

Holdings-Based Risk Attribution – Background and Concept

Date: June 2013
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Agenda

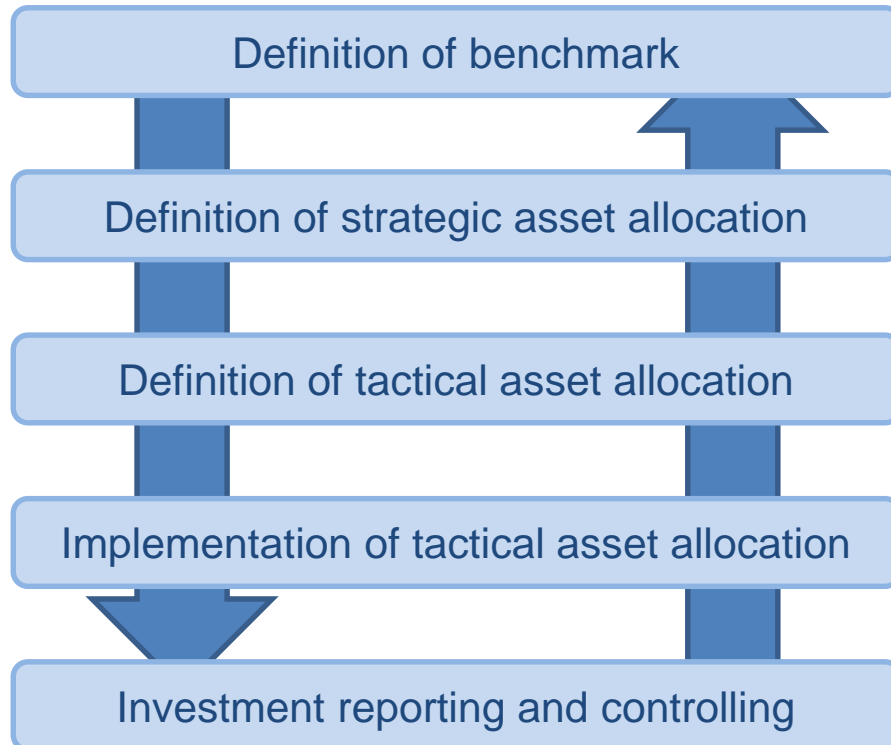
- Introductory thoughts
- Monitoring risk from a top down perspective
- Risk attribution – the big picture
- Holdings-based risk attribution – an example
- Decision-oriented risk attribution
- Outlook – bringing return and risk together
- Comments and questions
- Contact details and disclaimer

Introductory thoughts

Introductory thoughts – the investment process

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Investment management process

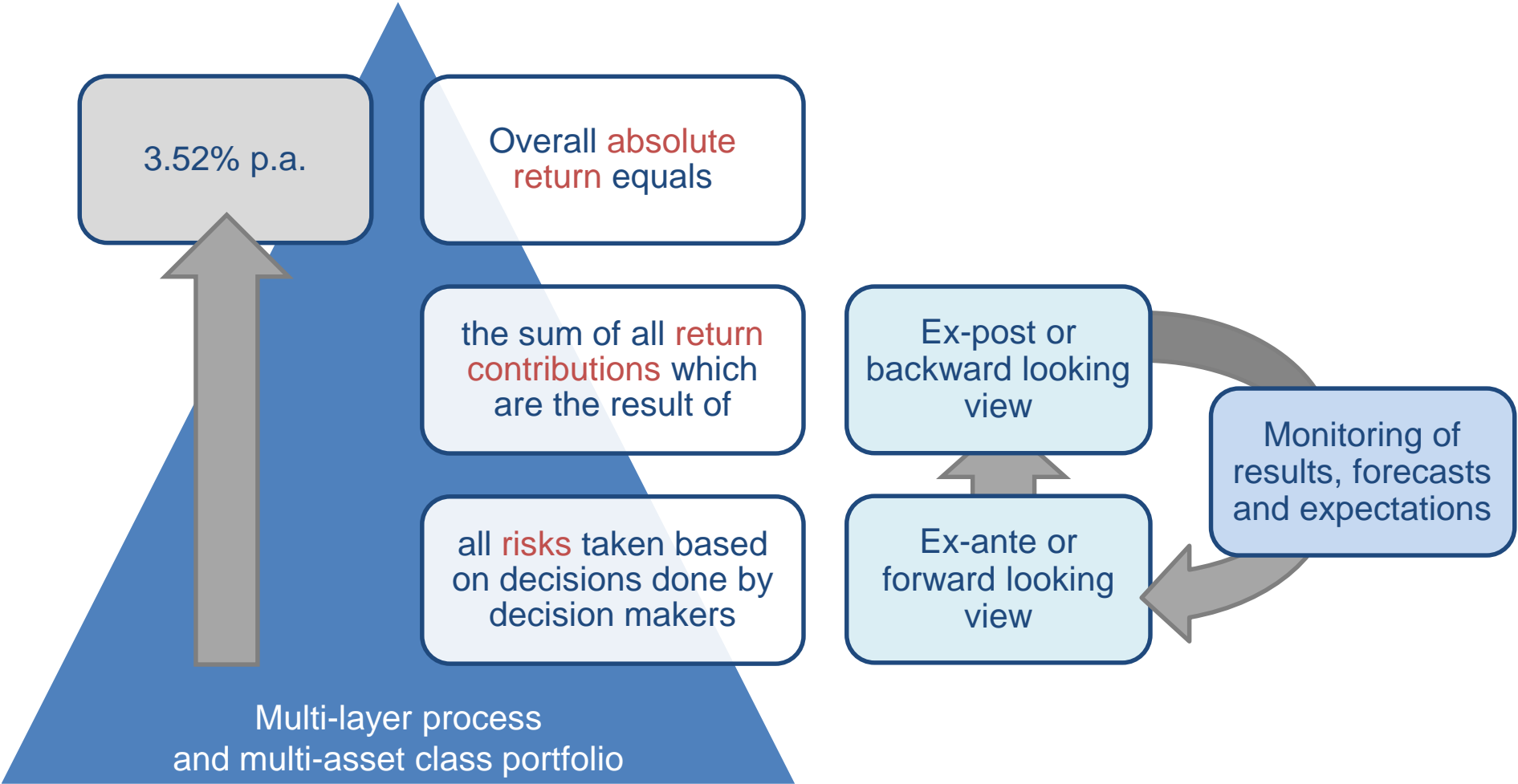


Tasks and duties of decision makers

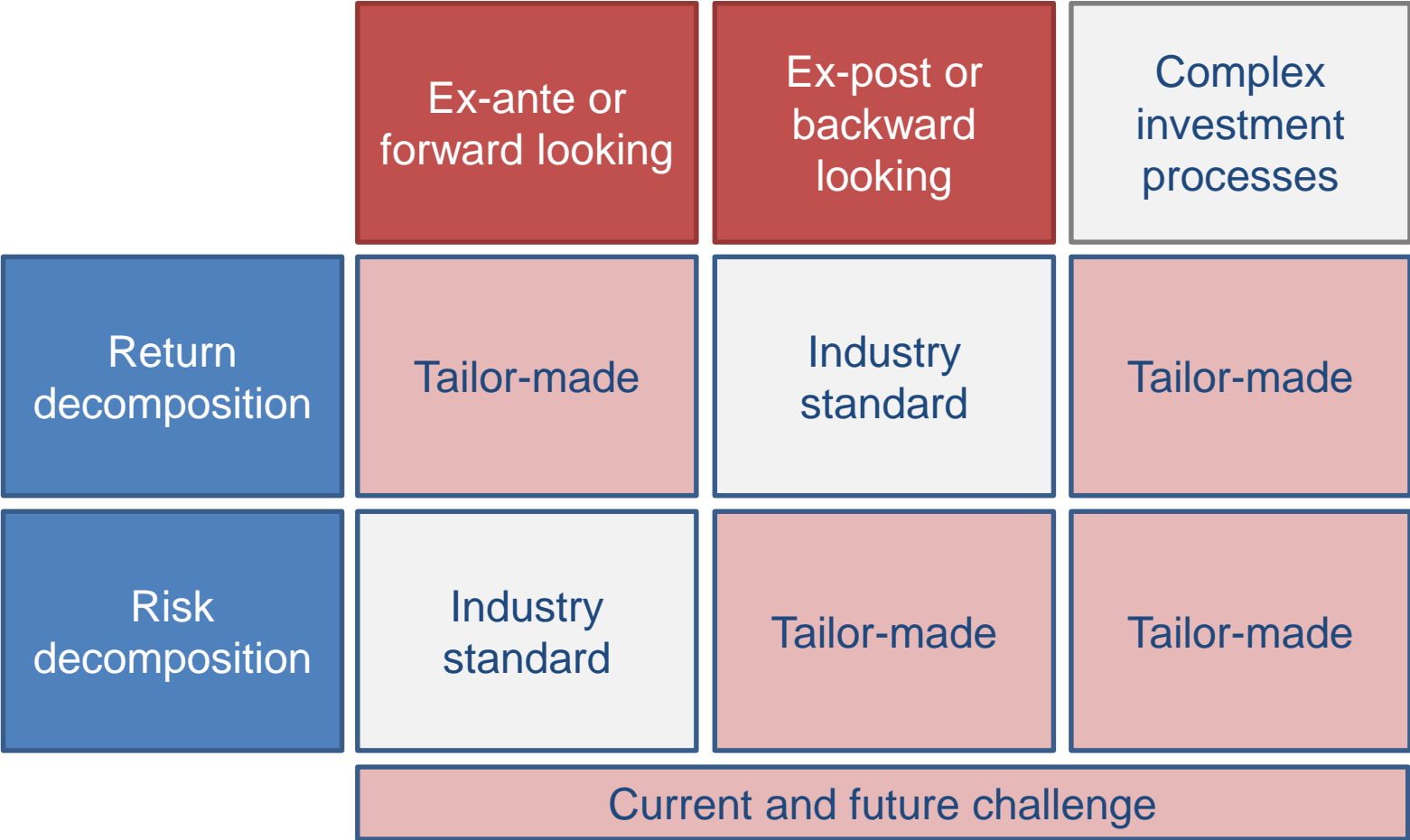
- Monitor target achievement.
- Review circumstances and forecasts relevant as input for decision-making process.
- **Determine contributions to and drivers for return and risk.**
- Systematic process evaluation and constant process improvement.
- Monitor compliance with laws and regulations, policies and procedures as well as investment restrictions.

Introductory thoughts – return generation process

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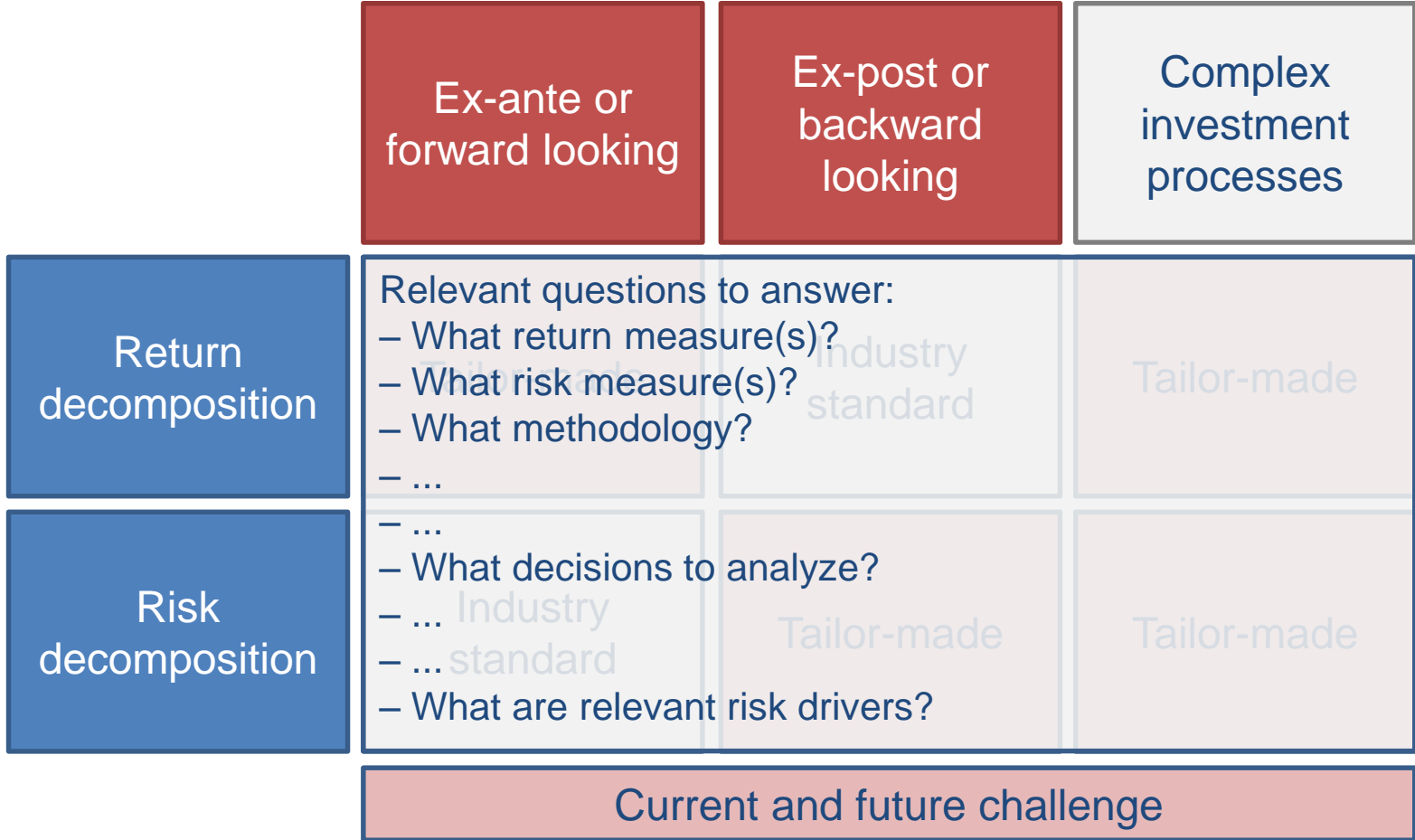


Introductory thoughts – performance analysis overview (3/4)



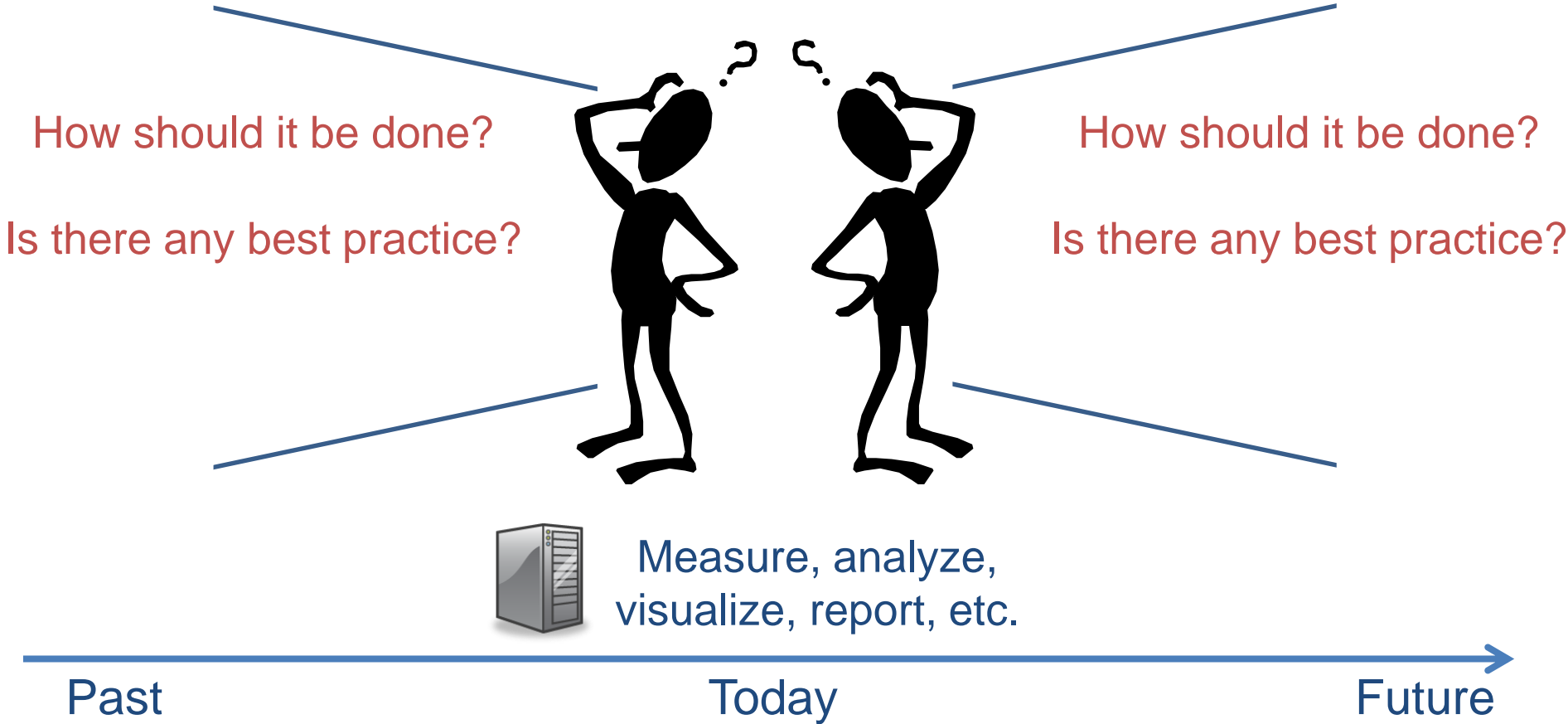
Introductory thoughts – relevant questions

(4a/4)



Introductory thoughts – relevant questions

(4b/4)



Monitoring risk from a top down perspective

Monitoring risk from a top down perspective

(1/4)

What was the impact of the investment committee on the overall excess risk?

What kind of investment decision added most to the overall excess risk?

Which asset class added most to the overall absolute risk?

Is the excess risk mainly due to the asset allocation decisions of the investment committee?

Did the index choice of the equity portfolios lower or increase the excess risk?

What was the impact of the stock picking decisions within the equity portfolios on the overall absolute risk?

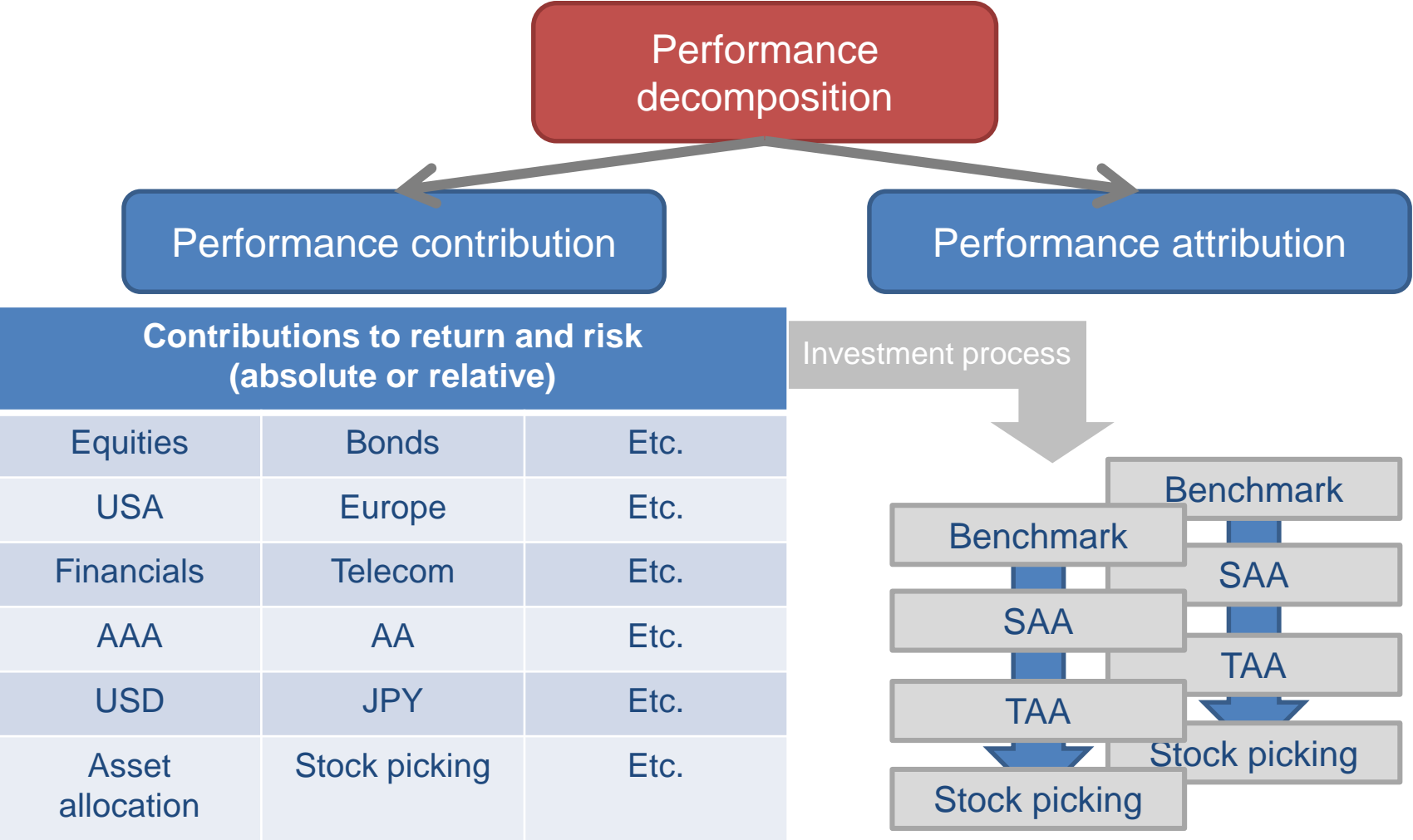
What is the impact of the proposed rebalancing on the risk profile of the total assets?



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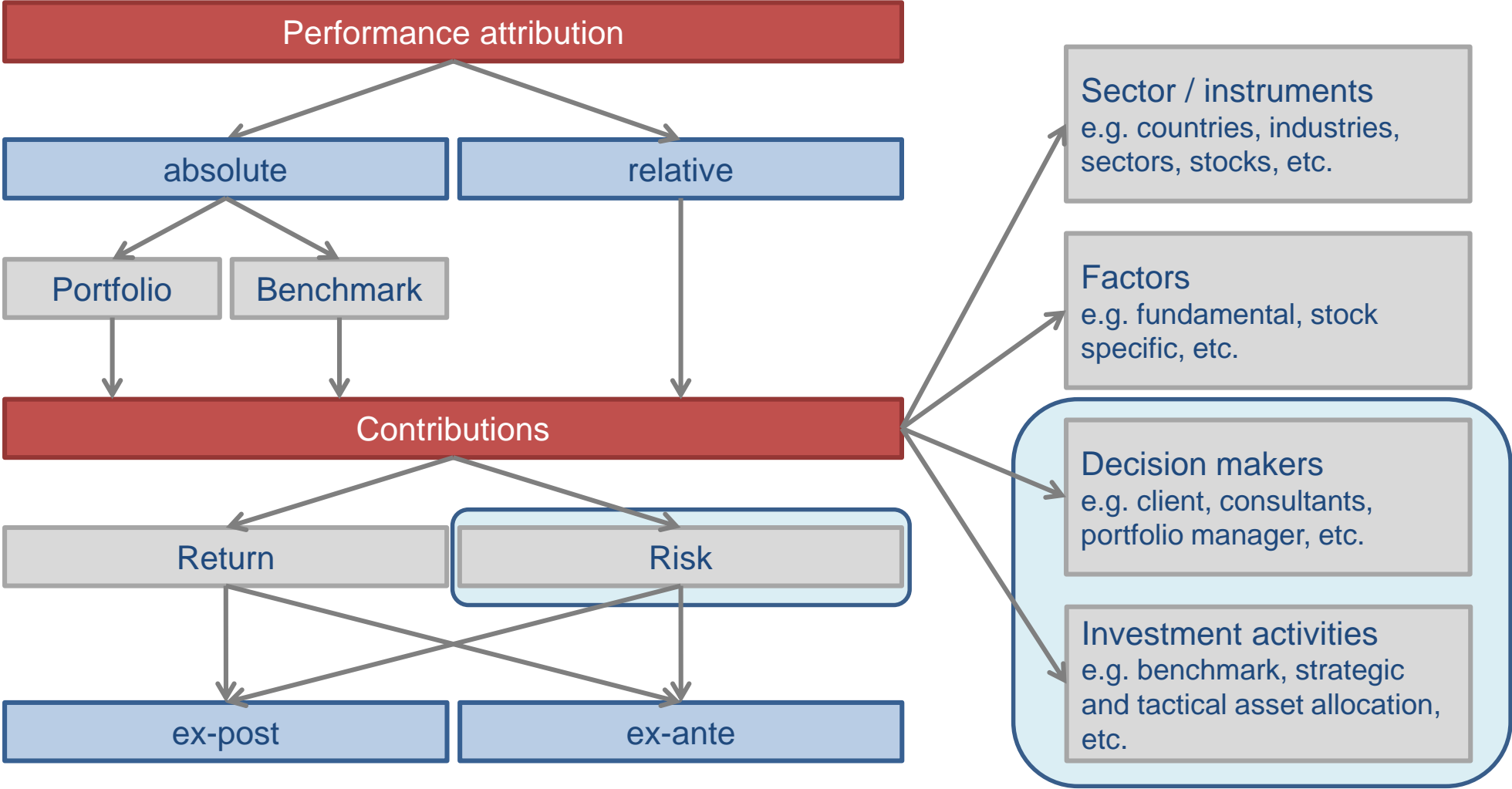
Monitoring risk from a top down perspective

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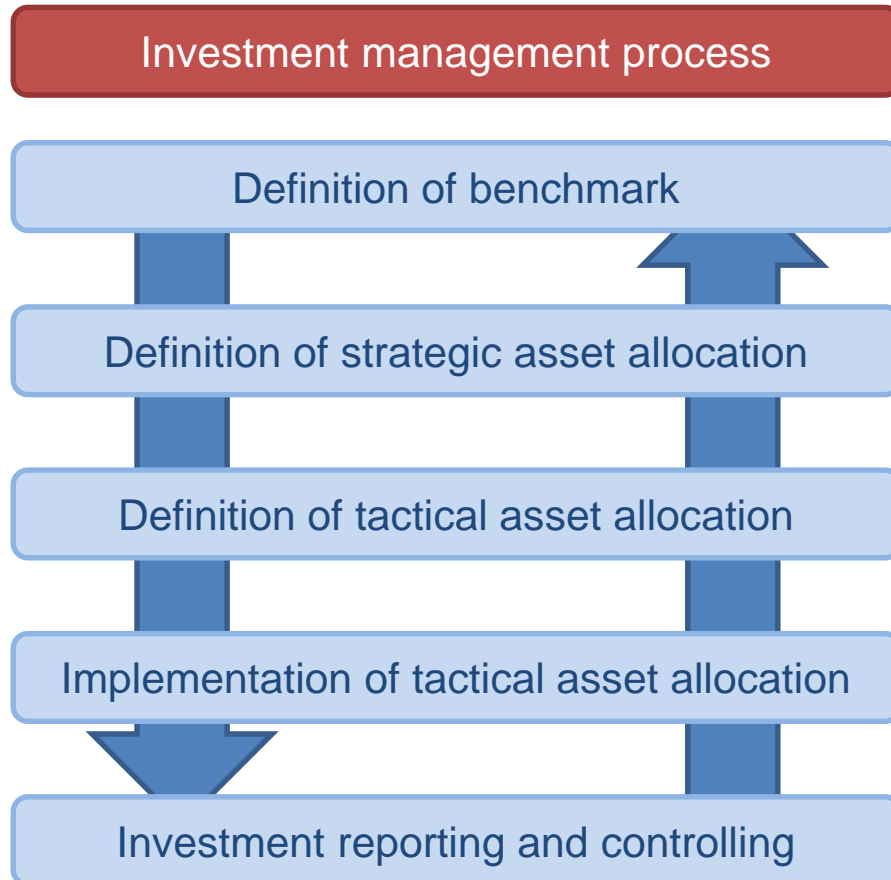
Monitoring risk from a top down perspective

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Monitoring risk from a top down perspective

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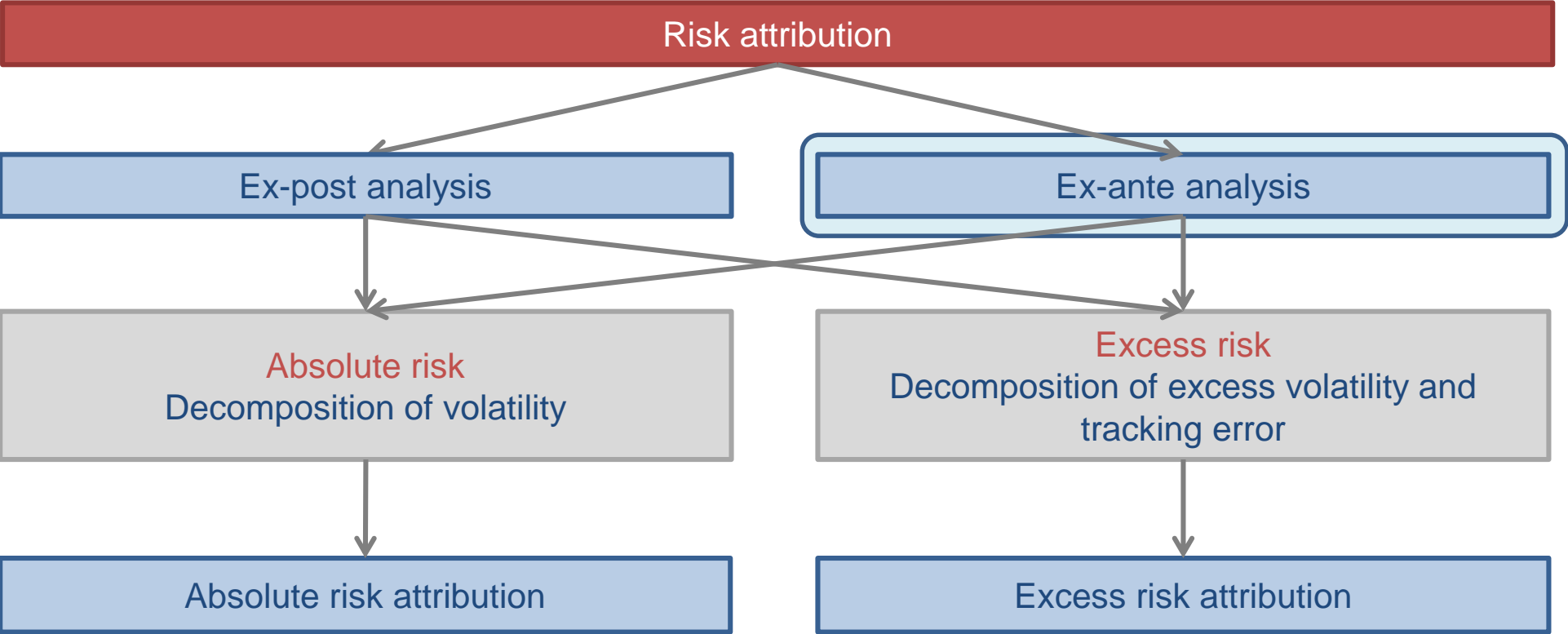
Relevant aspects to consider:

- Focus on all asset classes and the total portfolio and less – in isolation – on specific asset classes or carve-outs of the total portfolio.
- Focus more on the amount of risk and less on the kinds of risk.
- Focus on total risk of asset classes and portfolios and less on their risk characteristics or the individual investments.
- Focus on the overall result but also on the impact of individual decisions and decision makers.
- Focus on the intended and less on the actual consequences of investment decision – except for the last sub-process implementation.
- Focus on the total investment process and less on the individual sub-processes.

Risk attribution – the big picture

Risk attribution – the big picture

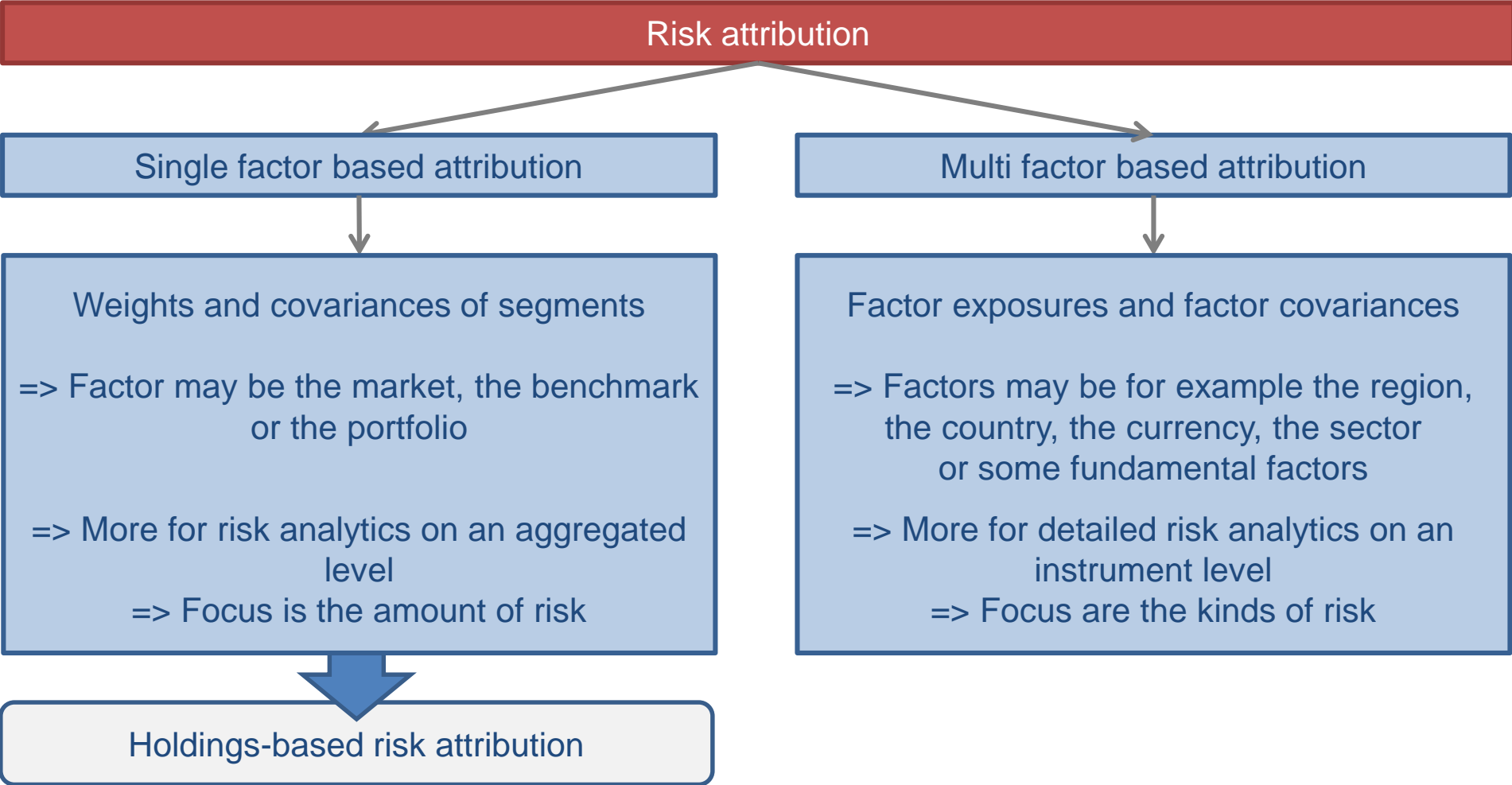
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Remark: Lot of other (statistical) risk measures can be considered. In the following we focus on variance and volatility.

Risk attribution – the big picture

(2/3)



Risk attribution – the big picture

(3/3)

	Weights	Volatilities p.a.	Contribution to Variance in %
Cash	5.00%	0.86%	-0.07%
Domestic Bonds	13.00%	2.88%	1.83%
Foreign Bonds	13.00%	8.41%	10.16%
Domestic Equities	21.00%	17.37%	42.04%
Foreign Equities	15.00%	17.83%	32.22%
Alternative Investments	7.00%	17.59%	13.48%
Real Estate	15.00%	1.27%	0.41%
Mortgages	11.00%	0.38%	-0.07%
Total	100.00%	7.83%	100.00%

Decomposition of the ex-ante (systematic) absolute risk of an multi asset class portfolio.

How much risk is coming from each asset class, each decision and each decision maker?

Risk Model: Global	Portfolio	Tracking Error
Total Risk (ex-ante)	18.81%	2.57%
Factor Specific Risk	18.66%	1.50%
- Region	11.50%	0.18%
- Country	6.98%	0.83%
- Industry	2.64%	0.77%
- Fundamental	1.44%	0.78%
- Currency	8.42%	0.27%
- Covariance (+/-)	9.35%	0.52%
Stock Specific Risk	2.39%	2.08%

Decomposition of the ex-ante absolute and relative excess risk of an equity portfolio.

How much risk is coming from each factor?

Holdings-based risk attribution – an example

Inputs and assumptions

Single factor based risk attribution using the investment portfolio as the explaining factor. Here we estimate and decompose the portfolio absolute risk by using the weighted risk characteristics of the asset classes the portfolio is invested in. For the estimation and the decomposition of the portfolio risk we need the following input data:

- Weights of the different asset classes for the investment portfolio for the **relevant** period.
- Estimated covariances between asset classes for the investment portfolio for the **relevant** period.

Some formulas

(1/3)

Since covariances are additive the risk of a portfolio can easily be decomposed.

$$R^P = \sum_{i=1}^n w_i^P \times R_i^P \Rightarrow$$

$$\sigma^2(R^P) = \sum_{i=1}^n \sum_{j=1}^n w_i^P \times w_j^P \times Cov(R_i^P, R_j^P) \Rightarrow$$

$$\sigma^2(R^P) = \sum_{i=1}^n (w_i^P)^2 \times \sigma^2(R_i^P) + \sum_{i=1}^n \sum_{\substack{j=1 \\ i \neq j}}^n w_i^P \times w_j^P \times Cov(R_i^P, R_j^P) \Rightarrow$$

Some formulas

(2/3)

$$\sigma^2(R^P) = \sum_{i=1}^n (w_i^P)^2 \times \sigma^2(R_i^P) + \sum_{i=1}^n \sum_{\substack{j=1 \\ i \neq j}}^n w_i^P \times w_j^P \times \text{Correl}(R_i^P, R_j^P) \times \sigma(R_i^P) \times \sigma(R_j^P)$$

Risk contributions can easily be calculated using the part of the portfolio risk based on the weighted variances of the individual asset classes. It is more difficult for the part of the portfolio risk based on the weighted covariances between the different asset classes – assuming correlated returns of the asset classes.

The weighted covariances between the different asset classes can be presented separate or can be assigned to the different asset classes by using a specific smoothing algorithm – where here we use the split 50/50.

Some formulas

(3/3)

$$\sigma^2(R^P) = \sum_{i=1}^m (w_i^P)^2 \times \sigma^2(R_i^P) + \sum_{i=1}^m \sum_{\substack{j=1, \\ j \neq i}}^n w_i^P \times w_j^P \times Cov(R_i^P, R_j^P)$$

$$\sigma^2(CR_i; R_i^P) = (w_i^P)^2 \times \sigma^2(R_i^P) + \sum_{\substack{j=1, \\ j \neq i}}^n w_i^P \times w_j^P \times Cov(R_i^P, R_j^P)$$

Starting point

	Weights	Volatilities p.a.
Cash	5.00%	0.30%
Domestic Bonds	7.00%	3.47%
Foreign Bonds hedged	5.00%	3.08%
Foreign Bonds unhedged	18.00%	6.79%
Mortgages	25.00%	1.08%
Domestic Equities	30.00%	17.42%
Foreign Equities	5.00%	18.92%
Domestic Real Estate	5.00%	6.91%
Total	100.00%	

$$\sigma^2(R^P) = \begin{pmatrix} w_1^P \\ \vdots \\ w_n^P \end{pmatrix}^T \times \begin{pmatrix} \sigma^2(R_1^P) & \dots & Cov(R_1^P, R_n^P) \\ \vdots & \ddots & \vdots \\ Cov(R_n^P, R_1^P) & \dots & \sigma^2(R_n^P) \end{pmatrix} \times \begin{pmatrix} w_1^P \\ \vdots \\ w_n^P \end{pmatrix}$$

Calculations

(1/2)

Covariance Matrix p.a.	Cash	Domestic Bonds	Foreign Bonds hedged	Foreign Bonds unhedged	Mortgages	Domestic Equities	Foreign Equities	Domestic Real Estate
Cash	0.00001	0.00002	0.00002	0.00000	0.00001	-0.00003	-0.00007	0.00000
Domestic Bonds	0.00002	0.00120	0.00063	0.00006	0.00024	-0.00089	-0.00169	-0.00005
Foreign Bonds hedged	0.00002	0.00063	0.00095	0.00068	0.00018	-0.00098	-0.00117	-0.00012
Foreign Bonds unhedged	0.00000	0.00006	0.00068	0.00461	0.00005	0.00390	0.00785	0.00023
Mortgages	0.00001	0.00024	0.00018	0.00005	0.00012	-0.00041	-0.00056	0.00000
Domestic Equities	-0.00003	-0.00089	-0.00098	0.00390	-0.00041	0.03036	0.02564	0.00084
Foreign Equities	-0.00007	-0.00169	-0.00117	0.00785	-0.00056	0.02564	0.03581	0.00085
Domestic Real Estate	0.00000	-0.00005	-0.00012	0.00023	0.00000	0.00084	0.00085	0.00478

Weight Matrix	Cash	Domestic Bonds	Foreign Bonds hedged	Foreign Bonds unhedged	Mortgages	Domestic Equities	Foreign Equities	Domestic Real Estate
Cash	0.25%	0.35%	0.25%	0.90%	1.25%	1.50%	0.25%	0.25%
Domestic Bonds	0.35%	0.49%	0.35%	1.26%	1.75%	2.10%	0.35%	0.35%
Foreign Bonds hedged	0.25%	0.35%	0.25%	0.90%	1.25%	1.50%	0.25%	0.25%
Foreign Bonds unhedged	0.90%	1.26%	0.90%	3.24%	4.50%	5.40%	0.90%	0.90%
Mortgages	1.25%	1.75%	1.25%	4.50%	6.25%	7.50%	1.25%	1.25%
Domestic Equities	1.50%	2.10%	1.50%	5.40%	7.50%	9.00%	1.50%	1.50%
Foreign Equities	0.25%	0.35%	0.25%	0.90%	1.25%	1.50%	0.25%	0.25%
Domestic Real Estate	0.25%	0.35%	0.25%	0.90%	1.25%	1.50%	0.25%	0.25%

Calculations

(2/2)

Contribution to Covariance	Cash	Domestic Bonds	Foreign Bonds hedged	Foreign Bonds unhedged	Mortgages	Domestic Equities	Foreign Equities	Domestic Real Estate
Cash	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Domestic Bonds	0.00000	0.00001	0.00000	0.00000	0.00000	-0.00002	-0.00001	0.00000
Foreign Bonds hedged	0.00000	0.00000	0.00000	0.00001	0.00000	-0.00001	0.00000	0.00000
Foreign Bonds unhedged	0.00000	0.00000	0.00001	0.00015	0.00000	0.00021	0.00007	0.00000
Mortgages	0.00000	0.00000	0.00000	0.00000	0.00001	-0.00003	-0.00001	0.00000
Domestic Equities	0.00000	-0.00002	-0.00001	0.00021	-0.00003	0.00273	0.00038	0.00001
Foreign Equities	0.00000	-0.00001	0.00000	0.00007	-0.00001	0.00038	0.00009	0.00000
Domestic Real Estate	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	0.00001

Contribution to Variance	Not smoothed	Smoothed
Cash	0.00000	0.00000
Domestic Bonds	0.00001	-0.00001
Foreign Bonds hedged	0.00000	0.00000
Foreign Bonds unhedged	0.00015	0.00044
Mortgages	0.00001	-0.00002
Domestic Equities	0.00273	0.00328
Foreign Equities	0.00009	0.00053
Domestic Real Estate	0.00001	0.00003
Covarianz	0.00124	
Total	0.00424	0.00424

Contribution to Variance in %	Not smoothed	Smoothed
Cash	0.00%	-0.01%
Domestic Bonds	0.14%	-0.28%
Foreign Bonds hedged	0.06%	-0.12%
Foreign Bonds unhedged	3.52%	10.42%
Mortgages	0.17%	-0.51%
Domestic Equities	64.48%	77.29%
Foreign Equities	2.11%	12.53%
Domestic Real Estate	0.28%	0.66%
Covarianz	29.24%	0.00%
Total Variance	100.00%	100.00%
Total Volatility	6.51%	

Results

	Weights	Volatilities p.a.	Contribution to Variance in %	Contribution to Variance	Contribution to Volatility
Cash	5.00%	0.30%	-0.01%	0.00000	0.00%
Domestic Bonds	7.00%	3.47%	-0.28%	-0.00001	-0.02%
Foreign Bonds hedged	5.00%	3.08%	-0.12%	0.00000	-0.01%
Foreign Bonds unhedged	18.00%	6.79%	10.42%	0.00044	0.68%
Mortgages	25.00%	1.08%	-0.51%	-0.00002	-0.03%
Domestic Equities	30.00%	17.42%	77.29%	0.00328	5.03%
Foreign Equities	5.00%	18.92%	12.53%	0.00053	0.82%
Domestic Real Estate	5.00%	6.91%	0.66%	0.00003	0.04%
Total	100.00%	6.51%	100.00%	0.00424	6.51%

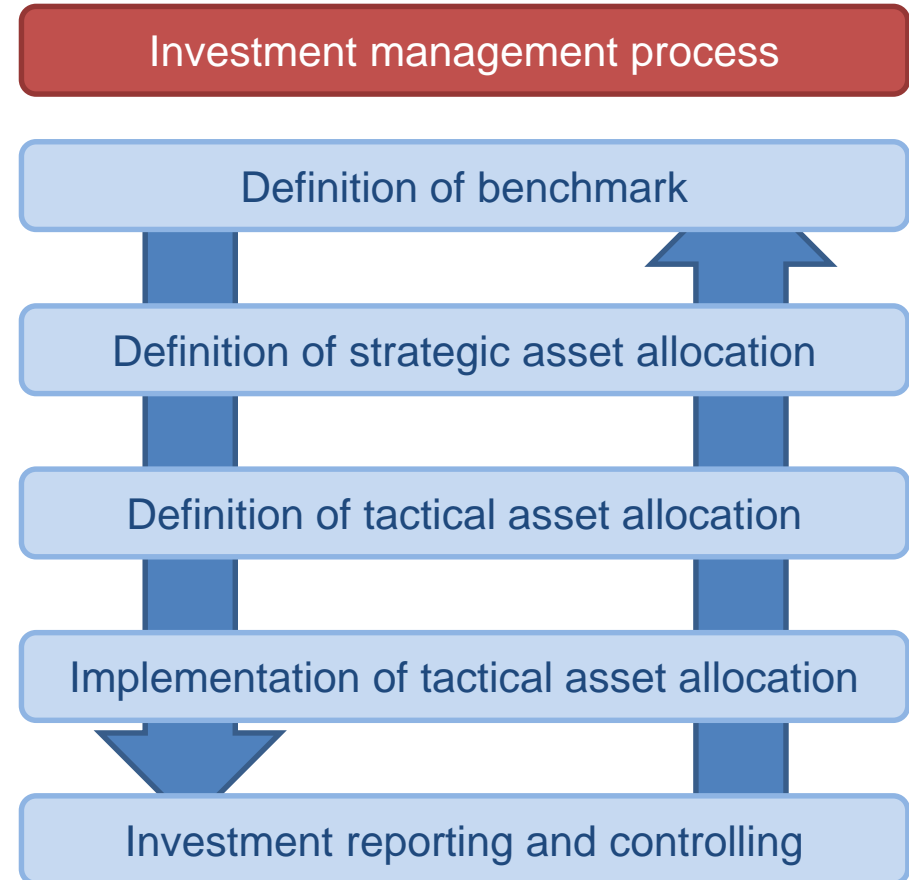
Remark: Contribution to volatility are approximated by the relative weights of the contributions of the variances multiplied with the portfolio volatility.

Decision-oriented risk attribution

Definition – Decision-oriented risk attribution

Decision-oriented risk attribution is the decomposition of the (absolute or excess) risk of an investment portfolio according to specific investment decisions done by specific decision makers.

The decomposition approach is difficult to standardize and therefore **normally tailor-made** as the relevant investment management processes differ – sometimes substantially.



Generic decomposition approach

(1/2)



Decision-oriented decomposition of the absolute (excess) risk allows to quantify the risk contribution or the value added of the individual decision makers and is based on the following steps:

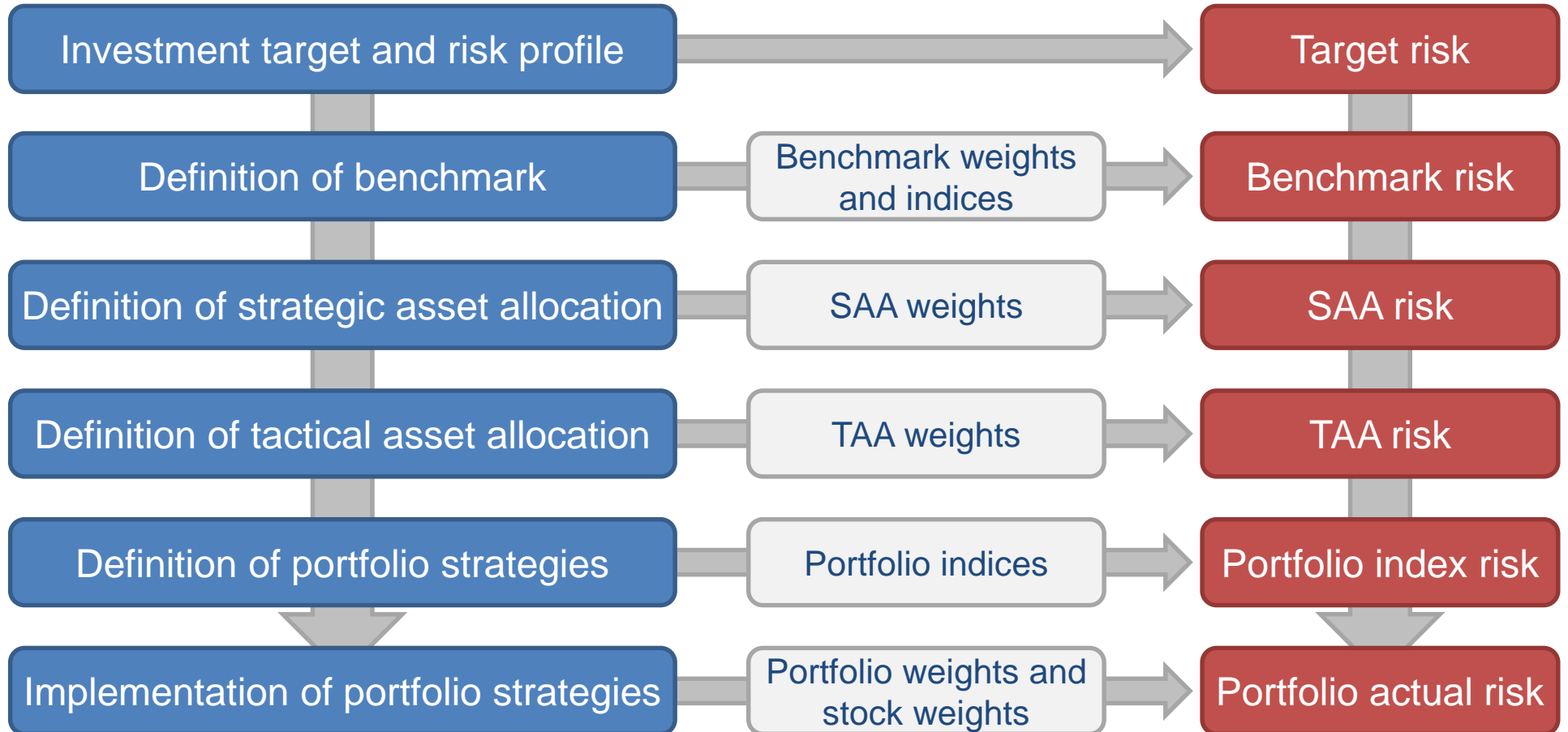
- **Step 1:** Identify the circumstances, the investment management setup, and derive relevant assumptions for calculation.
- **Step 2:** Mirror the specific investment decisions into (absolute) asset allocations.
- **Step 3:** Calculate the corresponding risk figures.
- **Step 4:** Assign the absolute risk as well as the risk differences to the investment decisions and to the relevant decision makers.

Mirror investment decisions

Weights	Benchmark	Strategic asset allocation	Tactical asset allocation	Portfolio strategies allocation	Actual portfolio allocation
Domestic bonds	10.00%	10.00%	10.00%	10.00%	12.00%
Foreign bonds	20.00%	10.00%	25.00%	25.00%	23.00%
Domestic equities	30.00%	35.00%	55.00%	55.00%	55.00%
Foreign equities	40.00%	45.00%	10.00%	10.00%	10.00%
Total assets	100.00%	100.00%	100.00%	100.00%	100.00%

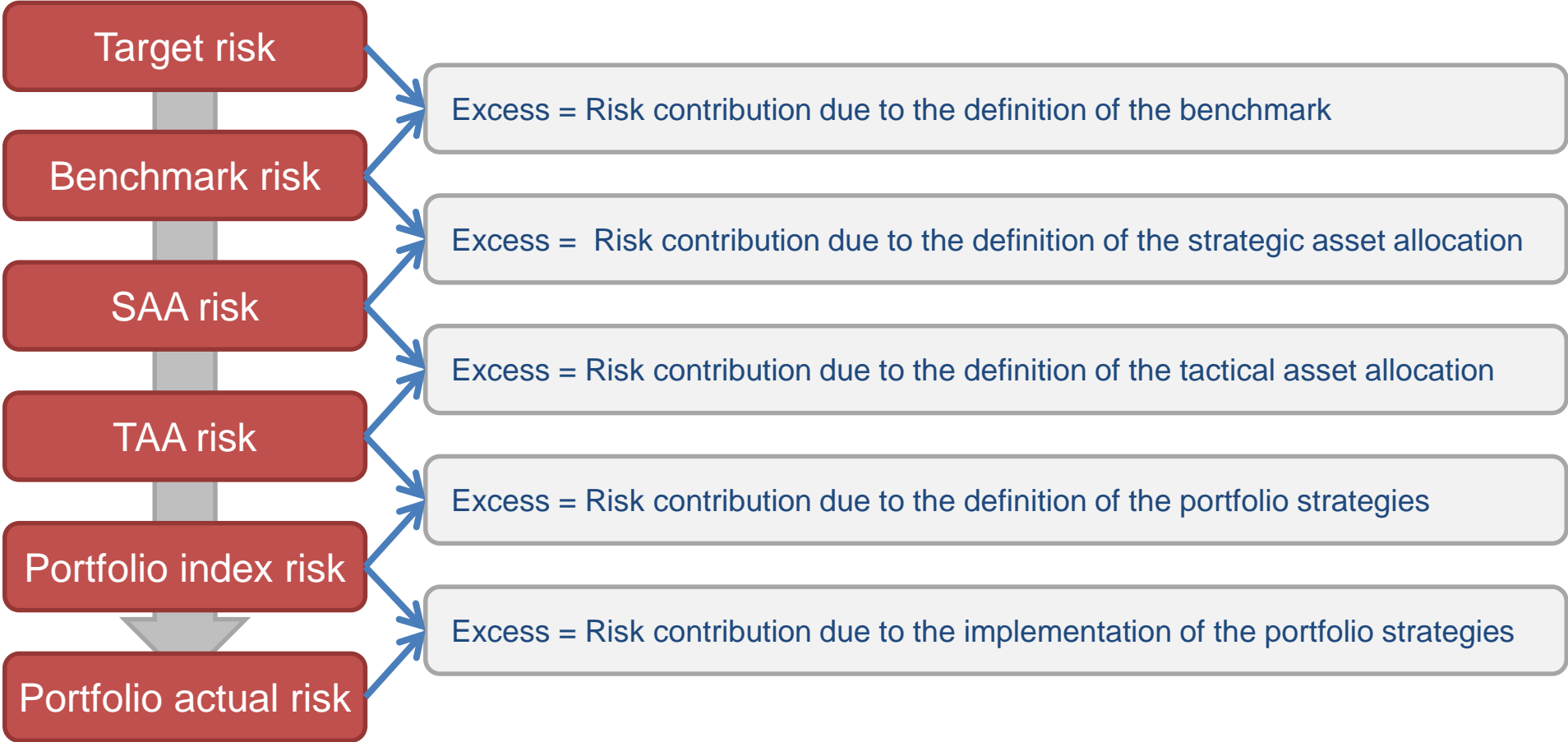
Calculation of risk figures

(1/6)



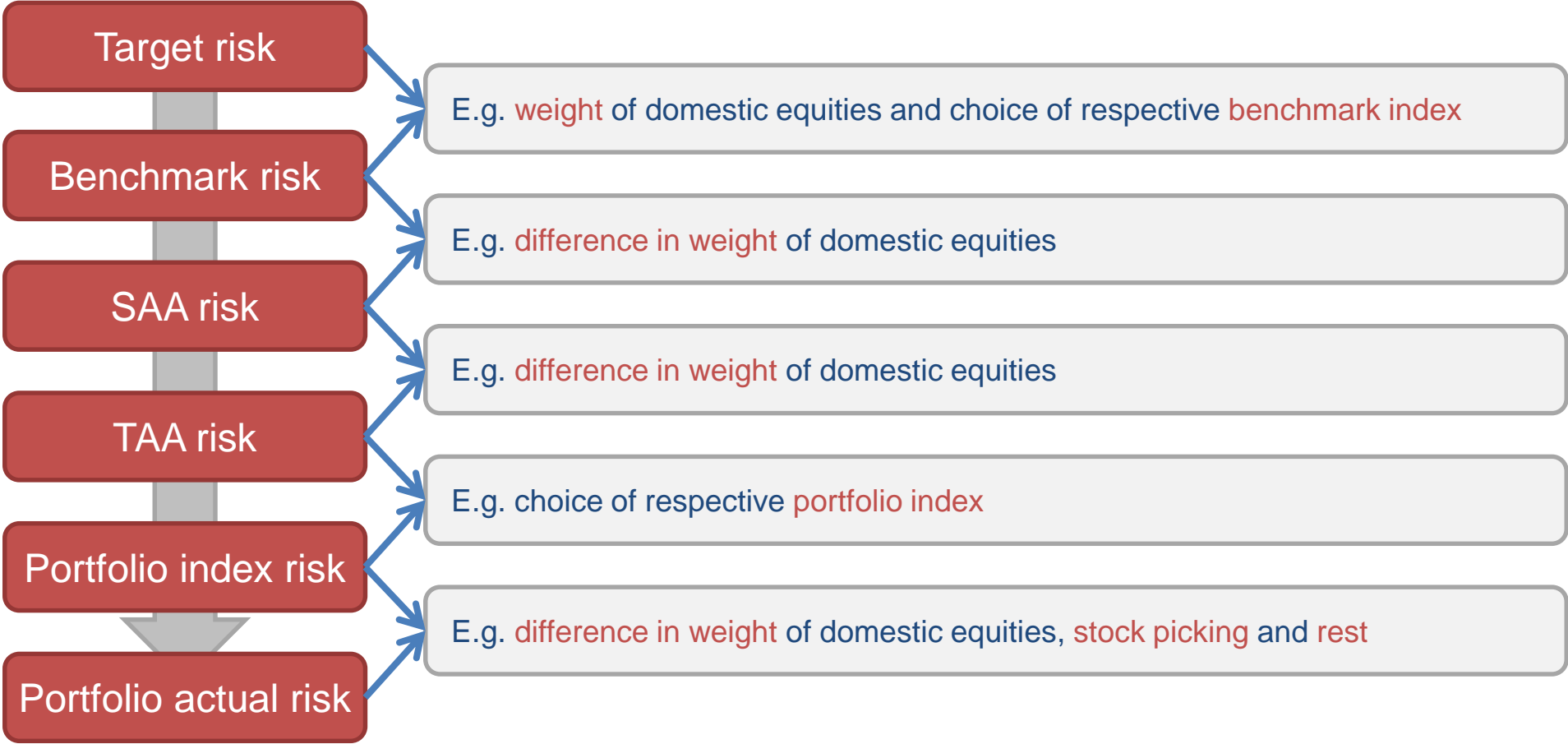
Calculation of risk figures

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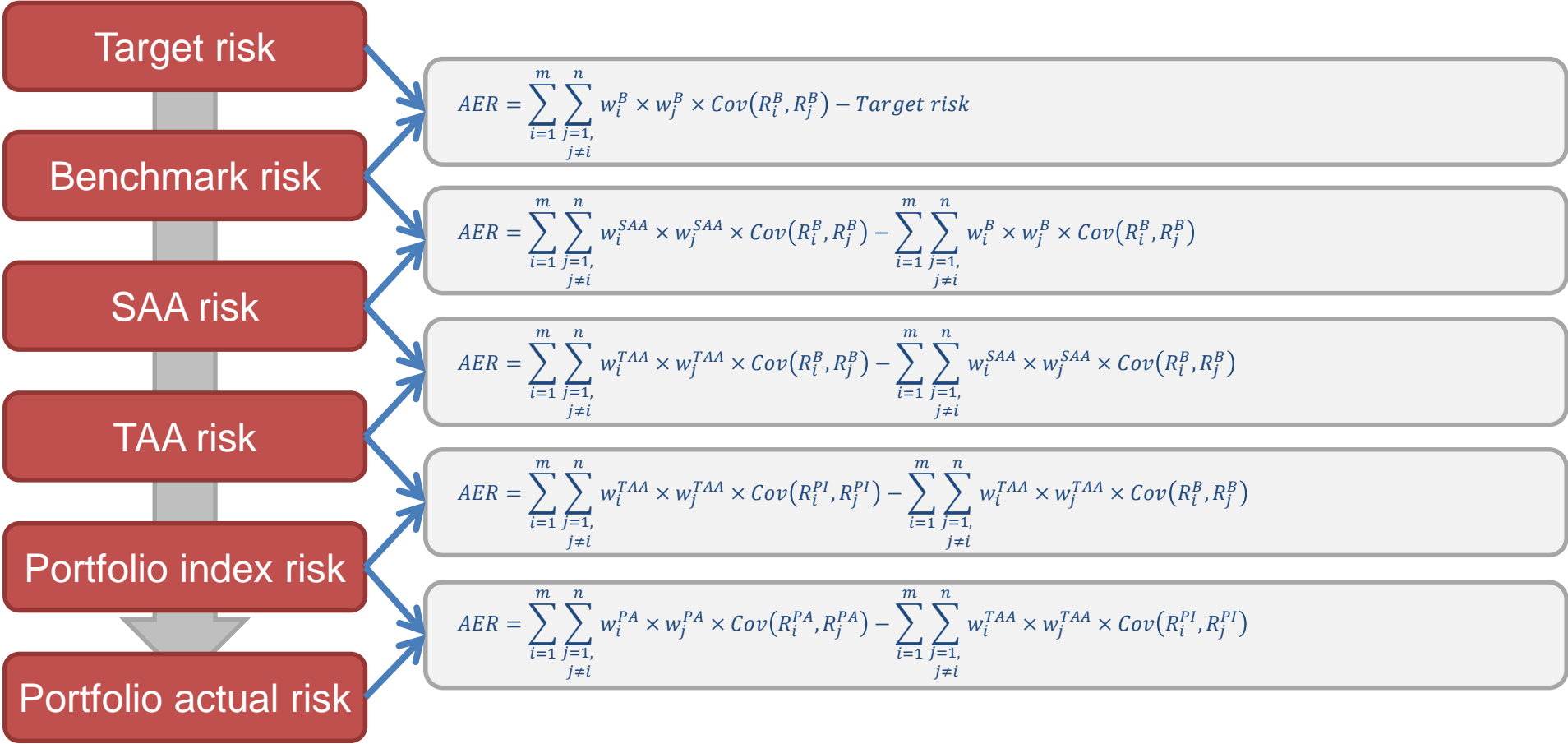
Calculation of risk figures

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Calculation of risk figures

(4/6)



Remark: Here we decompose the absolute excess risk – means the difference in total risk.

Calculation of risk figures

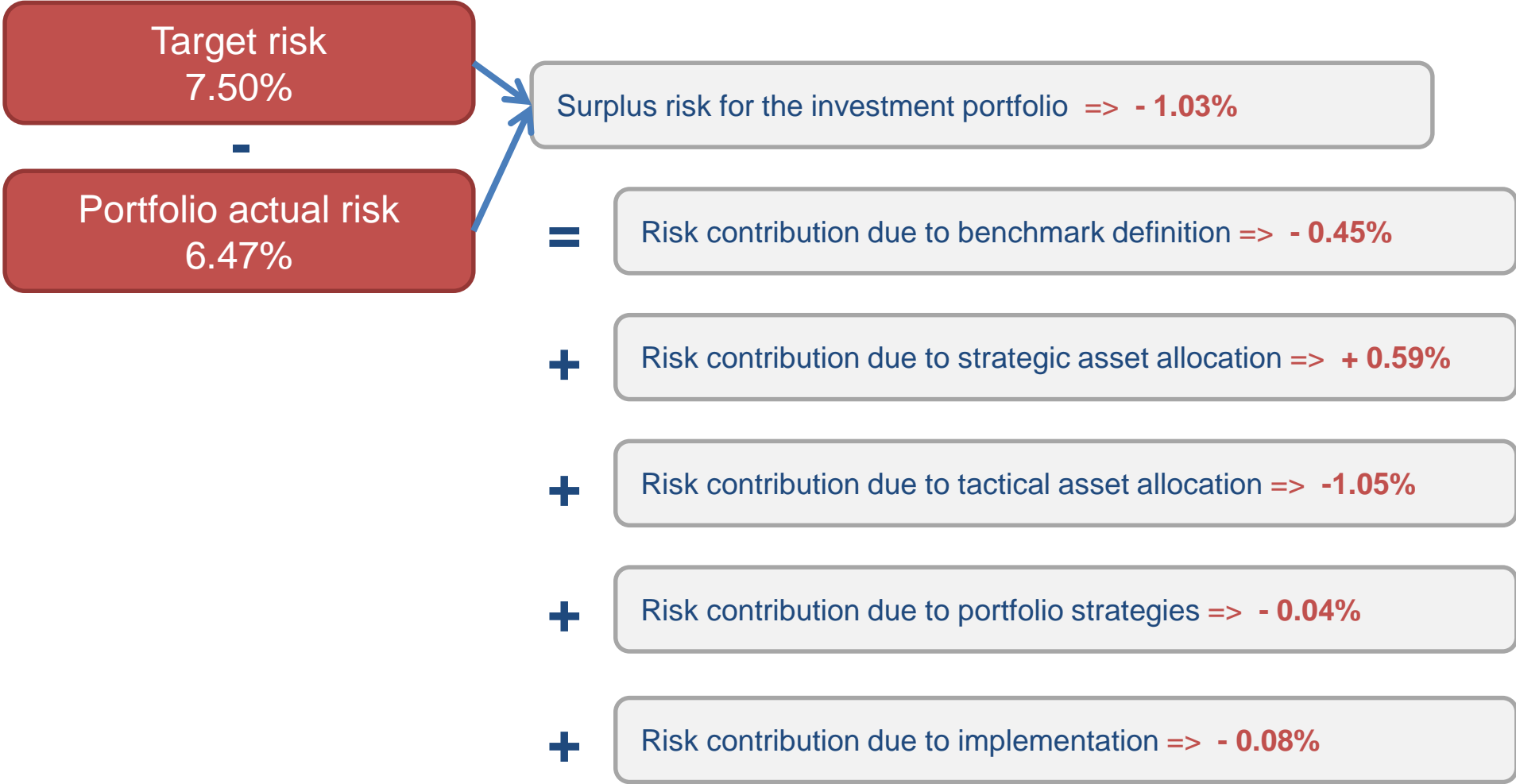
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Weights	Benchmark	Strategic asset allocation	Tactical asset allocation	Portfolio strategies	Implementation
Domestic Bonds 1	5.00%	5.00%	5.00%	5.00%	5.00%
Domestic Bonds 2	5.00%	5.00%	5.00%	5.00%	7.00%
Foreign Bonds 1	4.00%	2.00%	5.00%	5.00%	5.00%
Foreign Bonds 2	16.00%	8.00%	20.00%	20.00%	18.00%
Domestic Equities 1	13.64%	15.91%	25.00%	25.00%	25.00%
Domestic Equities 2	16.36%	19.09%	30.00%	30.00%	30.00%
Foreign Equities 1	20.00%	22.50%	5.00%	5.00%	5.00%
Foreign Equities 2	20.00%	22.50%	5.00%	5.00%	5.00%
Total	100.00%	100.00%	100.00%	100.00%	100.00%

Volatilities	Benchmark	Strategic asset allocation	Tactical asset allocation	Portfolio strategies	Implementation
Domestic Bonds 1	0.30%	0.30%	0.30%	0.31%	0.35%
Domestic Bonds 2	3.47%	3.47%	3.47%	2.99%	2.57%
Foreign Bonds 1	3.08%	3.08%	3.08%	3.02%	3.21%
Foreign Bonds 2	6.79%	6.79%	6.79%	6.34%	6.00%
Domestic Equities 1	1.08%	1.08%	1.08%	0.87%	0.78%
Domestic Equities 2	17.42%	17.42%	17.42%	17.58%	17.76%
Foreign Equities 1	18.92%	18.92%	18.92%	18.78%	18.69%
Foreign Equities 2	6.91%	6.91%	6.91%	3.37%	1.21%
Total	7.05%	7.64%	6.59%	6.55%	6.47%

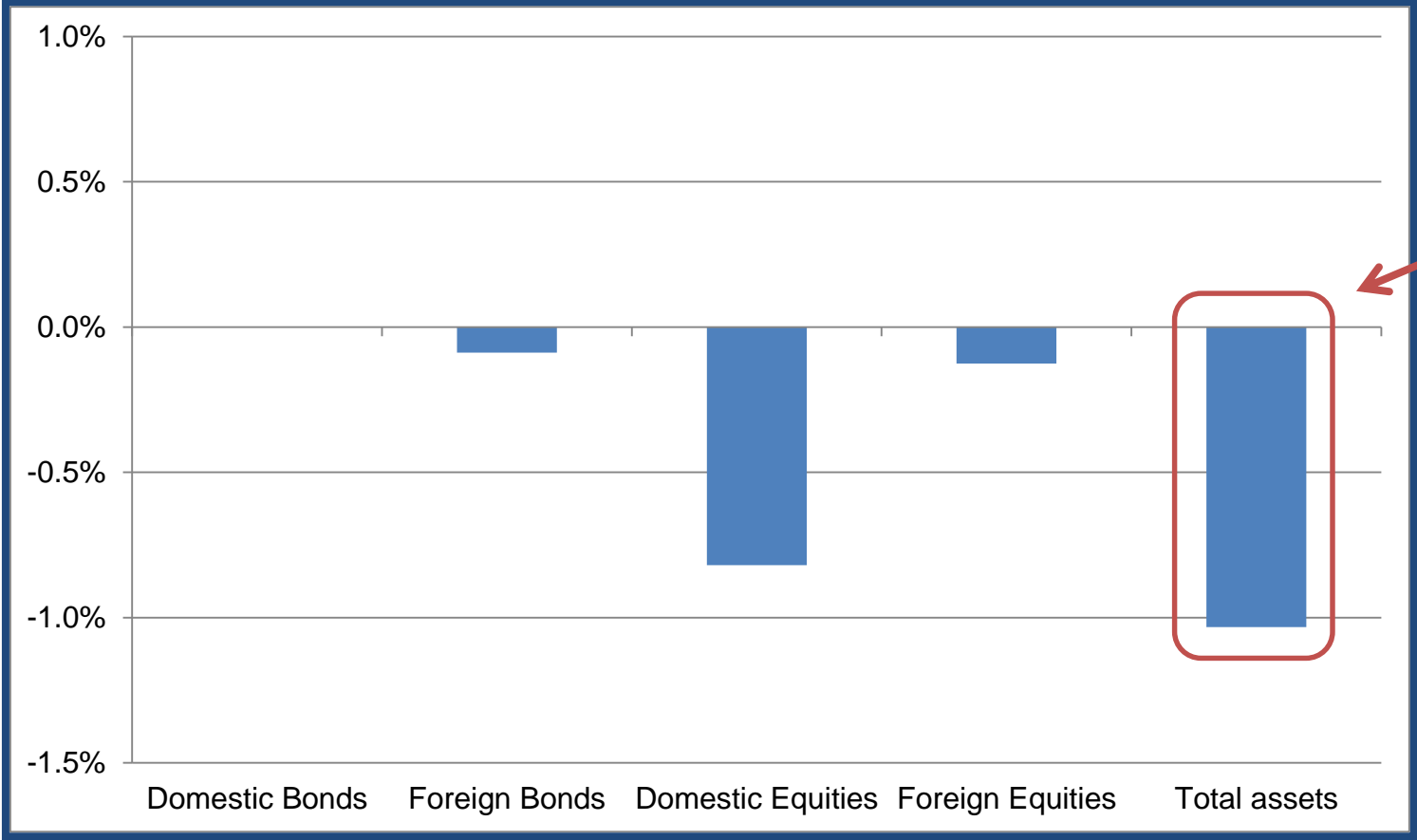
Calculation of risk figures

(6/6)



Assigning of absolute excess risk figures

(1/5)

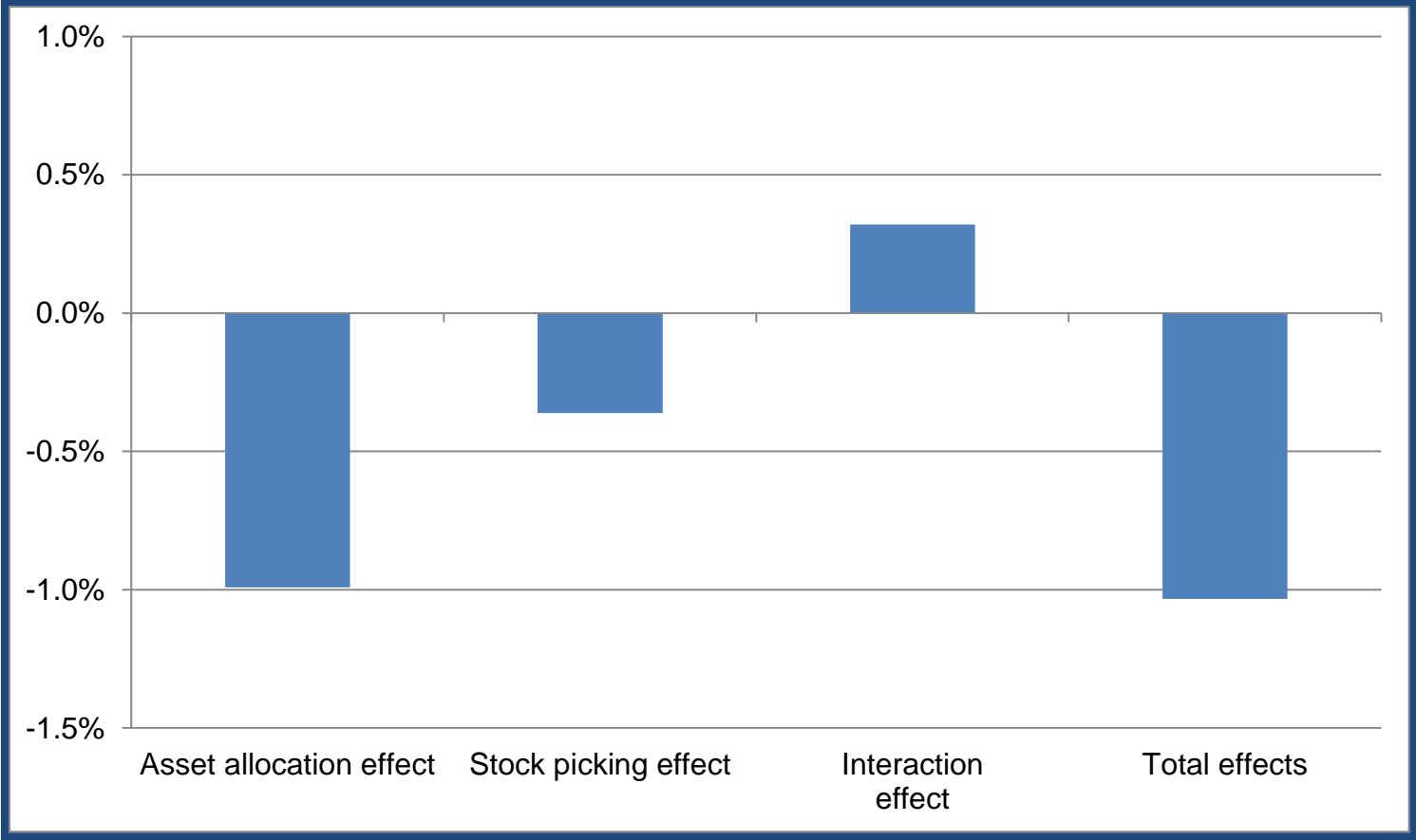


Including the added risk due to the definition of benchmark versus the target risk

Remark: Contribution to volatility are approximated by the relative weights of the contributions of the variances multiplied with the portfolio volatility.

Assigning of absolute excess risk figures

(2/5)

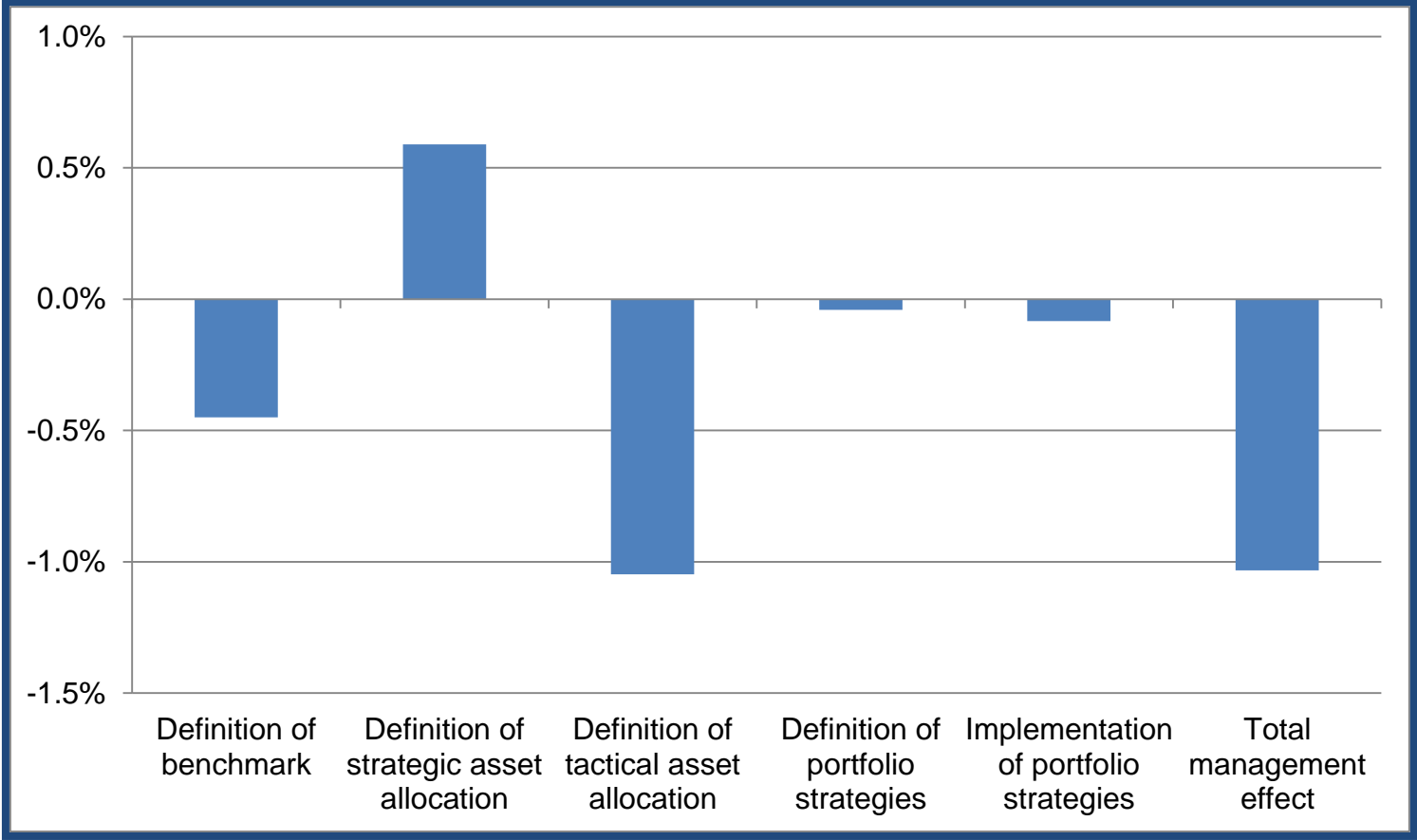


Decomposition of the absolute excess risk **if not reflecting** the investment management process

Remark: Contribution to volatility are approximated by the relative weights of the contributions of the variances multiplied with the portfolio volatility.

Assigning of absolute excess risk figures

(3/5)



Decomposition of the absolute excess risk reflecting the actual investment management process

Remark: Contribution to volatility are approximated by the relative weights of the contributions of the variances multiplied with the portfolio volatility.

Assigning of absolute excess risk figures

(4/5)

Management effects to excess risk	Asset allocation effect	Stock picking effect	Interaction effect	Total effects
Domestic Bonds	0.00%	0.01%	0.00%	0.00%
Foreign Bonds	-0.10%	-0.07%	0.01%	-0.09%
Domestic Equities	-0.76%	-0.02%	0.07%	-0.82%
Foreign Equities	-0.13%	-0.28%	0.24%	-0.13%
Total assets	-0.99%	-0.36%	0.32%	-1.03%



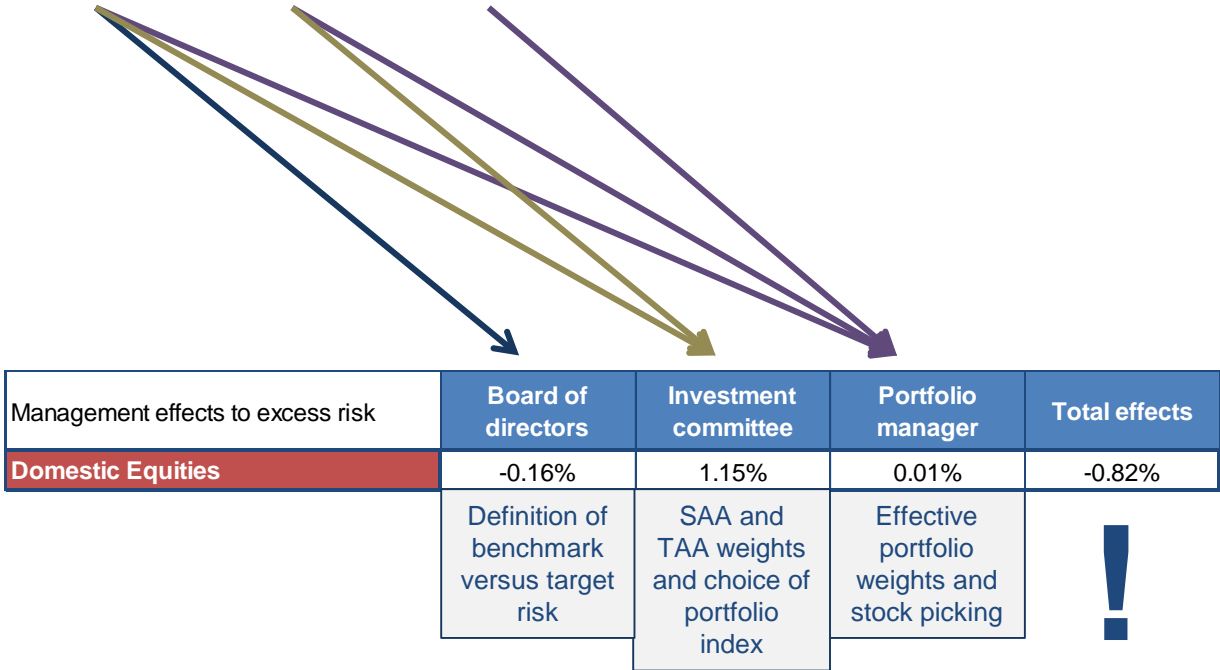
Management effects to excess risk	Board of directors	Investment committee	Portfolio manager	Total effects
Domestic Bonds	0.00%	0.01%	0.00%	0.00%
Foreign Bonds	-0.04%	-0.02%	-0.07%	-0.09%
Domestic Equities	-0.16%	1.15%	0.01%	-0.82%
Foreign Equities	-0.25%	-1.64%	-0.02%	-0.13%
Total assets	-0.45%	-0.50%	-0.08%	-1.03%

Remark: Contribution to volatility are approximated by the relative weights of the contributions of the variances multiplied with the portfolio volatility.

Assigning of absolute excess risk figures

(5/5)

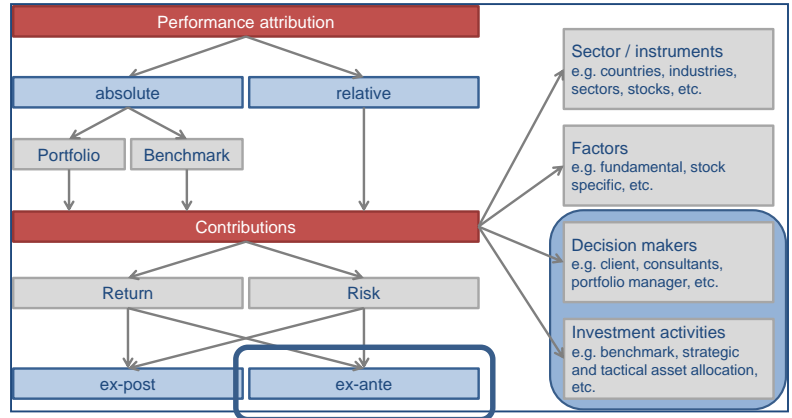
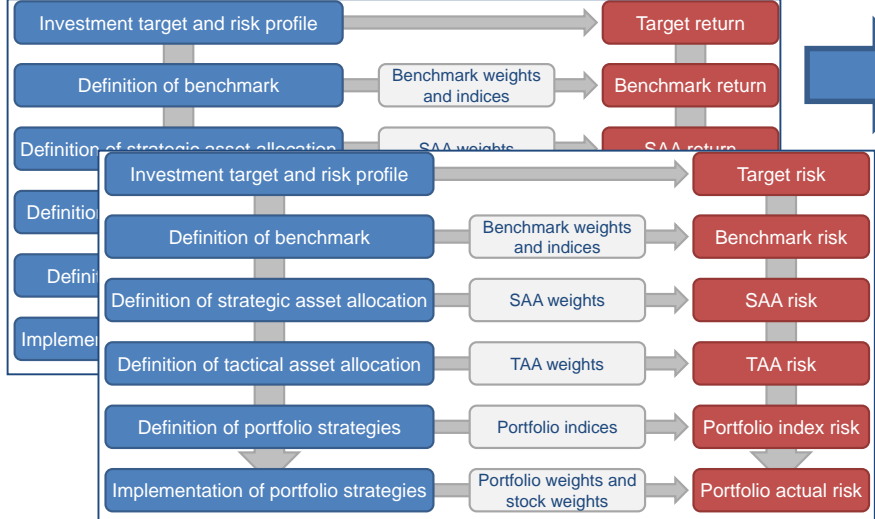
Management effects to excess risk	Asset allocation effect	Stock picking effect	Interaction effect	Total effects
Domestic Equities	-0.76%	-0.02%	0.07%	-0.82%



Remarks: Decomposition might change depending on the investment management process. Contribution to volatility are approximated by the relative weights of the contributions of the variances multiplied with the portfolio volatility.

Outlook – bringing return and risk together

Comprehensive performance attribution – An example (1/4)



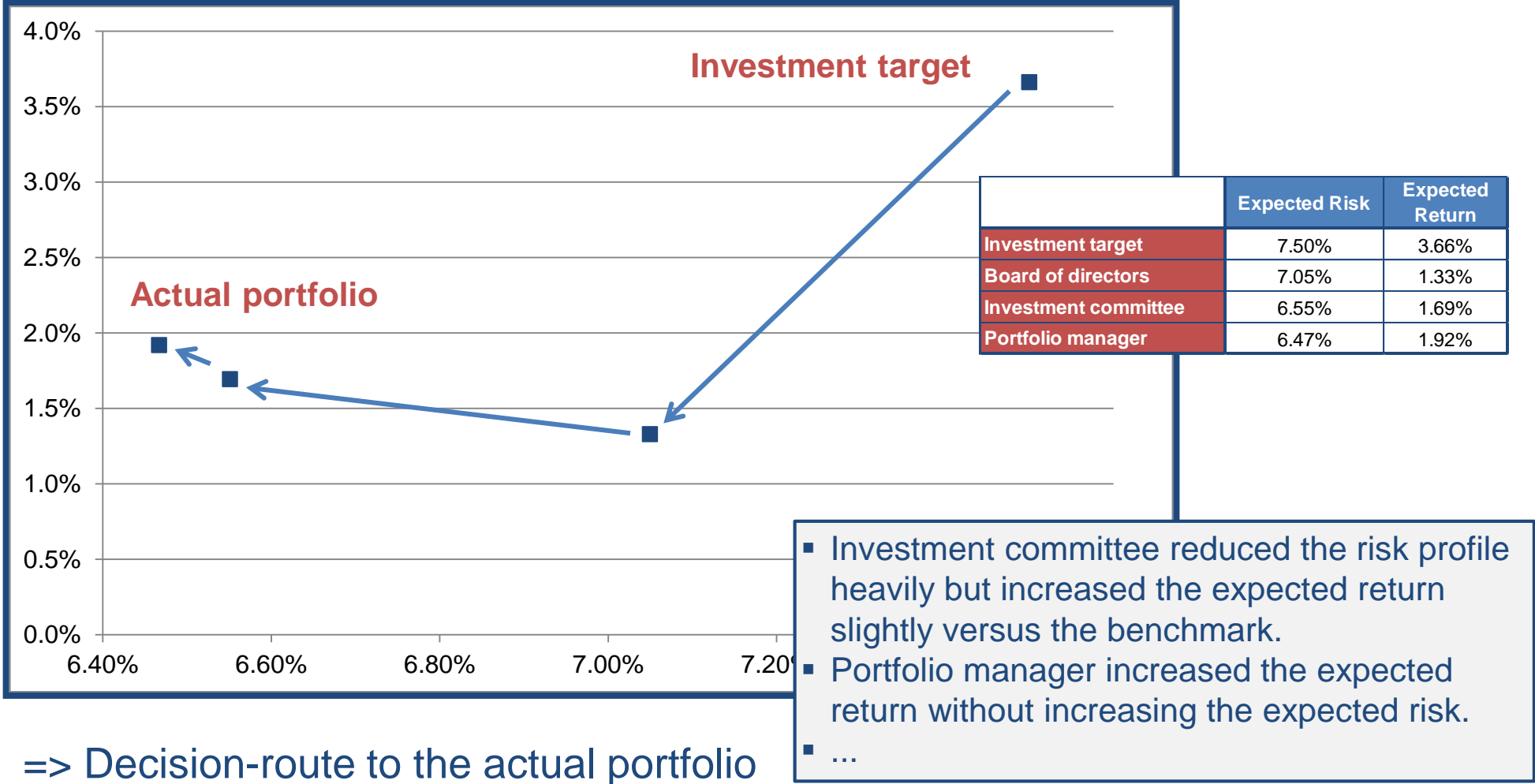
How much absolute or excess risk is coming from each asset class, each decision and each decision maker? And what where the consequences on the expected return?

	Expected Risk	Expected Return
Investment target	7.50%	3.66%
Board of directors	7.05%	1.33%
Investment committee	6.55%	1.69%
Portfolio manager	6.47%	1.92%

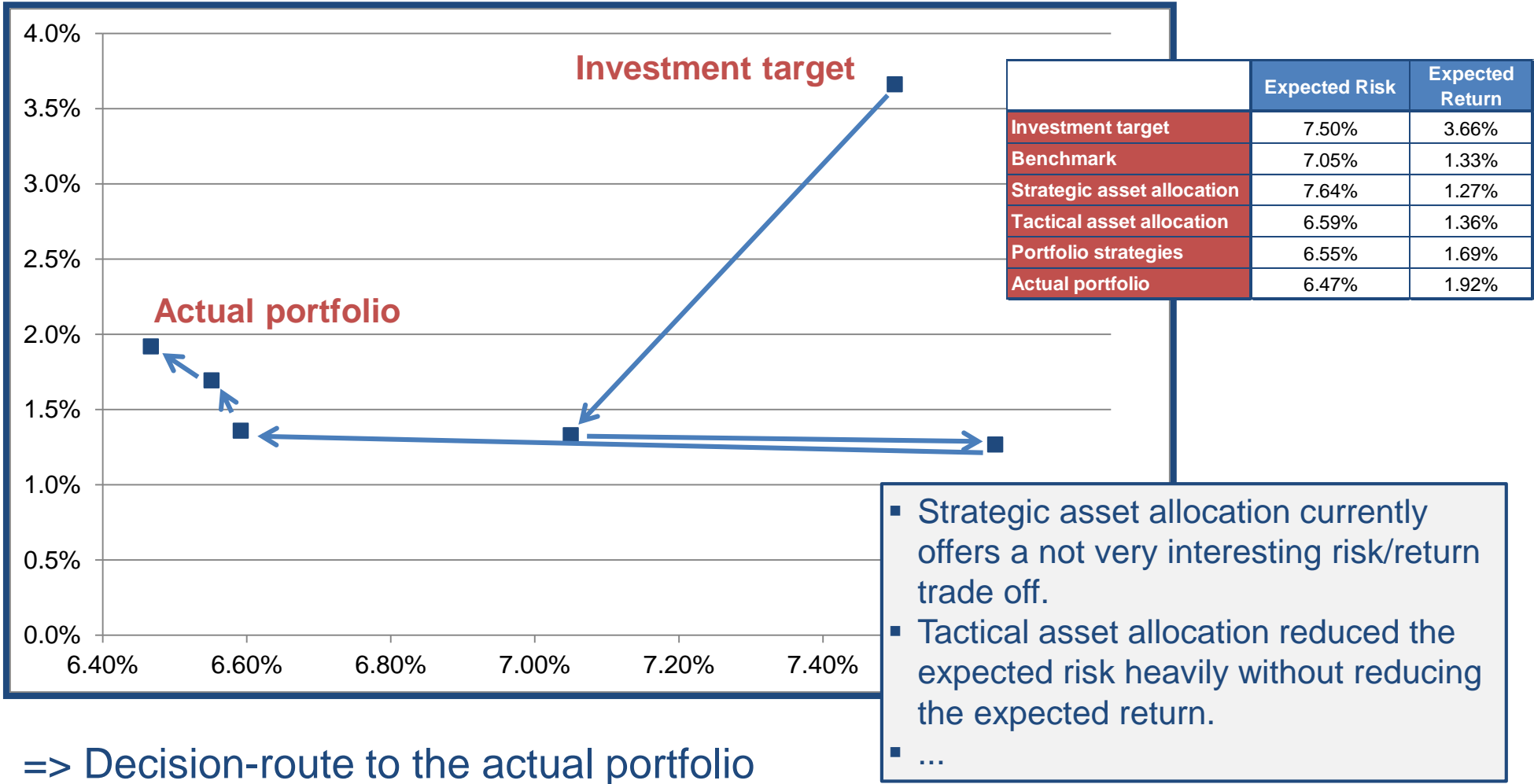
	Expected Risk	Expected Return
Investment target	7.50%	3.66%
Benchmark	7.05%	1.33%
Strategic asset allocation	7.64%	1.27%
Tactical asset allocation	6.59%	1.36%
Portfolio strategies	6.55%	1.69%
Actual portfolio	6.47%	1.92%

Interpretations.

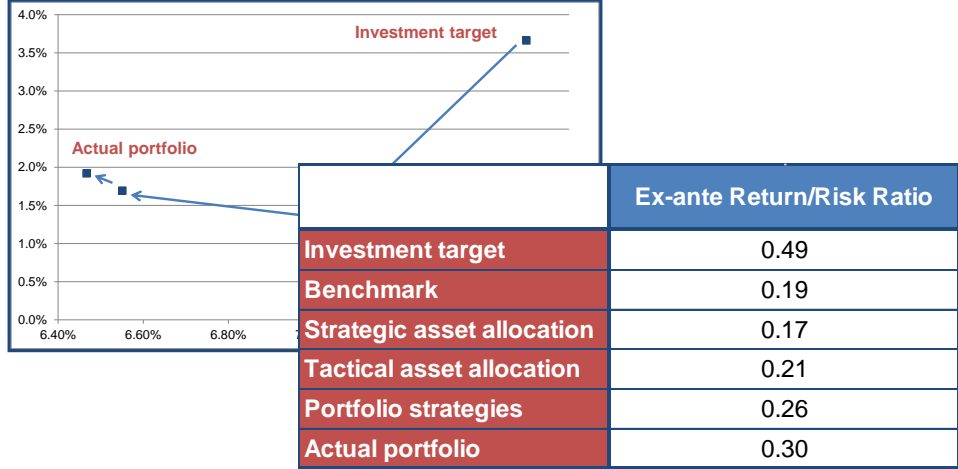
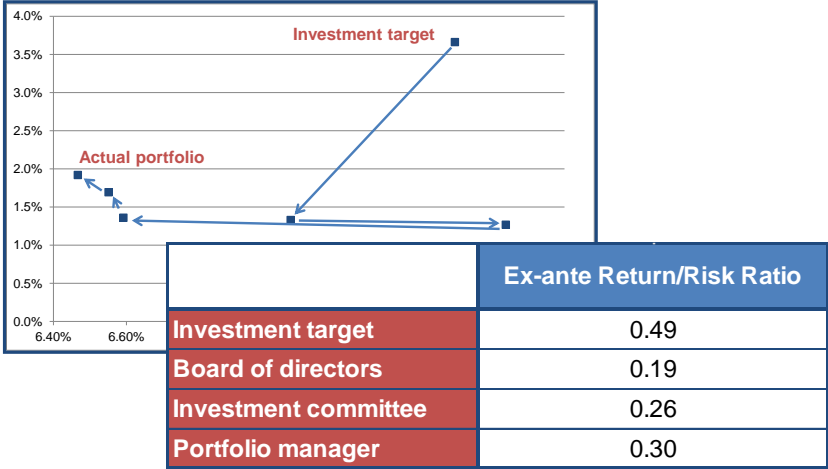
Comprehensive performance attribution – An example (2/4)



Comprehensive performance attribution – An example (3/4)

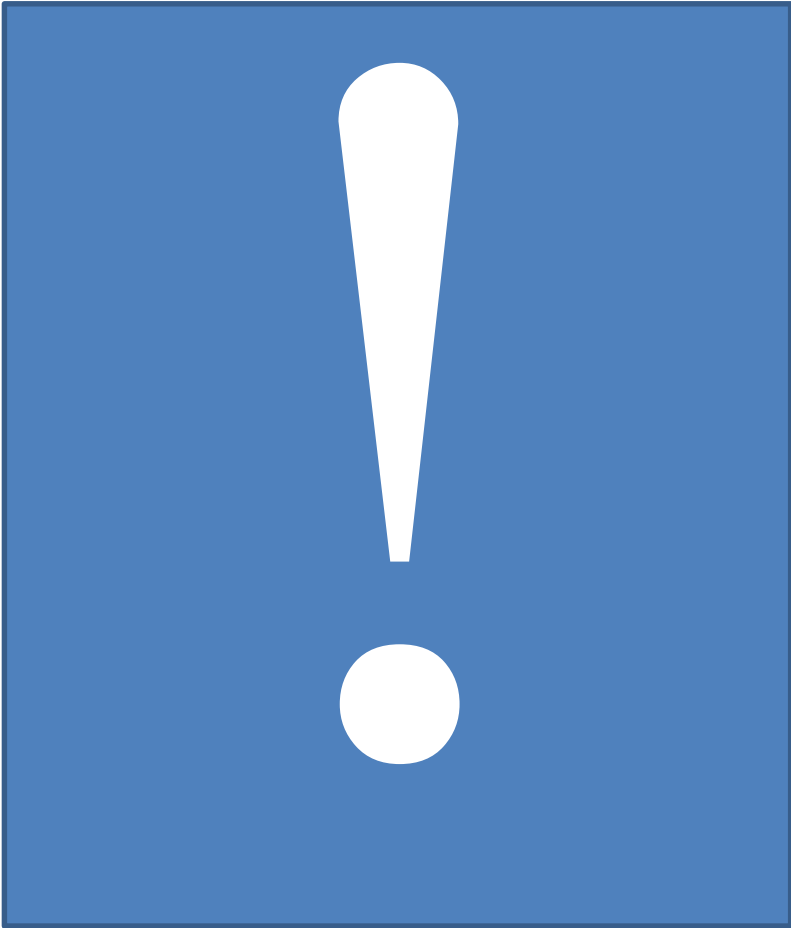


Comprehensive performance attribution – An example (4/4)



Comments and questions

Comments and questions



Contact details and disclaimer

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