EBA/CP/2020/10

4 June 2020

Consultation Paper

Draft Regulatory Technical Standards on the calculation of the stress scenario risk measure under Article 325bk(3) of Regulation (EU) No 575/2013 (Capital Requirements Regulation 2 - CRR2)

Contents

1. Responding to this consultation

The EBA invites comments on all proposals put forward in this paper and in particular on the specific questions summarised in 5.2.

Comments are most helpful if they:

- respond to the question stated;
- indicate the specific point to which a comment relates;
- contain a clear rationale;
- provide evidence to support the views expressed/ rationale proposed; and
- describe any alternative regulatory choices the EBA should consider.

Submission of responses

To submit your comments, click on the ‘send your comments’ button on the consultation page by 4 September 2020. Please note that comments submitted after this deadline, or submitted via other means may not be processed.

Publication of responses

Please clearly indicate in the consultation form if you wish your comments to be disclosed or to be treated as confidential. A confidential response may be requested from us in accordance with the EBA’s rules on public access to documents. We may consult you if we receive such a request. Any decision we make not to disclose the response is reviewable by the EBA’s Board of Appeal and the European Ombudsman.

Data protection

The protection of individuals with regard to the processing of personal data by the EBA is based on Regulation (EC) N° 45/2001 of the European Parliament and of the Council of 18 December 2000 as implemented by the EBA in its implementing rules adopted by its Management Board. Further information on data protection can be found under the Legal notice section of the EBA website.

2. Executive Summary

The amendments to Regulation (EU) No 575/2013 (the Capital Requirements Regulation – CRR) implement in EU legislation, inter alia, the revised requirements to compute own funds requirements for Market risk of the Basel III package, i.e. the Fundamental Review of the Trading Book (FRTB).

One of the key features of the FRTB is the classification of risk-factors that are included in the risk-measurement model of the bank as modellable or non-modellable. As a result, the standards set that institutions must calculate a separate stress scenario risk measure for each non-modellable risk factor (or non-modellable bucket). This has to be calibrated to be at least as prudent as the expected shortfall calibration used for modelled risks (i.e. a loss calibrated to a 97.5% confidence threshold over a period of extreme stress for the given risk factor or the given bucket).

These draft RTS set out the methodologies that institutions are required to use for the purpose of determining the extreme scenario of future shock that, when applied to the non-modellable risk factor, provides the stress scenario risk-measure. Setting out a clear methodology is deemed necessary to ensure a level playing field among institutions in the European Union.

More precisely, these draft RTS identify two over-arching approaches, upon which the EBA is consulting, that may be used by institutions for determining an extreme scenario of future shock. Only one of the two will be kept after consultation. Considering that each approach has its own specific features, two versions of the draft RTS are included in this CP to consistently present how the whole framework would work under each of those two approaches.

The first over-arching approach (Option A) requires institutions to identify a stress period for each broad risk factor category and to collect data for non-modellable risk factors on the stress period in order to determine an extreme scenario of future shock.

Under this first approach, the draft RTS set that institutions can:

- Use a direct method. This method consists of directly calculating the expected shortfall measure of the losses that would occur when varying the risk factor in a way calibrated to the relevant stress period. The CP highlights that this method provides reliable results only where the institution has a significant amount of data in the observation period and requires many loss calculations per risk factor, which leads to a high computational effort;

- Use a stepwise method. In line with this method, institutions approximate the expected shortfall of the losses by first calculating an expected shortfall measure on the returns observed for that risk factor and then calculating the loss corresponding to the movement in the risk factor identified by that expected shortfall measure. This stepwise method requires significantly fewer loss calculations.

How the expected shortfall on the returns has to be computed under the stepwise method depends on the number of observations available in the stress period. In particular, these draft RTS clarify how this has to be done where the number of observations for a non-modellable risk factor in the relevant observation period is insufficient to obtain meaningful statistical estimates.

The second over-arching approach (Option B) recognises that, for non-modellable risk factors, data availability in a period of stress might be limited and requires institutions to collect data on non-modellable risk factors on the current period. This approach aims at improving the quality of the data that is used to calibrate the extreme scenarios of future shocks. In accordance with this approach the extreme scenario of future shock for a non-modellable risk factor is determined by rescaling shocks calibrated on data observed in the current period.

Under this over-arching approach, institutions should use the stepwise method, i.e. as clarified above institutions are required to approximate the expected shortfall of the losses by first calculating an expected shortfall measure on the returns observed for that risk factor and to calculate the loss corresponding to the movement in the risk factor identified by that expected shortfall measure. In contrast to the previous over-arching approach, however, the direct method is not available under this approach.

As required in Article 325bk(3) of the CRR, these draft RTS also specify a regulatory extreme scenario of future shock that should be applied where the institution is unable to determine it based on the above-mentioned methodologies, or where the competent authority is unsatisfied with the extreme scenario of future shock generated by the institution. In line with the international standards, these draft RTS set that the regulatory extreme scenario of future shock is the one leading to the maximum loss that can occur due to a change in the non-modellable risk factor, and set a specific framework to be used where such maximum loss is not finite.

Finally, in line with the international standards:

- These draft RTS specify that institutions may calculate a stress scenario risk measure at regulatory bucket level (i.e. for more than one risk factor), where the institution used the regulatory bucketing approach to disprove the modellability of the risk factors within the regulatory buckets;
- These draft RTS set the formula that institutions should use where aggregating the stress scenario risk measures.

3. Background and rationale

The EU implementation of the FRTB requires that institutions using the internal model approach (IMA) are required to identify for each risk factor included in the risk-measurement model whether it is modellable or not. Precisely, institutions are required to assess the modellability of a risk factor on the basis of the requirements set out in Article 325be. Risk factors that do not meet those requirements are deemed non-modellable risk factors (NMRFs).

The FRTB standards set out that when a risk factor has been identified as 'non-modellable' it has to be capitalised, outside the Expected Shortfall measure, under a stress scenario which the standards do not specify in detail except that it should be calibrated to be at least as prudent as the expected shortfall calibration used for modelled risks (i.e. a loss calibrated to a 97.5% confidence threshold over a period of extreme stress for the given risk factor). With respect to the calculation of this stress scenario risk measure, Article 325bk of the CRR is more prescriptive and mandates the EBA under Article 325bk(3)(a) to develop draft regulatory technical standards to specify how to calculate the 'extreme scenario of future shock' and how to apply it to the non-modellable risk factors to form the stress scenario risk measure. In particular, that article specifies that in developing these RTS, the EBA should take into consideration that the level of own funds requirements for market risk of a non-modellable risk factor shall be as high as the level of own funds requirements for market risk that would have been calculated if that risk factor were modellable.

In addition, Article 325bk(3)(b) mandates the EBA to develop draft regulatory technical standards specifying a regulatory scenario of future shock that institutions may use where they are unable to develop an extreme scenario of future shock using the methodology outlined in Article 325bk(3)(a).

Finally, the EBA is also required to develop draft regulatory technical standards for defining the circumstances under which institutions may calculate the stress scenario risk measure (SSRM) for more than one non-modellable risk factor and how institutions are to aggregate the stress scenario risk-measures of all non-modellable risk factors.

In December 2017, the EBA published a Discussion Paper (DP) on the EU implementation of market risk and counterparty credit risk revised standards[1]. The paper discussed some of the most important technical and operational challenges for the purposes of implementing the FRTB and SA-CCR in the EU.

In that context, the EBA put forward a first proposal with respect to how institutions should determine the stress scenario risk measure for non-modellable risk factors and several questions were included in order to gather a first feedback around the proposed methodology. It should be noted that this first

[1] https://eba.europa.eu/sites/default/documents/files/documents/10180/2161587/a5f47920-54be-4b68-a25c-119c70606186/Discussion%20Paper%20on%20EU%20implementation%20of%20MKR%20and%20CCR%20revised%20standards%20%28EBA-DP-2017-04%29.pdf

proposal was based on the FRTB standards published in January 2016 which were not final at that stage and superseded in January 2019[2].

Considering the feedback received on the discussion paper, and in light of the final international standards, the EBA launched in July 2019 a data collection exercise[3] presenting several SSRM calculation method variants. The purpose of the data collection exercise was to apply the EBA NMRF methodology proposals in practice and gather data for ensuring an appropriate calibration of the NMRF SSRM.

Accordingly, this consultation paper (CP) should be seen as the result of the above mentioned iterative process where inputs from market participants have been sought several times.

3.1 Feedback received on the Discussion Paper

The consultation of the December 2017 EBA Discussion paper ran until 15 March 2018, and a public hearing took place on 5 February 2018. The EBA received eight public responses to the DP as well as six confidential responses[4].

The DP described a methodology to calculate the extreme scenario of future shock for each NMRF. The methodology in the DP provided a typically conservative proxy of a 97.5% ES calculation by estimating the more stable standard deviation and multiplying it with a constant $CL_{ES\ equiv}$. Moreover, the approach presented in the DP was designed to be more conservative where fewer data points were available, to account for a higher estimation error, controlled by a parameter CL_{sigma}.

In addition, the DP discussed possible options with respect to the fallback approach, i.e. the approach institutions should follow where they are not able to determine an extreme scenario of future shock; in this respect the DP explored the following two options:

(i) A 'maximum loss' approach, consistent with the fallback approach foreseen in the Basel FRTB rules text. The DP highlighted that the approach may be, in principle, conservative, but the concept of a maximum loss is not well defined for a variety of instruments.

(ii) A fallback approach based on the risk weight of the sensitivity based method that institutions should apply to their NMRFs in order to calculate the stress scenario risk measure (SSRM).

A brief summary of the feedback on the DP is provided below; as previously mentioned, the proposal included in the DP was based on the FRTB standards published in January 2016 which were not final at that stage. Accordingly, the feedback reported in this section should be considered cautiously as some provisions in the international standards have changed. Main feedback points were:

[2] Basel Committee on Banking Supervision, *"Minimum capital requirements for market risk"*, https://www.bis.org/bcbs/publ/d457.pdf

[3] https://eba.europa.eu/sites/default/documents/files/documents/10180/2844292/f9f8e5a5-fe34-4ba9-90c4-77dd2fed51fe/Instructions%20on%20NMRF%20data%20collection.pdf

[4] https://eba.europa.eu/regulation-and-policy/market-risk/discussion-paper-on-eu-implementation-of-mkr-and-ccr-revised-standards

- With regard to the definition of the observation period to be used for collecting representative data for each non-modellable risk factor (NMRF), the majority of respondents were in favor of use the single 1-year stress period used for modellable risk factors in the expected shortfall calculation (option c).

- With regard to risk factor data acceptable, the majority of respondents proposed using option b) with option c) as fallback. Accordingly, the data used in the computation of the stress-scenario risk-measure (SSRM) for NMRF should be of the same type as the data allowed in the ES calculation for MRF with some flexibility where there is not enough data available.

- With respect to additional conditions on the data observed for the NMRF, respondents showed preferences for computing SSRM using different data from the ones used for assessing risk factor modellability. In their opinion, both market quotes and stale observations should be allowed, even if there should be a minimum number of observations (could be 40), one per observation date. Otherwise, a fallback approach should apply.

- With respect to the definition of liquidity horizon for NMRF the majority of respondents were in favour of using the definition provided in the FRTB, without the additional maturity dimension.

- On the calibration of the parameter $CL_{ES\ equiv}$, option b) and option c) were the preferred options, i.e. institutions' calibrations and a floor, such that $CL_{ES\ equiv} \geq 3$.

- On the parameter CL_{sigma} : some participants claimed that the value for CL_{sigma} would be overly conservative.

Although not up for discussion in the consultation, the main concern of the respondents was the conservativeness of the simple-sum aggregation scheme. Any further elements of conservatism were therefore deemed unnecessary by participants. In addition, respondents made some valuable observations on the implementation (e.g. on the scaling of NMRF returns) and proposed some adjustments to the presented methodology.

With respect to the calculation of extreme scenario of future shocks, some respondents advocated to allow institutions to apply a reduced approach when they can demonstrate that their portfolio is monotonic or even linear with respect to certain NMRFs.

Some respondents suggested to allow for a 'direct loss based approach' for certain NMRFs, meaning that the ES is calculated directly from a series of portfolio losses implying the extreme scenario of future shock, instead of calculating the shock from a series of risk factor observation leading to a portfolio loss.

In general, those participants in the consultation argued that the 'direct loss based approach', was more logical when targeting equivalence to the ES. It was also advocated for allowing institutions to use the 'direct loss based approach' whenever sufficient data was available.

With respect to the fallback solution to determine the extreme scenario of future shock applicable to non-modellable risk factors, the majority of respondents were in favour of an approach prescribing a specific range of stress scenarios that institutions should apply to their NMRFs to determine the SSRM capital requirements. However, the majority of respondents claimed that the risk weights prescribed in the sensitivity based method were too high for the purpose of determining the stress scenarios.

3.2 Methodology for developing extreme scenarios of future shock applicable to non-modellable risk factors

As mentioned, the amended CRR mandates the EBA in accordance with Article 325bk(3)(a) to develop regulatory technical standards specifying how institutions should determine the 'extreme scenario of future shock' and how they have to apply it to the non-modellable risk factors (NMRFs) to form the stress scenario risk measure. Accordingly, this section of the CP describes the methodology that institutions should use for developing the extreme scenarios of future shock applicable to non-modellable risk factors.

As outlined in Article 325bk(1) of the CRR, once the institution determines the extreme scenario of future shock for a non-modellable risk factor in line with these RTS, the stress scenario risk measure is the loss that is incurred when such extreme scenario of future shock is applied to that risk factor.

In general, institutions will have to determine the extreme scenario of future shock for a non-modellable risk factor on a stand-alone basis, and accordingly, they will compute a stress scenario risk-measure by identifying the loss where the risk factor is subject to that extreme scenario of future shock and all other risk factors are kept unchanged. However, in line with the international standards, the institution is allowed to determine a unique extreme scenario of future shock for more than one non-modellable risk factor under certain circumstances.

Precisely, the Basel standards clarify that the modellability of risk factors belonging to a curve or to a surface is determined via either the so called (i) own bucketing approach or the (ii) regulatory bucketing approach. Where the institution opts for the regulatory bucketing approach, a bucket may include more than one risk factor; under this scenario, the institution is allowed to calculate the stress scenario risk measure at the level of the regulatory bucket, meaning that a single extreme scenario of future shock is determined for all the risk-factors in the regulatory bucket.

These draft RTS specify the circumstances under which institutions may calculate a stress scenario risk measure for more than one non-modellable risk factor in accordance with Article 325bk(3)(c) of the CRR2. In this respect, the draft RTS aim at transposing the Basel standards in EU legislation by allowing institutions to determine an extreme scenario of future shock at regulatory bucket level. As a result, this section will both present the methodology that institutions should use where determining the extreme scenario of future shock for a single non-modellable factor and for a non-modellable regulatory bucket.

As mentioned, Article 325bk(1) of the CRR already defines the term 'stress scenario risk-measure', i.e. the loss that is incurred when the extreme scenario of future shock (obtained in accordance with these RTS) is applied to the corresponding non-modellable risk factor. In the context of modellable risk factors institutions are required to first calculate an expected shortfall measure on a 10-day horizon and to rescale it in a second step to reflect the liquidity horizon of the underlying risk factor. Analogously to the treatment of modellable risk factors, the extreme scenario of future shock obtained in accordance with these draft RTS is calibrated on a 10-day horizon and the stress scenario risk-measure defined as in 325bk(1) is a loss calibrated on a 10-day horizon. Each stress scenario risk measure is then rescaled to reflect the liquidity horizons of the non-modellable risk-factors in the aggregation formula laid down in section 3.5 for obtaining the own funds requirements for market risk associated to all non-modellable risk factors.

3.2.1 Notations

In this subsection the notations used in the background section of this CP are laid down for the purpose of easing the read of the paper.

D^*	Figure date, i.e. date for which the stress scenario risk measure is calculated
j	Identifier of the NMRF
$D_1 < \ldots < D_M$	Dates at which a value of the NMRF has been recorded
$D_{t+1} - D_t$	Number of business days from D_t to D_{t+1}
$r_j(D)$	Value of the NMRF j at date D
r_j^*	Value of the NMRF j at figure date D^*, $r_j^* \equiv r_j(D^*)$.
$LH(j)$	Liquidity horizon of the NMRF j
$Ret(j,t,10)$	Return of the NMRF j between D_t and $D_t + 10$ business days (or nearest approximation)
$\hat{\sigma}_{Ret(j)}$	Estimated standard deviation of 10-day returns of the NMRF j
$CS(j)$	Calibrated shock for the NMRF j
$CSSRFR_{D^*}(j)$	Calibrated stress scenario risk factor range for the NMRF j on date D^*
$FS_{D^*}(j)$	Extreme scenario of future shock for the NMRF j on date D^*
$loss_{D^*}^{j}(r)$	Loss to the portfolio on date D^* when the NMRF j takes a value r
$\kappa_{D^*}^{j}$	Adjustment factor for tail non-linearity of the loss function for the NMRF j
$SS_{D^*}^{j}$	Stress scenario risk measure on date D^* for the NMRF j

3.2.2 General provisions

In this subsection some general provisions regarding the calculation of the stress scenario risk measure are presented. Although some of those provisions have been already reflected in the level 1 text they are recalled here to provide the reader with the 'full picture'; some others introduce techniques or requirements that will be relevant in several parts of the framework and as such are introduced in this subsection.

Frequency of the calculation of the stress scenario risk measure

The EU implementation of the FRTB requires institutions to calculate the stress scenario risk measure $SS_{D^*}^j$ for a single NMRF j on a daily basis. In particular, $SS_{D^*}^j$ denotes the stress scenario risk measure for the NMRF j on figure date D^* (i.e. the date for which the stress scenario risk measure is computed). Given that this provision is already included in the Article 325ba, it accordingly is not included in these draft RTS, but it taken as pre-requisite for the implementation.

Pricing functions to use where applying the extreme scenario of future shocks

Article 325bk(3)(a) requires the EBA to specify how institutions have to apply the extreme scenario of future shock once it has been determined. Under this mandate, the draft RTS specify that the extreme scenario of future shock should be applied in the same manner as in the expected shortfall model. Therefore, when calculating the loss corresponding to a future shock applied to a non-modellable risk factor, institutions must use the pricing functions of the internal risk-measurement model. Thus, in particular, regarding the passage of time effect ("theta" effect), if the ES model is based on instantaneous shocks, the same should hold for the stress scenario risk measure. This is to ensure that a risk factor can switch modellability status back and forth and being modelled consistently.

Specifications on the portfolio loss function

The portfolio loss function $loss_{D^*}(r_j)$ measures changes of the portfolio's value on the figure date when a risk factor changes, which is a difference of two present values. $PV(\vec{r})$ denotes the portfolio present value depending on all risk factors $\vec{r} = \{r_i\}$ (modellable and non-modellable).

The sign convention is that the worst losses have a positive sign, when the present value upon changing risk factors gets lower. The loss occurring when one single risk factor r_j has a value different from the initial value $r_j^* = r_j(D^*)$ at the figure date is:

$$\text{loss}_{D^*}^{\text{single}}(r_j) = PV(\vec{r}^*) - PV\left(r_j, \vec{r}_{i\neq j}^*\right)$$

This means that only r_j is set to a specific value, while the current values of the other risk factors $\vec{r}_{i\neq j}$ are not changed. Accordingly, the joint distribution of risk factors r_j and $\vec{r}_{i\neq j}$ is not needed because $\vec{r}_{i\neq j}$ are not changed.

Where a risk-factor belongs to a regulatory bucket B of risk factors $\{r_j \in B\}$, institutions may decide (in accordance with these draft RTS) to calculate the stress scenario risk measure at bucket level. Accordingly, it is essential to define a loss function at bucket level. For the purpose of these RTS, the loss (at bucket level) occurring when all risk factors in the regulatory bucket B have values different from the initial values $\{r_j^* \in B\}$ at the figure date is:

$$\text{loss}_{D^*}^{\text{Bucket}}(\{r_j \in B\}) = PV(\{r_j^* \in \text{B}\}, \{r_i^* \notin \text{B}\}\text{ fixed}) - PV(\{r_j \in B\}, \{r_i^* \notin \text{B}\}\text{ fixed})$$

As mentioned, Article 325bk(3)(a) requires the EBA to specify how institutions have to apply the extreme scenario of future shock once it has been determined. As a result, all these aspects regarding the loss function have been reflected in the draft RTS by requiring the institutions to apply the extreme scenario of future shock by keeping unchanged all other risk factors while shocking the relevant non-modellable risk factor (or the relevant non-modellable regulatory bucket where applicable).

Obtaining the series of 10 business days returns from the time series of observations

In several parts of the framework, institutions are required to determine the time series of 10 business days returns from the time series of values of a given non-modellable risk factor during a specific 1-year period P. Hence, this subsection outlines how institutions have to determine such time series of 10 business days returns whenever they are required to do so.

Given a 1-year period P and given a non-modellable risk factor j, in order to build the time series of nearest to 10 business days returns, institutions must first collect a time series of risk factor values (observations) $r_j(D)$ for risk factor j, where $r_j(D_t)$ denotes the observation at date D_t.

Let $\{D_1, \dots, D_M, D_{M+1}, \dots D_{M+d}\}$ be the vector representing the observations' dates within the 1-year period P extended by up to 20 business days[5]. Then, for a given non-modellable risk factor, the vector $\{D_1, \dots, D_M\}$ denotes the observation dates within the 1-year period P, and the vector $\{D_{M+1}, \dots D_{M+d}\}$ denotes the observation dates during the 20-business days period following the 1-year period P.

The time series may not always yield exactly 10 business days returns for all dates, as data may be sparse, and the concept of a 10 business days return is generalised as follows: for each date index $t \in \{1, \dots, M-1\}$, institutions should determine a "nearest next to 10 days" candidate $t_{nn}(t)$ by applying the following formula:

$$t_{nn}(t) = \underset{\substack{t' > t \\ t' \in \{2,\dots,M,M+1,\dots M+d\}}}{argmin} \left[\left| \frac{10\ days}{D_{t'} - D_t} - 1 \right| \right]$$

Accordingly, being $t \in \{1, \dots, M-1\}$, the 'starting observation' used to determine a return always lies in the 1-year period P, while the 'ending observation' $t' \in \{2, \dots, M,\ M+1, \dots M+d\}$ may lie in the 20-business days period following the 1-year stress period.

[5] Where the period P is a period in the past then it can be extended of 20 days; however, where P is a current period (i.e. last 12-months period), then the 20 days following such period fall *'in the future'*. Accordingly, the draft RTS refer to a one-year period extended by up to 20 business days to reflect also cases where such extension is not possible in practice. The 20 days extension is motivated by the minimum liquidity horizon for NMRF.

There might be cases where there are 2 dates $D_{t'}$ minimising the above mentioned absolute value[6]; the draft RTS address also that specific (and rare) case, specifying that institutions should select the date with a longer time horizon among those minimizing the absolute value.

Once the institution determined the date $t_{nn}(t)$ for a given t, then it should determine the nearest to 10 business days return, by first considering the return on the period between t and $t_{nn}(t)$ according to the institution's chosen return approach for this risk factor, and then rescaling it in order to obtain a 10 business days return approximation. For example, if the institution uses absolute returns for a given NMRF, then the 10 business days return is determined as:

$$Ret(r_j, t, 10) = \left(r_j\left(D_{t_{nn}(t)}\right) - r_j(D_t)\right) \times \sqrt{\frac{10 \text{ days}}{D_{t_{nn}(t)} - D_t}}$$

If the institution uses logarithmic returns for the NMRF, then the 10 business days return is determined as:

$$Ret(r_j, t, 10) = \log\left(\frac{r_j\left(D_{t_{nn}(t)}\right)}{r_j(D_t)}\right) \times \sqrt{\frac{10 \text{ days}}{D_{t_{nn}(t)} - D_t}}$$

More in general, in case of another return approach, e.g. an approach for interest rates where absolute returns for low levels of interest are mixed with a cross-over to relative returns for high levels of interest, the method for the 10-day return calculation outlined above should be applied accordingly.

As a result, the institution obtains the time series of $Ret(r_j, t, 10)$ for each $t \in \{1, \dots, N\}$, where $N = M - 1$.

Estimating the standard deviation of 10-days returns

In several parts of the framework, institutions are required to estimate the standard deviation of the time series of the nearest to 10 business days returns (obtained in accordance with the previous subsection) corresponding to a 1-year period P. Hence, this subsection outlines how institutions are required to estimate such standard deviation.

Given the sample $Ret(r_j, 1{,}10)$,…, $Ret(r_j, N, 10)$ of 10 business days returns (obtained as a result of the previous subsection) of a given non-modellable risk factor for a given 1-year period P, institutions must estimate the standard deviation of nearest to 10-day returns $\hat{\sigma}^P{}_{Ret(j)}$ with the following estimator:

$$\hat{\sigma}^P{}_{Ret(j)} = \sqrt{\frac{1}{N - 1.5} \times \sum_{t=1}^{N} \left(Ret(r_j, t, 10) - \overline{Ret(r_j, \cdot, 10)}\right)^2}$$

[6] For example where the dates minimising the absolute value occurred 6 and 30 business days after D_t, then |10/6-1|=|10/30-1|.

where $\overline{Ret(r_j,\cdot,10)}$ denotes the mean of the sample of returns.

Requirements on the data inputs for non-modellable risk factors

The EBA guidelines to be developed in accordance with Article 325bh(3) will set out requirements for data inputs for modellable risk factors. Hence, the criteria within those guidelines are not meant to be applicable to non-modellable risk factors. These draft RTS propose only few high-level requirements with respect to the data inputs to be used for developing the extreme scenario of future shock.

Precisely, these draft RTS set that:

- For the data that are used as inputs for the calibration of the downward and upward shock, institutions shall recognize only one risk factor value per day and no stale data shall be considered unless it represents actual market data;
- Stale data may be used for determining the value of the risk factor at figure date, i.e. the value that is shocked to determine the losses that would occur if those shocks were applied at figure date;
- Institutions shall use the time series that were used for calibrating shocks in the context of the expected shortfall for risk factors that were modellable in the past, and are now assessed as non-modellable.

It should be noted that Article 325bh set out the requirements for the internal risk-measurement model; the term 'internal risk-measurement model' appears to be used in a broad sense in the CRR as it encompasses any internal model used by the institution (e.g. the ES model used for obtaining the own funds requirements associated to modellable risk factors or the methodology used to calculate the stress scenario risk measure), as well as the pricing functions used by the institution to compute the RTPL under the PLA test. As a result, the requirement set out in Article 325bh(1)(g) governing the usage of proxies is relevant both in the context of modellable risk factors and non modellable risk factors, and accordingly the draft RTS do not include any further specifications around that aspect as it would otherwise be redundant.

3.2.3 Overarching approaches for determining the extreme scenario of future shock and determination of the stress period for the NMRF

The FRTB standards set out in paragraph 33.16 that “the capital requirements for each non-modellable risk factor (NMRF) are to be determined using a stress scenario that is calibrated to be at least as prudent as the ES calibration used for modelled risks (i.e. a loss calibrated to a 97.5% confidence threshold over a period of stress). In determining that period of stress, a bank must determine a common 12-month period of stress across all NMRFs in the same risk class”.

The amended CRR on-boards this requirement in the EU legislation by requiring the EBA to develop these RTS taking into considerations that the level of own funds requirements for market risk of a non-modellable risk factor should be as high as the level of own funds requirements for market risk that would have been calculated if that risk factor were modellable. Accordingly, the EBA developed these standards so that the stress scenario risk measure associated to a non-modellable risk factor corresponds to an expected shortfall measure of the losses that may occur due to a change in the non-modellable risk factor with a 97.5% confidence threshold over a period of stress.

The EBA consults as part of this consultation process on two different ways through which the abovementioned requirement set out in the Basel standards and in the EU implementation set out in the CRR can be met (see option A and option B below). These “two ways” reflect two different overarching approaches that could be implemented for determining the stress scenario risk measure corresponding to an extreme scenario of future shock:

- Option A: determination of the stress scenario risk measure directly from the stress period
- Option B: rescaling a shock calibrated on the current period to obtain a shock calibrated on the stress period

Furthermore, while presenting the two options it is also specified how institutions are required to identify the relevant stress period under each option. In line with the international standards, the determination of the stress period has to be performed at risk class level and should be performed on a quarterly basis.

Before introducing the two abovementioned options, it is worth recalling the approach set out in CRR for identifying the stress period for modellable risk factors: when calculating the expected shortfall for modellable risk factors, institutions are required as per Article 325bc(2)(c) to identify a stress period (at the satisfaction of the competent authority) and to calibrate to historical data from such period the data inputs used to determine the scenario of future shocks for the modellable risk factors. As specified in the CRR, such period of financial stress should be identified in a way that it maximizes the partial expected shortfall on a reduced set of risk factors PES_t^{RS} (see Article 325bc(2)(c)).

In the legal text, in order to ensure easier reading and facilitate the consultation process, the presentation, i.e. structure and order of Articles in Option A has been aligned to the structure of Option B. It should be noted that the order and structure might change depending on the option chosen after consultation.

Option A: determination of the stress scenario risk measure directly from the stress period

The first approach would require institutions to determine directly the stress scenario risk-measure from observations' data collected in the stress period. In other words, the observation period that is used to calibrate the shock applicable to the non-modellable risk factor is directly the stress period, i.e. institutions would have to consider the observation data $\boldsymbol{r_j(D)}$ for the NMRF j directly in the stress period, and would directly apply the methodology prescribed in these draft RTS on the basis of the time series constituted by those observations for determining the extreme scenario of future shock.

Should this option be kept after consultation, then institutions would need to apply the following steps in sequence to determine the stress risk measure:

1. The institution determines the stress period for each risk class using the definition of stress period laid down below.

2. The institution applies the provisions included in section 3.2.4.[7] considering as *observation period* the stress period. As a result, the institution obtains the extreme scenario of future shock for each non-modellable risk factor (or non-modellable bucket where applicable) calibrated on the stress period.

3. The institution calculates the stress scenario risk measure ($SS^{j,s}_{10\text{days},D^*}$) as the loss occurring when the extreme scenario of future shock is applied to the non-modellable risk factor j. As mentioned, such stress scenario risk-measure is then rescaled to reflect the liquidity horizons of the non-modellable risk-factors (but also other aspects e.g. the non-linearity of the loss function) directly in the aggregation formula laid down in section 3.5.

With respect to the notation, $SS^{j,S}_{10\text{days},D^*}$ denotes a 10-days stress scenario risk measure for the non-modellable risk factor j (or non-modellable bucket where applicable) calculated on the figure date D^* and calibrated on the stress period S^i .

Determination of the stress period

Under this option, the proposed draft RTS require institutions to identify one stress period for each of the five broad categories $i \in \{\text{IR, CS, EQ, FX, CM}\}$ of risk factors (risk classes). These draft RTS require institutions to determine the stress period at risk class level by identifying the 12-month period P maximising the value taken by the rescaled stress scenario risk measures $RSS^{j,P}_{D^*}$ associated to risk factors that are mapped to that risk class. Institutions are required to determine the 12-month stress period S^i as follows:

$$S^i = \underset{P}{argmax} \left[\sum_{j \in i} RSS^{j,P}_{D^*} \right]; \; i \in \{\text{IR, CS, EQ, FX, CM}\}$$

[7] As outlined later in the CP, under option A both the 'direct method' and the 'stepwise method' that are described in section '3.2.4. *Determination of the extreme scenario of future shock'* can be potentially used.

How institutions should calculate $RSS_{D^*}^{j,P}$ depends on the methodology that is used for determining the extreme scenario of future shock. In particular, as laid down later in this CP, these draft RTS identify two main methodologies for determining the extreme scenario of future shock: the stepwise method, and the direct method. In addition, in accordance with Article 325bk(3)(b), another regulatory approach has been designed where e.g. the competent authority is not satisfied with the extreme scenario of future shock obtained with the direct or stepwise method, such approach is based on the maximum loss that can occur due to a change in the NMRF and is further detailed in the following sections of this CP. In a nutshell[8]:

$$RSS_{D^*}^{j,P} = \begin{cases} \sqrt{\frac{LH_{adj}(j)}{10}} \times SS_{10\text{days},D^*}^{j,P} \times \kappa_{D^*}^{j} \text{ where } SS_{10\text{days},D^*}^{j,P} \text{ is obtained with the stepwise method} \\ \sqrt{\frac{LH_{adj}(j)}{10}} \times SS_{10\text{days},D^*}^{j,P} \times UC \text{ where } SS_{10\text{days},D^*}^{j,P} \text{ is obtained with the direct method} \\ \text{maximum loss or the expert} - \text{based maximum loss where applicable} \end{cases}$$

Where:

- $i \in \{\text{IR, CS, EQ, FX, CM}\}$ denotes the risk class of the risk factor j;

- $SS_{10\text{days},D^*}^{j,P}$ denotes the 10-days stress scenario risk measure for the non-modellable risk factor j (or non-modellable bucket where applicable) calculated on the figure date D^* and calibrated on the 12-month period P;

- $LH_{\text{adj}}(j)$ is the liquidity horizon of the non-modellable risk factor j adjusted to consider the 20-days floor to be applied for non-modellable risk factors in accordance with the international standards, i.e.:

$$LH_{\text{adj}}(j) = \max(20, LH(j))$$

  where $LH(j)$ is the liquidity horizon of the risk factor j obtained in accordance with the RTS on the determination of the liquidity horizon for a given risk factor as referred to in Article 325bd(7) of the CRR2.

- $\kappa_{D^*}^{j}$ denotes the non-linearity adjustment for the non-modellable risk factor j (or non-modellable bucket where applicable) and is relevant only where the institution used the stepwise method for obtaining the extreme scenario of future shock. Section 3.5.1. describes the meaning of such parameter, and provides institutions with the methodology for calculating it.

- UC is the uncertainty compensation factor capturing uncertainty due to the lower observability of non-modellable risk factors. It is relevant only where the institution used the direct method

[8] Section 3.5 further specifies how institutions are to calculate the rescaled stress scenario risk measures.

for obtaining the extreme scenario of future shock[9]. Section 3.5.2.sets how institutions should calculate the compensation factor UC.

In analogy to the treatment prescribed for modellable risk factors in Article 325bc(2) (although in that context a single stress period applicable to all risk factors has to be determined), institutions are required to scan the 12-months periods starting at least from 1 January 2007. As mentioned, the determination of the stress periods S^i for each risk class should be performed at least on a quarterly basis.

Option B: rescaling a shock calibrated on the current period to obtain a shock calibrated on the stress period

Before outlining the requirements under this second option, it should be noted that for modellable risk factors institutions are required to calculate the following quantities as per Article 325bb:

- A partial expected shortfall on the current period considering the full set of risk factors (PES_t^{FC});
- A partial expected shortfall on the current period considering a reduced set of risk factors (PES_t^{RC});
- A partial expected shortfall on the stress period considering a reduced set of risk factors (PES_t^{RS});

and are then required to determine the unconstrained expected shortfall as follows:

$$UES_t = PES_t^{RS} \cdot \max\left[\frac{PES_t^{FC}}{PES_t^{RC}}, 1\right]$$

In other words, banks are required to rescale PES_t^{RS} to consider that the unconstrained expected shortfall should measure the risk stemming from the full set of risk factors (and not just only stemming from reduced set of risk factors).

Under option B, similarly to the treatment proposed for modellable risk factors, the proposed draft RTS require institutions to first consider the observation data $r_j(D)$ for a given non-modellable risk factor that are observed in the last 12-months period (henceforth referred to as 'current period') and to calibrate downward and upward shocks on the basis of those observation data in accordance with one of the methodologies set out in these draft RTS. As a result, institutions obtain an upward and downward calibrated shock over the current period.

[9] As clarified in section '*Methodology S – the stepwise method*', the uncertainty due to the lower observability of non-modellable risk factors is already captured where calibrating the extreme scenario of future shock where institutions use the stepwise method to calibrate those shocks, while this is not the case for the direct method. As a result, UC is applicable only where the institutions use the direct method to avoid any sort of double counting.

To reflect that the stress scenario risk-measure should be as prudent as a loss calibrated to 97.5% confidence threshold over a period of stress (as required by the international standards) institutions are then required to rescale such calibrated shocks by means of a scalars ($m_{S,C}^{i}$ – see below how these scalars are determined) to obtain shocks calibrated over a period of stress. The international standards also specify that the stress period must be identified at risk class level, and in line with such requirement, these draft RTS set that that scalar has to be determined at risk class level.

Should this option be kept after consultation, institutions would need to apply the following steps in sequence to determine the stress risk measure:

1. The institution determines the stress period for each risk class using the definition of stress period laid down below. As a result of this step, the institution will also obtain the scalar $m_{S,C}^{i}$ for each risk class i.

2. The institution applies the provisions included in section '*Methodology S – the stepwise method*'[10] considering as *observation period* the current period. As a result, the institution calibrates a downward and an upward shock for each non-modellable risk factor (or non-modellable bucket where applicable) on the current period.

3. The institution multiplies the upward and downward shock calibrated on the current period for a given non-modellable risk factor mapped to the risk class i by the scalar $m_{S,C}^{i}$ to obtain an upward and a downward shock that are calibrated on the stress period. On the basis of those shocks, the extreme scenario of future shock is determined.

4. The institution calculates the stress scenario risk-measure ($SS_{10\text{days},D^*}^{j,s}$) as the loss occurring when the extreme scenario of future shock (i.e. the result of the previous step) is applied to the non-modellable risk factor j. Also in this case, such stress scenario risk-measure is then rescaled to reflect the liquidity horizons of the non-modellable risk-factors (but also other aspects e.g. the non-linearity of the loss function) in the aggregation.

With respect to the notation, $m_{S,C}^{i}$ denotes the scalar to be used to rescale a shock for a non-modellable risk factor belonging to the risk class i calibrated on the current period C to obtain a shock calibrated on the stress period S^i .

In accordance with the international standards, where performing the risk-factor eligibility test (RFET) institutions are free to perform the modellability assessment either on the period that is used to calibrate the current expected shortfall risk-measure or on another period that does not differ from the latter for more than one month. Consistently with such possibility, where performing the step 2 above, these draft RTS let institutions use as 'current period' a period that does not differ from the last 12-months period for more than one month if the institution used that possibility also in the context of the RFET assessment. It is worth stressing that such possibility is applicable only in the context of the second step, i.e. the scalar $m_{S,C}^{i}$ must be always determined on the basis of the actual last 12-

[10] As outlined later, under option B, institutions can use only the stepwise method (i.e. not the direct method) to determine the extreme scenario of future shock.

months period C and the stress period S^i (here below, the methodology to determine $m^i_{S,C}$ is laid down).

Determination of the stress period and of the scalar $m^i_{S,C}$

In general, given a 1-year period P_1 over which a shock for a given risk factor belonging to the risk class i is calibrated, the corresponding shock calibrated over another 1-year period P_2 can be obtained multiplying the future shock calibrated on P_1 by the scalar $m^i_{P2,P1}$ defined as follows:

$$m^i_{P2,P1} = \underset{\substack{j \in i \\ j \in Reduced\ Set\ of\ RFs\ in\ ES}}{trimmed\_mean_{0.01}} \left[\frac{\hat{\sigma}^{P2}{}_{Ret(j)}}{\hat{\sigma}^{P1}{}_{Ret(j)}}\right];\ i \in \{\text{IR, CS, EQ, FX, CM}\}$$

Where $trimmed\_mean_{0.01}$ denotes the function that, given any sample of observations as input and after removing an X number of lowest and highest observations, computes the average of that trimmed sample. The number X is the integer part of $N_{sample} \times 0.01 + 1$, where N_{sample} is the number of observations in the sample.

Where $\hat{\sigma}^{P}{}_{Ret(j)}$ is the estimated standard deviation of the nearest to 10-days returns for the modellable risk factor j in the period P[11]. It is worth highlighting that institutions are required to compute the mean on the ratio $\frac{\hat{\sigma}^{P2}{}_{Ret(j)}}{\hat{\sigma}^{P1}{}_{Ret(j)}}$ on the set of risk factors j that are modellable, belonging to the risk class i and that have been included by the institution in the reduced set of risk factors referred to in article 325bb. As a result, under this option, institutions would be required to collect data for non-modellable risk factors only in the current period.

On this basis, these draft RTS require institutions to identify the stress period S^i for a given risk class i as the 1-year period P maximizing the scalar $m^i_{P,C}$, i.e.:

$$S^i = \underset{P}{\text{argmax}}\left[m^i_{P,C}\right]$$

Where C is current period over which the expected shortfall measures PES^{FC}_t, PES^{RC}_t referred to in Article 325bb is calibrated. Also in this case, institutions are required to determine S^i by considering 1-year periods starting at least from 1 January 2007. Once S^i is determined, then $m^i_{S,C}$ is automatically obtained. As mentioned, the determination of the stress period S^i for each risk class should be performed at least on a quarterly basis.

In section 5.1, some pros and cons with respect to these two options above have been already identified and may be considered by respondents where providing their feedback on this consultation paper.

[11] In section '*3.2.2 General provisions*', the methodologies that institutions should use for obtaining the 10-days returns in a given period and for determining the estimated standard deviation have been outlined.

Remarks on the frequency of update of the components of the methodology

As clarified, the stress period should be updated quarterly both under option A and option B.

The determination of the stress period under option B is linked with the determination of the scalar $m_{S,C}^{i}$. Accordingly, these draft RTS specify that also the scalar $m_{S,C}^{i}$ is updated on a quarterly basis (i.e. when the stress period is updated); in other words, over the quarter, $m_{S,C}^{i}$ must be kept fixed (although the current period actually changes with the time).

As previously mentioned, in the context of modellable risk factors, institutions are required to calculate expected shortfall measures on the basis of shocks calibrated on the current period (e.g. PES_{t}^{FC}) and Article 325bc(3)(c) specifically requires institutions to update on a monthly basis the data inputs used to determine the shocks on the current period (i.e. institutions need to update the time series representing the last 12 months period that are used to generate the shocks at least on a monthly basis).

Consistently with that requirement, under option B institutions are required to update the time series representing the current period on a monthly basis, i.e. the time series used to perform step 2 under option B (i.e. the determination of the downward and upward calibrate shocks) must be updated on a monthly basis[12].

3.2.4 Determination of the extreme scenario of the shock

Institutions are required to determine a scenario of future shock by applying one of the methodologies described in this section. In particular, two variants are presented for each methodology depending on whether the institution calculates the stress scenario risk measure for a single non-modellable risk factor or for the non-modellable risk factors belonging to a non-modellable bucket.

Considering that for this consultation several options have been included in these draft RTS and that some of them are interlinked, here below an high-level summary on how this section (and these draft RTS) have been structured is presented. In particular, the methodologies that institutions may use for obtaining the extreme scenarios of future shock are the following (and are then detailed in the background section in the same order as here below):

- **Methodology D – Direct method for future shock**: the direct method requires institutions to derive the scenario of future shock by directly calculating the expected shortfall of the portfolio losses.
  - The subsection "*3.2.4.1 Direct method for determining the extreme scenario of future shock of a single non-modellable risk factor"* is relevant where the institution calculates the stress scenario risk measure for a single risk factor.
  - The subsection "*3.2.4.2 Direct method for determining the extreme scenario of future shock of non-modellable risk factors belonging to non-modellable buckets*" is relevant where the

[12] As mentioned, the time series representing the current period (that must be updated on a monthly basis) may be a time series of the observations on the last 12-months period, or a time series on an observation period that does not differ from the last 12-months period for more than one month.

institution calculates the stress scenario risk measure at regulatory bucket level in accordance with the possibility referred to in Article 325bk(3) of the CRR2.

The EBA believes that the *direct method* could be part of the final framework only in the case that option A in section 3.2.3. is retained following consultation, i.e. only where the observation period over which the shock is calibrated in accordance with this section of the CP is directly the stress period. Accordingly, the *direct method* should be considered as an option available on which the EBA consults under the scenario that option A is retained.

The direct method, although relatively straightforward from a mathematical point of view requires essentially daily data for an NMRF and an important computation effort from institutions potentially using it, because for each risk factor essentially loss evaluations need to be computed, while the other methods require only a few. On this basis, the EBA consults on whether the direct method will be used in practice by institutions or whether the computational burden will in substance keep institutions from using it. Should the EBA not receive evidence of the need of such method, the EBA will drop the option to use the direct method in its final draft RTS.

- **Methodology S - Stepwise method for future shock:** the stepwise method requires institutions to determine the scenario of future shock by steps. In particular:

  - The subsection *"3.2.4.3 Stepwise method for determining the extreme scenario of future shock of a single non-modellable risk factor"* is relevant where the institution calculates the stress scenario risk measure for a single risk factor. That subsection has been drafted reflecting the steps institutions should undertake; precisely:

    i. In the first step, institutions are required to determine a downward and upward calibrated shock that are applicable to the non-modellable risk factors. Depending on the number of return observations available, these draft RTS propose different methodologies for determining such calibrated shocks:

       (i) **Option 1**: *historical method*

       (ii) **Option 2.1:** *sigma method*

       (iii) **Option 2.2**: *asymmetrical sigma method*

       It should be noted that the EBA aims at reducing the number of options available to banks for determining such calibrated shocks. In particular, the EBA aims at removing one option among option 2.1 and option 2.2 in its final draft RTS after consultation. Accordingly, several questions have been included in this CP around this aspect to gather feedback from market participants.

       Should option B be retained, then institutions would be also required to rescale those shocks (which were not calibrated on the stress period in the first place) to obtain a shock that is reflecting the stress period.

(iv) **Option 3:** *the fallback method*

ii. In the second step, institutions are required to determine the so called *calibrated stress scenario risk factor range* by applying the shock obtained in accordance with the previous step to the value of the non-modellable risk factor at the figure date.

iii. In the third step, institutions are required to determine the extreme scenario of future shock by identifying the worst loss that the institution may incur should the non-modellable risk factor move within the identified calibrated stress scenario risk factor range.

- The subsection " *3.2.4.4 Stepwise method for determining the scenario of future shock of non-modellable risk factors belonging to non-modellable buckets*" is relevant where the institution calculates the stress scenario risk measure at bucket level in accordance with the possibility referred to in Article 325bk(3).

  These draft RTS identify two options that institutions may use for determining the extreme scenario of future shock at bucket level:

  - ***'Representative risk factor'*** **option:** the approach is based on the identification of a representative risk factor for the bucket and the application of a parallel shift to risk factors in the bucket.

    The subsection "*Determination of the extreme scenario of future shock of non-modellable risk factors belonging to non-modellable buckets applying the representative risk factor option*" outlines the steps that institutions must undertake where applying this option; precisely:

    i. A preliminary step prescribing the methodology that institutions should use for identifying the most representative risk factor is presented. Such preliminary step is relevant only in the context of the option requiring banks to identify the most representative risk factor in the bucket. In a nutshell, institutions are required to determine the downward and upward calibrated shock for each risk factor within the bucket by applying one of the options presented in the subsection 3.2.4.3 (e.g. historical method). The representative risk factor is then identified as the one with the highest absolute shock.

    ii. The second step consists in the identification of the so called calibrated stress scenario risk factor range by applying the shocks obtained in accordance with the previous step to the value of the representative risk factor at the figure date. Finally, the risk factors are moved in parallel, and the extreme scenario future shock is determined by identifying the representative risk factor movement (to which a parallel shift corresponds) in the range leading to the highest loss.

  - ***'Contoured shifts'*** **option*:*** the approach based on the application of contoured shifts of regulatory buckets.

The subsection "*Determination of the extreme scenario of future shock of non-modellable risk factors belonging to non-modellable buckets applying the contoured shift option*" outlines the steps that institutions must undertake where applying this option; precisely:

i. Institutions are required to determine downward and upward calibrated shocks for all risk factors in a regulatory bucket by applying one of the options presented in the subsection 3.2.4.3 (e.g. historical method).

ii. Then, scenarios are generated on the basis of the individual risk factor shock ranges by applying a fraction ranging from -1 to 1 to the individual risk factor shocks (leading to a 'contoured' family of shocks as opposed to a parallel shift); among those scenarios, the extreme scenario of future shock is the one leading to the worst loss.

It should be noted that the EBA aims at retaining only one option among the '*representative risk factor*' option and the '*contoured shifts*' option in its final draft RTS after consultation. Accordingly, several questions have been included in this CP around this aspect to gather feedback from market participants.

Finally, it is worth highlighting that the draft RTS set specific conditions with respect to the methodology that institutions can use for determining the extreme scenario of future shock depending on the number N of sample returns. The conditions expressed below are deemed necessary for ensuring that e.g. institutions use a meaningful statistical estimator to determine the extreme future shock in light of the number of observations in the observation period[13] for a given non-modellable risk factor.

Precisely:

- where the institution computes the stress scenario of future shock at risk factor level (i.e. not at bucket level), then:
  - Where $N \geq 200$ institutions can use the '*direct method*';
  - The institution can always use the stepwise method for determining the future shock. However, conditions apply with respect to the methodology to use in the first step of such methodology, i.e. the calibration of the upward and downward shock. Precisely:
    - Where $N \geq 200$ institutions can use the 'historical method' in the first step of the 'stepwise method' to calibrate the upward and downward shock;
    - Where $N \geq 12$ institutions can use the 'sigma method', and the 'asymmetrical sigma method' in the first step of the 'stepwise method ' to calibrate the upward and downward shock;

[13] As mentioned, and as further detailed in the following section, the observation period coincides with the stress period under option A, while it is the current period under option B.

- Where $N < 12$ institutions must use the 'fallback method' described in the first step of the 'stepwise method' to obtain the upward and downward shock.

- where the institution computes the stress scenario of future shock at bucket level, then:

  - Where $N \geq 200$ for all risk factors within the bucket then institutions can use the '*direct method'* at bucket level.

  - The institution can always use the stepwise method at bucket level. As outlined above, such method requires the calibration of upward and downward shocks at risk factor level regardless of whether the '*representative risk factor*' or the '*contoured shift*' option will be finally retained. In this context:

    - Where for a given risk factor within the bucket $N \geq 200$ institutions can use the '*historical returns method'* to calibrate the shock for that risk factor;

    - Where for a given risk factor within the bucket $N \geq 12$ institutions can use the *'sigma method', and the 'asymmetrical sigma method'* to calibrate the shock for that risk factor;

    - Where it exists a risk factor within the bucket for which $N < 12$ then institutions would need to calibrate the shocks for all risk factors within the bucket by using the '*fallback method'*.

Below the various methodologies are presented in detail.

Methodology D - The Direct Method

3.2.4.1 Direct method for determining the extreme scenario of future shock of a single non-modellable risk factor

As previously mentioned, the direct method requires institution to derive the extreme the scenario of future shock by directly calculating the expected shortfall of the worst losses. In particular, this subsection is relevant where the institution calculates the stress scenario risk measure for a single risk factor. This methodology is not available should these final RTS retain option B in section 3.2.3.

Step D.0 – obtain the 10 business days returns

From the time series of observations for a given non-modellable risk factor j in the relevant stress period S^i, institutions need to determine the time series of 10 days returns in accordance with the methodology prescribed in section 3.2.2.

As set out, institutions can use the direct method only where the number of returns $N \geq 200$ in the stress period.

Step D.1 – obtaining the extreme scenario of future shock

Given the sample $Ret(r_j, 1, 10)$,.....,$Ret(r_j, N, 10)$ of 10 business days returns of the NMRF and the portfolio loss function when those returns are applied to the value on figure date, these draft RTS define the extreme scenario of future shock as the set of returns giving rise to the expected shortfall of the worst losses. Accordingly, in order to determine the extreme scenario of future shock the draft RTS specify that institutions should first calculate the expected shortfall:

$$\widehat{\mathrm{ES}}_{\mathrm{Right}}\left[loss_{D^*}\left(r_j(D^*)\oplus Ret(r_j, t, 10)\right), \alpha\right] \ (1)$$

where the risk factor j is shifted according to its nearest to 10 days returns consistently with the return approach chosen (absolute, relative, log-returns, etc.) indicated with the symbol $\oplus$ and where the following definitions apply:

$$\widehat{\mathrm{ES}}_{\mathrm{Left}}(X, \alpha) \stackrel{\mathrm{def}}{=} \frac{-1}{\alpha N} \times \left\{\sum_{i=1}^{[\alpha N]} X_{(\mathrm{i})} + (\alpha N - [\alpha N]) X_{([\alpha N]+1)}\right\} \ (2)$$

$$\widehat{\mathrm{ES}}_{\mathrm{Right}}(X, \alpha) \stackrel{\mathrm{def}}{=} \widehat{\mathrm{ES}}_{\mathrm{Left}}(-X, \alpha) \ (3)$$

Where:

- $\alpha = 2.5\%$
- X is the order statistics of the sample in question of size N[14]

[14] Accordingly, X(i) represents the i-th smallest observation in the time series X.

- $[\alpha N]$ denotes the integer part of the product αN.

It should be noted that the sign convention leads to a positive number for the left tail of a distribution centered around zero.

Once the expected shortfall defined in formula (1) has been calculated, institutions should identify the extreme scenario of future shock as the one leading to a stress scenario risk-measure as defined in Article 325bk(1) equal to that expected shortfall. In other words, the extreme scenario of future shock is defined implicitly by first determining the corresponding loss.

3.2.4.2 Direct method for determining the extreme scenario of future shock of non-modellable risk factors belonging to non-modellable buckets

Where the institution calculates a single stress scenario risk measure for all risk factors belonging to a non-modellable bucket, they may do so by implementing the direct method at bucket level. Accordingly this subsection presents one of the methodologies institutions may use for that purpose. Also in this case the direct method at bucket level is not available should these final RTS retain option B in section 3.2.3.

Step D.0 –obtain the 10 business days returns

For each of the risk factors in the non-modellable bucket, institutions need to determine the time series of 10 business days returns in accordance with the methodology prescribed in section "*3.2.2 General provisions: obtaining the series of nearest to 10 days returns from the time series of observations*" from the time series of observations for a given non-modellable risk factor *j* in the relevant stress period S^i.

As set out, the direct method at bucket level can be used only where number of returns (in the stress period) $N \geq 200$ for all the risk factors within the bucket.

Step D.1 – determination of the extreme scenario of future shock

Analogously to the direct method for determining the extreme scenario of future shock for a single factor, institutions should determine the extreme scenario for risk factors $\{r_j \in B\}$ belonging to a bucket B by first calculating the following expected shortfall measure:

$$\widehat{\mathrm{ES}}_{\mathrm{Right}}\left[\mathrm{loss}_{D^*}^{\mathrm{Bucket}}\left(\left\{r_j(D^*) \oplus Ret\left(r_j, t, 10\right), r_j \in B\right\}\right), \alpha\right]$$

where each risk factor in the bucket $\{r_j \in B\}$ is shifted according to its nearest to 10 days returns (i.e. non-parallel shifts) according to the return approach chosen (absolute, relative, log-returns, etc.) indicated with the symbol $\oplus$. The definition of the statistical estimator $\widehat{\mathrm{ES}}_{\mathrm{Right}}(X, \alpha)$ introduced before applies also in this context.

Methodology S - the stepwise method

3.2.4.3 Stepwise method for determining the extreme scenario of future shock of a single non-modellable risk factor

As previously mentioned, the stepwise method requires institutions to determine the scenario of future shock by steps. In particular, the subsection is relevant where the institution calculates the stress scenario risk measure for a single risk factor.

As introduced before, in accordance with the stepwise method, institutions are required to first calibrate an upward and a downward shock on an observation period. Should option A in section 3.2.3 be kept following consultation, then institutions would need to calibrate the two shocks (applying step S.0 and S.1 of this section) using as observation period the stress period; should option B be kept following consultation, then institution would need to calibrate the two shocks (applying step S.0, S.1 and S.2) using as observation period the current period. Under option B, the shocks calibrated on the current period would be then multiplied by the scalar $m^{i}_{S,C}$.

Step S.0 – obtain the 10 business days returns

From the time series of observations for a given non-modellable risk factor j in the relevant observation period P (i.e. either the stress period or the current period depending on whether option A or option B applies), the institution needs to determine the time series of 10 business days returns in accordance with the methodology prescribed in section 3.2.2.

Step S.1: Determination of an upward and downward shock

In the first step, institutions are required to determine a downward and upward calibrated shock that are applicable to the non-modellable risk factors from the observations in the relevant observation period (i.e. see step S.0). The draft RTS propose several methodologies for determining such calibrated shocks:

(i) **Option 1**: *historical method*

(ii) **Option 2.1:** *sigma method*

(iii) **Option 2.2:** *asigma (i.e. asymmetrical sigma) methodology*

(iv) **Option 3:** *the fallback method*

Below the 3 options (option 2 with two variants) are outlined.

Option 1 – the historical method

As set out, the first step of the stepwise method can be performed using the historical method where $N \geq 200$. The number of returns N to consider is the number of returns in the period that has been used for obtaining the time series of nearest to 10-day returns in step S.0. In other words, under option

B, N is not the number of returns in the stress period, instead it is the number of returns in the current period.

Given the sample $Ret(r_j, 1{,}10)$,..., $Ret(r_j, N, 10)$ of 10-day returns of a given non-modellable risk factor (obtained as a result of step S.0), the historical method requires institutions to first calibrate an upward and a downward shock applicable to the risk factor by estimating the empirical expected shortfalls of the returns for the right and left tail.

Precisely, institutions should calculate the two shocks with the following formulas:

$$CS_{\text{down}}(r_j) = \widehat{\text{ES}}_{\text{Left}}(Ret(j), \alpha) \times \left(1 + \frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N-1.5)}}\right)$$

and

$$CS_{\text{up}}(r_j) = \widehat{\text{ES}}_{\text{Right}}(Ret(j), \alpha) \times \left(1 + \frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N-1.5)}}\right)$$

where the definitions of $\widehat{\text{ES}}_{\text{Left}}(X, \alpha)$, $\widehat{\text{ES}}_{\text{Right}}(X, \alpha)$ introduced before apply also in this context.

As set out in the formula, institutions are required to derive the two shocks multiplying the expected shortfall measures by an uncertainty compensation factor covering the uncertainty due to the lower observability of non-modellable risk factors, estimation error and the uncertainty in the underlying distribution. In particular:

- $\Phi^{-1}(\cdot)$ is the inverse of the standard normal cumulative distribution function.
- These draft RTS propose the parameter CL_{sigma} to be set to 90%.

As further detailed in Annex I, the uncertainty compensation factor $\left(1 + \frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N-1.5)}}\right)$ has been derived for the purpose of capturing the uncertainty due to lower observability of non-modellable risk factors in the context of the sigma method, i.e. that compensation factor suits for capturing the error in estimating a standard deviation. The compensation factor used to capture the error in estimating the expected shortfall in the historical method should be higher; however, for sake of simplicity and considering that for $N \geq 200$ the compensation factor is relatively small, these draft RTS propose to use the same compensation factor designed for the sigma method also in this context.

Option 2.1 – the sigma method

As set out, the first step of the stepwise method can be performed using the sigma method where $N \geq 12$. Also in this case, the number of returns N to consider is the number of returns in the period that has been used for obtaining the time series of nearest to 10-day returns in step S.0.

Given the sample $Ret(r_j, 1{,}10)$,..., $Ret(r_j, N, 10)$ of 10 business days returns of a given non-modellable risk factor (obtained as a result of step S.0), the institution should derive the upward and downward calibrated shock by first estimating the standard deviation of nearest to 10-day returns with the following estimator:

$$\hat{\sigma}_{Ret(j)} = \sqrt{\frac{1}{N-1.5} \times \sum_{t=1}^{N} \left(Ret(r_j, t, 10) - \overline{Ret(r_j, \cdot, 10)} \right)^2}$$

where $\overline{Ret(r_j, \cdot, 10)}$ denotes the mean of the sample of returns.

Next, institutions should rescale the standard deviation in order to get an estimation of the expected shortfall from the standard deviation of the nearest to 10 days return returns for the right and left tail; the draft RTS propose that institutions should perform such rescaling by means of a scalar (i.e. $C_{\mathrm{ES\ equiv}}$).

Precisely, given the estimated standard deviation $\hat{\sigma}_{Ret(j)}$ of 10-day returns of the NMRF, the calibrated shock should be calculated as:

$$CS_{\mathrm{down}}(r_j) = C_{ES} \times \hat{\sigma}_{Ret(j)} \times \left(1 + \frac{\Phi^{-1}(CL_{\mathrm{sigma}})}{\sqrt{2(N-1.5)}}\right)$$

and

$$CS_{\mathrm{up}}(r_j) = C_{ES} \times \hat{\sigma}_{Ret(j)} \times \left(1 + \frac{\Phi^{-1}(CL_{\mathrm{sigma}})}{\sqrt{2(N-1.5)}}\right)$$

Where:

- The proposed draft RTS set: $C_{ES} = 3$, and
- Also in this context $\left(1 + \frac{\Phi^{-1}(\mathrm{CL_{sigma}})}{\sqrt{2(N-1.5)}}\right)$ is the uncertainty compensation factor with the parameter CL_{sigma} set to 90%.

It is worth highlighting that following this methodology the institution obtains symmetric shocks, i.e. the upward and downward shocks are of the same size.

Option 2.2 – the asymmetrical sigma method (a-sigma method)

As set out, the first step of the stepwise method can be performed using the asymmetrical sigma method where $N \geq 12$. Also in this case, the number of returns N to consider is the number of returns in the period that has been used for obtaining the time series of 10-day returns in step S.0.

The sigma method presented above leads to the identification of an upward and a downward shock of the same size; in other words, the sigma method is symmetrical. However, in reality, risk factors often have a skewed underlying distribution (e.g. downward shocks are more severe than upward shocks); accordingly, an alternative methodology to the sigma method is proposed below to capture the asymmetry in the risk factor distribution.

Precisely, given the sample $Ret(r_j, 1{,}10)$,…, $Ret(r_j, N, 10)$ of 10 business days returns of the NMRF, of a given non-modellable risk factor (obtained as a result of step S.0), institutions should first split the returns at the median m, and should then determine the mean on the set of returns greater than the median $\hat{\mu}^{Ret(j)}_{Ret>m}$ and the mean on the set of returns lower (or equal) than the median $\hat{\mu}^{Ret(j)}_{Ret\le m}$. In formulas:

$$\hat{\mu}^{Ret(j)}_{Ret\le m} = \frac{1}{N_{\text{down}}} \times \sum_{\substack{t=1 \\ Ret(r_j,t,10)\le m}}^{N} Ret(r_j, t, 10)$$

$$\hat{\mu}^{Ret(j)}_{Ret>m} = \frac{1}{N_{\text{up}}} \times \sum_{\substack{t=1 \\ Ret(r_j,t,10)>m}}^{N} Ret(r_j, t, 10)$$

Where:

$$N_{\text{down}} = |Ret(r_j, t, 10) \ \ \le m|$$

$$N_{\text{up}} = |Ret(r_j, t, 10) > m|$$

Institutions should then calculate the following amounts representing the rescaled standard deviations calculated on the two sets of returns (with scaling factor C_{ES}) that are then shifted by $\hat{\mu}^{Ret(j)}_{Ret\le m}$ and $\hat{\mu}^{Ret(j)}_{Ret>m}$:

$$\widehat{\text{ASigma}}^{Ret(j)}_{\text{down}} = \left|\hat{\mu}^{Ret(j)}_{Ret\le m}\right| + C_{\text{ES}} \times \sqrt{\frac{1}{N_{\text{down}} - 1.5} \times \sum_{\substack{t=1, \\ Ret(r_j,t,10)\le m}}^{N} \left(Ret(r_j, t, 10) - \hat{\mu}^{Ret(j)}_{Ret\le m}\right)^2}$$

$$\widehat{\text{ASigma}}^{Ret(j)}_{\text{up}} = \left|\hat{\mu}^{Ret(j)}_{Ret>m}\right| + C_{\text{ES}} \times \sqrt{\frac{1}{N_{\text{up}} - 1.5} \times \sum_{\substack{t=1, \\ Ret(r_j,t,10)>m}}^{N} \left(Ret(r_j, t, 10) - \hat{\mu}^{Ret(j)}_{Ret>m}\right)^2}$$

Where:

- $C_{\text{ES}} = 3$

The calibrated shocks should be then calculated as:

$$CS_{\text{down}}(r_j) = \widehat{\text{ASigma}}_{\text{down}}^{Ret(j)} \times \left(1 + \frac{\Phi^{-1}(\text{CL}_{\text{sigma}})}{\sqrt{2(N_{\text{down}} - 1.5)}}\right)$$

And

$$CS_{\text{up}}(r_j) = \widehat{\text{ASigma}}_{\text{up}}^{Ret(j)} \times \left(1 + \frac{\Phi^{-1}(\text{CL}_{\text{sigma}})}{\sqrt{2(N_{\text{up}} - 1.5)}}\right)$$

Where also in this case:

- $\left(1 + \frac{\Phi^{-1}(\text{CL}_{\text{sigma}})}{\sqrt{2(N_{\text{down}} - 1.5)}}\right)$ and $\left(1 + \frac{\Phi^{-1}(\text{CL}_{\text{sigma}})}{\sqrt{2(N_{\text{up}} - 1.5)}}\right)$ are the uncertainty compensation factors with the parameter CL_{sigma} set to 90%.

As part of the consultation, the EBA consults on whether this methodology would improve by considering returns split at zero and not at the median, and accordingly, by calculating the mean among the negative and positive returns. The use of the median ensures that the same number[15] of nearest to 10-days return is used when calibrating the upward and downward shock. Should the returns be split at zero then some extra conditions on the minimum value that N_{up}, N_{down} for using this methodology must be introduced to avoid that e.g. the upward shock is calibrated with 2 or 3 observations only.

As previously mentioned, the EBA aims at removing one option following consultation among the *sigma method* and the *asigma method*. Accordingly, questions have been included as part of the consultation, to gather feedback from respondents about the pros and cons of the two methods.

Option 3 – The fallback method

Institutions are required to cover the first step of the stepwise method using the fallback method whenever $N < 12$. Also in this case, the number of returns N to consider is the number of returns in the period that has been used for obtaining the time series of 10-day returns in step S.0.

The EBA expects that only in very few cases institutions will actually be in the situation of using the fallback method; in particular, as mentioned, this happens where the number of observations for a risk-factor in the stress period is less than one per month on average. In light of the limited number of cases where it will be used, the fallback method is designed to be simple considering that any extra-layer of complexity may result in more costs than benefits.

The draft RTS propose the following as fallback method:

- where the non-modellable risk factor coincides with one of the risk factor included in the sensitivity based method (i.e. risk factors defined in section 3, subsection 1 of the CRR2 under chapter 1a - the alternative standardised approach)), then the institution should:

[15] Depending on whether N is even or odd the number of observations used for calibrating the upward shock may in reality vary of one unit.

1. Identify the risk-weight defined in the sensitivity based method for that risk factor as specified in section 6 of the CRR2 under chapter 1a - the alternative standardised approach;

2. Multiply such risk-weight by $1.3 \cdot \sqrt{\frac{10}{LH(j)}}$, where the liquidity horizon for the risk factor is obtained in accordance with Article 325bd(7) of the CRR2;

3. If option B is implemented then institutions would be also required to multiply the result of 1 and 2 by $1/m^{i}_{S,C}$.

The rescaling factor $\sqrt{\frac{10}{LH(j)}}$ has been included to ensure that regardless of the methodology (e.g. sigma method, fallback method), the institutions obtain an extreme scenario of future shock on a 10-day horizon. Indeed, the risk-weights in the sensitivity based method have been calibrated already capturing the liquidity horizon of the risk factors - the scalar $\sqrt{\frac{10}{LH(j)}}$ therefore exclude such effect.

The idea behind this approach is that the risk-weight prescribed in the standardised approach is deemed to represent a good starting point for determining an extreme scenario of future shock for a non-modellable risk factor. The scalar 1.3 has been included in these draft RTS to further provide the incentive to institutions to collect data for risk-factors with very low observability, and for ensuring that the fallback approach leads to a more conservative result than any other approach that was put in place in these draft RTS (e.g. sigma method).

It should be noted that the risk weights in the sensitivity based method already provide the institutions with the type of shocks that need to be applied, i.e. relative shocks or absolute shocks. Finally, the draft RTS specify that for (IMA) risk factors belonging to a curve or a surface that differ from the risk factors identified in the sensitivity based method only in the maturity dimension, the institution should use the risk-weight of the adjacent (SA) risk factor.

For example, if the institutions has in its internal risk-measurement model the risk factor representing the 1.2y tenor of a risk-free yield curve, then the absolute shock applicable to that risk factor should be 1.6% considering that 1.6% is the absolute shock applicable in the sensitivity based method for the 1y tenor of a risk-free yield curve.

As mentioned, if option B is finally retained then institutions would be required to divide the result of step 1 and step 2 above by the scalar $m^{i}_{S,C}$. This is made to ensure that all shocks resulting from the first step of the stepwise method are representative of the same period (i.e. the current period C – if option B is implemented)[16].

[16] As outlined later, if option B is implemented, institutions are required in the next step of the stepwise method to rescale all shocks corresponding to risk factors in the risk class 'i' by $m^{i}_{S,C}$. Accordingly, the resulting calibrated upward and downward shocks for a risk factor in the standardised approach is the shock identified in the sensitivity based-method rescaled to reflect a 10-day horizon.

Where the non-modellable risk factor is not a risk factor in the sensitivity based method, then the institution can opt for any of the following two options:

1. *'Same type of risk factor'* option: The draft RTS propose that the institution identifies another risk-factor (r_{other}) of the same nature of the non-modellable risk factor (r_{original}) for which more than 12 observations are available in the observation period. The institution would then need to apply the first step of the stepwise method (either by using the historical method, or the (a)sigma method) to that risk-factor to obtain a downward and upward calibrated shock for that risk factor and to then rescale it with the scalar $2/\left(1+\frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N_{other}-1.5)}}\right)$, to obtain shocks for the original NMRF, i.e.:

$$CS_{\text{down}}(r_{\text{original}}) = CS_{\text{down}}(r_{\text{other}}) * 2/\left(1+\frac{\Phi^{-1}(CL_{\text{sigma}})}{\sqrt{2(N_{\text{other}}-1.5)}}\right)$$

$$CS_{\text{up}}(r_{\text{original}}) = CS_{\text{up}}(r_{\text{other}}) * 2/\left(1+\frac{\Phi^{-1}(CL_{\text{sigma}})}{\sqrt{2(N_{\text{other}}-1.5)}}\right)$$

Where:

- $CS_{\text{down}}(r_{\text{other}})$ and $CS_{\text{up}}(r_{\text{other}})$ are the downward and upward calibrated shocks for the risk factor (r_{other}) that is of the same of the same nature of the non-modellable risk factor for which the institution needs to compute the stress scenario risk measure (r_{original}).

- N_{other} represents the number of return observations available for the risk factor r_{other} that have been used for determining $CS_{\text{down}}(r_{\text{other}}), CS_{\text{up}}(r_{\text{other}})$ in the first step of the stepwise method[17].

It should be noted that dividing $CS_{\text{up}}(r_{\text{other}}), CS_{\text{down}}(r_{\text{other}})$ by $\left(1+\frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N_{\text{other}}-1.5)}}\right)$ is made to offset the effect of the uncertainty compensation factor that is used by institutions where calibrating those shocks. However, institutions are also required to multiply those shocks by 2 which is an approximation of the value that the uncertainty compensation factor $\left(1+\frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N-1.5)}}\right)$ takes where only few observations are available.

In other words, if on the one hand institutions are allowed to use data from another risk factor (that is of the same nature) for calibrating the downward and upward shock, they are required to use an uncertainty factor resembling a case where only very few observations are available.

[17] If the final draft RTS will include the asigma method, then where the institution uses the asigma method, N_{other} would need to be substituted by $N_{otherUp}$ and $N_{otherDown}$ for the upward and downward shock respectively.

The draft RTS specify that r_{other} is considered to be of the same nature where it capture the same type of risk as r_{original} and it differs from r_{original} only for features that are not expected to have a significant impact on the final value of the calibrated shock.

2. '<u>Change in the period' option</u>: such option should be considered a possibility only if option B in section '3.2.3' is retained in the final RTS, i.e. should option A be retained in the final draft RTS then this possibility would be removed from these final draft RTS.

   Under such option, institutions are required to apply the first step of the stepwise method by considering as observation period for calibrating the downward and upward shock any 12-months observation period P^* for which $N \geq 12$ (instead of using the current period C). Institutions are then required to multiply such shock by $2/(m^i_{P^*,C} * \left(1 + \frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N_{P*} - 1.5)}}\right))$, i.e.:

$$CS^C_{\text{down}}(r_j) = CS^{P*}_{\text{down}}(r_j) * 2 * \frac{1}{m^i_{P^*,C}} * \frac{1}{\left(1+\frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N_{P*} - 1.5)}}\right)}$$

$$CS^C_{\text{up}}(r_j) = CS^{P*}_{\text{up}}(r_j) * 2 * \frac{1}{m^i_{P^*,C}} * \frac{1}{\left(1+\frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N_{P*} - 1.5)}}\right)}$$

   where:

   - $m^i_{P^*,C}$ is the scalar defined in section 3.2.3. for obtaining a shock in the current period P^* from a shock calibrated on the period C;
   - N_{P*} is the number of observations for the risk factor in the period P^*;
   - The '*superscript*' C and P^* on $CS_{\text{down}}(r_j)$ and $CS_{\text{up}}(r_j)$ have been included to distinguish the period for which those shocks are obtained.

   Also in this case, as in the '*same type of risk factor'* option, dividing the shock calibrated on P^* by $\left(1 + \frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N_{P*} - 1.5)}}\right)$ is made to offset the effect of the uncertainty factor that is used by institutions where calibrating those shocks; however, institutions are also required to multiply those shocks by 2 which is an approximation of the value that the compensation factor $\left(1 + \frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N - 1.5)}}\right)$ takes where only few observations are available. The multiplication of the shocks by m_{C,P^*} is made to ensure that all shocks resulting from the first step are relevant for the same period (i.e. the current period C if option B is implemented).

   Should the asymmetrical sigma method be kept in the final draft RTS, then the compensation factor $\left(1 + \frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N_{P*} - 1.5)}}\right)$ will be adjusted to use the number of observation N_{Up-P*} and $N_{Down-P*}$for consistency.

Step S.2: Rescaling the upward and downward shock calibrated on the observation period to obtain shocks on the stress period

This step is relevant only if option B in section 3.2.3 is retained, indeed under option A the observation period coincides with the stress period; thus, the downward and upward shock have been already calibrated on the stress period.

Should option B be finally retained, then, institutions would need to rescale the shocks obtained in the previous sub-step (i.e. step 2.1) for a non-modellable risk factor belonging to the risk-class i multiplying them by the scalar $m_{S,C}^{i}$ so that to obtain a shock calibrated on the stress period.

Step S.3: Determination of the calibrated stress scenario shock range

Explanatory text for consultation
Please note that for easing the read $CS_{\text{down}}(r_j), CS_{\text{up}}(r_j)$ should be considered already rescaled by the scalar $m_{S,C}^{i}$ in the case that option B is retained; i.e. $CS_{\text{down}}(r_j), CS_{\text{up}}(r_j)$ are the output of step S.0 and step S.1 and S.2 so as to be relevant for the stress periods.

In the third step of the '*stepwise method*', institutions are required to determine the so called *calibrated stress scenario risk factor range* by applying the shock obtained in accordance with the previous step to the value of the non-modellable risk factor at the figure date.

Precisely, the calibrated shocks $CS_{down}(r_j), CS_{up}(r_j)$ determined with one of the methods outlined before (i.e. *historical method, sigma method, asigma method, fallback method*) should be applied to the risk factor at the figure date $r_j(D^*)$ in both directions to obtain the calibrated stress scenario risk factor range, i.e.

$$CSSRFR\left(r_j(D^*)\right) = \left[r_j(D^*) \ominus CS_{\text{down}}(r_j), r_j(D^*) \oplus CS_{\text{up}}(r_j)\right]$$

which means

$$CSSRFR\left(r_j(D^*)\right) = \left[r_j(D^*) - CS_{\text{down}}(r_j), r_j(D^*) + CS_{\text{up}}(r_j)\right]$$

or

$$CSSRFR\left(r_j(D^*)\right) = \left[r_j(D^*) \times e^{-CS_{\text{down}}(r_j)}, r_j(D^*) \times e^{+CS_{\text{up}}(r_j)}\right]$$

or

$$CSSRFR\left(r_j(D^*)\right) = \left[r_j(D^*) \times \left(1 - CS_{\text{down}}(r_j)\right), r_j(D^*) \times \left(1 + CS_{\text{up}}(r_j)\right)\right]$$

depending on whether absolute, logarithmic, or relative returns are used for the NMRF. More in general (i.e. in case the institution uses another return approach), the calibrated stress scenario risk factor range should be calculated consistently with the return approach.

Step S.4: Determination of the extreme scenario future shock

In the last step, in principle, institutions should be required to determine the extreme scenario of future shock by identifying the worst loss that the institution may incur should the non-modellable risk factor move within the identified calibrated stress scenario risk factor range.

Precisely, given the calibrated stress scenario risk factor range $CSSRFR\left(r_j(D^*)\right)$ that has been determined in accordance with the previous step, the extreme scenario of future shock should be determined as an approximation to the risk factor movement in the range leading to the highest loss. In formula:

$$FS_{D^*}[r_j] = \underset{r_j \in Grid\left(r_j(D^*)\right)}{\operatorname{argmax}} [\mathrm{loss}_{D^*}^{\mathrm{single}}(r_j)]$$

Institutions participating to the data collection exercise were required in order to identify the extreme shock in $CSSRFR\left(r_j(D^*)\right)$ to evaluate the loss function on a grid of eleven equidistant points splitting the range in ten intervals. The set of those points was formally defined as follows:

$$Grid_{\text{data collection exercise}} = \left\{r_j(D^*) \ominus i \times \frac{CS_{\text{down}}(r_j)}{5}, r_j(D^*) \oplus i \times \frac{CS_{\text{up}}(r_j)}{5} \mid i = 1, \dots, 5\right\}$$

All institutions participating to the data collection exercise expressed concerns with respect to the computational effort that a valuation of the loss on eleven points would require and pointed out that in many cases the highest loss would occur at the boundaries of the in the $CSSRFR$.

Following the feedback received from participants to the data collection exercise, the EBA proposes to reduce the number of computations that are needed to identify the worst loss in the interval, by using only four points that must be evaluated which are formally defined as follows:

$$Grid_{\text{draft RTS}} = \left\{r_j(D^*) \ominus i \times \frac{CS_{\text{down}}(r_j)}{5}, r_j(D^*) \oplus i \times \frac{CS_{\text{up}}(r_j)}{5} \mid i = 4, 5\right\}$$

As mentioned, the extreme scenario of future shock corresponds to the risk factor movement among those identified in the grid leading to the worst loss. Accordingly, the stress scenario risk measure as defined in Article 325bk(1) of the CRR2 is the loss that is incurred when that extreme scenario of future shock applies.

3.2.4.4 Stepwise method for determining the extreme scenario of future shock of non-modellable risk factors belonging to non-modellable regulatory buckets

This subsection is relevant where the institution calculates the stress scenario risk measure at bucket level in accordance with the possibility referred to in Article 325bk(3) of the CRR2. As previously mentioned, the draft RTS identify two options that institutions may use for determining the extreme scenario of future shock at bucket level:

- ***'Representative risk factor'* option:** approach based on the identification of a representative risk factor for the bucket and the application of a parallel shift to risk factors in the bucket;
- ***'Contoured shifts'* option*:*** approach based on the application of contoured shifts of regulatory buckets.

Generally, the approaches for buckets are completely analogous to the single risk factor case with the extension that the shocks are defined for the set of all risk factors in a regulatory bucket. Determination of the extreme scenario of future shock of future shock of non-modellable risk factors belonging to non-modellable buckets applying the representative risk factor option

Step R.1: Preliminary step for to identify the representative risk factor for a bucket

When applying the '*representative risk factor*' option, institutions are required to first identify the representative risk factor for a given bucket for which the institution computes the stress scenario measure at bucket level.

For this purpose, for each of the risk factors in the non-modellable regulatory bucket, institutions need to determine the time series of 10 days returns in the relevant observation period P (where the relevant observation period P is the stress period S^i under option A and is the current period C under option B).

As a result, the institution obtains the sample $Ret(r_j, 1{,}10)$,…,$Ret(r_j, N, 10)$ of 10-day returns for all risk factors $\{r_j \in B\}$ in the regulatory bucket B.

Institutions are then required to determine a downward and upward calibrated shock for the purpose of identifying the most representative risk factor $\mathrm{r_B}$.

Precisely, the draft RTS set that institutions identify the upward and downward shock respectively $CS_{\mathrm{up}}(r_j)$ and $CS_{\mathrm{down}}(r_j)$ for all risk factors within the non-modellable bucket. For doing so, the institution should apply to each risk factor one of the methods that have been outlined for calibrating the shock of risk factors for which the institution calculates the stress risk measure for the risk factor on a stand-alone basis, i.e. *historical returns method, sigma method*, *asigma method*, or the *fallback method.*

As previously mentioned, institutions must use the fallback method to determine $CS_{\mathrm{up}}(r_j)$ and $CS_{\mathrm{down}}(r_j)$ for each risk factor, where it exists a risk factor j within the bucket for which $N < 12$.

Where none of the risk factors have less than twelve observations in the stress period, then, for a given risk factor with the bucket, the institution can use (always for determining $CS_{\mathrm{up}}(r_j)$ and $CS_{\mathrm{down}}(r_j)$) either the historical method, the sigma method or the asigma method, depending on the number of observations that are available for that risk factor.

Also in this case, should option B in section 3.2.3. be finally retained, then institutions would be required to rescale $CS_{\mathrm{up}}(r_j)$ and $CS_{\mathrm{down}}(r_j)$ with the scalar $m_{S,C}^{i}$ for a non-modellable risk factor belonging to the risk class i.

In other words, institutions need to apply step S.0, S.1 and S.2 of section 3.2.4.3 for each risk factor in the non-modellable bucket and need to identify the representative risk factor r_B as the one for which the institution got the highest absolute calibrated shock. Formally:

$$r_B = \underset{r_i \in B}{\operatorname{argmax}}[\max(CS_{\mathrm{up}}(r_i), CS_{\mathrm{down}}(r_i))]$$

Step R.2: Determination of the calibrated stress scenario shock range

Explanatory text for consultation

Please note that for easing the reading $CS_{\mathrm{down}}(r_B), CS_{\mathrm{up}}(r_B)$ should be considered already rescaled by the scalar $m_{S,C}^{i}$ in the case that option B is retained; i.e. $CS_{\mathrm{down}}(r_B), CS_{\mathrm{up}}(r_B)$ are already are already the output of step S.0, S.1, and S.2 applied at r_B so as to be relevant for the stress periods.

Analogously to the treatment proposed for a single non-modellable risk factor for which the institution computes a stress scenario risk measure, institutions are required to determine a calibrated stress scenario risk factor range for the representative risk factor r_B.

In particular, institutions are required to determine the so called *calibrated stress scenario risk factor range* by applying the shock obtained in accordance with the previous step to the value of the representative risk factor r_{B} at the figure date.

Precisely, the calibrated shocks $CS_{down}(r_B)$, $CS_{up}(r_B)$ determined with one of the methods outlined before (i.e. *historical returns method, sigma method, asigma method, fallback method*) should be applied to the risk factor at the figure date $r_B(D^*)$ in both directions to obtain the calibrated stress scenario risk factor range, i.e.

$$CSSRFR\big(r_B(D^*)\big) = \big[\mathrm{r_B}(D^*) \ominus CS_{\mathrm{down}}(\mathrm{r_B}), \mathrm{r_B}(D^*) \oplus CS_{\mathrm{up}}(\mathrm{r_B})\big]$$

which means:

$$CSSRFR(r_B(D^*)) = [\mathrm{r_B}(D^*) - CS_{\mathrm{down}}(\mathrm{r_B}),\ \mathrm{r_B}(D^*) + CS_{\mathrm{up}}(\mathrm{r_B})]$$

or

$$CSSRFR(r_B(D^*)) = \left[\mathrm{r_B}(D^*) \times e^{-CS_{\mathrm{down}}(r_j)}, \mathrm{r_B}(D^*) \times e^{+CS_{\mathrm{up}}(r_j)}\right]$$

or

$$CSSRFR(r_B(D^*)) = \left[\mathrm{r_B}(D^*) \times \left(1 - CS_{\mathrm{down}}(r_j)\right), \mathrm{r_B}(D^*) \times \left(1 + CS_{\mathrm{up}}(r_j)\right)\right]$$

depending on whether absolute, logarithmic, or relative returns are used for the NMRF. More in general (i.e. in case the institution uses another return approach), the calibrated stress scenario risk factor range should be calculated consistently with the return approach.

Step R.3: Determination of the extreme scenario of future shock

Explanatory text for consultation

Please note that for easing the reading $CS_{\mathrm{down}}(r_B), CS_{\mathrm{up}}(r_B)$ should be considered already rescaled by the scalar $m^i_{S,C}$ in the case that option B is retained; i.e. $CS_{\mathrm{down}}(r_B), CS_{\mathrm{up}}(r_B)$ are already are already the output of step S.0, S.1, and S.2 applied at r_B so as to be relevant for the stress periods.

For identifying the extreme scenario of future shock for the bucket in accordance with the '*representative risk factor*' option, institutions are required to apply parallel shifts to the risk factors within the bucket where such parallel shifts are obtained by shocking all risk factors with a parallel shock determined by the representative risk factor $\mathrm{r_B}$ for the bucket.

Formally, institutions are required to consider the loss when the risk factors are subject to parallel shift from the initial values $\{\mathrm{r_j}(\mathrm{D}^*), \mathrm{r_j} \in \mathrm{B}\}$ to $\{\mathrm{r_j}(\mathrm{D}^*) \oplus (\mathrm{r_B} - \mathrm{r_B}(\mathrm{D}^*)), \mathrm{r_j} \in \mathrm{B}\}$; in formulas:

$$\mathrm{loss}_{D^*}^{\mathrm{Bucket,parallel}}(r_B) = PV(\{r_j^* \in B\}, \{r_i^* \notin B\}\ \mathrm{fixed}) - PV(\{r_j(D^*) \oplus (r_B - r_B(D^*)), r_j \in B\}, \{r_i^* \notin \mathrm{B}\}\ \mathrm{fixed})$$

where each risk factor in the bucket $\{r_j \in B\}$ is shifted according to the relevant return approach (absolute, relative, log-returns, etc.) indicated with the symbol $\oplus$. An analogous definition applies for downward parallel shifts.

The draft RTS require institutions to determine the scenario of future shock $FS_{D^*}[\{r_j \in B\}]$ by determining the movement in the calibrated range (obtained in accordance with step R.2) that applied to the representative risk factor and to all other risk factors within the bucket by means of a parallel shift leads to the worst loss. In formulas:

$$FS_{D^*}[\{r_j \in B\}] = \underset{r_B \in CSSRFR(r_B(D^*))}{\mathrm{argmax}} [\mathrm{loss}_{D^*}^{\mathrm{Bucket,parallel}}(\{r_B\})]$$

Consistently with the treatment proposed for a single non-modellable risk factors for which a stress scenario risk measure is computed, for determining such scenario in $CSSRFR\big(r_B(D^*)\big)$, institutions are required in accordance with these draft RTS to evaluate the loss deriving from a parallel shift on a grid of four points. The set of points identifying the shocks to be applied to the representative risk factor that accordingly determine the size of the parallel shift is formally defined as follows:

$$Grid\big(r_B(D^*)\big) = \left\{ r_j(D^*) \ominus i \times \frac{CS_{\text{down}}(r_B)}{5}, r_j(D^*), r_j(D^*) \oplus i \times \frac{CS_{\text{up}}(r_B)}{5} \mid i = 4, 5 \right\}$$

Determination of the extreme scenario of future shock of non-modellable risk factors belonging to non-modellable buckets applying the contoured shifts option

Step C.1: Calibration of a downward and upward shock

Analogously to the treatment proposed for single non-modellable risk factors, institutions are required to determine a downward and upward calibrated shocks for regulatory buckets.

For this purpose, for each of the risk factors in the non-modellable regulatory bucket, institutions need to determine the time series of 10 days returns in the relevant observation period P (where the relevant observation period P is the stress period S^i under option A and is the current period C under option B).

As a result, the institution obtains the sample $Ret\big(r_j, 1{,}10\big)$,...,$Ret\big(r_j, N, 10\big)$ of 10-day returns for all risk factors $\{r_j \in B\}$ in the regulatory bucket B.

Furthermore, these draft RTS propose that institutions identify the upward and downward shock respectively $CS_{\text{up}}(r_j)$ and $CS_{\text{down}}(r_j)$ for all risk factors within the non-modellable bucket. For doing so, the institution should apply one of the methods that have been outlined for calibrating the shock of risk factors for which the institution calculates the stress risk measure for the risk factor on a stand-alone basis, i.e. *historical returns method, sigma method*, *asigma method,* or the *fallback method.*

Also in this case, should option B in section 3.2.3 be finally retained, then institutions would be required to rescale $CS_{\text{up}}(r_j)$ and $CS_{\text{down}}(r_j)$ with the scalar $m^i_{S,C}$ for a non-modellable risk factor belonging to the risk class i.

In other words, institutions need to apply step S.0, S.1 and S.2 of section 3.2.4.3 for each risk factor in the non-modellable bucket.

Step C.2: Determination of the extreme scenario of future shock

Explanatory text for consultation

Please note that for easing the reading, $CS_{\mathrm{down}}(r_j), CS_{\mathrm{up}}(r_j)$ should be considered already rescaled by the scalar $m^i_{S,C}$ in the case that option B is retained; i.e. $CS_{\mathrm{down}}(r_j), CS_{\mathrm{up}}(r_j)$ are already including the effect of the rescaling performed in accordance with step S.0, S.1, S.2 so as to be relevant for the stress periods.

The second and last step of the 'contoured shifts' option sets a methodology for deriving a unique extreme shock derived from shocks based on the individual risk factor shock ranges as opposed to the methodology prescribed under the '*representative risk factor*' option. Such methodology has been developed considering the feedback received from institutions participating to the data collection exercise on the '*representative risk factor*' option; hence it is the first time the EBA consults on it.

In particular, the methodology requires banks to multiply the calibrated shocks $CS_{\mathrm{down}}(j)$ and $CS_{\mathrm{up}}(j)$ that have been derived for each risk factor within the regulatory bucket by a "bucket shock strength" $\beta \in [0,1]$, and to obtain accordingly a vector of upward shocks and downward shocks:

$$v_\beta^{\mathrm{up}} = [\, \beta * CS_{\mathrm{up}}(1); \beta * CS_{\mathrm{up}}(2); \beta * CS_{\mathrm{up}}(3); \dots]$$

and

$$v_\beta^{\mathrm{down}} = [\, \beta * CS_{\mathrm{down}}(1); \beta * CS_{\mathrm{down}}(2); \beta * CS_{\mathrm{down}}(3); \dots]$$

As a result, the scenario of future shock should be the vector of upward shocks v_β^{up} or the vector of downward shocks v_β^{down} leading to the worst loss where scanning β in $[0,1]$, where the loss corresponding to upward shock is:

$$\mathrm{loss}_{D^*}^{\mathrm{Bucket,contoured\ up}}(\beta) = PV(\{r_j^* \in B\}, \{r_i^* \notin B\}\ \mathrm{fixed}) - PV\left(\left\{r_j(D^*) \oplus v_\beta^{up}(j), r_j \in B\right\}, \{r_i^* \notin \mathrm{B}\}\ \mathrm{fixed}\right)$$

and respectively the loss corresponding to downward shocks is defined as:

$$\mathrm{loss}_{D^*}^{\mathrm{Bucket,contoured\ down}}(\beta) = PV(\{r_j^* \in B\}, \{r_i^* \notin B\}\ \mathrm{fixed}) - PV(\{r_j(D^*) \ominus v_\beta^{down}(j), r_j \in B\}, \{r_i^* \notin \mathrm{B}\}\ \mathrm{fixed})$$

Also in this case, in principle, institutions should scan several values of β to identify the shock leading to the worst loss. Considering the feedback received from the data collection exercise, and consistently with the treatment proposed for the 'representative risk factor' option, institutions are required in accordance with these draft RTS to evaluate the loss function in four points.

Precisely, institutions are required to consider the following values of β to get the scenario of future shock:

$$\beta = [0.8, 1]$$

And accordingly they will obtain the shocks $v_{0.8}^{\text{up}}$, v_{1}^{up}, $v_{0.8}^{\text{down}}$, v_{1}^{down}, among which they have to select the one leading to the worst loss.

3.2.5 Non-pricing scenarios

As mentioned in section '*3.2.2 general provisions*', the draft RTS specify that the extreme scenario of future shock should be applied in the same manner as in the expected shortfall model. Therefore, when calculating the loss corresponding to a future shock applied to a non-modellable risk factor, institutions must use the pricing functions of the internal risk-measurement model.

There might be cases where the scenarios generated by the methodologies presented in these draft RTS may lead the pricers (i.e. the systems used by institutions for pricing financial instruments) to not provide a meaningful result where applied to the relevant non-modellable risk factor – this subsection refers to those scenario as 'non-pricing scenarios'. It is worth mentioning that those scenarios are not "non-pricing" per se; indeed, usually there are only "non-pricing" in the context of certain products (or even certain pricers).

Although the EBA already identified possible ways for addressing this potential issue, these draft RTS do not include any specifications around this aspect. In fact, the same problem might occur where a shock is applied to modellable risk factors while holding the non-modellable risk factors fixed resulting in a non-pricing scenario when calculating the partial expected shortfall figures in the IMA ES model in accordance with Article 325bc(3)(4), or might occur also under the current internal model approach where scenarios are generated for computing the Value-at-Risk figures.

As a result, the EBA consults on what are current banking practices for addressing the above mentioned issue, invites proposals to address it, and aims at including requirements following the consultation process to avoid practices that are not deemed prudentially sound. In particular, the EBA considers practices according to which the loss corresponding to a non-pricing scenario is set to zero, capped or discarded as inappropriate, and seeks for potential solutions that would address the issue only where it occurs (i.e. solutions that would target the specific product for which the scenario is a "non-pricing" one, rather than global measures that would impact also instruments for which the scenario is not 'non-pricing").

3.3 Regulatory extreme scenario of future shock that institution may use (or may be required to use) when unable to develop an extreme scenario of future shock

Article 325bk(3)(b) mandates the EBA to specify in the draft RTS a regulatory extreme scenario of future shock which institutions may use when they are unable to develop an extreme scenario of future shock in accordance with Article 325bk(3)(a) or which the competent authority may require the institutions to use when they are not satisfied of the extreme scenario of future shock developed by the institution.

In general, these draft RTS have been prescriptive with respect to the methodology that institutions should use for generating the extreme scenario of future shock in order to provide a harmonised approach in the Union. However, in light of the variety of the risk factors and positions that may be found in a risk-measurement model, a methodology for extreme scenarios of future shocks may not yield meaningful results for all risk factors under all circumstances.

For example in the fallback approach of the stepwise method under the '*same type of risk factor*' option, it may not be trivial for the institution to identify a risk factor of the same nature of the non-modellable risk factor from which a meaningful shock can be calibrated, or for example, the competent authority may deem that the risk factor that was deemed of the same nature of the non-modellable risk factor does not fit for the purpose of generating a shock which is meaningful (and conservative enough) for the 'original' risk factor.

Moreover, in particular risk factors that are parameters for curves or surfaces may pose specific challenges and there is the need to identify a 'last resort' approach that can be used for all kind of risk factors that the institution may have.

The Basel standards specify that if the competent authority is not satisfied with the shock generated by the institution, then the competent authority may require the institution to consider the maximum loss that may occur due to a change in the non-modellable risk factor as the stress scenario risk measure for that non-modellable risk factor.

In line with such requirement, these draft RTS specify that the regulatory extreme scenario of future shock is the one leading to the maximum loss that may occur due to a change in the non-modellable risk factor.

Where such maximum loss does not take a finite value (e.g. for short positions in shares or other derivatives), then institutions shall use an approach using quantitative and qualitative information available to determine a prudent value of the loss that can occur due to a change in the value of the non-modellable risk factor. Such loss must be determined targeting a level of certainty equal to 99.95%. In other words, the expert-based approach should result in the identification of a loss that cannot be exceeded in the 99.95% of the cases on a 10 business day horizon.

From a mathematical point of view, the maximum loss corresponds to a loss that cannot be exceeded in any case (i.e. a level of certainty equal to 100%). Accordingly, the level of confidence in case the maximum loss is not finite is set to be not too distant from a level of certainty equal of 100%, while allowing the methodology to identify a loss that may actually occur (although with low probability)[18].

The value of the loss calibrated on a day 10 horizon, should then be multiplied by $\sqrt{\frac{\mathrm{LH}_{\mathrm{adj}}(\mathrm{j})}{10}}$, where $\mathrm{LH}_{\mathrm{adj}}(\mathrm{j})$ is the relevant liquidity horizon floored at 20 days.

3.4 Circumstances under which institutions may calculate a stress scenario risk measure for more than one non-modellable risk factor

Article 325bk(3)(c) requires the EBA to specify the circumstances under which institutions may calculate a stress scenario risk measure for more than one non-modellable risk factor. The FRTB standards set that a bank may be permitted to calculate stress scenario capital requirements at the bucket level (using the same buckets that the bank uses to disprove modellability) for risk factors that belong to curves, surfaces or cubes (i.e. a single stress scenario capital charge for all the non-modellable risk factors that belong to the same bucket).

In its final draft RTS on the assessment of modellability of risk factors under Article 325be(3), the EBA included the possibility for institutions to use a so-called '*regulatory bucketing approach*' for assessing the modellability of risk factors at bucket level rather than at risk factor level. In accordance with the regulatory bucketing approach institutions may include more than one risk factor within the same regulatory bucket; this cannot happen under the so-called '*own bucketing approach*', where banks are required to include only one risk factor within each bucket.

On this basis, these draft RTS plainly on-board the FRTB standards by specifying that institutions may calculate a unique stress scenario risk measure for more than one non-modellable risk factors if those risk factors belong to the same regulatory bucket and the institutions use the regulatory bucketing approach for assessing the modellability of those risk factors.

[18] Building an analogy with the credit risk framework, the probability of default over a time horizon of 1 year for a name with rating A is about 5 basis points. As a result, the loss identified by the methodology occurs in probability terms as frequently as a single A rating name defaults over a 1 year period.

3.5 Aggregation of the stress scenario risk measures

The EBA is mandated by Article 325bk(3)(d) to specify how institutions are to aggregate the stress scenario risk measures that correspond to the losses incurred by the institution portfolio when the extreme scenario is applied to the non-modellable risk factors (or where applicable to a the non-modellable regulatory bucket). In other words, the EBA has to define the weights applicable to each stress scenario risk measure and the aggregation formula that has to be used for determining the capital requirements corresponding to non-modellable risk factors.

These draft RTS propose an aggregation formula that aims at capturing the following effects:

- The non-linearity in the loss function for non-modellable risk factors for which the institution identified the extreme scenario of future shock using the stepwise method. Indeed, differently from the direct method where institutions are required to calculate directly the expected shortfall of the losses, the stepwise method is based on the assumption that $ES\left(loss\left[r_j(D_t)\right]\right)$ is approximately equal to $loss\left(ES\left[r_j(D_t)\right]\right)$. However, when losses grow faster than linearly, the expected shortfall of losses for varying $r_j(D_t)$ is higher than the loss of the expected shortfall $r_j(D_t)$ (see Annex 3 of the 2017 EBA Discussion Paper for details). Accordingly, such non-linear effects should be captured in the aggregation formula.

- The uncertainty due to the lower observability of non-modellable risk factors, statistical estimation error and the uncertainty in the underlying distribution for non-modellable risk factors. It should be noted that where the institution applies the stepwise method such uncertainty is already captured where identifying the extreme scenario of future shock; accordingly, such effect has to be captured in the aggregation formula only for risk factors where the extreme scenario of future shock has been identified applying the direct method.

- The liquidity horizons of the relevant non-modellable risk factor since the general methodology has been designed to get a 10-days stress scenario risk measure, i.e. the general methodology does not capture yet the liquidity horizon of the risk factor.

- The correlation effects among non-modellable risk factors.

The aggregation formula leading to the capital charge associated to the non-modellable risk factors is the following, transposing the FRTB standard (33.17):

$$OFR_{NMRF} = \sqrt{\sum_{\substack{m=1,\\ m \text{ idiosyncratic} \\ \text{credit spread risk}}}^{N_{P,ICSR}} \left(RSS_{D^*}^{m,S}\right)^2} + \sqrt{\sum_{\substack{k=1,\\ k \text{ idiosyncratic} \\ \text{equity risk factor}}}^{N_{P,IERF}} \left(RSS_{D^*}^{k,S}\right)^2} + \sqrt{\left(\rho \times \sum_{\substack{j=1,\\ j \text{ not idiosyncratic} \\ \text{credit spread} \\ \text{nor} \\ \text{idiosyncratic} \\ \text{equity risk factor}}}^{N_P - N_{P,ICSR} - N_{P,IERF}} RSS_{D^*}^{j,S}\right)^2 + (1-\rho^2) \times \sum_{\substack{j=1,\\ j \text{ not idiosyncratic} \\ \text{credit spread nor} \\ \text{idiosyncaratic} \\ \text{equity risk factor}}}^{N_P - N_{P,ICSR} - N_{P,IERF}} \left(RSS_{D^*}^{j,S}\right)^2}$$

Where:

$$RSS_{D^*}^{j,S} = \begin{cases} \sqrt{\frac{LH_{adj}(j)}{10}} \times SS_{10\text{days},D^*}^{j,S} \times \kappa_{D^*}^{j} \text{ where } SS_{10\text{days},D^*}^{j,S} \text{ is obtained with the stepwise method} \\ \sqrt{\frac{LH_{adj}(j)}{10}} \times SS_{10\text{days},D^*}^{j,S} \times UC \text{ where } SS_{10\text{days},D^*}^{j,S} \text{ is obtained with the direct method}^{19} \\ \text{maximum loss where provisions in section 3.3 are applied} \end{cases}$$

Thus, where institutions determine the maximum loss in accordance with section 3.3 to obtain the stress scenario risk measure, institutions should consider that loss as the rescaled stress scenario risk-measure corresponding to the non-modellable risk factor (or non-modellable bucket where applicable) in the aggregation formula.

And:

- $\rho = 0.6$
- $i \in \{IR, CS, EQ, FX, CM\}$ denotes the risk class of the risk factor j;
- $SS_{10\text{days},D^*}^{j,S}$ denotes the 10-days stress scenario risk measure for the non-modellable risk factor j (or non-modellable bucket where applicable) calculated on the figure date D^* and calibrated on the stress period S^i ;
- $LH_{adj}(j)$ is the liquidity horizon of the non-modellable risk factor j adjusted to consider the 20-days floor to be applied non-modellable risk factors in accordance with FRTB 33.16(1), i.e.:

$$LH_{adj}(j) = \max(20, LH(j))$$

Where $LH(j)$ is the liquidity horizon of the risk factor j obtained in accordance with the RTS on the determination of the liquidity horizon for a given risk factor as per Article 325bd(7).

- $\kappa_{D^*}^{j}$ denotes the non-linearity adjustment for the non-modellable risk factor j (or non-modellable bucket where applicable) and is relevant only where the institution used the stepwise method for obtaining the extreme scenario of future shock. Here below in the subsection '*3.5.1 Calculation of the non-linearity adjustment*', the methodology to be used to compute such parameter is set out.

- UC is the uncertainty compensation factor capturing uncertainty due to the lower observability of non-modellable risk factors and is relevant only where the institution used the direct method for obtaining the extreme of future shock. Here below, subsection '*3.5.2. Calculation of the uncertainty compensation factor*' set how institutions should calculate the uncertainty compensation factor UC.

3.5.1 Calculation of the non-linearity adjustment

As mentioned above, the stepwise method is based on the assumption that $ES\left(loss\left[r_j(D_t)\right]\right)$ is approximately equal to $loss\left(ES\left[r_j(D_t)\right]\right)$. However, when losses grow faster than linearly, the expected shortfall of losses for varying $r_j(D_t)$ is higher than the loss of the expected shortfall $r_j(D_t)$. The same reasoning applies also where the institution is allowed to calculate the stress scenario risk measure at bucket level.

This subsection is structured as follows:

- In the subsection "*Non-linearity adjustment $\kappa_{D^*}^{j}$ for a single non-modellable risk factor*", the methodology that institutions should use for deriving the non-linearity adjustment $\kappa_{D^*}^{j}$ for cases where the stress scenario risk-measure is calculated at risk factor level is outlined.

- In the subsection "*Non-linearity adjustment $\kappa_{D^*}^{B}$ for non-modellable risk factors belonging to non-modellable buckets when the representative risk factor option is applie*d", the methodology that institutions should use for deriving the non-linearity adjustment $\kappa_{D^*}^{B}$ where the '*representative risk factor*' option is applied, is presented.

- In the subsection "*Non-linearity adjustment $\kappa_{D^*}^{B}$ for non-modellable risk factors belonging to non-modellable buckets when the contoured shift option is applied",* the methodology that institutions should use for deriving the non-linearity adjustment $\kappa_{D^*}^{B}$ where the '*contoured shift*' option is applied, is presented.

Non-linearity adjustment $\kappa_{D^*}^{j}$ for a single non-modellable risk factor

For a given non-modellable risk factor j, institutions have to calculate the 'non-linear adjustment' $\kappa_{D^*}^{j}$ where the extreme scenario of future shock is calculated in accordance with the stepwise method and such extreme scenario occurs at the boundaries of the calibrated stress scenario shock range at figure date $CSSRFR\left(r_j(D^*)\right)$.

Where the extreme scenario of future shock does not coincide with one of the boundary of the range (i.e. it does not coincide with either $CS_{up}(r_j)$ or $CS_{down}(r_j)$), then $\kappa_{D^*}^{j}$ should be set to one[20].

Precisely, the proposed draft RTS require to determine the adjustment as follows:

$$\kappa_{D^*}^{j} = \max\left[\kappa_{\min}, 1 + \frac{\mathrm{loss}_{D^*}(r_{j,-1}) - 2 \times \mathrm{loss}_{D^*}(r_{j,0}) + \mathrm{loss}_{D^*}(r_{j,1})}{2 \times \mathrm{loss}_{D^*}(r_{j,0})} \times (\phi - 1) \times 25\right]$$

Where the tail shape parameter ϕ is used for approximating the difference of the expected shortfall of losses due to risk factor movements and the loss of the expected shortfall of risk factor movements in the tail of the risk factor movements in a quadratic approximation. In particular:

- Where the institution used the *historical method* of the *stepwise method* for calibrating the upward and downward shock, and the extreme scenario of future shock corresponds to an downward shock:

$$\phi = \hat{\phi}_{\mathrm{Left}}(Ret(j), \alpha) = \frac{\frac{1}{\alpha N} \times \left\{\sum_{i=1}^{[\alpha N]} Ret(j)_{(\mathrm{i})}{}^{2} + (\alpha N - [\alpha N]) Ret(j)_{([\alpha N]+1)}{}^{2}\right\}}{\left\{\widehat{\mathrm{ES}}_{\mathrm{Left}}(Ret(j), \alpha)\right\}^{2}}$$

Where:

- $Ret(j)$ is the order statistics of the time series of 10-business days returns for the non-modellable risk factor j. In other words $Ret(j)_{(\mathrm{i})}$ represents the i-th smallest observation in that time series.
- $\alpha = 2.5\%$.
- N is the number of observations in the time series of 10-business days returns for the non-modellable risk factor j.
- $[\alpha N]$ denotes the integer part of the product αN.

- Where the institution used the historical method of the stepwise method for calibrating the upward and downward shock, and the extreme scenario of future shock corresponds to an upward shock:

$$\phi = \hat{\phi}_{\mathrm{Right}} = \hat{\phi}_{\mathrm{Left}}(-Ret(j), \alpha)$$

i.e. institutions have to calculate the $\hat{\phi}_{\mathrm{Left}}$ for the order statistics $(-Ret(j))$.

- Where the institution used the *sigma, the asymmetrical sigma method or the fallback method* of the *stepwise method* for calibrating the upward and downward shock then:

$$\phi = 1.04$$

[20] In a 'continuous world', If the extreme scenario of future shock coincides with a point in the middle of the range, then in that point the loss function is concave (point of local max). Hence, there is no need to capture the non-linearity effect.

And where:

$$h = \begin{cases} \dfrac{CS_{up}(r_j)}{5} \text{ where the extreme scenario of future shock is } \mathrm{CS_{up}(r_j)} \\ \dfrac{CS_{down}(r_j)}{5} \text{ where the extreme scenario of future shock is } \mathrm{CS_{down}(r_j)} \end{cases}$$

$$r_{j,0} = \begin{cases} r_j(D *) \oplus CS_{up}(r_j) \; where\ the\ extreme\ scenario\ of\ future\ shock\ is\ CS_{up}(r_j) \\ r_j(D *) \ominus CS_{down}(r_j) \; where\ the\ extreme\ scenario\ of\ future\ shock\ is\ CS_{down}(r_j) \end{cases}$$

And:

$$r_{j,-1} = r_{j,0} \ominus h$$

$$r_{j,+1} = r_{j,0} \oplus h$$

It should be noted that the size of the step h has been built to allow the institution to re-use the values of the loss function in two outermost points in the scanning of calibrated stress scenario risk factor range.

Finally:

- $\kappa_{\min}$ = 0.9, which sets the lower boundary of $\kappa_{D^*}^{j}$

Non-linearity adjustment $\kappa_{D^*}^{B}$ for risk factors belonging to non-modellable buckets when the ‘representative risk factor option’ is applied

For a given non-modellable regulatory bucket B, institutions have to calculate the ‘non-linear adjustment’ $\kappa_{D^*}^{B}$ where the extreme scenario of future shock occurs at one of the boundaries of the calibrated stress scenario shock range determined for the representative risk factor r_B at figure date $CSSRFR(r_B(D^*))$. In all other cases, $\kappa_{D^*}^{B}$ should be set to one.

Precisely, the proposed draft RTS require institutions to determine the adjustment as follows:

$$\kappa_{D^*}^{B} = \max\left[\kappa_{\min}, \frac{\mathrm{loss}_{D^*}^{\mathrm{parallel}}(r_{B,-1}) - 2 \times \mathrm{loss}_{D^*}^{\mathrm{parallel}}(r_{B,0}) + \mathrm{loss}_{D^*}^{\mathrm{parallel}}(r_{B,+1})}{2 \times \mathrm{loss}_{D^*}^{\mathrm{parallel}}(r_{B,0})} \times (\phi - 1) \times 25\right]$$

Where ϕ is also in this case the tail shape parameter and should be calculated as follows:

- Where the institution used the *historical method* of the *stepwise method* for calibrating the upward and downward shock of the representative risk factor and the extreme scenario of future shock corresponds to a parallel downward shock:

$$\phi = \hat{\phi}_{\text{Left}}(Ret(B), \alpha) = \frac{\frac{1}{\alpha N} \times \left\{\sum_{i=1}^{[\alpha N]} Ret(B)_{(\mathrm{i})}{}^2 + (\alpha N - [\alpha N])Ret(B)_{([\alpha N]+1)}{}^2\right\}}{\left\{\widehat{\mathrm{ES}}_{\text{Left}}(Ret(B), \alpha)\right\}^2}$$

Where:

- $Ret(B)$ is the order statistics of the time series of 10-business days returns for the representative risk factor B. In other words $Ret(B)_{(\mathrm{i})}$ represents the i-th smallest observation in that time series.
- $\alpha = 2.5\%$.
- N is the number of observations in the time series of 10-business days returns for the non-modellable risk factor j.
- $[\alpha N]$ denotes the integer part of the product αN.

- Where the institution used the historical method of the stepwise method for calibrating the upward and downward shock, and the extreme scenario of future shock corresponds to an upward shock:

$\phi = \hat{\phi}_{\text{Right}} = \hat{\phi}_{\text{Left}}(-Ret(B), \alpha)$

i.e. institutions have to calculate the $\hat{\phi}_{\text{Left}}$ for the order statistics $(-Ret(B))$.

- Where the institution used the *sigma, the asymmetrical root mean squared returns or the fallback method* of the *stepwise method* for calibrating the upward and downward shock:

$$\phi = 1.04$$

And where:

$$h = \begin{cases} \dfrac{CS_{up}(r_B)}{5} \text{ if the future shock is given by a parallel shift of size } \mathrm{CS_{up}}(\mathrm{r_B}) \\ \dfrac{CS_{down}(r_B)}{5} \text{ if the future shock is given by a parallel shift of size } \mathrm{CS_{down}}(\mathrm{r_B}) \end{cases}$$

$$r_{B,0} = \begin{cases} r_B(D*) \oplus CS_{up}(r_B) \; if\ the\ future\ shock\ is\ given\ by\ a\ parallel\ shift\ of\ size\ CS_{up}(r_B) \\ r_B(D*) \ominus CS_{down}(r_B) \; if\ the\ future\ shock\ is\ given\ by\ a\ parallel\ shift\ of\ size\ CS_{down}(r_B) \end{cases}$$

And:

$$r_{B,-1} = r_{B,0} \ominus h$$

$r_{B,+1} = r_{B,0} \oplus h$

It should be noted that the size of the step h has been built to allow the institution to re-use the values of the loss function in two outermost points in the scanning of calibrated stress scenario risk factor range.

Finally:

- κ_{min} = 0.9, which sets the lower boundary of $\kappa_{D^*}^{B}$

Non-linearity adjustment $\kappa_{D^*}^{B}$ for risk factors belonging to non-modellable buckets when the 'contoured shift option' is applied

Also in this case, for a given non-modellable regulatory bucket B,institutions have to calculate the 'non-linear adjustment' $\kappa_{D^*}^{B}$ where the extreme scenario of future shock occurs for $\beta = 1$ (either where applied to the vector of upward shocks or to the vector of downward shocks). If the extreme scenario of future shock occurs has been identified for $\beta < 1$, then $\kappa_{D^*}^{B}$ should be set to 1.

In particular:

- Where the extreme scenario of future shock corresponds to an upward shift of risk factors in the bucket the proposed draft RTS require to determine the adjustment as follows:

$$\kappa_{D^*}^{B} = \max\left[\kappa_{\text{min}}, \frac{\text{loss}_{D^*}^{\text{bucket,contoured,up}}(\beta_{-1}) - 2\times\text{loss}_{D^*}^{\text{bucket,contoured up}}(\beta_0) + \text{loss}_{D^*}^{\text{bucket,contoured up}}(\beta_1)}{2\times\text{loss}_{D^*}^{\text{parallel}}(\beta_0)} \times (\phi_{avg} - 1) \times 25\right]$$

- Where the extreme scenario of future shock corresponds to a downward shift of risk factors in the bucket the proposed draft RTS require to determine the adjustment as follows:

$$\kappa_{D^*}^{B} = \max\left[\kappa_{\text{min}}, \frac{\text{loss}_{D^*}^{\text{bucket,contoured,down}}(\beta_{-1}) - 2\times\text{loss}_{D^*}^{\text{bucket,contoured down}}(\beta_0) + \text{loss}_{D^*}^{\text{bucket,contoured down}}(\beta_1)}{2\times\text{loss}_{D^*}^{\text{parallel}}(\beta_0)} \times (\phi_{avg} - 1) \times 25\right]$$

Where in both cases:

- $\beta_{-1} = 0.8$
- $\beta_0 = 1$
- $\beta_1 = 1.2$

And where ϕ_{avg} is the average of the ϕ_i calculated for each risk factor belonging to the bucket in accordance with the methodology set for calculating ϕ at risk factor level in the previous section '*Non-linearity adjustment $\kappa_{D^*}^{j}$ for a single non-modellable risk factor'.*

Finally:

- $\kappa_{\min}$ = 0.9, which sets the lower boundary of $\kappa_{D^*}^{B}$

3.5.2 Calculation of the uncertainty compensation factor UC

As mentioned, UC is the uncertainty compensation factor capturing uncertainty due to the lower observability of non-modellable risk factors and is relevant only where the institution used the direct method for obtaining the extreme scenario of future shock.

Where the institution uses the stepwise method, then when calibrating the downward and upward shock (e.g. via the historical method), the institution captures the uncertainty where estimating those shock by means of an uncertainty compensation factor set equal to $\left(1+\frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N-1.5)}}\right)$. As a result, the uncertainty due to the lower observability of non-modellable risk factors is already captured where calibrating the shocks.

Where using the direct method, institutions calculate directly the expected shortfall on the losses in the stress period. As a result, the extreme scenario of future shock is implicitly defined; in other words, the extreme scenario of future shock is the shock for which the stress scenario risk measure (on a 10-day horizon) corresponds to the expected shortfall of the losses estimated in accordance with section '*Methodology D – The Direct Method*'. Given this peculiarity of the direct method (i.e. the fact that the extreme scenario of future shock is implicitly defined), the uncertainty in estimating the expected shortfall of the losses is captured in the aggregation formula. Analogously to the compensation factor proposed in the context of the stepwise method, $UC=\left(1+\frac{\Phi^{-1}(CL_{sigma})}{\sqrt{2(N-1.5)}}\right)$ also where institutions use the direct method.

4. Draft regulatory technical standards on the calculation of the stress scenario risk measure under Article 325bk(3) of Regulation (EU) No 575/2013 (Capital Requirements Regulation 2 - CRR2)

In between the text of the draft RTS/ITS/Guidelines/advice that follows, further explanations on specific aspects of the proposed text are occasionally provided, which either offer examples or provide the rationale behind a provision, or set out specific questions for the consultation process. Where this is the case, this explanatory text appears in a framed text box.

COMMISSION DELEGATED REGULATION (EU) No …/..

of XXX

supplementing Regulation (EU) No 575/2013 of the European Parliament and of the Council with regard to regulatory technical standards on the calculation of the stress scenario risk measure under Article 325bk(3) of Regulation (EU) No 575/2013

(Text with EEA relevance)

Box for consultation purposes:

The EBA consults as part of this consultation process on two different ways through which the abovementioned requirement set out in CRR 2 and also in the Basel standards can be met (see the two options for the RTS, option A and option B, below). These two ways reflect two different overarching approaches that could be implemented for determining the stress scenario risk measure corresponding to an extreme scenario of future shock:

Option A: determination of the stress scenario risk measure directly from the stress period

Option B: rescaling a shock calibrated on the current period to obtain a shock calibrated on the stress period

2 separate versions of the draft RTS reflecting those two options have been drafted. Below, the draft RTS in accordance with option A is presented.

Draft RTS for Option A

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EU) No 575/2013 of 26 June 2013 of the European Parliament and of the Council on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012[21], and in particular the fourth subparagraph of Article 325bk(3) thereof,

Whereas:

(1) The market risk own funds requirements under the alternative internal model approach set out in Part Three, Title IV, Chapter 1b of Regulation (EU) No 575/2013 for risk factors that are not assessed to be modellable in accordance with Article 325be of that Regulation may significantly contribute to the total own funds requirements for market risk that an institution, for which the permission referred to in Article 325az has been granted, is required to meet. Accordingly, in order to ensure a level playing field among institutions in the Union and to minimise regulatory arbitrage, this Regulation should further develop international standards and set out specific and detailed methodologies for developing an extreme scenario of future shock for a non-modellable risk factor.

(2) The quality of the data and the number of observations that are available to determine a future shock for a non-modellable risk factor may vary significantly from one non-modellable risk factor to another. In order to ensure an appropriate development of the extreme scenario of future shock for a wide range of cases, this Regulation should provide alternative sets of methodologies that institutions may use depending on the number of observations that are available for a non-modellable risk factor. In addition, this Regulation should require institutions to reflect in their calculations that the estimates or values used to determine the extreme scenario of future shock have a higher uncertainty and should become more conservative when less data are available.

(3) One method to determine the extreme scenario of future shock for a non-modellable risk factor should consist of directly calculating the expected shortfall measure of the losses that would occur when varying that risk factor in a way calibrated to the relevant stress period. However, such a direct method would provide reliable results only where the institution has a significant amount of data in the observation period and would require many loss calculations per risk factor leading to a high computational effort in such a method. Thus, this regulation should identify another method aiming at mitigating those drawbacks.

(4) The alternative method should aim at mitigating those drawbacks by a stepwise approach. It is possible to approximate the expected shortfall of the losses that may

[21] [21] OJ L 176, 27.6.2013, p. 1.

occur following a change in the non-modellable risk factor by first calculating an expected shortfall on the returns observed for that risk factor and by then calculating the loss corresponding to the movement in the risk factor identified by that expected shortfall. Since such an approximation requires a significant lower number of loss calculations than the direct method, it constitutes a sound basis for an alternative methodology.

(5) In addition, such stepwise method should also address the specific case where the number of observations for a non-modellable risk factor in the relevant observation period is insufficient to obtain accurate and prudent estimates. Since such specific situation can be expected to occur only in a limited number of cases, those cases should be addressed by leveraging on methodologies that institutions have implemented for other non-modellable risk factors for which they have more observations.

(6) To ensure the alignment of the Union with the international standards, the market risk own funds requirements under the alternative internal model in relation to non-modellable risk factors should be calibrated to a period of stress that is common to all non-modellable risk factors in the same broad risk factor category referred to in Article 325bd of Regulation (EU) No 575/2013. Therefore, this Regulation should require institutions to identify a stress period for each broad risk factor category and to collect data for non-modellable risk factors on the stress period identified for the category to which they belong in order to determine an extreme scenario of future shock on the basis of data observed during that period.

(7) To ensure that the level of own funds requirements for market risk of a non-modellable risk factor is as high as if that risk factor was modellable in accordance with the requirement set out in Article 325bk(3) of Regulation (EU) No 575/2013, this Regulation should require institutions to calibrate such level to an expected shortfall of losses at a 97.5% confidence level over a period of stress. Accordingly, the statistical estimators and the parameters included in this Regulation should be set to ensure such confidence is met.

(8) In order to ensure the alignment of the Union with the international standards, the regulatory extreme scenario of future shock should be the one leading to the maximum loss that may occur due to a change in the non-modellable risk factor. This regulation should also clarify what institutions should consider as maximum loss where this is not finite.

(9) In accordance with the international standards institutions may determine the stress scenario risk measure for more than one non-modellable risk factors, where those risk factors are part of a curve or a surface and they belong to the same non-regulatory bucket among those set out in Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013] and their modellability has been assessed in accordance with the standardised bucketing approach referred to in that Regulation. To avoid any deviation of the Union from the international standards, this regulation should allow institutions to compute a unique stress scenario risk measure for more than one non-modellable risk factor under those conditions only.

(10) Institutions should be required to aggregate the stress scenario risk-measure by first rescaling them to reflect risks that were not yet captured where determining the

extreme scenario of future shock e.g. the liquidity horizons of the non-modellable risk factors, and by then applying the aggregation formula agreed in the international standards.

(11) This Regulation is based on the draft regulatory technical standards submitted by the European Banking Authority to the Commission.

(12) EBA has conducted open public consultations on the draft regulatory technical standards on which this Regulation is based, analysed the potential related costs and benefits, and requested the opinion of the Banking Stakeholder Group established in accordance with Article 37 of Regulation (EU) No 1093/2010[22],

HAS ADOPTED THIS REGULATION:

Text for consultation purposes

The EBA consults as part of this consultation process on two different ways through which the abovementioned requirement set out in CRR 2 and also in the Basel standards can be met (see the two options for these RTS, option A and option B, below). These two ways reflect two different overarching approaches that could be implemented for determining the stress scenario risk measure corresponding to an extreme scenario of future shock:

Option A: determination of the stress scenario risk measure directly from the stress period

Option B: rescaling a shock calibrated on the current period to obtain a shock calibrated on the stress period

Some questions included for consultation are relevant both in the context of option A and of option B. As a result, the same question may have been included both under option A and under option B. When a question included in option B has been already included under option A, then such question has been written in *italic* when presented in option B. Please respond to the same question only once; please also refer to the section 'overview questions for consultation' at the end of this paper for responding in the correct order.

Q1. What is your preferred option among option A (stress period based extreme scenario of future shock) and option B (extreme scenario of future shock rescaled to stress period)? Please elaborate highlighting pros and cons.

Q2. What are characteristics of the data available for NMRF in the data observation periods under options A and B?

[22] Regulation (EU) No 1093/2010 of the European Parliament and of the Council of 24 November 2010 establishing a European Supervisory Authority (European Banking Authority), amending Decision No 716/2009/EC and repealing Commission Decision 2009/78/EC (OJ L 331, 15.12.2020, p. 12).

SECTION 1

DEVELOPMENT AND APPLICATION OF THE EXTREME SCENARIO OF FUTURE SHOCKS

Article 1

Development and application of the extreme scenario of future shocks at risk factor level

1. Institutions shall develop the extreme scenario of future shock for a non-modellable risk factor for the purposes of Article 325bk(3)(a) of Regulation (EU) No 575/2013 by applying either the direct method in accordance with paragraph 2 and under the condition set out in paragraph 3 or the stepwise method in accordance with paragraph 4.

2. Institution determining the extreme scenario of future shock for a non-modellable risk factor with the direct method shall apply the following steps in sequence:

(a) they shall determine a time series of losses as follows:

> (i) they shall determine in accordance with Article 3 the time series of 10 business days returns for the non-modellable risk factor on the stress period determined in accordance with Article 8;
>
> (ii) they shall shock the value of the non-modellable risk factor by each value in the time series obtained in point (i);
>
> (iii) they shall determine the time series of losses by calculating the losses which would occur if the non-modellable risk factor had the values in the time series obtained in point (ii).

(b) they shall calculate the estimate of the right-tail expected shortfall in accordance with Article 7(2) for the time series of the losses obtained in accordance with point (a).

(c) the shock leading to a loss equal to the estimate of the right-tail expected shortfall obtained in accordance with point (b) shall constitute the extreme scenario of future shock for the non-modellable risk factor.

3. Institutions may use the direct method referred to in paragraph 2 to determine the extreme scenario of future shock under the condition that the number of observations in time series referred to in paragraph 2(a)(i) is greater than or equal to 200.

4. Institutions determining the extreme scenario of future shock for a non-modellable risk factor with the stepwise method shall apply the following steps in sequence:

(a) they shall determine the time series of 10 business days returns for the non-modellable risk factor in accordance with Article 3 on the stress period determined in accordance with Article 8;

(b) they shall determine an upward and a downward calibrated shock from the time series of 10 business days returns referred to in point (a) in accordance with one of following methods:

(i) the historical method set out in Article 4, provided that the number of observations in the time series referred to in point (a) is greater than or equal to 200;

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two version of Article 1(4)(b)(ii) will be kept.

(ii) the sigma method set out in Article 5, provided that the number of observations in the time series referred to in point (a) is greater than or equal to 12;

(ii) the asymmetrical sigma method set out in Article 5, provided that the number of observations in the time series referred to in point (a) is greater than or equal to 12;

(iii) the fallback method set out in Article 6, which shall be applied where the number of observations in the time series referred to in point (a) is lower than 12;

(c) for each shock included in the following grid, institutions shall calculate the loss that occurs when that shock is applied to the non-modellable risk factor:

$$grid = \left\{\frac{4}{5} \cdot CS_{\text{down}}, CS_{\text{down}}, \frac{4}{5} \cdot CS_{\text{up}}, CS_{\text{up}}\right\}$$

Where:

- CS_{down} is the downward calibrated shock obtained as a result of point (b);
- CS_{up} is the upward calibrated shock obtained as a result of point (b).

(d) the shock, from among those included in the grid referred to in point (c), which leads to the highest loss shall constitute the extreme scenario of future shock for the non-modellable risk factor.

Text for consultation

Under option A, these draft RTS identify two methodologies that institutions may use for determining the extreme scenario of future shock, namely the direct and the stepwise method.

The direct method, although relatively straightforward from a mathematical point of view requires essentially daily data for an NMRF and an important computation effort from institutions potentially using it, because for each risk factor essentially loss evaluations need to be computed, while the other methods require only a few. On this basis, the EBA consults on whether the direct method will be used in practice by institutions or whether the computational burden will in substance keep institutions from using it. Should the EBA not receive evidence of the need of such method, the EBA will drop the option to use the direct method in its final draft RTS.

Questions for consultation

Q3. Do you think that institutions will actually apply the direct method to derive the extreme scenario of future shock or do you think that given the computational efforts that it requires and considering that the historical method typically provides very similar results it will not be used in practice? As stated in the background section of this CP, the EBA will drop the direct method from the framework if not provided with clear evidence for its need.

Article 2

Development and application of the extreme scenario of future shocks at bucket level

1. Where institutions calculate a stress scenario risk measure for more than one non-modellable risk factor as referred to in Article 325bk(2)(c) of Regulation (EU) No 575/2013 and under the conditions set out in Article 11, institutions shall determine an extreme scenario of future shock for the non-modellable bucket to which those risk factors belong in accordance Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013] by either applying the direct method in accordance with paragraph 2 and under the condition set out in paragraph 3 or by applying the stepwise method in accordance with paragraph 4.

2. Institutions determining the extreme scenario of future shock for a non-modellable bucket with the direct method shall apply the following steps in sequence:

(a) they shall determine a time series of losses as follows:

> (i) for each non-modellable risk factor within the non-modellable bucket they shall determine in accordance with Article 3 the time series of nearest to 10 business days returns on the stress period determined in accordance with Article 8;

(ii) the institution shall drop from each time series obtained in accordance with point (i), values corresponding to dates for which not all those time series have an observation;

(iii) for each non-modellable risk factor within the non-modellable bucket, they shall shock the value of the non-modellable risk factor by each value in the corresponding time series obtained as result of point (ii);

(iv) they shall determine the time series of losses by calculating for each date corresponding to an observation in the time series obtained as a result of point (iii), the loss that would occur if the non-modellable risk factors in the non-modellable bucket had the values included in those time series for that date.

(b) they shall calculate the estimate of the right-tail expected shortfall in accordance with Article 7(2) for the time series of the losses obtained as a result of point (a);

(c) the scenario of shocks leading to a loss equal to the estimate of the right-tail expected shortfall obtained as a result of point (b) shall constitute the extreme scenario of future shock for the non-modellable bucket;

3. An institution may use the direct method referred to in paragraph 2 to determine the extreme scenario of future shock for a non-modellable bucket, under the condition that the number of observations in the time series referred to in paragraph 2(a)(iv) is greater or equal than 200.

4. An institution determining the extreme scenario of future shock for a non-modellable standardised bucket with the stepwise method shall apply the following steps in sequence:

(a) for each non-modellable risk factor within the non-modellable standardised bucket they shall determine the time series of 10 business days returns in accordance with Article 3 on the stress period determined in accordance with Article 8;

(b) for each non-modellable risk factor within the non-modellable standardised bucket, they shall determine an upward and a downward calibrated shock from the corresponding time series of 10 business days returns referred to in point (a) in accordance with one of the following methods:

(i) the historical method set out in article 4, provided that the number of observations in the time series referred to in point (a) corresponding to the non-modellable risk factor is greater than or equal to 200;

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions of Article 2(4)(b)(ii) will be kept.

(ii) the sigma method set out in Article 5, provided that the number of observations in the time series referred to in point (a) corresponding to the non-modellable risk factor is greater than or equal to 12;

(ii) the asymmetrical sigma method set out in Article 5, provided that the number of observations in the time series referred to in point (a) corresponding to the non-modellable risk factor is greater than or equal to 12;

(iii) the fallback method set out in article 6, which shall be applied to all non-modellable risk factors within the non-modellable bucket where there is at least one non-modellable risk factor in the non-modellable bucket for which the number of observations in the time series of 10 business days returns referred to in point (a) is lower than 12;

Below two different options are presented for consultation with respect to the determination of the extreme scenario of future shock at bucket level. Only one of the options in relation to paragraphs (c), (d) and (e) of Article 2(4) will be kept in the final draft RTS.

Option 1: Representative risk factor – parallel shift option:

(c) they shall identify the representative risk factor in the non-modellable bucket by identifying the risk factor to which the highest absolute shock among the downward and upward calibrated shocks resulting from point (b) corresponds;

(d) for each shock included in the following grid, they shall calculate the loss that occurs when that shock is applied to all risk factors within the non-modellable bucket:

$$Grid = \left\{\frac{4}{5} \cdot CS^R_{down}, CS^R_{down}, \frac{4}{5} \cdot CS^R_{up}, CS^R_{up}\right\}$$

Where:

- CS^R_{down} is the downward shock obtained as a result of point (b) for the representative risk factor identified in accordance with point (c);
- CS^R_{up} is the upward shock obtained as a result of point (b) for the representative risk factor identified in accordance with point (c);

(e) they shall consider as the extreme scenario of future shock for the non-modellable bucket that scenario, from among those identified by the shock in the grid referred to in point (d), to which the highest loss among those computed in accordance with point (d) corresponds.

Option 2: Contoured shift option:

(c) they shall calculate both of the following:

- the loss corresponding to a scenario where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from step (c) multiplied by β, in two cases: where $\beta = 1$ and where β= 0.8;
- the loss corresponding to a scenario where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from step (c) multiplied by β, in two cases: where $\beta = 1$ and where β= 0.8;

(d) the scenario of shocks to which the highest loss among those computed in accordance with point (c) corresponds shall constitute the extreme scenario of future shock for the non-modellable bucket.

Text for consultation

Two different options are presented for consultation with respect to the determination of the extreme scenario of future shock at bucket level. The first one requires institutions to determine it by means of a parallel shift, while the second one by means of a contoured shift. The contoured shift option has been designed on the basis of the feedback received during the data collection exercise from institutions that took part to that exercise.

Question for consultation

Q4. What is your preferred option among (i) the representative risk factor – parallel shift option, and (ii) the contoured shift option? Please elaborate highlighting pros and cons.

Article 3

Determination of the time series of 10 business days returns

1. Institutions shall determine the time series of 10 business days returns for the stress period in relation to a given non-modellable risk factor by applying the following steps in sequence:

(a) they shall determine the time series of observations for the non-modellable risk factor during the stress period; institutions shall include in this time series only one observation per business day and the observations shall represent actual market data;

(b) institutions shall extend the time series referred to in point (a) by including the observations available within the period of up to 20 business days following the stress period;

(c) in relation to each date D_t, for which there is an observation in the time series resulting from point (a), excluding the last observation, institutions shall determine among the dates with an observation in the extended time series referred to in point (b) the date $D_{t'}$ following D_t, that minimizes the following value:

$$v = \left| \frac{10\ days}{D_{t'} - D_t} - 1 \right|$$

Where:

- D_t is the date for which there is an observation in the time series referred to in point (a), excluding the last observation;
- $D_{t'}$ is a date following D_t with an observation in the extended time series referred to in point (b);
- the difference $D_{t'} - D_t$ is expressed in business days;

where there is more than one date minimising that value, the date $D_{t'}$ shall be the date among those minimising that value that occurred later in time;

(d) in relation to each date D_t, for which there is an observation in the time series resulting from point (a), excluding the last observation, they shall determine the corresponding 10 business days return by determining the return for the non-modellable risk factor over the period between the date D_t of the observation and the date $D_{t'}$ minimising the value v in accordance with point (c), and subsequently rescaling it to obtain a return over a 10 business days period.

2. The time series referred to in paragraph 1(a) shall at least include the observations that were used for calibrating the scenarios of future shocks referred to in Article 325bc of Regulation (EU) No 575/2013, where that risk factor has been previously assessed to be modellable in accordance with Article 325be of Regulation (EU) No 575/2013.

3. For the purposes of paragraph 1(b), institutions shall extend the stress period by the same number of business days for each non-modellable risk factor.

Text for consultation

In accordance with these draft RTS, institutions are required to obtain a time series of 10 business returns starting from the observations available in the observation period for the non-modellable risk factor. The EBA consults on the methodology prescribed in these draft RTS to build such time series.

Question for consultation

Q5. What are your views on how institutions are required to build the time series of 10 business days returns? Please elaborate.

Article 4

Upward and downward calibrated shocks with the historical method

1. For determining the downward calibrated shock from a time series of 10 business days returns for a non-modellable risk factor with the historical method, institutions shall use the following formula:

$$Calibrated\ downward\ shock = \widehat{\mathrm{ES}}_{\mathrm{Left}}(Ret) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$$

Where:

- Ret denotes the time series of 10 business days returns of the non-modellable risk factor;
- $\widehat{\mathrm{ES}}_{\mathrm{Left}}(Ret)$ is the estimate of the left-tail expected shortfall for the time series Ret calculated in accordance with Article 7(1)
- N represents the number of observations in the time series Ret
- $C_{UC} = 1.28$

2. For determining the upward calibrated shock from a time series of 10 business days returns for a non-modellable risk factor with the historical method, institutions shall use the following formula:

$$Calibrated\ upward\ shock = \widehat{\mathrm{ES}}_{\mathrm{Right}}(Ret) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$$

Where:

- Ret denotes the time series of 10 business days returns
- $\widehat{\mathrm{ES}}_{\mathrm{Right}}(Ret)$ is the estimate of the right-tail expected shortfall for the time series Ret calculated in accordance with Article 7(2)
- N represents the number of observations in the time series Ret
- $C_{UC} = 1.28$

Below two different options (the sigma method option, and the asymmetrical sigma method option) are presented for consultation with respect to the method that institutions could use for determining a downward and an upward calibrate shock where more than 12 observations in the time series of 10 business days returns are available. Only one version of Article 5 will be kept in the final draft RTS.

Option 1: the sigma method

Article 5

Upward and downward calibrated shocks with the sigma method

For determining the upward and downward calibrated shock from a time series of 10 business days returns for a non-modellable risk factor with the sigma method, institutions shall use:

(a) in relation to the upward calibrated shock the following formula:

$$Calibrated\ upward\ shock = C_{ES} \cdot \widehat{\sigma}(Ret) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$$

(b) in relation to the downward calibrated shock the following formula:

$$Calibrated\ downward\ shock = C_{ES} \cdot \widehat{\sigma}(Ret) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$$

Where:

- Ret denotes the time series of 10 business days returns of the non-modellable risk factor;
- $\widehat{\sigma}(Ret)$ is the estimate of the standard deviation for the time series Ret calculated in accordance with Article 7(3)
- N represents the number of observations in the time series of 10 business days returns
- $C_{ES} = 3$
- $C_{UC} = 1.28$

Option 2: the asymmetrical sigma method

Article 5

Upward and downward calibrated shocks with the asymmetrical sigma method

1. For determining the upward and downward calibrated shock from a time series of 10 business days returns for a non-modellable risk factor with the asymmetrical sigma method, institutions shall apply the following steps in sequence:

(a) they shall determine the median of the observations within the time series, and split the 10 business days returns comprised in that time series into the two following subsets:

(i) the subset of 10 business days returns which value is lower than or equal to the median;

(ii) the subset of 10 business days returns which value is greater than the median;

(b) for each subset referred in point (a), they shall compute the mean of the 10 business days returns in the subset;

(c) they shall determine the downward calibrated shock in accordance with the following formula:

$$Calibrated\ downward\ shock$$

$$= \left(|\hat{\mu}_{Ret \leq m}| + C_{ES} \cdot \sqrt{\frac{1}{N_{\mathrm{down}} - 1.5} \times \sum_{\substack{i=1, \\ Ret_{(\mathrm{i})} \leq m}}^{N} \left(Ret_{(\mathrm{i})} - \hat{\mu}_{Ret \leq m}\right)^2} \right) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N_{\mathrm{down}} - 1.5)}}\right)$$

where:

- Ret denotes the time series of 10 business days returns of the non-modellable risk factor;
- $Ret_{(\mathrm{i})}$ is the i-th observation in the 10 business days returns time series Ret;
- m is the median of the 10 business days returns time series Ret;
- $\hat{\mu}_{Ret \leq m}$ denotes the mean of the 10 business days returns obtained as a result of point (b) on the subset identified in point (a)(i);
- $|\hat{\mu}_{Ret \leq m}|$ is the absolute value of $\hat{\mu}_{Ret \leq m}$;
- N_{down} is the number of 10 business days returns in the subset identified in point (a)(i);
- N is the number of observations in the 10 business days returns time series Ret;
- $C_{ES} = 3$;
- $C_{UC} = 1.28$;

(d) they shall determine the upward calibrated shock in accordance with the following formula:

$$\mathit{Calibrated\ upward\ shock} = \left(|\hat{\mu}_{Ret>m}| + C_{ES} \cdot \sqrt{\frac{1}{N_{\mathrm{up}} - 1.5} \times \sum_{\substack{i=1,\\ Ret_{(\mathrm{i})} > m}}^{N} \left(Ret_{(\mathrm{i})} - \hat{\mu}_{Ret>m} \right)^2} \right) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N_{\mathrm{up}} - 1.5)}} \right)$$

where:

- Ret denotes the time series of 10 business days returns of the non-modellable risk factor;
- $Ret_{(\mathrm{i})}$ is the i-th observation in the 10 business days returns time series Ret;
- m is the median of the 10 business days returns time series Ret;
- $\hat{\mu}_{Ret>m}$ denotes the mean of the 10 business days returns obtained as a result of point (b) on the subset identified in point (a)(ii);
- $|\hat{\mu}_{Ret>m}|$ is the absolute value of $\hat{\mu}_{Ret>m}$;
- N_{up} is the number of observations in the subset identified in point (a)(ii);
- N is the number of observations in the 10 business days returns time series Ret;
- $C_{ES} = 3$;
- $C_{UC} = 1.28$;

Text for consultation

The sigma method option and the asymmetrical sigma method option are presented above for consultation with respect to the method that institutions could use for determining a downward and an upward calibrate shock where more than 12 observations in the time series of 10 business days returns are available.

The sigma method presented above leads to the identification of an upward and a downward shock of the same size; in other words, the sigma method is symmetrical. However, in reality, risk factors often have a skewed underlying distribution (e.g. downward shocks are more severe than upward shocks); accordingly, an alternative methodology to the sigma method is proposed below to capture the asymmetry in the risk factor distribution.

The EBA aims at removing one option following consultation among the sigma method and the asymmetrical sigma method.

Questions for consultation

Q6. What is your preferred option among (i) the sigma method and (ii) the asymmetrical sigma method for determining the downward and upward calibrated shocks? Please highlight the pros and cons of the options. In addition, do you think that in the asymmetrical sigma method, returns should be split at the median or at another point (e.g. at the mean, or at zero)? Please elaborate.

Q7. What are your views on the value taken by the constant C_{ES} for scaling a standard deviation measure to approximate an expected shortfall measure?

Q8. What are your views on the uncertainty compensation factor $\left(1+\frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$? Please note that this question is also relevant for the purpose of the historical method.

Article 6

Calibrating upward and downward shocks with the fallback method

1. For determining the upward and downward calibrated shock from the time series of 10 business days returns for a non-modellable risk factor with the fallback method, institutions shall apply one of the methodologies set out in this Article.

2. Where the non-modellable risk factor coincides with one of the risk factors defined in Part Three, Title IV, Chapter 1a, Section 3, Subsection 1 of Regulation (EU) No 575/2013, institutions shall determine the upward and downward calibrated shocks by applying the following steps in sequence:

(a) they shall identify the risk-weight assigned to that risk factor in accordance with Part Three, Title IV, Chapter 1a of Regulation (EU) No 575/2013;

(b) they shall multiply that risk-weight by $1.3 \cdot \sqrt{\frac{10}{LH}}$

Where:

- LH is the liquidity horizon of the non-modellable risk factor referred to in Article 325bd of Regulation (EU) No 575/2013

(c) the upward and downward calibrated shock shall be the result of point (b).

3. Where the non-modellable risk factor is a point of a curve or a surface and it differs from other risk factors as defined in Part Three, Title IV, Chapter 1a, Section 3, Subsection 1 of Regulation (EU) No 575/2013 only in relation to the maturity dimension, institutions shall determine the upward and downward calibrated shocks by applying the following steps in sequence:

(a) from those risk factors defined in Part Three, Title IV, Chapter 1a, Section 3, Subsection 1 of Regulation (EU) No 575/2013 differing from the non-modellable risk factor only in the maturity dimension, they shall identify the risk factor that is the closest in the maturity dimension to the non-modellable risk factor;

(b) they shall identify the risk-weight assigned in accordance with Part Three, Title IV, Chapter 1a of Regulation (EU) No 575/2013 to the risk factor identified in accordance with point (a);

(c) they shall multiply that risk-weight by $1.3 \cdot \sqrt{\frac{10}{LH}}$

where:

- LH is the liquidity horizon of the non-modellable risk factor referred to in Article 325bd of Regulation (EU) No 575/2013

(d) the upward and downward calibrated shock shall be the result of point (c).

3. Where the non-modellable risk factor does not meet the conditions for determining the corresponding upward and downward calibrated shocks in accordance with either paragraph 1 or paragraph 2, the institution shall apply the method set out in paragraph 4.

4. The method referred to in paragraph 3 to determine the upward and downward calibrated shocks for the non-modellable risk-factor shall consist in selecting a risk factor that meets the conditions laid down in paragraph 5 and applying the following steps in sequence:

(a) for the selected risk factor, institutions shall determine in accordance with Article 3 the time series of 10 business days returns on the stress period determined in accordance with Article 8;

(b) institutions shall determine the downward shock and upward calibrated shock for the selected risk factor with one of the following methods:

(i) The historical method set out in article 4, provided that the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a) is greater or equal than 200.

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions of Article 6(4)(b)(ii) will be kept.

(ii) The sigma method set out in article 5.

(ii) The asymmetrical sigma method set out in article 5.

(c) institutions shall determine the downward calibrated shock for the non-modellable risk factor by multiplying the downward shock for the selected risk factor obtained in accordance with point (b) by $2/\left(1+\frac{C_{UC}}{\sqrt{2(N_{other}^{down}-1.5)}}\right)$

Where:

- $C_{UC} = 1.28$

- N_{other}^{down} is one of the following, depending on which method has been used to determine the downward calibrated shock for the selected risk factor in accordance with point (b):

  (i) the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a), where the institution used the historical method for determining the downward calibrated shock for the selected risk factor;

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions below will be retained: (ii) the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a), where the institution used the sigma method for determining the downward calibrated shock for the selected risk factor; (ii) the number of observations in the subset identified in Article 5(1)(a)(i) when applying the asymmetrical method for the selected risk factor, where the institution used the asymmetrical sigma method for determining the downward calibrated shock for the selected risk factor;

(d) institutions shall determine the upward calibrated shock for the non-modellable risk factor by multiplying the upward shock for the selected risk factor obtained in accordance with point (b) by $2/\left(1+\frac{C_{UC}}{\sqrt{2(N_{other}^{up}-1.5)}}\right)$

Where:

- $C_{UC} = 1.28$

- N_{other}^{up} is one of the following, depending on which method has been used to determine the upward calibrated shock for the selected risk factor in accordance with point (b):

  (i) the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a), where the institution used the historical method for determining the upward calibrated shock for the selected risk factor;

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions below will be retained: (ii) the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a), where the institution used the sigma method for determining the upward calibrated shock for the selected risk factor; (ii) the number of observations in the subset identified in Article 5(1)(a)(ii) when applying the asymmetrical method for the selected risk factor, where the institution used the asymmetrical sigma method for determining the upward calibrated shock for the selected risk factor;

5. The selected risk factor referred to in paragraph 4 shall meet the following conditions:

(a) it belongs to the same broad risk factor category and broad risk factor subcategory referred to in Article 325bd of Regulation (EU) No 575/2013 of the non-modellable risk factor;

(b) it is of the same nature as the non-modellable risk factor;

(c) it differs from the non-modellable risk factor for features that do not lead to an underestimation of the volatility of the non-modellable risk factor, including under stress conditions;

(d) its time series of 10 business days returns referred to in paragraph 4(a) contains at least 12 observations.

Text for consultation The fallback method has to be used by institutions whenever less than 12 returns are available in the time series of 10 business returns. The EBA expects that only in very few cases institutions will actually be in the situation of using the fallback method. The version included in these RTS presents major changes with respect to the fallback method that institutions were required to implement for the purpose of the data collection exercise and it has been revised considering feedback received in that context. As a result, the EBA consults on the new specific aspects characterising it.

Questions for consultation

Q9. What are your views on the fallback method that is envisaged for risk factors that are included in the sensitivity-based method? Please elaborate.

Q10. What are your views on the fallback method that is envisaged for risk factors that are not included in the sensitivity-based method? Please comment on both the 'other risk factor' method, and the 'changing period method'.

Q11. What are your views on the conditions identified in paragraph 5 that the 'selected risk factor' must meet under the 'other risk factor' method? What would be other conditions ensuring that a shock generated by means of the selected risk factor is accurate and prudent for the corresponding non-modellable risk factor?

Article7

Statistical estimators

1. Institutions shall calculate the estimate of the left-tail expected shortfall of a time series X with the following formula:

$$\widehat{\mathrm{ES}}_{\mathrm{Left}}(X) = \frac{-1}{\alpha N} \times \left\{ \sum_{i=1}^{[\alpha N]} X_{(\mathrm{i})} + (\alpha \cdot N - [\alpha \cdot N]) \cdot X_{([\alpha \cdot N]+1)} \right\}$$

Where:

- N is the number of observations in the time series;
- α = 2.5%;
- $[\alpha \cdot N]$ denotes the integer part of the product $\alpha \cdot N$
- $X_{(\mathrm{i})}$ denotes the i-th smallest observation in the time series X

2. Institutions shall calculate the estimate of the right-tail expected shortfall of a time series X with the following formula:

$$\widehat{\mathrm{ES}}_{\mathrm{Right}}(X) = \widehat{\mathrm{ES}}_{\mathrm{Left}}(-X)$$

Where:

- $\widehat{\mathrm{ES}}_{\mathrm{Left}}(-X)$ is the estimate of left-tail expected shortfall for the time series $-X$ calculated in accordance with paragraph 1.

3. Institutions shall calculate the estimate of the standard deviation of a time series X with the following formula:

$$\hat{\sigma}(X) = \sqrt{\frac{1}{N-1.5} \times \sum_{i=1}^{N} \left(X_{(\mathrm{i})} - \bar{X}\right)^2}$$

Where:

- $X_{(\mathrm{i})}$ is the i-th observation in the time series X
- $\bar{X}$ is the average of the observations within the time series X
- N is the number of observations within the time series X

Article 8

Determination of the stress period

1. Institutions shall determine the stress period for a broad risk factor category, by identifying the 12-months observation period maximising the following value:

$$\sum_{j \in i} RSS^{j}$$

Where:

- i denotes the broad risk factor category;
- j is the index denoting the non-modellable risk factors or the non-modellable buckets for which the institution calculates the stress scenario risk-measure belonging to the broad risk factor category i;
- RSS^{j} is the rescaled stress scenario measure for the non-modellable risk factor or the non-modellable bucket j calculated in accordance with Article 12;

2. For the purposes of identifying the stress period referred to in paragraph 3, institutions shall use an observation period starting at least the 1 January 2007, to the satisfaction of the competent authorities.

3. Institutions shall update the stress period referred to in paragraph 1 at least with a quarterly frequency.

Text for consultation

The international standards specify that the stress period has to be identified for each risk category. However, they do not clarify how such stress period has to be determined. Accordingly these draft RTS identify the measure that institutions are expected to maximize for the purpose of determining it.

Question for consultation

Q12. What are your views on the definition of stress period under option A (i.e. the period maximizing the rescaled stress scenario risk measures for risk factors belonging to the same broad risk factor category)? What would be an alternative proposal?

Article 9

Computation of the losses

1. For the purposes of this Regulation, institutions shall calculate the loss corresponding to a scenario of future shocks applied to one or more non-modellable risk factors, by calculating the loss on the portfolio of positions for which the institution calculates the own funds requirements for market risk in accordance with the alternative internal model approach in Part Three, Title IV, Chapter 1b of Regulation (EU) No 575/2013, that occurs when that scenario of future shocks is applied to that or those non-modellable risk factors and all other risk factors are kept unchanged.

2. For the purpose of this Regulation, institutions shall calculate the loss corresponding to a scenario of future shocks applied to one or more non-modellable risk factors, by using the pricing methods used in the risk measurement model.

SECTION 2

REGULATORY EXTREME SCENARIO OF FUTURE SHOCKS

Article 10

Determination of the regulatory extreme scenario of future shock

1. The regulatory extreme scenario of future shock referred to in Article 325bk(2) of Regulation (EU) No 575/2013 shall be the shock leading to the maximum loss that may occur due to a change in the non-modellable risk factor where such maximum loss is finite.

2. Where the maximum loss referred to in paragraph 1 is not finite, an institution shall apply the following steps in sequence for determining the regulatory extreme scenario of future shock:

(a) it shall use an expert-based approach using qualitative and quantitative information available to identify a loss due to a change in the value taken by the non-modellable risk factor that will not be exceeded with a level of certainty equal to 99.95% on a 10 business day horizon;

(b) it shall multiply the loss obtained in accordance with point (a) by $\sqrt{\frac{LH_{\text{adj}}}{10}}$;

where:

- $LH_{adj} = \max(20, LH)$, and where LH is the liquidity horizon for the non-modellable risk factor or for the risk factors within the non-modellable bucket referred to in Article 325bd of Regulation (EU) No 575/2013;

(c) it shall identify the regulatory extreme scenario of future shock as the shock leading to the loss resulting from points (a) and (b).

3. Where institutions calculate a stress scenario risk measure for more than one non-modellable risk factor as referred to in Article 325bk(3)(c) of Regulation (EU) No 575/2013, the regulatory extreme scenario of future shock referred to in Article 325bk(2) of Regulation (EU) No 575/2013 shall be the scenario leading to the maximum loss that may occur due to a change in the values taken by those non-modellable risk factors.

4. Where institutions calculate a stress scenario risk measure for more than one non-modellable risk factor as referred to in Article 325bk(3)(c) of Regulation (EU) No 575/2013 and the maximum loss referred to in paragraph 3 is not finite, an institution shall apply the following steps in sequence for determining the regulatory extreme scenario of future shock:

(a) it shall use an expert-based approach using qualitative and quantitative information available to identify a loss due to a change in the values taken by the non-modellable risk factors that will not be exceeded with a level of certainty equal to 99.95% on a 10 business day horizon;

(b) it shall multiply the loss obtained in accordance with point (a) by $\sqrt{\frac{LH_{\text{adj}}}{10}}$;

where:

- $LH_{adj} = \max(20, LH)$, where LH is the liquidity horizon for the non-modellable risk factors referred to in Article 325bd of Regulation (EU) No 575/2013;

(c) it shall identify the regulatory extreme scenario of future shock as the scenario leading to the loss resulting from points (a) and (b).

Text for consultation

The international standards specify that institutions may be required by the competent authority to compute the maximum loss that can occur following a change in the value taken by the non-modellable risk factor. However, there may be cases where such loss is not finite. As a result, the EBA proposes a definition upon which it consults. In addition, the EBA seeks feedback around how institutions are currently treating 'non-pricing scenarios' (see section 3.2.5 of the background section).

Questions for consultation

Q13. What are your views on the definition of maximum loss that has been included in these draft RTS for the purpose of identifying the loss to be used as maximum loss when the latter is not finite? What would be an alternative proposal?

Q14. How do you currently treat non-pricing scenarios (see section 3.2.5 of the background section) if they occur where computing the VaR measures? How do you envisage implementing them in (i) the IMA ES model and (ii) the SSRM, in particular in the case of curves and surfaces being partly shocked? What do you think should be included in these RTS to address this issue? Please put forward proposals that would not provide institutions with incentives that would be deemed non-prudentially sound and that would target only the instruments and the pricers for which the scenario can be considered a 'non-pricing scenario'.

SECTION 3

CIRCUMSTANCES UNDER WHICH INSTITUTIONS MAY CALCULATE A STRESS SCENARIO RISK MEASURE FOR MORE THAN ONE NON-MODELLABLE RISK FACTOR

Article 11

Circumstances for the calculation of a stress scenario risk-measure for more than one non-modellable risk factor

The circumstances under which institutions may calculate a stress scenario risk-measure for more than one non-modellable risk factor shall be the following:

(a) the risk factors belong to the same standard pre-defined bucket among those identified in Article 5(2) of Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013];

(b) the institution assessed the modellability of those risk factors, by determining the modellability of the standard pre-defined bucket to which they belong in accordance with Article 4(1) of Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013];

SECTION 4

AGGREGATION OF THE STRESS SCENARIO RISK MEASURES

Article 12

Aggregation of the stress scenario risk measures

1. For the purposes of aggregating the stress scenario risk measures as referred to in Article 325bk(3)(d) of Regulation (EU) No 575/2013, an institution shall for each stress scenario risk measure it has computed determine the corresponding rescaled stress scenario risk measure as follows:

(a) where the institution determined the extreme scenario of future shock for a single risk factor in accordance with the stepwise method referred to in Article 1(4), the corresponding rescaled stress scenario risk measure shall be calculated with the following formula:

$$RSS = \sqrt{\frac{LH_{\text{adj}}}{10}} \times SS \times \kappa$$

Where:

- RSS is the rescaled stress scenario risk measure
- SS is the stress scenario risk measure for the non-modellable risk factor;
- $LH_{adj} = \max(20, LH)$, where LH is the liquidity horizon referred to in Article 325bd(1) of Regulation (EU) No 575/2013 for the non-modellable risk factor;
- $\kappa$is the non-linearity coefficient for the non-modellable risk factor calculated in accordance with Article 13;

(b) where the institution determined a stress scenario risk measure for more than one risk factor by determining an extreme scenario of future shock in accordance with the stepwise method referred to in Article 2(4) for the non-modellable bucket comprising those risk factors, the corresponding rescaled stress scenario risk measure shall be calculated with the following formula:

$$RSS = \sqrt{\frac{LH_{\text{adj}}}{10}} \times SS \times \kappa$$

Where:

- SS is the stress scenario risk measure for the non-modellable bucket;

- $LH_{adj} = \max(20, LH)$, where LH is the liquidity horizon referred to in Article 325bd(1) of Regulation (EU) No 575/2013 for the risk factors within the non-modellable bucket;
- κ is the non-linearity coefficient for the non-modellable bucket to be calculated in accordance with Article 14;

(c) where the institution determined the extreme scenario of future shock for a single risk factor in accordance with the direct method referred to in Article 1(2), the corresponding rescaled stress scenario risk measure shall be calculated with the following formula:

$$RSS = \sqrt{\frac{LH_{\mathrm{adj}}}{10}} \times SS \times UC$$

Where:

- RSS is the rescaled stress scenario risk measure
- SS is the stress scenario risk measure for the non-modellable risk factor;
- $LH_{adj} = \max(20, LH)$, where LH is the liquidity horizon referred to in Article 325bd(1) of Regulation (EU) No 575/2013 for the non-modellable risk factor;
- UC is the uncertainty compensation to be calculated in accordance with Article 16.

(d) where the institution determined a stress scenario risk measure for more than one risk factor by determining an extreme scenario of future shock in accordance with the direct method referred to in Article 2(2) for the non-modellable bucket comprising those risk factors, the corresponding rescaled stress scenario risk measure shall be calculated with the following formula:

$$RSS = \sqrt{\frac{LH_{\mathrm{adj}}}{10}} \times SS \times UC$$

Where:
- RSS is the rescaled stress scenario risk measure
- SS is the stress scenario measure;
- $LH_{adj} = \max(20, LH)$, where LH is the liquidity horizon referred to in Article 325bd(1) of Regulation (EU) No 575/2013 for the risk factors within the non-modellable bucket;
- UC is the uncertainty compensation to be calculated in accordance with Article 16.

(e) where the institution determined a stress scenario risk measure by determining a regulatory extreme scenario of future shock in accordance with Article 10, the corresponding rescaled stress scenario risk measure shall be equal to that stress scenario risk measure.

2. Institutions shall aggregate the stress scenario risk measures by applying the following formula:

$$\sqrt{\sum_{\substack{k=1,\\ k \text{ idiosyncratic} \\ \text{credit spread risk factor}}} (RSS^k)^2} + \sqrt{\sum_{\substack{l=1,\\ l \text{ idiosyncratic} \\ \text{equity risk factor}}} (RSS^l)^2} + \sqrt{\left(\rho \times \sum_{\substack{j=1,\\ j \text{ not idiosyncratic} \\ \text{credit spread} \\ \text{nor} \\ \text{idiosyncratic} \\ \text{equity risk factor}}} RSS^j\right)^2 + (1-\rho^2) \times \sum_{\substack{j=1,\\ j \text{ not idiosyncratic} \\ \text{credit spread nor} \\ \text{idiosyncaratic} \\ \text{equity risk factor}}} (RSS^j)^2}$$

where:

- k denotes the non-modellable risk factor or non-modellable bucket for which the institution determined a stress scenario risk measure that was classified as reflecting idiosyncratic credit spread risk only in accordance with paragraph 3;
- l denotes the non-modellable risk factor or non-modellable bucket for which the institution determines a stress scenario risk measure that was classified as reflecting equity risk only in accordance with paragraph 4;
- j denotes a non-modellable risk factor or non-modellable bucket for which the institution determines a stress scenario risk measure that was not classified as reflecting idiosyncratic credit spread risk only in accordance with paragraph 3 or idiosyncratic equity risk only in accordance with paragraph 4;
- RSS^k, RSS^l, RSS^j are respectively the rescaled stress scenario measures for the non-modellable risk factors or the non-modellable buckets k, l, j calculated in accordance with paragraph 1;
- $\rho = 0.6$;

3. For classifying a non-modellable risk factor as reflecting idiosyncratic credit spread risk only, all of the following conditions shall be met:

(a) the nature of the risk factor is such that it shall reflect idiosyncratic credit spread risk only;
(b) the value taken by the risk factor shall not be driven by systematic risk components;
(c) the institution performs and documents the statistical tests that are used to verify the condition in point (b);

Conditions (a), (b) and (c) shall be met for each risk factor in the non-modellable bucket, for classifying a non-modellable bucket as reflecting idiosyncratic credit spread risk only.

4. For classifying a risk factor as reflecting idiosyncratic equity risk only, all of the following conditions shall be met:

(a) the nature of the risk factor is such that it shall reflect idiosyncratic equity risk only;
(b) the value taken by the risk factor shall not be driven by systematic risk components;
(c) the institution performs and documents the statistical tests that are used to verify the condition in point (b).

Conditions (a), (b) and (c) shall be met for each risk factor in the non-modellable bucket, for classifying a non-modellable bucket as reflecting idiosyncratic equity risk only.

Text for consultation

Risk factors reflecting idiosyncratic credit spread risk and idiosyncratic equity risk are aggregated with zero correlation in the aggregation formula provided in these draft RTS. The EBA consults on the conditions to meet for identifying a risk factor as reflecting credit spread risk and idiosyncratic equity risk.

Question for consultation

Q15. What are your views on the conditions included in these draft RTS for identifying whether a risk factor can be classified as reflecting idiosyncratic credit spread risk only (resp. idiosyncratic equity risk only)? Please elaborate.

Article 13

Non-linearity coefficient for a single risk factor

Where the stress scenario risk measure for which an institution is determining the non-linearity coefficient has been determined for a single risk factor, such non-linearity coefficient shall be determined as follows:

(a) where the extreme scenario of future shock for the non-modellable risk factor does not coincide with either the downward calibrated shock or the upward calibrated shock obtained as a result of point (b) in article 1(4) then the institution shall set $\kappa = 1$ for that non-modellable risk factor.

(b) where the extreme scenario of future shock for the non-modellable risk factor coincides with the downward calibrated shock obtained as a result of point (b) of Article 1(4) then the institution shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi - 1) \times 25\right]$$

where:

- $\kappa_{\min} = 0.9$;
- ϕ is the tail parameter for the non-modellable risk factor calculated in accordance with Article 15;
- loss_0 is the loss that occurs if the non-modellable risk factor is shocked with the downward shock CS_{down} obtained as a result of point (b) of Article 1(4);

- loss_{-1} is the loss that occurs if the non-modellable risk factor is shocked with a downward shock equal to $\frac{4}{5} \cdot CS_{down}$, where CS_{down} is the downward shock obtained as a result of point (b) of Article 1(4).
- loss_{+1} is the loss that occurs if the non-modellable risk factor is shocked with a downward shock equal to $\frac{6}{5} \cdot CS_{down}$, where CS_{down} is the downward shock obtained as a result of point (b) of Article 1(4).

(c) where the extreme scenario of future shock for the non-modellable risk factor coincides with the upward calibrated shock obtained as a result of point (b) of Article 1(4) then the institution shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\text{min}}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi - 1) \times 25\right]$$

Where:

- $\kappa_{\text{min}} = 0.9$;
- ϕ is the tail parameter for the non-modellable risk factor calculated in accordance with article 15;
- loss_0 is the loss that occurs if the non-modellable risk factor is shocked with the upward shock CS_{up} obtained as a result of point (b) of Article 1(4);
- loss_{-1} is the loss that occurs if the non-modellable risk factor is shocked with an upward shock equal to $\frac{4}{5} \cdot CS_{up}$, where CS_{up} is the upward shock obtained as a result of point (b) of Article 1(4).
- loss_{+1} is the loss that occurs if the non-modellable risk factor is shocked with an upward shock equal to $\frac{6}{5} \cdot CS_{up}$, where CS_{up} is the upward shock obtained as a result of point (b) of Article 1(4).

Options for consultation: Depending on whether in the final draft RTS the representative risk factor option or the contoured shift option (see Article 2) will be retained, one of the two versions of Article 14 will be retained:

Under the representative risk factor option:

Article 14

Non-linearity coefficient for a bucket

1. Where the stress scenario risk measure for which an institution is determining the non-linearity coefficient has been determined for a non-modellable bucket, the non-linearity coefficient shall be determined as follows:

(a) where the extreme scenario of future shock for the non-modellable bucket does not coincide with a shock applied to all risk factors within the non-modellable bucket that in size equals the downward calibrated shock or the upward calibrated shock obtained for the representative risk factor in the non-modellable bucket referred to in Article 2(4)(c), the institution shall set the non-linearity coefficient $\kappa = 1$ for that non-modellable bucket;

(b) where the extreme scenario of future shock for the non-modellable bucket is a downward shock applied to all risk factors within the non-modellable bucket and the size of that shock coincides with the downward calibrated shock obtained as a result of point (b) of Article 2(4) for the representative risk factor in the non-modellable bucket referred to in point (c) of Article 2(4), the institution shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi - 1) \times 25\right]$$

where:

- $\kappa_{\min} = 0.9$;
- ϕ is the tail parameter for the representative risk factor calculated in accordance with paragraph 15;
- loss_0 is the loss that occurs if all the risk factors within the bucket are shocked by the downward shock CS^R_{down}, where CS^R_{down} is the downward calibrated shock obtained as a result of point (b) of Article 2(4) for the representative risk factor;
- loss_{-1} is the loss that occurs if all the risk factors within the bucket are shocked by the downward shock $\frac{4}{5} \cdot CS^R_{down}$, where CS^R_{down} is the downward calibrated shock obtained as a result of point (b) of Article 2(4) for the representative risk factor;
- $\text{loss}_{+1}$is the loss that occurs if all risk factors within the bucker are shocked with a downward shock equal to $\frac{6}{5} \cdot CS^R_{down}$, where CS^R_{down} is the downward shock obtained as a result of point (b) of Article 2(4) for the representative risk factor.

(c) where the extreme scenario of future shock for the non-modellable bucket is an upward shock applied to all risk factors within the non-modellable bucket and the size of that shock coincides with the calibrated upward shock obtained as a result of point (b) of Article 2(4) for the representative risk factor in the non-modellable bucket referred to in point (c) of Article 2(4), the institution shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi - 1) \times 25\right]$$

Where:

- $\kappa_{\min} = 0$;
- ϕ is the tail parameter for the representative risk factor calculated in accordance with Article 15;
- loss_0 is the loss that occurs if all the risk factors within the bucket are shocked by the upward shock CS_{up}^R, where CS_{up}^R is the upward calibrated shock obtained as a result of point (b) of Article 2(4) for the representative risk factor;
- loss_{-1} is the loss that occurs if all the risk factors within the bucket are shocked by the upward shock $\frac{4}{5} \cdot CS_{up}^R$, where CS_{up}^R is the upward calibrated shock obtained as a result of point (b) of Article 2(4) for the representative risk factor;
- loss_{+1} is the loss that occurs if all risk factors within the bucket are shocked by the upward shock equal to $\frac{6}{5} \cdot CS_{up}^R$, where CS_{up}^R is the upward calibrated shock obtained as a result of point (b) of Article 2(4) for the representative risk factor.

Under the contoured shift option:

Article 14

Non-linearity coefficient for a bucket

1. Where the stress scenario risk measure for which an institution is determining the non-linearity coefficient has been determined for a non-modellable bucket, the non-linearity coefficient shall be determined as follows:

(1) Where the extreme scenario of future shock does not correspond to a scenario identified in Article 2(4)(c) for $\beta = 1$, the institution shall set the non-linearity coefficient $\kappa = 1$ for that non-modellable bucket;

(2) If the extreme scenario of future shock is a scenario where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from point (b) of article 2(4), institutions shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi_{avg} - 1) \times 25\right]$$

Where:

- $\kappa_{\min} = 0$;
- ϕ_{avg} is the average of the tail parameters calculated in accordance with Article 15 for each of the risk factors within the bucket;
- loss_0 is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from point (b) of article 2(4);
- loss_{+1} is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from point (b) of article 2(4) multiplied by 1.2;
- loss_{-1} is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from point (b) of article 2(4) multiplied by 0.8;

(3) where the extreme scenario of future shock is a scenario where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from point (b) of article 2(4), institutions shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi_{avg} - 1) \times 25\right]$$

Where:

- $\kappa_{\min} = 0$;
- ϕ_{avg} is the average of the tail parameters calculated in accordance with Article 15 for each of the risk factors within the bucket;
- loss_0 is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from point (b) of article 2(4);
- loss_{+1} is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from point (b) of article 2(4) multiplied by 1.2;
- loss_{-1} is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from point (b) of article 2(4) multiplied by 0.8;

Text for consultation

The stepwise method is based on the assumption that $ES\left(loss\left[r_j(D_t)\right]\right)$ is approximately equal to $loss\left(ES\left[r_j(D_t)\right]\right)$. However, when losses grow faster than linearly, the expected shortfall of losses for varying $r_j(D_t)$ is higher than the loss of the expected shortfall $r_j(D_t)$. Accordingly, such non-linear effects is captured in the aggregation formula. The EBA consults on some specific aspects with respect to the methodology that institutions are required to use for determining that non-linearity coefficient.

Questions for consultation

Q16. What are your views on flooring the value taken by non-linearity coefficient κ to 0.9? Please elaborate.

Q17. What are your views on the definition of the tail parameter ϕ_{avg} where a contoured shift is applied (i.e. average of the tail parameters of all risk factors within the regulatory bucket)? Please elaborate.

Article 15

Calculation of the tail parameter

1. Institutions shall calculate the tail parameter for a given non-modellable risk factor as follows:

(a) Where institutions used the historical method referred to in Article 4 for determining the upward and downward shock of that non-modellable risk factor and the extreme scenario of future shock is a downward shock, they shall calculate the tail parameter by applying the following formula:

$$\phi = \frac{\frac{1}{\alpha N} \times \left\{\sum_{i=1}^{[\alpha N]} Ret_{(\mathrm{i})}{}^2 + (\alpha \cdot N - [\alpha \cdot N]) \cdot Ret_{([\alpha N]+1)}{}^2\right\}}{\left\{\widehat{\mathrm{ES}}_{\mathrm{Left}}(Ret)\right\}^2}$$

Where:

- $\alpha = 2.5\%$
- Ret is the time series of 10 business days returns for the non-modellable risk factor used in the historical method referred to in Article 4
- $Ret_{(\mathrm{i})}$ represents the smallest i-th observation in the time series Ret
- $[\alpha \cdot N]$ denotes the integer part of $\alpha \cdot N$
- $\widehat{\mathrm{ES}}_{\mathrm{Left}}(Ret)$ is the estimate of the left-tail expected shortfall for the time series Ret calculated in accordance with Article 7(1)

(b) Where institutions used the historical method referred to in Article 4 for determining the upward and downward shock of that non-modellable risk factor and the extreme scenario of future shock is a downward shock, they shall calculate the tail parameter by applying the following formula:

$$\phi = \frac{\frac{1}{\alpha N} \times \left\{\sum_{i=1}^{[\alpha N]} (-Ret)_{(\mathrm{i})}{}^2 + (\alpha N - [\alpha N])(-Ret)_{([\alpha N]+1)}{}^2\right\}}{\left\{\widehat{\mathrm{ES}}_{\mathrm{Right}}(Ret)\right\}^2}$$

Where:

- $\alpha = 2.5\%$
- Ret is the time series of 10 business days returns for the non-modellable risk factor used in the historical method referred to in Article 4
- $-Ret_{(\mathrm{i})}$ represents the smallest i-th observation in the time series $-Ret$
- $[\alpha \cdot N]$ denotes the integer part of $\alpha \cdot N$
- $\widehat{\mathrm{ES}}_{\mathrm{Right}}(Ret)$ is the estimate of the right-tail expected shortfall for the time series Ret calculated in accordance with Article 7(2)

(c) In all other cases institutions shall set the tail parameter $\phi = 1.04$

Text for consultation

In these draft RTS, institutions are required to calculate ϕ when the historical method was used for determining the extreme scenario of future shock, while in all other cases institutions are to set it to 1.04. The EBA consults on whether it would be beneficial for institutions to set the parameter to 1.04 in all cases.

Question for consultation

Q18. Would you consider it beneficial to set the tail parameter ϕ to the constant value 1.04 regardless of the methodology used to determine the downward and upward calibrated shock (i.e. setting ϕ = 1.04 also under the historical method, instead of using the historical estimator)? Please elaborate.

Article 16

Calculation of the uncertainty factor

1. Where the stress scenario risk measure for which the institution is determining the uncertainty compensation has been determined for a single risk factor, such uncertainty compensation shall be equal to:

$$UC = \left(1 + \frac{C_{UC}}{\sqrt{2(N - 1.5)}}\right)$$

Where:

- N is the number of observations in the time series referred to in article 1(2)(a)(i) from which the extreme scenario of future shock has been determined for the non-modellable risk factor in accordance with that article.
- $C_{UC} = 1.28$

2. Where the stress scenario risk measure for which the institution is determining the uncertainty compensation has been determined for a non-modellable bucket, then uncertainty compensation shall be equal to:

$$UC = \left(1 + \frac{C_{UC}}{\sqrt{2(N - 1.5)}}\right)$$

Where:

- N is the number of observations in the time series referred to in Article 2(2)(a)(iv) from which the extreme scenario of future shock has been determined for the non-modellable bucket in accordance with that article.
- $C_{UC} = 1.28$

Article 17

This Regulation shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels,

For the Commission
The President

[For the Commission
On behalf of the President]

COMMISSION DELEGATED REGULATION (EU) No …/..

of XXX

supplementing Regulation (EU) No 575/2013 of the European Parliament and of the Council with regard to regulatory technical standards on the calculation of the stress scenario risk measure under Article 325bk(3) of Regulation (EU) No 575/2013

(Text with EEA relevance)

Box for consultation purposes:

The EBA consults as part of this consultation process on two different ways through which the abovementioned requirement set out in the CRR, and also in the Basel standards, can be met (see the two options for an RTS, option A and option B below).These two ways reflect two different overarching approaches that could be implemented for determining the stress scenario risk measure corresponding to an extreme scenario of future shock:

Option A: determination of the stress scenario risk measure directly from the stress period

Option B: rescaling a shock calibrated on the current period to obtain a shock calibrated on the stress period

2 separate versions of these draft RTS reflecting those two options have been drafted. Below, these draft RTS in accordance with option B is presented.

Draft RTS for Option B

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EU) No 575/2013 of 26 June 2013 of the European Parliament and of the Council on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012[23], and in particular the fourth subparagraph of Article 325bk(3) thereof,

Whereas:

(1) The market risk own funds requirements under the alternative internal model approach set out in Part Three, Title IV, Chapter 1b of Regulation (EU) No 575/2013 for risk factors that are not assessed to be modellable in accordance with Article 325be of that Regulation may significantly contribute to the total own funds requirements for market risk that an institution, for which the permission referred to in Article 325az has been granted, is required to meet. Accordingly, in order to ensure a level playing field among institutions in the Union and to minimise regulatory arbitrage, this Regulation should further develop international standards and set out specific and detailed methodologies for developing an extreme scenario of future shock for a non-modellable risk factor.

(2) Given that, it is possible to approximate the expected shortfall of the losses that may occur following a change in the non-modellable risk factor, and since that would keep the computational effort minimal, this Regulation should provide for such an approximation in order to calculate the expected shortfall of the losses. The method should consist in first calculating an expected shortfall on the returns observed for that risk factor and then calculating the loss corresponding to the movement in the risk factor identified by that expected shortfall.

(3) The quality of the data and the number of observations that are available to determine a future shock for a non-modellable risk factor may vary significantly from one non-modellable risk factor to another. In order to ensure an appropriate development of the extreme scenario of future shock for a wide range of cases, this Regulation should provide alternative sets of methodologies that institutions may use depending on the number of observations that are available for a non-modellable risk factor. In addition, this Regulation should require institutions to reflect in their calculations that the estimates or values used to determine the extreme scenario of future shock have a higher uncertainty and should become more conservative when less data are available.

(4) This Regulation should also address the specific case where the number of observations for a non-modellable risk factor in the relevant observation period is insufficient to obtain accurate and prudent estimates. Since such specific situation

[23] [23] OJ L 176, 27.6.2013, p. 1.

can be expected to occur only in a limited number of cases, those cases should be addressed by leveraging on methodologies that institutions have implemented for other non-modellable risk factors for which they have more observations.

(5) To ensure the alignment of the Union with the international standards, the market risk own funds requirements under the alternative internal model associated to non-modellable risk factors should be calibrated to a period of stress that is common to all non-modellable risk factors in the same broad risk factor category referred to in Article 325bd of Regulation (EU) No 575/2013 and that is updated with a quarterly frequency.

(6) Considering that for non-modellable risk factors, data availability in a period of stress might be limited, institutions should be required to collect data on non-modellable risk factors on a current period to foster the quality of the data that are used to calibrate the extreme scenarios of future shocks. Thus, institutions should be required to calibrate shocks on the data observed in the current period and to rescale those shocks to reflect the stress period conditions that are typical of the broad risk category to which the non-modellable risk factor belongs.

(7) To ensure that the level of own funds requirements for market risk of a non-modellable risk factor is as high as if that risk factor was modellable in accordance with the requirement set out in Article 325bk(3) of Regulation (EU) No 575/2013, this Regulation should require institutions to calibrate such level to an expected shortfall of losses at a 97.5% confidence level over a period of stress. Accordingly, the statistical estimators and the parameters included in this Regulation should be set to ensure such confidence is met.

(8) In order to ensure the alignment of the Union with the international standards, the regulatory extreme scenario of future shock should be the one leading to the maximum loss that may occur due to a change in the non-modellable risk factor. This regulation should also clarify what institutions should consider as maximum loss where this is not finite.

(9) In line with the international standards institutions may determine the stress scenario risk measure for more than one non-modellable risk factors, where those risk factors are part of a curve or a surface and they belong to the same non-regulatory bucket among those set out in Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013] and their modellability has been assessed in accordance with the standardised bucketing approach referred to in that Regulation. To avoid any deviation of the Union from the international standards, this regulation should allow institutions to compute a unique stress scenario risk measure for more than one non-modellable risk factor under those conditions only.

(10) Institutions should be required to aggregate the stress scenario risk-measure by first rescaling them to reflect risks that were not yet captured where determining the extreme scenario of future shock e.g. the liquidity horizons of the non-modellable risk factors, and by then applying the aggregation formula agreed in the international standards.

(11) This Regulation is based on the draft regulatory technical standards submitted by the European Banking Authority to the Commission.

(12) EBA has conducted open public consultations on the draft regulatory technical standards on which this Regulation is based, analysed the potential related costs and benefits, and requested the opinion of the Banking Stakeholder Group established in accordance with Article 37 of Regulation (EU) No 1093/2010[24],

HAS ADOPTED THIS REGULATION:

Questions for consultation

Q1. *What is your preferred option among option A (stress period based extreme scenario of future shock) and option B (extreme scenario of future shock rescaled to stress period)? Please elaborate highlighting pros and cons.*

Q2. *What are characteristics of the data available for NMRF in the data observation periods under options A and B?*

SECTION 1

DEVELOPMENT AND APPLICATION OF THE EXTREME SCENARIO OF FUTURE SHOCKS

Article 1

Development and application of the extreme scenario of future shocks at risk factor level

1. Institutions shall develop the extreme scenario of future shock for a non-modellable risk factor for the purposes of Article 325bk(3)(a) of Regulation (EU) No 575/2013 by applying the following steps in sequence:

(a) they shall determine the time series of 10 business days returns for the non-modellable risk factor on the preceding 12 months in accordance with Article 3;

(b) they shall determine an upward and a downward calibrated shock from the time series of 10 business days returns referred to in point (a) in accordance with one of following methods:

(i) the historical method set out in Article 4, provided that the number of observations in the time series referred to in point (a) is greater than or equal to 200;

[24] Regulation (EU) No 1093/2010 of the European Parliament and of the Council of 24 November 2010 establishing a European Supervisory Authority (European Banking Authority), amending Decision No 716/2009/EC and repealing Commission Decision 2009/78/EC (OJ L 331, 15.12.2020, p. 12).

Options for consultation: Depending on whether in the the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions of Article 1(1)(b)(ii) will be kept.

(ii) the sigma method set out in Article 5, provided that the number of observations in the time series referred to in point (a) is greater than or equal to 12;

(ii) the asymmetrical sigma method set out in Article 5, provided that the number of observations in the time series referred to in point (a) is greater than or equal to 12;

(iii) the fallback method set out in Article 6, which shall be applied where the number of observations in the time series referred to in point (a) is lower than 12;

(c) they shall multiply the upward and the downward calibrated shocks obtained as result of point (b) by $m_{S,C}^{i}$ which shall be determined in accordance with the following formula:

$$m_{S,C}^{i} = \underset{j \in i}{trimmed\_mean_{0.01}} \left[\frac{\hat{\sigma}^{S}{}_{Ret_j}}{\hat{\sigma}^{C}{}_{Ret_j}} \right]$$

Where:

- i denotes the broad risk factor category referred to in Article 325bd of Regulation (EU) No 575/2013 to which the non-modellable risk factor belongs;

- $j \in i$ denotes all risk factors belonging to the broad risk factor category i in the subset of the modellable risk factors chosen by the institution in accordance with Article 325bc(2)(a) of Regulation (EU) No 575/2013;

- $\hat{\sigma}^{S}{}_{Ret_j}$ denotes the standard deviation calculated in accordance with Article 7(3) of the time series of 10 business days returns obtained in accordance with Article 3 for the risk factor j on the stress period S as determined in accordance with Article 8;

- $\hat{\sigma}^{C}{}_{Ret_j}$ denotes the standard deviation calculated in accordance with Article 7(3) of the time series of 10 business days returns obtained in accordance with Article 3 for the risk factor j on the preceding 12-months period C.

- $trimmed\_mean_{0.01}$ denotes the function that, given any sample of observations as input and after removing an X number of lowest and highest observations, computes the average of that trimmed sample. The number X is the integer part of $N_{sample} \times 0.01 + 1$, where N_{sample} is the number of observations in the sample.

Institutions shall update the value taken by $m_{S,C}^{i}$ at the same date at which the stress period is updated in accordance with article 8.

(d) for each shock included in the following grid, institutions shall calculate the loss that occurs when that shock is applied to the non-modellable risk factor:

$$grid = \left\{ \frac{4}{5} \cdot CS_{\text{down}}, CS_{\text{down}}, \frac{4}{5} \cdot CS_{\text{up}}, CS_{\text{up}} \right\}$$

Where:

- CS_{down} is the downward calibrated shock obtained as a result of point (c);
- CS_{up} is the upward calibrated shock obtained as a result of point (c).

(e) that shock which lead to the highest loss computed in accordance with point (d) shall constitute the extreme scenario of future shock for the non-modellable risk factor.

2. Where an institution has in accordance with Article 1(2) of Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013] chosen to replace the 12 months period referred to Article 1(1) of that Regulation with another 12-months period, it shall apply the shift in time resulting from the application of that Article to the 12 months period referred to in point (a) of paragraph 1 and use such shifted 12-months period where applying that point.

3. Institutions shall update the time series referred to in paragraph 1(a) on a monthly basis.

Article 2

Development and application of the extreme scenario of future shocks at bucket level

1. Where institutions calculate a stress scenario risk measure for more than one non-modellable risk factor as referred to in Article 325bk(3)(c) of Regulation (EU) No 575/2013, they shall determine an extreme scenario of future shock for the non-modellable bucket to which those risk factors belong in accordance Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013].

2. Institutions shall determine the extreme scenario of future shock for a non-modellable standardised bucket as referred to in paragraph (1) by applying the following steps in sequence:

(a) for each non-modellable risk factor within the non-modellable standardised bucket they shall determine the time series of 10 business days returns on the preceding 12 months period in accordance with Article 3;

(b) for each non-modellable risk factor within the non-modellable standardised bucket, they shall determine an upward and a downward calibrated shock from the corresponding time series of 10 business days returns referred to in point (a) in accordance with one of the following methods:

(i) the historical method set out in article 4, provided that the number of observations in the time series referred to in point (a) corresponding to the non-modellable risk factor is greater than or equal to 200;

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions of Article 2(2)(b)(ii) will be kept.

(ii) the sigma method set out in Article 5, provided that the number of observations in the time series referred to in point (a) corresponding to the non-modellable risk factor is greater than or equal to 12;

(ii) the asymmetrical sigma method set out in Article 5, provided that the number of observations in the time series referred to in point (a) corresponding to the non-modellable risk factor is greater than or equal to 12;

(iii) the fallback method set out in article 6, which shall be applied to all non-modellable risk factors within the non-modellable bucket where there is at least one non-modellable risk factor in the non-modellable bucket for which the number of observations in the time series of 10 business days returns referred to in point (a) is lower than 12;

(c) For each non-modellable risk factor, they shall multiply the upward and the downward shock obtained as result of point (b) by $m^i_{S,C}$ calculated in accordance with Article 1(1)(c).

Below two different options are presented for consultation with respect to the determination of the extreme scenario of future shock at bucket level. Only one of the options in relation to paragraphs (d), (e) and (f) of Article 2(2) will be kept in the final draft RTS.

Option 1: Representative risk factor – parallel shift option:

(d) they shall identify the representative risk factor in the non-modellable bucket by identifying the risk factor to which the highest absolute shock among the downward and upward calibrated shocks resulting from point (c) corresponds;

(e) for each shock included in the following grid, they shall calculate the loss that occurs when that shock is applied to all risk factors within the non-modellable bucket:

$$Grid = \left\{ \frac{4}{5} \cdot CS_{down}^{R}, CS_{down}^{R}, \frac{4}{5} \cdot CS_{up}^{R}, CS_{up}^{R} \right\}$$

Where:
- CS_{down}^{R} is the downward shock obtained as a result of point (c) for the representative risk factor identified in accordance with point (d);

- CS_{up}^{R} is the upward shock obtained as a result of point (c) for the representative risk factor identified in accordance with point (d);

(f) they shall consider as the extreme scenario of future shock for the non-modellable bucket that scenario, from among those identified by the shock in the grid referred to in point (e), to which the highest loss among those computed in accordance with point (e) corresponds.

Option 2: Contoured shift option:

(d) they shall calculate both of the following:

(i) the loss corresponding to a scenario where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from step (c) multiplied by β, in two cases: where $\beta = 1$ and where β= 0.8;

(ii) the loss corresponding to a scenario where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from step (c) multiplied by β, in two cases: where $\beta = 1$ and where β= 0.8;

(e) the scenario of shocks to which the highest loss among those computed in accordance with point (d) corresponds shall constitute the extreme scenario of future shock for the non-modellable bucket.

3. Where an institution has in accordance with Article 1(2) of Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013] chosen to replace the 12 months period referred to Article 1(1) of that Regulation with another 12-months period, it shall apply the shift in time resulting from the application of that Article to the 12 months period referred to in point (a) of paragraph 2 and use such shifted 12-months period where applying that point.

4. Institutions shall update the time series referred to in paragraph 2(a) on a monthly basis.

Question for consultation

Q4. *What is your preferred option among (i) the representative risk factor – parallel shift option, and (ii) the contoured shift option? Please elaborate highlighting pros and cons.*

Article 3

Determination of the time series of 10 business days returns

1. Institutions shall determine the time series of 10 business days returns for a 12 months observation period in relation to a given non-modellable risk factor by applying the following steps in sequence:

(a) they shall determine the time series of observations for the non-modellable risk factor on the 12 months observation period; iinstitutions shall include in this time series only one observation per business day and the observations shall represent actual market data;

(b) institutions shall extend the time series referred to in point (a) by including the observations available within the period of up to 20 business days following the 12 months observation period;

(c) in relation to each date D_t, for which there is an observation in the time series resulting from point (a), excluding the last observation, institutions shall determine among the dates with an observation in the extended time series referred to in point (b) the date $D_{t'}$ following D_t that minimizes the following value:

$$v = \left|\frac{10\ days}{D_{t'} - D_t} - 1\right|$$

Where:

- D_t is the date for which there is an observation in the time series referred to in point (a), excluding the last observation;

- $D_{t'}$ is a date following D_t with an observation in the extended time series referred to in point (b);

- the difference $D_{t'} - D_t$ is expressed in business days;

where there is more than one date minimising that value, the date $D_{t'}$ shall be the date among those minimising that value that occurred later in time;

(d) in relation to each date D_t, for which there is an observation in the time series resulting from point (a), excluding the last observation, they shall determine the corresponding 10 business days return by determining the return for the non-modellable risk factor over the period between the date D_t of the observation and the date $D_{t'}$ minimising the value v in accordance with point (c), and subsequently rescaling it to obtain a return over a 10 business days period.

2. The time series referred to in paragraph 1(a) shall at least include the observations that were used for calibrating the scenarios of future shocks referred to in Article 325bc of Regulation (EU) No 575/2013, where that risk factor has been previously assessed to be modellable in accordance with Article 325be of Regulation (EU) No 575/2013.

3. For the purposes of paragraph 1(b), institutions shall extend the 12 months observation period by the same number of business days for each non-modellable risk factor.

Question for consultation

Q5. *What are your views on how institutions are required to build the time series of 10 business days returns? Please elaborate.*

Article 4

Upward and downward calibrated shocks with the historical method

1. For determining the downward calibrated shock from a time series of 10 business days returns for a non-modellable risk factor with the historical method, institutions shall use the following formula:

$$Calibrated\ downward\ shock = \widehat{\mathrm{ES}}_{\mathrm{Left}}(Ret) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N - 1.5)}}\right)$$

Where:

- Ret denotes the time series of 10 business days returns of the non-modellable risk factor;
- $\widehat{\mathrm{ES}}_{\mathrm{Left}}(Ret)$ is the estimate of the left-tail expected shortfall for the time series Ret calculated in accordance with Article 7(1)
- N represents the number of observations in the time series Ret
- $C_{UC} = 1.28$

2. For determining the upward calibrated shock from a time series of 10 business days returns for a non-modellable risk factor with the historical method, institutions shall use the following formula:

$$\mathit{Calibrated\ upward\ shock} = \widehat{\mathrm{ES}}_{\mathrm{Right}}(Ret) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$$

Where:
- Ret denotes the time series of 10 business days returns
- $\widehat{\mathrm{ES}}_{\mathrm{Right}}(Ret)$ is the estimate of the right-tail expected shortfall for the time series Ret calculated in accordance with Article 7(2)
- N represents the number of observations in the time series Ret
- $C_{UC} = 1.28$

Below two different options (the sigma method option, and the asymmetrical sigma method option) are presented for consultation with respect to the method that institutions could use for determining a downward and an upward calibrate shock where more than 12 observations in the time series of 10 business days returns are available. Only one version of Article 5 will be kept in the final draft RTS.

Option 1: the sigma method

Article 5

Upward and downward calibrated shocks with the sigma method

For determining the upward and downward calibrated shock from a time series of 10 business days returns for a non-modellable risk factor with the sigma method, institutions shall use:

(a) in relation to the upward calibrated shock the following formula:

$$\mathit{Calibrated\ upward\ shock} = C_{ES} \cdot \widehat{\sigma}(Ret) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$$

(b) in relation to the downward calibrated shock the following formula:

$$\mathit{Calibrated\ downward\ shock} = C_{ES} \cdot \widehat{\sigma}(Ret) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$$

Where:
- Ret denotes the time series of 10 business days returns of the non-modellable risk factor;

- $\widehat{\sigma}(Ret)$ is the estimate of the standard deviation for the time series Ret calculated in accordance with Article 7(3)
- N represents the number of observations in the time series of 10 business days returns
- $C_{ES} = 3$
- $C_{UC} = 1.28$

Option 2: the asymmetrical sigma method

Article 5

Upward and downward calibrated shocks with the asymmetrical sigma method

1. For determining the upward and downward calibrated shock from a time series of 10 business days returns for a non-modellable risk factor with the asymmetrical sigma method, institutions shall apply the following steps in sequence:

(a) they shall determine the median of the observations within the time series, and split the 10 business days returns comprised in that time series into the two following subsets:

(i) the subset of 10 business days returns which value is lower than or equal to the median;

(ii) the subset of 10 business days returns which value is greater than the median;

(b) For each subset referred in point (a), they shall compute the mean of the 10 business days returns in the subset;

(c) they shall determine the downward calibrated shock in accordance with the following formula:

$$Calibrated\ downward\ shock$$

$$= \left(\left| \hat{\mu}_{Ret \leq m} \right| + C_{ES} \cdot \sqrt{\frac{1}{N_{\text{down}} - 1.5} \times \sum_{\substack{i=1, \\ Ret_{(\text{i})} \leq m}}^{N} \left(Ret_{(\text{i})} - \hat{\mu}_{Ret \leq m} \right)^2} \right) \cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N_{\text{down}} - 1.5)}} \right)$$

Where:

- Ret denotes the time series of 10 business days returns of the non-modellable risk factor;
- $Ret_{(\text{i})}$ is the i-th observation in the 10 business days returns time series Ret;
- m is the median of the 10 business days returns time series Ret;
- $\hat{\mu}_{Ret \leq m}$ denotes the mean of the 10 business days returns obtained as a result of point (b) on the subset identified in point (a)(i);

- $|\hat{\mu}_{Ret \leq m}|$ is the absolute value of $\hat{\mu}_{Ret \leq m}$;
- N_{down} is the number of 10 business days returns in the subset identified in point (a)(i);
- N is the number of observations in the 10 business days returns time series Ret;
- $C_{ES} = 3$;
- $C_{UC} = 1.28$;

(d) they shall determine the upward calibrated shock in accordance with the following formula:

$$Calibrated\ upward\ shock$$

$$= \left(|\hat{\mu}_{Ret>m}| + C_{ES} \cdot \sqrt{\frac{1}{N_{\text{up}} - 1.5} \times \sum_{\substack{i=1, \\ Ret_{(\text{i})} > m}}^{N} \left(Ret_{(\text{i})} - \hat{\mu}_{Ret>m} \right)^2} \right)$$

$$\cdot \left(1 + \frac{C_{UC}}{\sqrt{2(N_{\text{up}} - 1.5)}} \right)$$

Where:

- Ret denotes the time series of 10 business days returns of the non-modellable risk factor;
- $Ret_{(\text{i})}$ is the i-th observation in the 10 business days returns time series Ret;
- m is the median of the 10 business days returns time series Ret;
- $\hat{\mu}_{Ret>m}$ denotes the mean of the 10 business days returns obtained as a result of point (b) on the subset identified in point (a)(ii);
- $|\hat{\mu}_{Ret>m}|$ is the absolute value of $\hat{\mu}_{Ret>m}$;
- N_{up} is the number of observations in the subset identified in point (a)(ii);
- N is the number of observations in the 10 business days returns time series Ret;
- $C_{ES} = 3$;
- $C_{UC} = 1.28$;

Questions for consultation

Q6. *What is your preferred option among (i) the sigma method and (ii) the asymmetrical sigma method for determining the downward and upward calibrated shocks? Please highlight the pros and cons of the options. In addition, do you think that in the asymmetrical sigma method, returns should be split at the median or at another point (e.g. at the mean, or at zero)? Please elaborate.*

Q7. *What are your views on the value taken by the constant C_{ES} for scaling a standard deviation measure to approximate an expected shortfall measure?*

Q8. *What are your views on the uncertainty compensation factor $\left(1+\frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$? Please note that this question is also relevant for the purpose of the historical method.*

Article 6

Calibrating upward and downward shocks with the fallback method

1. For determining the upward and downward calibrated shock from the time series of 10 business days returns for a non-modellable risk factor with the fallback method, institutions shall apply one of the methodologies set out in this Article.

2. Where the non-modellable risk factor coincides with one of the risk factors defined in Part Three, Title IV, Chapter 1a, Section 3, Subsection 1 of Regulation (EU) No 575/2013, institutions shall determine the upward and downward calibrated shocks by applying the following steps in sequence:

(a) they shall identify the risk-weight assigned to that risk factor in accordance with Part Three, Title IV, Chapter 1a of Regulation (EU) No 575/2013;

(b) they shall multiply that risk-weight by $1.3 \cdot \sqrt{\frac{10}{LH}}$

Where:

- LH is the liquidity horizon of the non-modellable risk factor referred to in Article 325bd of Regulation (EU) No 575/2013

(c) they shall divide the result of point (b) by $m_{S,C}^{i}$ calculated in accordance with Article 1(1)(c).

(d) the upward and downward calibrated shock shall be the result of point (c).

3. Where the non-modellable risk factor is a point of a curve or a surface and it differs from other risk factors as defined in Part Three, Title IV, Chapter 1a, Section 3, Subsection 1 of Regulation (EU) No 575/2013 only in relation to the maturity dimension, institutions shall determine the upward and downward calibrated shocks by applying the following steps in sequence:

(a) from those risk factors defined in Part Three, Title IV, Chapter 1a, Section 3, Subsection 1 of Regulation (EU) No 575/2013 differing from the non-modellable risk factor only in the maturity dimension, they shall identify the risk factor that is the closest in the maturity dimension to the non-modellable risk factor;

(b) they shall identify the risk-weight assigned in accordance with Part Three, Title IV, Chapter 1a of Regulation (EU) No 575/2013 to the risk factor identified in accordance with point (a);

(c) they shall multiply that risk-weight by $1.3 \cdot \sqrt{\frac{10}{LH}}$

Where:

- LH is the liquidity horizon of the non-modellable risk factor referred to in Article 325bd of Regulation (EU) No 575/2013

(d) they shall divide the result of point (c) by $m_{S,C}^{i}$ calculated in accordance with Article 1(1)(c).

(e) the upward and downward calibrated shock shall be the result of point (d).

3. Where the non-modellable risk factor does not meet the conditions for determining the corresponding upward and downward calibrated shocks in accordance with either paragraph 1 or paragraph 2, the institution shall apply one among the methods set out in paragraphs 4 and 6.

4. For the purposes of paragraph 3, one method that institutions may apply to determine the upward and downward calibrated shocks for the non-modellable risk-factor, shall consist in selecting a risk factor that meets the conditions laid down in paragraph 5 and applying the following steps in sequence:

(a) For the selected risk factor, institutions shall determine in accordance with Article 3 the time series of 10 business days returns on the observation period that was used to determine the time series of 10 business days returns referred to in paragraph 1 for the non-modellable risk factor.

(b) Institutions shall determine the downward shock and upward calibrated shock for the selected risk factor with one of the following methods:

(i) The historical method set out in article 4, provided that the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a) is greater or equal than 200.

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions of Article 6(4)(b)(ii) will be kept.

(ii) The sigma method set out in article 5.

(ii) The asymmetrical sigma method set out in article 5.

(c) Institutions shall determine the downward calibrated shock for the non-modellable risk factor by multiplying the downward shock for the selected risk factor obtained in accordance with point (b) by $2/\left(1+\frac{C_{UC}}{\sqrt{2(N_{other}^{down}-1.5)}}\right)$

Where:

- $C_{UC} = 1.28$
- N_{other}^{down} is one of the following, depending on which method has been used to determine the downward calibrated shock for the selected risk factor in accordance with point (b):

  (i) the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a), where the institution used the historical method for determining the downward calibrated shock for the selected risk factor;

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions below will be retained:

(ii) the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a), where the institution used the sigma method for determining the downward calibrated shock for the selected risk factor;

(ii) the number of observations in the subset identified in Article 5(1)(a)(i) when applying the asymmetrical method for the selected risk factor, where the institution used the asymmetrical sigma method for determining the downward calibrated shock for the selected risk factor;

(d) Institutions shall determine the upward calibrated shock for the non-modellable risk factor by multiplying the upward shock for the selected risk factor obtained in accordance with point (b) by $2/\left(1+\frac{C_{UC}}{\sqrt{2(N_{other}^{up}-1.5)}}\right)$

Where:

- $C_{UC} = 1.28$

- N_{other}^{up} is one of the following, depending on which method has been used to determine the upward calibrated shock for the selected risk factor in accordance with point (b):

  (i) the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a), where the institution used the historical method for determining the upward calibrated shock for the selected risk factor;

> **Options for consultation:** Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions below will be retained:
>
> (ii) the number of observations in the time series of 10 business days returns for the selected risk factor referred to in point (a), where the institution used the sigma method for determining the upward calibrated shock for the selected risk factor;
>
> (ii) the number of observations in the subset identified in Article 5(1)(a)(ii) when applying the asymmetrical method for the selected risk factor, where the institution used the asymmetrical sigma method for determining the upward calibrated shock for the selected risk factor;

5. The selected risk factor referred to in paragraph 4 shall meet the following conditions:

(a) it belongs to the same broad risk factor category and broad risk factor subcategory referred to in Article 325bd of Regulation (EU) No 575/2013 of the non-modellable risk factor;

(b) it is of the same nature as the non-modellable risk factor;

(c) it differs from the non-modellable risk factor for features that do not lead to an underestimation of the volatility of the non-modellable risk factor, including under stress conditions;

(d) its time series of 10 business days returns referred to in paragraph 4(a) contains at least 12 observations.

6. For the purposes of paragraph 3, one method that institutions may apply to determine the downward and upward calibrated shocks, shall consist in applying the following steps in sequence:

(a) Institutions determine the 10 business days returns time series for the non-modellable risk factor in accordance with Article 3 considering as observation period a 12-months period chosen by the institution. The 12-months period chosen by the institution shall lead to a time series of 10 business days returns including at least 12 observations.

(b) Institutions determine a downward shock and upward calibrated shock for the time series referred to in point (a) with one of the following methods:

(i) The historical method set out in article 4. For using this method, the number of observations in the time series shall be greater or equal than 200.

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions of Article 6(6)(b)(ii): (ii) The sigma method set out in article 5. (ii) The asymmetrical sigma method set out in article 5.

(c) Institutions determine the downward calibrated shock for the non-modellable risk factor multiplying the downward calibrated shock resulting from point (b) by

$$2 * \frac{1}{m^{i}_{P*,C}} \cdot \frac{1}{\left(1 + \frac{C_{UC}}{\sqrt{2(N^{down}_{P*} - 1.5)}}\right)}$$

Where:

- $C_{UC} = 1.28$

- N^{down}_{P*} is one of the following, depending on which method has been used to determine the downward calibrated shock in accordance with point (b):

  (i) it is the number of observations in the time series of 10 business days returns referred to in point (a), where the institution used the historical method for determining the downward calibrated shock;

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions below will be retained: (ii) the number of observations in the time series of 10 business days returns referred to in point (a), where the institution used the sigma method for determining the downward calibrated shock; (ii) the number of observations in the subset identified in Article 5(1)(a)(i) when applying the asymmetrical method for the time series referred to in point (a), where

the institution used the asymmetrical sigma method for determining the downward calibrated shock;

and where:

$$m^{i}_{P^*,C} = \underset{j \in i}{trim\_average_{0.01}} \left[\frac{\hat{\sigma}^{P^*}{}_{Ret_j}}{\hat{\sigma}^{C}{}_{Ret_j}} \right]$$

where:

- i denotes the broad risk factor category to which the non-modellable risk factor belongs;
- $j \in i$ denotes all risk factors belonging to the broad risk factor category i in the subset of the modellable risk factors chosen by the institution in accordance with Article 325bc(2)(a) of Regulation (EU) No 575/2013;
- $\hat{\sigma}^{P^*}{}_{Ret_j}$ denotes the standard deviation calculated in accordance with Article 7(3) of the time series of 10 business days returns obtained for the risk factor j on the observation period P^* chosen by the institutions in accordance with point (a);
- $\hat{\sigma}^{C}{}_{Ret_j}$ denotes the standard deviation calculated in accordance with Article 7(3) of the time series of 10 business days returns obtained for the risk factor j on the preceding 12-months period C.
- $trim\_average_{0.01}$ denotes the function that, given any sample of observations as input and after removing an X number of lowest and highest observations, computes the average of that trimmed sample. The number X is the integer part of $N_{sample} \times 0.01 + 1$, where N_{sample} is the number of observations in the sample.

Institutions shall update $m^{i}_{P^*,C}$ at the same date at which the stress period is updated in accordance with article 8.

(d) Institutions determine the upward calibrated shock for the non-modellable risk factor multiplying the calibrated upward calibrated shock resulting from point (b) by:

$$2 \cdot \frac{1}{m^{i}_{P^*,C}} \cdot \frac{1}{\left(1 + \frac{C_{UC}}{\sqrt{2(N^{up}_{P*} - 1.5)}}\right)}$$

where:

- $C_{UC} = 1.28$;

- N^{up}_{P*} is one of the following, depending on which method has been used to determine the upward calibrated shock in accordance with point (b);

(i) it is the number of observations in the time series of 10 business days returns referred to in point (a), where the institution used the historical method for determining the upward calibrated shock;

Options for consultation: Depending on whether in the final draft RTS the sigma method or the asymmetrical sigma method (see Article 5) will be retained, one of the two versions below will be retained:

(ii) the number of observations in the time series of 10 business days returns referred to in point (a), where the institution used the sigma method for determining the upward calibrated shock;

(ii) the number of observations in the subset identified in Article 5(1)(a)(ii) when applying the asymmetrical method for the time series referred to in point (a), where the institution used the asymmetrical sigma method for determining the upward calibrated shock;

- $m^{i}_{P^*,C}$ as defined as in point (c)

Questions for consultation

Q9. *What are your views on the fallback method that is envisaged for risk factors that are included in the sensitivity-based method? Please elaborate.*

Q10. *What are your views on the fallback method that is envisaged for risk factors that are not included in the sensitivity-based method? Please comment on both the 'other risk factor' method, and the 'changing period method'.*

Q11. *What are your views on the conditions identified in paragraph 5 that the 'selected risk factor' must meet under the 'other risk factor' method? What would be other conditions ensuring that a shock generated by means of the selected risk factor is accurate and prudent for the corresponding non-modellable risk factor?*

Article 7

Statistical estimators

1. Institutions shall calculate the estimate of the left-tail expected shortfall of a time series X with the following formula:

$$\widehat{\mathrm{ES}}_{\mathrm{Left}}(X) = \frac{-1}{\alpha N} \times \left\{ \sum_{i=1}^{[\alpha N]} X_{(\mathrm{i})} + (\alpha \cdot N - [\alpha \cdot N]) \cdot X_{([\alpha \cdot N]+1)} \right\}$$

where:

- N is the number of observations in the time series;
- α = 2.5%;
- $[\alpha \cdot N]$ denotes the integer part of the product $\alpha \cdot N$
- $X_{(\mathrm{i})}$ denotes the i-th smallest observation in the time series X

2. Institutions shall calculate the estimate of the right-tail expected shortfall of a time series X with the following formula:

$$\widehat{\mathrm{ES}}_{\mathrm{Right}}(X) = \widehat{\mathrm{ES}}_{\mathrm{Left}}(-X)$$

where:

- $\widehat{\mathrm{ES}}_{\mathrm{Left}}(-X)$ is the estimate of left-tail expected shortfall for the time series $-X$ calculated in accordance with paragraph 1.

3. Institutions shall calculate the estimate of the standard deviation of a time series X with the following formula:

$$\hat{\sigma}(X) = \sqrt{\frac{1}{N - 1.5} \times \sum_{i=1}^{N} \left(X_{(\mathrm{i})} - \bar{X} \right)^2}$$

Where:

- $X_{(\mathrm{i})}$ is the i-th observation in the time series X
- $\bar{X}$ is the average of the observations within the time series X
- N is the number of observations within the time series X

Article 8

Determination of the stress period

1. Institutions shall determine the stress period for a broad risk factor category, by identifying the 12-months observation period P maximising the value of $m^{i}_{P,C}$:

$$m^{i}_{P,C} = \underset{j \in i}{trimmed\_mean_{0.01}} \left[\frac{\hat{\sigma}^{P}{}_{Ret_j}}{\hat{\sigma}^{C}{}_{Ret_j}} \right]$$

where:

- i denotes the broad risk factor category
- $j \in i$ denotes all risk factors belonging to the broad risk factor category i in the subset of the modellable risk factors chosen by the institution in accordance with Article 325bc(2)(a) of Regulation (EU) No 575/2013.
- $\hat{\sigma}^{P}{}_{Ret(j)}$ denotes the standard deviation calculated in accordance with article 7(3) of the time series of 10 business days returns obtained in accordance with Article 3 for the risk factor j on the observation period P;
- $\hat{\sigma}^{C}{}_{Ret(j)}$ denotes the standard deviation calculated in accordance with Article 7(3) of the time series of 10 business days returns obtained in accordance with Article 3 for the risk factor j on the preceding 12-months period C.
- $trimmed\_mean_{0.01}$ denotes the function that, given any sample of observations as input and after removing an X number of lowest and highest observations, computes the average of that trimmed sample. The number X is the integer part of $N_{sample} \times 0.01 + 1$, where N_{sample} is the number of observations in the sample.

2. For the purpose of identifying the stress period referred to in paragraph 1, institutions shall use an observation period starting at least the 1 January 2007, to the satisfaction of the competent authorities.

3. Institutions shall update the stress period referred to in paragraph 1 at least with a quarterly frequency.

Text for consultation

The overarching approach proposed under option B institutions are required to obtain a shock calibrated on the stress period rescaling a shock calibrated on the current period. The draft RTS specify that such rescaling has to be performed by means of the scalar $m^{i}_{S,C}$ which is obtained via a trimmed mean. The EBA consults on whether the definition of such scalar is appropriate, and on whether more specifications are needed for cases where the institution does not have any modellable risk factor in a risk class.

Questions for consultation

Q19. Do you agree with the definition of the rescaling factor $m^{i}_{S,C}$ under option B or do you think that the rescaling of a shock from the current period to the stress period should be performed differently? Please elaborate.

Q20. The scalar $m^{i}_{S,C}$ is obtained by using data related to modellable risk-factors in a specific risk class (i.e. the class i). As a result, such a scalar is not defined where an institution does not have any modellable risk factor in this risk class. How do you think the scalar $m^{i}_{S,C}$ should be determined in those cases? Please elaborate.

Article 9

Computation of the losses

1. For the purposes of this Regulation, institutions shall calculate the loss corresponding to a scenario of future shocks applied to one or more non-modellable risk factors, by calculating the loss on the portfolio of positions for which the institution calculates the own funds requirements for market risk in accordance with the alternative internal model approach in Part Three, Title IV, Chapter 1b of Regulation (EU) No 575/2013, that occurs when the scenario of future shocks is applied to that or those non-modellable risk factors and all other risk factors are kept unchanged.

2. For the purpose of this Regulation, institutions shall calculate the loss corresponding to a scenario of future shocks applied to one or more non-modellable risk factors, by using the pricing methods used in the risk measurement model.

SECTION 2

REGULATORY EXTREME SCENARIO OF FUTURE SHOCKS

Article 10

Determination of the regulatory extreme scenario of future shock

1. The regulatory extreme scenario of future shock referred to in Article 325bk(2) of Regulation (EU) No 575/2013 shall be the shock leading to the maximum loss that may occur due to a change in the non-modellable risk factor where such maximum loss is finite.

2. Where the maximum loss referred to in paragraph 1 is not finite, an institution shall apply the following steps in sequence for determining the regulatory extreme scenario of future shock:

(a) it shall use an expert-based approach using qualitative and quantitative information available to identify a loss due to a change in the value taken by the non-modellable risk factor that will not be exceeded with a level of certainty equal to 99.95% on a 10 business day horizon;

(b) it shall multiply the loss obtained in accordance with point (a) by $\sqrt{\frac{LH_{\mathrm{adj}}}{10}}$;

where:

- $LH_{adj} = \max(20, LH)$, where LH is the liquidity horizon for the non-modellable risk factor or for the risk factors within the non-modellable bucket referred to in Article 325bd of Regulation (EU) No 575/2013;

(c) it shall identify the regulatory extreme scenario of future shock as the shock leading to the loss resulting from points (a) and (b).

3. Where institutions calculate a stress scenario risk measure for more than one non-modellable risk factor as referred to in Article 325bk(2)(c) of Regulation (EU) No 575/2013, the regulatory extreme scenario of future shock referred to in Article 325bk(2) of Regulation (EU) No 575/2013 shall be the scenario leading to the maximum loss that may occur due to a change in the values taken by those non-modellable risk factors.

4. Where institutions calculate a stress scenario risk measure for more than one non-modellable risk factor as referred to in Article 325bk(2)(c) of Regulation (EU) No 575/2013 and the maximum loss referred to in paragraph 3 is not finite, an institution shall apply the following steps in sequence for determining the regulatory extreme scenario of future shock:

(a) it shall use an expert-based approach using qualitative and quantitative information available to identify a loss due to a change in the values taken by the non-modellable risk factors that will not be exceeded with a level of certainty equal to 99.95% on a 10 business day horizon;

(b) it shall multiply the loss obtained in accordance with point (a) by $\sqrt{\frac{LH_{\text{adj}}}{10}}$;

where:

- $LH_{adj} = \max(20, LH)$, where LH is the liquidity horizon for the non-modellable risk factors referred to in Article 325bd of Regulation (EU) No 575/2013;

(c) it shall identify the regulatory extreme scenario of future shock as the scenario leading to the loss resulting from points (a) and (b).

Questions for consultation

Q13. *What are your views on the definition of maximum loss that has been included in these draft RTS for the purpose of identifying the loss to be used as maximum loss when the latter is not finite? What would be an alternative proposal?*

Q14. *How do you currently treat non-pricing scenarios (see section 3.2.5 of the background section) if they occur where computing the VaR measures? How do you envisage implementing them in (i) the IMA ES model and (ii) the SSRM, in particular in the case of curves and surfaces being partly shocked? What do you think should be included in these RTS to address this issue? Please put forward proposals that would not provide institutions with incentives that would be deemed non-prudentially sound and that would target only the instruments and the pricers for which the scenario can be considered a 'non-pricing scenario'.*

SECTION 3

CIRCUMSTANCES UNDER WHICH INSTITUTIONS MAY CALCULATE A STRESS SCENARIO RISK MEASURE FOR MORE THAN ONE NON-MODELLABLE RISK FACTOR

Article 11

Circumstances for the calculation of a stress scenario risk-measure for more than one non-modellable risk factor

The circumstances under which institutions may calculate a stress scenario risk-measure for more than one non-modellable risk factor shall be the following:

(d) the risk factors belong to the same standardised bucket among those identified in Article 5(2) of Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013];

(e) the institution assessed the modellability of those risk factors, by determining the modellability of the standardised bucket to which they belong in accordance with Article 4(1) of Commission Delegated Regulation (EU) xx/2020 [RTS on criteria for assessing the modellability of risk factors under Article 325be(3) of Regulation (EU) No 575/2013];

SECTION 4

AGGREGATION OF THE STRESS SCENARIO RISK MEASURES

Article 12

Aggregation of the stress scenario risk measures

1. For the purposes of aggregating the stress scenario risk measures as referred to in Article 325bk(3)(d) of Regulation (EU) No 575/2013, an institution shall for each stress scenario risk measure it has computed determine the corresponding rescaled stress scenario risk measure as follows:

(a) where the institution determined the extreme scenario of future shock for a single risk factor in accordance with Article 1, the corresponding rescaled stress scenario risk measure shall be calculated with the following formula:

$$RSS = \sqrt{\frac{LH_{\mathrm{adj}}}{10}} \times SS \times \kappa$$

where:

- RSS is the rescaled stress scenario risk measure
- SS is the stress scenario risk measure
- $LH_{adj} = \max(20, LH)$, where LH is the liquidity horizon referred to in Article 325bd(1) of Regulation (EU) No 575/2013 for the non-modellable risk factor;
- $\kappa$is the non-linearity coefficient for the non-modellable risk factor calculated in accordance with Article 13;

(b) where the institution determined a stress scenario risk measure for more than one risk factor by determining an extreme scenario of future shock in accordance with Article 2 for the non-modellable bucket comprising those risk factors, the corresponding rescaled stress scenario risk measure shall be calculated with the following formula:

$$RSS = \sqrt{\frac{LH_{\mathrm{adj}}}{10}} \times SS \times \kappa$$

where:

- RSS is the rescaled stress scenario risk measure
- SS is the stress scenario risk measure;
- $LH_{adj} = \max(20, LH)$, where LH is the liquidity horizon referred to in Article 325bd(1) of Regulation (EU) No 575/2013 for the risk factors within the non-modellable bucket;
- κ is the non-linearity coefficient for the non-modellable bucket to be calculated in accordance with Article 14;

(c) where the institution determined a stress scenario risk measure by determining a regulatory extreme scenario of future shock in accordance with Article 10, the corresponding rescaled stress scenario risk measure shall be equal to that stress scenario risk measure.

2. Institutions shall aggregate the stress scenario risk measures by applying the following formula:

$$\sqrt{\sum_{\substack{k=1,\\ k \text{ idiosyncratic} \\ \text{credit spread risk factor}}} (RSS^k)^2} + \sqrt{\sum_{\substack{l=1,\\ l \text{ idiosyncratic} \\ \text{equity risk factor}}} (RSS^l)^2} + \sqrt{\left(\rho \times \sum_{\substack{j=1,\\ j \text{ not idiosyncratic} \\ \text{credit spread} \\ \text{nor} \\ \text{idiosyncratic} \\ \text{equity risk factor}}} RSS^j\right)^2 + (1-\rho^2) \times \sum_{\substack{j=1,\\ j \text{ not idiosyncratic} \\ \text{credit spread nor} \\ \text{idiosyncaratic} \\ \text{equity risk factor}}} (RSS^j)^2}$$

Where:

- k denotes the non-modellable risk factor or non-modellable bucket for which the institution determined a stress scenario risk measure that was classified as reflecting idiosyncratic credit spread risk only in accordance with paragraph 3;
- l denotes the non-modellable risk factor or non-modellable bucket for which the institution determines a stress scenario risk measure that was classified as reflecting equity risk only in accordance with paragraph 4;
- j denotes a non-modellable risk factor or non-modellable bucket for which the institution determines a stress scenario risk measure that was not classified as reflecting idiosyncratic credit spread risk only in accordance with paragraph 3 or idiosyncratic equity risk only in accordance with paragraph 4;
- RSS^k, RSS^l, RSS^j are respectively the rescaled stress scenario measures for the non-modellable risk factors or the non-modellable buckets k, l, j calculated in accordance with paragraph 1;
- $\rho = 0.6$;

3. For classifying a non-modellable risk factor as reflecting idiosyncratic credit spread risk only, all of the following conditions shall be met:

(a) the nature of the risk factor is such that it shall reflect idiosyncratic credit spread risk only;
(b) the value taken by the risk factor shall not be driven by systematic risk components;
(c) the institution performs and document the statistical tests that are used to verify the condition in point (b);

Conditions (a), (b) and (c) shall be met for each risk factor in the non-modellable bucket, for classifying a non-modellable bucket as reflecting idiosyncratic credit spread risk only.

4. For classifying a risk factor as reflecting idiosyncratic equity risk only, all of the following conditions shall be met:

(a) the nature of the risk factor is such that it shall reflect idiosyncratic equity risk only;
(b) the value taken by the risk factor shall not be driven by systematic risk components;
(c) the institution performs and document the statistical tests that are used to verify the condition in point (b).

Conditions (a), (b) and (c) shall be met for each risk factor in the non-modellable bucket, for classifying a non-modellable bucket as reflecting idiosyncratic equity risk only.

Question for consultation
Q15. *What are your views on the conditions included in these draft RTS for identifying whether a risk factor can be classified as reflecting idiosyncratic credit spread risk only (resp. idiosyncratic equity risk only)? Please elaborate.*

Article 13

Non-linearity coefficient for a single risk factor

Where the stress scenario risk measure for which an institution is determining the non-linearity coefficient has been determined for a single risk factor, such non-linearity coefficient shall be determined as follows:

(a) where the extreme scenario of future shock for the non-modellable risk factor does not coincide with either the downward calibrated shock or the upward calibrated shock obtained as a result of point (c) in article 1(1) then the institution shall set $\kappa = 1$ for that non-modellable risk factor.

(b) where the extreme scenario of future shock for the non-modellable risk factor coincides with the downward calibrated shock obtained as a result of point (c) of Article 1(1) then the institution shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi - 1) \times 25\right]$$

where:

- $\kappa_{\min} = 0.9$;
- ϕ is the tail parameter for the non-modellable risk factor calculated in accordance with Article 15;
- loss_0 is the loss that occurs if the non-modellable risk factor is shocked with the downward shock CS_{down} obtained as a result of point (c) of Article 1(1);
- loss_{-1} is the loss that occurs if the non-modellable risk factor is shocked with a downward shock equal to $\frac{4}{5} \cdot CS_{down}$, where CS_{down} is the downward shock obtained as a result of point (c) of Article 1(1).

- loss_{+1} is the loss that occurs if the non-modellable risk factor is shocked with a downward shock equal to $\frac{6}{5} \cdot CS_{down}$, where CS_{down} is the downward shock obtained as a result of point (c) of Article 1(1).

(c) where the extreme scenario of future shock for the non-modellable risk factor coincides with the upward calibrated shock obtained as a result of point (c) of Article 1(1) then the institution shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi - 1) \times 25\right]$$

where:

- $\kappa_{\min} = 0.9$;
- ϕ is the tail parameter for the non-modellable risk factor calculated in accordance with article 15;
- loss_0 is the loss that occurs if the non-modellable risk factor is shocked with the upward shock CS_{up} obtained as a result of point (c) of Article 1(1);
- loss_{-1} is the loss that occurs if the non-modellable risk factor is shocked with an upward shock equal to $\frac{4}{5} \cdot CS_{up}$, where CS_{up} is the upward shock obtained as a result of point (c) of Article 1(1).
- loss_{+1} is the loss that occurs if the non-modellable risk factor is shocked with an upward shock equal to $\frac{6}{5} \cdot CS_{up}$, where CS_{up} is the upward shock obtained as a result of point (c) of Article 1(1).

Options for consultation: Depending on whether in the final draft RTS the representative risk factor option or the contoured shift option (see Article 2) will be retained, one of the two versions of Article 14 will be retained:

Under the representative risk factor option:

Article 14

Non-linearity coefficient for a bucket

1. Where the stress scenario risk measure for which an institution is determining the non-linearity coefficient has been determined for a non-modellable bucket, the non-linearity coefficient shall be determined as follows:

(a) where the extreme scenario of future shock for the non-modellable bucket does not coincide with a shock applied to all risk factors within the non-modellable bucket that in size equals the downward calibrated shock or the upward calibrated shock obtained for the representative risk factor in the non-modellable bucket referred to in Article 2(2)(d), the institution shall set the non-linearity coefficient $\kappa = 1$ for that non-modellable bucket;

(b) where the extreme scenario of future shock for the non-modellable bucket is a downward shock applied to all risk factors within the non-modellable bucket and the size of that shock coincides with the downward calibrated shock obtained as a result of point (c) of Article 2(2) for the representative risk factor in the non-modellable bucket referred to in point (d) of Article 2(2), the institution shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi - 1) \times 25\right]$$

Where:

- $\kappa_{\min} = 0.9$;
- ϕ is the tail parameter for the representative risk factor calculated in accordance with paragraph 15;
- loss_0 is the loss that occurs if all the risk factors within the bucket are shocked by the downward shock CS_{down}^R, where CS_{down}^R is the downward calibrated shock obtained as a result of point (c) of Article 2(2) for the representative risk factor;
- loss_{-1} is the loss that occurs if all the risk factors within the bucket are shocked by the downward shock $\frac{4}{5} \cdot CS_{down}^R$, where CS_{down}^R is the downward calibrated shock obtained as a result of point (c) of Article 2(2) for the representative risk factor;
- $\text{loss}_{+1}$is the loss that occurs if all risk factors within the bucker are shocked with a downward shock equal to $\frac{6}{5} \cdot CS_{down}^R$, where CS_{down}^R is the downward shock obtained as a result of point (c) of Article 2(2) for the representative risk factor.

(c) where the extreme scenario of future shock for the non-modellable bucket is an upward shock applied to all risk factors within the non-modellable bucket and the size of that shock coincides with the calibrated upward shock obtained as a result of point (c) of Article 2(2) for the representative risk factor in the non-modellable bucket referred to in point (d) of Article 2(2), the institution shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi - 1) \times 25\right]$$

Where:

- $\kappa_{\min} = 0$;
- ϕ is the tail parameter for the representative risk factor calculated in accordance with Article 15;

- loss_0 is the loss that occurs if all the risk factors within the bucket are shocked by the upward shock CS_{up}^R, where CS_{up}^R is the upward calibrated shock obtained as a result of point (c) of Article 2(2) for the representative risk factor;
- loss_{-1} is the loss that occurs if all the risk factors within the bucket are shocked by the upward shock $\frac{4}{5} \cdot CS_{up}^R$, where CS_{up}^R is the upward calibrated shock obtained as a result of point (c) of Article 2(2) for the representative risk factor;
- loss_{+1} is the loss that occurs if all risk factors within the bucket are shocked by the upward shock equal to $\frac{6}{5} \cdot CS_{up}^R$, where CS_{up}^R is the upward calibrated shock obtained as a result of point (c) of Article 2(2) for the representative risk factor.

Under the contoured shift option:

Article 14

Non-linearity coefficient for a bucket

1. Where the stress scenario risk measure for which an institution is determining the non-linearity coefficient has been determined for a non-modellable bucket, the non-linearity coefficient shall be determined as follows:

(1) Where the extreme scenario of future shock does not correspond to a scenario identified in Article 2(2)(d) for $\beta = 1$, the institution shall set the non-linearity coefficient $\kappa = 1$ for that non-modellable bucket;

(2) Where the extreme scenario of future shock is a scenario where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from point (c) of article 2(2), institutions shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\text{min}}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi_{avg} - 1) \times 25\right]$$

where:

- $\kappa_{\text{min}} = 0$;
- ϕ_{avg} is the average of the tail parameters calculated in accordance with Article 15 for each of the risk factors within the bucket;
- loss_0 is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from point (c) of article 2(2);
- loss_{+1} is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from point (c) of article 2(2) multiplied by 1.2;

- loss_{-1} is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding upward shock resulting from point (c) of article 2(2) multiplied by 0.8;

(3) Where the extreme scenario of future shock is a scenario where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from point (c) of article 2(2), institutions shall calculate the non-linearity coefficient with the following formula:

$$\kappa = \max\left[\kappa_{\min}, 1 + \frac{\text{loss}_{-1} - 2 \times \text{loss}_0 + \text{loss}_{+1}}{2 \times \text{loss}_0} \times (\phi_{avg} - 1) \times 25\right]$$

where:

- $\kappa_{\min} = 0$;
- ϕ_{avg} is the average of the tail parameters calculated in accordance with Article 15 for each of the risk factors within the bucket;
- loss_0 is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from point (c) of article 2(2);
- loss_{+1} is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from point (c) of article 2(2) multiplied by 1.2;
- loss_{-1} is the loss occurring where each risk factor in the non-modellable bucket is shocked by the corresponding downward shock resulting from point (c) of article 2(2) multiplied by 0.8;

Questions for consultation

Q16. *What are your views on flooring the value taken by non-linearity coefficient κ_{D^*} to 0.9? Please elaborate.*

Q17. *What are your views on the definition of the tail parameter ϕ_{avg} where a contoured shift is applied (i.e. average of the tail parameters of all risk factors within the regulatory bucket)? Please elaborate.*

Article 15

Calculation of the tail parameter

1. Institutions shall calculate the tail parameter for a given non-modellable risk factor as follows:

(a) where institutions used the historical method referred to in Article 4 for determining the upward and downward shock of that non-modellable risk factor and the extreme scenario of future shock is a downward shock, they shall calculate the tail parameter by applying the following formula:

$$\phi = \frac{\frac{1}{\alpha N} \times \left\{ \sum_{i=1}^{[\alpha N]} Ret_{(\mathrm{i})}{}^2 + (\alpha \cdot N - [\alpha \cdot N]) \cdot Ret_{([\alpha N]+1)}{}^2 \right\}}{\left\{ \widehat{\mathrm{ES}}_{\mathrm{Left}}(Ret) \right\}^2}$$

where:

- $\alpha = 2.5\%$
- Ret is the time series of 10 business days returns for the non-modellable risk factor used in the historical method referred to in Article 4
- $Ret_{(\mathrm{i})}$ represents the smallest i-th observation in the time series Ret
- $[\alpha \cdot N]$ denotes the integer part of $\alpha \cdot N$
- $\widehat{\mathrm{ES}}_{\mathrm{Left}}(Ret)$ is the estimate of the left-tail expected shortfall for the time series Ret calculated in accordance with Article 7(1)

(b) Where institutions used the historical method referred to in Article 4 for determining the upward and downward shock of that non-modellable risk factor and the extreme scenario of future shock is a downward shock, institutions shall calculate the tail parameter by applying the following formula:

$$\phi = \frac{\frac{1}{\alpha N} \times \left\{ \sum_{i=1}^{[\alpha N]} (-Ret)_{(\mathrm{i})}{}^2 + (\alpha N - [\alpha N])(-Ret)_{([\alpha N]+1)}{}^2 \right\}}{\left\{ \widehat{\mathrm{ES}}_{\mathrm{Right}}(Ret) \right\}^2}$$

where:

- $\alpha = 2.5\%$
- Ret is the time series of 10 business days returns for the non-modellable risk factor used in the historical method referred to in Article 4
- $-Ret_{(\mathrm{i})}$ represents the smallest i-th observation in the time series $-Ret$
- $[\alpha \cdot N]$ denotes the integer part of $\alpha \cdot N$

- $\widehat{\mathrm{ES}}_{\mathrm{Right}}(Ret)$ is the estimate of the right-tail expected shortfall for the time series Ret calculated in accordance with Article 7(2)

(c) In all other cases institutions shall set the tail parameter $\phi = 1.04$

Question for consultation

Q18. *Would you consider it beneficial to set the tail parameter ϕ to the constant value 1.04 regardless of the methodology used to determine the downward and upward calibrated shock (i.e. setting ϕ = 1.04 also under the historical method, instead of using the historical estimator)? Please elaborate.*

Article 16

This Regulation shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels,

For the Commission
The President

[For the Commission
On behalf of the President]

5. Accompanying documents

5.1 Draft cost-benefit analysis / impact assessment

Article 325bk(3) of the CRR2 mandates the EBA to develop draft RTS specifying:

a) how institutions are to develop 'extreme scenarios of future shock' and how to apply those to the non-modellable risk factors to calculate the stress scenario risk measure;

b) a regulatory scenario of future shock that institutions may use where they are unable to develop an extreme scenario of future shock using the methodology outlined in point (a) or which competent authorities may require institutions to apply;

c) the circumstances under which institutions may calculate a stress scenario risk measure for more than one non-modellable risk factor;

d) how institutions are to aggregate the stress scenario risk measures of all non-modellable risk factors included in their trading book positions and non-trading book positions that are subject to foreign exchange risk or commodity risk.

Article 10(1) of Regulation (EU) No 1093/2010 (EBA Regulation) provides that any RTS developed by the EBA should be accompanied by an analysis of 'the potential related costs and benefits. This analysis should provide an overview of different options considered in drafted in the RTS, relevant findings regarding them, the options proposed and the potential impact of these options.

This section presents the cost-benefit analysis of the provisions included in the draft RTS that are described in this CP. The analysis provides an overview of the problems identified, the options proposed to address those problems and the costs and benefits of those options.

A. Background and Problem identification

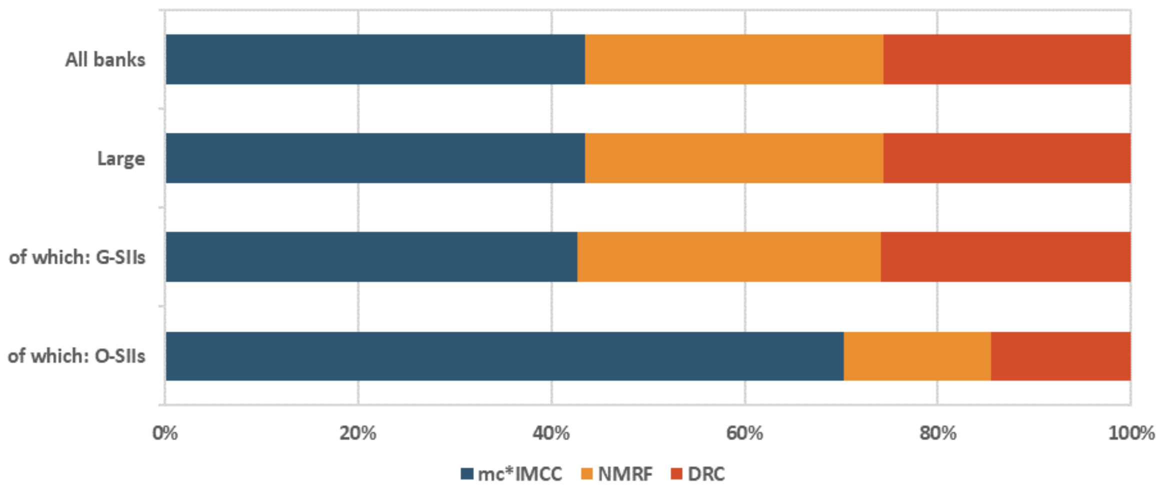
In accordance with Article 325be of the CRR2, institutions using the alternative internal model approach (IMA) (i.e. an internal Expected Shortfall model) are required to identify for each risk factor included in the risk-measurement model whether it is modellable or not. A risk factor is deemed modellable when it passes the assessment of modellability of risk factors as described in the pertaining draft RTS, i.e. mainly based on the characteristics of representative real price observations.[25] Risk factors that do not pass the requirements of the modellability assessment are deemed as non-modellable risk factors.

[25] EBA/RTS/2020/03, EBA FINAL draft Regulatory Technical on criteria for assessing the modellability of risk factors under the Internal Model Approach (IMA) under Article 325be(3) of Regulation (EU) No 575/2013 (revised Capital Requirements Regulation – CRR2)

The CRR2 sets out that when a risk factor has been identified as 'non-modellable' it has to be capitalised, outside the Expected Shortfall measure, by calculating the stress scenario risk measure for that risk factor. [26] This measure represents the loss that is incurred in all trading book positions or non-trading book positions that are subject to foreign exchange or commodity risk of the portfolio, which includes that non-modellable risk factor when an extreme scenario of future shock is applied to that risk factor. However, the CRR2 does not specify how to develop such extreme scenarios of future shocks or how to apply them to the NMRF. The lack of such specification could lead to inconsistent application of the market risk framework for non-modellable risk factors across EU institutions.

According to the EBA QIS 2018 Q4 data, a sizeable share of the market risk requirements of IMA banks is attributed to NMRF. On average, the overall contribution of NMRF to total IMA capital requirements stands at around 30% (see Figure 1). Although these figures do not take into account the methodology put forward in this CP, they still indicate the relevance of NMRF for European banks.

Figure 1: Composition of FRTB-IMA RWA, by bank size



Sources: EBA 2018-Q4 QIS data and EBA calculations.
Notes: Based on a sample of 13 banks: Large (13), of which G-SIIs (7), of which O-SIIs (6). mc, multiplication factor; IMCC, capital requirement for modellable risk factors; NMRF, capital requirements for non-modellable risk factors; DRC, default risk capital requirement.

The NMRF capital requirements reported by banks are highly dependent on portfolio composition as well as assumptions and methodological choices made by the banks. As such, reported values show significant variation, with the median NMRF contribution standing at around 10% and the

[26] Similarly, the FRTB standards specify that the capital requirements for each NMRF are to be determined using a stress scenario that is calibrated to be at least as prudent as the expected shortfall calibration used for modelled risks (i.e. a loss calibrated to a 97.5% confidence threshold over a period of extreme stress for the given risk factor). In determining that period of stress, a bank must determine a common 12-month period of stress across all NMRFs in the same risk class. The FRTB standards do not provide any other detail for this stress scenario.

interquartile range at 34%.[27] Based on the qualitative information provided alongside the 2018 QIS templates, it appears that the assumptions and methodologies used by banks to calculate the NMRF capital requirement are subject to significant differences. This indicates that banks are currently facing technical and operational challenges in estimating NMRF capital requirements, given the lack of clarity and harmonisation related to the NMRF implementation methodology and the early stage of their implementations, which forces banks to rely on approximations and expert judgement in many cases.

B. Policy objectives

The specific objective of these draft RTS are to establish a common universal methodology for calculating the extreme scenario of shock and applying it to the non-modellable risk factors to estimate the stress scenario risk measure. In this way, these draft RTS aim to ensure a consistent implementation of the market risk framework across EU institutions.

Moreover, they also aim to provide institutions with a regulatory scenario of future shock as a fallback in cases where they are unable to calculate an extreme scenario of future shock using the prescribed methodology.

Generally, these draft RTS aim to create a level playing field, promote convergence of institutions practises and enhance comparability of own funds requirements across the EU. Overall, these draft RTS are expected to promote the effective and efficient functioning of the EU banking sector.

C. Options considered, Cost-Benefit Analysis, Preferred Options

EBA NMRF data collection

The EBA has conducted an extensive voluntary data collection in 2019 to inform the impact assessment and policy choices in these draft RTS.[28] The data collection was addressed to all institutions that use an internal model approach for calculating capital requirements for market risk. Institutions were asked to apply the EBA stress scenario risk measure (SSRM) methodology, as put forward in the accompanying instructions, for the relevant risk factors in the following portfolios:

- at minimum, the 2019 EBA market risk benchmarking exercise portfolios;
- prospective FRTB desks that are relevant for the institutions;
- portfolios with non-linear and/or non-monotonic loss profiles; and/or
- portfolios that depend on a curve, surface or cube.

[27] Some banks reported 0% contribution of NMRF possibly because either all risk factors pass the risk factor eligibility test (RFET) or banks at the time did not have the capability to calculate SES and report zero to bypass aggregation checks within the QIS template.

[28] https://eba.europa.eu/eba-publishes-its-roadmap-for-the-new-market-and-counterparty-credit-risk-approaches-and-launches-consultation-on-technical-standards-on-the-ima-under

It should be noted that the EBA SSRM methodology described in the instructions of the data collection was, to a certain extent, different from the methodology put forward in these draft RTS. In fact, the input received during the data collection was used to improve, adjust and/or extend the methodology and ensure an appropriate calibration of its key parameters.

Methodology and data quality

The analysis presented in this section uses all risk factors provided, instead of only risk factors assessed as non-modellable. The rationale behind this choice is: (i) to maximize the usage of data provided; (ii) at the time of the data collection, the modellability assessment was not implemented and thus the assessment was done on a best effort basis; (iii) the outcome of the modellability assessment can change for the same risk factor (i.e. it can switch between modellable and non-modellable).

As part of the data collection, institutions were requested to submit the time series of their risk factors relevant for the portfolios or desks reported. EBA has calculated risk factors returns based on the return type (e.g. absolute returns, relative returns, etc.) specified by participants. For some specific return types, there are deviations for returns whose values do not depend only on the two risk factor values on two dates (e.g. returns on underlyings adjusted by volatility).

Given that most institutions submitted data for the EBA benchmarking portfolios, some of the risk factors used in the below analysis may be overlapping. However, institutions have used different models for the same portfolio and therefore all the risk factors were retained. As a robustness check, the analysis was repeated on different sets of risk factors, e.g. for each institution separately. The results were qualitatively the same.

Sample and summary statistics

A total of 8 institutions participated in the NMRF data collection exercise (see

Table 1). All institutions reported figures for the 2019 or 2020 EBA market risk benchmarking exercise portfolios and 4 institutions reported figures for some of their own desks up to top of the house.[29]

Table 1: NMRF data collection sample, by country

Country	Number of banks
DE	1
FR	4
GB	1
IT	2
Total	**8**

Sources: EBA NMRF data collection and EBA calculations.

[29] Some participants preferred to submit data based on the 2020 EBA market risk benchmarking exercise.

The portfolios provided cover a total number of 48,285 risk factors, of which 15,546 were classified by participants as NMRF (Table 2). The number of risk factors provided by each bank varies significantly, with some providing as few as around 60 risk factors and others providing up to around 40,000 risk factors (Table 3). The median bank has provided around 800 risk factors. The majority of the risk factors are related to the equity risk, general interest rate and credit spread risk category. This is also true for the NMRF.

On average, 32% of the total risk factors provided are considered to be NMRF, keeping in mind that the assessment of modellability was not considered mature and provided on a best effort basis. The credit spread risk category and general interest rate risk appear to have the higher share of NMRF relative to the total risk factors belonging to that risk category. On the other hand, the commodity risk category appears to have the lowest share.

Table 2: Total number of risk factors and NMRF included in the data collection, by risk cateogry

Risk factor category	Total number of risk factors	Of which: time series provided	Total number of NMRF	Of which: time series provided	Average share of NMRF
COMM	2,921	2,921	211	211	7%
CS	11,510	11,448	4,943	4,913	43%
EQ	16,016	15,686	4,485	4,482	28%
FX	3,389	3,276	685	685	20%
IR	14,449	10,737	5,222	4,516	36%
Total	**48,285**	**44,068**	**15,546**	**14,807**	**32%**

Sources: EBA NMRF data collection and EBA calculations.

Table 3: Distribution of number of risk factors and NMRF included in the data collection, by bank and risk cateogry

	Number of banks	Min	Q1	Median	Q3	Max	Average
ALL RF: of which	**8**	**58**	**370**	**825**	**2321**	**40603**	**6036**
COMM	8	0	0	8	101	2614	417
CS	8	0	30	72.5	124	11058	1439
EQ	8	0	5	53	192	15486	2002

	Number of banks	Min	Q1	Median	Q3	Max	Average
FX	8	0	3	40	72	3155	424
IR	8	27	184	508	1909	8290	1806
ALL NMRF: of which	**8**	**0**	**81**	**537**	**818**	**12367**	**1943**
COMM	8	0	0	0	10	187	30
CS	8	0	0	34	113	4645	618
EQ	8	0	0	35	96	4193	561
FX	8	0	0	0	65	553	86
IR	8	0	47	271	777	2789	653
Share NMRF to total RF	**8**	**0%**	**15%**	**27%**	**55%**	**100%**	**37%**

Sources: EBA NMRF data collection and EBA calculations.

Policy options

Over-arching approaches: Option A and Option B for the calibration to a period of stress

The consultation paper presents two options for calibrating an extreme scenario of future shock to a period of stress (Option A and B).

Option 1a: Determination of the stress scenario risk measure directly from the stress period (Option A in the CP)

Option 1b: Rescaling a shock calibrated on the current period to obtain a shock calibrated on the stress period (Option B in the CP)

Option 1a uses directly the risk factor observations in a stress period to obtain calibrated shocks for the stress period. The stress period for each risk category is determined as the period that maximises the rescaled stress scenario risk measure RSS for that risk category.

Option 1b uses the risk factor observations in the current period[30] – where data availability is generally higher – to obtain intermediate shocks, which are then rescaled, by means of a scalar, to obtain calibrated shocks for the stress period. The scalar represents the ratio of volatilities in the current and stress period for each risk class and is computed using the reduced set of modellable risk factors in the ES model as specified in Article 325bc(2)(a) of the CRR2, which are available in

[30] As explained in the draft RTS, institutions may use as 'current period' either the actual last 12-months period, or the period used for assessing the modellability of risk factors.

both periods. The stress period is determined as the period that maximises the scalar for that risk category. The use of modellable factors for computing the scalar aims to reduce the operational burden for institutions, as it would allow them to collect data for non-modellable risk factors only in the current period (and not the stress period).[31] It is expected that the ratio of volatilities in the current and stress period would be similar for MRF and NMRF belonging to the same risk category. This is because a risk factor can switch modellability status between modellable and non-modellable given that the modellability assessment is based on real price observations, which do not necessarily correspond to the data used to calibrate the shocks (typically daily data). The analysis from the data collection confirms there is no significant difference between the volatility ratios between stress and current period for MRF and NMRF.

While Option 1a appears to be a straightforward way of obtaining calibrated shocks in the stress period, data availability for non-modellable risk factors in a past stress period (which for most institutions currently corresponds to the great financial crisis) might be limited. This is because trading strategies, instruments and thus, the risk factor landscape have likely changed since then.

Option 1b recognises these challenges and allows institutions to use data for non-modellable risk factors in the current period only, where data availability is expected to be better. For the stress period, only the data for the reduced set of modellable factors that would be used for the calculation of the scalar are needed, which are expected to be readily available as these are used for the calculation of the expected shortfall. Nevertheless, the scaling of these intermediate shocks from the current year to a period of stress remains a source of inaccuracy.

In terms of operational burden, Option 1a can be more burdensome for institutions, as they would be required to scan and apply the entire NMRF SSRM methodology for all 12-month periods starting at least from 1 January 2007 in order to identify the stress period. In contrast, under Option 1b, institutions have to scan and calculate only the scalar for all 12-month periods starting at least from 1 January 2007, in particular without the need to evaluate portfolio losses as would be needed for the entire NMRF SSRM methodology.

Both options are put forward for consultation. The EBA intends to keep only one of the two options in the final draft RTS.

Scalar $m_{S,C}^{i}$ under Option B

Under option B, an institution multiplies the upward and downward shock calibrated on the current period (C) for a given non-modellable risk factor mapped to the risk class i by the scalar $m_{S,C}^{i}$ to obtain an upward and a downward shock that are calibrated on the stress period (S). On the basis of those shocks, the extreme scenario of future shock is determined.

The EBA has considered two options for the scalar $m_{S,C}^{i}$:

Option 2a: Based on the ratio of the standard deviation of risk factor returns (i.e. volatilities)

[31] Data on the reduced set of modellable risk factors in the ES model as specified in Article 325bc(2)(a) of the CRR2 would have to be collected in any case as part of the ES model calculation.

Option 2b: Based on the ratio of expected shortfalls of risk factor returns

Under Option 2a, the scalar $m_{S,C}^{i}$ is defined as follows:

$$m_{S,C}^{i} = \underset{\substack{j \in i \\ j \in \text{Reduced Set of RFs in ES}}}{\text{trimmed mean}_{0.01}} \left[\frac{\hat{\sigma}^{S}{}_{Ret(j)}}{\hat{\sigma}^{C}{}_{Ret(j)}}\right];\ i \in \{\text{IR, CS, EQ, FX, CM}\}$$

where $\hat{\sigma}^{P}{}_{Ret(j)}$ is the estimated standard deviation of the nearest to 10-days returns for the modellable risk factor j in the period P.

Under Option 2b, the scalar $m_{S,C}^{i}$ is defined as follows:

$$m_{S,C}^{i} = \frac{1}{2} \times$$

$$\left\{ \underset{\substack{j \in i \\ j \in \text{Reduced Set of RFs in ES}}}{\text{trimmed mean}_{0.01}} \left[\frac{\widehat{ES}_{Left}^{S}(Ret(j),\alpha)}{\widehat{ES}_{Left}^{C}(Ret(j),\alpha)}\right] + \underset{\substack{j \in i \\ j \in \text{Reduced Set of RFs in ES}}}{\text{trimmed mean}_{0.01}} \left[\frac{\widehat{ES}_{Right}^{S}(Ret(j),\alpha)}{\widehat{ES}_{Right}^{C}(Ret(j),\alpha)}\right] \right\};$$

$$i \in \{\text{IR, CS, EQ, FX, CM}\}$$

Option 2b is more coherent with the overall methodology, as the calibrated shocks for the current period are based on the ES of the returns. Moreover, it caters for situations where the distribution of returns is more fat-tailed in the stress period compared to the current period, which may not be fully captured by the standard deviation ratio. However, Option 2a is simpler and the standard deviation is a more robust measure than the ES.

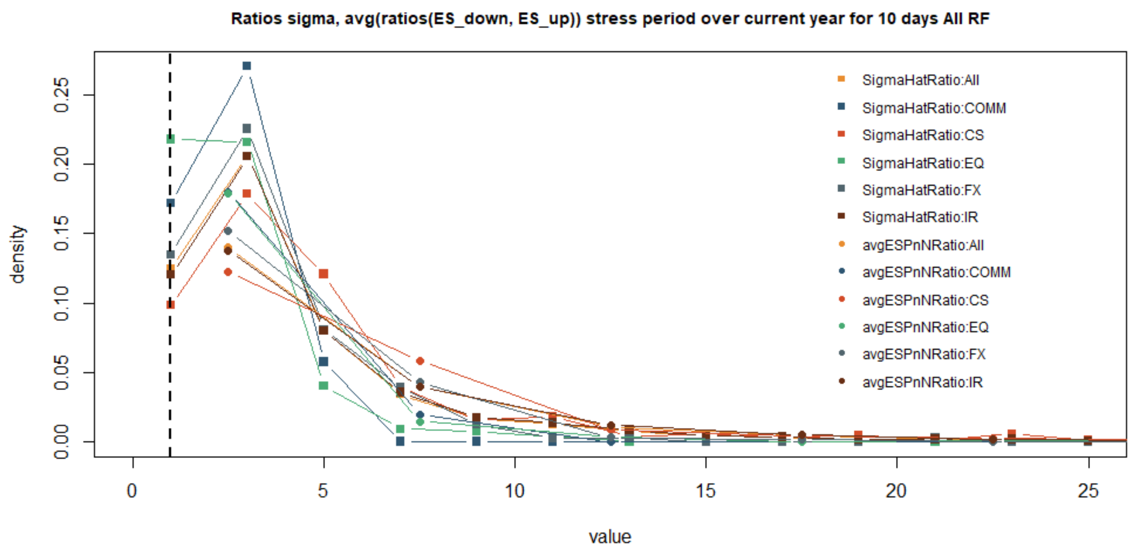
Figure 2 shows the distribution of the two ratios per risk category. The variation within a risk category can be high and in some cases, the ratios can extend to very high numbers. To avoid situations where a few outliers distort the simple mean, the EBA proposes to use instead the trimmed mean. This involves the calculation of the mean after discarding given parts of a probability distribution or sample at the high and low end, and typically discarding an equal amount at both ends. The number of points to be discarded is usually given as a percentage of the total number of points. The CP proposes to use the one percent symmetrically trimmed mean slightly modified, such that for any sample size N the smallest and largest value are removed, by trimming the $\text{Int}[1 + 0.01\ N]$ smallest and largest values. In cases where there are no outliers, the differences between the simple mean and the trimmed mean is very small. However, in cases where there are some outliers (e.g. as in the case of IR risk category, see

Figure 3) it would allow institutions to disregard the 1% highest and lowest values of the ratios.

Figure 3 shows a comparison of the two ratios per risk category. The results show that the difference between the trimmed mean ratios of the volatilities and expected shortfalls are relatively small. However, both ratios exhibit high dispersion within a risk category. This suggests that the additional benefits of Option 2b in terms of increased accuracy are rather limited to outweigh the costs of additional complexity. For all risk categories, the ES ratios are slightly higher than the standard deviation ratio implying that Option 2a yields less conservative results than Option 2b.

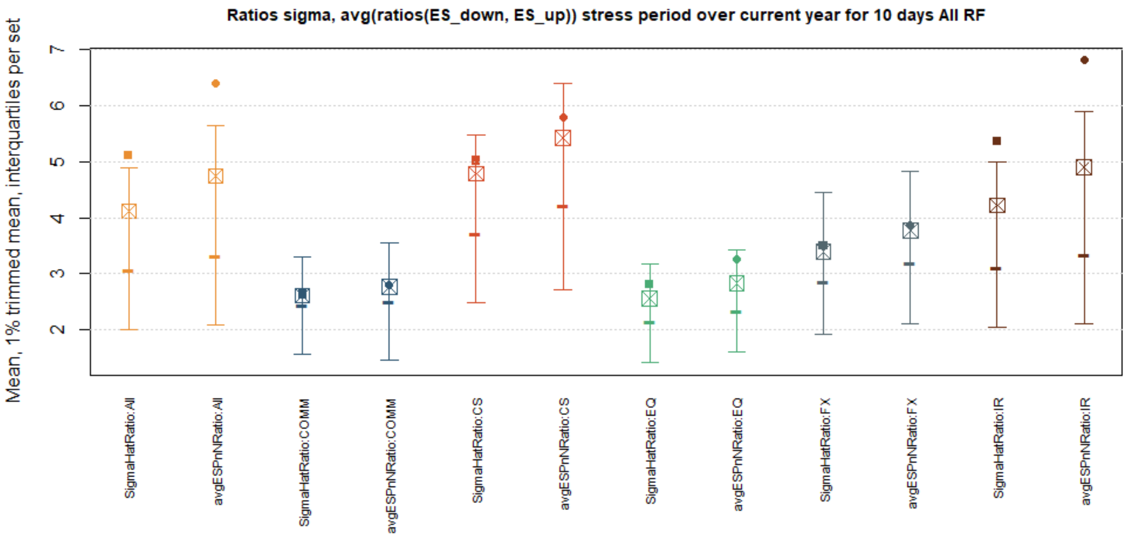
Option 2a is preferred.

Figure 2: Ratio of sigma (volatilities) and average left and right tail ES between stress and current period for Options 2a and 2b



Sources: EBA NMRF data collection and EBA calculations.
Notes: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one maximising the scalar. The current period uses data from the most recent year provided, which for most time series this corresponds to mid-2018 until mid-2019 for most time series.

Figure 3: Ratio of sigma (standard deviation) and average left and right tail ES between stress and current period for Options 2a and 2b



Sources: EBA NMRF data collection and EBA calculations.
Notes: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one maximising the scalar. The current period uses data from the most recent year provided, which for most time series this corresponds to mid-2018 until mid-2019 for most time series.

Direct method under Option A

Under Option A, the CP allows the use of two methodologies to determine a scenario of future shock: the direct method[32] and the stepwise method. In contrast, Option B only allows the stepwise method, as the EBA believes that the direct method would be inconsistent with this overarching approach.

Under the direct method for determining a scenario of future shock, institutions should first calculate the expected shortfall using the historical estimator:

$$\widehat{\mathrm{ES}}_{\mathrm{Right}}\left[loss_{D^*}\left(r_j(D^*)\oplus Ret\left(r_j,t,10\right)\right),\alpha\right]\ (1)$$

The extreme scenario of future shock is then determined as the weighted set of shocks leading to a stress scenario risk-measure as defined in Article 325bk(1) equal to the historical estimator of the expected shortfall.

The EBA has considered the following options:

Option 3a: Allow the use of the direct method under Option A

[32] The 'direct method' for determining a scenario of future shock is not to be confused with the determination of the stress scenario risk measure directly from the stress period.

Option 3b: Do not allow the use of the direct method under Option A

From a mathematical point of view, the direct method provides a conceptually simple and accurate estimate of an extreme scenario of future shock, as it is directly derived from the ES of the corresponding loss function. However, it requires significant computation effort from institutions to compute loss evaluations for each risk factor. For daily data (250 returns) it requires at least 250/6 = 41.7 times more portfolio loss evaluations for each risk factor than the step-wise methods (at maximum six evaluations are needed for scanning the maximum loss and pre-computing the non-linearity adjustment for both CSSRFR boundaries). Against this backdrop, it is expected that only a limited number of institutions may be willing to use the direct method.

In the data collection, only one institution provided figures based on the direct method. The remaining institutions indicated that, given the high operational burden of the direct method, they could not provide such estimates within the timeframe of the data collection. For the institution that provided data, the results under the direct method were very close to the historical method.

Option 3a is kept as part of the consultation. As discussed above, this option is only relevant in case Option A for the calibration to a period of stress is kept in the final draft RTS. In that case, the EBA would consider dropping the direct method, unless clear evidence is provided that it should be kept and why.

Symmetric or asymmetric sigma method

Under the historical method, institutions calibrate an upward and a downward shock applicable to the risk factor by estimating the empirical expected shortfalls of the returns for the right and left tail. Given that financial time series are usually skewed, this method often results in an upward and downward shock of different size. The EBA has considered incorporating such asymmetry in the sigma method, i.e. when the historical method is not available.

Option 4a: Calculate symmetric shocks (sigma method)

Option 4b: Calculate asymmetric shocks (asigma method)

Under Option 4a, the calibrated shocks are calculated as:

$$CS_{\mathrm{down}}(r_j) = C_{ES} \times \hat{\sigma}_{Ret(j)} \times \left(1 + \frac{C_{\mathrm{UC}}}{\sqrt{2(N-1.5)}}\right)$$

and

$$CS_{\mathrm{up}}(r_j) = C_{ES} \times \hat{\sigma}_{Ret(j)} \times \left(1 + \frac{C_{\mathrm{UC}}}{\sqrt{2(N-1.5)}}\right)$$

This option uses the estimate of the standard deviation and results in symmetric shocks, i.e. the upward and downward shocks are of the same size.

Under Option 4b, the calibrated shocks are calculated as:

$$CS_{\mathrm{down}}(r_j) = \widehat{\mathrm{ASigma}}_{\mathrm{down}}^{Ret(j)} \times \left(1 + \frac{C_{\mathrm{UC}}}{\sqrt{2(N_{\mathrm{down}} - 1.5)}}\right)$$

And

$$CS_{\mathrm{up}}(r_j) = \widehat{\mathrm{ASigma}}_{\mathrm{up}}^{Ret(j)} \times \left(1 + \frac{C_{\mathrm{UC}}}{\sqrt{2(N_{\mathrm{up}} - 1.5)}}\right)$$

where:

$$\widehat{\mathrm{ASigma}}_{\mathrm{down}}^{Ret(j)} = \left|\hat{\mu}_{Ret \le m}^{Ret(j)}\right| + C_{\mathrm{ES}} \times \sqrt{\frac{1}{N_{\mathrm{down}} - 1.5} \times \sum_{\substack{t=1, \\ Ret(r_j,t,10) \le m}}^{N} \left(Ret(r_j, t, 10) - \hat{\mu}_{Ret \le m}^{Ret(j)}\right)^2}$$

$$\widehat{\mathrm{ASigma}}_{\mathrm{up}}^{Ret(j)} = \left|\hat{\mu}_{Ret > m}^{Ret(j)}\right| + C_{\mathrm{ES}} \times \sqrt{\frac{1}{N_{\mathrm{up}} - 1.5} \times \sum_{\substack{t=1, \\ Ret(r_j,t,10) > m}}^{N} \left(Ret(r_j, t, 10) - \hat{\mu}_{Ret > m}^{Ret(j)}\right)^2}$$

This option splits the returns along the median value, m, and calculates the mean and the standard deviation for the upper and lower half of the returns.[33] This results in asymmetric shocks for skewed return distributions, i.e. the upward and downward shocks are of different size.

Option 4b caters better for skewed distributions and increases the accuracy of the calibrated shocks if compared to the historical method. However, more quantities need to be estimated and the uncertainty compensation is higher by about $\sqrt{2}$, because the number of returns below and above the median is half the full set of data points, so that the statistical uncertainty is higher.

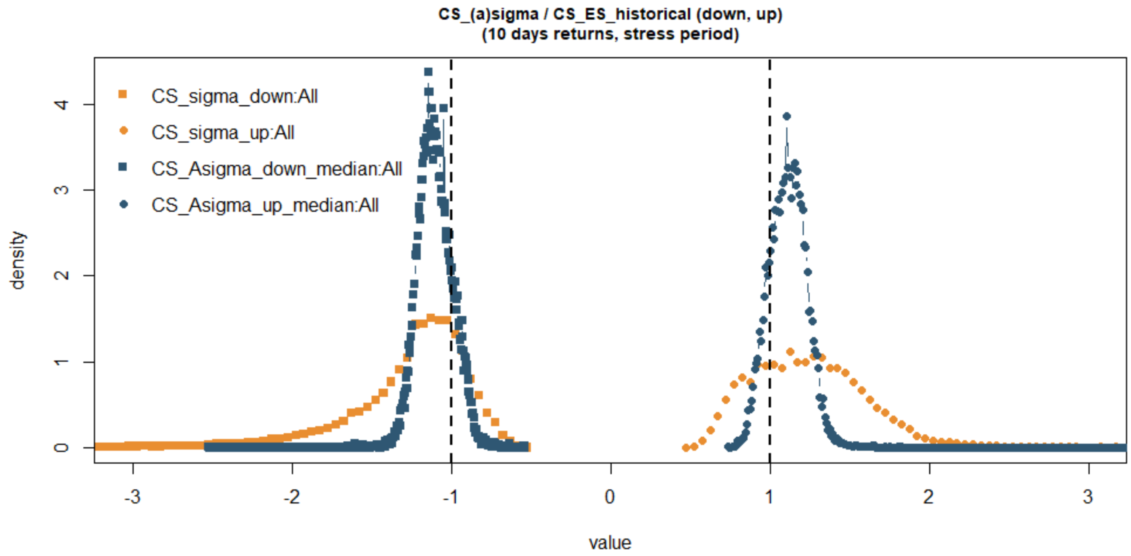
Figure 4 and Figure 5 shows the ratio of the downwards and upward calibrated shocks under the sigma/asigma method relative to the downwards and upward calibrated shocks under the historical method, for the stress and current period, respectively. As can be seen, the ratio based on the asigma method is much more narrowly centered around 1 than the sigma method. In particular, very large absolute values (i.e. calibrated shock is much larger than the historical ES) are much rarer for the asigma method.

The sigma method of Option 4b is less complex and thus more robust than the asigma method, requires somewhat less computational effort from institutions and works well on average when data for the historical method is insufficient. The uncertainty compensation is smaller, because

[33] The EBA has also considered splitting the returns into a ‘down’ and an ‘up’ part using as a split point the zero value or the mean of the returns. Overall, the split at the median performed well and has the practical advantage that the time series of returns is split exactly in half, while e.g. there could be much fewer positive than negative returns in the observation period.

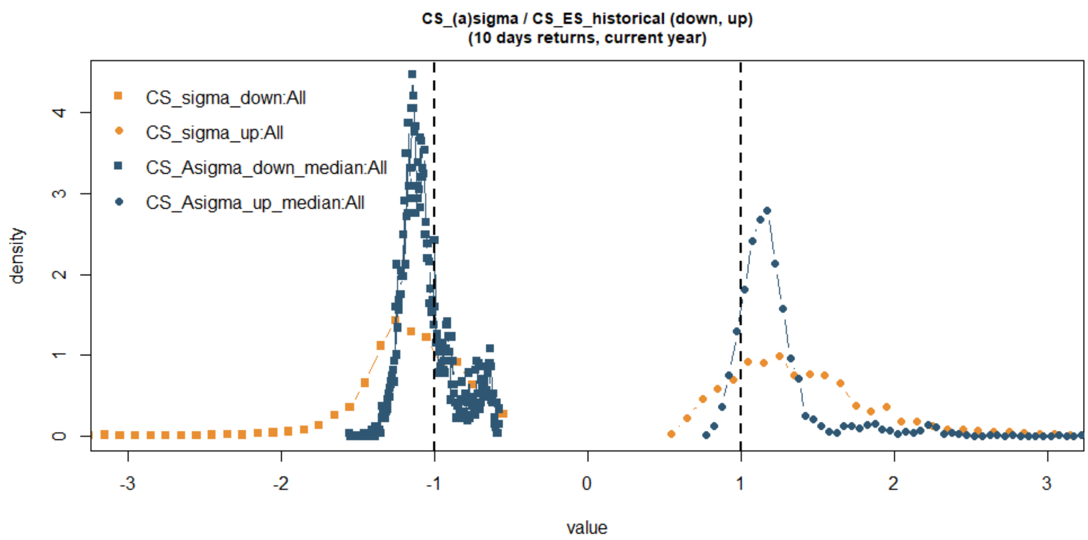
more data points are used in the estimation of sigma. However, it cannot cater for asymmetric returns.

Figure 4: Comparison of calibrated shocks based on historical method, sigma method and asigma method, stress period



Sources: EBA NMRF data collection and EBA calculations.
Notes: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one prescribed in the CP.

Figure 5: Comparison of calibrated shocks based on historical method, sigma method and asigma method, current period



Sources: EBA NMRF data collection and EBA calculations.
Notes: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one prescribed in the CP.

Both options are put forward for consultation. The EBA intends to maintain only one of the options in the final draft RTS.

Bucketing approach

Option 5a: Representative risk factors and parallel shifts

Option 5b: Contoured shifts

Under Option 5a, institutions are required to first identify the representative risk factor for a given regulatory bucket for which the institution computes the stress scenario measure at bucket level. Second, they need to calibrate the upward and downward shock for the representative factor. Finally, they apply a parallel shift to all risk factors within the bucket based on the calibrated shock of the representative factor.

Under Option 5b, institutions are required to calibrate the upward and downward shock for all risk factors within a given regulatory bucket. The resulting shocks are then multiplied by a scalar $\beta \in [0, 1]$ – the "bucket shock strength" –, to obtain a vector of upward shocks (v_β^{up}) and downward shocks (v_β^{down}), following the 'contour' of the shock strengths of the risk factors in the regulatory bucket, hence the name. The scenario of future shock is the vector of upward shocks v_β^{up} or the vector of downward shocks v_β^{down} leading to the worst loss when scanning β in $[0, 1]$.

While Option 5a is simpler, Option 5b has the potential to achieve shifts of regulatory buckets that are more closely aligned to historical risk factor movements.[34] Moreover, it can alleviate to a certain extent the concerns on the discontinuity created by shocking the risk factors within a bucket while keeping fixed those in the adjacent buckets. However, it is more complex and potentially more burdensome to implement for institutions.

Both options are put forward for consultation. The EBA intends to maintain only one of the two options in the final draft RTS.

Calibration of C_{ES}

Under the stepwise method, the calibrated shocks correspond to the expected shortfall with the specified confidence level of 97.5% for a non-modellable risk factor. In the historical method, the expected shortfall is estimated directly from the observed data if a sufficient number of observations are available to obtain an accurate estimate. Instead, in the sigma method, institutions first calculate an estimate of the standard deviation and then rescale it to get an approximation of the expected shortfall used for the calibrated shocks. Such rescaling is performed by a scalar C_{ES}, which approximates the ratio of the expected shortfall to the standard deviation. More formally:

$$C_{\mathrm{ES}}(Ret(j), \alpha) = \mathrm{ES}(Ret(j), \alpha) / \hat{\sigma}_{Ret(j)}$$

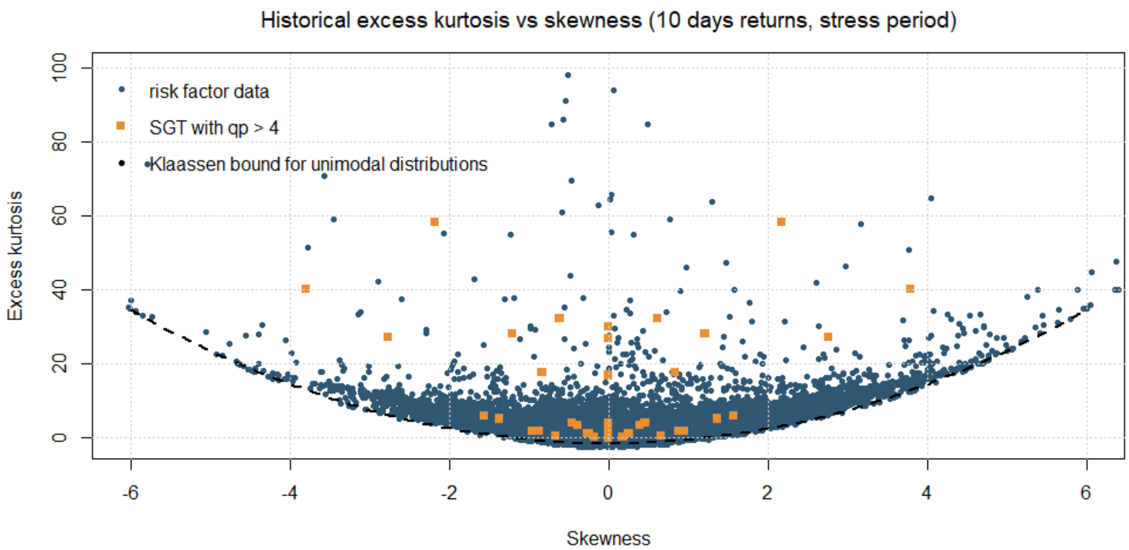
[34] During the data collection, some participants highlighted that particularly at the short end of a curve, the movements are not parallel, but rather the very short end is moving more strongly than longer maturities.

The value of C_{ES} depends on the distribution of the NMRF and the confidence level.[35] While the confidence level is set at 97.5%, the distribution of NMRF returns can vary widely and so can the exact value of C_{ES} if calculated for a particular NMRF.

Skewness and excess kurtosis were computed for risk factor returns based on the data collection data, showing that the time series are often significantly non-Gaussian in both the stress period and current period.[36] Figure 6 and Figure 7 shows that on average excess kurtosis is positive, suggesting fatter tails than the Gaussian distribution. In addition, the risk factor distribution is generally skewed (i.e. "leans" to one side).

The green dots correspond to theoretical SGT distributions as used in Annex I. Overall, the SGT distributions capture the effects of skewness and kurtosis present in the data well, while skewness is somewhat understated by the SGT distributions analysed.

Figure 6: Historical (excess) kurtosis and skewness of 10-business day returns, stress period



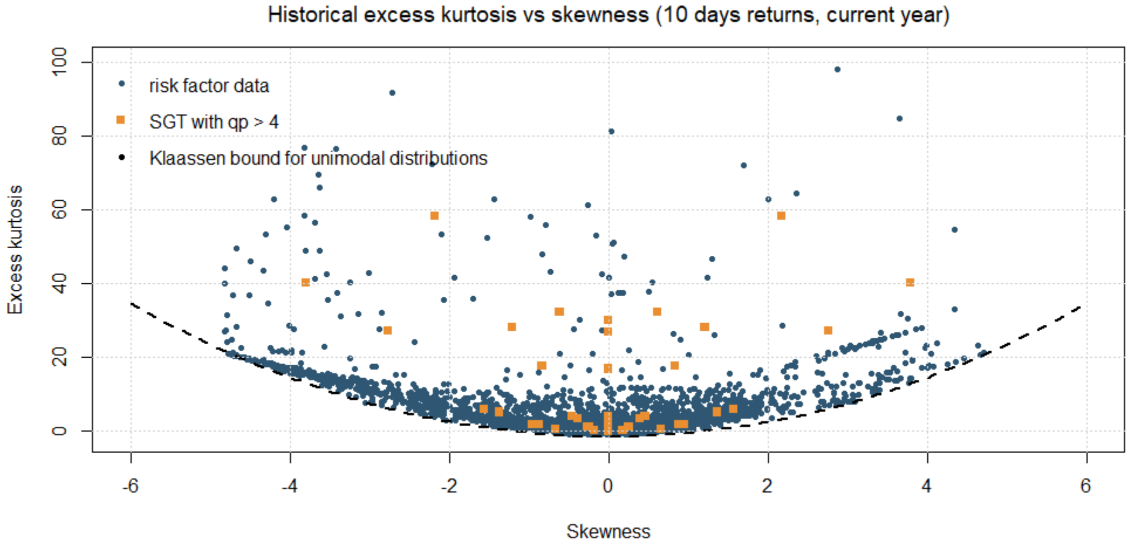
Sources: EBA NMRF data collection and EBA calculations.
Note: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one prescribed in the CP. For unimodal distributions, excess kurtosis is bounded from below by squared skewness plus 186/125 - 3 (Klaassen bound), which is indicated by a dashed line.[37]

[35] Strictly speaking, the value of C_{ES} would also depend on whether the sigma or asigma method is used.

[36] The normal (Gauss) distribution has zero skewness (i.e. is symmetrical) and zero excess kurtosis.

[37] Chris A.J. Klaassen, Philip J. Mokveld, Bert Van Es, "Squared Skewness Minus Kurtosis Bounded By 186/125 for Unimodal Distributions", Statistics & Probability Letters Volume 50, Issue 2, 1 November 2000, Pages 131-135, DOI: 10.1016/S0167-7152(00)00090-0

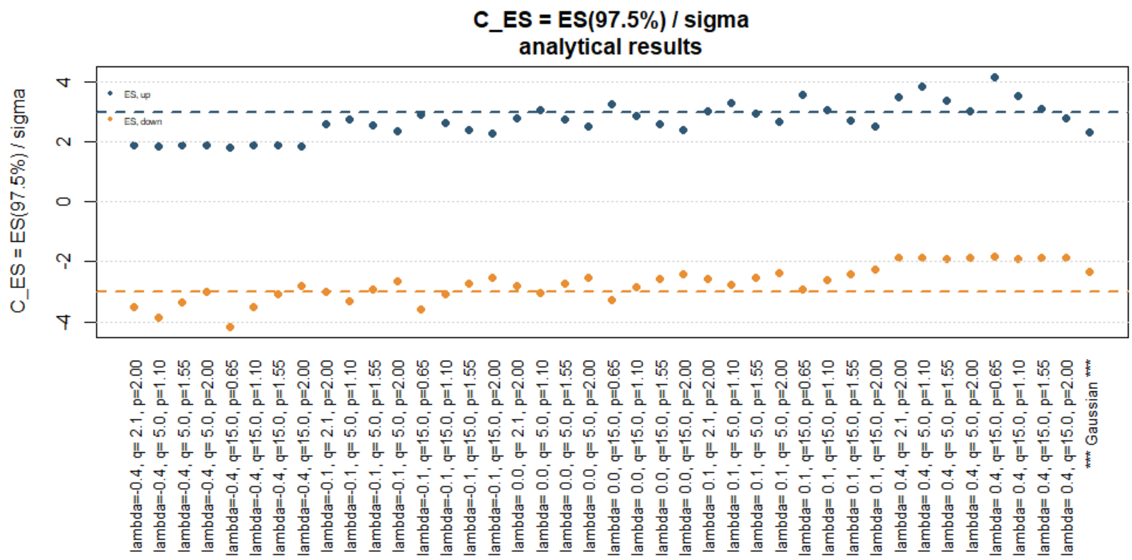
Figure 7: Historical (excess) kurtosis and skewness of 10-business day returns, current period



Sources: EBA NMRF data collection and EBA calculations.
Notes: The current period uses data from the most recent year provided, which for most time series this corresponds to mid-2018 until mid-2019 for most time series. For unimodal distributions, excess kurtosis is bounded from below by squared skewness plus 186/125 - 3 (Klaassen bound), which is indicated by a dashed line.

Under the Gaussian distribution, $C_{\mathrm{ES}}(Ret(j), 0.975) = 2.3378$. However, for skewed or more fat-tailed distributions as exemplified with SGT distributions, the expected shortfall can be substantially higher (see Figure 8). The scalar increases both with skewness (increasing with parameter $lambda$) and 'fat-tailedness' (increasing with lower values for $q * p$) and varies substantially based on the underlying distribution. In order to cover a wide range of plausible underlying distributions, C_{ES} needs to be set sufficiently higher than the value for the normal distribution. As such, the question of the calibration of C_{ES} can be formulated as to how much non-normality should be captured.

Figure 8: Estimates of C_{ES} for different skewed generalised t-distributions (SGT)

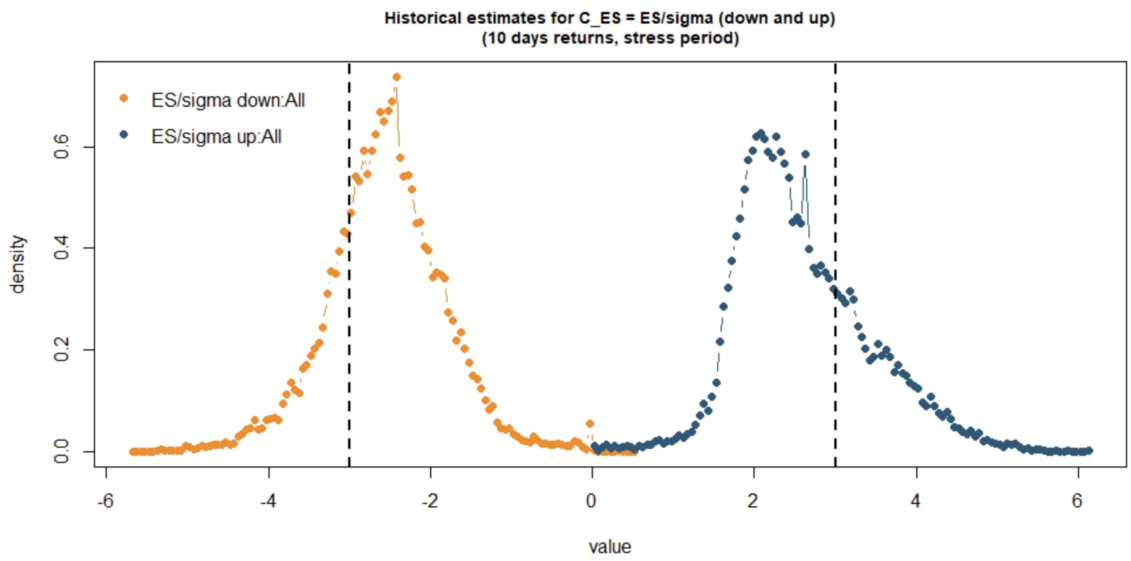


Sources: EBA NMRF data collection and EBA calculations.

Figure 9 and Figure 10 show the distribution of the historical estimates of C_{ES} based on the sigma method for the stress and current period, respectively. The historical estimates of C_{ES} are presented separately for the left and right tail ES. Similarly, Figure 11 and Figure 12 show the distribution of the historical estimates of C_{ES} based on the asigma method for the stress and current period, respectively.

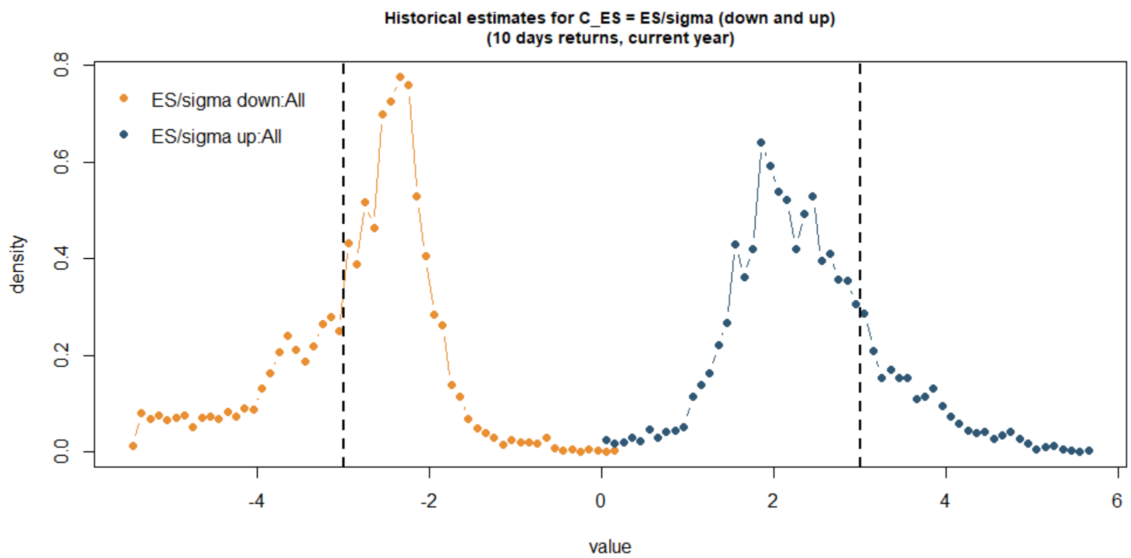
The peaks of the histograms are somewhat narrower for the asigma method, implying that there is a lower variation in the empirical values of C_{ES}. Likely, this is because skewness can be better reflected in the asigma method, which has four estimated parameters (two means and two sigmas) instead of one (sigma) in the sigma method.

Figure 9: Historical estimates for C_{ES} based on sigma method, stress period



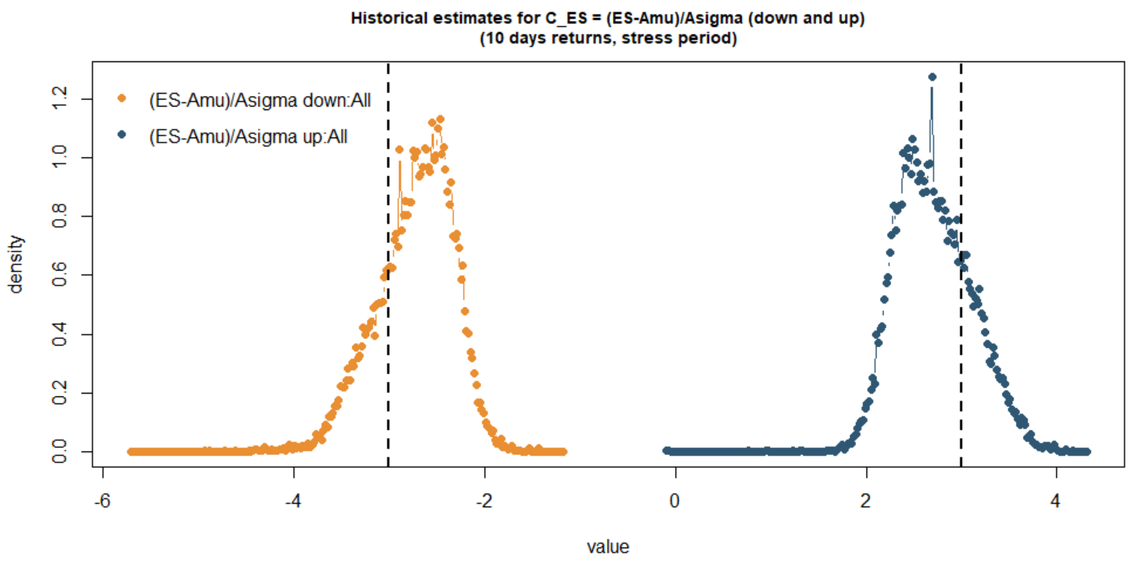
Sources: EBA NMRF data collection and EBA calculations.
Notes: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one prescribed in the CP.

Figure 10: Historical estimates for C_{ES} based on sigma method, current period



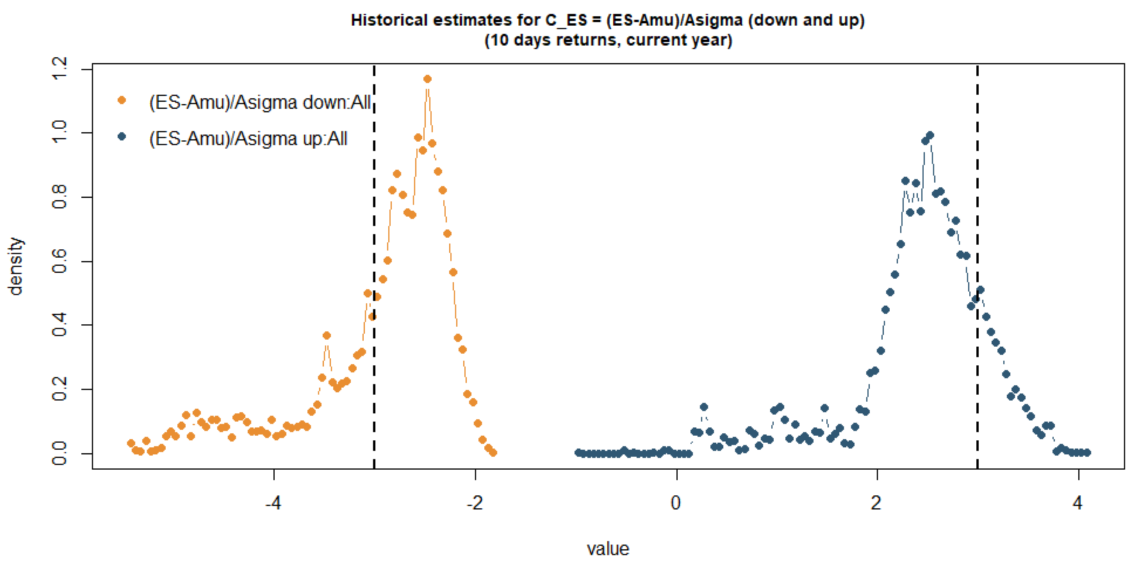
Sources: EBA NMRF data collection and EBA calculations.
Notes: The current period uses data from the most recent year provided, which for most time series this corresponds to mid-2018 until mid-2019 for most time series.

Figure 11: Historical estimates for C_{ES} based on asigma method, stress period



Sources: EBA NMRF data collection and EBA calculations.
Notes: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one prescribed in the CP.

Figure 12: Historical estimates for C_{ES} based on asigma method, current period



Sources: EBA NMRF data collection and EBA calculations.
Notes: The current period uses data from the most recent year provided, which for most time series this corresponds to mid-2018 until mid-2019 for most time series.

Table 4 shows the summary statistics of the historical estimates of C_{ES}. The (absolute) median C_{ES} ranges from 2.3 to 2.8 and the mean from 2.4 to 3. The third quartile of $|C_{\mathrm{ES}}|$ is about to 3 for most shocks (from 2.9 to 3.4, noting that the down shocks were assigned a negative sign, so that the first quartile corresponds to the third quartile of $|C_{\mathrm{ES}}|$. The values are formatted in bold).

The choice of $C_{\mathrm{ES}} = 3$, as proposed in the CP, will be moderately conservative for some combinations of method and period, while close to the mean for some others. It roughly corresponds to the third quartile of observed values, suggesting that 75% of the underlying distributions would be covered, while for 25% of the risk factors C_{ES} would be too small.

Table 4: Summary statistics for historical estimates of C_{ES} based on sigma and asigma method, stress and current period

	Count	Mean	Median	StdDev	Q1	Q3	Min	Max
Sigma method, 10 days returns, stress period								
ES/sigma down	28472	-2.55	-2.55	0.72	**-2.98**	-2.12	-5.70	0.54
ES/sigma up	28472	2.59	2.45	0.81	2.02	**3.08**	0.01	6.13
Sigma method, 10 days returns, current year								
ES/sigma down	5393	-2.82	-2.60	0.87	**-3.26**	-2.26	-5.49	0.12
ES/sigma up	5393	2.36	2.27	0.85	1.81	**2.85**	0.00	5.61
Asigma method, 10 days returns, stress period								
(ES-Amu)/Asigma down	28467	-2.73	-2.69	0.40	**-2.98**	-2.44	-5.71	-1.16
(ES-Amu)/Asigma up	28467	2.71	2.68	0.40	2.42	**2.98**	-0.09	4.30
Asigma method, 10 days returns, current year								
(ES-Amu)/Asigma down	5352	-2.91	-2.72	0.70	**-3.14**	-2.44	-5.42	-1.84
(ES-Amu)/Asigma up	5352	2.45	2.52	0.66	2.22	**2.85**	-0.96	4.06

Sources: EBA NMRF data collection and EBA calculations.

Notes: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one prescribed in the CP. The current period uses data from the most recent year provided, which for most time series this corresponds to mid-2018 until mid-2019 for most time series.

The EBA believes that setting C_{ES} = 3 strikes the right level of conservatism, considering that the sigma method is a simplified method and a first fallback to the more accurate historical method.

Calibration of the uncertainty compensation

The uncertainty compensation factor $\left(1 + \frac{C_{\mathrm{UC}}}{\sqrt{2(N-1.5)}}\right)$ has been designed for the purpose of capturing and compensating the uncertainty in computing calibrated shocks in order to avoid an undue underestimation. See Annex 1 for more details.

Number of observations needed for the different stepwise methods

The CP prescribes three different methods for calibrating shocks based on the minimum number of returns available for each risk factor.

The historical method can be used for risk factors with more than 200 returns, the sigma method for risk factors with more than 12 returns; otherwise, the fallback method should be used. The aim of the proposed waterfall approach is to cater for all non-modellable risk factors with different data availability, ranging from daily data to almost no observations at all. The guiding principle of the waterfall approach is that the more data is available, the more detailed the calibration can be performed, while for less data a simpler and more robust approach is needed.

In particular, the expected shortfall at 97.5% confidence is a tail measure which takes into account only 2.5% of the data points. By setting the minimum number for the historic method to 200, the historical ES estimator uses at least 200 * 2.5% = 5 points in the tail. This value seems appropriate in order to allow time series that have about a total of two months of data missing within a year. Conversely, for a risk factor with less than 200 data points, less than five data points would be taken into account, making the ES unstable and entailing higher estimation error (see Figure 19 in Annex I on the uncertainty compensation).

The estimation of the standard deviation is statistically much more robust than the expected shortfall as can be seen from the standard deviation of the quantities. Figure 18 in Annex I shows the standard deviation of the estimated standard deviation (sigma). Twelve returns seems to lead to a still acceptable estimation error. Note that N=12 for the asigma method means six points above and below the median, similar to the requirement for the historic method (five).

Fallback method

In the instructions of the data collection, the EBA has put forward a fallback approach, which included a list of prescribed calibrated shocks for each broad risk factor subcategory. The shocks were calibrated based on the risk weights applied in these subcategories in the sensitivities-based approach (i.e. standardised method). Given the feedback received during the data collection, the EBA has substantially re-designed the fallback approach. The following options were considered:

Option 6a: Based on a list of prescribed calibrated shocks for each broad risk factor subcategory (as in the data collection instructions)

Option 6b: For risk factors that coincide with one of the risk factors included in the sensitivities-based method, calibrate shocks based on the respective risk weights. For all remaining risk factors, use the ‘same type of risk factor’ option or the ‘change in period’ option.

Option 6a is a simple and harmonised method for calculating calibrated shocks. However, it covers only the risk factors that are included in the sensitivities-based method (i.e. the prescribed list). Option 6b allows the use of the fallback approach for all risk factors. It is also more flexible in case data is available for another time period or the same type of risk factor. It is also expected to be less conservative than Option 6a.

Option 6b is preferred.

Nearest to 10 business days return method

In the instructions of the data collection, the EBA requested institutions to calculate the nearest 10 day returns using a five day "block-out period". The aim was to avoid that the last observation within the observation period was used very often, when computing the returns from the last 11 observations in the period. Given the experience from the data collection, the EBA has considered the following options:

Option 7a: Use a five-day block-out period

Option 7b: Extend the 1 year period by 20 business days

Under Option 7a, for each date index $t \in \{1, \dots, M-1\}$ for which an observation is available a "nearest next to 10 days" candidate $t_{nn}(t)$ should be determined by applying the following formula:

$$t_{nn}(t) = \underset{\substack{t' > t \\ D_M - D_t > 5 \text{ days} \\ t' \in \{2,\dots,M\}}}{\operatorname{argmin}} \left[\left|\frac{10 \text{ days}}{D_{t'} - D_t} - 1\right|\right]$$

The return for date index t'should only be considered when $D_M - D_t > 5$ days, in order to avoid having too many returns using the last data point $r_j(D_M)$. As a result of this "block-out period", the number N of sample returns might be smaller than the number of risk factor value observations minus one, $M - 1$.

Let $\{D_1, \dots, D_M, D_{M+1}, \dots D_{M+d}\}$ be the vector representing the observations' dates within the 1y-stress period extended by 20 business days. Then, for a given non-modellable risk factor, the vector $\{D_1, \dots, D_M\}$ represents the observation dates within the 1y-stress period, and the vector $\{D_{M+1}, \dots D_{M+d}\}$ represent the observation dates during the 20 business days following the 1y-stress period.

Under Option 7b, for each date index $t \in \{1, \dots, M-1\}$ a "nearest next to 10 days" candidate $t_{nn}(t)$ should be determined by applying the following formula:

$$t_{nn}(t) = \underset{\substack{t' > t \\ t' \in \{2,\dots,M,M+1,\dots M+d\}}}{\operatorname{argmin}} \left[\left|\frac{10 \text{ days}}{D_{t'} - D_t} - 1\right|\right]$$

Accordingly, being $t \in \{1, \dots, M-1\}$ and $t' \in \{2, \dots, M,\ M+1, \dots M+d\}$, the 'starting' observation used to determine a return always lies in the 1-year stress period, while the 'ending observation' may lie in the 20-days period following the 1-year stress period. In this case, $N = M - 1$.

While participants to the data collection did not provide any comment on the block-out period method, some did not implement it correctly. Therefore, the EBA considered Option 7b, which extends the observation dates by up to 20 business days, without using such block-out period. The choice of 20 days corresponds to the minimum liquidity horizon assumed for NMRF.

The choice of the method has little influence on the final calibrated shocks. Option 7b has the advantage that it ensures that the number of returns equals the number of level observations minus one, which makes the IT implementation simpler. Moreover, it allows for slightly more data points to be used, improving statistical stability.

Option 7b is preferred.

Searching for the maximum loss in CSSRFR

In the last step of the stepwise method, institutions are required to determine the extreme scenario of future shock by identifying the worst loss incurred when the non-modellable risk factor moves within the identified calibrated stress scenario risk factor range.

Institutions participating to the data collection exercise were required, in order to identify the extreme shock in $CSSRFR\left(r_j(D^*)\right)$, to evaluate the loss function on a grid of eleven equidistant points (the current value and ten scanning points) splitting the range in ten intervals. The set of those points was formally defined as follows:

$$Grid_{\text{data collection exercise}} = \left\{ r_j(D^*) \ominus i \times \frac{CS_{\text{down}}(r_j)}{5}, r_j(D^*), r_j(D^*) \oplus i \times \frac{CS_{\text{up}}(r_j)}{5} \mid i = 1, \dots, 5 \right\}$$

However, a majority of participating institutions expressed concerns with respect to the computational effort that a valuation of the loss on ten points in addition to the current value would require and claimed that in many cases the highest loss would occur at the boundaries of the $CSSRFR$.

Following this feedback the EBA has considered the following options:

Option 8a: Evaluate the loss function on a grid of eleven equidistant points splitting the range in ten intervals

Option 8b: Evaluate the loss function on a grid of four points (the two outer points in each direction)

Under Option 8b, the search of the maximum loss by scanning of the calibrated stress scenario risk factor range (CSSRFR) is done by searching a grid consisting of four points:

$$\text{Grid}_{\text{draft RTS}} = \left\{ \begin{matrix} r_j(D^*) \ominus 100\%\ CS_{\text{down}}(r_j), r_j(D^*) \ominus 80\%\ CS_{\text{down}}(r_j), \\ r_j(D^*) \oplus 80\%\ CS_{\text{up}}(r_j), r_j(D^*) \oplus 100\%\ CS_{\text{up}}(r_j) \end{matrix} \right\}$$

While in theory the maximum loss could occur at any point in the CSSRFR, it is more likely to occur at the boundaries, i.e. for the strongest shocks. Indeed, the loss incurred if a risk factor stays constant is typically very small (in case the passage of time effect is not captured, it is exactly zero). The data collection asked institutions to identify where the highest loss was observed and indeed, this was mostly (but not always) at the boundaries of the CSSRFR.

Option 8b has the advantage of reducing significantly the computation burden for institutions, by only requiring computing the loss at 4 points – the two outer points in both directions. The main idea is that a maximum loss is unlikely to occur at small risk factor movements, while not necessarily always at the strongest shocks in the CSSRFR. Therefore, under Option 8b, the search for the maximum loss is not performed at the center of the CSSRFR as in Option 8a, but only at the 80% and 100% downward or upward calibrated shock. Moreover, the grid points correspond to the step width h for the non-linearity adjustment and can be directly re-used for the computation of this adjustment, reducing further the computation burden for institutions.

Option 8b is preferred.

Calibration of tail parameter ϕ

The stepwise method is based on the idea that $ES(loss[r_j(D_t)])$ is approximately equal to $loss(ES[r_j(D_t)])$. However, when losses grow faster than linearly (e.g. when the loss function is convex), the expected shortfall of losses for varying $r_j(D_t)$ is higher than the loss under the expected shortfall of $r_j(D_t)$. As a result, for a given non-modellable risk factor j, institutions have to calculate the 'non-linearity adjustment' $\kappa^j_{D^*}$ where the extreme scenario of future shock is calculated in accordance with the stepwise method and such extreme scenario occurs at the boundaries of the calibrated stress scenario shock range at figure date $CSSRFR\left(r_j(D^*)\right)$. The non-linearity adjustment $\kappa^j_{D^*}$ is determined as follows:

$$\kappa^j_{D^*} = \max\left[\kappa_{\min}, 1 + \frac{\mathrm{loss}_{D^*}(r_{j,-1}) - 2 \times \mathrm{loss}_{D^*}(r_{j,0}) + \mathrm{loss}_{D^*}(r_{j,1})}{2 \times \mathrm{loss}_{D^*}(r_{j,0})} \times (\phi - 1) \times 25\right]$$

where,

$$h = \begin{cases} \dfrac{CS_{\mathrm{up}}(r_j)}{5} \text{ where the extreme scenario of future shock is } \mathrm{CS_{up}}(\mathrm{r_j}) \\ \dfrac{CS_{\mathrm{down}}(r_j)}{5} \text{ where the extreme scenario of future shock is } \mathrm{CS_{down}}(\mathrm{r_j}) \end{cases}$$

$$r_{j,0} = \begin{cases} r_j(D *) \oplus CS_{\mathrm{up}}(r_j) \text{ where the extreme scenario of future shock } is\ CS_{\mathrm{up}}(r_j) \\ r_j(D *) \ominus CS_{\mathrm{down}}(r_j) \text{ where the extreme scenario of future shock is } CS_{\mathrm{down}}(r_j) \end{cases}$$

and

$$r_{j,-1} = r_{j,0} \ominus h$$

$r_{j,+1} = r_{j,0} \oplus h$

The step width h was set to a value that balances the need to grasp a meaningful part of the tails of the returns, but also be small enough to provide a meaningful local curvature measure at the left or right boundary of CSSRFR. In other words, it is a compromise between wide enough and local enough. In the data collection, the step width 20% appeared to work well in practice, as no feedback was received that this value was unsuitable in any way.

One institution participating in the data collection exercise pointed out that also portfolios whose value depends linearly on the given NMRF can attract a non-linearity correction $\kappa_{D^*}^{j}$ different from 1. In fact, this can be the case when the application operator $\oplus/\ominus$ of the chosen return type is non-linear (e.g. for log returns). In this situation, the three stencil points $r_{j,-1}$, $r_{j,0}$ and $r_{j,1}$ (which correspond to the application of 80%, 100% and 120% of $CS_{\mathrm{up/down}}$, respectively) might exhibit unequal spacing, thereby yielding a non-zero estimate for the second derivative. This behavior is compatible with the derivation of the quadratic approximation formula, and therefore intentional.

The tail parameter ϕ is used in the formula for approximating the relative difference of the expected shortfall of losses due to risk factor movements and the loss of the expected shortfall of risk factor movements in the tail of the risk factor movements in a quadratic approximation. More precisely, ϕ measures how the expectation value of squares in the tail of a distribution relates to the square of the expectation value, the ES,

$$\hat{\phi}_{\mathrm{Left/Right}}\big(Ret(j)\big) \stackrel{\mathrm{def}}{=} \frac{E\big[Ret(j)^2 \,\big|Ret(j) \text{ in left/right } \alpha - \text{tail}\big]}{\big\{\widehat{\mathrm{ES}}_{\mathrm{Left/Right}}(Ret(j),\alpha)\big\}^2}.$$

The tail parameter depends very strongly on the distribution of the NMRF. As exemplified with SGT distributions in Figure 13, the tail parameter ϕ can vary substantially for different distributions. It increases strongly with decreasing peakedness parameter p.

Figure 13: Tail parameter ϕ for different skewed generalised t-distributions (SGT)

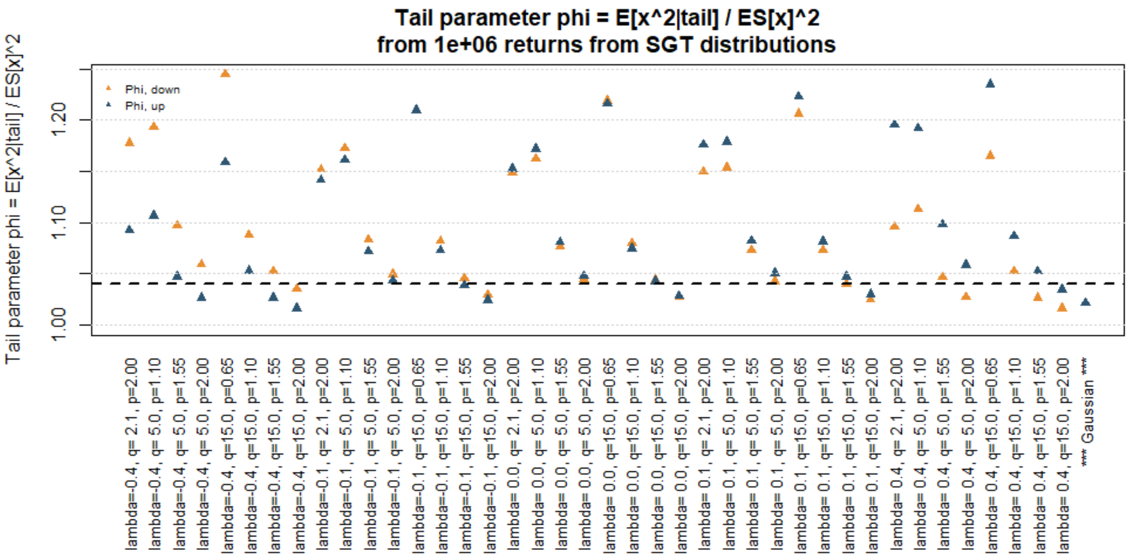
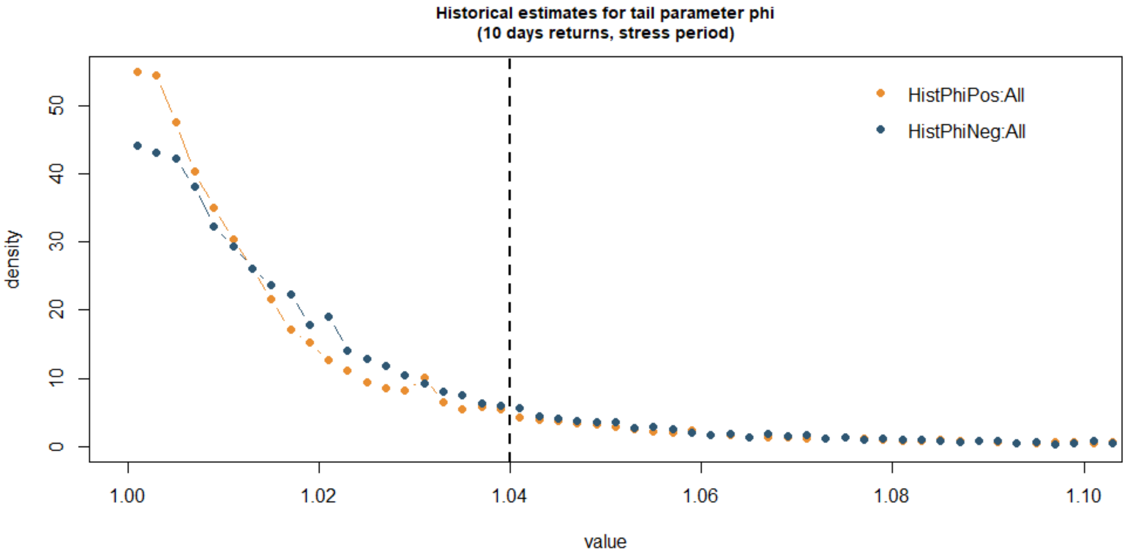


Figure 14 and Figure 15 show the histogram of the values for ϕ in the stress periods and the current year. Table 5 shows the summary statistics for ϕ. The historical estimates of ϕ range from 1 to 6.1, with a mean of about 1.04 and with 75% percent of the estimates being below 1.03 as depicted by the third quartile.

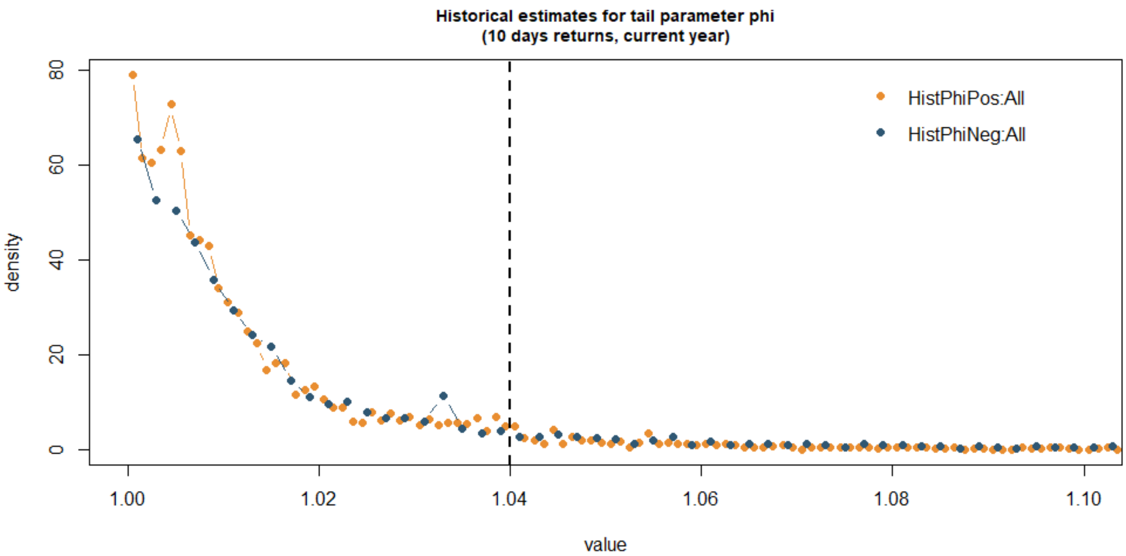
Under the sigma method, institutions are not allowed to estimate ϕ based on historical data, as the estimate is based on an expected shortfall calculation, for which too few data points are available (and hence the choice of sigma method in the first place). The value of ϕ is proposed to be fixed at 1.04, which is close to the average of all mean values reported individually for the left and right tails and the stress and current year (actual value is 1.043). This value $\phi = 1.04$ was previously proposed in an industry feedback and is a bit smaller than the value used in the NMRF SSRM data collection exercise (1.05).

Figure 14: Historical estimates of tail parameter ϕ, stress period



Sources: EBA NMRF data collection and EBA calculations.
Notes: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one prescribed in the CP.

Figure 15: Historical estimates of tail parameter ϕ, current period



Sources: EBA NMRF data collection and EBA calculations.
Notes: The current period uses data from the most recent year provided, which for most time series this corresponds to mid-2018 until mid-2019 for most time series.

Table 5: Distribution of historical estimates of tail parameter ϕ, stress and current period

	Count	Mean	Median	StdDev	1stQuart	3rdQuart	Min	Max
Sigma method, 10 days returns, stress period								
Phi left	28800	1.04	1.01	0.19	1.01	1.03	1.00	5.71
Phi right	28800	1.03	1.01	0.12	1.01	1.03	1.00	6.23
Sigma method, 10 days returns, current year								
Phi left	5387	1.03	1.01	0.14	1.00	1.02	1.00	3.90
Phi right	5387	1.06	1.01	0.32	1.00	1.03	1.00	5.76

Sources: EBA NMRF data collection and EBA calculations.
Notes: The stress period used for each category was the one defined by the institution – on a best effort basis – and does not necessarily correspond to the one prescribed in the CP. The current period uses data from the most recent year provided, which for most time series this corresponds to mid-2018 until mid-2019 for most time series.

Under the historical method, the EBA has considered the following options:

Option 9a: Estimate the tail parameter ϕ using historical data

Option 9b: Set $\phi = 1.04$.

While the historical estimate under Option 9a provides a number that is more accurate than a global estimate, there is estimation error in ϕ.

Both options are retained for consultation.

Floor for the non-linear adjustment (κ_{min})

Most financial instruments are non-linear (longer dated bonds, put and call options at the money being simple examples). Therefore, a non-linearity adjustment is generally required in order not to ignore effects of non-linearity. In practice, for some portfolios the non-linearity effect may be small, while for others it is more material. However, without a quantitative measure it is difficult to assess if a noticeable non-linearity effect occurs and how strong it is.

The non-linearity adjustment is a simple quadratic approximation for adjusting for losses growing non-linearly for very large risk factor shocks. In computing the quadratic approximation, the curvature of the loss function is determined with a three-point stencil with a step width h set to 20% of the relevant calibrated shock. Due to the limitations of the approach, the benefit of the non-linearity adjustment is floored at $\kappa_{\text{min}} = 0.9$.

To identify an adequate lower bound for the non-linearity adjustment, the exact adjustment can be evaluated in the very beneficial situation where the loss function, hypothetically, increases linearly until hitting the left or right bound of CSSRFR and then is flat. Under distributional assumptions compatible with the choice $\phi = 1.04$, this yields a non-linearity adjustment of $\kappa_{\text{min}} = 0.9$. Adjustments smaller than this value are therefore likely due to inaccuracies of the quadratic approximation, and should not be recognised.

5.2 Overview of questions for consultation

Q1. What is your preferred option among option A (stress period based extreme scenario of future shock) and option B (extreme scenario of future shock rescaled to stress period)? Please elaborate highlighting pros and cons.

Q2. What are characteristics of the data available for NMRF in the data observation periods under options A and B?

Q3. Do you think that institutions will actually apply the direct method to derive the extreme scenario of future shock or do you think that given the computational efforts that it requires and considering that the historical method typically provides very similar results it will not be used in practice? As stated in the background section of this CP, the EBA will drop the direct method from the framework if not provided with clear evidence for its need.

Q4. What is your preferred option among (i) the representative risk factor – parallel shift option, and (ii) the contoured shift option? Please elaborate highlighting pros and cons.

Q5. What are your views on how institutions are required to build the time series of 10 business days returns? Please elaborate.

Q6. What is your preferred option among (i) the sigma method and (ii) the asymmetrical sigma method for determining the downward and upward calibrated shocks? Please highlight the pros and cons of the options. In addition, do you think that in the asymmetrical sigma method, returns should be split at the median or at another point (e.g. at the mean, or at zero)? Please elaborate.

Q7. What are your views on the value taken by the constant C_{ES} for scaling a standard deviation measure to approximate an expected shortfall measure?

Q8. What are your views on the uncertainty compensation factor $\left(1 + \frac{C_{UC}}{\sqrt{2(N-1.5)}}\right)$? Please note that this question is also relevant for the purpose of the historical method.

Q9. What are your views on the fallback method that is envisaged for risk factors that are included in the sensitivity-based method? Please elaborate.

Q10. What are your views on the fallback method that is envisaged for risk factors that are not included in the sensitivity-based method? Please comment on both the 'other risk factor' method, and the 'changing period method'.

Q11. What are your views on the conditions identified in paragraph 5 that the 'selected risk factor' must meet under the 'other risk factor' method? What would be other conditions ensuring that a shock generated by means of the selected risk factor is accurate and prudent for the corresponding non-modellable risk factor?

Q12. What are your views on the definition of stress period under option A (i.e. the period maximizing the rescaled stress scenario risk measures for risk factors belonging to the same broad risk factor category)? What would be an alternative proposal?

Q13. What are your views on the definition of maximum loss that has been included in these draft RTS for the purpose of identifying the loss to be used as maximum loss when the latter is not finite? What would be an alternative proposal?

Q14. How do you currently treat non-pricing scenarios (see section 3.2.5 of the background section) if they occur where computing the VaR measures? How do you envisage implementing them in (i) the IMA ES model and (ii) the SSRM, in particular in the case of curves and surfaces being partly shocked? What do you think should be included in these RTS to address this issue? Please put forward proposals that would not provide institutions with incentives that would be deemed non-prudentially sound and that would target only the instruments and the pricers for which the scenario can be considered a 'non-pricing scenario'.

Q15. What are your views on the conditions included in these draft RTS for identifying whether a risk factor can be classified as reflecting idiosyncratic credit spread risk only (resp. idiosyncratic equity risk only)? Please elaborate.

Q16. What are your views on flooring the value taken by non-linearity coefficient κ to 0.9? Please elaborate.

Q17. What are your views on the definition of the tail parameter ϕ_{avg} where a contoured shift is applied (i.e. average of the tail parameters of all risk factors within the regulatory bucket)? Please elaborate.

Q18. Would you consider it beneficial to set the tail parameter ϕ to the constant value 1.04 regardless of the methodology used to determine the downward and upward calibrated shock (i.e. setting ϕ = 1.04 also under the historical method, instead of using the historical estimator)? Please elaborate.

Q19. Do you agree with the definition of the rescaling factor $m_{S,C}^{i}$ under option B or do you think that the rescaling of a shock from the current period to the stress period should be performed differently? Please elaborate.

Q20. The scalar $m_{S,C}^{i}$ is obtained by using data related to modellable risk-factors in a specific risk class (i.e. the class i). As a result, such a scalar is not defined where an institution does not have any modellable risk factor in this risk class. How do you think the scalar $m_{S,C}^{i}$ should be determined in those cases? Please elaborate.

5.3 Annex I: uncertainty compensation factor (UC)

Introduction

Non-modellable risk factors are characterised by lower market observability and potentially lower data availability. The guiding idea behind the uncertainty compensation factor (UC) employed in the stress scenario risk measure is that higher uncertainty should be compensated for in the calibrated shocks.

The sources of uncertainty of the calibrated shocks obtained by the different methods as described in the main text are:

A. statistical estimation error

B. parameter choice uncertainty

C. uncertainty of each data point due to low market observability

Statistical estimation error arises when using $N = 12 \ldots \sim 250$ returns for the computation of a calibrated shock from returns in the one year observation period, because such a relatively small number does not provide a high statistical accuracy. Parameter choice uncertainty is present in the parameters of the sigma and asigma methods, as well as in the non-linearity correction. The uncertainty of each data point due to low market observability is due to the nature of non-modellable risk factors.

For the purpose of the SSRM, all these effects are addressed by a single uncertainty compensation factor given by:

$$UC(C_{\mathrm{UC}}, N) \stackrel{\mathrm{def}}{=} \left(1 + \frac{C_{\mathrm{UC}}}{\sqrt{2(N-1.5)}}\right)$$

where $C_{\mathrm{UC}} = 1.28$.

The proposed uncertainty compensation factor, and in particular its functional form in the number of relevant returns N is derived from the statistical estimation error for the standard deviation of independent, identical, normal distributions in the large N limit.

In the asigma method the number of relevant returns above and below the median is taken to be $N/2$ in the calibration period and therefore $N/2$ is used in the uncertainty compensation factor instead of N.

Clearly, real risk factor distributions in the relevant calibration period for obtaining extreme scenarios of future shock do not follow these distributional assumptions in general. Moreover, the same uncertainty compensation factor is applied for all the different methods for the calibrated shocks, while they are based on different statistical quantities (e.g. historical expected shortfall or the historical standard deviation) and different parameters.

Therefore, the following questions are relevant:

1. Is the uncertainty compensation factor N dependency (the functional form) working also in case the calibrated shock is computed for non-normal distributions and not based on the standard deviation?

2. Is the calibration constant C_{UC} value appropriate for the various methods?

This annex is organized as follows: first, the derivation of the UC is recalled; then, the distribution parameters for random distributions which are used in the study in this annex are described. Next, the first question on the dependency on the number of return observations is addressed. Finally, the second question on the appropriateness of the level of the constant C_{UC} is looked at.

Derivation of the UC as statistical estimation error

This section is summarizing the derivation of the uncertainty compensation factor as presented in the 2017 discussion paper on the EU implementation of market risk and counterparty credit risk revised standards (EBA/DP/2017/04[38], Annex 4).

Assume N returns of a risk factor which are identically and independently distributed (i.i.d.) as normal distributions with unobserved true population standard deviation and zero mean. The core idea is that the standard deviation of the estimator for the return's standard deviation is Chi-distributed with $N-1$ degrees of freedom. For large N, the Chi-distribution can be approximated by a normal distribution with standard deviation σ_{Chi}. In order to achieve a given confidence level in the estimation of the standard deviation of returns, the term

$$\Phi^{-1}(\mathrm{CL}_{\mathrm{sigma}}) \times \frac{\sigma_{\mathrm{Chi}}(N-1)}{\sqrt{N-1.5}}$$

has to be added to the estimate. Using the large N limit of σ_{Chi},

$$\sigma_{\mathrm{Chi}}(N-1 \to \infty) \approx \frac{1}{\sqrt{2}}$$

and adding unity to get a multiplicative factor, one arrives at the uncertainty compensation factor above.

The constant C_{UC} was set by choosing 90% as confidence level for the estimation of the sample standard deviation of the i.i.d. normal case in the large N limit, with $\Phi^{-1}(\mathrm{CL}_{\mathrm{sigma}} = 90\%) = C_{UC} = 1.28$.

Note that because the calibrated shocks are not standard deviations, but approximations of expected shortfalls, this confidence level says little about the confidence level for the calibrated shocks. It needs to be demonstrated that it is an appropriate approach for the historical method, the sigma and asigma methods.

[38] https://eba.europa.eu/sites/default/documents/files/documents/10180/2161587/a5f47920-54be-4b68-a25c-119c70606186/Discussion%20Paper%20on%20EU%20implementation%20of%20MKR%20and%20CCR%20revised%20standards%20%28EBA-DP-2017-04%29.pdf

Setting the SGT parameters

The simulation approach employed in this annex uses families of normalised Skewed Generalised t-distributions (SGT)[39] for risk factor returns (like in the 2017 discussion paper), in order to have well defined distributional properties and being able to compare distribution metrics for small N samples with their large N limit, approximating the true values of the parent distribution.

SGT distributions replicate stylised facts of risk factor returns well, in particular skewness and fatter tails than a normal distribution[40]. The parameter $lambda$ controls the skewness, the parameter q controls the tail thickness, and the parameter p controls the peakedness.

The normal distribution is obtained for $lambda = 0$, $q = \infty$, and $p = 2$, and the Student-t distribution family with $n = qp$ degrees of freedom is obtained for $lambda = 0$, and $p = 2$.

Figure 16 shows some examples for SGT distributions investigated for the analysis here. It can be seen that they can exhibit skewness, sharper peaks and fatter tails.

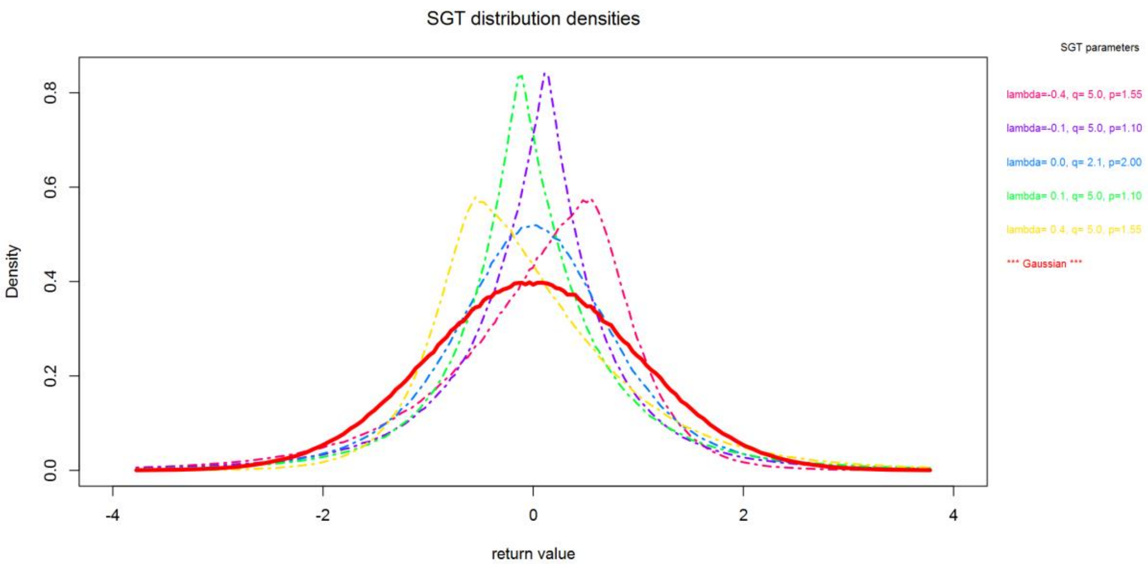


Figure 16

SGT distributions can be used to approximate a wide range of the NMRF return data distributions that are to be capitalised under the stress scenario risk measure.

For determining the relevant parameter ranges, SGT distributions were fitted to the nearest to 10 business days risk factor returns generated from the data gathered in the SSRM data collection exercise[41].

[39] P. Theodossiou, “Financial Data and the Skewed Generalized T Distribution,” Management Science, vol. 44, pp. 1650-1661, December 1998. Available: https://ssrn.com/abstract=65037.

[40] McDonald, J.B. and Michelfelder, R.A. (2017) “*Partially Adaptive and Robust Estimation of Asset Models: Accommodating Skewness and Kurtosis in Returns”.* Journal of Mathematical Finance, 7, 219-237. https://doi.org/10.4236/jmf.2017.71012

[41] Using the R package ‘SGT’, https://cran.r-project.org/web/packages/sgt/index.html and its fit function sgt.mle().

In order to take all risk classes into account, summary statistics for the SGT parameters per risk class were calculated. In particular, per risk class the first and third quartile of each SGT parameter were computed, and used as a basis for obtaining relevant SGT parameter ranges. Half of the parameters for risk factors of a risk class would fall in these ranges (unconditionally on other parameters). Those ranges are more robust than e.g. high quantiles. The analysis was performed for the stress period, the most recent year of data and full time series from 2007 to 2019 available.

Values in the following table 6, are rounded and correspond to values in the ranges of historical skewness and excess kurtosis values observed in the stress and current period (green squares in Figure 5 and Figure 6 in the cost-benefit analysis / impact assessment section).

SGT parameter	**Low**	**high**
lambda	-0.4	0.4
q (tail)	2.1	15 (∞ is Gaussian)
p (peakedness)	0.65	2 (Gaussian)

Table 6

In the simulation study only SGT parameter combinations leading to finite first four moments, i.e. $p > 4$ were used. To illustrate the range of distributions investigated, Figure 17 shows the standardized excess kurtosis vs. the standardized skewness for all SGT parameter combinations. The Gaussian distribution corresponds to the point at the origin. The dashed parabola is the Klaassen bound[42] for unimodal distributions, $Excess\ kurtosis \geq\ skew^2 + \frac{186}{125} - 3$.

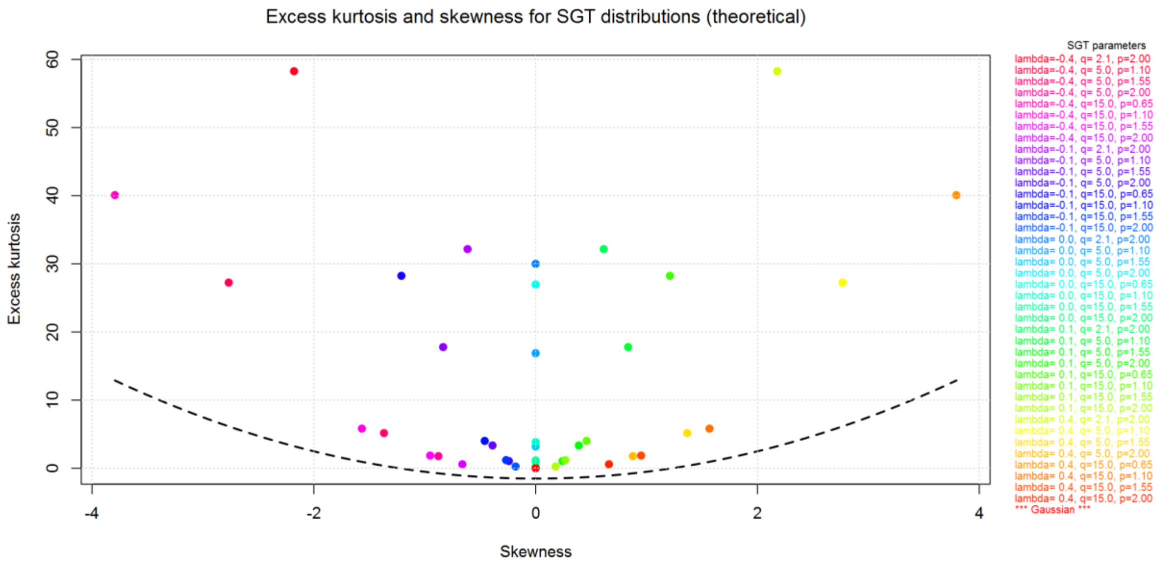


Figure 17

More extreme values for the SGT parameters were observed. For the purpose of this analysis, the choice of the SGT parameters is not crucial: a different range of SGT distribution parameters would

[42] Chris A.J. Klaassen, Philip J. Mokveld, Bert Van Es, „Squared Skewness Minus Kurtosis Bounded By 186/125 for Unimodal Distributions”, Statistics & Probability Letters Volume 50, Issue 2, 1 November 2000, Pages 131-135, DOI: 10.1016/S0167-7152(00)00090-0

modify the dispersion of the values presented in the following sections, without altering the conclusions.

The SGT distribution parameter ranges in **Error! Reference source not found.** are in line with the parameter ranges of the analysis shown in the 2017 discussion paper, which was based on literature values. The parameter range considered here is somewhat extending those ranges, which is due to the greater variety of risk factors considered.

Description of the simulation method

In a first step, a large N sample ($N = 2 \cdot 10^7$) was drawn from an SGT distribution for a given SGT parameter set from which risk metrics and calibrated shocks according to the different methodologies in the main part of this consultation paper were computed to obtain an approximation of the “true” values by using historical estimators[43].

In a second step, small samples of returns of size 12 to 250 mimicking the returns in a one year calibration period are drawn, from which the standard deviation and calibrated shocks are obtained according to the historical, sigma and asigma method. These are random quantities and show fluctuations. Therefore, this small return sample step is repeated many times ($5 \cdot 10^4$) to obtain statistical information on the small sample quantities, i.e. typically the calibrated shocks, to allow extracting information on the probability of underestimation of the true (large sample) values.

Simulation results: Functional form

The first question was to check whether the functional from of the UC is appropriate for the different calibrated shock methods.

To this end, Figure 17 shows the standard deviation of sigma (i.e. standard deviation of the estimated standard deviation of the small sample returns in the calibration period). It can be seen that the overall shape of the curves are similar for all SGT parameter sets, including the Gaussian (normal distribution) case, which was used as a starting point for the derivation of $UC(C_{UC}, N)$. The stronger the deviations from the normal distribution is, the larger the sampled estimation error.

[43] There are analytical results for risk measures for the SGT distribution (e.g. ES), c.f. Theodossiou, Panayiotis, “*Risk Measures for Investment Values and Returns Based on Skewed-Heavy Tailed Distributions: Analytical Derivations and Comparison*“ (May 11, 2018). Available at SSRN: https://ssrn.com/abstract=3194196. It uses a different parametrisation which needs to be converted into the q, p notation here.

For the asigma method no analytical result are known to the EBA. Therefore, for all large N values the same simulation based estimation method as for the small sample returns was used, for which it had to be developed anyway. For the ES the large N simulated values were compared to the analytical results and the deviations were negligible at the used sample size.

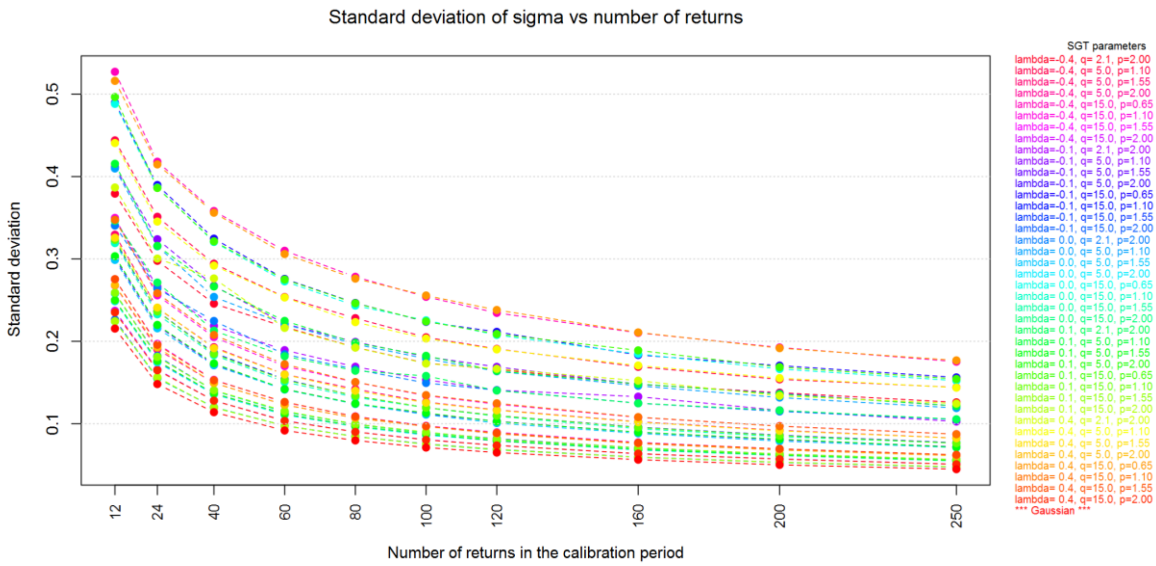


Figure 18

Figure 18 shows a similar behaviour for the standard deviation of the sampled 97.5% expected shortfall for the historic method.

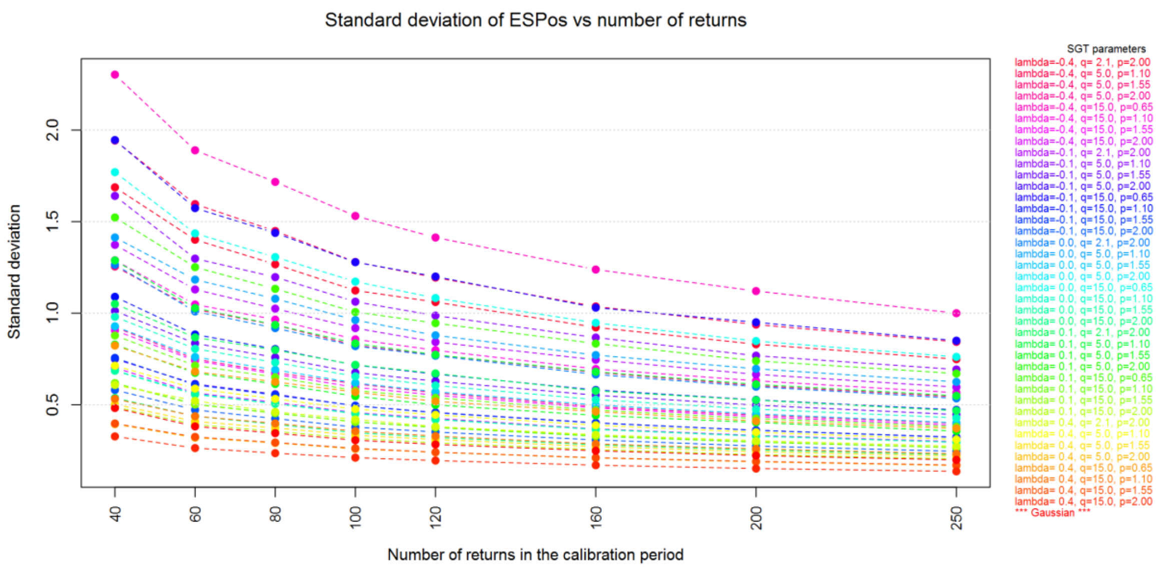


Figure 19

The estimation error of the expected shortfall is much larger than that of sigma. This can be understood from the observation that the 97.5% expected shortfall is computed only from $N/40$ points in the tail, while the standard deviation is more robust, because it is computed from N returns, while giving more weights to the tails. From these figures one can guess that the statistical uncertainty in the historic method is higher than for the sigma and Asigma methods, which however have a much higher parameter uncertainty. One also sees that the SGT distribution parameters have a strong influence on the estimation error as measured with the standard deviation as does the number of returns when N decreases.

For assessing the uncertainty compensation factor, we define the "empirical" uncertainty compensation factor (EUC) which is the factor that would ensure that a calibrated shock obtained for the small sample in the calibration period, $CS_{\text{calibration}}$, is not underestimating the true (large N) value of the left or right expected shortfall $CS_{N\to\infty}^{\text{ES hist}}$with a given confidence level CL:

$$P\left(EUC \cdot CS_{\text{calibration}} < CS_{N\to\infty}^{\text{ES hist}}\right) = CL$$

Note that implicitly the EUC depends on the parameter choices in the calibrated shock method for the sigma and asigma method: if C_{ES} is increased, then the calibrated shock is higher and the probability of underestimating $CS_{N\to\infty}^{\text{ES hist}}$ gets smaller. E.g. for the Gaussian case, the theoretical value[44] is $C_{\text{ES}}^{\text{Gaussian}} = 2.34$, such that the uncertainty compensation is actually too high in this case for the chosen confidence level (it would be correct if $C_{\text{ES}} = C_{\text{ES}}^{\text{Gaussian}}$).

$UCF(C_{\text{UC}}, N)$ defined above depends on N, the number of returns observed in the calibration period and we assume that the empirical uncertainty compensation factor can be written in the same form. In order to verify the functional form in N, we re-write

$$EUC = 1 + \frac{C_{EUC}}{\sqrt{2(N-1.5)}} \Leftrightarrow C_{EUCF} = \sqrt{2(N-1.5)} \cdot (EUC - 1)$$

If horizontal lines were obtained when plotting the right hand side of the last expression versus N, the N dependency would be well described. In Figure 20 this is done for the calibrated shock in the sigma method and a confidence level of 90%, which was plotted because it was used in the derivation of UC. Indeed overall, the values are roughly on horizontal lines, with noticeable deviations for small N. The dashed horizontal line is the value 1.28. Analogous plots can be done for the asigma method (Figure 21) and the historical method (Figure 22) with similar results.

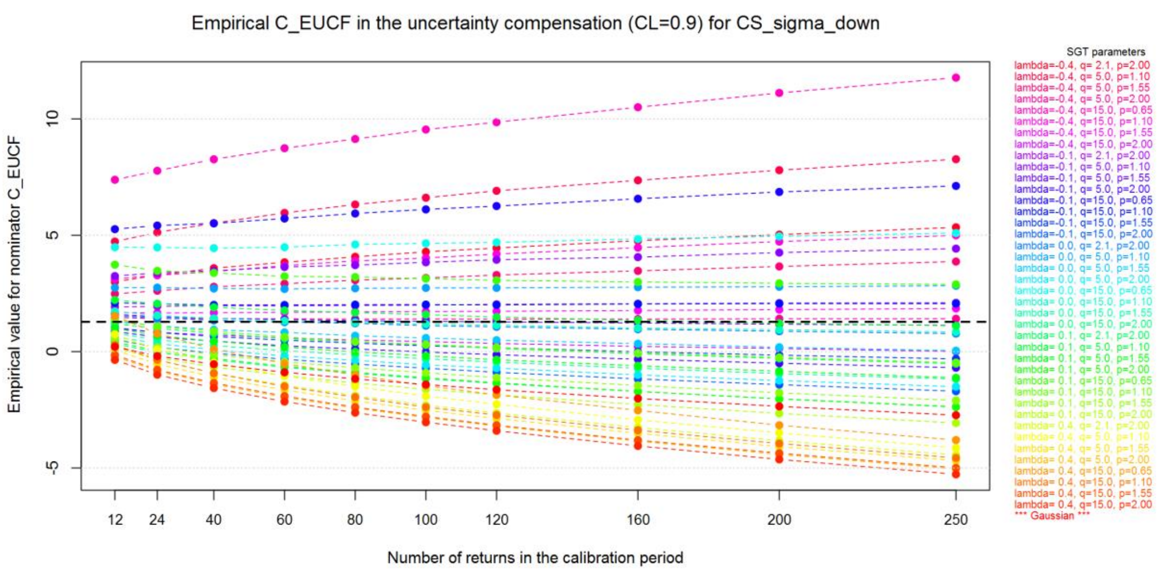


Figure 20

[44] See Annex 4 of the 2017 Discussion Paper for details.

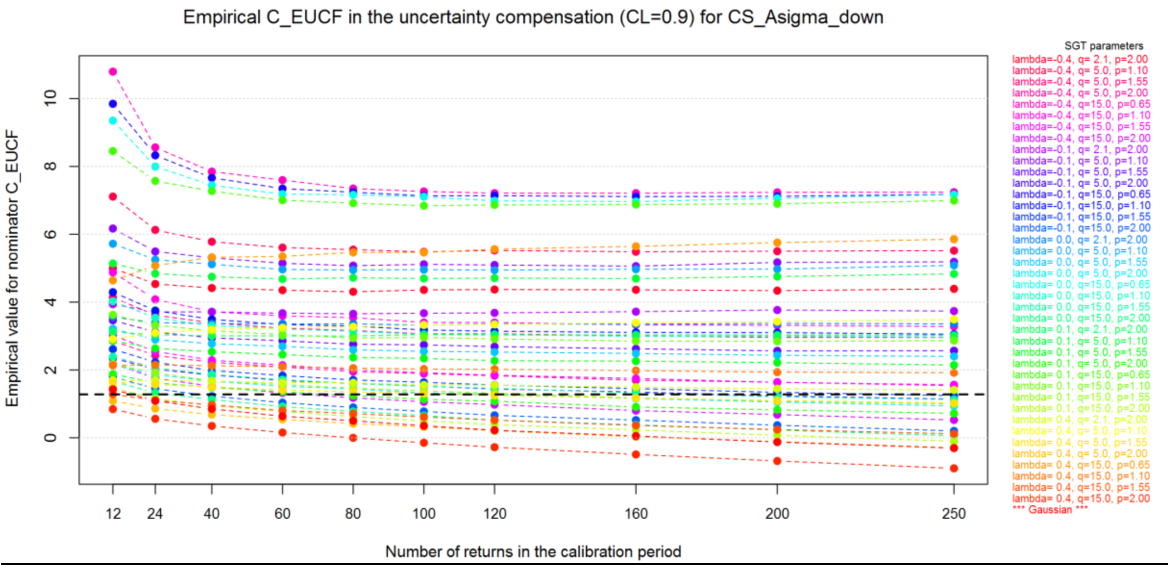


Figure 21

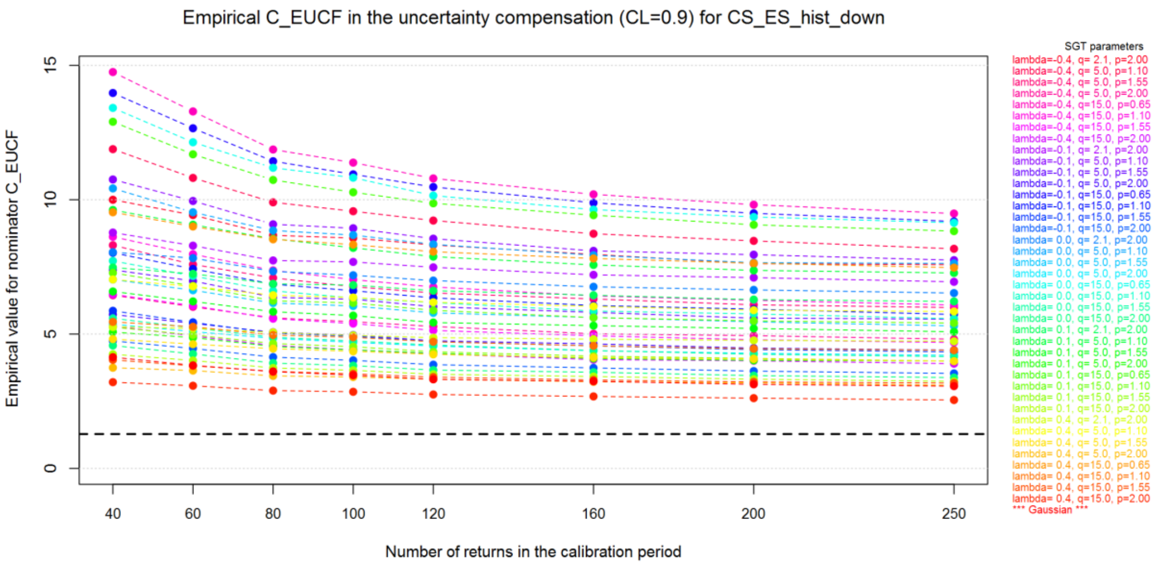


Figure 22

The confidence level 90% is not necessary for calibrated shocks in the SSRM methodology, while a minimum requirement should be that in 50% of cases the true quantity is not underestimated, in other words that the median value is targeted. The corresponding values for the constant C_{EUC} are presented in Figure 23, Figure 24, and Figure 25.

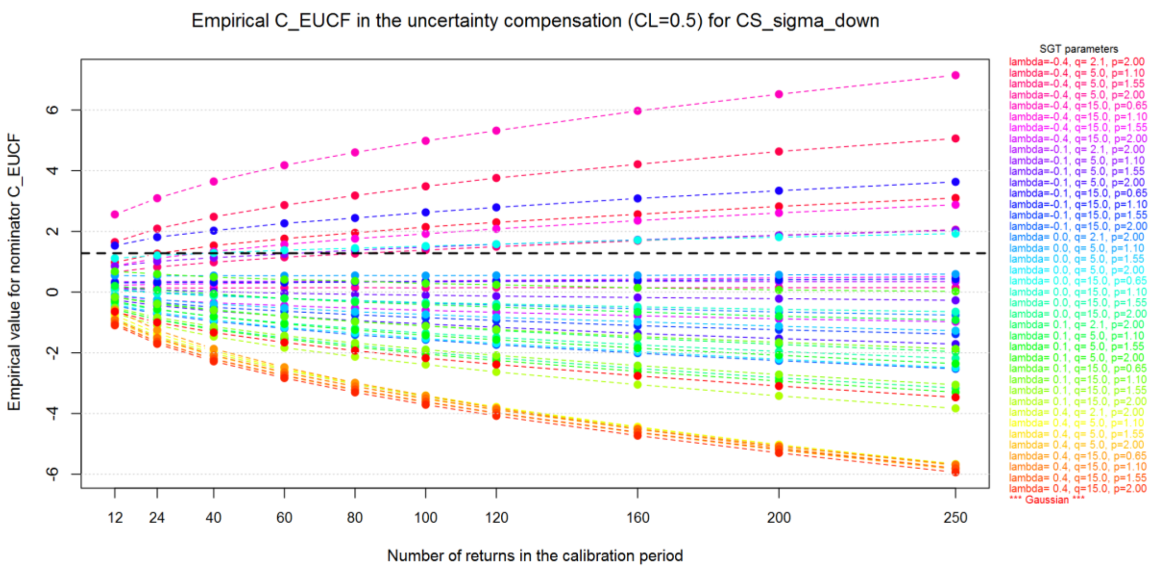


Figure 23

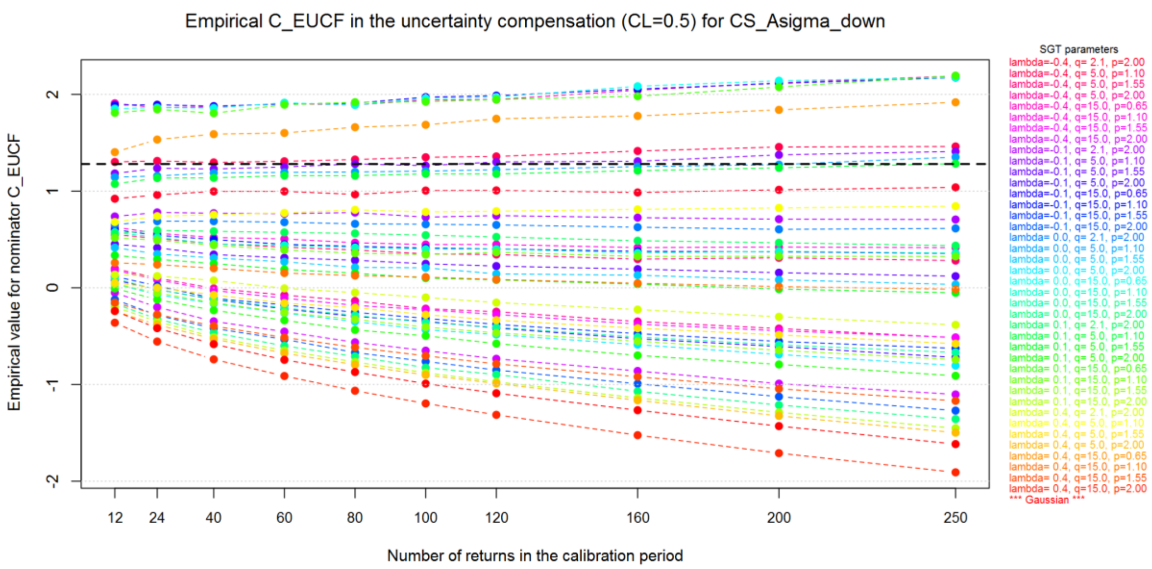


Figure 24

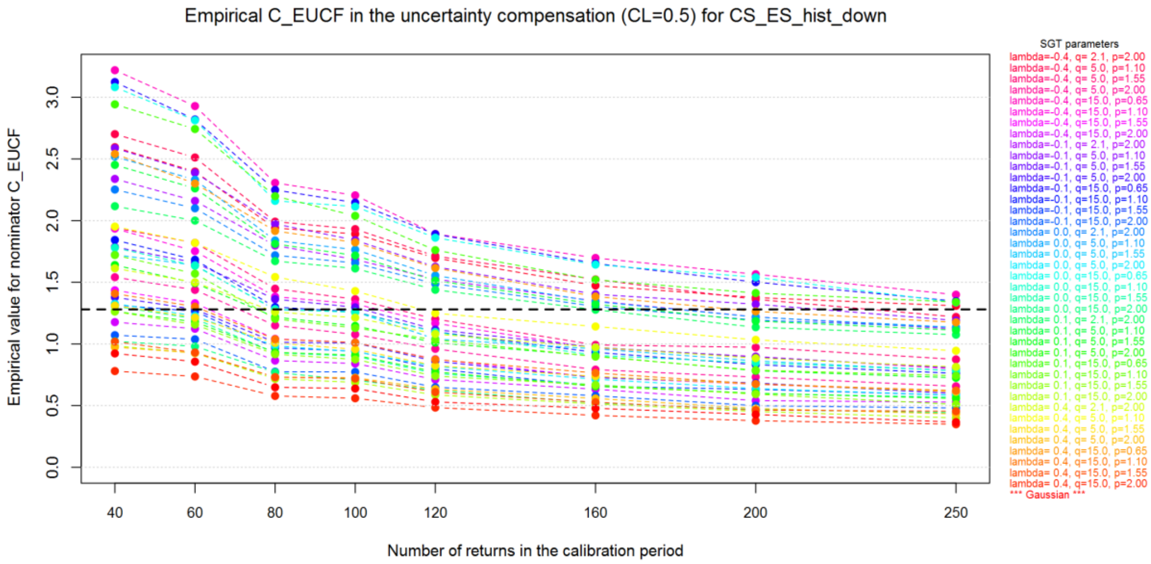


Figure 25

To summarize, the first question can be answered by affirming that the functional form of $UCF(C_{UC}, N)$ is suitable for all calibrated shock methods contemplated, with deviations occurring for small N and more pronounced in case of non-Gaussian distributions.

One also sees that the parameter C_{UC} would theoretically need to be set to different values depending on the method for the calibrated shock, on the distributional parameters and given targeted confidence level, which brings us to the second question: its value.

Simulation results: probability of underestimation using UC

The SSRM methodology aims at providing calibrated shocks based on the small sample of returns in the calibration period which do not underestimate the true value. In this section we show the probability that a calibrated shock according to the different methods including UC (using $C_{UC} = 1.28$) underestimates the true value given by the expected shortfall in the large sample.

Besides the statistical estimation error, we identified in the introduction two other sources of uncertainty: parameter choice uncertainty and uncertainty due to lower market observability.

For the historical method (and the direct method) parameter choice uncertainty is not an issue, because they are mostly parameter free, besides the non-linearity correction. Uuncertainty due to lower market observability is inherent in the nature of NMRF, thus $UCF(C_{\mathrm{UC}}, N)$ is always positive.

Therefore, UC for the historical method does not need to be significantly conservative, i.e. the probability that the calibrated shocks in the historical method underestimates the true value should be about 50%. Because $N \geq 200$ in the historical method, $UCF(C_{\mathrm{UC}}, N)$ gets small for those N, so that the uncertainty correction does not have a material impact.

The following Figure 25 confirms that UC leads to about 50% probability of underestimation for the calibrated shocks obtained via the historical method (CS_ES_hist) in the relevant range $N \geq 200$.

The colours indicate that the underestimation probability is often around 50% (green), somewhat lower for near Gaussian distributions and somewhat higher for more non-Gaussian distributions. In other words, UC provides some buffer for non-normality in the historical method.

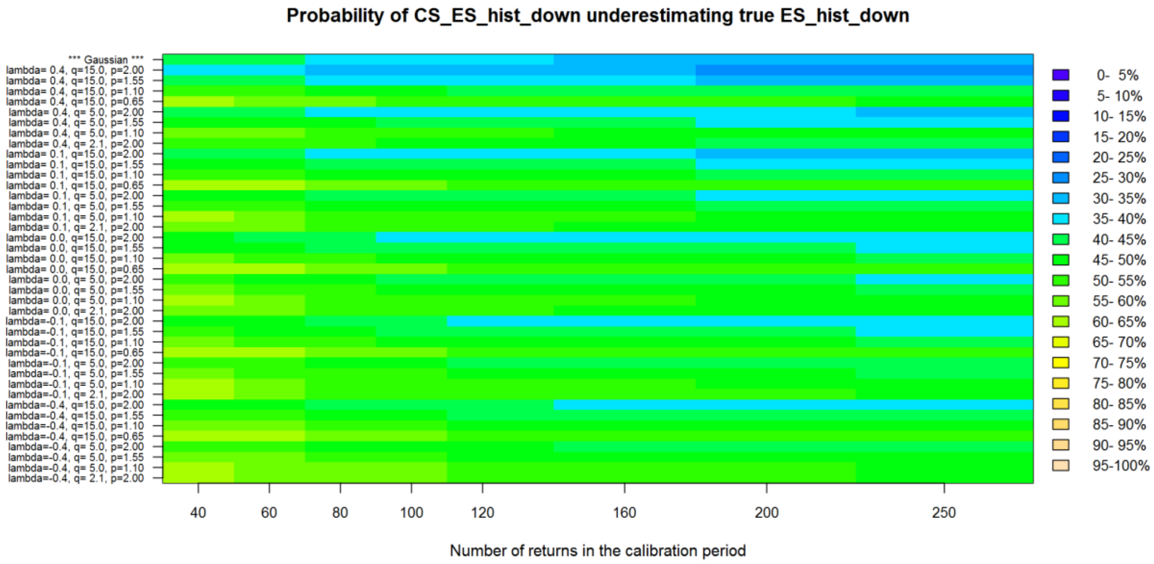


Figure 26

The sigma and asigma methods are both strongly dependent on the parameter choice for C_{ES}, leading to more dispersion in the probabilities of underestimation: for a near Gaussian SGT distribution, the probability of underestimation is lower (because C_{ES} is too high for those distributions, as the theoretical Gaussian result is 2.34), while for more non-Gaussian SGT distributions, the probability of underestimation is higher (because C_{ES} is too low, as the theoretical value would be higher).

Because the sigma method is symmetrical, it cannot reflect asymmetry in the return, while the asigma method does. One can therefore expect the dispersion to be more pronounced in the sigma method. This is visible in Figure 26 and Figure 27. The probability of underestimation reaches about 95% for the sigma method and 60% in the asigma method (in the ochre to yellow-green colour fields for strongly non-Gaussian distributions). For the sigma method the near-Gaussian cases are almost never underestimated.

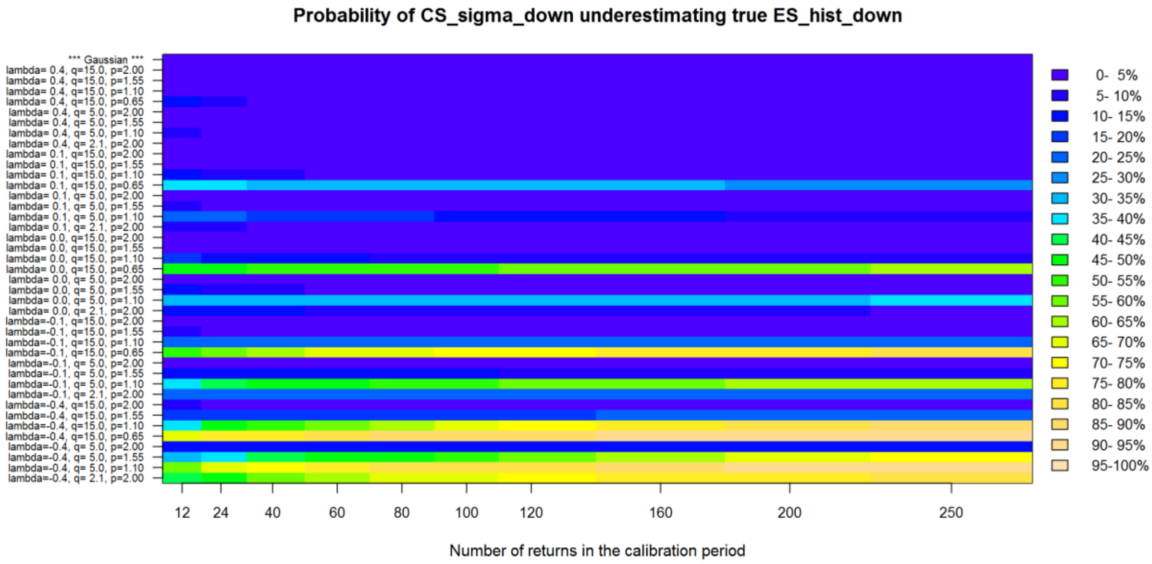


Figure 27

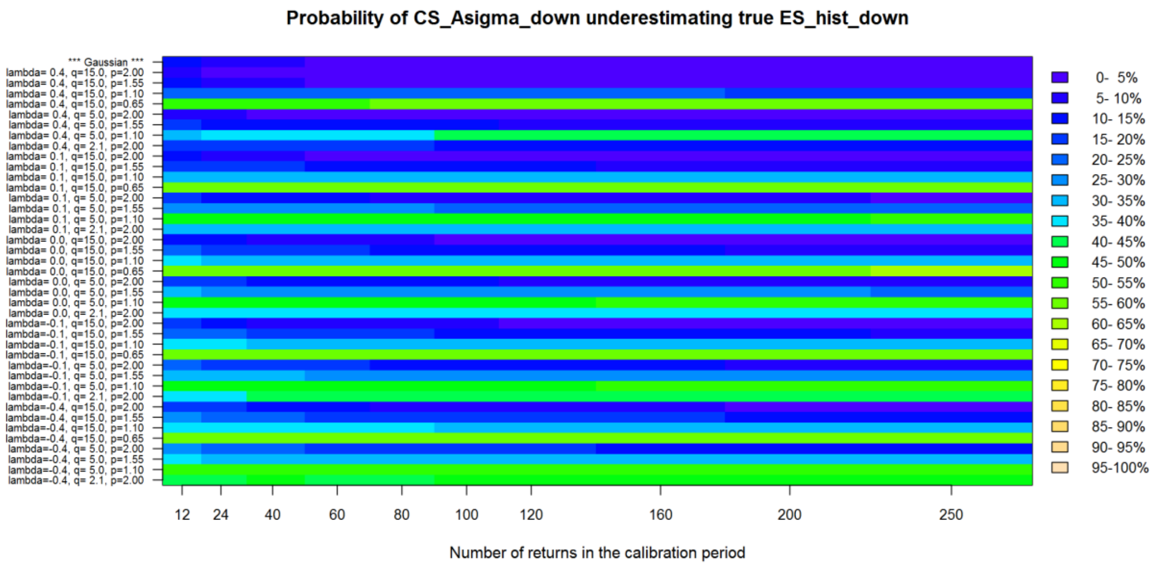


Figure 28

To summarize, the single calibration constant $\mathrm{C_{UC}} = 1.28$ in the uncertainty compensation factor $\mathrm{UC(C_{UC}, N)} = \left(1 + \frac{\mathrm{C_{UC}}}{\sqrt{2(\mathrm{N}-1.5)}}\right)$ can be considered appropriate for the purpose of the stress scenario risk measure: While achieving a small buffer for non-normality in the historical method, it is still acceptable for the sigma and asigma method overall.