}) \tag{23}$$

whereas

- $m = 3$, whereas $t = -m$ shall be the business day that is m business days prior to $t = 0$.
- $Cov_{short,-m} = 0$
- $Cov_{long,-m} = 0$
- $\lambda_{short} = 0.930685282$
- $\lambda_{long} = 0.98267132$
- $r_{short,i,t}$ Daily return as of t of constituent i.
- $r_{long,i,t}$ Weekly return as of t of constituent i.
- $\sigma_{short,i,t}$ Short-term standard deviation of a constituent i.
- $\sigma_{long,i,t}$ Long-term standard deviation of a constituent i.
- $\rho_{short,t}$ Short-term correlation of constituent 1 and 2 as of t.
- $\rho_{long,t}$ Long-term correlation of constituent 1 and 2 as of t.
- ρ_t Correlation of constituent 1 and 2 as of t.