JC-2017-49

19 July 2018

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. The document was last updated on 19 July 2018.

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

Calculate the Market risk measure (MRM)

Go to Section 2

Calculate the Credit risk measure (CRM)

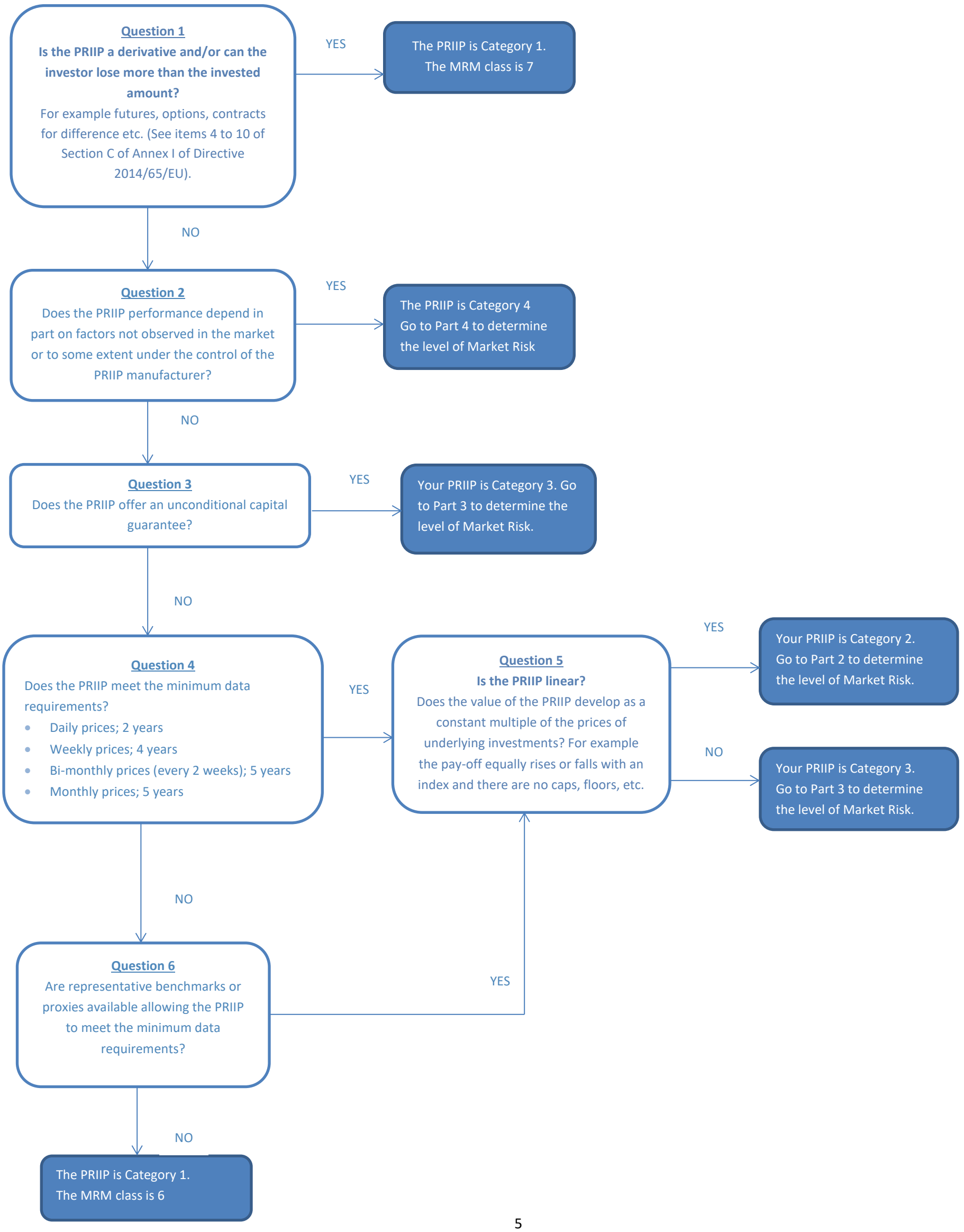
Go to Section 3

Aggregate MRM and CRM into an SRI according to the table below in point 52 of Annex II, part 3

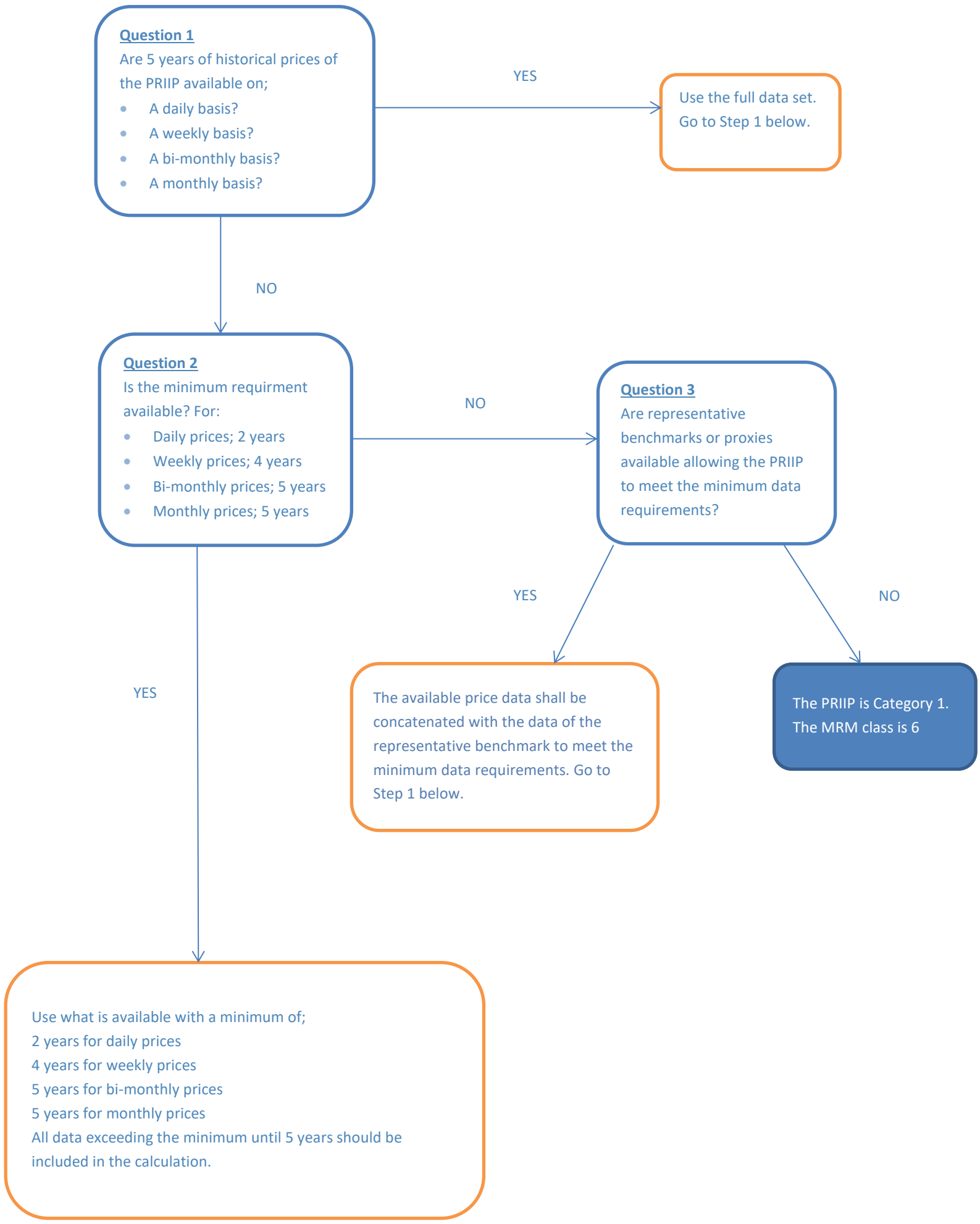
CRM class \ MRM class	MR1	MR2	MR3	MR4	MR5	MR6	MR7
CR1	1	2	3	4	5	6	7
CR2	1	2	3	4	5	6	7
CR3	3	3	3	4	5	6	7
CR4	5	5	5	5	5	6	7
CR5	5	5	5	5	5	6	7
CR6	6	6	6	6	6	6	7

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 1 and 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 %

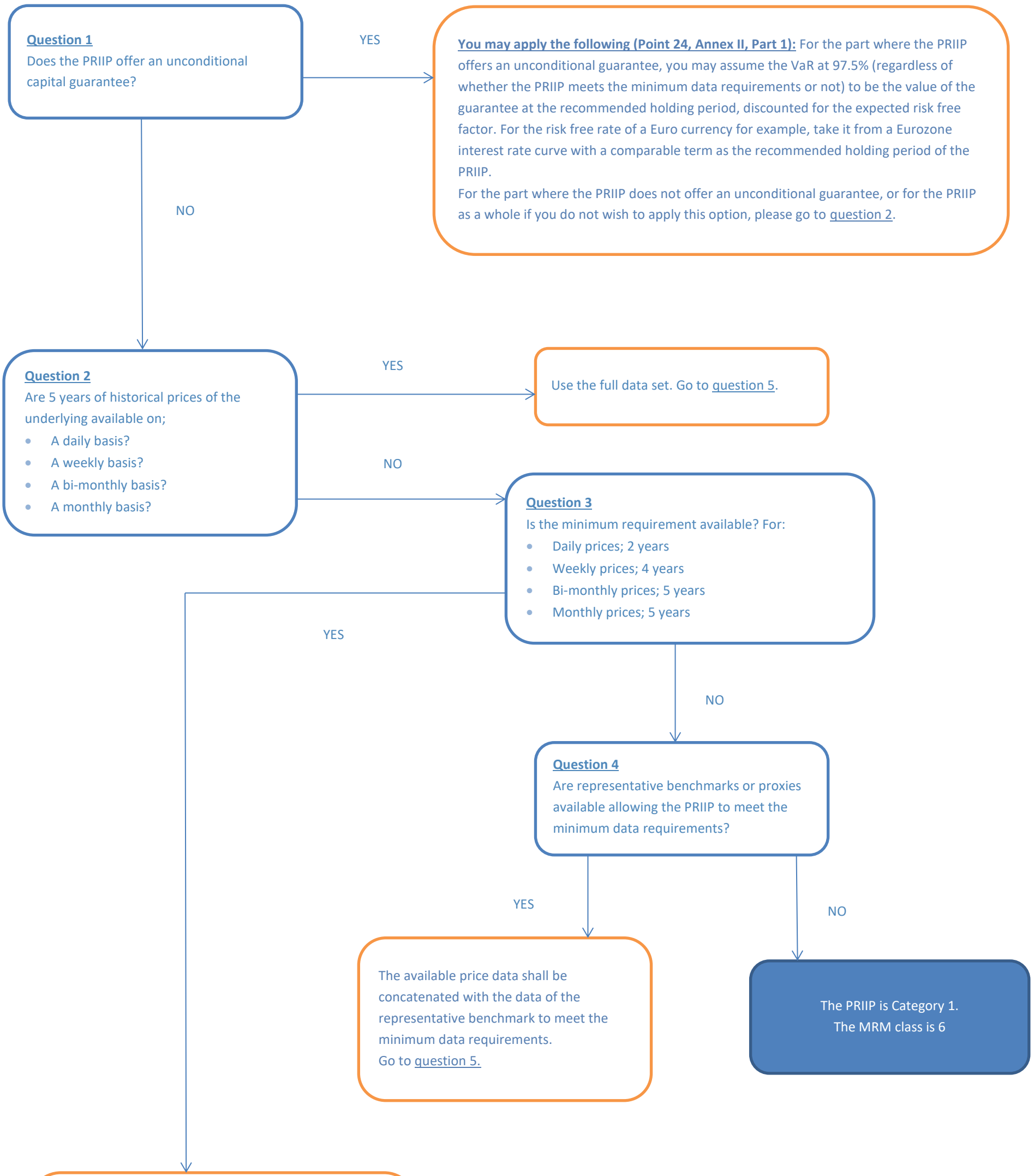
5 years of daily observed prices (Euro Stoxx 50 from 01.05.12 to 25.05.17)

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			$VEV_{Return\ Space} = \frac{\sqrt{z_\alpha^2 - 2 * VaR_{Return\ Space}} - z_\sigma}{\sqrt{T}}$
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	$VEV_{Price\ Space} = \frac{\sqrt{z_\alpha^2 - 2 * \ln(VaR_{Price\ Space})} - z_\alpha}{\sqrt{T}}$
$(z_\alpha \text{^} 3 - 3z_\alpha)/24$	-0.068717874			
$(2z_\alpha \text{^} 3 - 5z_\alpha)/36$	-0.146067276			

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

NO

Adjust for the Quanto effect using the following term:
$\rho\sigma\sigma_{ccy}N$

Step 5
Compute the value of the underlying at the recommended holding period by taking the exponential of the corrected (and possibly adjusted) return.

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)

EACH SIMULATED PERIOD IN THE RHP (RHP=12 DAYS)	EXAMPLE SIMULATION: SIMULATION 1 RANDOMLY SELECT ONE OBSERVED PERIOD OVER 1280 PERIODS (5*256)		RETURN FOR ALL UNDERLYING CONTRACTS
1		754	0,003144319
2		247	0,000786848
3		840	-0,034100705
4		137	1,21011E-05
5		117	0,012355476
6		524	-0,000889222
7		195	0,002623287
8		138	0,000278285
9		457	0,014583841
10		717	0,001495982
11		809	-0,01294047
12		259	-0,00477314

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

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

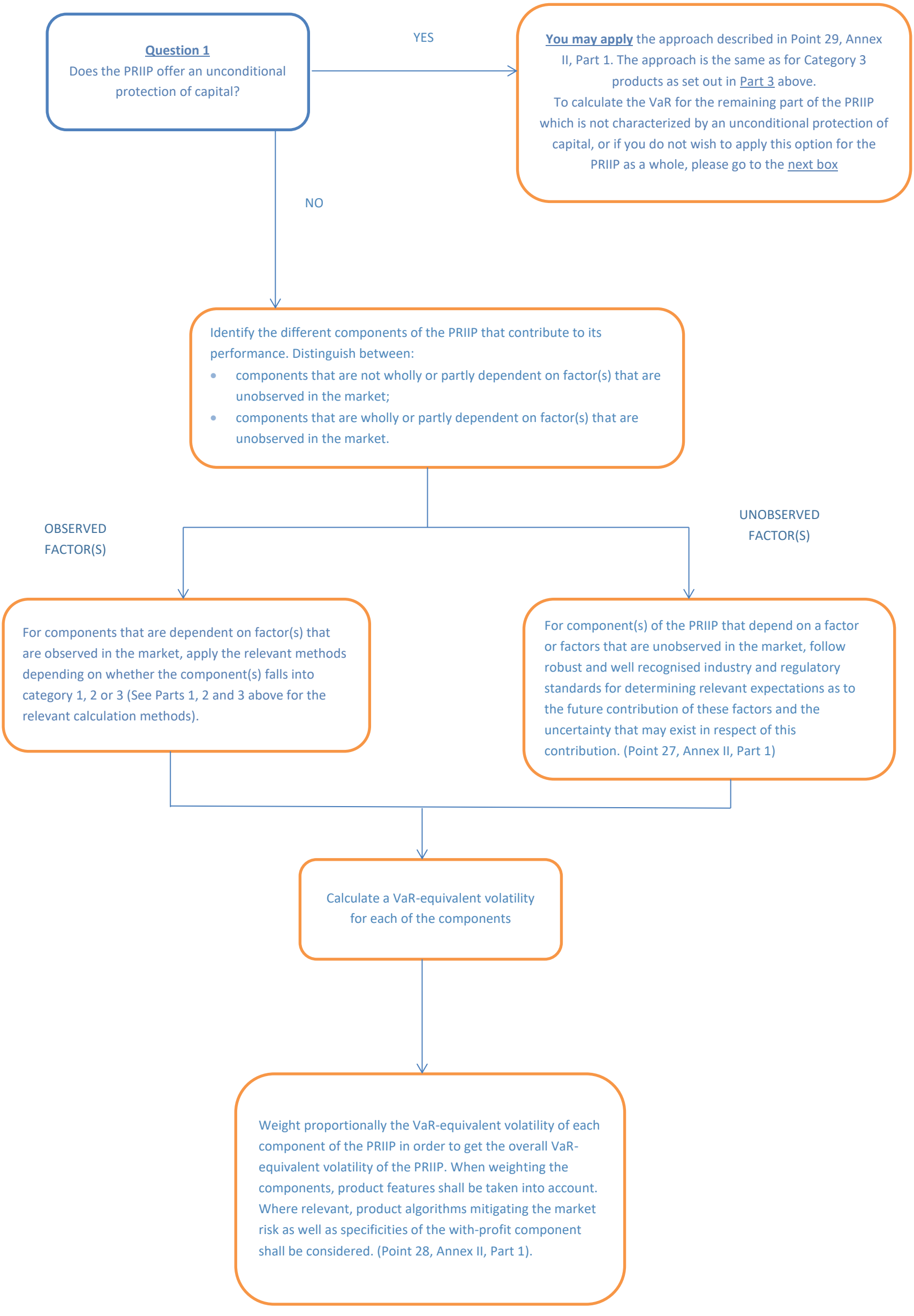
RISK-FREE RETURN OVER THE RHP	0,000568027
SUM OF SIMULATED RETURNS	-0,017423398
E[RETURN risk-neutral]	-0,016855371
E [RETURN MEASURED]	0,004067173
0,5 σ2 N	0,00089943
ADJUSTED SIMULATED RETURN:	-0,021821974
EXP of SIMULATED RETURN	0,978414403
RHP LENGTH:	12 DAYS

DISTRIBUTION OF SIMULATIONS		
SIMULATIONS	RANK	VALUE
1	9	0,9784144
2	1	1,05729999
3	15	0,9277006
4	14	0,93097185
5	12	0,94650357
6	6	0,99116702
7	17	0,92026668
8	8	0,97890466
9	3	1,01099443
10	2	1,01111948
11	5	0,99193409
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

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)

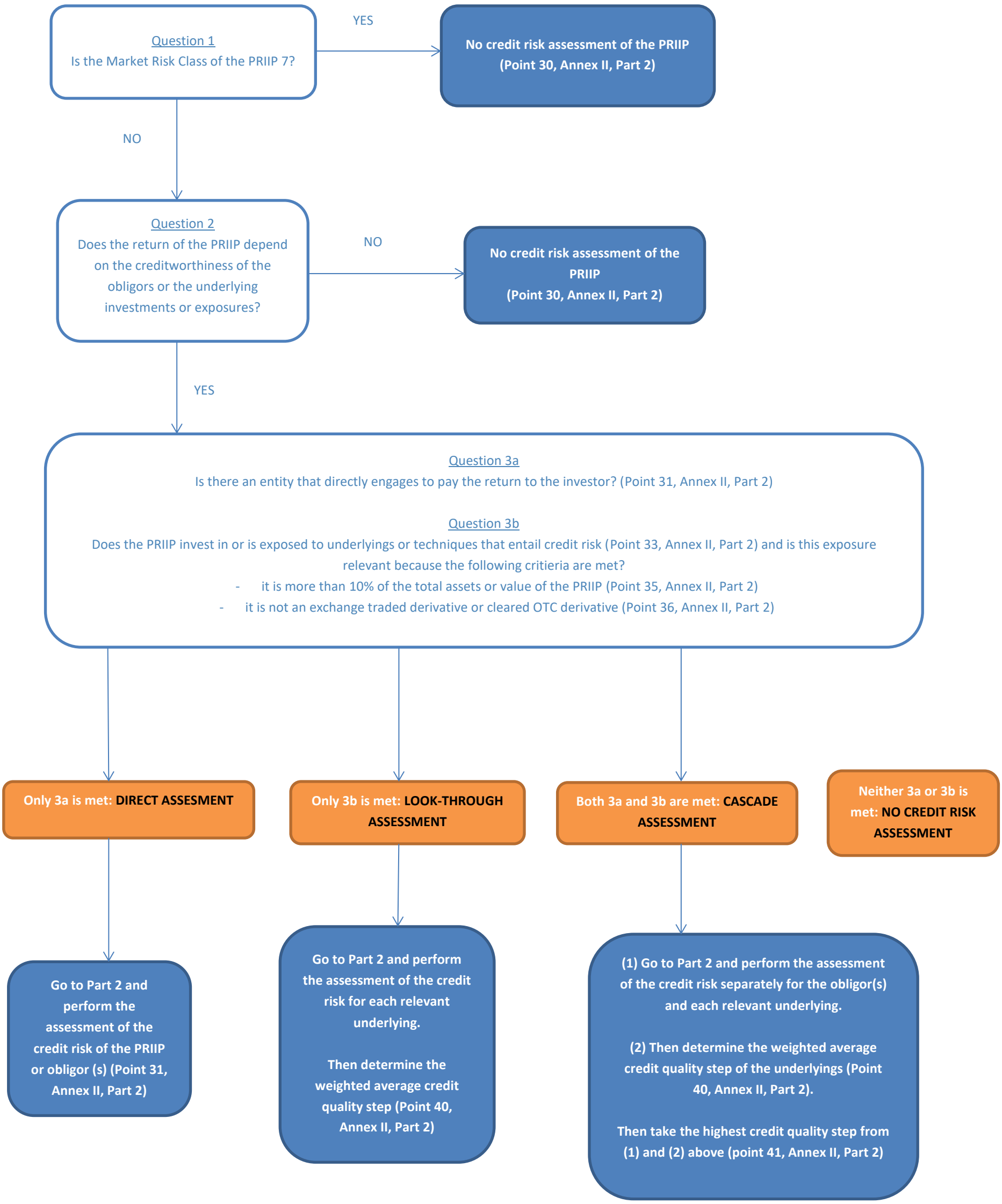
AVG RETURN (OBSERVED):	0,000338931	
DEV. STANDARD OF RETURNS (OBSERVED):	0,01224357	
DATA COUNT (5 years of daily prices):	1280	
RISK FREE RATE (%/yr):	1,2	
MRM PERCENTILE:	2,5	
TRADING DAYS PER YEAR:	256	
INV NORMAL:	-1,95996398	
USED RANK MRM:	975	
Recommended holding period expressed in years (T)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

Part 4: Category 4 PRIIPs

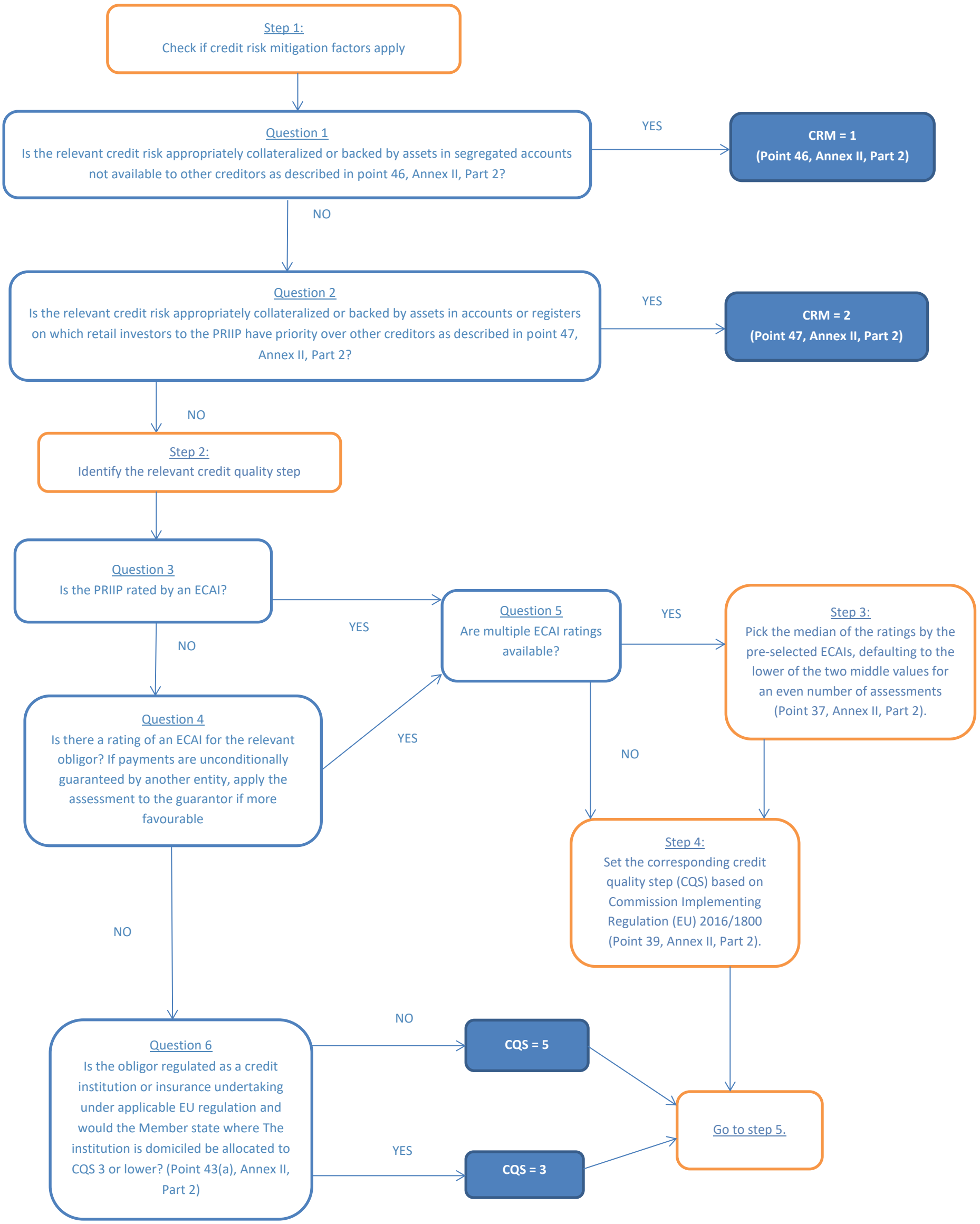


Section 3: Credit Risk Measure

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?

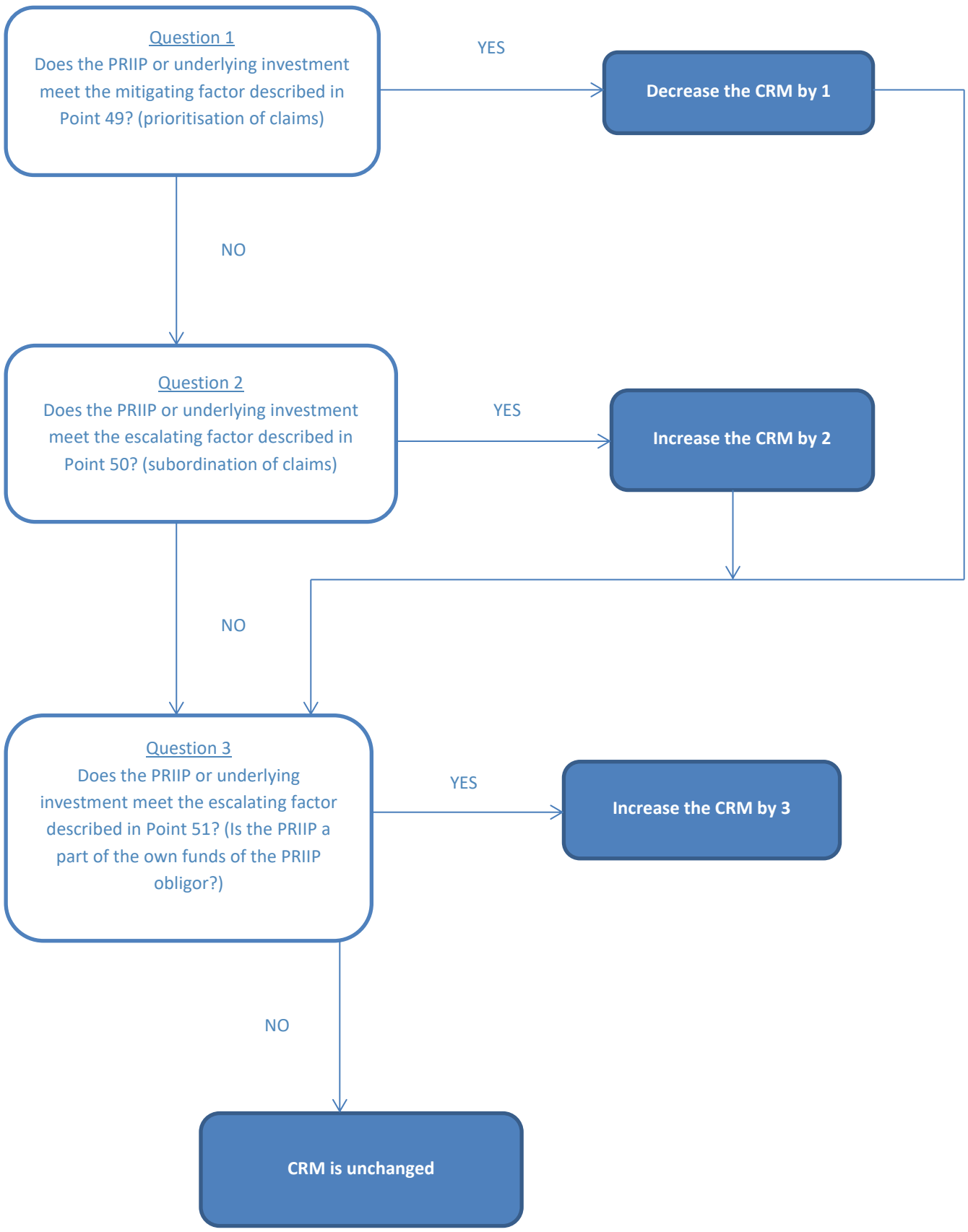
YES

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

NO

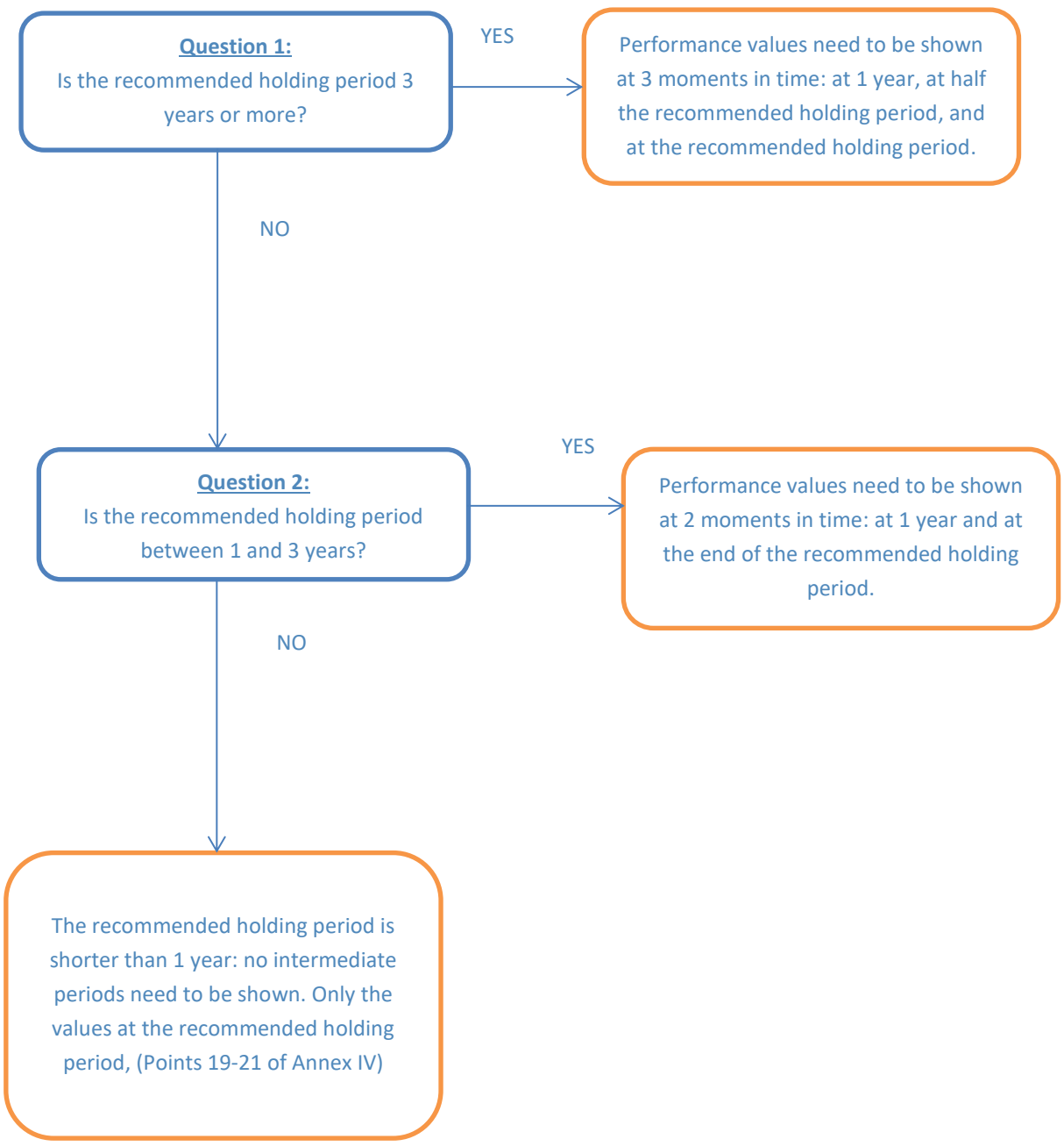
Go to Part 3

Part 3: Mitigating or escalating factors

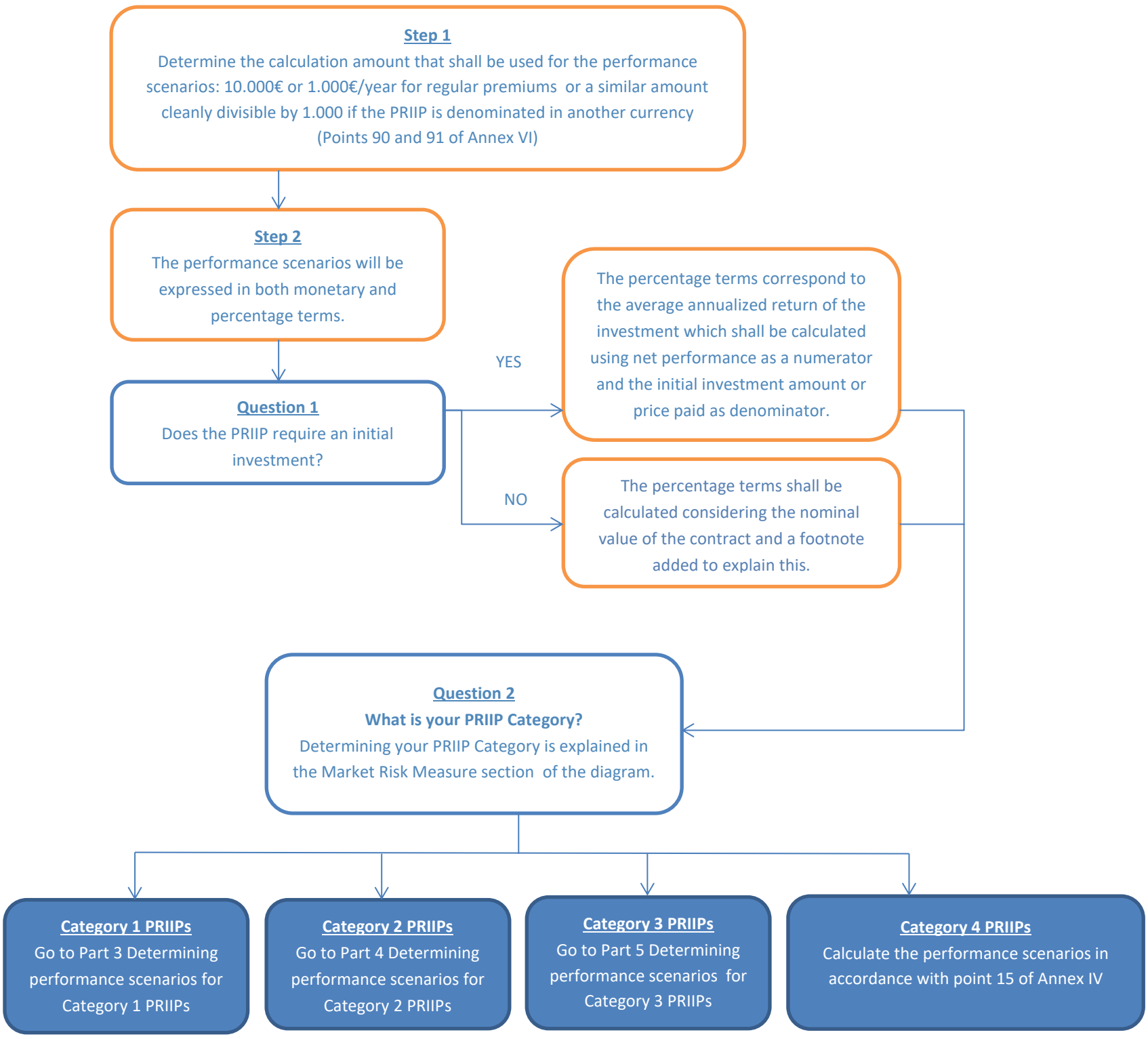


B. Performance Scenarios

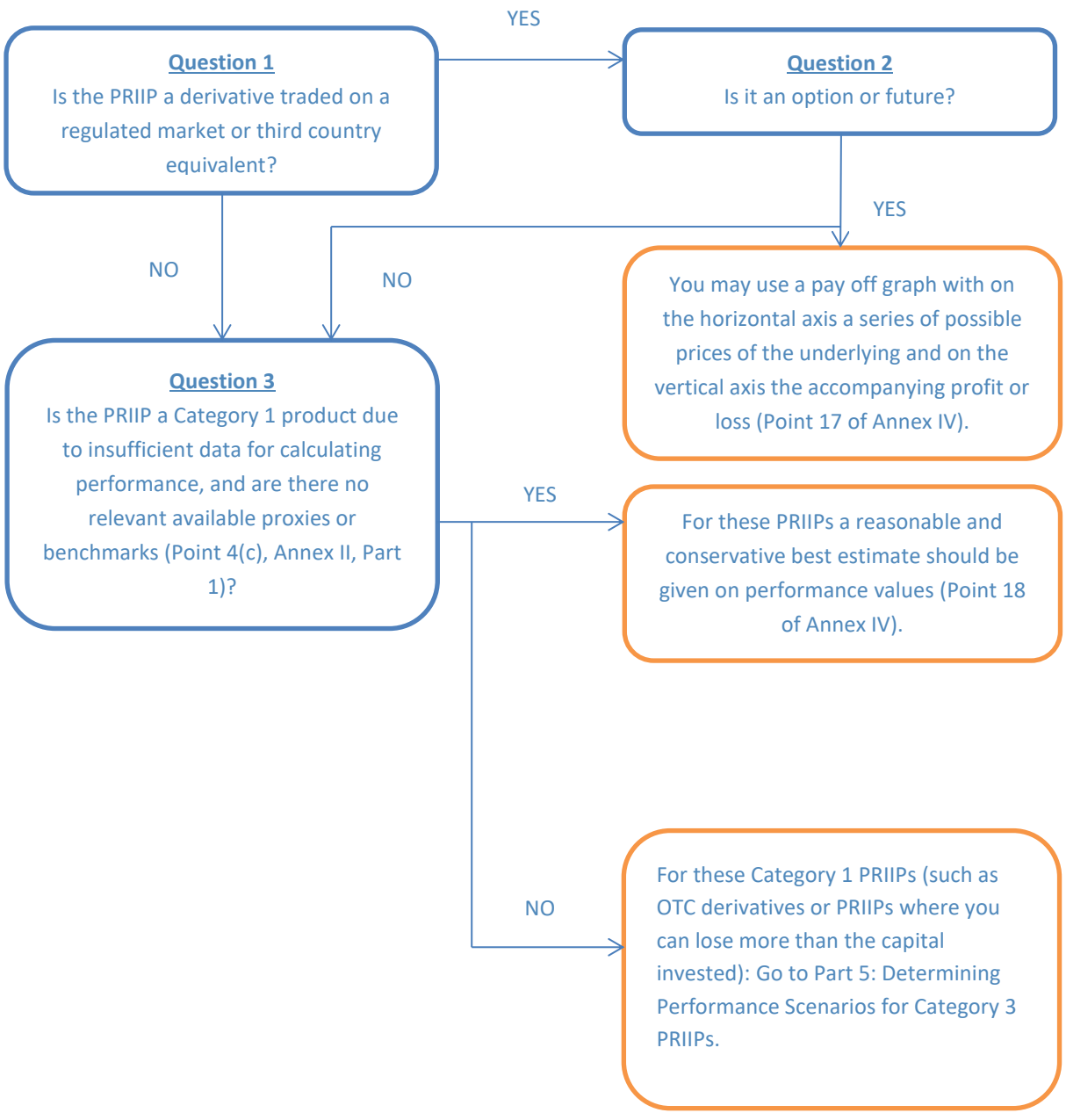
Part 1: Determining the holding periods that need to be shown



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;

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

Moderate scenario;

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

Favourable scenario;

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

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 $t_i = t_{(N-w)}$

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

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.

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:

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

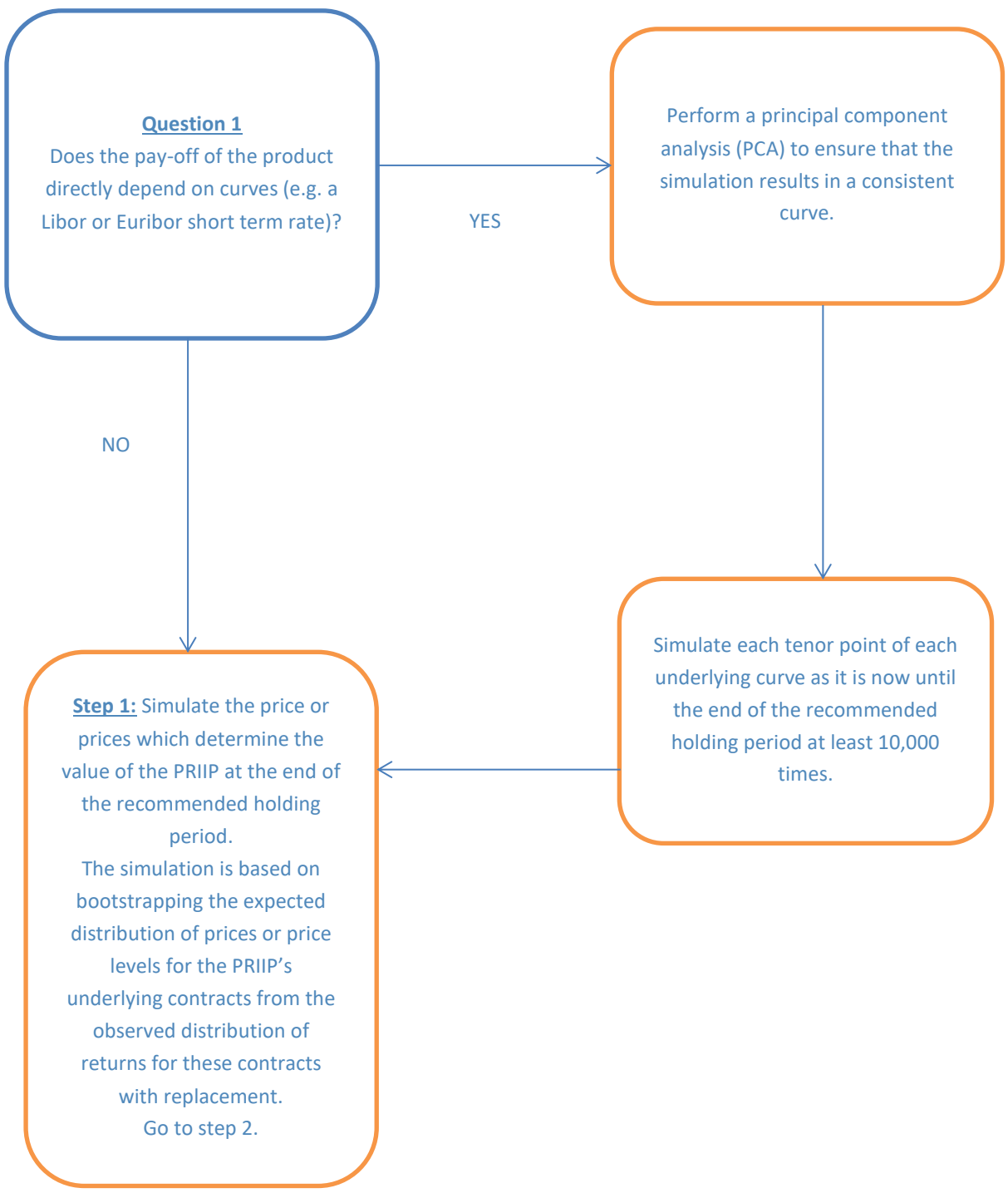
RHP 1, 3 and 5 years, 5 years of daily observed prices (Euro Stoxx 50 – from 01.05.12 to 25.02.17)

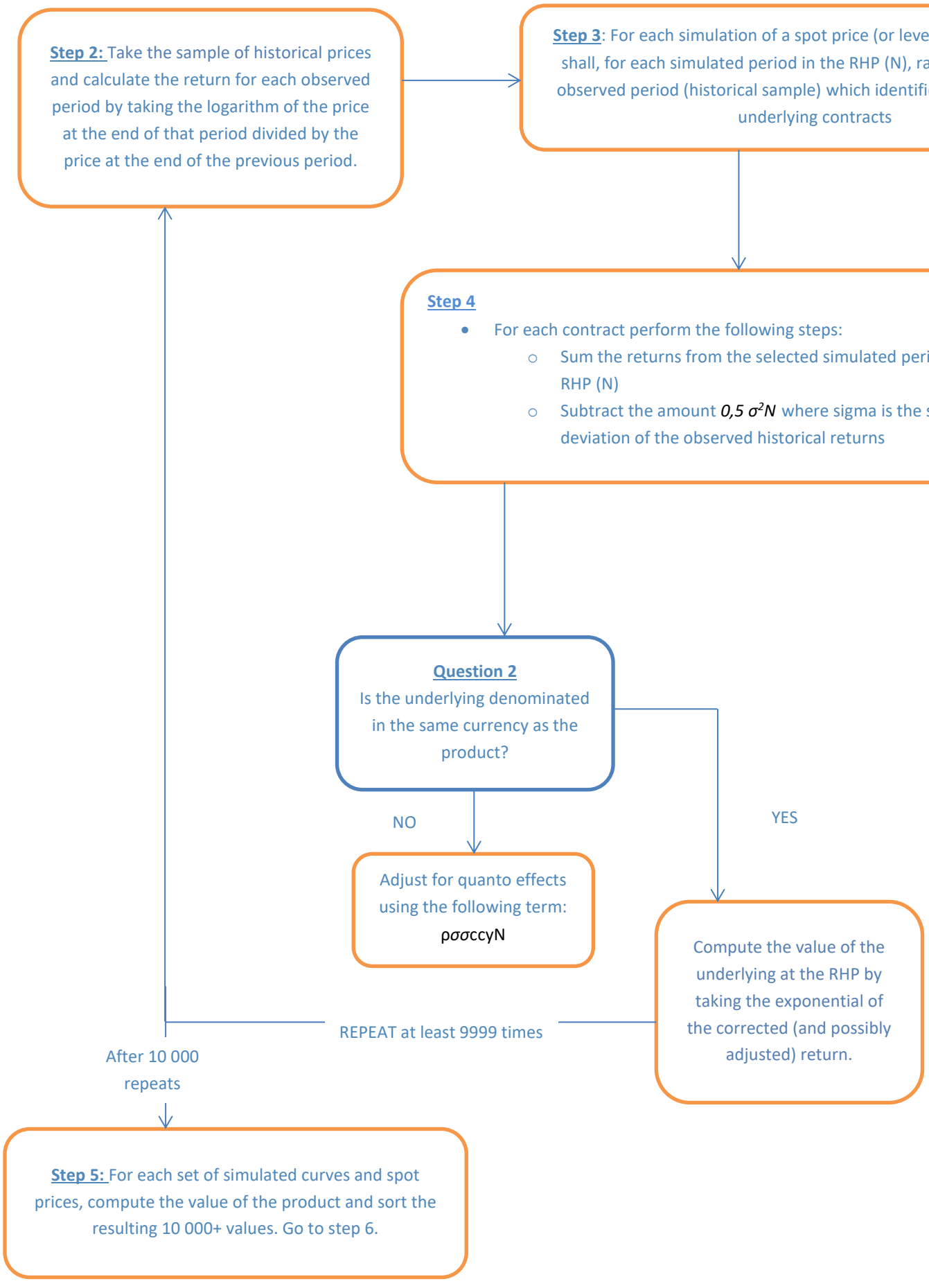
		Stressed Performance Scenario			
	α	z_α	$(z_\alpha^2-1)/6$	$(z_\alpha^3-3z_\alpha)/24$	$(2z_\alpha^3-5z_\alpha)/36$
RHP 1 YEAR - Annex IV, point 11	1%	-2,326347874	0,735315739	-0,233787728	-0,376337746
RHP OTHER HOLDING PERIODS - Annex IV, point 11	5%	-1,644853627	0,284257242	0,020180747	-0,018782716
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**

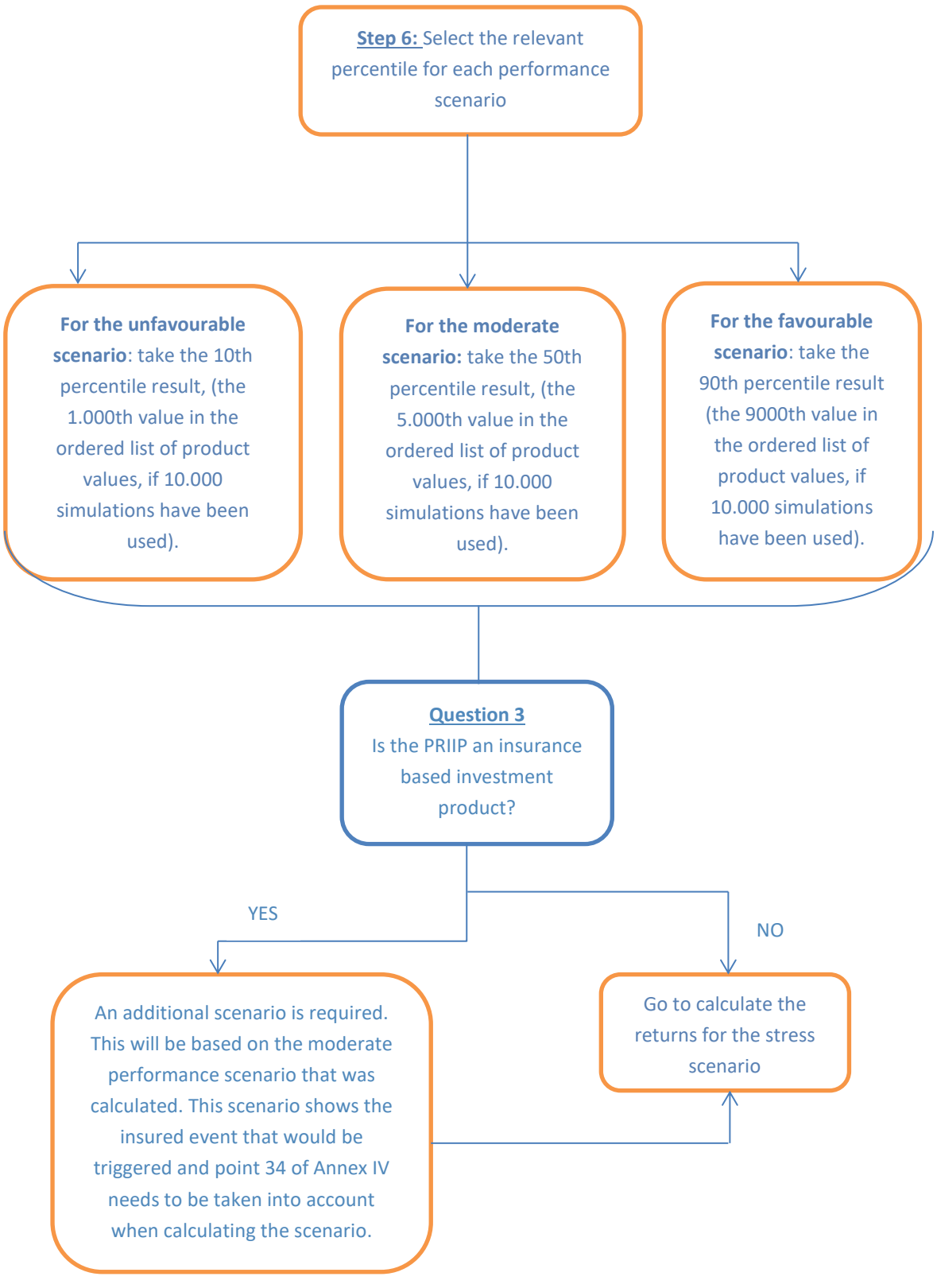
Part 5: Determining Performance Scenarios for Category 3 PRIIPs

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 σ²N 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 [Updated 19 July 2018]

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 $\frac{1}{2}\sigma^{*2}N$ (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 1-4: 1.000 simulations, RHP of 1 year, 5 years of daily prices

RECOMMENDED HOLDING PERIOD = N = 1 YEAR = 256 OBS

W=21 days

DATE	PRICE		RETURN OBSERVED	N		Rolling volatility
01/10/2012	2498,81				t_0	
02/10/2012	2493,59	r_1	-0,002091179	1	t_1	-0,004593693
03/10/2012	2492,48	r_2	-0,00044524	2	t_2	-0,00097806
04/10/2012	2485,75	r_3	-0,002703774	3	t_3	-0,00593938
05/10/2012	2531,21	.	0,018123024	4	.	0,039810846
08/10/2012	2496,09	.	-0,013971942	5	.	-0,030692163
09/10/2012	2472,23	.	-0,00960493	6	.	-0,021099149
10/10/2012	2456,54	.	-0,006366722	7	.	-0,013985776
11/10/2012	2487,08	.	0,012355476	8	.	0,027141272
12/10/2012	2469,09	.	-0,00725967	9	.	-0,015947316
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	$t_{N-w+1} = 1281 - 21 + 1 = 1261$	0,004099078
25/09/2017	3537,81	.	.	.		
26/09/2017	3536,38	.	-0,000404287	1278		
27/09/2017	3555,17	r_{1279}	0,005299277	1279		
28/09/2017	3563,64	r_{1280}	0,002379612	1280		
29/09/2017	3594,85	r_{1281}	0,008719771	1281		

RECOMMENDED HOLDING PERIOD = 1 YEAR = 256 OBS

W = 21

Starting from ti=t1 rolling until ti=t (H-w+1)=1281-21+1=1261

DATE	PRICE	RETURN OBSERVED		Rank	Rolling volatility		Stressed returns $r_t^{adj} = r_t * \frac{W_{\sigma_S}}{\sigma_S}$
01/10/2012	2498,81						
02/10/2012	2493,59	r_1	-0,002091179	444	$w_{t1}\sigma_S$	0,011057907	-0,004593693
03/10/2012	2492,48	r_2	-0,00044524	441	$w_{t2}\sigma_S$	0,011103686	-0,00097806
04/10/2012	2485,75	r_3	-0,002703774	416	$w_{t3}\sigma_S$	0,011382599	-0,00593938
05/10/2012	2531,21		0,018123024	415		0,011392173	0,039810846
08/10/2012	2496,09		-0,013971942	445		0,011039906	-0,030692163
09/10/2012	2472,23		-0,00960493	466		0,010703712	-0,021099149
10/10/2012	2456,54		-0,006366722	398		0,011627466	-0,013985776
11/10/2012	2487,08		0,012355476	409		0,011536689	0,027141272
12/10/2012	2469,09		-0,00725967	428		0,011224976	-0,015947316
15/10/2012	2485,12		0,006471286	440		0,011127023	0,014215474
16/10/2012	2547,9		0,024948542	437		0,011170169	0,05480446
17/10/2012	2569,83		0,008570258	611		0,009813873	0,018826286
18/10/2012	2574,19		0,001695173	665		0,009571617	0,003723786
19/10/2012	2542,24		-0,012489339	600		0,009863843	-0,02743533
22/10/2012	2531,1		-0,004391591	408		0,011538548	-0,009647008
23/10/2012	2477,92		-0,021234492	403		0,011594165	-0,046645807
24/10/2012	2490,58		0,005096116	477		0,010641736	0,011194639
25/10/2012	2483,43		-0,002874946	473		0,010663114	-0,006315393
26/10/2012	2496,1		0,005088845	460		0,010752758	0,011178664
29/10/2012	2478,84		-0,006938805	454		0,010821046	-0,015242472
30/10/2012	2515,99	r_{21}	0,014875655	470		0,010680698	0,032677351
31/10/2012	2503,64	r_{22}	-0,004920691	529		0,010236645	-0,010809282
01/11/2012	2533,87	r_{23}	0,012002105	492		0,01051815	0,026365023
02/11/2012	2547,15	r_{24}	0,005227309	520		0,010276718	0,011482829
05/11/2012	2517,67	r_{25}	-0,011641216	528		0,01023911	-0,025572259

RECOMMENDED HOLDING PERIOD = 1 YEAR = 256 OBS
W = 21

Starting from ti=t1 rolling until ti=t (H-w+1)=1281-21+1=1261

DATE	PRICE	RETURN OBSERVED		Rank	Rolling volatility		Stressed returns $r_t^{adj} = r_t * \frac{W_{\sigma_S}}{\sigma_S}$
01/10/2012	2498,81						
02/10/2012	2493,59	r_1	-0,002091179	444	$w_{t1}\sigma_S$	0,011057907	-0,004593693
03/10/2012	2492,48	r_2	-0,00044524	441	$w_{t2}\sigma_S$	0,011103686	-0,00097806
04/10/2012	2485,75	r_3	-0,002703774	416	$w_{t3}\sigma_S$	0,011382599	-0,00593938
05/10/2012	2531,21		0,018123024	415		0,011392173	0,039810846
08/10/2012	2496,09		-0,013971942	445		0,011039906	-0,030692163
09/10/2012	2472,23		-0,00960493	466		0,010703712	-0,021099149
10/10/2012	2456,54		-0,006366722	398		0,011627466	-0,013985776
11/10/2012	2487,08		0,012355476	409		0,011536689	0,027141272
12/10/2012	2469,09		-0,00725967	428		0,011224976	-0,015947316
15/10/2012	2485,12		0,006471286	440		0,011127023	0,014215474
16/10/2012	2547,9		0,024948542	437		0,011170169	0,05480446
17/10/2012	2569,83		0,008570258	611		0,009813873	0,018826286
18/10/2012	2574,19		0,001695173	665		0,009571617	0,003723786
19/10/2012	2542,24		-0,012489339	600		0,009863843	-0,02743533
22/10/2012	2531,1		-0,004391591	408		0,011538548	-0,009647008
23/10/2012	2477,92		-0,021234492	403		0,011594165	-0,046645807
24/10/2012	2490,58		0,005096116	477		0,010641736	0,011194639
25/10/2012	2483,43		-0,002874946	473		0,010663114	-0,006315393
26/10/2012	2496,1		0,005088845	460		0,010752758	0,011178664
29/10/2012	2478,84		-0,006938805	454		0,010821046	-0,015242472
30/10/2012	2515,99	r_{21}	0,014875655	470		0,010680698	0,032677351
31/10/2012	2503,64	r_{22}	-0,004920691	529		0,010236645	-0,010809282
01/11/2012	2533,87	r_{23}	0,012002105	492		0,01051815	0,026365023
02/11/2012	2547,15	r_{24}	0,005227309	520		0,010276718	0,011482829
05/11/2012	2517,67	r_{25}	-0,011641216	528		0,01023911	-0,025572259

RECOMMENDED HOLDING PERIOD = 1 YEAR = 256 OBS

W = 21

Starting from ti=t1 rolling until ti=t (H-w+1)=1281-21+1=1261

DATE	PRICE	RETURN OBSERVED		Rank	Rolling volatility		Stressed returns $r_t^{adj} = r_t * \frac{W_{\sigma_S}}{\sigma_S}$
01/10/2012	2498,81						
02/10/2012	2493,59	r_1	-0,002091179	444	$w_{t1}\sigma_S$	0,011057907	-0,004593693
03/10/2012	2492,48	r_2	-0,00044524	441	$w_{t2}\sigma_S$	0,011103686	-0,00097806
04/10/2012	2485,75	r_3	-0,002703774	416	$w_{t3}\sigma_S$	0,011382599	-0,00593938
05/10/2012	2531,21		0,018123024	415		0,011392173	0,039810846
08/10/2012	2496,09		-0,013971942	445		0,011039906	-0,030692163
09/10/2012	2472,23		-0,00960493	466		0,010703712	-0,021099149
10/10/2012	2456,54		-0,006366722	398		0,011627466	-0,013985776
11/10/2012	2487,08		0,012355476	409		0,011536689	0,027141272
12/10/2012	2469,09		-0,00725967	428		0,011224976	-0,015947316
15/10/2012	2485,12		0,006471286	440		0,011127023	0,014215474
16/10/2012	2547,9		0,024948542	437		0,011170169	0,05480446
17/10/2012	2569,83		0,008570258	611		0,009813873	0,018826286
18/10/2012	2574,19		0,001695173	665		0,009571617	0,003723786
19/10/2012	2542,24		-0,012489339	600		0,009863843	-0,02743533
22/10/2012	2531,1		-0,004391591	408		0,011538548	-0,009647008
23/10/2012	2477,92		-0,021234492	403		0,011594165	-0,046645807
24/10/2012	2490,58		0,005096116	477		0,010641736	0,011194639
25/10/2012	2483,43		-0,002874946	473		0,010663114	-0,006315393
26/10/2012	2496,1		0,005088845	460		0,010752758	0,011178664
29/10/2012	2478,84		-0,006938805	454		0,010821046	-0,015242472
30/10/2012	2515,99	r_{21}	0,014875655	470		0,010680698	0,032677351
31/10/2012	2503,64	r_{22}	-0,004920691	529		0,010236645	-0,010809282
01/11/2012	2533,87	r_{23}	0,012002105	492		0,01051815	0,026365023
02/11/2012	2547,15	r_{24}	0,005227309	520		0,010276718	0,011482829
05/11/2012	2517,67	r_{25}	-0,011641216	528		0,01023911	-0,025572259

Percentile RHP = 1 (Paragraph 10, letter d, Annex IV)

99

Used rank (RHP = 1)

13

Inferred stressed volatility (RHP = 1 year)

W_{σ_S} 0,02550764

Observed Standard Deviation 0,0116118 σ_S

Standard Deviation of the Adjusted Returns 0,02550764 σ^*

Mean stressed returns 0,000623663 μ^*

Steps 5-8: 1.000 simulations, RHP of 1 year, 5 years of daily prices

DAY	1	2	3	.	.	.	254	255	256	SUM OF RETURNS	SIMULATED RETURN (in accordance with §13 - point d - Annex IV)	RANK	PRICE OF UNDERLYING CONTRACT (in accordance with §22 - point d - Annex II)
Simulation 1	0,013598	0,031242	0,044856	.	.	.	-0,00126	6,03E-06	-0,02104	0,413474141	0,17053447	273	1,185938531
Simulation 2	0,074886	-0,00067	-0,04431	.	.	.	-0,01584	-0,01253	0,027162	0,281284623	0,038344952	395	1,039089607
Simulation 3	-0,01468	-0,02962	-0,00446	.	.	.	0,030057	-0,0132	-0,02117	0,28923852	0,046298848	385	1,047387374
Simulation 4	0,023658	0,019734	-0,02168	.	.	.	0,003057	-0,08292	0,026948	0,425650118	0,182710447	266	1,200466759
.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.
Simulation 997	-0,00321	0,038641	0,006074	.	.	.	-0,0145	-0,01405	0,005984	-0,602766117	-0,845705788	961	0,429254289
Simulation 998	0,014822	-0,00663	0,022018	.	.	.	-0,04148	-4,1E-05	-0,01584	-0,031255577	-0,274195248	671	0,760183636
Simulation 999	-0,02288	0,006382	0,00786	.	.	.	0,020355	-0,00783	-0,01213	0,087894897	-0,155044774	566	0,856376833
Simulation 1000	-0,00098	0,024603	0,009817	.	.	.	0,017645	0,046207	-0,01081	0,243051832	0,000112161	401	1,000112167

	Percentile stressed scenario		Rank Stressed Scenario	Stressed Scenario
	Paragraph 14 Annex IV			
RHP = 1 Y	z_α	1	990	0,465482834

Part 6: Calculating the performance scenarios for the intermediate periods