JC-2017-49

16 August 2017

PRIIPs – Flow diagram for the risk and reward calculations in the PRIIPs KID

1. Introduction

The diagrams below set out the calculation steps for the Summary Risk Indicator (market risk and credit risk assessment) and Performance Scenario calculations described in Commission Delegated Regulation (EU) 2017/653.

They are being published as part of the Question and Answer (Q&A) material developed by the European Supervisory Authorities (ESAs) on the application of the requirements for the PRIIPs KID as practical convergence tools used to promote common supervisory approaches and practices in accordance with Article 29(2) of the ESA Regulations.

The diagrams are of a non-binding nature and do not constitute professional or legal advice. The legal requirements that need to be compiled with are those in Commission Delegated Regulation (EU) 2017/653 and not the text included in these diagrams. Please also be aware that the ESAs could adopt a formal position, which is different from the one expressed in this document.

All article references are to Commission Delegated Regulation (EU) 2017/653 unless otherwise stated.

The ESAs will review this document periodically or based on questions or comments from external stakeholders and updates are expected over time.

2. Table of Contents

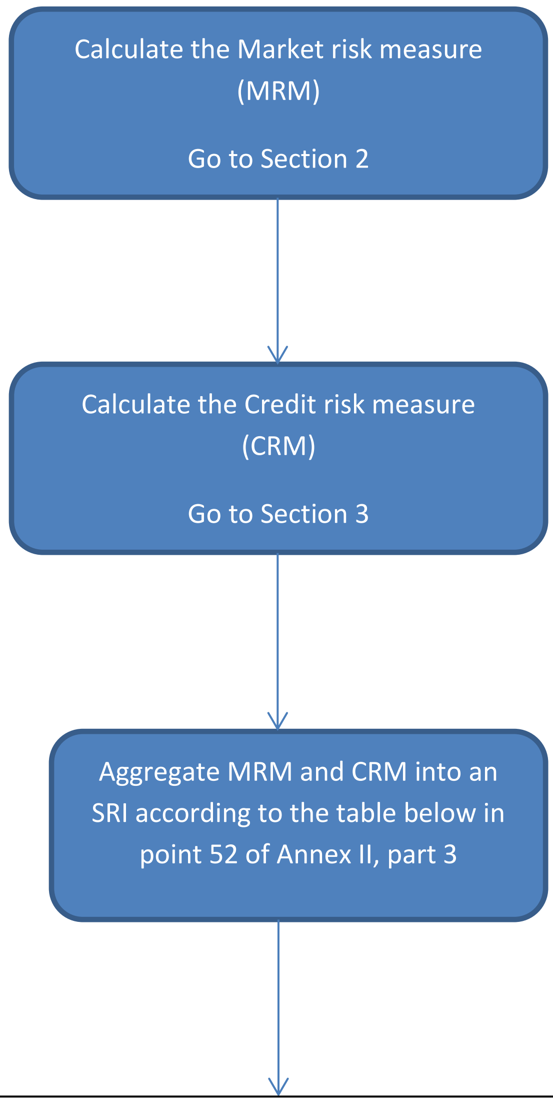
3. Acronyms used

CQS	Credit Quality Step
CRM	Credit Risk Measure
ECAI	External Credit Assessment Institution
ESAs	European Supervisory Authorities
EXP	Exponential
KID	Key Information Document
MRM	Market Risk Measure
OTC	Over The Counter
PCA	Principal Component Analysis
PRIIP	Package Retail and Insurance-based Investment Product
Q&A	Question and Answer
RHP	Recommended Holding Period
SRI	Summary Risk Indicator
VaR	Value-at-risk
VEV	VaR-Equivalent Volatility

4. Flow Diagrams

A. Summary Risk Indicator (SRI)

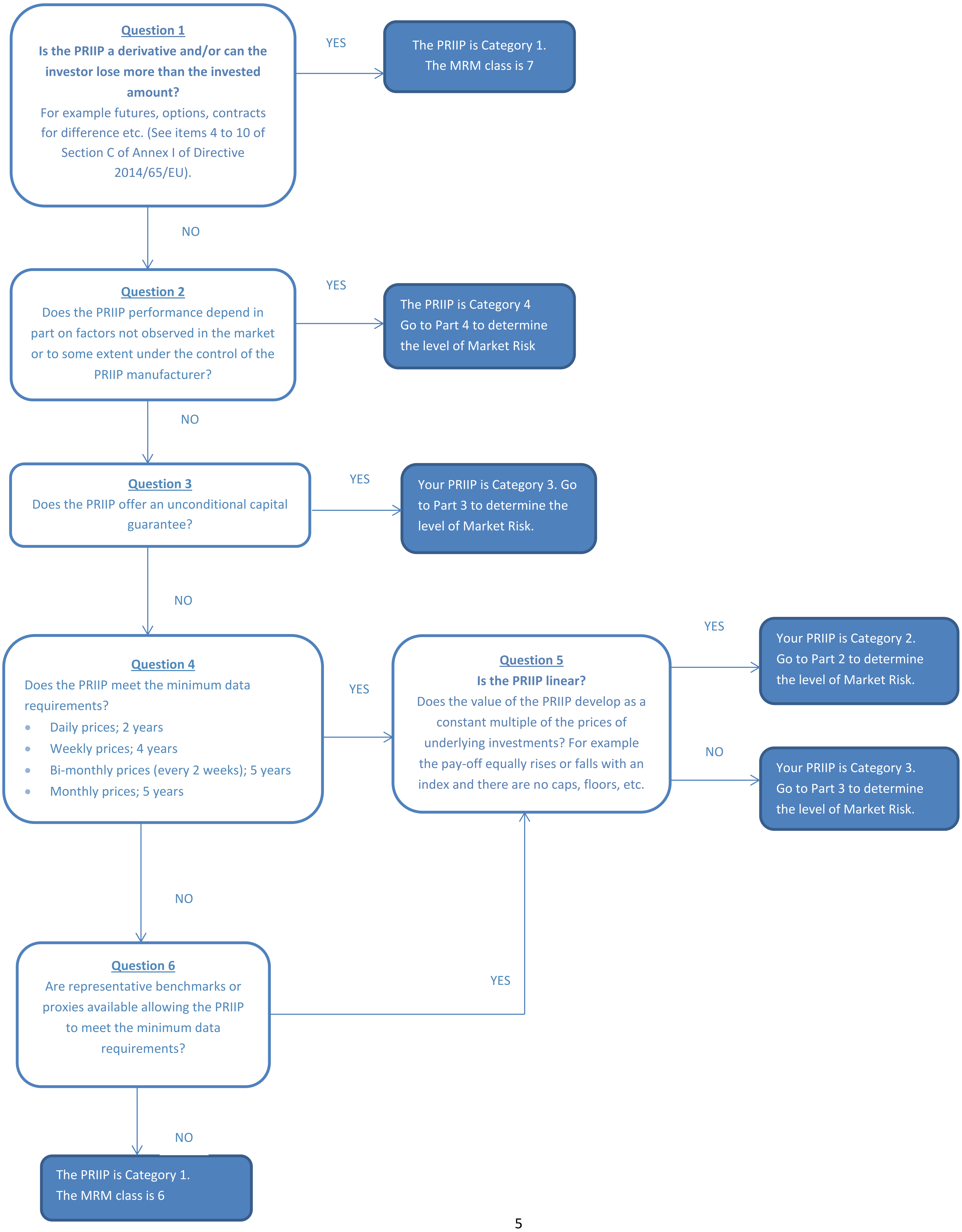
Section 1: Calculating the Summary Risk Indicator



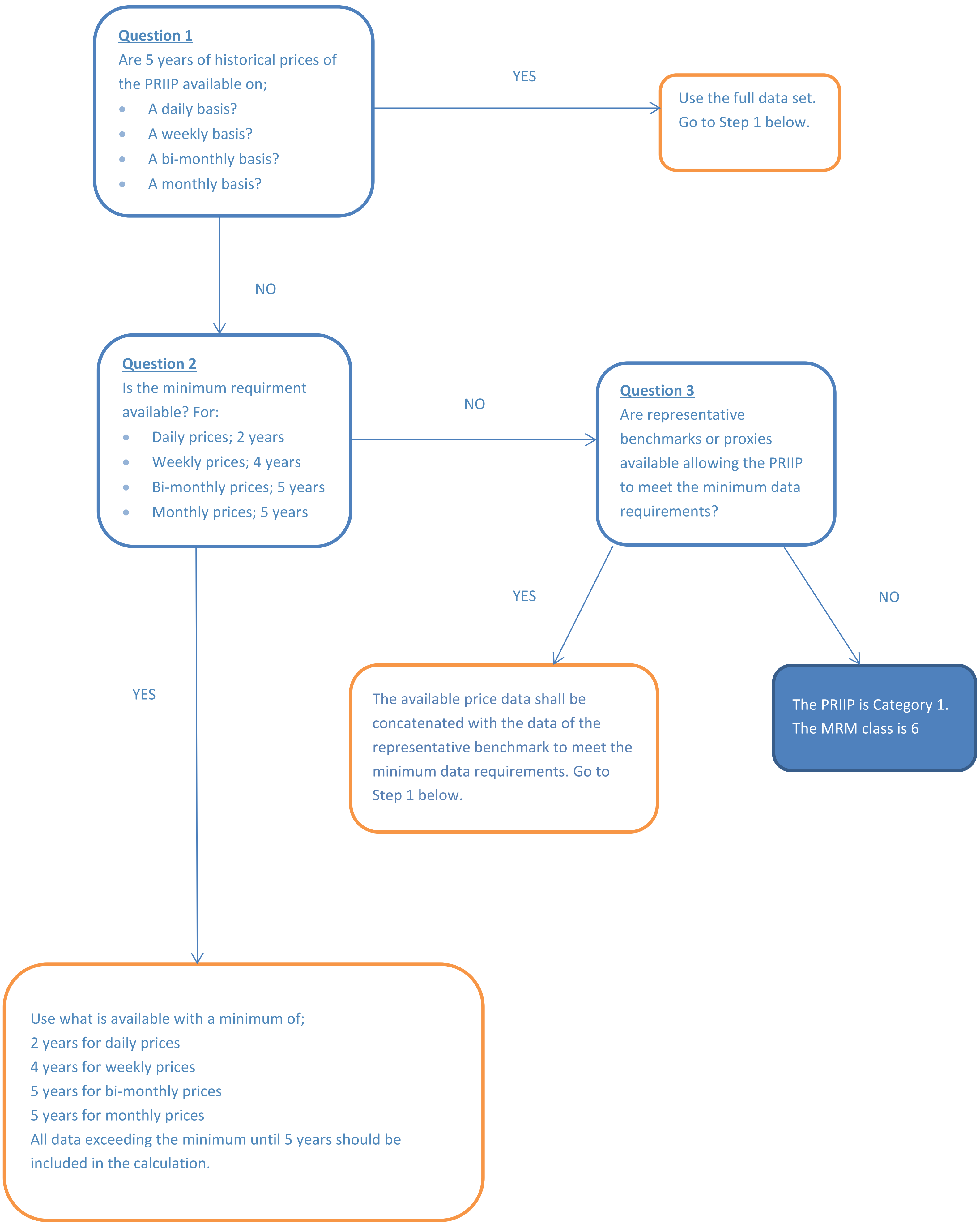
CRM class \ MRM class	MR1	MR2	MR3	MR4	MR5	MR6	MR7
CR1	1	2	3	4	5	6	7
CR2	1	2	3	4	5	6	7
CR3	3	3	3	4	5	6	7
CR4	5	5	5	5	5	6	7
CR5	5	5	5	5	5	6	7
CR6	6	6	6	6	6	6	7

Section 2: Market Risk Measure

Part 1: Determine the PRIIP Category to select the applicable methodology



Part 2: Category 2 (linear) PRIIPs



Step 1

To calculate the VaR Return Space using the Cornish Fisher expansion, you need the history of observed returns of the PRIIP. The returns are calculated by taking the natural logarithm of the price at the end of the current period divided by the price at the end of the previous period.

Zeroeth Moment (M_0): This is the number of observed returns.

First Moment (M_1): This is the average of the observed returns.

Second Moment (M_2): This is the average of the square of each return less M_1. It summarises the variance or width of the distribution of the returns.

The standard deviation (σ) is the square root of M_2.

Third Moment (M_3): This is the average of the cube of each return less M_1. It summarises the asymmetry or skewness of the distribution of the returns.

The skew (μ_1) is M_3 divided by the cube of the standard deviation.

Fourth Moment (M_4): This is the average of the fourth power of each return less M_1. It summarises the extent of wider tails or kurtosis of the distribution of the returns.

The excess kurtosis (μ_2) is M_4 divided by the fourth power of the standard deviation less 3

Step 2

Now the formula can be applied to the data:

$$VaR_{RETURN\ SPACE} = \sigma \sqrt{N} * (-1{,}96 + 0{,}474 * \mu_1 / \sqrt{N} - 0{,}0687 * \mu_2 / N + 0{,}146 * \mu_1^2 / N) - 0{,}5\sigma^2 N$$

where N represents the number of trading periods in the recommended holding period

Question 4

Is the PRIIP managed according to investment policies and/or strategies according to point 14 of Annex I, Part 1?

YES

Question 5

Has a revision of the policy taken place within the period over which the price data is used?

YES

To determine VEV take the maximum of the 2 options below;

1. VEV of the returns of the pro-forma asset mix that is consistent with the reference asset allocation of the fund at the time of the computation;
2. The VEV which is consistent with the risk limit of the fund, if any and appropriate.

NO

To determine VEV take the maximum of the 3 options below;

1. The VEV as computed under step 3.
2. VEV of the returns of the pro-forma asset mix that is consistent with the reference asset allocation of the fund at the time of the computation;
3. The VEV which is consistent with the risk limit of the fund, if any and appropriate.

NO

Step 3

After determining the VaR in Return space, now the VEV should be determined. This can be done by the following formula;

$$VEV = \{\sqrt{(3.842 - 2 * VaR_{RETURN\ SPACE})} - 1.96\} / \sqrt{T}$$

where T is the length of the recommended holding period in years.

Question 6

Is the calculation based on monthly price data?

NO

The MRM class is assigned based on the table to the right in point 2 of Annex II, Part 1.

YES

The MRM class is assigned based on the table to the right in point 2 of Annex II, Part 1and increased by one MRM class.

MRM class	Annualised volatility (VEV)
1	< 0,5 %
2	≥0,5 % and <5,0 %
3	≥5,0 % and <12 %
4	≥12 % and <20 %
5	≥20 % and <30 %
6	≥30 % and <80 %
7	≥80 %

Calculation Example Category 2 PRIIPs

5 years of daily observed prices (Euro Stoxx 50 from 01.05.12 to 25.05.17)

Trading days per year	256	**365 (number of days) – 104 (number of weekend days) – 5 (public holidays) = 256 days**			
M0 (under paragraph 10 of Annex II)	1280	**Number of observations in the period 256*5=1280**			
M1	0,0003389	**Mean of all the observed returns in the sample (daily)**			
M2	0,000149905	Second Moment $M_2 = \sum_i \frac{(r_i - M_1)^2}{M_0} = \sigma^2$	**Volatility**	0,01224357	$\sigma = \sqrt{M_2}$
M3	-6,44479E-07	Third Moment $M_3 = \sum_i (r_i - M_1)^3 / M_0$	**Skew**	-0,351143435	$\mu_1 = M_3 / M_2^{1,5}$
M4	1,46705E-07	Fourth Moment $M_4 = \sum_i (r_i - M_1)^4 / M_0$	**Excess Kurtosis**	3,528503383	$\mu_2 = (M_4 / M_2^2) - 3$

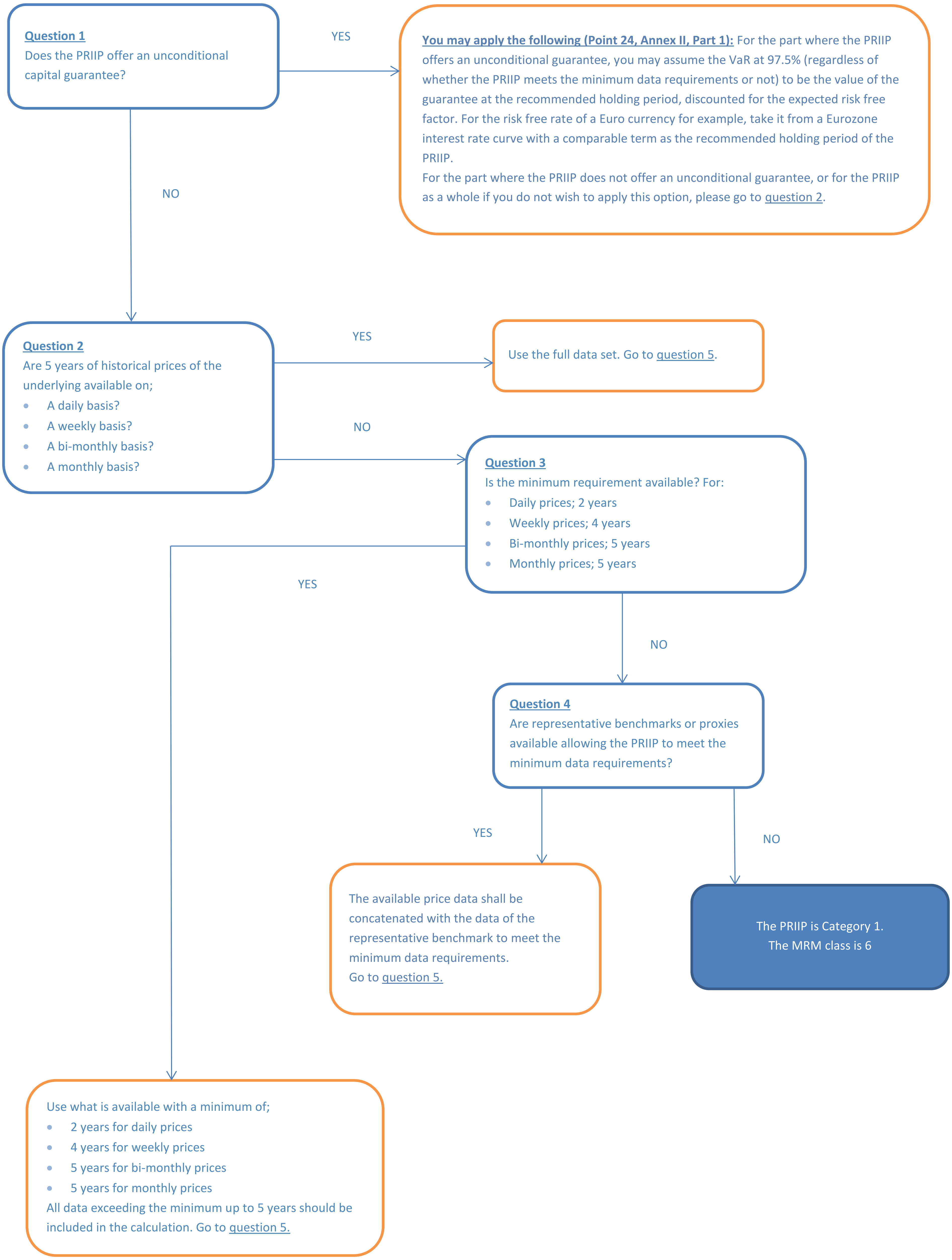
Daily σ	0,01224357		
Confidence level	2,50%	**Polynomial**	**Divisor**
z_α	-1,959963985	z^2-1	6
Annualized Volatility (1Y) $\sigma\sqrt{N}$	19,59%	z^3-3z	24
$(z_\alpha^2 - 1)/6$	0,47357647	2z^3-5z	36
$(z_\alpha\text{^}3 - 3z_\alpha)/24$	-0,068717874		
$(2z_\alpha^{\wedge}3 - 5z_\alpha)/36$	-0,146067276		

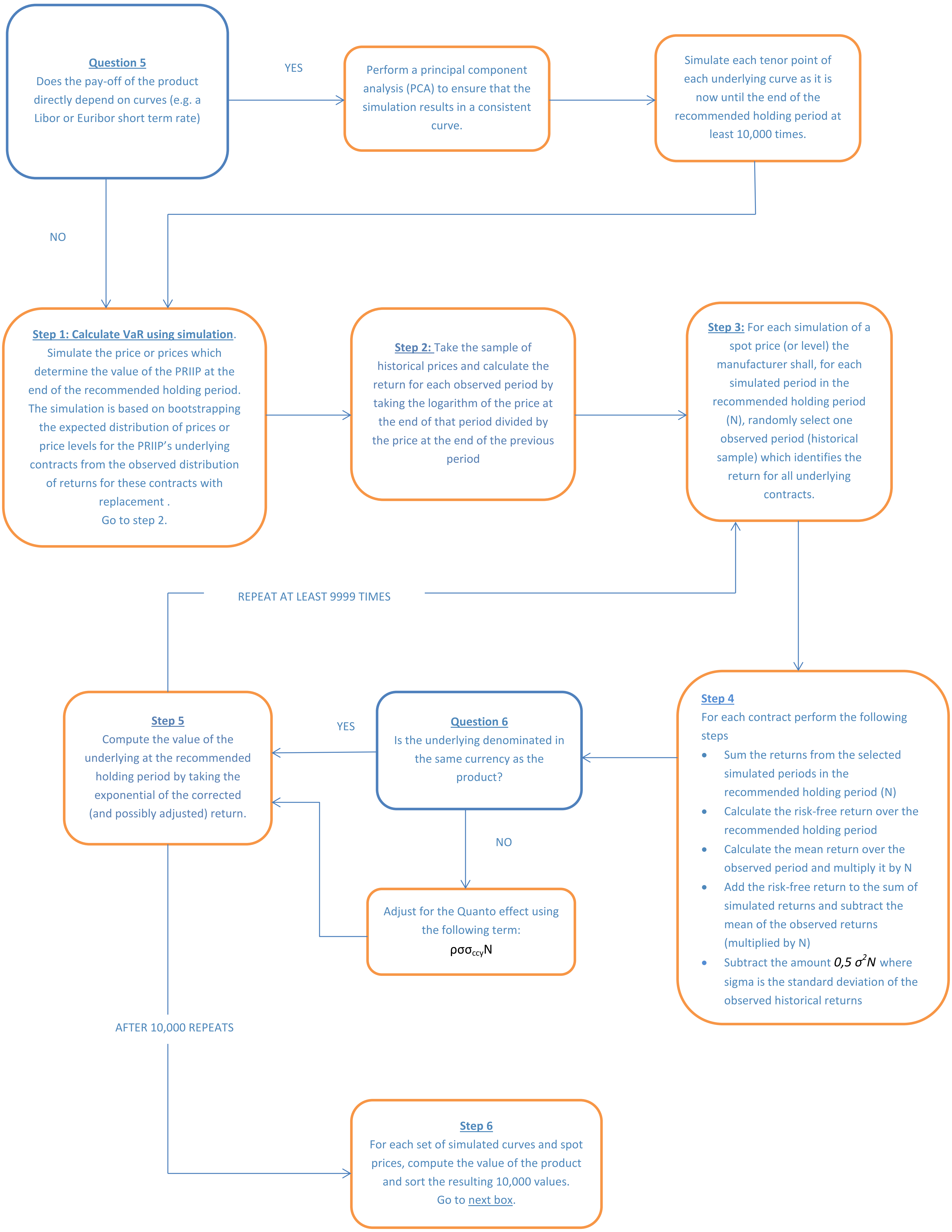
$$VEV_{Return\ Space} = \frac{\sqrt{z_\alpha^2 - 2 * VaR_{Retunr\ Space}} - z_\sigma}{\sqrt{T}}$$

$$VEV_{Price\ Space} = \frac{\sqrt{z_\alpha^2 - 2 * \ln(VaR_{Price\ Space})} - z_\alpha}{\sqrt{T}}$$

RHP (Recommended Holding Period expressed in years)	Number of Days	VaR (Return Space)	VEV Return Space	MRM class	VaR-equivalent volatility (VEV)
1	256	-0,4053	0,1969	1	<0,5%
3	768	-0,7247	0,1964	2	0,5%-5,0%
5	1280	-0,9566	0,1963	3	5,0%-12%
10	2560	-1,4081	0,1962	4	12%-20%
20	5120	-2,1029	0,1961	5	20%-30%
50	12800	-3,6764	0,1960	6	30%-80%
				7	>80%

Part 3: Category 3 PRIIPs (non-linear products)




Question 5
Does the pay-off of the product directly depend on curves (e.g. a Libor or Euribor short term rate)
YES
Perform a principal component analysis (PCA) to ensure that the simulation results in a consistent curve.
Simulate each tenor point of each underlying curve as it is now until the end of the recommended holding period at least 10,000 times.
NO
Step 1: Calculate VaR using simulation. Simulate the price or prices which determine the value of the PRIIP at the end of the recommended holding period. The simulation is based on bootstrapping the expected distribution of prices or price levels for the PRIIP's underlying contracts from the observed distribution of returns for these contracts with replacement .
Go to step 2.
Step 2: Take the sample of historical prices and calculate the return for each observed period by taking the logarithm of the price at the end of that period divided by the price at the end of the previous period
Step 3: For each simulation of a spot price (or level) the manufacturer shall, for each simulated period in the recommended holding period (N), randomly select one observed period (historical sample) which identifies the return for all underlying contracts.
REPEAT AT LEAST 9999 TIMES
Step 4
For each contract perform the following steps
Sum the returns from the selected simulated periods in the recommended holding period (N)
Calculate the risk-free return over the recommended holding period
Calculate the mean return over the observed period and multiply it by N
Add the risk-free return to the sum of simulated returns and subtract the mean of the observed returns (multiplied by N)
Subtract the amount $0,5\ \sigma^2 N$ where sigma is the standard deviation of the observed historical returns
Question 6
Is the underlying denominated in the same currency as the product?
YES
Step 5
Compute the value of the underlying at the recommended holding period by taking the exponential of the corrected (and possibly adjusted) return.
NO
Adjust for the Quanto effect using the following term:
$\rho\sigma\sigma_{ccy}N$
AFTER 10,000 REPEATS
Step 6
For each set of simulated curves and spot prices, compute the value of the product and sort the resulting 10,000 values.
Go to next box.

Take the $VaR_{PRICE\ SPACE}$ from these sorted values at the 97.5% interval or the 2.5% percentile of the distribution of the PRIIP's values and discount it to the present date using the expected risk-free discount factor.

Step 7 - Calculate VEV and MRM Class

The VEV is given by:

$$VEV = \{\sqrt{(3.842 - 2 * \ln(VaR_{PRICE\ SPACE}))} - 1.96\} / \sqrt{T}$$

Where T is the length of the recommended holding period in years (Point 17, Annex II, Part 1).

Only in cases where the product is called or cancelled before the end of the recommended holding period according to the simulation, the period in years until the call or cancellation is used.

Question 8

Is the calculation based on monthly price data?

NO

The MRM class is assigned based on the table below (Point 2, Annex II, Part 1).

YES

The MRM class is assigned based on the table below and increased with one MRM class (Point 18, Annex II, Part 1).

MRM class	Annualised volatility (VEV)
1	< 0,5 %
2	≥0,5 % and <5,0 %
3	≥5,0 % and <12 %
4	≥12 % and <20 %
5	≥20 % and <30 %
6	≥30 % and <80 %
7	≥80 %

Steps 1-6: 12 days RHP, 20 simulations, 1280 observed daily prices (5 years – Euro Stoxx 50 – from 01.05.12 to 28.04.17)

	EXAMPLE SIMULATION: SIMULATION 1		DISTRIBUTION OF SIMULATIONS		
EACH SIMULATED PERIOD IN THE RHP (RHP=12 DAYS)	RANDOMLY SELECT ONE OBSERVED PERIOD OVER 1280 PERIODS (5*256)	RETURN FOR ALL UNDERLYING CONTRACTS	SIMULATIONS	RANK	VALUE
1	754	0,003144319	1	9	0,9784144
2	247	0,000786848	2	1	1,05729999
3	840	-0,034100705	3	15	0,9277006
4	137	1,21011E-05	4	14	0,93097185
5	117	0,012355476	5	12	0,94650357
6	524	-0,000889222	6	6	0,99116702
7	195	0,002623287	7	17	0,92026668
8	138	0,000278285	8	8	0,97890466
9	457	0,014583841	9	3	1,01099443
10	717	0,001495982	10	2	1,01111948
11	809	-0,01294047	11	5	0,99193409
12	259	-0,00477314	12	19	0,91167231
			13	10	0,95711822
			14	4	0,99512444
			15	18	0,91342991
			16	7	0,98975916
			17	20	0,90900029
			18	11	0,94922686
			19	13	0,93321018
			20	16	0,92273156

$$Return = E[Return_{risk-neutral}] - E[Return_{measured}] - 0{,}5\sigma^2 N - \rho\sigma\sigma_{ccy} N$$

$$E[Return_{risk-neutral}] = Riskfree\ Return + Sum\ of\ simulated\ returns$$

RISK-FREE RETURN OVER THE RHP	0,000568027
SUM OF SIMULATED RETURNS	-0,017423398
E[RETURN risk-neutral]	-0,016855371
E [RETURN MEASURED]	0,004067173
0,5 σ2 N	0,00089943
ADJUSTED SIMULATED RETURN:	-0,021821974
EXP of SIMULATED RETURN	0,978414403
RHP LENGTH:	12 DAYS

Step 7: RHP = 1 AND 3 YEARS, 1000 simulations, 1280 observed daily prices (5 years – Euro Stoxx 50 – from 01.05.12 to 28.04.17)

AVG RETURN (OBSERVED):	0,000338931	
DEV. STANDARD OF RETURNS (OBSERVED):	0,01224357	
DATA COUNT (5 years of daily prices):	1280	
RISK FREE RATE (%/yr):	1,2	
MRM PERCENTILE:	2,5	
TRADING DAYS PER YEAR:	256	
INV NORMAL:	-1,95996398	
USED RANK MRM:	975	
Recommended holding period expressed in years (T)		
YEARS	1	3
VaR (price space):	0,6832	0,4957
VEV:	0,1856	0,1907

Part 4: Category 4 PRIIPs

Question 1
Does the PRIIP offer an unconditional protection of capital?

YES

You may apply the approach described in Point 29, Annex II, Part 1. The approach is the same as for Category 3 products as set out in Part 3 above.
To calculate the VaR for the remaining part of the PRIIP which is not characterized by an unconditional protection of capital, or if you do not wish to apply this option for the PRIIP as a whole, please go to the next box

NO

Identify the different components of the PRIIP that contribute to its performance. Distinguish between:

- components that are not wholly or partly dependent on factor(s) that are unobserved in the market;
- components that are wholly or partly dependent on factor(s) that are unobserved in the market.

OBSERVED FACTOR(S)

For components that are dependent on factor(s) that are observed in the market, apply the relevant methods depending on whether the component(s) falls into category 1, 2 or 3 (See Parts 1, 2 and 3 above for the relevant calculation methods).

UNOBSERVED FACTOR(S)

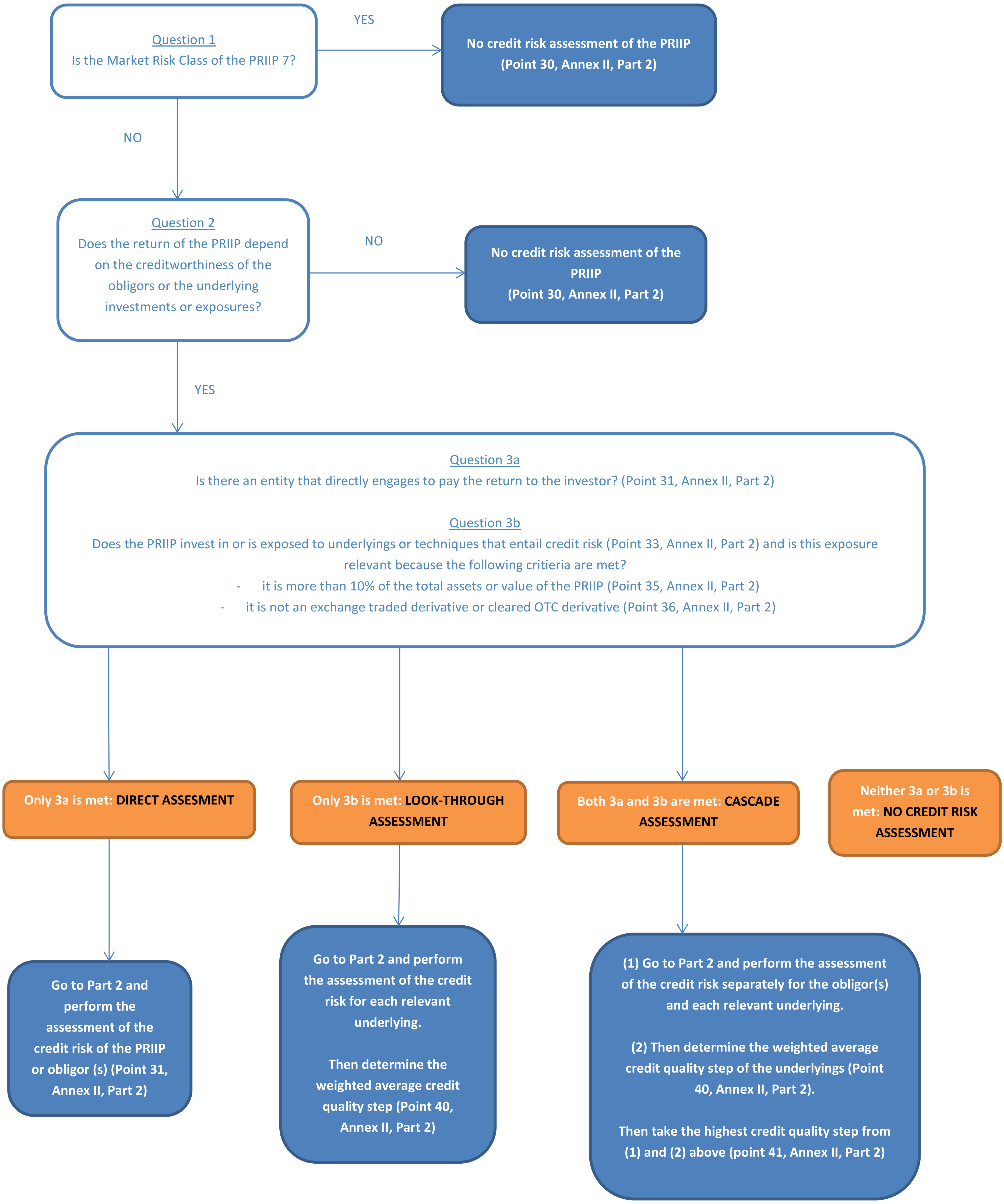
For component(s) of the PRIIP that depend on a factor or factors that are unobserved in the market, follow robust and well recognised industry and regulatory standards for determining relevant expectations as to the future contribution of these factors and the uncertainty that may exist in respect of this contribution. (Point 27, Annex II, Part 1)

Calculate a VaR-equivalent volatility for each of the components

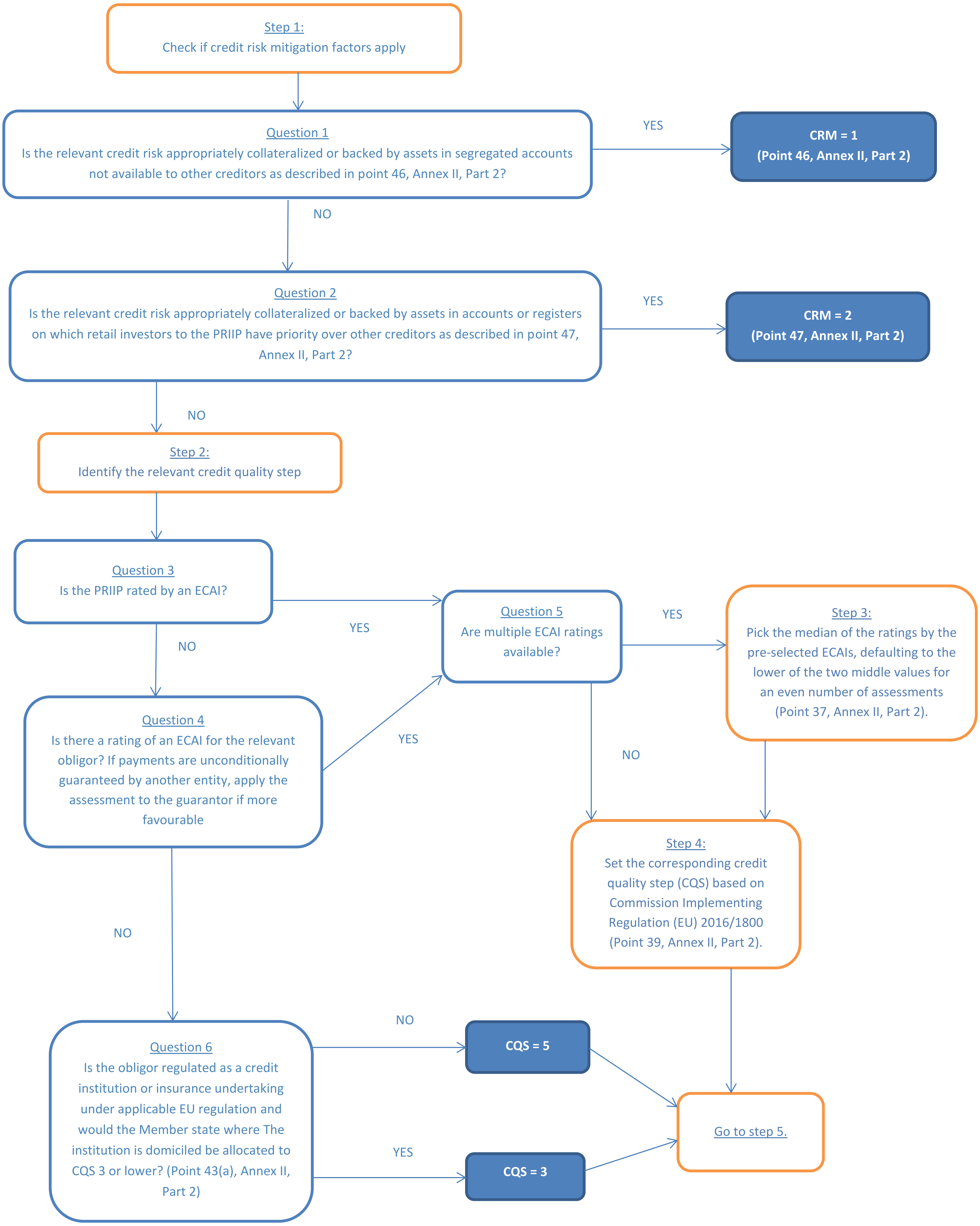
Weight proportionally the VaR-equivalent volatility of each component of the PRIIP in order to get the overall VaR-equivalent volatility of the PRIIP. When weighting the components, product features shall be taken into account. Where relevant, product algorithms mitigating the market risk as well as specificities of the with-profit component shall be considered. (Point 28, Annex II, Part 1).

Section 3: Credit Risk Measure

Part 1: Should credit risk be assessed and if so how



Part 2 Assessment of credit risk



Step 5: Allocation of credit assessment corresponding to the credit quality steps

Adjust the CQS depending on the term of the PRIIP according to the table below in point 42, Annex II, Part 2 unless the credit assessment assigned reflects the term of the PRIIP.

Credit quality step pursuant to point 38 of this Annex	Adjusted credit quality step, in the case where the maturity of the PRIIP, or its recommended holding period where a PRIIP does not have a maturity, is up to one year	Adjusted credit quality step, in the case where the maturity of the PRIIP, or its recommended holding period where a PRIIP does not have a maturity, ranges from one year up to twelve years	Adjusted credit quality step, in the case where the maturity of the PRIIP, or its recommended holding period where a PRIIP does not have a maturity, exceeds twelve years
0	0	0	0
1	1	1	1
2	1	2	2
3	2	3	3
4	3	4	5
5	4	5	6
6	6	6	6

Step 6

Convert the CQS into a CRM measure according to the table below in point 45, Annex II, Part 2

Adjusted credit quality step	**Credit risk measure**
0	1
1	1
2	2
3	3
4	4
5	5
6	6

Question 7:

Is there any other relevant credit risk to assess?

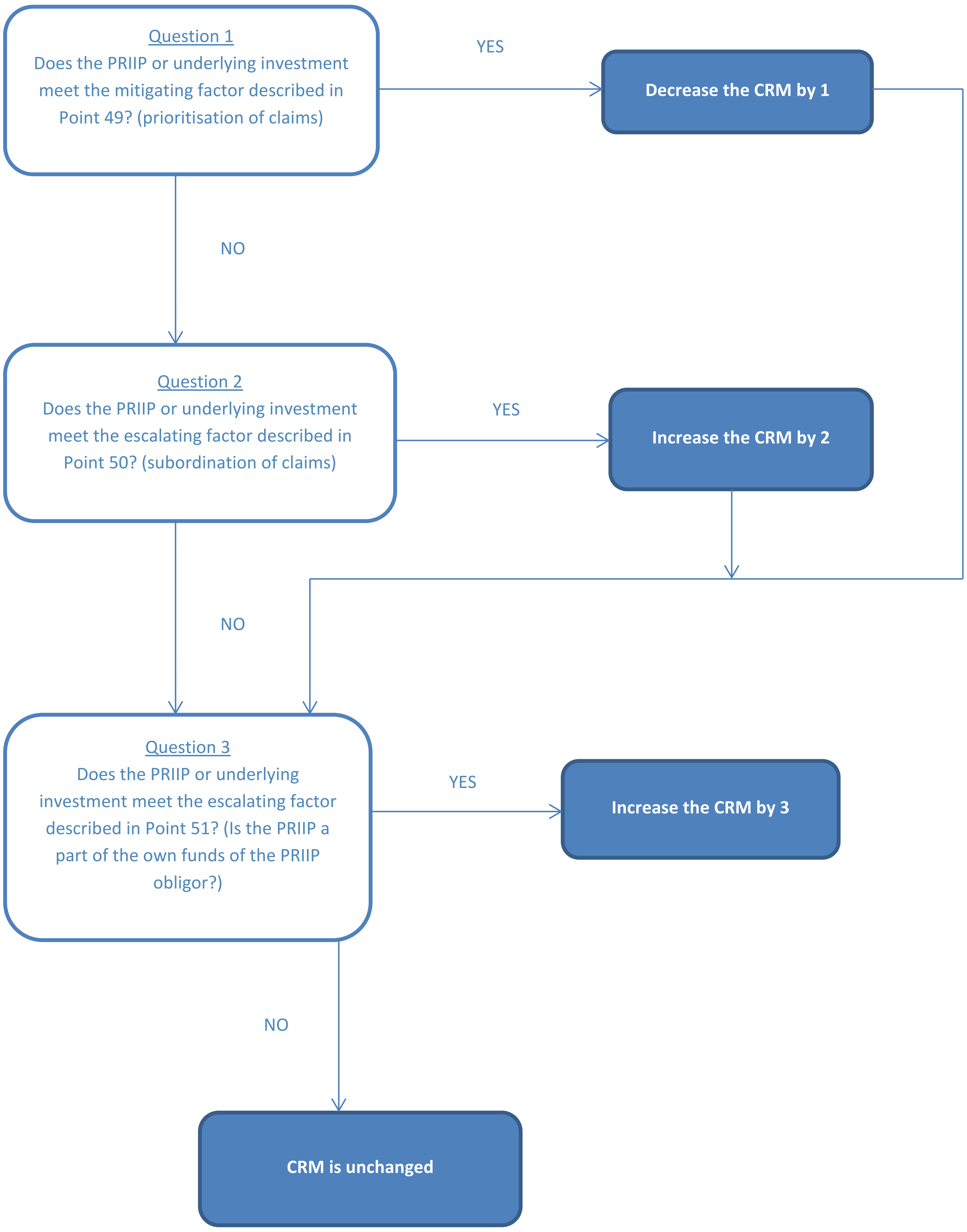
YES

Go to the start of Part 2 and repeat assessment for the other relevant credit risks

NO

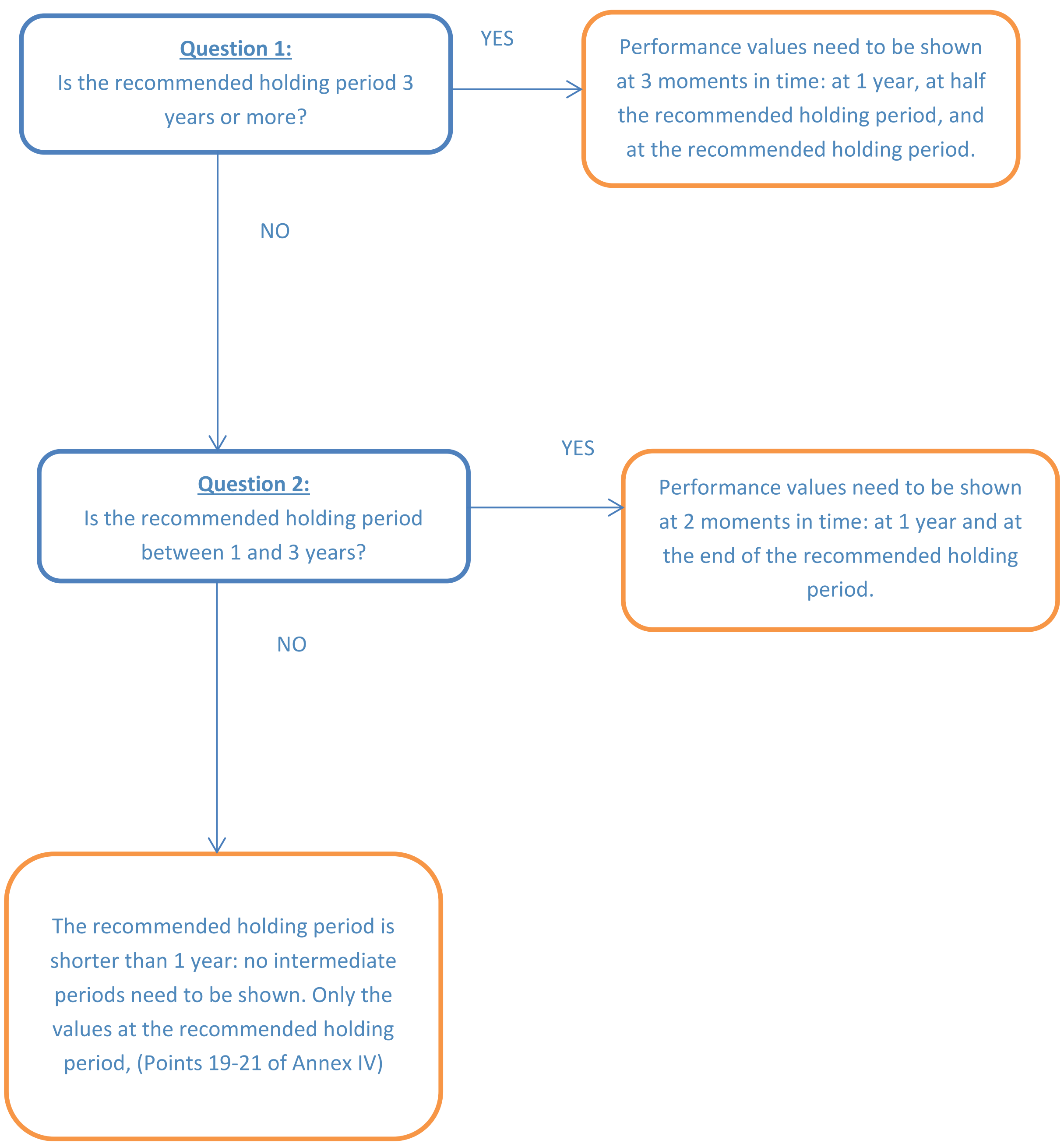
Go to Part 3

Part 3: Mitigating or escalating factors

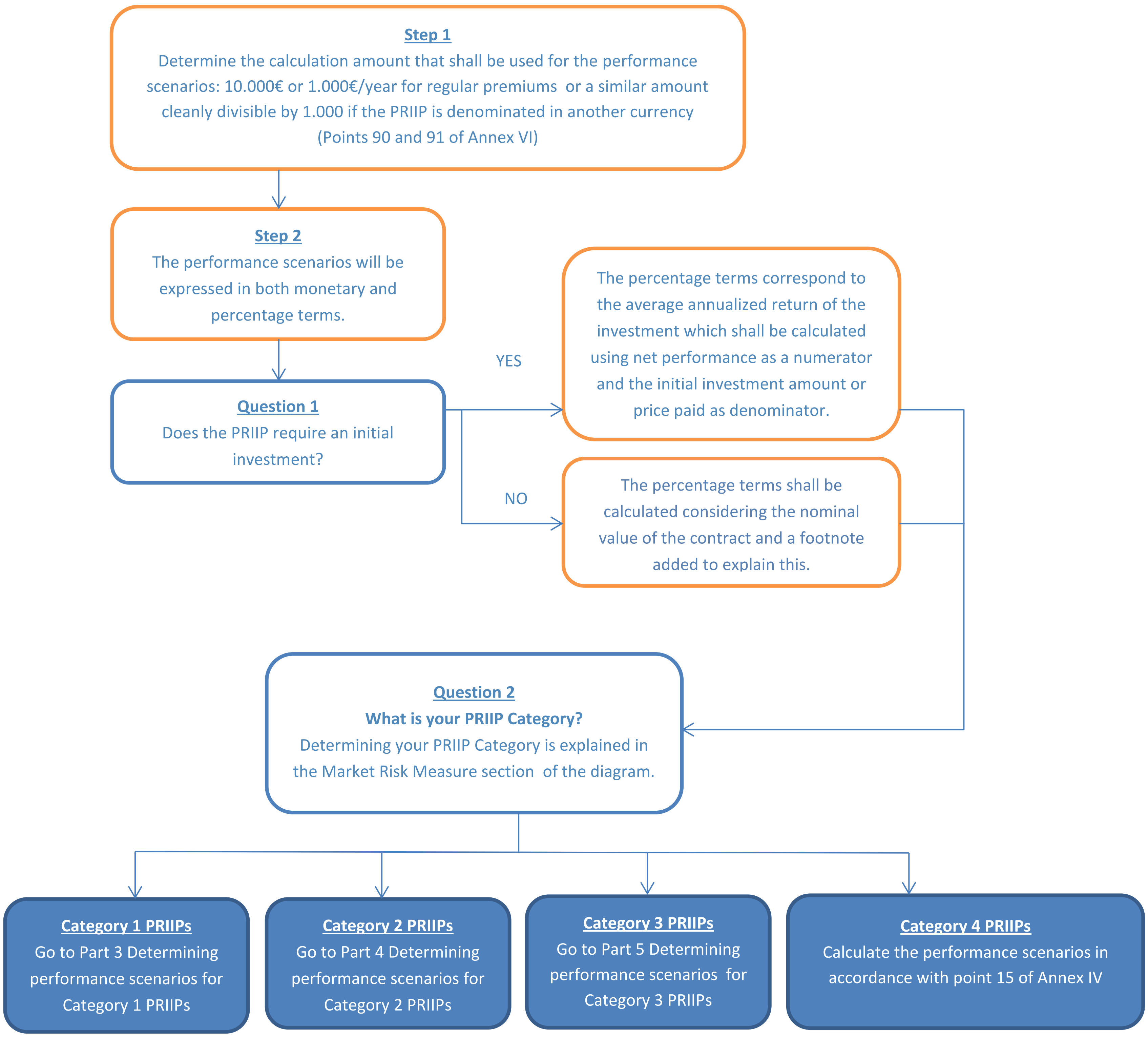


B. Performance Scenarios

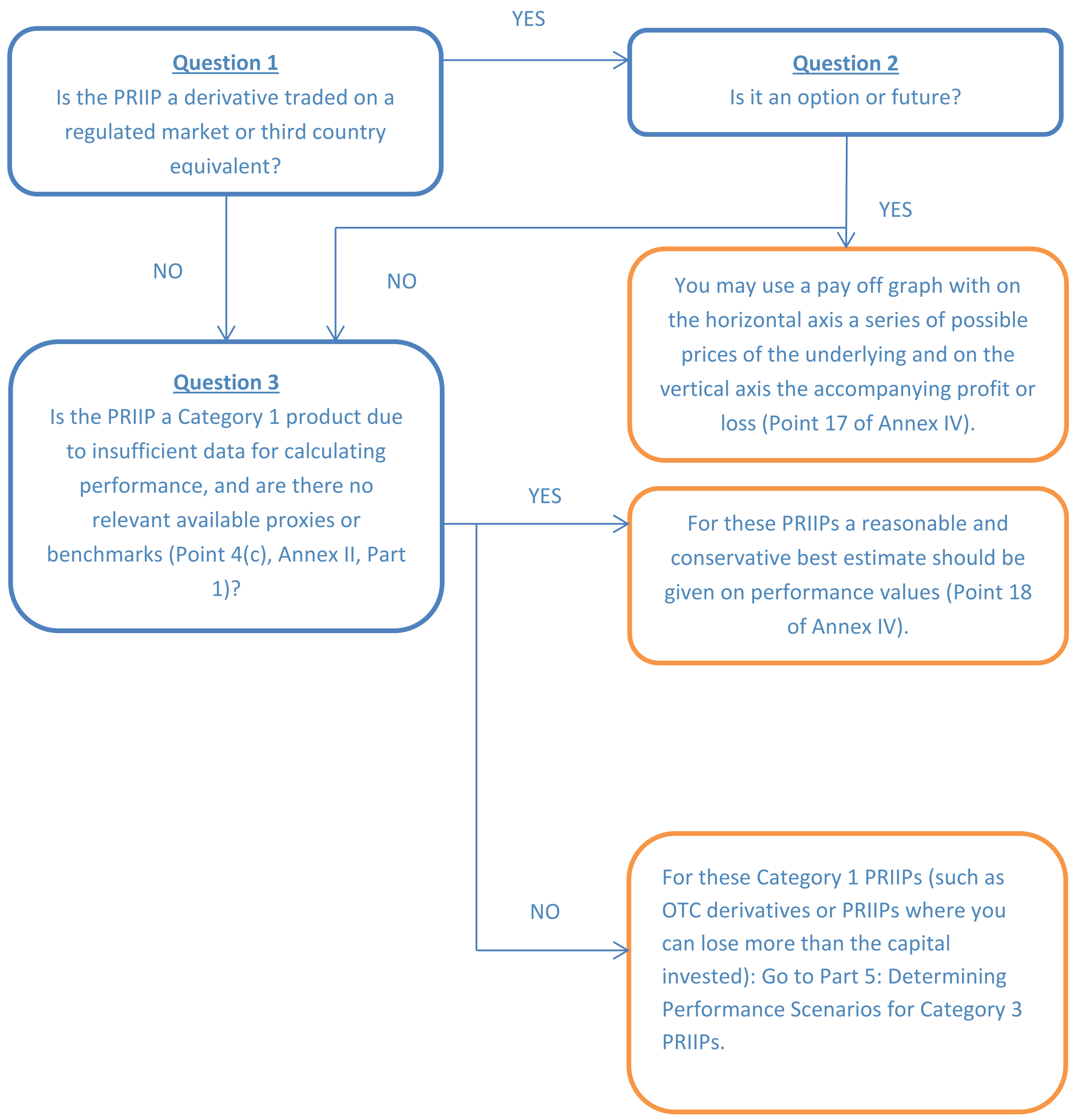
Part 1: Determining the holding periods that need to be shown



Part 2: Determining calculation amounts and applicable methodology



Part 3: Determining Performance Scenarios for Category 1 PRIIPs



Part 4: Determining Performance Scenarios for Category 2 PRIIPs

a) Performance calculations for the unfavourable, moderate and favourable scenarios

The items listed below are needed in order to calculate the **performance values for the relevant holding period**. Most values are known already from the calculation for MRM, except for N.

The values for the recommended holding period and the intermediate holding periods are calculated by the same formulas as displayed below, changing only N which is different at the recommended holding period compared to the intermediate holding periods.

- N - is the number of trading days, weeks or months within the holding period. So for a Recommended Holding Period of 5 years and If there is daily price data N= 5*~252 = 1260;
- Exp - the exponential of;
- M_1 - the mean of the distribution of all the observed returns in the historical period;
- σ – standard deviation or volatility of the distribution;
- μ_1 - skew of the distribution;
- μ_2 - the excess kurtosis of the distribution.

Unfavourable scenario;

$$\text{Exp} \left[M_1 * N + \sigma \sqrt{N} * \left(-1.28 + 0.107 * \mu_1 / \sqrt{N} + 0.0724 * \mu_2 / N - 0.0611 * \mu_1^2 / N\right) - 0.5\sigma^2 N \right]$$

Moderate scenario;

$$\text{Exp} \left[M_1 * N - \sigma \mu_1 / 6 - 0.5\sigma^2 N \right]$$

Favourable scenario;

$$\text{Exp} \left[M_1 * N + \sigma \sqrt{N} * \left(1.28 + 0.107 * \mu_1 / \sqrt{N} - 0.0724 * \mu_2 / N + 0.0611 * \mu_1^2 / N\right) - 0.5\sigma^2 N \right]$$

Calculation Example Category 2 PRIIPs unfavourable, moderate and favourable scenarios

5 years of observed daily prices (Euro Stoxx 50 – from 01.05.12 to 25.05.17), RHP 1, 3 and 5 years , examples considering an investment amount of 1 €

	α	z_α	$(z_\alpha^2 - 1)/6$	$(z_\alpha^3 - 3z_\alpha)/24$	$(2z_\alpha^3 - 5z_\alpha)/36$
Unfavorable Scenario - Critical values	10%	-1,281551566	0,107062403	0,072494466	0,061060634
Moderate Scenario - Critical values	50%	0	-0,166666667	0	0
Favorable Scenario - Critical values	90%	1,281551566	0,107062403	-0,072494466	-0,061060634

	Standard Performance Scenarios			
	Point 9 - letters (a), (b), (c) - Annex IV		RHP	
	RHP	**5 years**	**1 year**	**3 years**
N is the number of trading periods in the recommended holding period		1280	256	768
$\sigma\sqrt{N}$		0,438039282	0,195897122	0,339303769
Unfavorable scenario		0,799432892	0,832148758	0,792589109
Moderate scenario		1,402994819	1,070681172	1,225626426
Favorable scenario		2,456450066	1,374349473	1,890801557

b) Performance calculations for the stress scenario

Step 1: Identify a sub interval of length w which corresponds to the following intervals:

	1 year	> 1 year
Daily prices	21	63
Weekly prices	8	16
Monthly prices	6	12

Step 2: Identify for each sub interval of length w the historical lognormal returns r_t, where $t=t_0, t_1, t_2, \ldots, t_N$.

Step 3: Measure the volatility based on the formula below starting from $t_i = t_o$ rolling until $t_i = t_{(N-w)}$

$$w_{ti}\sigma_S = \sqrt{\frac{\Sigma_{t_i}^{t_{i+w}}\left(r_{ti} - {}_{t_i}^{t_{i+w}}M_1\right)^2}{M_W}}$$

Where M_w is the count of number of observations in the sub interval

and

$${}_{t_i}^{t_{i+w}}M_1$$

is the mean of all the historical lognormal returns in the corresponding sub interval.

Question 1:

Is the holding period longer than 1

NO

Infer the value that corresponds to the 99th percentile to give the stressed volatility ($W_{\sigma S}$).

In the formula below use the extreme percentile z_α that corresponds to 1% which is equal to -2.32

YES

Infer the value that corresponds to the 90th percentile to give the stressed volatility ($W_{\sigma S}$).

In the formula below use the extreme percentile z_α that corresponds to 5% which is equal to -1.64

Use the following formula to calculate the expected values at the end of the relevant holding period:

$$Scenario_{Stress} = exp\left[w_{\sigma S}\sqrt{N}\left(z_\alpha + \left[\frac{z_\alpha^2 - 1}{6}\right]\frac{\mu_1}{\sqrt{N}} + \left[\frac{(z_\alpha^3 - 3z_\alpha)}{24}\right]\frac{\mu_2}{N} - \left[\frac{(2z_\alpha^3 - 5z_\alpha)}{36}\right]\frac{\mu_1^2}{N}\right) - 0.5w_{\sigma_S^2}N\right]$$

Calculation Example Category 2 PRIIPs stress scenario

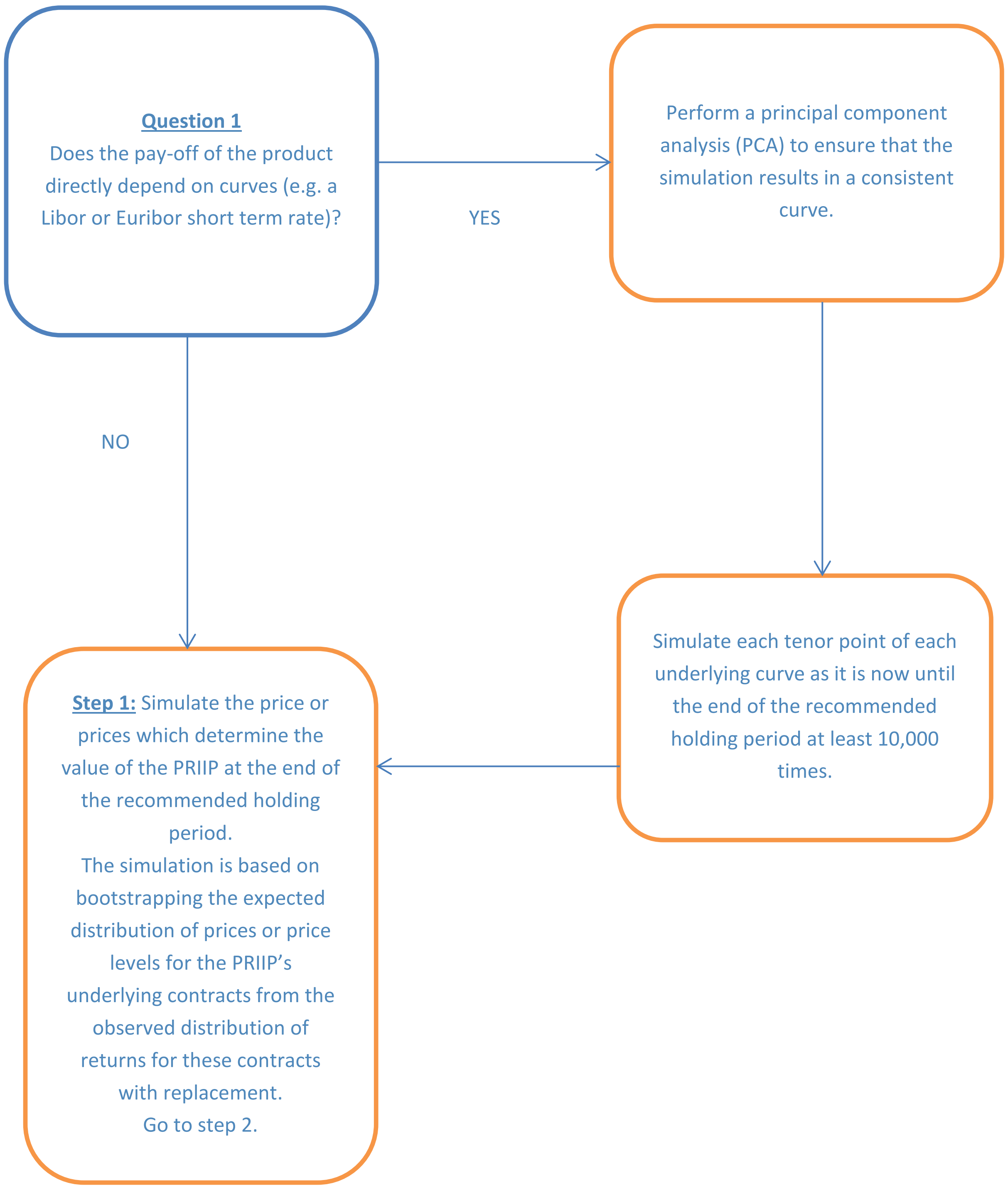
RHP 1, 3 and 5 years, 5 years of daily observed prices (Euro Stoxx 50 – from 01.05.12 to 25.02.17)

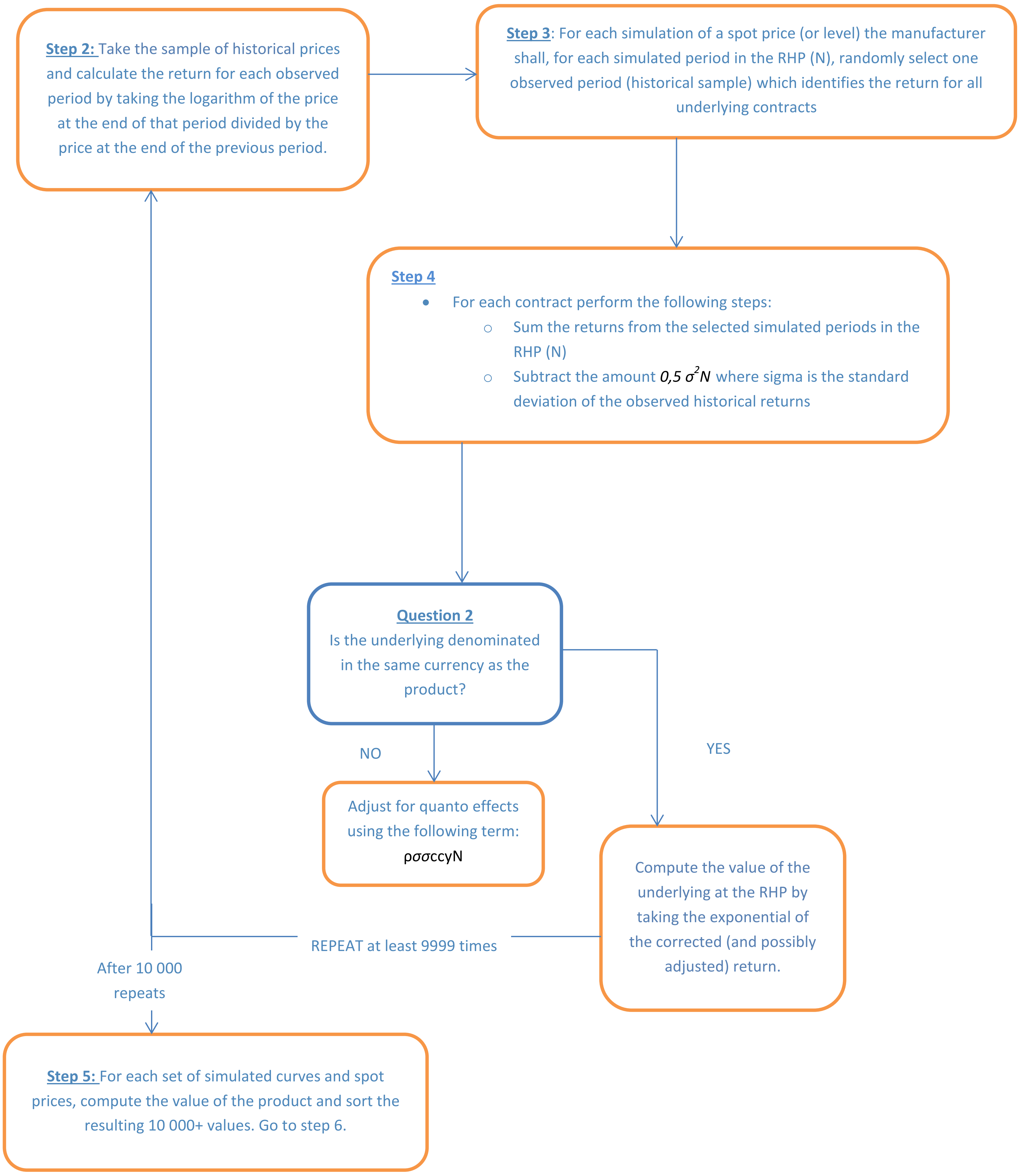
Stressed Performance Scenario					
	α	z_α	$(z_\alpha^2 - 1)/6$	$(z_\alpha^3 - 3z_\alpha)/24$	$(2z_\alpha^3 - 5z_\alpha)/36$
RHP 1 YEAR - Annex IV, point 11	1%	-2,326347874	0,735315739	-0,233787728	-0,376337746
RHP OTHER HOLDING PERIODS - Annex IV, point 11	5%	-1,644853627	0,284257242	0,020180747	-0,018782716
Stressed volatility 1 year - Annex IV, point 10(d)	**0,025767278**				
Stressed volatility 3 years - Annex IV, point 10(d)	**0,017657123**			**RHP**	
Stressed volatility 5 years - Annex IV, point 10(d)	**0,017152366**		**5 years**	**1 year**	**3 years**
N is the number of trading periods in the recommended holding period			1280	256	768
$W_{\sigma_S}\sqrt{N}$			0,613661699	0,412276441	0,489328534
STRESSED SCENARIO			**0,301389802**	**0,349241623**	**0,396012057**

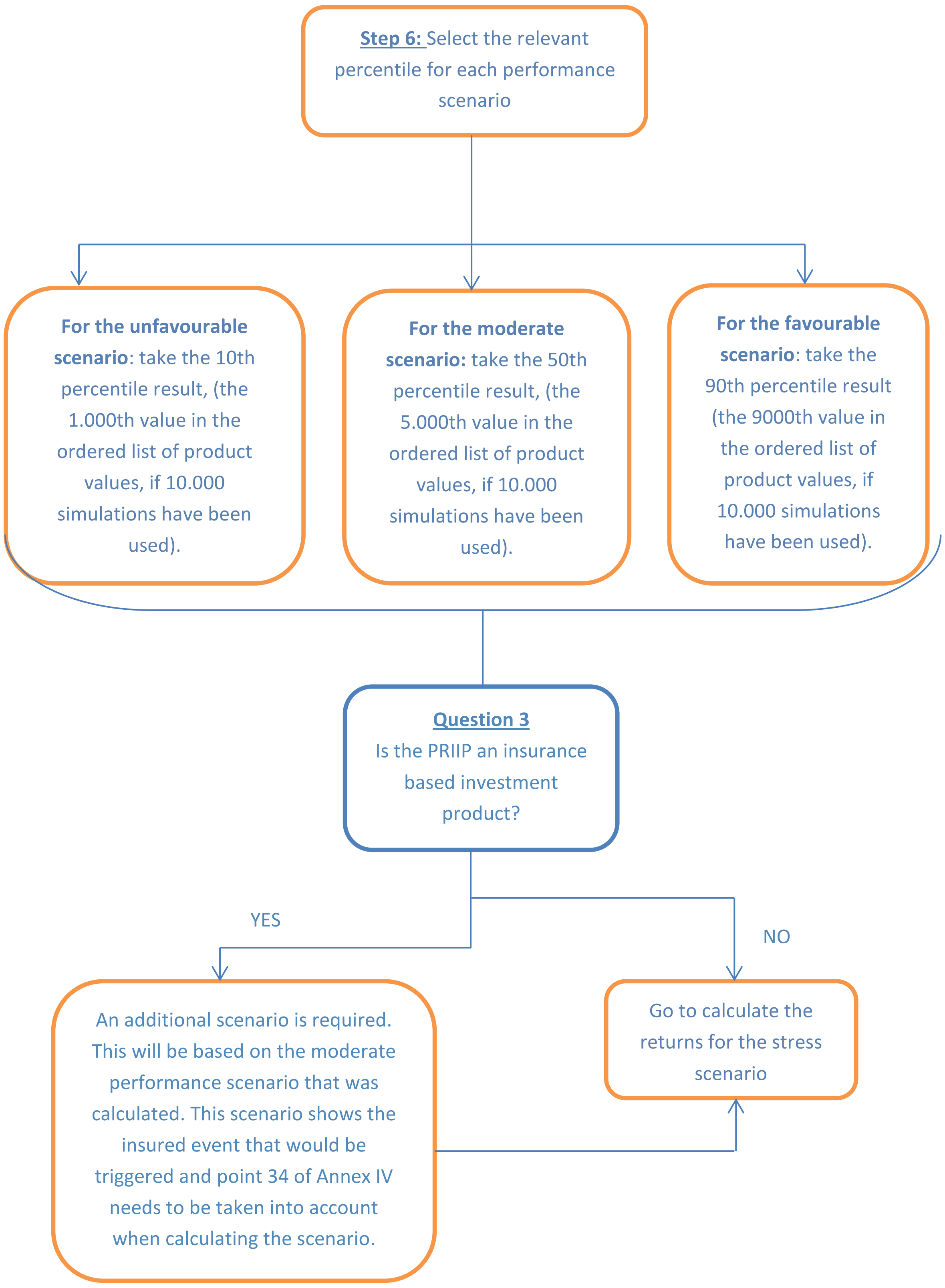
Part 5: Determining Performance Scenarios for Category 3 PRIIPs

Please note that the performance scenarios hinge on the same simulated data as the MRM calculations, hence manufacturers are not required to make a new simulation when switching from the MRM to the Performance Scenarios calculations. However, the complete process for the performance scenarios is described in this Part for the sake of clarity.

a) Performance calculations for the unfavourable, moderate and favourable scenarios




Step 2: Take the sample of historical prices and calculate the return for each observed period by taking the logarithm of the price at the end of that period divided by the price at the end of the previous period.
Step 3: For each simulation of a spot price (or level) the manufacturer shall, for each simulated period in the RHP (N), randomly select one observed period (historical sample) which identifies the return for all underlying contracts
Step 4
For each contract perform the following steps:
Sum the returns from the selected simulated periods in the RHP (N)
Subtract the amount $0,5\ \sigma^2 N$ where sigma is the standard deviation of the observed historical returns
Question 2
Is the underlying denominated in the same currency as the product?
NO
YES
Adjust for quanto effects using the following term: ρσσccyN
Compute the value of the underlying at the RHP by taking the exponential of the corrected (and possibly adjusted) return.
REPEAT at least 9999 times
After 10 000 repeats
Step 5: For each set of simulated curves and spot prices, compute the value of the product and sort the resulting 10 000+ values. Go to step 6.


Step 6: Select the relevant percentile for each performance scenario
For the unfavourable scenario: take the 10th percentile result, (the 1.000th value in the ordered list of product values, if 10.000 simulations have been used).
For the moderate scenario: take the 50th percentile result, (the 5.000th value in the ordered list of product values, if 10.000 simulations have been used).
For the favourable scenario: take the 90th percentile result (the 9000th value in the ordered list of product values, if 10.000 simulations have been used).
Question 3
Is the PRIIP an insurance based investment product?
YES
NO
An additional scenario is required. This will be based on the moderate performance scenario that was calculated. This scenario shows the insured event that would be triggered and point 34 of Annex IV needs to be taken into account when calculating the scenario.
Go to calculate the returns for the stress scenario

Calculation Example Category 3 PRIIPs unfavourable, moderate and favourable scenarios

1000 simulations, RHP 1 and 3 years, 5 years of daily observed prices (Euro Stoxx 50 from 01.05.12 to 28.04.17)

Recommended holding period in years (T)

	Percentile	Rank (over 1000 simulations)
Used Rank Unfavourable scenario	10th	900
Used Rank Moderate scenario	50th	500
Used Rank Favourable scenario	90th	100

YEARS	1	3
Unfavorable Scenario	0,848537	0,780318
Moderate Scenario	1,086382	1,23794
Favourable Scenario	1,39373	1,936616

The scenarios values under different performance scenarios shall be calculated in a similar manner as the market risk measure (MRM) - Point 4 Annex IV and Point 12 letter a, b Annex IV)

b) Performance calculations for the stress scenario

Step 1: Identify a sub interval of length w which corresponds to the following intervals:

	1year	> 1 year
Daily prices	21	63
Weekly prices	8	16
Monthly prices	6	12

Step 2: Identify for each sub interval of length w the historical lognormal returns r_t, where $t=t_0, t_1, t_2, \ldots, t_N$.

Step 3: Measure the volatility based on the formula below starting from $t_i = t_o$ rolling until $t_i = t_{(N-w)}$

$$w_{ti}\sigma_S = \sqrt{\frac{\sum_{t_i}^{t_{i+w}}\left(r_{ti} - {}_{t_i}^{t_{i+w}}M_1\right)^2}{M_W}}$$

Where M_w is the count of number of observations in the sub interval and

$${}_{t_i}^{t_{i+w}}M_1$$

is the mean of all the historical lognormal returns in the corresponding sub interval.

Infer the stressed volatility $W_{\sigma S}$ that corresponds to the 99th percentile for 1 year and the 90th percentile for the other holding periods

Step 4: Rescale historical returns r_t, based on the formula set out below

$$r_t^{adj} = r_t * \frac{W_{\sigma_S}}{\sigma_S}$$

where σ_S is the standard deviation of the observed historical returns

Go to step 5.

Step 5: Calculate the mean of the adjusted returns { r_t^{adj} }. The mean stressed return is denoted as μ*below.

Step 6: Randomly select one observed period which identifies the return for all underlying contracts.

Step 7: For each simulation, calculate the asset price at the end of the recommended holding period by:

- Randomly selecting N returns from the set { r_t^{adj} }
- Summing the selected returns and subtracting μ*N
- Subtracting ½σ*^{2} N (σ* denotes the standard deviation of the adjusted returns)
- Adjusting for quanto impact if applicable
- Exponentiating the result

Step 8: The stress scenario shall be the the value of the PRIIP at the extreme percentile that corresponds to 1% for 1 year and to 5% for the other holding periods.

Go to Part 6: Calculating the performance scenarios for the intermediate periods

Steps 1-3: 1000 simulations, RHP of 2 years

RECOMMENDED HOLDING PERIOD = N = 2 YEAR = 512 OBS

W=63 days

Starting from ti=t0 rolling until ti=t(N-w)=512-63=449

DATE	PRICE		OBSERVED RETURNS	N		Rolling volatility
04/05/2015	3632,94				t_0	
05/05/2015	3546,56	r_1	-0,024064118	1	t_1	0,011821003
06/05/2015	3558,03	r_2	0,003228901	2	t_2	0,010212764
07/05/2015	3556,21	r_3	-0,00051165	3	t_3	0,010615001
08/05/2015	3649,48	.	0,025889321	4	.	0,011073765
11/05/2015	3624,41	.	-0,006893175	5	.	0,00829045
12/05/2015	3573,1	.	-0,01425795	6	.	0,00849749
13/05/2015	3553,42	.	-0,005523046	7	.	0,00737515
14/05/2015	3602,22	.	0,013639802	8	.	0,007389004
15/05/2015	3573,07	.	-0,008125152	9	.	0,012145054
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
23/01/2017	3273,04	.	-0,002604259	445	.	0,009510134
24/01/2017	3281,53	.	0,009160707	446	.	0,009459426
25/01/2017	3326,15	.	-0,002328776	447	.	0,009354546
26/01/2017	3319,13		-0,002037409	448		0,009401931
27/01/2017	3303,33	$r_{T-w} = 512 - 63 = 449$	0,008093104	449	$t_{T-w} = 512 - 63 = 449$	0,009386922

<u>Step 4</u>: 1000 simulations, RHP of 2 years

Percentile RHP > 1
95

Inferred volatility (RHP > 1 year)
0,018101868

W_{σ_S}

Used rank (RHP > 1)
45

Observed Standard Deviation
0,013630478

$$r_t^{adj} = r_t * \frac{W_{\sigma_S}}{\sigma_S}$$

DATE	Rank	Rolling volatility	Stressed returns
04/05/2015	38	0,010556603	-0,04568
05/05/2015	57	0,009673011	-0,02817
06/05/2015	56	0,009676026	0,001279
07/05/2015	55	0,00967635	-0,00281
08/05/2015	50	0,009972533	0,015142
11/05/2015	49	0,01006383	0,018321
12/05/2015	45	0,010207575	-0,01762
13/05/2015	34	0,01152721	-0,01695
14/05/2015	32	0,012145054	0,016882
15/05/2015	31	0,012591142	-0,00417
18/05/2015	29	0,01293892	-0,01061
19/05/2015	30	0,012933856	0,014619
20/05/2015	28	0,013087051	-0,02976
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
25/04/2017	.	3583,16	0,021522
26/04/2017	.	3578,71	-0,00547
27/04/2017	.	3563,29	-0,00479
28/04/2017	r_{T-w}	3559,59	0,019014

Steps 5-6: 1000 simulations, RHP of 2 years

SIMULATED RETURNS IN THE RHP (RHP=512 DAYS = 2 YEARS)												
DAY	**1**	**2**	**3**	**.**	**.**	**.**	**509**	**510**	**511**	**512**		**Sum of stressed returns**
Simulation 1	0,027392	0,014038	-0,2117	.	.	.	0,008783	0,01293	0,026752	0,01903		1,056163
Simulation 2	-0,00293	-0,01822	-0,01513	.	.	.	-0,00293	0,003203	-0,01623	-0,00621		0,371867
Simulation 3	0,015496	-0,001	-0,01035	.	.	.	0,029695	0,006496	-0,00374	0,011948		0,464389
Simulation 4	-0,02976	0,02458	0,011466	.	.	.	0,001153	0,026313	-0,01102	-0,00943		0,542711
.	.	.	.	.	.	.	.	.	.	.		.
.	.	.	.	.	.	.	.	.	.	.		.
.	.	.	.	.	.	.	.	.	.	.		.
Simulation 997	0,038841	0,008783	-0,01705	.	.	.	-0,00612	0,029132	-0,03364	-0,00746		0,399851
Simulation 998	-0,01503	-0,00293	0,007265	.	.	.	0,024164	-0,03123	-0,02629	-0,00383		0,144918
Simulation 999	-0,01903	0,029695	0,007654	.	.	.	-0,00612	0,02476	0,006858	0,054131		0,65239
Simulation 1000	0,017111	0,001153	-0,00915	.	.	.	-0,00374	0,011466	0,029465	-0,00612		-0,31238

Steps 7-8: 1000 simulations, RHP of 2 years

	Sum of stressed returns		Simulated stressed returns	Rank	Simulated stressed prices
Simulation 1	0,547871		-0,308473702	716	0,734567
Simulation 2	0,23742	$E[Return_{MEASURED}] = N\mu^{*}$	0,036099698	380	1,036759
Simulation 3	0,11592	**0,376425586**	0,209019028	236	1,232468
Simulation 4	0,526658		-0,145282546	570	0,864778
Simulation 5	0,388818		0,500883786	68	1,650179
.	.		.	.	.
.	.		.	.	.
.	.		.	.	.
.	.		.	.	.
Simulation 997	0,423087		-0,057786731	512	0,943851
Simulation 998	0,26424		-0,046921846	500	0,954162
Simulation 999	0,030446		0,222387303	251	1,249055
Simulation 1000	-0,20313		-0,66079576	904	0,51644

	Percentile stressed scenario z_{α}	Rank Stressed Scenario	Stressed Scenario
RHP = 2 Y (512 days)	5	950	0,488090936

Part 6: Calculating the performance scenarios for the intermediate periods