Risk Management and Trading: How to deal with Uncertainty and Black Swans from a retail trader prospective.

Systematic approach in investing

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October 19, 2019

Minsk, Belarus

BIO

Filippo, Quantitative Analyst, Assistant Vice President, is within State Street's ERM Model Validation Group. Having joined State Street in 2017, Filippo's works is concentrated on projects related to Counterparty Credit Risk, Market Risk, Stress Testing and FX High Frequency Trading. Previous to State Street, he was a researcher at University of Lugano. His research was focused on Computational Finance, Copulas and Extreme Value Theory. He has earned a MSc in Statistics from University of Florence.

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Agenda

Risk Awareness

Portfolio Construction and Risk Management= looking for α

References

Appendix

How to manage risks in a systematic way: Be rationally bold!

Tail Risk

Correlation

Position Limits

Diversification

Don't Panic! (Smart Exit)

Risk Awareness

Something to always keep in mind.....

Realized returns reflect both common (systematic) risk factors and asset-specific (idiosyncratic) risk. Risk premia compensate investors for systematic risk that cannot be diversified away, whereas idiosyncratic risk can be diversified away and does not warrant any risk premium

Anti Ilmanen
Expected Returns. An Investor's Guide to Harvesting Market Rewards

..... and Investment Risks

Market risk

- Equity risk
- Interest rate risk
- Currency risk
- Margining risk

Liquidity risk

Credit risk

- Corporate Bonds
- Sovereign Bonds
- Derivatives linked to mortages, loans etc

Concentration risk

Departing from Rationality

Let's start with a game:

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- 2 investment opportunities: Stock A and Stock B:

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- 2 investment opportunities: Stock A and Stock B:
  i) Stock A yields a sure gain of €240000
  ii) Stock B yields €1 million with probability 25 % and zero with probability 75 %

Departing from Rationality

Let's start with a game:

- 2 investment opportunities: Stock A and Stock B:
  i) Stock A yields a sure gain of €240000
  ii) Stock B yields €1 million with probability 25 % and zero with probability 75 %
  iii) Stock A or B?

Departing from Rationality

Let's start with a game:

- 2 investment opportunities: Stock A and Stock B:
  1. i) Stock A yields a sure gain of €240000
  2. ii) Stock B yields €1 million with probability 25 % and zero with probability 75 %
  3. iii) Stock A or B?
- 2 more investment opportunities: Stock C and Stock D

Departing from Rationality

Let's start with a game:

- 2 investment opportunities: Stock A and Stock B:
    i) Stock A yields a sure gain of €240000
    ii) Stock B yields €1 million with probability 25 % and zero with probability 75 %
    iii) Stock A or B?
- 2 more investment opportunities: Stock C and Stock D
    i) Stock C will have a sure loss of €750000

Departing from Rationality

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- 2 investment opportunities: Stock A and Stock B:
  i) Stock A yields a sure gain of €240000
  ii) Stock B yields €1 million with probability 25 % and zero with probability 75 %
  iii) Stock A or B?
- 2 more investment opportunities: Stock C and Stock D
  i) Stock C will have a sure loss of €750000
  ii) Stock D will have no loss of with 25% probability, but a loss of €1 million with 75% probability

Departing from Rationality

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    iii) Stock A or B?
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    i) Stock C will have a sure loss of €750000
    ii) Stock D will have no loss of with 25% probability, but a loss of €1 million with 75% probability
    iii) Stock C or D?

Risk seeker or avoider?

- Risk Avoider
- Risk Seeker
- Risk Neutral

Behavioural Tendency

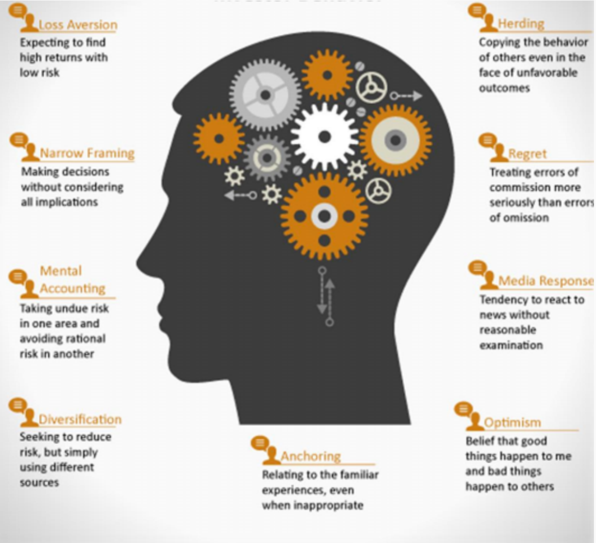


Figure 1: *Source:* DALBARffs 22nd Annual Quantitative Analysis of Investor Behavior

Portfolio Construction and Risk Management= looking for α

Questions

- **Question 1:** Which kind of risk would I like to manage?
- **Answers:** Volatility, Correlation, Tail Risk

- **Question 2:** How do I measure the risk?
- **Answers:** Volatility, Correlation, Tail dependence

Common language

- Expected Returns
- Variance (Monthly, Annualized)
- Variance-Covariance matrix
- Correlation Matrix
- Sharpe Ratio
- Value at Risk (VaR)
- Expected Shortfall (ES)
- Diversification Ratio
- Concentration Ratio
- Marginal Risk Contribution

A snapshot

1. **Goal:** Minimum Variance
2. **Goal:** Maximum Sharpe Ratio
3. **Goal:** Minimum Correlation
4. **Goal:** Equal Risk Contribution
5. **Goal:** Minimum Tail Dependence

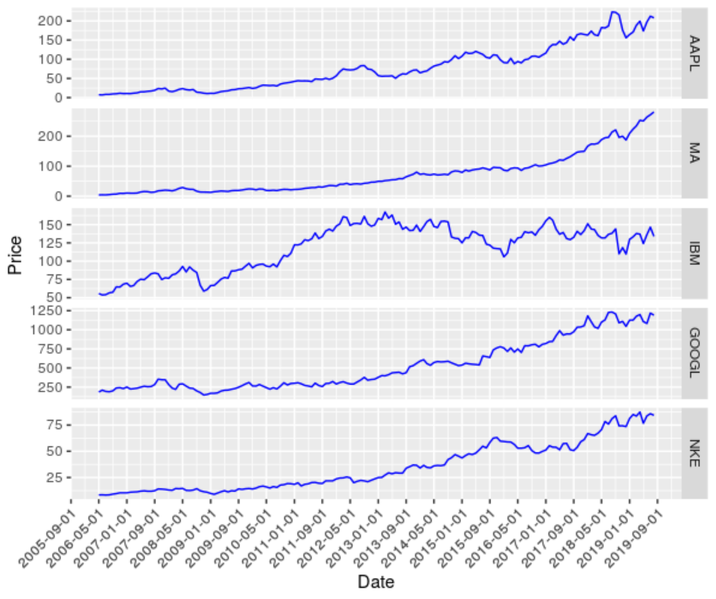
Equity Portfolio

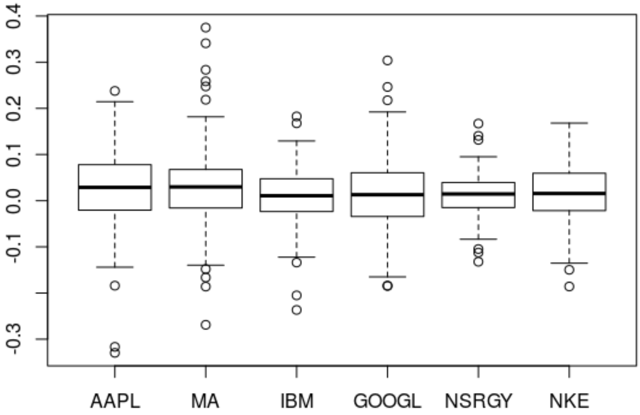
- Investment in US Equity market. Six stocks are selected based on some criteria

Table 1: Summary Statistics 2006/05/01 - 2019/08/01. *Data Source:* Yahoo Finance

	AAPL	MA	IBM	GOOGL	NSRGY	NKE
Monthly Returns	2.53%	3.17%	0.73%	1.48%	1.19%	1.67%
Monthly Variance	0.80%	0.75%	0.34%	0.63%	0.21%	0.41%
Yearly Returns	30.31%	38.10%	8.74%	17.77%	14.24%	20.01%
Yearly Variance	9.64%	9.00%	4.11%	7.59%	2.50%	4.87%

Data Visualization and preliminary insights




0.4
0.3
0.2
0.1
0.0
-0.1
-0.3
AAPL
MA
IBM
GOOGL
NSRGY
NKE

Risks and Rewards: some examples

1. **Goal:** Minimum Variance
2. **Goal:** Maximum Sharpe Ratio

Table 2: Portfolio Weights under GMV Approach

Stocks	Weights
AAPL	0.00%
MA	3.45%
IBM	23.29%
GOOGL	2.92%
NSRGY	53.46%
NKE	16.88%
Total Sum	100%

Table 3: Portfolio Weights under Maximum Sharpe Ratio Approach

Stocks	Weights
AAPL	9.72%
MA	34.81%
IBM	0%
GOOGL	0%
NSRGY	36.08%
NKE	19.39%
Total Sum	100%

3. **Goal:** Minimum Correlation

Table 4: Portfolio Weights under Most Diversified Portfolio (MDP)

Stocks	Weights
AAPL	7.57%
MA	10.77%
IBM	19.68%
GOOGL	8.84%
NSRGY	34.46%
NKE	18.67%
Total Sum	100%

4. **Goal:** Equal RC

Table 5: Portfolio Weights under ERC Approach

Stocks	Weights
AAPL	11.22%
MA	12.04%
IBM	19.01%
GOOGL	12.68%
NSRGY	27.31%
NKE	17.73%
Total Sum	100%

5. **Goal:** Minimum Lower Tail Dependence

Table 6: Portfolio Weights under Minimum Tail (MTP)

Stocks	Weights
AAPL	13.40%
MA	15.18%
IBM	15.07%
GOOGL	11.75%
NSRGY	31.55%
NKE	13.04%
Total Sum	100%

Figure 2: Comparison stocks allocation

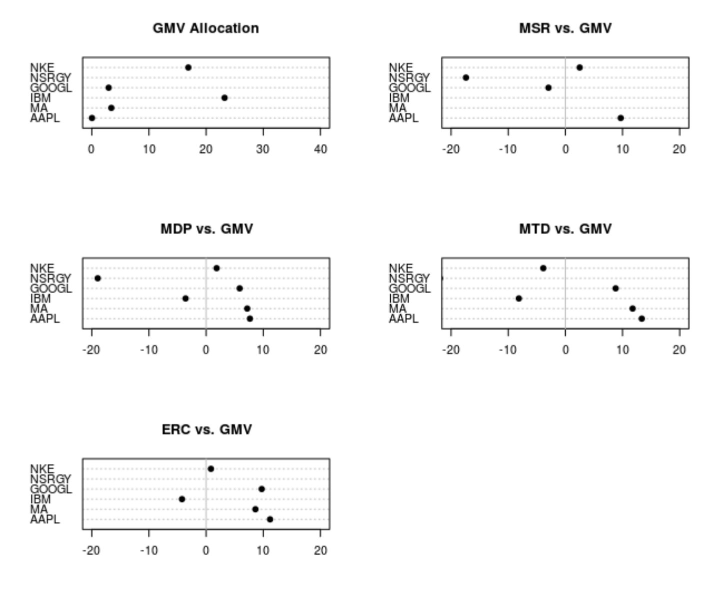


Figure 3: Ex post Portolio monthly returns

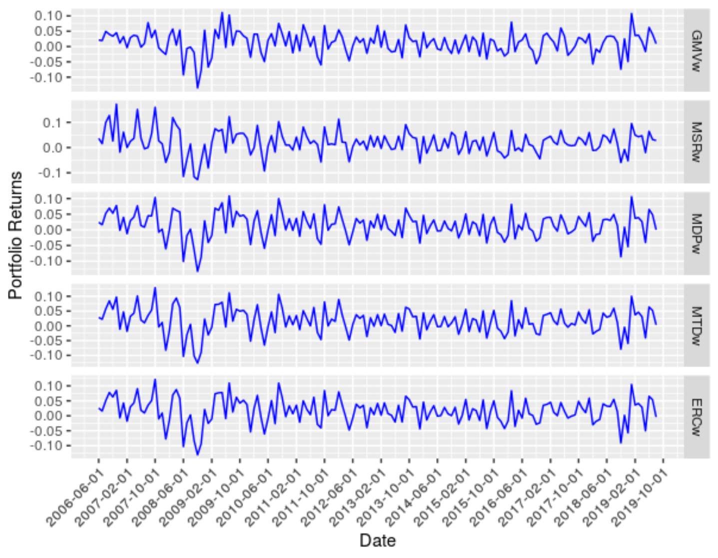
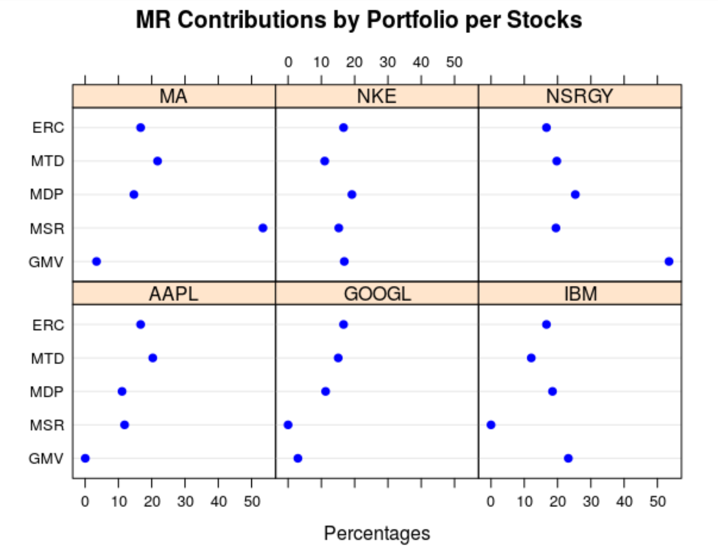


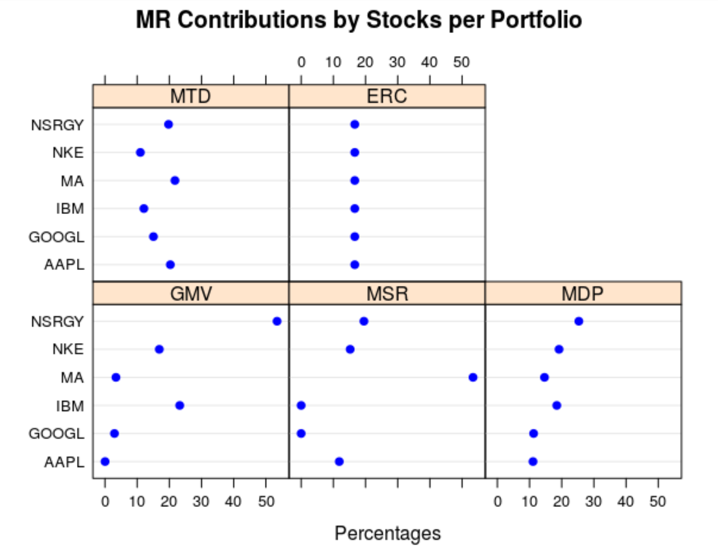
Table 7: Summary Statistics 2006/05/01- 2019/08/01. Results reported are from R script *MinskExamplePortfolio.R*

Stocks	MINVAR	MAXSR	MDP	MTD	ERC
Expected Returns	14.812%	24.623%	18.128 %	20.094%	19.136 %
Volatility	13.131%	16.786%	14.108 %	15.193%	14.946%
Sharpe Ratio	1.012	1.377	1.179	1.223	1.180
Correlation	0.531	0.492	0.427	0.435	0.429
ES95	7.749	8.884	8.038	8.831	8.700
VaR95	5.001	5.739	4.839	5.266	5.415
Diversification Ratio	1.427	1.392	1.529	1.504	1.516
Concentration Ratio	0.311	0.306	0.182	0.174	0.168

Table 8: Marginal Risk Contribution Stocks across portfolios

Statistics	MINVAR	MAXSR	MDP	ERC	MTD
AAPL	0.035	11.85	20.312	16.666	11.099
MA	3.418	53.40	21.748	16.666	14.670
IBM	23.248	0	12.092	16.666	18.498
GOOGL	2.962	0	15.0612	16.666	11.300
NSRGY	53.471	19.51	19.761	16.666	25.328
NKE	16.866	15.23	11.024	16.666	19.103


MR Contributions by Portfolio per Stocks
MA
NKE
NSRGY
AAPL
GOOGL
IBM
ERC
MTD
MDP
MSR
GMV
0
10
20
30
40
50
Percentages


MR Contributions by Stocks per Portfolio
MTD
ERC
GMV
MSR
MDP
NSRGY
NKE
MA
IBM
GOOGL
AAPL
0 10 20 30 40 50
Percentages

Take-Home

- GMV yelds the portfolio with the smallest volatility but the underline assumption is that the returns are symmetric-distributed
- MDP yields the greatest diversification,but this approach has as strong assumption: symmetric correlation between assets
- Risk-averse investors would prefer MTD portfolio since he seeks for positive returns (right tail) and needs protection from downside risks (left tail of the returns distribution)

Conclusions

And then at the end of the day, the most important thing is how good you are at risk control. Ninety-percent of any great trader is going to be the risk control.

Paul Tudor Jones

References

Supporting material can be found here:

https://github.com/macalusofilippo/MinskConference

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Bibliography

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Appendix

Value at Risk

Given some confidence level $\alpha \in (0, 1)$, the Value at Risk of a portfolio at α is given by the smallest number l such that the probability of the loss L is greater than l is no larger than $(1 - \alpha)$

$$
\begin{aligned}
VaR_\alpha &= \inf\{l \in \mathbb{R} : P(L > l) \leq 1 - \alpha\} && (1)\\
&= inf\{l \in \mathbb{R} : G_L(l) \geq \alpha\} && (2)
\end{aligned}
$$

- VaR at confidence α does not give any information about the severity of losses which occur with probability less than $1 - \alpha$

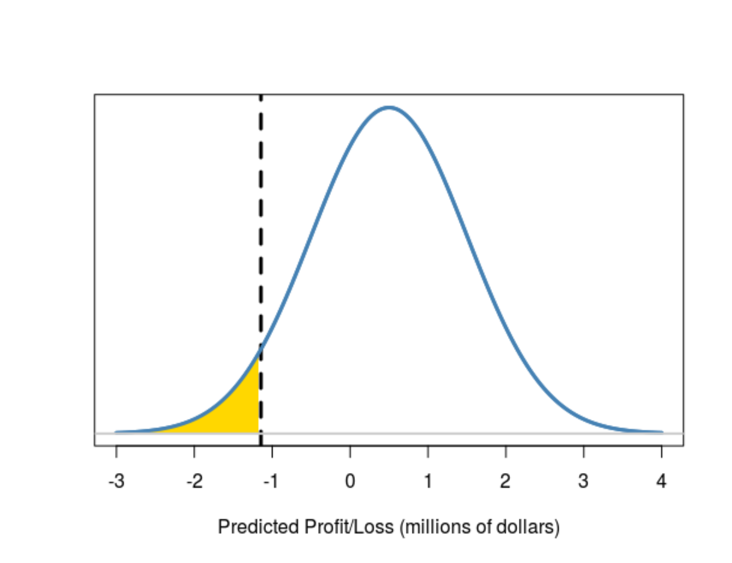
Expected Shortfall

For a loss L with $\mathbb{E}[|L|] < \infty$ and distribution function G_L, the Expected Shortfall at confidence level $\alpha \in (0, 1)$ is defined as

$$\begin{aligned} ES_\alpha &= \frac{1}{1-\alpha}\int_\alpha^1 q_u(G_L)du && (3) \\ &= \frac{1}{1-\alpha}\int_\alpha^1 VaR_u(L)du && (4) \end{aligned}$$

- ES_α is the average of VaR_α over all $u \geq \alpha$, then $ES_\alpha \geq VaR_\alpha$
- ES_α looks further into the tail of G_L and it measures the severity

Figure 4: Valut at Risk (dashed line) and Expected Shortfall (yellow area)



Diversification Ratio

- Σ is the Variance-Covariance Matrix of the returns of N assets
- $\boldsymbol{\sigma}$ is the vector of the N asset volatilities
- $\boldsymbol{\omega}$ is the vector of weights of the N assets

$$\boldsymbol{DR} = \frac{\boldsymbol{\omega}'\boldsymbol{\sigma}}{\sqrt{\boldsymbol{\omega}'\boldsymbol{\Sigma}\boldsymbol{\omega}}} \tag{5}$$

- Numerator: weighted average volatility of the single asset
- Denominator: portfolio standard deviation

Portfolio solutions with highly concentrated allocation or highly correlated returns $\rightarrow$ poor diversified

Concentration Ratio

- ω_i is the portfolio weights of asset i
- σ_i is the volatility of asset i

$$CR = \frac{\sum_{i=1}^{N} (\omega_i \sigma_i)^2}{\left(\sum_{i=1}^{N} \omega_i \sigma_i \right)^2} \tag{6}$$

Margin Risk Contribution

Let $\sigma(x) = \sqrt{w'\Sigma w}$ be the risk of a porfolio. By applying Euler decomposition,

$$\sigma(x) = \sum_{i=1}^{n} \sigma_i(w) = \sum_{i=1}^{n} w_i \frac{\partial \sigma(w)}{\partial w_i} \tag{7}$$

- $\frac{\partial \sigma(w)}{\partial w_i}$ is the marginal risk contribution
- $\sigma_i(w) = w_i \frac{\partial \sigma(w)}{\partial w_i}$ is the risk contribution of $i-$asset

Global Minimum Variance Portfolio

The global minimum-variance portfolio (GMV), is the portfolio with the lowest possible return variance. The solution is achieved by

$$P_{GMV} = \underset{\omega \in \Omega}{\arg\min}\, \omega' \Sigma \omega \tag{8}$$

$\omega_i \in [0, 1], \sum_{i=1}^{n} \omega_i = 1$

Maximum-Sharpe Ratio Portfolio

The maximum Sharpe ratio portfolio (MSR), is the portfolio with the greatest possible Sharpe Ratio. The solution is achieved by

$$P_{MSR} = \arg\max_{\omega \in \Omega} \frac{r'\omega - r_f}{\sqrt{\omega' \Sigma \omega}} \tag{9}$$

$\omega_i \in [0, 1]$, $\sum_{i=1}^{n} \omega_i = 1$

- $\boldsymbol{r}$ is the vector of returns
- $\boldsymbol{r_f}$ is the risk-free rate

Most-Diversified Portfolio

The Most-Diversified Portfolio

$$P_{MDP} = \arg\max_{\omega \in \Omega} DR \tag{10}$$

$\omega_i \in [0, 1]$, $\sum_{i=1}^{n} \omega_i = 1$

- The diversification ratio is maximized by minimizing $\omega' C \omega$, where C is the correlation matrix
- The weights are determined in two stages:
    1. The allocation is established such the resulting mix of assets is the least correlated.
    2. The obtained weights are inversely adjusted by the volatility of the asset and normalized

Equal Risk Contribution Portfolio

The Equal Risk Contribution

$$P_{ERC} : \omega_i(\Sigma\omega)_i = \omega_j(\Sigma\omega)_j \tag{11}$$

$\omega_i \in [0, 1], \sum_{i=1}^{n} \omega_i = 1$

Optimal Tail Dependence Portfolio

- We need to introduce the concept of Copula
- Joint Distribution Function: $G_{X,Y}(x, y) = P(X \leq x, Y \leq y)$
- The joint distribution function can be rewritten as $G_{X,Y}(x, y) = C(G_X(x), G_Y(y))$, where C is the copula
- The lower tail dependence coefficient is $\lambda_L = \lim_{u \to 0} \frac{C(u,u)}{u}$
- Approach similar to MDP
    1. First step: Derive optimal solution if TDC-matrix is used with main-diagonal elements are set to one.
    2. Second step: Re-scale optimal weight vectors by assets volatility (riskiness).