ECB guide to internal models

Risk-type-specific chapters

**For any future reference,
please use the <ins>consolidated version</ins>.**

Contents

Foreword

1. Articles 143, 283 and 363 of Regulation (EU) No 575/2013 (CRR)[1] require the European Central Bank (ECB) to grant permission to use internal models for credit risk, counterparty credit risk and market risk where the requirements set out in the corresponding chapters of the CRR are met by the institutions concerned. Based on the current applicable European Union (EU) and national law, the ECB guide to internal models provides transparency on how the ECB understands those rules and how it intends to apply them when assessing whether institutions meet these requirements.

2. The guide is also intended as a document for the internal use of the different supervisory teams, with the aim of ensuring a common and consistent approach to matters related to internal models. When applying the relevant regulatory framework in specific cases, the ECB will take into due consideration the particular circumstances of the institution concerned.

3. This guide should not be construed as going beyond the current existing applicable EU and national law and therefore is not intended to replace, overrule, or affect applicable EU and national law.

   In accordance with the requirements set out in the CRR, the European Banking Authority (EBA) has drafted various regulatory technical standards (RTS). These include the Final Draft RTS on assessment methodology for the Internal Ratings-based (IRB) Approach and the Final Draft Regulatory Technical Standards on the specification of the assessment methodology for competent authorities regarding compliance of an institution with the requirement to use internal models for market risk and assessment of significant share.[2] These specify how competent authorities should assess compliance with the regulatory framework defined in the CRR. The Final Draft RTS have not yet been adopted by the European Commission, but the ECB is of the view that the parts of both Final Draft RTS referred to in the Guide express an appropriate understanding of the CRR. Some parts of this guide may require revision once the European Commission has adopted the RTS by means of a Delegated

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[1] Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 (OJ L 176, 27.6.2013, p. 1). For the purposes of this document the reader's attention is also drawn to the corrigendum published on 30 November 2013 (OJ L 321, 30.11.2013, p. 6).

[2] Final Draft Regulatory Technical Standards on the specification of the assessment methodology for competent authorities regarding compliance of an institution with the requirements to use the IRB Approach in accordance with Articles 144(2), 173(3) and 180(3)(b) of Regulation (EU) No 575/2013 (EBA/RTS/2016/03).
See also: Final Draft Regulatory Technical Standards on the specification of the assessment methodology for competent authorities regarding compliance of an institution with the requirements to use internal models for market risk and assessment of significant share under points (b) and (c) of Article 363(4) of Regulation (EU) No 575/2013 (EBA/RTS/2016/07).
Note that there are no RTS on assessment methodology mandated for the assessment of the Internal Model Method (IMM) for calculating counterparty credit risk (CCR) exposures.

Regulation. The ECB will amend or delete those parts of the guide when the RTS enter into force.

4.   The first version of the guide[3] was made available on 28 February 2017. Within the execution of the targeted review on internal models (TRIM) project, the guide has been updated, taking into consideration the industry feedback and the experience gained from on-site supervisory investigations. In this context, the revised versions of the credit risk, market risk and counterparty credit risk chapters are now being published for consultation. The general topics chapter was published for consultation on 28 March 2018.

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[3]   Guide for the Targeted Review of Internal Models.

Credit risk

1 Scope of the credit risk chapter

1. The purpose of this chapter is to provide transparency on how the ECB understands a number of topics related to internal models used for the internal ratings-based (IRB) approach, including an initial section covering data maintenance for this approach. It is important to note that this chapter does not aim to cover exhaustively all topics of the Capital Requirements Regulation (CRR)[4] for the IRB approach that could be subject to review during internal model investigations. On these selected topics, the chapter is aligned with the European Banking Authority (EBA) Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (hereinafter EBA GL on PD and LGD).

2 Data maintenance for the IRB approach

2.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	142	(1)(1)
		144	
		174	(b)
		175	(1)
		176	
		189	(1), (2)(c)
		190	(4)
Other references			
Final Draft RTS on assessment methodology for IRB[5]	21/07/2016	32, 75, 76, 77, 78	
Basel Committee on Banking supervisions (BCBS) 239[6]	09/01/2013	Principles 1-11	

Once adopted by the European Commission, the Final Draft Regulatory Technical Standards (RTS) on assessment methodology for internal ratings-based (IRB)

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[4] Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 (OJ L 176, 27.6.2013, p. 1). For the purposes of this document the reader's attention is also drawn to the corrigendum published on 30 November 2013 (OJ L 321, 30.11.2013, p. 6).

[5] Final Draft Regulatory Technical Standards on the specification of the assessment methodology for competent authorities regarding compliance of an institution with the requirements to use the IRB Approach in accordance with Articles 144(2), 173(3) and 180(3)(b) of Regulation (EU) No 575/2013, referred to in this guide as "Final Draft RTS on assessment methodology for IRB"

[6] BCBS paper on *Principles for effective risk data aggregation and risk reporting*, January 2013.

approach will become additional relevant legal references. Currently the RTS only exist in a final draft version.

2. In accordance with Article 144(1) of the CRR, an institution's systems for the management and rating of credit risk exposures must be sound and implemented with integrity. In particular, the institution must collect and store all relevant data to provide effective support to its credit risk measurement and management processes. The ECB understands that, in order to comply with these requirements, institutions should deploy robust, well-documented and adequately tested information technology (IT) systems, together with sound data management practices.

3. Consequently, this section of the guide sets out the principles regarding the following elements for the management of IRB data:[7]

   (a) IT systems: infrastructure and implementation testing;

   (b) policies, roles and responsibilities in data processing and data quality management;

   (c) components of the data quality management framework.

2.2 IT systems: infrastructure and implementation testing

2.2.1 Infrastructure

4. Sound and robust IT infrastructures play an essential role in supporting the institution's rating systems. In addition, and in accordance with Article 175(1) of the CRR, institutions must document the design and operational details of their rating systems.

5. With regard to the soundness and robustness of institutions' IT infrastructure, the ECB considers that Article 78(2) and (3) of the Final Draft RTS on assessment methodology for IRB provides a good understanding of the elements that institutions should take into account in order to comply with the data-related requirements of the CRR.[8]

6. Further, to comply with the documentation requirements for the rating systems as established under Article 144(1)(e) and Article 175(1) of the CRR, it is the ECB's view that institutions should document and keep an updated register of all current and past versions of the following elements of a rating system:

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[7] The ECB acknowledges that there are other relevant elements of data management not covered in this guide which institutions should take into account.

[8] See Articles 144(1)(d) and 176 of the CRR.

(a) the model's data[9] flow (from data entry to reporting and for both historical data and current exposure data), identifying the relevant workflows and procedures relating to data extraction, data collection, data storage and data transformations;

(b) the relevant sources of data and the global map of IT systems and databases involved in the calculation systems used for the purposes of the IRB approach;

(c) the relevant functional specification of IT systems and databases, including their size, date of construction and data dictionaries, specifying the content of the fields and of the different values inserted in them, with clear definitions of data items;

(d) the relevant technical specification of IT systems and databases, including the type of database, tables, database management system, database architecture, and data models given in any standard data modelling notation;

(e) the audit trail procedures for critical IT systems and databases.

To allow an independent knowledgeable third party to obtain a detailed outline of the different IT elements of the rating systems, the documentation produced by the institution should be clear and understandable.

2.2.2 Implementation testing

7. In order to ensure the integrity and robustness of IT systems[10] and in particular that, in terms of IT, the implementation of the models is successful and error-free, institutions should have in place a consistent process for testing the relevant IRB systems and applications upon first implementation and on an ongoing basis. This IT-testing process should be clearly defined and documented in an organisation-wide policy and procedure.

8. To achieve its objective the policy should consider all potential events that should trigger a testing procedure and their impact on the tests to be conducted. The trigger events that should be considered include: software releases or material IT-related changes, regulatory changes, model methodology changes and the extension of the range of application of a rating system.

9. IT implementation tests to be considered include the following:

(a) unit/component/module tests;

(b) integration tests (of units and between systems);

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[9] This refers to the model's internal data, external data or pooled data.
[10] See Article 144(1)1 of the CRR.

(c)   system tests (this includes functionality, performance – in normal and stress scenarios – and security and portability tests);

(d)   user acceptance testing (functional testing);

(e)   regression testing.

10.   In principle, the unit(s) responsible for performing the implementation tests should be clearly identified and the results of the tests should be documented. It is the ECB's view that as a general rule institutions should develop a standardised format for the documentation of test results.

2.3   Policies, roles and responsibilities in data processing and data quality management

11.   For institutions to be able to comply with the requirement to collect and store all relevant data established under Article 144(1)(d) of the CRR, it is the ECB's understanding that policies and rules on data management should be defined at group level[11] for both of the following aspects: data processing (i.e. data collection, storage, validation, migration, actualisation and use), and data quality management (see section 2.4 of this chapter).

12.   As for data processing, and in particular with regard to manual interventions and data transfers, the following principles should be considered:

(i)   to ensure that all data transformations are traceable and controlled, general guidelines and rules should be clearly formalised with regard to manual interventions within the data processing;

(ii)   to ensure timeliness and accountability, all data transfers should be formally agreed upon (for example by means of service-level agreements) by data providers and data users (for both outsourced and in-house processes).

13.   To ensure the integrity of the data processes, the policies and rules on data management should clearly set out the relevant data governance arrangements. It is also expected that these policies and rules will specify the different roles and responsibilities assigned to data management. These include data ownership and data quality roles and responsibilities, for both business areas and IT owners, throughout the entire credit risk modelling life cycle (including all IT systems used). These policies should take into account the following principles.

(a)   The responsibilities of business area owners include:

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[11]   See section 2.1 of the general topics chapter of the ECB guide to internal models for the definition and implementation of group-wide principles and guidelines.

       (i)   ensuring data are correctly entered, kept up to date and aligned with the institution's data definitions;

       (ii)   ensuring that data aggregation capabilities and reporting practices are consistent with the institution's policies.

(b)   IT owners are responsible for supporting the operation of the systems for data collection, processing, transformation and storage during the entire life cycle of the data.

(c)   Different business areas and IT owners may be appointed throughout the data life cycle. However, each data source, IT system and process step should have an assigned business area and/or IT owner that can be formally identified.

2.4   Data quality management framework

14.   Institutions must have in place a process for vetting data inputs into the model. This must include an assessment of the accuracy, completeness and appropriateness of the data.[12] To comply with this requirement and to ensure the quality of the data used for credit risk measurement and management processes, it is the ECB's view that institutions should establish and implement an effective data quality management framework that is formalised in a set of policies and procedures. This framework should be applicable to all data used in IRB-related processes, i.e. internal data, external data and pooled data, if any. In addition, it should ensure that reliable risk information is available to enable an institution's risk profile to be assessed accurately and drive sound decision-making within the institution and by external stakeholders, including competent authorities.

15.   The ECB considers that the data quality management framework is effective when it encompasses the following components:

(a)   sound underlying governance principles, including allocation of roles and responsibilities for the management of data quality, to ensure in particular that data quality management activities are independent of data processing activities (see section 2.4.1 of this chapter), and the active steering of data quality;

(b)   a description of the scope in terms of risk data coverage (see section 2.4.2);

(c)   data quality standards covering all relevant data quality dimensions, i.e. completeness, accuracy, consistency, timeliness, uniqueness, validity, availability and traceability (see section 2.4.3);

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[12]   See Article 174(b) of the CRR.

(d)   consistent criteria and a systematic metrics approach to assess compliance with data quality standards; this should be supported by sufficient data quality controls along the entire IRB data chain (see section 2.4.4);

(e)   procedures for constantly assessing and improving the quality of data (see section 2.4.5);

(f)   reporting procedures on data quality allowing for sufficient understanding of the quality of the data supporting the IRB models (see section 2.4.6).

The following sections further develop the above-mentioned elements.

2.4.1   Governance principles for the data quality management framework

16.   The data quality management framework:

(a)   should be approved by the institution's management body or a designated committee thereof and senior management, as part of their responsibilities;

(b)   should be distributed throughout the organisation to the relevant staff;

(c)   should be periodically assessed in order to verify its adequacy, and be updated and improved whenever necessary;

(d)   should be subject to regular review by the internal audit function or another comparable independent auditing unit.[13]

17.   The roles of the different units, internal bodies and staff involved in the data quality management process should be defined in such a way as to ensure that the data handling process is sufficiently independent from the data quality management process.

18.   The ECB considers it good practice for institutions to have a dedicated independent unit with an overall view of and responsibility for the management of data quality. Where an independent unit is established, the size of this unit should be proportionate to the nature, size and degree of complexity of the institution's business and organisational structure.

2.4.2   Scope of the data quality management framework

19.   The data quality management framework:

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[13]   For further details on the review of the rating systems by internal audit, see section 6 – Internal audit of the general topics chapter of the guide.

(a) should cover all relevant data quality dimensions: completeness, accuracy, consistency, timeliness, uniqueness, validity, availability and traceability (see paragraph 21);

(b) should cover the whole data life cycle, from data entry to reporting, and encompass both historical data and current application databases.

20. If institutions use data provided by third parties, the ECB considers it good practice for them to ensure that the third party has data quality processes in place to ensure the accuracy, completeness and appropriateness of the data provided.[14]

2.4.3 Data quality standards in the data quality management framework

21. In accordance with Article 174(b) of the CRR, institutions must implement a process for vetting data inputs into the model which must include an assessment of the accuracy, completeness and appropriateness of data. The ECB understands that, in order to comply with this requirement, institutions should establish data quality standards that set the objectives and overall scope of the data quality management process. To this end, these standards should be defined for the following data quality dimensions[15] for all data inputs into the model and at each stage of the data life cycle:

(a) completeness (values are present in any attributes that require them);

(b) accuracy (data are substantively error-free);

(c) consistency (a given set of data can be matched across the institution's different data sources);

(d) timeliness (data values are up to date);

(e) uniqueness (aggregate data are free from any duplication arising from filters or other transformations of source data);

(f) validity (data are founded on an adequate and rigorous classification system that ensures their acceptance);

(g) availability/accessibility (data are made available to the relevant stakeholders);

(h) traceability (the history, processing and location of the data under consideration can be easily traced).

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[14] See Article 174(b) of the CRR.

[15] It is the ECB's view that the CRR reference to appropriateness of data inputs encompasses the following additional data quality dimensions: consistency, timeliness, uniqueness, validity, availability/accessibility and traceability.

2.4.4 Data quality controls

22. Data quality should be measured in an integrated and systematic way. The measurement system and the frequency of its application should be formalised.

23. Indicators and their corresponding tolerance levels and thresholds should be set in order to monitor compliance with the standards established and should be combined with visual systems (e.g. red/amber/green traffic-light system) and dashboards for monitoring and reporting purposes.

24. Indicators should be supported by effective and sufficient data quality checks and controls throughout the data life cycle, from data entry to reporting, and for both historical data and current application data. Data quality checks and controls should include reconciliation across and within systems, including between accounting and IRB data. An effective control framework should therefore be in place to ensure that sound controls and related procedures are implemented, especially for manual processes.

2.4.5 Remediation of data quality issues

25. A process for the identification and remediation of data quality deficiencies should be in place in order to constantly improve data quality and promote compliance with the data quality standards.

26. Data quality assessments should be carried out by an independent unit (see paragraph 18) whose recommendations are issued with an indication of their priority, based on the materiality of the incidents identified. All such data quality incidents should be recorded and monitored by an independent data quality unit. For each of the data quality incidents, an owner responsible for resolving the incident should be appointed and an action plan for dealing with the incident drawn up on the basis of the priority assigned. Remediation timelines should depend on the severity and impact of the incident and the implementation timelines required to resolve it. Data quality incidents should be resolved – rather than mitigated – at source level by taking a prudent approach.

2.4.6 Data quality reporting

27. In accordance with Article 189(2)(c) of the CRR, the institution's senior management must ensure, on an ongoing basis, that the ratings systems are working properly. To accomplish this, the ECB understands that a formal reporting process on the quality of risk data should be in place with the objective of improving the quality of data and enabling an assessment of the potential impact of data quality in own fund requirements calculations. In general, this reporting should be presented in a standardised format with clear and concise content, including the following:

(a) comprehensive overview of the performance of the model in terms of data quality, including external data and pooled data, if any, at all stages of the IRB life cycle, from data entry to reporting, for both historical data and current exposure data;

(b) findings and, where applicable, recommendations to address detected weaknesses or shortfalls;

(c) sufficient and appropriate evidence that the recommendations have been adequately addressed and properly implemented (e.g. by means of a status report).

28. In accordance with Article 189(1) of the CRR, the management body or a designated committee thereof and senior management must possess a general understanding of the rating systems of the institution and a detailed comprehension of its associated management reports. To comply with this requirement, the ECB understands that reports on the quality of risk data should be submitted to these parties. In addition, the ECB considers it good practice for these reports to also be submitted to all other relevant staff, including modellers, internal validation, internal audit, data quality managers, data owners and other business units involved.

29. Data quality reports should be produced and submitted to senior management more frequently than annually to enable senior management to ensure, on an ongoing basis, that the rating systems are operating properly in accordance with Article 189(2)(c) of the CRR.

3 Data requirements

3.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	144	(1)(d)
		171	(1)(a), (b)
		172	(3)
		174	(b), (c), (e)
		176	
		178	(4)
		179	(1)(a), (c), (d), (2)(a), (b)
EBA GL on PD and LGD	20/11/2017		15-35
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	45, 48, 50, 56	

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

30. In accordance with Article 144(1)(d) of the CRR, institutions must collect and store all relevant data to provide effective support to their credit risk measurement and management processes. Furthermore, good data quality is a fundamental condition for developing a robust rating system. The ECB considers that, to comply with these requirements and ensure the quality of data, institutions should have sound policies, processes and methods in place, under paragraphs 15 to 34 of the EBA GL on PD and LGD for assessing and improving the quality and representativeness of the data used in the modelling and risk quantification process.

31. Since the data-related requirements of the CRR also apply in cases where an institution estimates conversion factors (CCFs), paragraph 30 is also relevant for such institutions.

3.2 Use of external data

32. Data-related requirements established under the CRR apply to all data: internal, external or pooled. In the ECB's understanding, therefore, paragraph 30 is also relevant in the event that an institution uses external or pooled data. The principles on the collection and storage of data are relevant to the institutions' own data and to the data received from the pool.

33. To ensure that credit risk management and measurement processes are built on appropriate data, for the purposes of risk differentiation, risk quantification and review of estimates institutions should assess whether external data can be

used to complement internal data when they consider they do not have sufficient available internal data.

34. If an institution uses statistical models and other mechanical methods to assign exposures to obligors or facilities grades or pools, the data used to build the model must be representative of the population of the institution's actual obligors or facilities.[16] If external data are used, the same requirements with regard to representativeness[17] must be applicable vis-à-vis the bank's portfolio or portfolio subset for which the external data are used.

35. Proving representativeness in cases where an institution uses external data is generally more difficult as internal data are scarce. If an institution cannot provide sufficient proof that the external data are representative, in the ECB's view it may still use external data if it shows (by quantitative analysis and/or qualitative argumentation) that the information gained from the use of the external data outweighs any drawbacks stemming from the deficiencies identified and an appropriate margin of conservatism (MoC) is applied. In particular, institutions should provide evidence that the model's performance does not deteriorate when including information derived from the external data, and that the parameter estimates are not biased. To assess these issues, the institution should conduct quantitative and qualitative validation analyses specifically designed for this purpose.

36. In accordance with Article 174(b) of the CRR, if an institution uses statistical models and other mechanical methods to assign exposures to obligors or facilities grades or pools, it must have in place a process for vetting data inputs to the model, which should include an assessment of the accuracy, completeness and appropriateness of the data. In addition, and in accordance with Article 179(1)(a), in quantifying the risk parameters to be associated with rating grades or pools institutions must incorporate all relevant data, information and methods. To comply with these requirements, institutions should ensure that, when external data are used for risk differentiation, risk quantification or review of estimates, they know the data sources and the most relevant data processing operations of the variables acting as direct model inputs performed by the data provider. Institutions should be able to differentiate between internal and external data and to document which information is internal and which information is received from external data sources. To ensure that the data remain appropriate, institutions should provide an adequate rationale in the event that, for the purpose of risk differentiation, risk quantification or review of estimates, they modify the external data acquired, select only part of a wider external database or use different external providers.

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[16] See Articles 174(c) and 179(1)(d) of the CRR.

[17] As established under Articles 174(c) and 179(1)(d) of the CRR.

3.3 Use of external bureau scores or external ratings as input variables in the rating process

37. Where an institution uses external credit bureau scores or external ratings as input variables in the rating process, and in particular when externally sourced scores are the main (or one of the main) input variable(s) of the overall internal rating, there is a risk that an internal model may not consider all relevant information. In the ECB's understanding, institutions mitigate this risk when they comply with the following principles.

    (a) The external scores or ratings and/or data are regularly updated or refreshed, especially where credit bureau information is dynamic and is used not only for the application rating but also for the ongoing behavioural rating.

    (b) Institutions understand the structure and nature of external scores or ratings and their key drivers. They also regularly verify that the results of the credit bureau score continue to be appropriate input variables in their credit rating process, for example by reviewing any changes in the credit bureau score methodology.

    (c) Validation requirements are similar to those applied to other input variables.

    (d) Even when the external score or rating is the main (or one of the main) driver(s) of the internal rating, the institution ensures that all relevant internal information regarding the creditworthiness of the obligor is taken into account in the internal rating.

    (e) When external scores or ratings are used as the main (or one of the main) driver(s) of the internal rating, in addition to the practices referred to in paragraph 128(b) of the General Topics chapter of this guide, institutions should demonstrate a good understanding of the drivers affecting the external scores or ratings. In addition institutions should ensure that external providers inform them of all significant changes applied to the credit bureau scoring or the rating methodology.

    (f) When external scores or ratings are used as the main (or one of the main) driver(s) of the internal rating, institutions demonstrate that the additional relevant internal information considered in the model and its weighting are sufficient to ensure that the internal rating does not merely replicate the results of the external bureau scores or the external ratings used.

    (g) When institutions make use of external scores or ratings or any other judgement-based assessment provided by a third party as input variables in the rating process, they should ensure that any potential correlation between the relevant risk drivers does not lead to bias or a double-counting effect in the risk parameter estimates. This can be especially relevant in these cases, due to the potential use of duplicated information.

(h)   The institution remains responsible for the performance of the model.

3.4   Use of pooled data[18]

38.   The use of pooled data is treated similarly to the situation where internal data are combined with data derived from a different (and external) set of obligors or facilities as mentioned in section 3.2.

39.   In accordance with Article 179(2)(a) of the CRR, where an institution uses data that are pooled across institutions the rating systems and criteria of other institutions in the pool must be similar to its own. To comply with this requirement an institution should, among other things:

(a)   ensure that there is a common definition of the key drivers and processes;

(b)   ensure that policies and procedures considered for human judgement, including overrides[19], can be applied in a consistent and comparable manner across all participating institutions.

40.   In addition, when institutions share a common obligor they should ensure that this does not lead to any bias or double-counting effect in the risk parameter estimates (for example, double counting of default events). In particular, for the estimation of probability of default (PD), the institution should ensure that each common obligor is only taken into account once in the calculation of one-year default rates.

3.5   Use of purchased rating systems or models (pool models[20, 21])

41.   In accordance with the last sentence of Article 144(1) of the CRR, the requirements to use an IRB approach, including own estimates and CCFs, apply also where an institution has implemented a rating system, or model used within a rating system, that it has purchased from a third party. To comply with this provision, institutions should ensure in such cases that all relevant internal information for model development and parameter calibration is taken into account. In particular, long-run averages (LRAs) of default rates, loss given default (LGD) and CCFs based only on internal data should always be

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[18]   The paragraphs below are also relevant in cases where institutions use pooled data from institutions belonging to the same banking group.

[19]   Article 172(3) of the CRR.

[20]   It may occur that institutions not only pool their data, but develop a shared or common rating model based on these pooled data which is then applied by each participating institution to its portfolio(s). Institutions which pool data may work together very closely, disclosing to each other more information than simply publicly available external data, and even sharing the same rating and validation processes. The practice of pooling data can, at one extreme, be similar to the use of external data and, at the other, be more analogous to the sharing of data between two units in the same institution.

[21]   The paragraphs below are also relevant in cases where institutions use pooled data that are generated from institutions belonging to the same banking group.

computed and considered for calibration. The institution remains responsible for the performance of the rating system or model.

42. In addition, to ensure the integrity of the rating systems or internal models when institutions make use of pool models, and to comply with this provision, the principles set out below should be followed.

    (a) If PD estimates are calculated using pooled data, institutions should verify that the data used for risk quantification meet the data requirements for default rate calculation as clarified in paragraph 77 below, or that the data are adjusted accordingly.

    (b) Where several institutions use a common pool model, each should ensure that its rating process is aligned to the extent that all input risk drivers are defined in the same way across all participating institutions. The institutions should also ensure that all assessments of the qualitative components of the rating model are performed in a comparable manner.

    (c) If a pool model is used for the estimation of PD and LGD parameters, the model-relevant parts of the process for managing distressed obligors (including the strategy before and after default) of the participating institutions should be aligned. If this is not possible, differences should be taken into account in the estimates. In the case of a pool model for the estimation of LGD parameters, model-relevant parts of the workout processes should also be aligned and differences in methodology taken into account.

    (d) Institutions should ensure that all relevant internal information with respect to the creditworthiness of an obligor is taken into account and the rating is updated with new information in a timely manner. Validation of the pool model, including testing of discriminatory power and predictive power, should be applied by each institution on its own portfolio.

    (e) Each institution should remain responsible for the performance of the rating model on its own portfolio.

43. To ensure that its ratings systems are operating properly on an ongoing basis, if an institution introduces systematic adjustments to the outputs of the pool model, the institution concerned should initiate internal procedures to analyse whether significant weaknesses in the model exist and whether a model change needs to be triggered.

3.6 Consistency in the definition of default

44. In accordance with Article 178(4) of the CRR, institutions that use external data that are not in themselves consistent with the definition of default laid down in paragraph 1 of that Article must make appropriate adjustments to achieve broad equivalence with the definition of default. To comply with this requirement,

institutions should ensure that when they make use of external data or pooled data they have a complete understanding of the definition of default applied to these data and perform a comparison between the definition of default used and the requirements of Article 178 of the CRR. If there are differences between the definition of default applied in the external or pooled data and the institution's own definition of default, the institution should assess the differences and describe the adjustments made to the risk estimates, in order to achieve the required level of consistency with the internal definition of default. It should also include an appropriate MoC to account for the adjustments included. These adjustments should be appropriately documented and justified, in particular by providing reasonable assurance that they do not undermine the validity of the approach for the purposes of risk differentiation and risk quantification.

3.7 Use of human judgement

45. In accordance with Article 171(1)(a) of the CRR, institutions must have specific definitions, processes and criteria for assigning exposures to grades or pools. The grade and pool definitions must be sufficiently detailed. To comply with this provision, institutions should ensure that, when human judgement is used in the assignment of exposures to grades or pools, there is a framework in place that establishes clear and detailed guidelines and procedures on the application of human judgement (e.g. through the use of pre-defined questionnaires). The use of human judgement should be documented in a way that ensures the rating assignment can be understood and replicated by a third party.[22]

46. When human judgement is used for the purpose of risk differentiation, for example in the setting of the model's assumptions, the identification of risk drivers and determination of their weights, or the identification and combination of model components, there is a risk of the model-based assignments being inaccurate. To mitigate this risk, institutions should ensure that the incorporation of human judgement is appropriately managed and proportionate to the number of available observations.

47. In accordance with Article 174(e) of the CRR, the results of the statistical model must be complemented by human judgement, especially by taking into account all information not included in the model. The higher the number of relevant observations, the more the institutions should rely on the outcomes of the statistical model.

48. For the purposes of quantifying the risk parameters to be associated to grades or pools, estimates must not be based purely on judgemental considerations.[23] To this end, where human judgement is used to a greater extent because of the

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[22] Article 171(1)(b) of the CRR.

[23] Article 179(1)(a) of the CRR.

low number of available internal observations, institutions should apply a higher MoC to their estimates to account for additional uncertainty.

49. In addition, whenever human judgement is used in the estimation of risk parameters (for either risk differentiation or risk quantification purposes) institutions are expected to have in place a framework under paragraph 35 of the EBA GL on PD and LGD.

4   Probability of default

4.1   Structure of PD models

4.1.1   Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	144	(1)(a), (e)
		161	(3)
		169	(1), (2)
		170	(1)(a) to (f), (2), (3)(a) to (c), (4)
		171	(2)
		172	(1)(a), (d)
		173	(1)(b)
		174	(1)(a), (c)
		179	(1)(a)
		180	(1)(a), (g), (2)(a)
		201, 202, 203, 236	
EBA GL on PD and LGD	20/11/2017		20-27, 56-69, 96, 97, 98(b)
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	24	(3)(c)
		34 to 38, 41	

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

50. In accordance with Article 179(1)(a) of the CRR, estimates must be based on the material drivers of the risk parameters. The relevant material risk drivers and rating criteria may be taken into consideration in several ways:

    (a)   when assigning exposures to different PD models;

    (b)   at a PD model level when assigning exposures to different ranking/scoring methods;

(c)   as explanatory variables in ranking/scoring methods;

(d)   as drivers in the process for the assignment of PDs to grades or pools (e.g. calibration segments).

51.   When choosing the risk drivers for the models there is a risk that risk drivers that capture the characteristics of defaulted obligors could be inappropriately inferred as relevant risk drivers for the portfolio. To mitigate this risk, institutions should take appropriate measures against model misspecification with regard to overfitting. This is particularly relevant where default data for the development of the model are scarce.

52.   In accordance with Article 144(1)(a) of the CRR, institutions' rating systems must provide for a meaningful assessment of obligor and transaction characteristics, a meaningful differentiation of risk and accurate and consistent quantitative estimates of risk To comply with this requirement, it is the ECB's understanding that PD models should perform adequately on economically significant and material sub-ranges of application. The sub-ranges are identified by splitting the full range of application of the PD model into different parts on the basis of potential drivers for risk differentiation, including the following drivers,[24] where relevant:

(a)   for PD models covering exposures to small and medium-sized enterprises (SMEs): country, industry (e.g. statistical classification of economic activities in the European Community (abbreviated as NACE[25]) code section classification A to U), size of obligor (e.g. different buckets in terms of total assets), past delinquency (e.g. obligors with delinquency events, i.e. days past due, in the last 12 months);

(b)   for PD models covering retail exposures: client type (e.g. high net worth/private banking, other individuals, self-employed, SMEs), product type (e.g. consumer credit, credit card, other), region (e.g. nomenclature of territorial units for statistics (NUTS) 1, 2 or 3 as defined by Eurostat), past delinquency (e.g. obligors with delinquency events, i.e. days past due, in the last 12 months), maturity (e.g. original or remaining maturity);

(c)   for PD models covering retail exposures secured by real estate: region (e.g. NUTS 1, 2 or 3 as defined by Eurostat), type of real estate (e.g. residential, commercial, other), past delinquency (e.g. obligors with delinquency events, i.e. days past due, in the last 12 months), maturity (e.g. original or remaining maturity);

(d)   for PD models covering exposures to financial institutions: business model (deposit-taking institutions, investment banking, insurance firms, other),

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[24]   When external credit bureau scores or ratings are used as the main (or one of the main) driver(s) of the internal rating, the set of all exposures for which the external score or rating is not available should also be considered a significant sub-range of application.

[25]   *Nomenclature statistique des activités économiques dans la Communauté Européenne.*

jurisdiction (or global region as appropriate) and size (defined buckets of total assets);

(e) for PD models covering exposures to large corporates: industry (e.g. NACE code section classification A to U), country (or global region as appropriate) and size (defined buckets of total turnover).

53. In accordance with Article 169(1) of the CRR, where an institution uses multiple rating systems, the rationale for assigning an obligor or a transaction to a rating system must be documented and applied in a manner that appropriately reflects the level of risk. To comply with this requirement institutions should, in terms of the range of application of a PD model:

(a) clearly describe its range of application (and sub-divisions into different ranking/scoring methods and calibration segments) and also include an explanation of the risk drivers which the institution has considered, but decided not to use;

(b) ensure that there are no overlaps in the range of application of different PD models and that each obligor or facility to which the IRB approach should be applied can be clearly assigned to one particular PD model.

4.1.2 Risk differentiation

Principles for all model types

54. Article 170 of the CRR lays down requirements related to the structure of rating systems. To comply with these requirements and with reference to Articles 36 to 38 of the Final Draft RTS on assessment methodology for IRB, institutions should, among other things, ensure a meaningful differentiation of risk which takes into account (i) the distribution of obligors or facilities; (ii) the homogeneity of obligors or facilities assigned to the same grade or pool; and (iii) the different levels of risk across obligors or facilities assigned to different grades or pools to which a different PD is applied.

55. To ensure that the PD model performs adequately in terms of risk differentiation, institutions should adopt the following approach.

(a) Define metrics (considering both their evolution over time and specific reference dates) with well-specified targets, taking into account tolerance levels that reflect the uncertainty of the metrics, and take action to rectify any deviations from these targets that exceed the tolerance levels. Separate targets and tolerances may be defined for initial development and ongoing performance.

(b) Ensure that the tools used to assess risk differentiation are sound and adequate considering the available data, and that they are also evidenced

by records of the time series of realised default rates or loss rates for grades or pools under different economic conditions.

Principles specific for grades and pools

56. A grade or pool is understood by the ECB as the subset of obligors or facilities to which the same PD is applied for the calculation of regulatory capital requirements, irrespective of how this PD has been assigned (e.g. through the use of masterscales).

Distribution of obligors or facilities across grades or pools

57. Article 170(1)(c) and (d) and 170(3)(b) and (c) of the CRR requires, among other things, that the number of grades and pools is adequate to achieve meaningful risk differentiation and quantification of the PD at the grade or pool level. To comply with this requirement, institutions should:

    (a) justify the criteria applied when determining the number of grades or pools and the proportion of obligors or facilities assigned to each;

    (b) ensure that the concentration of numbers of obligors or facilities is not excessive in any grade or pool; any significant concentrations should be supported by convincing empirical evidence of the homogeneity of risk for those obligors or facilities;

    (c) ensure that no grade or pool has too few obligors or facilities, unless this is supported by convincing empirical evidence of the adequacy of the grouping of the exposures in question.

Homogeneity within grades

58. Article 170(1)(b) and (d) and 170(3)(b) and (c) of the CRR requires, among other things, that the structure of rating systems must ensure the homogeneity of obligors or facilities assigned to the same grade or pool. In accordance with this requirement and under paragraph 69 of the EBA GL on PD and LGD:

    (a) homogeneity is understood as obligors or facilities assigned to a grade having a reasonably similar default risk to ensure that the grade-level default rate is representative of all obligors or facilities in that grade;

    (b) in cases where it is found (through the use of additional drivers or a different discretisation of the existing ones) that a material subset of obligors or facilities within a grade/pool yields a significantly different default rate to that of the rest of the grade or pool, this is considered to indicate a lack of homogeneity.

Risk differentiation across grades or pools

59. To comply with the requirement to ensure adequate risk differentiation across grades or pools,[26] institutions should ensure that there are no significant overlaps in the distribution of the default risk between grades or pools. This should be ensured through a meaningful differentiation of the default rates of each grade.

Principles specific for direct estimates

60. See paragraph 87.

4.1.3   Grade assignment dynamics

61. In order to ensure a meaningful assessment of obligor characteristics,[27] when assigning obligors or facilities to a grade or pool institutions should follow paragraphs 66 to 68 of the EBA GL on PD and LGD. Although the time horizon used in PD estimation is one year, it is the ECB's understanding that the rating/grade/pool assignment process should also adequately anticipate and reflect risk over a longer time horizon and take into account plausible changes in economic conditions. In order to achieve this objective:

    (a) all relevant information should be included in the rating/grade/pool assignment process, giving an appropriate balance between drivers that are predictive only over a short time horizon and drivers that are predictive over a longer time horizon;

    (b) a horizon of two to three years is considered to be appropriate for most portfolios;

    (c) in accounting for plausible changes in economic conditions, the institution should consider at least past observed default patterns;

    (d) the model should perform under different economic conditions.

    As a consequence of the above, institutions' grade assignment dynamics should also adequately anticipate and reflect in the assignment of grades the potential realisation of the risk during the longer time horizon. For clarity, this does not mean that grades remain stable during the longer time horizon in the event of changes in idiosyncratic risk.

62. Additionally, the following principles apply under the specific situations considered in (a) to (c) below:

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[26]   As required by Articles 170(1)(b) and (d) and 170(3)(b) and (c) of the CRR.

[27]   Article 144(1)(a) of the CRR.

(a) when using external scores or ratings (e.g. from an external bureau or external rating agency) as drivers for the purpose of risk differentiation within a specific model, institutions should identify the grade assignment dynamics embedded in the external rating and understand the effect on their own grade assignment dynamics, considering the other risk drivers used;

(b) when using external ratings as target variables for the purpose of risk differentiation within a specific model (see section 4.1.5), institutions should take all necessary measures to preserve their own grade assignment dynamics, if necessary;

(c) when mapping internal grades to external grades in order to use external default rates to estimate PD, institutions should ensure that the grade assignment dynamics of the external ratings are sufficiently similar to their own internal grade assignment dynamics, or perform the necessary adjustments to compensate for any differences.

4.1.4   Use of ratings of third parties

63. In accordance with Article 179(1)(a) of the CRR, institutions must include all relevant data and information in their own PD estimates. To comply with this requirement, institutions should have a clear policy[28] specifying the conditions under which the rating of a third party which has a contractual or organisational relationship with an obligor of the institution (third-party support) may be taken into account in the risk assessment of that obligor. This policy should meet the following criteria.

    (a) It should specify in which situations the rating of a parent entity could be taken into account in the risk assessment of other entities of the group. In particular, the policy should specify those situations in which obligors are assigned to a better grade than their parent entities.

    (b) It should include provisions on the use of ratings of third parties that provide contractual support to more than one obligor. As a general rule, the policy should include, but not be limited to, possible prioritisation, eligibility, and the impact on the rating of the supporting third party.

64. Articles 201 to 203 of the CRR establish requirements for the eligibility of unfunded credit protection. To comply with these requirements, institutions may recognise the guarantee by applying the risk weight of the guarantor under the standardised approach to the covered part of the exposure, if no own estimates of LGD and CCFs are used (Foundation IRB (F-IRB))[29]. This applies when an obligor is guaranteed by a third party that is not in the range of application of a

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[28]   As part of the policies mentioned in paragraph 62 of the EBA GL.

[29]   Within section 4.1.4, paragraph 64 is specifically referring to institutions not using own estimates of LGD and CCFs.

PD model and the guarantee fulfils all requirements for credit risk mitigation (CRM), consistently with paragraph 44 of the EBA Report on the CRM Framework. In such situations, under paragraph 74 of the EBA GL on PD and LGD, the guaranteed obligor should be included in the calculation of the one-year default rate of the grade the obligor is assigned to, before the recognition of the guarantee.

65. In addition, when the institution reflects substitution effects[30] arising from CRM in the ratings assigned to a material number of exposures within a rating system, there is a risk that the process of assigning exposures to grades or pools might not provide for a meaningful differentiation of risk, as a result of the inclusion of obligors with significantly different risk levels within the same rating grade.[31] To mitigate this risk, institutions should verify that obligors guaranteed by a third party under the standardised approach do not carry a significantly different level of risk from those in the same rating grade without such a guarantee, and that no separate calibration segment as referred to in paragraph 97 of the EBA GL on PD and LGD is required.

66. When, under paragraph 62(a) of the EBA GL on PD and LGD, an institution performs a rating transfer across different rating systems that do not share the same obligor rating scale, it should ensure that the mapping between rating scales is performed in such a way that the final PD estimate (including MoC) assigned to the guaranteed exposure amount is not better than the final PD estimate (including MoC) being transferred from a third party. Article 171(2) of the CRR establishes that information used to assign obligors and facilities to grades or pools must be current. To comply with this requirement, if a material proportion of exposures or obligors within a rating system receives a rating from another IRB rating system as a result of rating transfers, institutions should ensure that the transferred ratings are automatically updated when the rating of the third party changes or when the PDs of the rating system to which the third party belongs are re-estimated.

67. In accordance with Article 179(1)(a) of the CRR, estimates must be plausible and intuitive and must be based on the material drivers of the respective risk parameters. To comply with this requirement, institutions should have sufficient empirical evidence to justify situations where an obligor has an equal or better PD estimate than the third party providing support as a consequence of the treatments specified in paragraph 62(c) of the EBA GL on PD and LGD. In addition, differences between the various forms of contractual support should be considered in the PD models, unless there is sufficient empirical evidence

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[30] Substitution effects are understood as: the application of the treatment set out in article 236 of the CRR (i.e. the possibility to replace the PD of the obligor with the PD of the protection provider, or with a PD between that of the borrower and that of the guarantor); or the recognition of a guarantee by applying the risk weight of the guarantor under the standardised approach to the covered part of the exposure, as described in paragraph 65 of this chapter.

[31] In accordance with Article 170(3)(c) of the CRR, the process of assigning exposures to grades or pools must provide for a meaningful differentiation of risk, for a grouping of sufficiently homogenous exposures, and must allow for accurate and consistent estimation of loss characteristics at grade or pool level.

that these differences are not relevant risk drivers. This understanding should also be taken into account if the rating of the third party is being considered as an indication for an override under paragraph 62(b) of the EBA GL on PD and LGD.

68. In addition, in the situation described in paragraph 62(b) of the EBA GL on PD and LGD, where a rating of a third party is being taken into account as an indication for an override of the assignment of the relevant obligor to a grade or pool, institutions should not assign a rating to an obligor that is better than the rating of the third party as a consequence of an override resulting solely from the existence of this third-party support.

69. Furthermore, when third-party support is used extensively in the scope of application of a PD model, institutions should consider its existence as a potential relevant driver for risk differentiation, in accordance with section 4.1.2.

4.1.5 Use of shadow rating models

70. The ECB understands a shadow rating model (SRM) to be an internal rating approach that selects and weighs the risk drivers to be used for risk differentiation purposes by identifying the main factors that explain external ratings provided by an external credit assessment institution or similar organisation, rather than internal directly observed defaults.

71. In accordance with Article 144(1)(e) of the CRR, institutions must document the rationale for their rating systems. To comply with this requirement, institutions should justify and document the rationale for the use (and the continued use) of the SRM, instead of the internal default prediction model, and also document the alternative approaches that have been considered, in accordance with Article 41 of the Final Draft RTS on assessment methodology for IRB. In addition, and without prejudice to the risk differentiation requirements, when developing the model institutions should set explicit threshold criteria in terms of capacity to explain the target ratings and take appropriate action when those thresholds are not met.

72. Assignment criteria and processes must be periodically reviewed to determine whether they remain appropriate for the current portfolio and external conditions.[32] To comply with this requirement, as part of the review of estimates institutions should take all reasonable steps to demonstrate how the model performs on the application population in terms of predicting defaults or, if that is not possible (when there are not enough internal default data), at least in terms of predicting the target ratings.

73. In accordance with Article 170(1)(b) of the CRR, institutions' rating systems must have an obligor rating scale which reflects exclusively the quantification of

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[32] Article 169(2) of the CRR.

the risk of obligor default. To this end, institutions should adjust the ratings used as targets for their SRMs if they do not solely embed default risk. They should also document such adjustments.

74. In accordance with Article 174(1)(a) of the CRR, when an institution uses a statistical model and other mechanical methods to assign exposures to obligors or facilities, the input variables must form a reasonable and effective basis for the resulting predictions. To comply with this requirement, when the institution uses an SRM external ratings should not be used as risk drivers in addition to target variables.

75. When assigning obligors and facilities to grades or pools institutions must take all relevant information into account.[33] To comply with this requirement, when different information sources are used institutions should ensure that they understand the impact of any differences between these sources and establish adequate procedures to ensure that these differences are adequately addressed. In addition, institutions should account for situations where entities switch from rated to non-rated status for the target ratings over time, including when the reason for non-rated status is not credit-related, and document this accordingly.

76. Furthermore, the data used to build the model must be representative of the population of the institution's actual obligors or exposures.[34] To comply with this requirement, institutions should analyse and provide evidence of the representativeness of the data used for model development consistently with paragraphs 20 to 27 of the EBA GL on PD and LGD.

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[33] Article 171(2) of the CRR.

[34] Article 174(c) of the CRR.

4.2 PD risk quantification

4.2.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	4	(1)(78)
		144	(1)(a)
		169	(3)
		170	(1)(b)
		179	(1)(b)
		180	(1)(a), (f), (h), (2)(a), (e)
		185	(b)
EBA GL on PD and LGD	20/11/2017		70-99
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	48, 49	

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

77. In accordance with Article 180(1) of the CRR, for exposures to corporates, institutions, central governments and central banks and for equity exposures, institutions must estimate PDs by obligor grade from the LRA of one-year default rates. In accordance with Article 180(2) of the CRR, for retail exposures, institutions must estimate PDs by obligor/facility grade or pool from LRAs of one-year default rates. To comply with these requirements, institutions should follow sections 4.2.2 to 4.2.6 below.

4.2.2 Calculation of observed average default rates

78. For the calculation of the one-year default rate and observed average default rates, institutions should follow paragraphs 73 to 81 of the EBA GL on PD and LGD, also considering the following.

    (a) It is the understanding of the ECB that, for retail exposures and when the definition of default is applied at facility level, paragraphs 73 to 81 of the EBA GL on PD and LGD can be applied facility level.

    (b) Exposures for which there is no commitment (considering on-balance sheet exposures, off-balance sheet items and unadvised limits) at reference date should be excluded from the calculation of the default rate. Conversely, if there is an exposure at default (EAD) estimate, then these exposures should be included in the calculation of the default rate.

79. For the purpose of choosing an appropriate approach under paragraph 80 of the EBA GL on PD and LGD, it is the ECB's understanding that overlapping one-year time windows should preferably be used when the analysis performed by the institution under paragraphs 80(a), 80(b) and/or 80(d) of the EBA GL on PD and LGD reveals any of the following:

    (a) the proportion of short-term and terminated contracts and/or the respective distribution of default rates is not stable over time;

    (b) the observed average default rate using overlapping one-year time windows is significantly different from the observed average default rate using non-overlapping one-year time windows;

    (c) there is a significant variation between the observed average default rates calculated using non-overlapping one-year time windows on different reference calculation dates within a year.

80. Institutions should estimate PDs taking their own internal data into consideration. The more internal default experience an institution has, the less importance it needs to give to external data. In cases where institutions use external or pooled data series to complement their internal data for the purpose of PD estimation, they must ensure that these data are representative in accordance with section 3.2 of this guide. Institutions should also ensure that the average observed default rates from external/pooled data are calculated separately from those based on internal data. The direction and magnitude of the differences between these averages should be properly analysed and documented when calibrating the model, including the adequacy of the MoC considered, and duly followed up in the review of estimates.

4.2.3   Calibration to the LRA default rate

81. To calculate the LRA default rate, institutions should follow paragraphs 82 to 86 of the EBA GL on PD and LGD. If an institution makes adjustments to the observed average default rates in order to obtain LRA default rates under paragraph 85(b) of the EBA GL on PD and LGD, these adjustments should be based on (external) default rates, or – if no appropriate default rates are available – on other observed indicators relevant for the type of exposures considered.

82. For the purpose of assessing the representativeness of the historical observation period used for the likely range of variability of one-year default rates under paragraph 83 of the EBA GL on PD and LGD, the following should be taken into account.

    (a) Where the scarcity of internal exposures and/or defaults might unduly influence the variability of internally observed default rates (i.e. where the variability driven by statistical uncertainty is so high in comparison with the structural variability of default rates that it hampers any analysis of them),

institutions should assess whether external or pooled default rate series can be used to identify the relevant historical observation period for the likely range of variability of one-year default rates. The external or pooled default series used should be relevant for the specific portfolio at least in terms of geographical composition, sectoral distribution and other relevant risk drivers. When no relevant default rate series can be identified, the items described in paragraphs 83(b) and 83(c) of the EBA GL on PD and LGD should play a crucial role in the assessment.

(b) When taking into account the existence of one-year default rates relating to bad years as reflected by economic indicators that are relevant for the considered types of exposures within the historical observation period as referred to in paragraph 83(b) of the EBA GL on PD and LGD, institutions should ensure that such indicators are relevant for the portfolio at least in the terms of geographical composition, sectoral distribution and other risk drivers relevant to the portfolio, including the list of drivers referred to in section 4.1.

83. With respect to calibration to the LRA default rate, institutions should follow paragraphs 87 to 99 of the EBA GL on PD and LGD. If an institution chooses the approach referred to in paragraph 92(b) of the EBA GL on PD and LGD, it should perform additional tests as part of the development and ongoing monitoring of its models to ensure that the final (post-calibration) PDs reflect the LRA default rate of each grade. Specifically, institutions should ensure that there are no systematic deviations when comparing the estimated PDs with the LRA default rate of the grades, i.e. the direction of divergences across grades should be random.

4.2.4 Weighting for retail exposures

84. Notwithstanding paragraph 81, for retail exposures institutions need not give equal importance to historical data if more recent data are a better predictor of loss rates.[35] In the understanding of the ECB an institution may consider that the more recent data are a better predictor of loss rates and may give more importance to recent historical data if the following apply.

(a) There is a significant improvement in the predictive power when using the more recent data with respect to the predictive power resulting from the use of an arithmetic average under paragraph 81 of the EBA GL on PD and LGD. This improvement should be evidenced by comparing the estimated PDs for each grade with the realised default rates covering as long a period as possible, in accordance with Article 185(b) of the CRR.

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[35] Article 180(2)(e) of the CRR.

(b)   Older data are considered as non-representative as a result of specific policy or business changes in the bank, but not in order to reflect current trends in default rates directly related to macroeconomic conditions.

(c)   The weighting approach is used in a consistent manner over time and any change in the applied weights of historical data is appropriately justified.

4.2.5   PD quantification based on mapping to external grades

85.   The ECB interprets the possibility for institutions to attribute the default rate observed for the grades of a rating agency or similar organisation to its own grades in accordance with Article 180(1)(f) of the CRR as being equivalent to the use of external data for PD quantification at a more aggregated level (external grade) rather than at the obligor/facility level. Accordingly, sections 3.2 and 4.2.2 of this chapter are relevant for institutions that do so.

86.   In accordance with Article 180(1)(f) of the CRR, mappings must be based on a comparison of internal rating criteria with the criteria used by the external organisation and on a comparison of the internal and external ratings of any common obligors. Biases or inconsistencies in the mapping approach or underlying data must be avoided. To comply with these requirements, institutions should follow the paragraphs listed below.

(a)   Institutions should ensure that the quality of the mapping between internal and external rating scales at a given date and over time is consistent and provides for an adequate level of predictive ability. They should make sure that common obligors used as a basis for the mapping are sufficiently representative of the obligors in the application portfolio.

(b)   When mapping internal grades to external grades, institutions should document and analyse any differences between the external and internal rating scales, especially differences caused by adding further information for risk differentiation purposes, in line with paragraph 36.

(c)   Institutions should adjust the external rating scale if such rating scale does not solely embed default risk.[36] They should also document such adjustments.

(d)   When mapping internal grades to external grades and using the default rates of the external grades provided by the organisation, if the latter has a material number of obligors for which it no longer provides a rating (withdrawn rating), the institution should take this into account. It should adjust the external default rates accordingly, if necessary, and take into consideration the provisions of paragraph 75 of the EBA GL on PD and

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[36]   In accordance with Article 170(1)(b) of the CRR, institutions' rating systems must have an obligor rating scale which reflects exclusively the quantification of the risk of obligor default.

LGD. In the event that an adjustment is performed, the institution should add the necessary MoC.

4.2.6   Specific requirements for direct PD estimates

87. In order to use direct PD estimates for the calculation of own funds requirements in accordance with Article 169(3) of the CRR, institutions should follow paragraphs 96 and 98(b) of the EBA GL on PD and LGD. To assess whether the theoretical assumptions of the probability model underlying the estimation methodology are satisfied to a sufficient extent in practice under paragraph 96 of the EBA GL on PD and LGD, institutions should do the following.

(a) Ensure good risk differentiation properties across the full PD range of the rating system.

(b) Have an adequate and documented concept in place specifying the calibration function currently implemented (concrete functional form), including the underlying theoretical assumptions and the established processes to conduct the PD calibration. It is the ECB's understanding that institutions should ensure consistency between the score-inferred PDs and the observed default rates and should understand and justify the transformation of the scores into PD values.

(c) Ensure that any transformation of the scores resulting from the probability model that is applied during the calibration does not change the ranking of the obligors/facilities (in other words, co-monotonicity between scores/raw PDs and PD values should be ensured). Moreover, institutions should avoid any undue influence of extreme values of score-inferred PDs on the shape of the calibration function. Additionally, and when institutions use different calibration functions for different sub-ranges, they should ensure that this mix is appropriate (both in terms of the functional forms used and the cut-offs selected) and that it is appropriately justified.

(d) Ensure that there is a relevant number of observations across the whole range of score-inferred PDs. Particular interest should be paid to situations where the probability model is extended to ranges of PD values where there are not enough defaulted observations.

(e) Ensure that there are no excessive concentrations of exposures or obligors within the PD range of the rating system. In addition, high concentrations of observations in a specific range of score-inferred PDs should be properly analysed and justified in terms of homogeneity.

(f) For the purpose of performing the additional tests at grade level referred to in paragraph 92(b) of the EBA GL on PD and LGD, grades should be understood as sub-ranges of PD values. These sub-ranges should be defined in a way that:

(i)   represents sufficiently narrow ranges of PD values;

(ii)   contains a sufficient number of observations to ensure a meaningful calculation of the LRA default rate of the sub-range.

88. In cases where institutions map the PDs to a masterscale (defined in terms of PD bounds) as a final step in the PD estimation process (using masterscale discrete PDs for the purpose of risk-weighted exposure amounts (RWEA) calculation), there is a risk that the mapping process could distort RWEAs. To mitigate this risk, institutions should verify that deviations between the masterscale PDs and the average of the direct PDs assigned to obligors in each grade do not show a systematic or material bias towards underestimation of PD per grade over time. This analysis should be provided for both the portfolio and for each grade.

5 Loss given default

5.1 Realised LGD

5.1.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	4	(1)(55)
		5	(2)
		144	(1)(e)
		161	(2), (3)
		164	(2)
		166	(1)
		174	(c)
		175	(1), (4)(a)
		176	(4), (5)
		179	(1)(a), (c), (d) and sub-paragraph 2
		181	(1)(a), (h), (i), (j), (2)(b) and sub-paragraph 2
		182	(3)
		183	(2)
		185	(a)
		191	
EBA GL on PD and LGD	20/11/2017		37(a)(viii), 100-103, 131-146
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	3	(1), (2)(d), (3)
		11	(2)(a)
		17	(1)(a)
		30	(1)(a)
		31, 32	
		39	(a)
		40	(2)(a), (b)
		45	(1)(a), (c), (d), (2)(a), (b)
		50	
		51	(b), (c), (d), (g), (h)
		52	(b), (c)
EBA Guidelines on the definition of default[37]	18/01/2017		44, 51, 71, 72, 77

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[37] Guidelines on the application of the definition of default under Article 178 of Regulation (EU) No 575/2013, as referred in the guide as "EBA GL on the definition of default".

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

5.1.2 Reference dataset

89. Under paragraph 102 of the EBA GL on PD and LGD, institutions should estimate LGDs on the basis of their own loss or recovery experience. Institutions may supplement their own historical data on defaulted exposures with external data. The more own loss experience (i.e. the more internal defaults) an institution has, the less importance it needs to give to external data. Institutions should ensure that their own historical experience contains a minimum number of defaults in order to determine whether external data are sufficiently representative.

90. To ensure that LGD estimations are accurate and are not underestimated as a result of different external and internal recovery processes, institutions should place greater importance on comparisons of internal recovery processes with the recovery processes underlying the external data, in cases where a high weight is assigned to external data. In such cases, a higher category "A" MoC should be considered, in order to reflect the uncertainty of the estimation under paragraph 37(a)(viii) of the EBA GL on PD and LGD.

91. When institutions use information derived from the market price of defaulted financial instruments to supplement their internal loss or recovery experience data, there is a risk of misspecification of their LGD estimates. To mitigate this risk, institutions should ensure the following:

    (a) institutions should verify whether the development sample is representative of the application portfolio at least in terms of regions and product type, even when those variables have not been identified as relevant risk drivers;

    (b) losses derived from market prices should be increased to reflect indirect costs, as specified in paragraph 146 of the EBA GL on PD and LGD.

5.1.3 Calculation of realised LGD

92. Article 4(1)(55) of the CRR defines LGD as the ratio of the loss on an exposure due to the default of a counterparty to the amount outstanding at default. For the purposes of Article 181(1)(a) of the CRR, institutions are required to calculate realised LGD. To comply with this requirement, it is the ECB's understanding that institutions should calculate realised LGD under paragraphs 100 to 103 and 131 to 146 of the EBA GL on PD and LGD. In addition, when performing this calculation institutions should follow the observations in the succeeding paragraphs.

93. In accordance with Article 181(1)(h) of the CRR, institutions must have estimates of LGD in-default and expected loss best estimate (ELBE) on defaulted exposures. To comply with this requirement, it is the ECB's understanding that all principles regarding the calculation of realised LGD should be applied for the estimation of LGD on non-defaulted exposures and for the estimation of LGD in-default and ELBE on defaulted exposures, unless mentioned otherwise (that is, if the reference date is considered instead of the date of default).

94. Where, in the case of retail exposures and purchased corporate receivables, institutions derive LGD estimates from realised losses and appropriate estimates of PDs in accordance with Articles 161(2) and 181(2)(a) of the CRR and under paragraph 103 of the EBA GL on PD and LGD, all the principles regarding realised LGD should apply to realised losses.

95. Institutions must document the specific definitions of default and loss used internally and ensure that they are consistent with the definitions set out in the CRR.[38] To comply with these requirements, institutions should have in place sufficiently detailed policies and procedures to ensure that the realised LGD is calculated consistently and accurately, including the implementation of the definition of economic loss. These policies and procedures should include sufficiently detailed documentation to allow third parties to replicate the calculation of realised LGD. To ensure that the policies and procedures are implemented in an appropriate and adequate manner, the calculation process should be regularly reviewed by an independent unit.

96. In accordance with Article 181(1)(a) of the CRR and under paragraph 100 of the EBA GL on PD and LGD, institutions should calculate the realised LGD at facility level for each default. In exceptional cases, the ECB considers institutions to be compliant with the requirement to calculate realised LGD at facility level if they can prove that the recovery is not performed at individual facility level but at a more aggregated level (for example, several facilities of the same or different types secured by the same collateral). The realised LGD can therefore be calculated at a more aggregated level than individual facility level. For this exceptional deviation from the calculation of realised LGD at facility level to be acceptable, institutions should:

    (a) provide evidence that recovery at aggregated level is legally enforceable.

    (b) on a regular basis (as often as review of estimates is performed or more often), provide evidence that recovery at a more aggregated level than single facility level is in practice enforced. This evidence should be based on the institution's historical practice and data and demonstrate that both the recovery process and its outcomes in terms of realised loss or recovery are the same for all the facilities considered at the aggregated level. Specifically, institutions should be able to prove that all collateral

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[38] Article 175(3) of the CRR.

within an aggregation is called irrespective of the product triggering default (thus, for a current account as for a home loan) and that realised loss or observed recovery is the same for all types of facility within the aggregation.

(c) for retail exposures where institutions use definition of default at facility level in accordance with the last sentence of Article 178(1) of the CRR, ensure that the default is triggered for all aggregated facilities.

In addition, institutions following this approach should:

(d) ensure that the parameters are applied in a manner that is consistent with how they have been estimated, i.e. across aggregated facilities;

(e) ensure that no bias results from the aggregation of facilities, by validating the estimates (PD, LGD, CCF) at the more aggregated level also.

97. As mentioned in paragraph 92, for the purposes of Article 181(1)(a) of the CRR institutions are required to calculate realised LGD, which is defined by Article 4(1)(55) of the CRR as the ratio of the loss on an exposure due to the default of a counterparty to the amount outstanding at default. Furthermore, Article 5(2) of the CRR defines loss as an economic loss, including material discount effects, and material direct and indirect costs associated with collecting on the instrument. In accordance with these provisions, it is the ECB's understanding that institutions should calculate realised LGD as a ratio of the economic loss to the outstanding amount of the credit obligation at the moment of default, including any amount of principal, interest or fee (hereinafter outstanding amount at default). To calculate realised LGD, institutions should follow paragraphs 131 to 146 of the EBA GL on PD and LGD. In addition, they should pay particular attention to the following points.

(a) Outstanding amount at default includes any part of the exposure that has been forgiven or written-off before or at the date of default (paragraph 134 of the EBA GL on PD and LGD). This amount is equal to the accounting value gross of credit risk adjustment (i.e. "provisions") (Article 166(1) of the CRR). This amount also includes interest and fees capitalised in the institution's income statement before the moment of default. However, interest and fees capitalised after the moment of default are not considered (paragraphs 137-138 of the EBA GL on PD and LGD). Where institutions include additional drawings after the moment of default to estimate CCFs, these additional drawings discounted to the moment of default are added to the outstanding amount at default in the denominator (paragraphs 139-142 of the EBA GL on PD and LGD). In other words, institutions should ensure that the exposure used for CCF estimation is consistent with the denominator of the LGD.

(b) Economic loss is calculated under paragraph 132 of the EBA GL on PD and LGD. This also applies in the specific case of facilities that return to non-defaulted status, where losses arising from payment delays are

expected to be accounted for as well as the "artificial cash flow" envisaged by paragraph 135 of the EBA GL on PD and LGD.

(c) When recoveries are not directly observed but calculated on the basis of the difference between exposure values at two consecutive dates or derived, even partially, from some other treatment, all assumptions should be duly justified and clearly documented in order to adequately replicate the recovery flows that occur during the recovery process in accordance with letters a) and b) above. Institutions are expected to pay particular attention to the treatment of interest and fees capitalised after default, the treatment of additional drawings and the treatment of write-offs.

98. The economic loss as defined in Article 5(2) of the CRR also includes material discounts. In the understanding of the ECB, paragraph 134 of the EBA GL on PD and LGD refers to all losses incurred through forgiveness or write-off, including all losses that can trigger a default under Article 178 of the CRR, as further specified in the EBA GL on the definition of default. Therefore, where a default has been triggered by a sale of a credit obligation, the loss as calculated in accordance with paragraph 44 of the EBA GL on the definition of default should be taken into full consideration. Similarly, and where institutions open new facilities to replace previously defaulted facilities as part of restructuring or for technical reasons, the realised loss should reflect the decrease in the degree of financial obligation arising from changes in the contractual conditions (i.e. material forgiveness or postponement of payment of principal, interest, or fees). The amount by which the financial obligation has diminished should be calculated under paragraph 51 of the EBA GL on the definition of default.

99. Realised LGD for individual facilities may be zero or lower when it is the actual result of the recovery process (for example, where additional recoveries offset the discounting effect and costs). Institutions should, however, pay particular attention to no-loss exposures, since they may reveal issues with the calculation of realised losses – for example, costs not being adequately allocated to recovery processes, or inadequate treatment of amounts forgiven or written off.

5.1.4 Treatment of multiple defaults

100. For the purpose of LGD estimation and in order to ensure an appropriate measurement of economic loss as defined in Article 5(2) of the CRR, institutions should consider an exposure that returns to normal status and subsequently defaults in a short period of time as being constantly defaulted from the moment the first default occurred. This treatment should be applied under paragraph 101 of the EBA GL on PD and LGD. In addition, institutions should follow the observations in the following paragraphs.

(a) When the proportion of subsequent defaults occurring on individual facilities over a period of more than nine months is significant, institutions should either substantiate the independence of both (or more) default

events or extend the period considered for the identification of multiple defaults under paragraph 101 of the EBA GL on PD and LGD. Substantiating independence means providing sufficient evidence establishing that the second (or subsequent) default is unconnected with the original default event. It may include analysis of the curing process.

(b) Time considered between two defaults is conditional upon the existence and length of probation periods. For historical data where institutions have not adopted the minimum three-month probation period on non-distressed restructured facilities under paragraph 71 of the EBA GL on the definition of default, they should consider a 12-month period for the application of paragraph 101 of the EBA GL on PD and LGD. Where they have not adopted the minimum 12-month probation period on distressed restructured facilities under paragraph 72 of the EBA GL on the definition of default, they should consider a 21-month period for the application of paragraph 101 of the EBA GL on PD and LGD.

(c) In the particular case of an institution opening new facilities to replace previously defaulted facilities as part of restructuring or for technical reasons, it should be able to make or trace a connection between the restructured facility and the facility (or facilities) previously advanced and which it is restructuring.

5.2 LGD structure

5.2.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	143	(3) sub-paragraph 2
		144	(1)(a), (f), (h)
		169	(3)
		170	(1)(e), (f), (3)(b), (c), (4)
		174	(d)
		175	(1), (4)(b)
		179	(1)(a)
		185	(a), (b), (c)
		190	(1)
EBA GL on PD and LGD	20/11/2017		121, 122, 123
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	11	(1), (2)(a)
		12	(a), (f)
		16	(3)(c)
		32	(2)(b), (5)(b)
		34, 36, 37, 38	
		39	(b)
		41	(a)
		43	
		51	(i)

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

101. In order to comply with the requirements regarding the structure of LGD models as set out in Article 170(1)(e) and (f) and 170(3)(b) and (c) of the CRR, institutions should follow the observations below.

102. LGD estimates must be based on the material drivers of risk.[39] To comply with this requirement, institutions should identify and analyse potential risk drivers under paragraphs 121-123 of the EBA GL on PD and LGD. When selecting the risk drivers, institutions should take into consideration any changes in product mix or characteristics between the reference and default dates.

103. Institutions' rating systems must provide for a meaningful assessment of obligor and transaction characteristics, a meaningful differentiation of risk and accurate and consistent quantitative estimates of risk.[40] It is the ECB's understanding

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[39] Article 179(1)(a) of the CRR.

[40] Article 144(1)(a) of the CRR.

that to comply with this requirement institutions should demonstrate that, in terms of the range of application of LGD models, the model performs adequately (in terms of discriminatory power and predictive power) on economically significant and material sub-ranges of application of the rating systems. The sub-ranges are identified by splitting the full range of application of the LGD model into different parts on the basis of potential drivers for risk differentiation, including the drivers referred to in paragraph 121 of the EBA GL on PD and LGD.

104. The number of grades and pools must be adequate for a meaningful risk differentiation and for the quantification of the LGD at the grade or pool level.[41] To comply with this requirement, institutions should ensure the following

    (a) an adequate distribution of facilities across grades or pools in the datasets used for development and (initial and regular) validation. For this purpose:

        (i) any unusually low number of facilities in a grade or pool is expected to be supported by empirical evidence of the adequacy of isolating those facilities in a specific grade or pool;

        (ii) any unusually high concentration of facilities in a grade or pool is expected to be supported by empirical evidence of homogeneity within these grades or pools (for example by analysing whether some potential risk drivers (e.g. exposure size) that could further differentiate between riskier and less risky facilities have not been considered).

    (b) sufficient homogeneity of the risk within each grade or pool by providing empirical evidence that the grade-level LGD is adequate for all facilities in that grade. For this purpose, in cases where it is found (through the use of additional drivers or a different discretisation of the existing ones) that a material subset of facilities within a grade or pool yields a significantly different average realised LGD to that of the rest of the grade or pool, this is considered to indicate a lack of homogeneity.

    (c) sufficient heterogeneity of the risk across grades or pools by providing empirical evidence that the average realised LGD is different across consecutive grades or pools, for subsets for which there is a meaningful order.

105. Where an institution uses direct estimates of risk parameters, these may be seen as estimates assigned to grades on a continuous rating scale.[42] In this case, in the ECB's understanding the same requirements apply when an institution uses direct estimates of risk parameters as apply to grade-based models. To comply with these requirements, institutions are expected to ensure risk differentiation in accordance with the following principles.

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[41] Article 170(1)(e) and (f) and 170(3)(b) and (c) of the CRR.
[42] Article 169(3) of the CRR.

(a) If the LGD estimates used to calculated the risk-weighted exposure amounts are based on default weighted LRAs of realised LGDs for grades or pools, irrespective of whether at some point direct LGD estimates may have been used to define such grades or pools, this grade or pool level is the relevant one for the application of the principles set out in paragraph 104.

(b) When the situation described in point (a) above does not apply and, instead, several components are estimated separately and then combined in order to obtain the direct LGD estimates at facility level, institutions should provide empirical evidence that these components are independent. In the event of dependency, institutions are expected to adequately reflect this dependency in the models (for example using relevant risk drivers). The combination of components is expected to cover all possible losses relevant for the calculation of realised losses. For example, in cases where zero loss is assumed for some termination or stage during the recovery process, usually for cured processes or processes closed in the pre-litigation, this should be supported by empirical evidence.

(c) In the case of other direct LGD estimates (i.e. where no components are defined) the principles above are expected to be applied where relevant.

106. In addition to paragraph 105 above and when institutions split the facilities into different components (for example secured and unsecured), there is a risk that a meaningful differentiation of risk will not be achieved at facility level. To mitigate this risk, institutions should ensure that no bias is introduced in the risk differentiation when combining the different components in order to obtain the final LGD estimate at facility level. Specifically:

(a) the allocation of recovery flows to these components should be adequately documented and implemented in a consistent way;

(b) risk differentiation (analogous to risk quantification) should be ensured with respect to facility level.

5.3 Risk quantification

5.3.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	179	(1)(a), (1)(d)
		181	(1)(a), (b), (e), (f) and (2) sub-paragraph 2
		185	(b)
EBA GL on PD and LGD	20/11/2017		100, 116-118, 147-164
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	50	(c)
		51	(a) to (f), (i)

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

5.3.2 Observed average LGD

107. To comply with the requirement of obtaining an LRA LGD in accordance with Article 181(1)(a) of the CRR, institutions should calculate the observed average LGD under paragraphs 147, 148, 154-157 and 160 of the EBA GL on PD and LGD. When performing this calculation, institutions should follow the principles set out below.

108. Under paragraph 147 of the EBA GL on PD and LGD, default observations that are triggered close to the time of the LGD estimation process (i.e. observations with a recent default when the LGD is being estimated) are part of the historical observation period and should be included in the reference dataset (RDS). Since for these recent defaults only limited information is available regarding the full recovery process, the treatment of incomplete recovery processes envisaged in paragraph 158 of the EBA GL on PD and LGD is more complex and could add uncertainty to the LGD estimates. It is the ECB's understanding that to mitigate this risk institutions may establish a minimum period of time during which the default should be observed in order for it to be considered in the calculation of the observed average LGD. This minimum period should be adequately justified and institutions should ensure that all relevant information regarding defaults observed for a shorter period (e.g. a change in the characteristics of defaults) is considered in the LGD estimates. In any case this period should not be longer than 12 months.

109. For the purposes of LGD estimation (and validation), long recovery processes are expected to be considered as closed under paragraph 156 of the EBA GL on PD and LGD. The objective of defining the maximum period of the recovery

process ("time-to-workout") is to avoid situations where institutions give consideration to overly optimistic recoveries from open exposures that are already at a very advanced stage of the recovery process. To achieve this, the specification of the "time-to-workout" should be supported by evidence of the observed pace of recoveries and be consistent with the nature of the products concerned, the type of exposures and the operational recovery process. In addition, the institution should substantiate and clearly document the studies that support the formulation of the time-to-workout and should pay particular attention to the following.

(a) The specific moment after the date of default at which nearly nil evolution of the average cumulative recovery rates is observed. For example, when the cumulative recovery curves show a pronounced increase after which they flatten out, the time spent in default after the significant increase occurs could be used directly as the time-to-workout, especially in the case of unsecured exposures.

(b) The period of time after the date of default where the cumulative percentage of closed/recovered exposures flattens.

(c) The number of exposures used to construct the curves referred to at letters (a) and (b) above, in order to identify situations where only a few cases contribute to the shape of the curves.

(d) The expected recovery rate conditioned to vintages higher than the time-to-workout.

(e) For secured exposures, the share of exposures for which recoveries from collateral have not yet been realised.

5.3.3 Treatment of incomplete recovery processes and recovery processes where collateral has been repossessed and not yet sold

110. In order to obtain an LRA LGD in accordance with Article 181(1)(a) of the CRR, institutions should ensure that the relevant information from incomplete recovery processes is taken into account in a conservative manner. For this purpose, institutions should analyse their incomplete recovery processes and extract the information relevant for LGD estimation under paragraphs 153-159 of the EBA GL on PD and LGD. In addition, institutions should:

(a) justify and document their methodology for the treatment of incompleteness, and in particular how they comply with paragraph 159 of the EBA GL on PD and LGD;

(b) for the purpose of paragraph 159(a) of the EBA GL on PD and LGD in particular, base the extrapolation of future recoveries on defaults arising from vintages (i.e. group of defaults observed in a given year) for which,

during the period already observed, similar average past recoveries have been realised;

    (c)   in order to ensure transparency regarding the impact from the treatment of incompleteness, assess the sensitivity of the treatment of incompletes with respect to the main assumptions.

111. In specific cases where institutions have taken possession of but not yet sold the collateral, there is a risk that the value of repossession might not adequately reflect the value of the repossessed collateral. To mitigate this risk, institutions should estimate haircuts to the value of the collateral under paragraphs 116-118 of the EBA GL on PD and LGD. In order to ensure transparency regarding the impact from the treatment of repossessed collateral, institutions should:

    (a)   compare the estimated haircuts with the available observations regarding the repossession and subsequent sale of similar types of collateral;

    (b)   assess the impact on the LRA LGD of the inclusion of the repossessed collaterals (for example by applying a haircut of 100% to cases where collaterals have been repossessed but not yet sold).

5.3.4   Long-run average

112. To comply with the requirement of obtaining an LRA LGD by facility grade or pool in accordance with Article 181(1)(a) of the CRR, institutions should estimate LGDs under paragraphs 100 and 149-164 of the EBA GL on PD and LGD. When performing this estimation, institutions should follow the observations below.

113. Under paragraph 150 of the EBA GL on PD and LGD, institutions should calculate the LRA LGD as an arithmetic average of realised LGDs over a historical observation period weighted by a number of defaults. When performing this calculation, institutions should observe the following points.

    (a)   In the event of definition of default applied at obligor level, where two facilities of the same obligor are assigned to the same facility grade or pool, two options are seen as compliant for calculating the average. The first is to compute the average weighted by the total number of facilities within that facility grade. The second is to first take the exposure-weighted average realised LGD at the obligor level and then take the arithmetic average LGD weighted by the number of defaulted obligors within the LGD grade. Institutions should demonstrate that the approach they use does not distort the actual observed loss.

            [Based on the feedback received during the consultation, the ECB will consider if the two options mentioned above should be kept for the calculation of the LRA LGD]

(b) Under paragraph 160 of the EBA GL on PD and LGD, the realised LGD of each observation should be floored at zero for the purpose of LGD estimation. In cases where LGD estimates for specific facility grades or pools are low or even zero (in exceptional cases), in order to ensure that these estimates are accurate and not driven by (systematic) errors or distortions institutions should ensure that their estimation process is accurate. In particular, they should ensure that there is a sufficient number of observations supporting the estimate and that these outcomes are carefully monitored and scrutinised.

(c) Under paragraph 162 of the EBA GL on PD and LGD, institutions should apply an appropriate treatment to extremely high values of realised LGDs much above 100%, at the level of data quality, risk drivers, assignment to grades or pools or assignment to calibration segments. To ensure that the estimates are accurate, institutions are not expected to cap realised LGD values (i.e. to replace the observed value by a pre-defined value when the observed value is above the pre-defined one).

114. Institutions can calibrate LGD estimates to the LRA LGD calculated at the level of the calibration segment under paragraph 161(b) of the EBA GL on PD and LGD. When calibration segments are used for the purpose of LGD estimations, institutions are expected to base their decision on a sound rationale, in particular on quantitative evidence. It is the ECB's understanding that, to comply with Article 181(1)(a) of the CRR, institutions should also calculate the LRA LGD at a more granular level than the calibration segment (i.e. individual LGD grades or pools if estimation is discrete or ranges of LGD grades if the estimation is continuous). The level should be appropriate for the application of the model. In addition, institutions should ensure that there are no systematic deviations when comparing the estimated LGDs with the LRA of realised LGDs at this more granular level, i.e. the direction of divergences should be random.

115. Where the LGD is the result of a combination of different components (for example, secured and unsecured components), there is a risk that systematic deviations could be introduced to the estimation when combining these different components. In this case, the direction of divergences would not be random. To mitigate this risk, institutions should do the following.

(a) Provide evidence that the assumptions underlying the specification of the formula being used for the LGD estimation hold true to a sufficient extent in practice. Specifically, they should ensure that the different components are independent or, if dependency exits, that such dependency is adequately reflected in the LGD methodology.

(b) For defaults in the RDS which are closed or considered closed, compare the realised LGD at facility level with the estimates of LGD. Separate tests should be performed for the LGD applied to the performing portfolio and the LGD in-default. Analogous tests should be performed at component level.

(c) In the case of models based on components with underlying data covering time windows with different lengths and/or periods for each of the components, ensure that no bias is introduced in the LGD estimates at facility level with respect to the LRA. The analysis referred to in point (b) should be performed, at least, for the available common time period.

116. Notwithstanding paragraph 113, for retail exposures institutions need not give equal importance to historical data if more recent data are a better predictor of loss rates.[43] It is the ECB's understanding that an institution may consider the more recent data to be a better predictor of loss rates and may give more importance to recent historical data if its methodology is in line with paragraphs 150 to 152 of the EBA GL on PD and LGD and if the following apply.

(a) There is a significant improvement in predictive power when using the more recent data with respect to the predictive power resulting from the use of an arithmetic average under paragraph 150 of the EBA GL on PD and LGD. This improvement would be evidenced by comparing the estimated LGDs for each grade with the average realised LGD covering as long a period as possible in accordance with Article 185(b) of the CRR.

(b) The oldest data are considered as non-representative as a result of specific policy or business changes in the bank, but not in order to reflect current trends in loss rates directly related to macroeconomic conditions.

(c) The weighting approach is used in a consistent manner over time and any change in the applied weights of historical data is appropriately justified.

117. In accordance with Article 179(1)(a) of the CRR, an institution's own estimates must incorporate all relevant data and must be derived using both historical experience and empirical evidence. To comply with these requirements, when institutions use external or pooled data to complement their own loss or recovery experience, they should ensure that LRA LGDs derived from external or pooled data are also calculated separately from those based on internal data. In addition, the direction and magnitude of the differences between these averages should be properly analysed and documented when calibrating the model, including the adequacy of the MoC considered, and duly followed up in the review of estimates.

118. Article 179(1)(d) of the CRR requires, among other things, that the population of exposures represented in the data used for estimation, the lending standards used when the data were generated and other relevant characteristics must be comparable with those of the institution's exposures and standards. Paragraph 164 of the EBA GL on PD and LGD further specifies that institutions should take into account not only the current characteristics of the portfolio but also, where relevant, any changes to the structure of the portfolio that are expected to happen in the foreseeable future. When institutions perform adjustments to their

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[43] Article 181(2), last paragraph, of the CRR.

LGD estimates in order to comply with these requirements, it is the ECB's understanding that the following principles should apply.

(a) The adjustment should be based on a comparison of the data used in risk quantification with the institution's application portfolio. In many circumstances (for example where a type of product has been discontinued by the institution), the addition of these characteristics as risk drivers for LGD estimation is the most simple and effective way of dealing with issues of non-representativeness.

(b) In the event of changes in lending or recovery policies, institutions should make only conservative adjustments until they are able to provide empirical evidence concerning the impact of the new policies. Such evidence should be based on the inclusion in the RDS of data from periods more recent than the change of policy.

(c) All economic and market conditions experienced in the past and reflected in historical observations should be considered by institutions as part of foreseeable economic and market conditions (paragraph 147 of the EBA GL on PD and LGD). They are not, therefore, a reason to perform adjustments.

5.3.5 Downturn LGD

Note: This section of the guide might require revisions once the EBA concludes the works on the RTS on economic downturn and the GL on downturn adjustment.

119. To obtain LGD estimates that are appropriate for an economic downturn in accordance with Article 181(1)(b) of the CRR, institutions should have in place a framework in line with paragraphs 120 to 122 below. In addition, and to ensure that these estimates are accurate, institutions are expected to compare their estimates with a reference value calculated in accordance with paragraph 123 below.

120. Institutions characterise an economic downturn in terms of economic and credit indicators. This is done on the basis of the observed evolution of these indicators over a historical period. When analysing historical series in order to characterise a downturn period, institutions should take the following into consideration.

(a) The length of the historical dataset of economic indicators should be at least the most recent 20 years.

(b) As a minimum, and where relevant, institutions should consider (for all exposure types) indicators (analysed separately) such as GDP growth, unemployment rates, interest rates, inflation rates, system-wide default rates and credit losses, complemented by internal series (i.e. default rates,

losses) where available. Additional indicators should be considered for the following types of exposure:

   (i)   exposures to corporate and retail SMEs – sectoral/industry indices;

   (ii) exposures to residential real estate – house prices, region-specific indices;

   (iii) exposures to other retail – consumer leverage ratio[44] or similar information.

   (c) The specified downturn period should be a minimum of one year. Longer periods could be also be considered in order to account for cases where the historical data show longer stress periods for some indicators, or where the peaks or troughs of different economic indicators are not reached simultaneously but are nonetheless the effect of one single overall downturn. In such cases, the downturn period should be long enough to reflect the continued stressed situation.

121. Consequently, the specified downturn conditions are evidenced by elevated levels of realised LGD including treatment for incomplete recovery processes (in accordance with paragraph 110 above) at portfolio level, or at the relevant sub-range of application, driven by stressed levels of the relevant economic indicators (as specified in paragraph 120 above).

122. Institutions should derive LGD estimates which are appropriate for the downturn conditions specified, following the principles set out in paragraphs 120 and 121 above. Any lag between the beginning of the downturn period and the date of the impact on the realised LGDs should be taken into account. This means that even where high levels of realised LGD are not experienced simultaneously with the stress seen in economic indicators, but are still the result of such stress, they should be considered as the LGD estimates appropriate for the economic downturn.

123. In assessing the accuracy of those of the LGD estimates that are appropriate for an economic downturn, institutions should compare the LGD estimates derived in accordance with paragraph 122 above with a reference value derived according to the following steps.

   (a) First, institutions should identify, from the most recent 20 years, the two individual years with the highest observed losses considering the defaults observed in those years.

        Given the current circumstances (adverse economic conditions experienced in many countries since 2008), the most recent 20 years can be replaced with the most recent 10 years for estimations made during 2017. Thereafter, this period should be increased by one year each year

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[44] The consumer leverage ratio can be calculated as the ratio of total household debt to disposable personal income.

until the period of 20 years is reached, provided representativeness requirements are met. Institutions should be able to provide evidence that the period considered actually contains years which include adverse economic conditions.

To identify the two individual years referred to above, institutions should (i) group all defaults within the RDS and corresponding exposures and losses by the year in which the default occurred and obtain the ratio of total losses to total exposure; and (ii) select the two individual years with the highest ratio of total losses to total exposure. This analysis should consider years for which the maximum length of recovery process has been observed.

(b) Second, institutions should calculate reference values as the average realised LGD from those two individual years (see paragraph 123(a) above) for each facility grade or pool that they use. When the LGD estimates result from combining different components (for example, secured and unsecured), the reference values can be calculated at the level of each of the components and the comparison made at this level.[45]

Where the downturn LGD estimates (by facility grade or pool) or, if applicable, estimates of model components (including MoC) obtained by the institution are lower than those resulting from the reference value described above, the institution should be able to provide evidence that its downturn LGD methodology is aligned with the target of elevated LGDs driven by economic conditions (as specified in paragraph 121 above).

The reference value referred to in this paragraph should not be considered as a valid methodological option. Institutions are expected to develop internal methodologies compliant with paragraphs 120 to 122 above to estimate LGD appropriate for an economic downturn.

124. Where an institution does not have a data series with the length described above or cannot provide evidence that the available data include adverse economic conditions, to comply with the requirement to estimate LGD appropriate for an economic downturn the approach described above should be applied with the available data series and an add-on or MoC should be applied.

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[45] Examples are set out below:

  (a) where the institution uses secured as against unsecured components, it may be necessary (depending on the specificities of the model) to at least establish a comparison between the observed values for defaults occurring during those two individual years and those actually used by the institution for their DT LGD estimates of (i) collateral haircuts and (ii) average realised LGD as regards the uncollateralised component;

  (b) where the institution uses cure probabilities as well as LGDs for "cured" and "not cured" as components of the model, the realisation of each of these three components during the two individual years should be compared with the DT LGD estimates actually being used by the institution.

  Where the estimates for a particular component are made on the basis of grade or pool, the reference value for that component should be computed and compared for each grade or pool. Where the uncollateralised LGD is estimated by grades, a reference value should be obtained and a comparison made for each grade.

In doing this, the institution should take into consideration the economic environment observed for the data available. In other words, the better the observed economic environment, the higher the add-on or MoC should be.

5.4 Estimation of EL_{BE} and LGD in-default

5.4.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	179	(1)(c)
		181	(1)(a), (h), (j) and (2) sub-paragraph 2
		185	(a) to (c)
EBA GL on PD and LGD	20/11/2017		165 to 193
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	11	(3)(a)
		46	(d)
		50	
		51	(c)
		54	

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

125. In accordance with Article 181(1)(h) of the CRR, for the specific case of exposures already in default institutions must use the sum of their best estimate of expected loss for each exposure, given current economic circumstances and exposure status and their estimate of the increased loss rate caused by possible additional unexpected losses during the recovery period. To comply with these requirements, institutions should estimate EL_{BE} and LGD in-default under paragraphs 165 to 193 of the EBA GL on PD and LGD. In this process, institutions should follow the observations below.

126. In accordance with Article 181(1)(h) of the CRR, the EL_{BE} must represent the best estimate of expected loss given current economic circumstances and exposure status. To comply with this requirement, it is the ECB's understanding that institutions should take into consideration the economic conditions expected over the period of the recovery process, and in particular reflect downturn conditions in the EL_{BE}, if and only if current economic conditions are in a downturn or a downturn is expected over the period of the recovery process. This can be done either by adding the relevant macroeconomic and economic factors as drivers of the EL_{BE} model under paragraph 183 of the EBA GL on PD and LGD, or alternatively through an adjustment to the LRA as referred to in paragraph 184 of the EBA GL on PD and LGD.

127. Under paragraph 193 of the EBA GL on PD and LGD, LGD in-default can be estimated directly or as the sum of EL_{BE} and an add-on capturing the unexpected loss related to the exposures in default that may occur during the recovery period. In particular, the following should be taken into consideration.

(a) The use of a constant charge for unexpected losses for all defaulted exposures is not risk sensitive. In the ECB's understanding, therefore, it does not allow an accurate assessment of risk. Where an institution does use a constant charge, it should justify this. It should demonstrate that the constant charge in question is an adequate estimate of all the components of unexpected loss envisaged in paragraph 193(b) of the EBA GL on PD and LGD during the remaining recovery period, i.e. between the date for which estimates are being applied and the final closure of the recovery process. This analysis should be performed at least for every calibration segment.

(b) LGD in-default estimates are generally expected to be higher than EL_{BE} estimates and only equal for duly justified individual exposures, which are expected to be very limited.

6 Conversion factors

6.1 Commitments, unadvised limits and scope of application

6.1.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal Background			
CRR	26/06/2013	4	(1)(56)
		151	(7), (8)
		166	(1) to (8)(a), (b), (c), (d), (10)

128. In accordance with Article 151(7) and (8) of the CRR, institutions must use own estimates of CCFs for the retail exposure class and may use own estimates of CCFs for the corporate, institutional, central government and central bank exposure classes. In both cases (retail and non-retail exposure classes), the scope of CCF modelling is, in the ECB's understanding, limited to the off-balance sheet items referred to in Article 166(8) of the CRR.[46] The treatment of off-balance-sheet items other than those mentioned in Article 166(1) to (8) of the CRR is specified in Article 166(10). In accordance with Article 166(10) of the CRR, an exposure value must be a specific percentage of an off-balance-sheet

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[46] The understanding of the ECB is also supported by EBA Single Rulebook Q&A, Question ID: 2014_1263.

item's value, based on the classification of off-balance-sheet items established in Annex I of the CRR.

129. Conversion factor means the ratio of the currently undrawn amount of a commitment that could be drawn and that would therefore be outstanding at default to the currently undrawn amount of the commitment. The extent of the commitment is determined by the advised limit, unless the unadvised limit is higher.[47] The exposure value for the items listed in Article 166(8) of the CRR must be calculated as the committed but undrawn amount multiplied by a CCF.[48] To calculate the exposure value as required by Article 166(8) of the CRR, institutions should adopt the following approach.

(a) Treat a facility as an exposure from the earliest date at which the facility is recorded in the institution's systems in a way that would allow the obligor to make a drawing. An unadvised limit is any credit limit defined by the institution (i) that is above the limit the obligor has been informed of by the institution; and (ii) according to which additional drawings are possible, at least temporarily. This higher (unadvised) credit limit may be disregarded if its availability is subject to a further credit assessment by the institution, as long as this additional assessment includes a re-rating or a confirmation of the rating of the obligor.

(b) Consider as "commitment" any contractual arrangement that has been offered by the institution and accepted by the obligor to extend credit, purchase assets or issue credit substitutes.

(c) Consider as "conditionally cancellable commitment" any such arrangement that can be and will be cancelled by the institution if the obligor fails to meet conditions set out in the facility documentation, including conditions that must be met by the obligor prior to any initial or subsequent drawdown under the arrangement.

(d) Consider as "credit lines" all lines including products such as facilities granted for construction where the payments to the obligor are made according to the progress of the construction. Products such as guarantees are not, however, included in the concept of credit lines.

130. For institutions not using own estimates of CCFs for exposures to corporates, institutions, central governments and central banks, Article 166(8) of the CRR defines the CCFs to be used for the purpose of calculating RWEA. In accordance with Article 166(8)(a) and (c) of the CRR, institutions not using their own estimates of CCFs for non-retail exposures are permitted to apply a 0% CCF, under certain conditions.

It is the ECB's understanding that, to comply with the conditions established under Article 166(8)(a) and (c) of the CRR and to apply a 0% CCF, institutions

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[47] Article 4(1)(56) of the CRR.
[48] Article 166(8) of the CRR.

should have in place internal control systems that allow them to monitor the obligor's financial condition and to act in the event that a deterioration in the obligor's credit quality is detected. They should also be able to provide evidence that the internal control systems work effectively. For this purpose, institutions should demonstrate that there is only a very limited number of exposures of a particular type observed during the previous year for which the EAD is higher than the drawn amount at the reference date. This analysis should be performed on a regular basis. The ECB considers it good practice when institutions perform this analysis on an annual basis.

6.2   Realised CCFs

6.2.1   Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	175	(3)
		176	(4)
		178	(1)
		179	
		182	(1)(a)
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	57	

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

131. To ensure that a consistent and accurate approach is adopted to calculate the realised CCFs, institutions should have in place sufficiently detailed policies and procedures. For institutions to comply with the data-related requirements set out in Article 176(4) of the CRR, their RDS:

    (a)   should not be capped at the principal amount outstanding or at facility limits;

    (b)   should include all credit obligations (paragraph 16 of the EBA GL on the definition of default), especially accrued interest, other due payments (e.g. fees) and limit excesses.

132. In accordance with Article 182(1)(a) of the CRR, institutions must calculate the realised CCF at facility level for each default. In cases where realised LGD is calculated at a more aggregated level than single facility level as described in paragraph 96 above, CCF estimation can be performed at facility level or at the LGD aggregation level. One such example is where CCF is estimated by facility

while several facilities are aggregated for LGD purposes since they are all secured by the same collateral. In this case, institutions should:

(a) for retail exposures where they use the definition of default at facility level in accordance with the last paragraph of Article 178(1) of the CRR, apply full contagion of default across aggregated facilities;

(b) ensure consistency between estimation and application of the parameters;

(c) ensure that no bias results from the aggregation of facilities by validation of the estimates (PD, LGD, CCF) also at the more aggregated level.

133. For the purposes of Article 182(1)(a) of the CRR, institutions must compute realised CCF. To comply with this requirement, in the understanding of the ECB institutions should adopt the following approach.

(a) Calculate realised CCF as the ratio of the difference between the EAD and the exposure at the reference date in the numerator, and the difference between the limit at reference date and the exposure at reference date (i.e. the amount available to be drawn at the reference date) in the denominator. This does not mean that, to address the issues with the "region of instability", institutions may not use direct EAD realisation (as referred to in paragraph 139(a) of this chapter).

(b) Ensure that the definition of exposure is identical to the one used for LGD estimation. In particular, treatment of post-default drawings should be identical for the exposures used in both the LGD and CCF estimations.

(c) For each reference date and in cases where the same facility defaults more than once during the observation period, consider as date of default relevant for CCF purposes the date of the first default.

6.3 CCF structure

6.3.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	170	
		182	
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	170	
		172	(1)(b), (2)
		174	
		175	(4)

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

134. To comply with the requirements for the structure of the CCF models established in Article 170 of the CRR, and particularly when considering the risk drivers envisaged by paragraph (4) of that Article, institutions should meet the following requirements.

    (a) Demonstrate a detailed understanding of the impact on CCF estimates of changes in customer product mix or characteristics that take place between reference and default dates and the materiality of that impact. If the impact is material, institutions should address it within their own estimation process. This is because changes in exposure characteristics (e.g. a change in the value of the limit) or "product profile transformations" (e.g. a revolving loan that has been converted into a term loan or vice versa) which commonly occur between reference and default dates have a high potential to introduce substantial arbitrariness and downward bias into institutions' estimates of CCFs.

    (b) Analyse the risk drivers not only at 12 months prior to default (the fixed horizon approach) but also within the year before default (the cohort approach). When choosing the appropriate reference date for a risk driver, institutions should take into account its volatility over time.

    (c) Ensure that the models reflect the institution's current policies and strategies regarding account monitoring, including limit monitoring, and payment processing.

6.4 CCF risk quantification

6.4.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	144	(1)(a)
		166	(8)
		169	(3)
		182	
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	56 to 58	

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

135. The exposure value for undrawn commitments is calculated as the committed but undrawn amount multiplied by a CCF.[49] CCFs can also be derived from direct estimates (for example by modelling total facility EAD) in accordance with Article 169(3) of the CRR. In this case, and in order to comply with Article 182(1)(a) of the CRR, it is the ECB's understanding that institutions should also calculate the LRA CCF at a level more granular than calibration segment that is appropriate for the application of the model, namely using individual CCF values if estimation is discrete or sub-ranges of CCF values if estimation is continuous. In addition, institutions should ensure that there are no systematic deviations when comparing the estimated CCFs with the LRA realised CCFs in sub-ranges. In other words, the direction of divergences should be random.

136. In accordance with Article 182(1)(a) and (b) of the CRR, institutions are required to calculate the default weighted LRA CCF separately for each facility grade or pool. To comply with this requirement, institutions should adopt the following approach.

    (a) Ensure that the historical observation period is as broad as possible and contains data from different periods characterised by different economic circumstances, including bad years as reflected by economic indicators that are relevant for the type of exposures considered.

    (b) Calculate the observed average CCF for each facility grade or pool on all defaults observed in the historical observation period. Institutions should apply an appropriate treatment to extremely high values of realised CCF much above 100%, at the level of data quality, risk drivers, assignment to grades or pools or assignment to calibration segments. To ensure that the estimates are accurate, it is the ECB's understanding that institutions are

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[49] Article 166(8) of the CRR.

not expected to cap realised CCF values. In other words, they are not expected to replace the observed value by a pre-defined value when the observed value is above the pre-defined one.

(c)   When the historical observation period is considered to be representative of the LRA, the average realised CCFs should be computed as the arithmetic average of the yearly averages of realised CCFs in that period.

(d)   When the historical observation period is not considered to be representative of the LRA:

   (i)   if bad years are under-represented in the historical observation period, the observed average CCF should be adjusted upwards in order to estimate an LRA CCF;

   (ii) if bad years are over-represented in the historical observation period, the observed average CCF may be adjusted to estimate an LRA CCF where there is a significant correlation between the economic indicators referred to in paragraph 120 and the available observed CCF.

(e)   It is the ECB's understanding that, where CCF estimates for specific facility grades or pools are low or even zero (in exceptional cases) before the MoC is applied, and in order to ensure that these estimates are accurate and not driven by (systematic) errors or distortions, institutions should ensure that their estimation process is pertinent and accurate. In particular, they should ensure that, in these specific facility grades or pools, there is only a very limited number of exposures for which the exposure at the moment of default is higher than the drawn amount at the reference date, and that these outcomes are carefully monitored and scrutinised.

137. Notwithstanding paragraph 136, for retail exposures an institution need not give equal importance to historical data if more recent data are a better predictor of drawdowns. In the ECB's understanding, an institution may consider that the more recent data are a better predictor of drawdowns and may give more importance to recent historical data if the following apply.

(a)   There is a significant improvement in predictive power when using the more recent data compared with the predictive power resulting from the use of an arithmetic average. This improvement can be evidenced by comparing the estimated CCFs for each grade with the average realised CCF covering as long a period as possible as set out in Article 185(b) of the CRR.

(b)   The oldest data are considered as non-representative as a result of specific policy or business changes in the bank, but not in order to reflect current trends in realised CCFs directly related to macroeconomic conditions.

(c)   The weighting approach is used in a consistent manner over time and any change in the applied weights of historical data is appropriately justified.

138. To comply with the requirements of Article 182(1)(b) and to have CCF estimates that are appropriate for an economic downturn, institutions should apply the methodology for characterising an economic downturn as described in paragraph 120 above. To this end, an impact assessment should be performed to identify which identified downturn period is most strongly evidenced by elevated levels of realised CCFs. Any lag between the downturn period and the date of the impact on the realised CCFs should be taken into account. This means that where high levels of realised CCFs are not experienced simultaneously with the downturn periods, but nevertheless result from it, these high CCFs should be considered as the CCFs appropriate for the economic downturn.

139. In order to ensure a meaningful assessment of transaction characteristics as required by Article 144(1)(a) of the CRR, particular attention should be given to the following observations.

(a)   A common issue in estimating CCFs concerns facilities close to being fully drawn at the relevant reference date, as a result of the instability that may be observed in the estimates (also known as "region of instability"). To mitigate this risk, institutions should ensure that their CCF model is robust and provides estimates that are effectively protected against undesirable issues caused by the "region of instability" and/or that their estimates are adjusted adequately.

(b)   Article 182 of the CRR lays down the requirements for CCF estimates. In cases where institutions apply a fixed yet conservatively specified CCF (e.g. 100%), the ECB considers them to be compliant with the requirements when these estimates are applied in specific circumstances, such as scarcity of data and low materiality of the scope of application, for example in the event that the facility has no on-balance exposure until the first disbursement and estimates are monitored and validated.

7 Model-related MoC

7.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	179	(1)(f)
EBA GL on PD and LGD	20/11/2017		36 to 52, 92(b)
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	47	

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

140. Institutions must add to their estimates an MoC that is related to the expected range of estimation errors.[50] To comply with this requirement, institutions are expected to follow paragraphs 36 to 52 of the EBA GL on PD and LGD.

141. Since the MoC requirements laid down by the CRR also apply in cases where institutions estimate CCFs, paragraph 140 is also relevant in such cases.

142. In the understanding of the ECB, to reflect the dispersion of the statistical estimators as set out in paragraph 43(b) of the EBA GL on PD and LGD, institutions should adopt the following approach.

    (a) For PD, estimate an MoC to account for statistical uncertainty/sampling error affecting the LRA estimate at grade level stemming from the variability of each year's default rate and from the period considered. This MoC should be defined on the basis of the distribution of the estimator, i.e. the average default rate across time, and therefore reflect sensitivity to the period considered.

      Institutions need to be aware of and deal adequately with the dependency between default rates over time on the quantification of the MoC, e.g. when using overlapping windows for the calculation of default rates.

      The above principles also apply for institutions using direct estimates and for institutions using the LRA default rate at the level of the calibration segment level as referred to in paragraph 92(b) of the EBA GL on PD and LGD.

    (b) Similarly, for LGD and CCF, estimate an MoC to account for statistical uncertainty/sampling error affecting the estimates and, when material, for

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[50] Article 179(1)(f) of the CRR.

the statistical uncertainty that can arise from other estimates used in the LGD LRA and CCF LRA estimation processes.

(c)   It is the ECB's understanding that the statistical uncertainty of the estimates that can additionally arise from the estimation of the risk differentiation function (i.e. the assignment to grades or pools) should also be considered.

8   Review of estimates

8.1   Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	172	(3)
		174	(e)
		179	(1)(a), (c)
EBA GL on PD and LGD	20/11/2017		217 to 221
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	37	part 2
		46	

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

143. Institutions must review their estimates whenever new information comes to light but at least on an annual basis.[51] To comply with this requirement, they are expected to have in place a framework under paragraphs 217 to 221 of the EBA GL on PD and LGD.

144. Since the review of estimates requirements under the CRR also apply in cases where an institution estimates CCFs, paragraph 143 is also relevant to such cases.

145. In the ECB's understanding and for the purposes of paragraph 143, the following principles apply.

(a)   For PD models and regarding the analysis of the predictive power envisaged by paragraph 218(c) of the EBA GL on PD and LGD:

(i)   the analysis should be performed at grade level; for institutions using direct PD estimates, it should be performed at a sufficient level of granularity;

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[51]   Article 179(1)(c) of the CRR.

(ii) institutions should use a range of metrics to assess predictive ability, including statistical tests and graphical analysis of the evolution of default rates and PD.

(b) The analysis referred to in paragraph 218(c)(i) of the EBA GL on PD and LGD should also consider, for CCFs, whether including the most recent data leads to a significant change in the LRA CCF or downturn CCF.

(c) For LGD models that result from a combination of different components (for example, secured and unsecured components), the back-testing analysis referred to in paragraph 218(c)(ii) of the EBA GL on PD and LGD should be run at both component and facility level.

(d) In addition, institutions should consider in their frameworks for the review of estimates the availability of data for different exposure types, taking into account the specificities of the model architecture, including the existing and potential risk drivers, under paragraph 220 of the EBA GL on PD and LGD. When data are scarce, they should use complementary analyses for those exposure types where quantitative measures prove inconclusive, as a result, for example, of the low number of exposures available.

(e) Where internal data are not considered sufficient to establish fixed targets and tolerances for defined metrics and tools to assess the performance of the PD model in terms of risk differentiation, institutions should define and put in place the appropriate actions to address this.[52] These actions could encompass, for example, the use of complementary analyses for those cases where the results for the application of metrics and tools are proven to be inconclusive.

(f) When external credit bureau scores or ratings are used as the main (or one of the main) driver(s) of the internal rating, in cases where significant changes are applied to the credit bureau scoring institutions should consider the possibility of adjusting their internal data following the changes applied to the score, and whenever the input variables are no longer considered appropriate in their credit rating process.

146. In the case of material models where the assignment of the grade is based on a statistical model and where there is a risk that slight changes in the ranking of the obligors, or in the boundaries between grades, could lead to significant changes in the RWEA in that portfolio, the framework referred to in paragraph 143 should also include an analysis of whether the inclusion of the most recent data in the RDS used for model development would lead to materially different model outcomes. This analysis should be conducted on a three-yearly basis, or more often, depending on the materiality of the model. The analysis should consider, in particular, whether the discriminatory power of the PD, LGD or CCF models would be materially increased when re-estimating the model parameters on the basis of the updated RDS. Portfolios should be considered

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[52] As set out in Article 37 Part 2 of the Final Draft RTS on assessment methodology for IRB.

as falling into this category when, for example: (i) a limited number of obligors represents an important share of the total exposure; or (ii) exposures are concentrated near the boundaries between two grades.

147. When the number of default observations is low, to analyse whether the main

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	162	(2)(f), (3)
Other references			
Final Draft RTS on assessment methodology for IRB	21/07/2016	73	(d)(i), (ii)

148. drivers of the observed defaults are appropriately reflected in the model in accordance with Article 179(1)(a) of the CRR[53] institutions should analyse individual defaults (or at least a sample of them where the number of defaults makes analysing all of them unduly burdensome). However, the model should not be adapted simply to fit singular events from the institution's file review.

149. In accordance with Article 172(3) of the CRR, for grade and pool assignments institutions must document those situations in which human judgement may override the inputs or outputs of the assignment process. In addition, institutions must complement the statistical model by human judgement and human oversight to review model-based assignments and ensure that the models are used appropriately.[54] Furthermore, review procedures must be designed to find and limit errors associated with model weaknesses.[55] To comply with these requirements, institutions should assess the impact of the application of human judgement on risk differentiation capability (e.g. on discriminatory power), under paragraph 218(b) of the EBA GL on PD and LGD.

9 Calculation of maturity for non-retail exposures

9.1 Relevant regulatory references

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IRB will become additional relevant legal references. Currently that document only exists in a final draft version.

150. For the cases described in Article 162(2)(f) of the CRR, the maturity parameter (M) must be the maximum remaining time (in years) that the obligor is permitted to take to fully discharge its contractual obligations. In the ECB's understanding, M should be calculated using the expiry date of a facility. The repayment date of a current drawn amount should not be used.

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[53] This article requires that estimates be based on the material drivers of the respective risk parameters.
[54] Article 174(e) of the CRR.
[55] Article 174(e) of the CRR.

151. To ensure that the calculation of the maturity parameter is correct and to avoid any possible errors, for the purposes of Article 162(3) of the CRR institutions should adequately justify and document any exemptions from the one-year maturity floor.

Market risk

1 Scope of the market risk chapter

1. The purpose of this chapter is to provide transparency on how the ECB understands a number of topics related to internal models used in the calculation of own funds requirements for market risk. It is important to note that this chapter does not aim to cover exhaustively all topics that could be subject to review during internal model investigations (such as, for example, model governance). The topics covered in the market risk chapter have been selected taking into account the requirements of the Capital Requirements Regulation (CRR)[56] and focus on certain modelling aspects relating, for example, to regulatory back-testing of VaR models, to VaR and stressed VaR (sVaR) methodologies, and to the incremental default and migration risk charge (IRC) methodology.

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[56] Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 (OJ L 176, 27.6.2013, p. 1). For the purposes of this document the reader's attention is also drawn to the corrigendum published on 30 November 2013 (OJ L 321, 30.11.2013, p. 6).

2 Scope of the internal model approach

2.1 Regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	4	(1)
		6	(1)
		7	
		11	(1)
		18	
		92	(3), (4)
		104, 106, 325, 349	
		350	(1), (2)
		352	(2), (3)
		353	(3)
		362, 363	
		364	(2)
		367	(2), (3)
		368, 370, 372	
		386	(1), (3)
CDR on materiality of extensions and changes of the IMA [57]	04/03/2015		
Other references			
EBA Guidelines on the IRC [58]	16/05/2012		4, 7
Final Draft RTS on assessment methodology for IMA and significant share [59]	22/11/2016	Section 2, recital (20)	

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IMA and significant share will become an additional relevant regulatory reference. Currently that document only exists in a final draft version.

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[57] Commission Delegated Regulation (EU) 2015/942 amending Delegated Regulation (EU) No 529/2014 supplementing Regulation (EU) No 575/2013 of the European Parliament and of the Council as regards regulatory technical standards for assessing the materiality of extensions and changes of internal approaches when calculating own funds requirements for market risk (OJ L 154, 19.6.2015, p. 1) referred to in this guide as the "CDR on materiality of extensions and changes of the IMA".

[58] European Banking Authority (EBA) Guidelines on the Incremental Default and Migration Risk Charge (IRC) (EBA/GL/2012/3), referred to in this guide as the "EBA Guidelines on the IRC".

[59] EBA Final Draft Regulatory Technical Standards on the specification of the assessment methodology for competent authorities regarding compliance of an institution with the requirements to use internal models for market risk and assessment of significant share under points (b) and (c) of Article 363(4) of Regulation (EU) No 575/2013 (EBA/RTS/2016/07), referred to in this guide as the "Final Draft RTS on assessment methodology for IMA and significant share".

2.2 Delimitation of the regulatory trading book

2. According to Article 4(1)(86) of the CRR, "trading book" means all positions in financial instruments and commodities held by an institution either with trading intent, or in order to hedge positions held with trading intent.

3. In accordance with Article 104(1) of the CRR, institutions must have clearly defined policies and procedures for determining which positions to include in the trading book for the purpose of calculating their capital requirements (referred to in this guide as the "regulatory trading book"). The ECB understands that, in this context, "positions" refers to instruments or transactions, and not to risk positions as referred to in the glossary included in this guide. The ECB understands that positions that are classified as "held for trading" for accounting purposes are presumed to be included in the regulatory trading book. Therefore, institutions should be able to list all positions that are classified as "held for trading" for accounting purposes but not included in the regulatory trading book, and should be able to justify these exclusions.

4. As the instruments and transactions are included either in the regulatory trading book or in the non-regulatory trading book (referred to in this guide as the "banking book"), the ECB understands that the policies required by Article 104(1) of the CRR should also encompass rules for moving instruments between the regulatory trading book and the banking book.

5. In order for the ECB to assess the appropriateness and implementation of the policies and procedures for determining which positions to include in the regulatory trading book, the ECB can, on the basis of Article 10 of the SSM Regulation[60], require institutions to provide a list of types of positions and instruments allocated to the regulatory trading or the banking book, identify all related transactions including their relevant characteristics, and justify such allocation.

6. In view of their nature in terms of trading intent, the ECB considers that the following types of instruments and transactions are expected to be included in the regulatory trading book:

   (a) instruments in the correlation trading portfolio;

   (b) instruments resulting from securities underwriting commitments;

   (c) instruments held as accounting trading assets or liabilities ("held for trading" assets and liabilities);[61]

   (d) instruments resulting from market-making activities;

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[60] Council Regulation (EU) No 1024/2013 of 15 October 2013 conferring specific tasks on the European Central Bank concerning policies relating to the prudential supervision of credit institutions (OJ L 287, 29.10.2013, p. 63), referred to in this guide as the "SSM Regulation".

[61] Under IFRS 9, these instruments would be held within a trading business model and would be accounted for at fair value though the profit and loss (P&L) account.

(e) listed equities (other than equity investment funds);

(f) trading-related repo-style transactions (repo-style transactions that are (i) entered into for liquidity management purposes and are (ii) valued at accrual for accounting purposes, are not presumed to be trading-related);

(g) instruments that would give rise to net short risk positions[62] for equity risk or credit risk in the banking book;

(h) options including bifurcated embedded derivatives[63] from instruments issued out of the banking book that relate to credit or equity risk.

7. In view of their nature in terms of trading intent, the ECB considers that the following types of positions and instruments are expected be included in the banking book:

(a) unlisted equities;

(b) instruments designated for securitisation warehousing;

(c) real estate holdings;

(d) retail credit and credit to small and medium-sized enterprises (SMEs);

(e) other types of credit;

(f) equity investments in a fund for which the institution cannot obtain liquid prices;[64]

(g) derivative instruments that have any of the types of instrument mentioned in sub-paragraphs (a) to (f) as an underlying asset;

(h) instruments held for the purpose of hedging a particular risk of a position in any of the types of instrument mentioned in sub-paragraphs (a) to (g).

8. In addition, for each category listed in paragraphs 6 and 7, institutions should be able to indicate whether the corresponding positions are included within the scope of the internal model approach (IMA).

9. In accordance with Article 106 of the CRR, internal hedges (as defined in Article 4(1)(96) of the CRR) must be properly documented and not be primarily intended to avoid or reduce own funds requirements. Therefore institutions

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[62] An institution will have a net short risk position for equity risk or credit risk if the present value of the position increases when an equity price decreases or when the credit spread of an issuer or group of issuers of debt increases.

[63] Bifurcation means the separation of a derivative that is embedded in a hybrid security and that has to be separated according to accounting rules from the host security, and which has to be accounted for using the accounting rules for derivatives.

[64] Where an institution is aware of the underlying investments of the fund on a daily basis, the underlying investments might be assigned to the trading or banking book depending on their characteristics.

should be able to identify[65] all internal hedges and should document their treatment for the purpose of calculating own funds requirements for market risk. In accordance with Article 106(1)(d) of the CRR, the market risk that is generated by an internal hedge must be dynamically managed in the regulatory trading book within the authorised limits. For this reason, the ECB considers that proper documentation should distinguish between:

(a) hedges of a banking book credit risk exposure (or counterparty credit risk exposure) using an internal risk transfer with the regulatory trading book;

(b) hedges of a banking book equity risk exposure using a hedging instrument purchased from the market through the regulatory trading book;

(c) hedges of a banking book interest rate risk exposure using an internal risk transfer with the regulatory trading book;

(d) hedges of a banking book foreign exchange risk exposure using an internal risk transfer with the regulatory trading book;

(e) hedges of a banking book commodity risk exposure using an internal risk transfer with the regulatory trading book;

(f) eligible hedges (as defined in Article 386(1) of the CRR) that are included in the credit valuation adjustment capital charge.

Additionally, institutions should be able to identify internal transactions which are in the regulatory trading book[66] and within the scope of the internal model, and show that these transactions do not contribute to the own funds requirements obtained using the internal model.

10. In accordance with Article 386(3) of the CRR, eligible credit valuation adjustment hedges in the regulatory trading book must not be included in the calculation of the own funds requirements for specific risk of debt instruments. The ECB therefore considers that they should be included in the scope of calculation of own funds requirements for general risk (for example, included in the VaR or stressed VaR (sVaR), or treated through the framework for risks not in the VaR engine – see section 7). Additionally, other (i.e. non-eligible) credit valuation adjustment hedges in the regulatory trading book should be included in the calculation of own funds requirements for market risk (i.e. general and specific risk).

11. Back-to-back transactions in the regulatory trading book (i.e. transactions exactly matched with a third-party transaction) are generally included in the calculation of own funds requirements for market risk. The ECB considers that back-to-back transactions included in the scope of the internal model may be

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[65] To "identify" here means to be able to spot these trades among the institution's transactions. The institution is not required to be able to segregate internal hedges in dedicated portfolios on which specific analysis is carried out.

[66] For example, transactions within the scope of the IMA made between two trading units.

excluded from the calculation of own funds requirements, provided that institutions are able to document them and demonstrate that there are no residual market risks stemming from these transactions. However, potential profit and loss (P&L) generated by these back-to-back transactions should be considered in the back-testing (for those P&L components that are not excluded from the actual or hypothetical P&L). This is because, although they do not carry residual market risks, such back-to-back transactions could generate P&L (for example, at the inception of the trade, or where the transaction is closed before maturity).

2.3 Treatment of banking book positions

12. In accordance with Article 92(4)(a) of the CRR, for foreign exchange (FX) risk and commodities risk the own funds requirements must include those arising from all the business activities of an institution. Therefore, the ECB understands that for FX risk and commodities risk, the requirements for the calculation of own funds and, in particular, the internal models approach are not limited only to regulatory trading book positions but also include the positions in the banking book.

13. For institutions that have approval to use the IMA for FX risk, the ECB is aware that the modelling of banking book FX positions in the internal model may be challenging owing to different trade booking systems and different market data processes for the banking book and for the regulatory trading book. In accordance with Article 363(2) of the CRR, permission to use internal models for market risk will be granted only if the internal model covers a significant share of the positions of a certain risk category.[67] Therefore, institutions may exclude banking book FX positions from the scope of the internal model, provided that they can demonstrate to the satisfaction of the ECB that the scope of the approved internal model nevertheless covers a significant share of the positions of the FX risk category. If that is the case, the banking book FX exclusions should be treated in the same way as those positions excluded from the regulatory trading book (see section 2.5).

14. In accordance with Article 92(3)(c) of the CRR, the own funds requirements for foreign exchange risk must be determined in accordance with the CRR provisions for market risk (using either the standardised approach or the IMA). Therefore, where excluded from the internal model, the banking book FX positions must be subject to own funds requirements calculated according to the standardised approach. The ECB considers a prudent approach to be that for the purpose of this own funds requirement calculation, banking book FX positions are not netted with regulatory trading book FX positions.

15. In accordance with Article 368(1)(e) of the CRR, institutions must have established procedures for monitoring and ensuring compliance with a

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[67] See also Section 2 of the Final Draft RTS on assessment methodology for IMA and significant share.

documented set of internal policies and controls concerning the overall operation of their internal models. To satisfy the requirements of Article 368(1)(e) of the CRR, institutions should have documented processes and methodologies in place for determining FX positions. The ECB considers that in order to adequately cover the overall operation of the internal model, such documentation should include, in particular, the intermediate steps followed for calculating the FX positions, beginning with each individual subsidiary and proceeding to the group level (for example, before and after netting, the treatment of intragroup deals, the methodology applied to derive the FX position of banking book items including whether the institution applies the provisions of Article 352(3) of the CRR).

If an institution excludes any balance sheet items denominated in foreign currency from the FX positions in accordance with the provisions of Article 352(2) of the CRR, it should document in detail which positions are covered by the exclusion – including details on the materiality of each of them – and the justification for the exclusion, so that the institution can demonstrate that the provisions of the article have been complied with. In particular, this also applies at the consolidated and sub-consolidated levels to balance sheet items in foreign currencies that stem from consolidated subsidiaries and is without prejudice to the extent and manner of prudential consolidation prescribed in Article 18 of the CRR.

16. In order for the ECB to assess whether banking book FX positions have been excluded from the scope of application of the IMA for the sole purpose of reducing the own funds requirements for market risk, the ECB can, on the basis of Article 10 of the SSM Regulation, require an institution to estimate the difference between the own funds requirements calculated under the standardised approach and the own funds requirements calculated under the IMA[68] for those banking book FX positions.[69]

17. The ECB is aware that (in contrast to FX positions) it is not common practice to include commodities positions in the banking book. However, where an institution has permission to use the internal model for commodities risk, commodities positions in the banking book should not be systematically excluded from the scope of application of the internal model.

2.4   Partial use models

18. If an institution does not have permission to use an internal model to calculate the own funds requirements for market risk for all of the six risk categories listed in Article 363(1) of the CRR, but only for some of them (for the purposes of this guide, referred to as "partial use"), the institution must apply the standardised

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[68]   For estimating the own funds requirements under the IMA, the calculation can be based on only one date, rather than the average over the last 60 business days.

[69]   FX positions excluded from the scope of the calculation of the own funds requirements for market risk in accordance with Article 352(2) of the CRR would not need to be considered for this comparison.

approach in accordance with Article 363(2) of the CRR to calculate the own funds requirements for the risk categories for which it has not been granted permission.

19. In the case of portfolios for which the bulk of the risks fall outside the scope of the approved risk categories of an internal model,[70] institutions may completely carve out such portfolios from the scope of application of the internal model, provided that the internal model still covers a significant share of the relevant risk categories. The ECB considers it best practice to carve out such portfolios only if the overall own funds requirements for market risk after the carve-out are higher than they would have been if the carve-out had not been performed. Institutions should duly notify the ECB of such exclusions in accordance with the CDR on materiality of extensions and changes to the IMA. Institutions should, nevertheless, ensure that the risks of these portfolios are adequately managed. Institutions should determine the own funds requirements for the carved-out portfolios according to the standardised approach (for all risk categories, including those for which the institution has permission to use the internal model).

20. Portfolios for which the bulk of the risks fall within the scope of the model approval should be included in the calculation of own funds requirements using the internal model (for the risk categories within the scope of the internal model permission). The own funds requirements for the risks not included in the scope of the internal model permission should be determined according to the standardised approach.

21. In accordance with Article 362 of the CRR, general risk of debt instruments refers to the risk of a price change due to a change in the level of interest rates. The ECB considers that this is a reference to risk-free interest rates. In accordance with Article 362 of the CRR, general risk of equity instruments refers to the risk of a price change due to a change of a broad equity-market movement unrelated to any specific attributes of individual securities. The ECB considers that this is a reference to index movements. An institution without permission to use the IMA for the specific risk of debt or equity instruments, and which applies a different definition of general risk of debt or equity instruments (as applicable) should be able to demonstrate that the definition/s it applies lead to at least the same level of own funds requirements that would result from applying the principles of this paragraph.

2.5 Exclusion of positions in the regulatory trading book from the scope of application of the IMA

22. In accordance with Article 363(2) of the CRR, an internal model must cover a significant share of the positions of each risk category for which the permission

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[70] A typical example would be a portfolio of equity options for an institution that has no permission to model equity risk, so that it only models the position risk of debt instruments.

is granted. The ECB understands that this requirement applies not only on the date on which the permission is granted, but on an ongoing basis. The ECB is aware that institutions have a certain margin of discretion not to include all positions exposed to the relevant approved risk categories, provided that the internal model still covers a significant share of those positions. In the ECB's view, exclusions would be justified where the inclusion of those positions in the internal model is operationally challenging (for example, in the case of products requiring a more sophisticated modelling approach). Exclusions should never be made for the sole purpose of reducing the overall own funds requirements for market risk.

The ECB considers that to be able to demonstrate that the internal model covers a significant share of positions, institutions should monitor the exclusion of market risk positions, including the materiality of those positions. In the case of FX and commodities risks, this monitoring should also extend to exclusions of banking book positions. This monitoring should consider all excluded positions in accordance with each relevant scope of approval of the internal model, which could be at individual ("solo"), sub-consolidated, or consolidated level. Institutions should be able to justify such exclusions and demonstrate that the risk of the excluded positions is adequately managed.

23. The own funds requirements for the positions excluded from the internal model (including any banking book positions) should be determined according to the standardised approach. Additionally, institutions should be able to demonstrate that the level of own funds requirements under the standardised approach is commensurate with the risks of those positions.

24. The ECB considers that an appropriate approach to calculating the own funds requirements for derivatives on unusual underlyings (such as temperature, weather or mortality)[71] could be to include them in the scope of the IMA (the "exotic" risks might be treated under the "risks not in the model engines (RNIME)[72]" framework, where necessary). However, institutions may use the standardised approach for these positions, provided that they can demonstrate that the level of own funds requirements under the standardised approach is commensurate with the risks of such positions.

25. The ECB considers that a materiality criterion at transaction level (for example, a notional amount lower than a certain EUR amount) is not an appropriate criterion by itself for an exclusion from the scope, because the cumulative effect of these transactions may be a material position. Therefore, this type of exclusion should not be applied.

26. If back-to-back transactions are excluded from the calculation of own funds requirements using the internal model (in the circumstances set out in

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[71] The EBA considers that certain "unusual" underlyings, such as freight rate, weather derivatives or emission certificates can be considered as, or assimilated to, commodities (see the EBA Single Rulebook Q&A, Question ID: 2014_934).

[72] See section 7 for more details.

paragraph 11), it is not necessary – as it is with other excluded positions – to calculate the own funds requirements for these transactions under the standardised approach, as no residual market risks stem from them.

2.6 Treatment of specific positions

2.6.1 Own debt exposures

27. For the purposes of this guide, the meaning of "own debt" requires clarification, given that the CRR does not provide a definition. As defined in Article 4(1)(47) of the CRR, "consolidated situation" means the situation that results from applying the requirements of the CRR to an institution as if that institution formed, together with one or more other entities, a single institution. As defined in Article 4(1)(49) of the CRR, "sub-consolidated basis" means "[…] on the basis of the consolidated situation of a parent entity […] that is not the ultimate parent entity". Therefore, the ECB considers an acceptable approach to be that when determining their own debt positions, institutions using an IRC model also take into account the debt positions in their subsidiaries within the scope of prudential consolidation, depending on the level within the group of the institution using the IRC model.

28. By way of illustration, the positions described in the following situations can be considered as own-debt exposures. Figures 1, 2 and 3 below each illustrate an example, as indicated.

   Figure 1: Where the institution is the group EU parent institution –
   all positions in debt exposures to institutions within the prudential consolidation scope should be considered as own debt exposures.

   Figure 2: Where the institution is the sub-consolidating institution or financial holding company that is not the ultimate EU parent institution –
   all positions in debt exposures to institutions within the relevant prudential sub-consolidation scope should be considered as own debt exposures.

   Figure 3: Where the institution is a subsidiary without dependent subsidiaries (solo) – all debt exposures of an institution to itself at the solo level should be considered as own debt exposures.

   This is without prejudice to other definitions of own debt that institutions may apply and that the ECB will assess on a case-by-case basis to take into account specific circumstances.
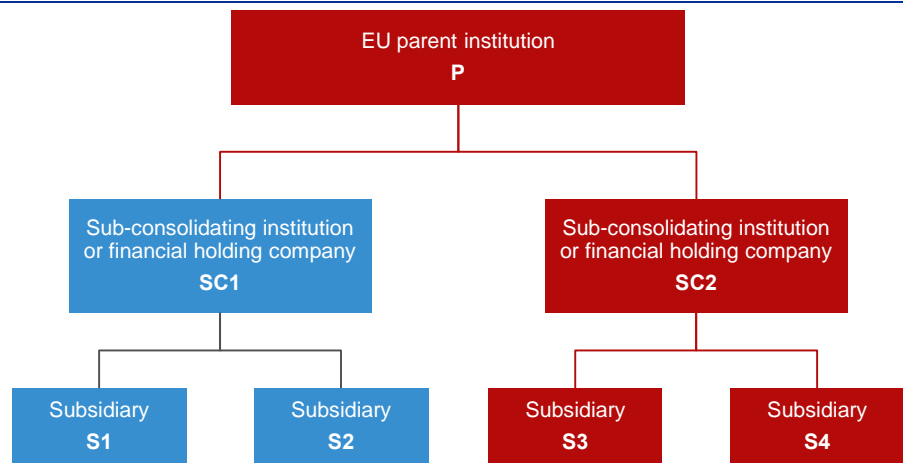
Figure 1

Own-debt positions at the consolidated level
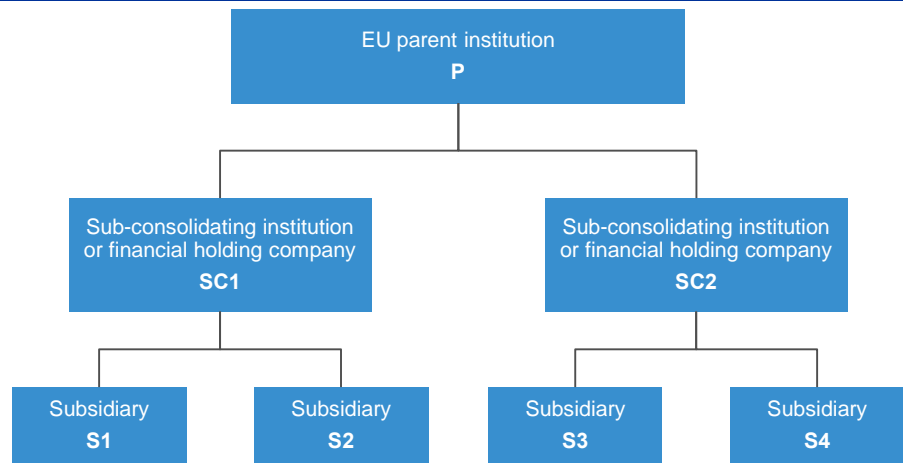
Own-debt positions at the consolidated level are shown with a blue background.

Figure 2

Own-debt positions at the sub-consolidated level of the sub-consolidating institution or financial holding company SC1

Own-debt positions at the sub-consolidated level of the sub-consolidating institution or financial holding company SC1 are shown with a blue background, while non-own-debt-positions at the sub-consolidated level of SC1 are shown with a red background.

Figure 3

Own-debt positions at the solo level of subsidiary S1
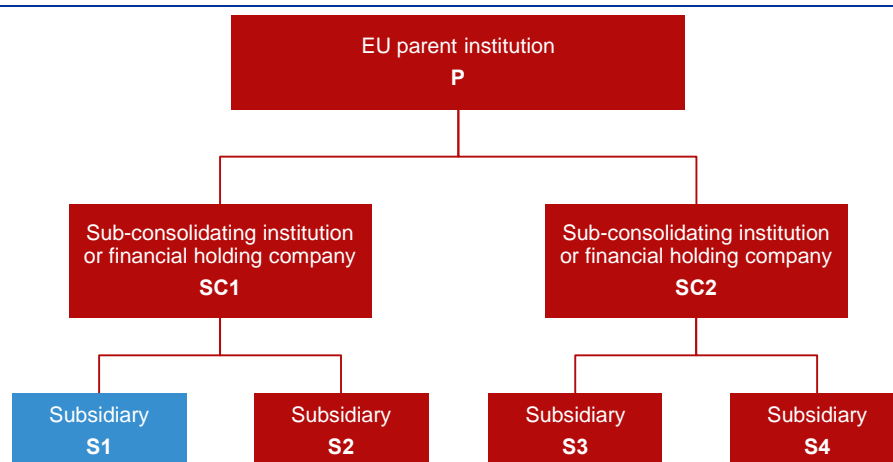
Own-debt positions at the solo level of subsidiary S1 are shown with a blue background, while non-own-debt positions at the solo level of S1 are shown with a red background.

29. Under paragraphs 7.1 and 7.2 of the EBA Guidelines on the IRC, for long or short positions in an institution's own debt which may arise from trading or market-making activity in its own-debt issuances, or from trading protection in the institution's own name (for example, via an index), the institution should only model the migration risk. The default risk of these positions should not be modelled in the IRC approach.

To ensure consistency with the IRC model when modelling the specific risk of debt instruments in the VaR and sVaR models, institutions should include their own creditworthiness.[73] The ECB considers it best practice to model such own creditworthiness as (a) separate risk factor(s) in the VaR and sVaR models.[74]

30. As regards the general risk of debt instruments for own debt, and in the absence of any specific provision in the CRR or the EBA Guidelines on the IRC, the ECB understands that the general risk of own debt instruments should be accommodated in the internal model if the institution has the relevant approval.

2.6.2 Positions in defaulted debt

31. Under paragraph 4.5 of the EBA Guidelines on the IRC, institutions should include in the calculation of the IRC the positions in defaulted debt that are held in the regulatory trading book, where material. In order for the ECB to assess the appropriateness of the treatment of such positions, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to provide a list of

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[73] This refers exclusively to position risk taken against debt issued by the institution or derivatives referencing that debt and does not refer to debit valuation adjustments (DVA).

[74] This understanding is also supported by Recital (20) of the Final Draft RTS on assessment methodology for IMA and significant share.

all positions in defaulted debt that are held in the regulatory trading book, along with the following information:

(a) the market value of the exposure;

(b) notional value of the exposure;

(c) a Boolean variable indicating whether the positions are included in the VaR/sVaR;

(d) a Boolean variable indicating whether the positions are included in the IRC.

32. The ECB considers that to reflect paragraph 4.5 of the EBA Guidelines on the IRC, material positions in defaulted debt should be included in the scope of the IMA. It also considers it best practice that non-material positions are included in the IMA; either in the VaR, sVaR (and IRC) engines or under the "risks not in the model engines" (RNIME) framework for the VaR, sVaR (and IRC).

33. Under paragraph 4.5 of the EBA Guidelines on the IRC, positions in defaulted debt held in the regulatory trading book should, where material, be included in the calculation of the IRC. In accordance with the requirement in Article 372(d) of the CRR as it relates to Article 370(e), the IRC model must be sensitive to material idiosyncratic differences between similar but not identical positions. Therefore, the ECB considers that when modelling the risk of price changes of positions in defaulted debt in the IRC, and to account for those idiosyncratic differences, institutions should apply a specific calibration of the recovery rates which is appropriate for the positions in defaulted debt. If an institution does not have the capacity to model price changes of positions in defaulted debt in the IRC model (for example, owing to IT constraints), the ECB considers that an appropriate way to account for those differences is to apply a stressed price of the positions in defaulted debt that is proven to be adequately conservative given the quantile and holding period of the IRC.

34. The ECB considers that default should be an absorbing state (i.e. once a position has defaulted it does not migrate to a different state). Therefore, the ECB considers it best practice that no migration from default to non-default states is considered in the IRC model.

2.6.3 Collective investment undertakings

35. This paragraph, and the following paragraphs 36 to 41 inclusive, apply to all exposures that institutions may have in collective investment undertakings (CIUs), as referred to in Article 4(1)(7) of the CRR (including exchange-traded funds (ETFs), equity investments in hedge funds, etc.) – which for the purposes of these paragraphs are referred to as "positions in CIUs" – and also apply to derivative instruments that have these instruments as underlying assets.

36. In accordance with Articles 368(1)(e) and 104(2) of the CRR, institutions must have established procedures for ensuring compliance with a documented set of internal policies and controls concerning the overall operation of their internal models and the regulatory trading book. Therefore, the ECB considers that in order to ensure that an appropriate treatment is applied to positions in CIUs in their internal models for market risk, institutions should have a documented set of policies and controls in place to identify, for each CIU, the following:

    (a) the risk categories, as listed in Article 363 of the CRR, to which the CIU is subject;

    (b) whether the criteria as defined in Article 349 of the CRR are fulfilled;

    (c) whether daily look-through is possible, as referred to in Article 350(1) of the CRR;

    (d) where daily look-through is not possible, whether the requirements as laid down in Article 350(2) of the CRR are satisfied – in particular, institutions should define and document the methodology used to assess the correlation between the CIU and the index/basket that it tracks;

    (e) the extent to which the CIU can be marked-to-market daily by reference to an active, liquid two-way market as referred to in Article 104(2)(b) of the CRR (for example, whether a daily liquid price is available).

37. The above information in relation to each CIU should be documented. In the ECB's view it is necessary to update the information regularly, in order to ensure that the documented information is based on the current characteristics of the positions in CIUs and fully reflects the market risk to which the positions are exposed. The ECB considers that an appropriate update frequency for existing positions in CIUs is at least annual, as one year is a reasonable time in which significant changes in the market or in the positions in CIUs could occur. In addition, this time frame would allow institutions to use the outcomes of the updates in the review of their overall risk management process, as referred to in Article 368(2) of the CRR. For new positions in CIUs, the ECB considers that the procedure should take place before the investment in a new CIU is approved internally, in order to ensure that institutions compute own funds requirements for the positions in CIUs in compliance with the CRR requirements.

38. For the foreign exchange market risk related to CIUs, the CRR contemplates a specific treatment. In accordance with Article 367(2)(b) of the CRR, the actual foreign exchange positions of a CIU must be taken into account in the internal model. Institutions may rely on third-party reporting of the foreign exchange positions of a CIU where the correctness of that reporting is adequately ensured. If an institution is not aware of the foreign exchange positions of a CIU, this position must be carved out and treated in accordance with Article 353(3) of the CRR.

39. As regards general and specific risk of equity instruments, general and specific risk of debt instruments, and commodities risk: for those positions in CIUs for which the conditions for either the look-through approach (as referred to in Article 350(1) of the CRR) or the representation approach (as referred to in Article 350(2) of the CRR) are met, the ECB considers that in order to ensure an accurate risk measurement, the own funds requirements for the general and specific risk of equity instruments, the general and specific risk of debt instruments and the commodities risk should be calculated by incorporating the underlying investments of the relevant CIU – or the index/basket that it tracks – into the internal model for the risk categories for which the institution has permission to use internal models.

Where an institution with internal model approval for specific risk of debt instruments includes listed equity positions in the IRC, it should be consistent in including in the IRC either the underlying listed equity positions of the CIU, or those of the index/basket that the CIU tracks.

40. For positions in CIUs where neither the conditions for the look-through approach as referred to in Article 350(1) of the CRR nor the conditions for the representation approach as referred to in Article 350(2) of the CRR are met, the following apply.

    (a) In accordance with Article 364(2)(a) of the CRR, institutions using an internal model to calculate their own funds requirements for specific risk of debt instruments must fulfil an additional own funds requirement for specific risk of debt instruments in accordance with the standardised approach for positions in CIUs under Articles 348 to 350 of the CRR.

    (b) The ECB considers that the positions in CIUs can be incorporated into the VaR and sVaR models as a single risk factor to account for the general and specific risk of equity, the general risk of debt instruments, and the commodities risk of the positions in CIUs. As is the case for any other position, sufficient observable information on market risk should be available. The ECB considers that a suitable approach is to use the daily liquid price of the CIU.

41. For those risk categories in respect of which the institution does not use an internal model to compute own funds requirements for market risk, or for positions in CIUs to which none of the abovementioned provisions apply, the institution should compute the own funds requirements for the respective positions in CIUs according to the standardised approach for CIUs.

2.7 Aggregation requirements

42. In accordance with Article 363 of the CRR, competent authorities may grant permission to institutions to calculate their own funds requirements for market risk by using their internal models instead of, or in combination with, the standardised approach – provided that the internal model covers a significant

share of the positions of a certain risk category. In accordance with Articles 6(1) and 11(1) of the CRR, institutions must meet the own funds requirements on an individual basis (unless a derogation in the circumstances set out in Article 7 of the CRR has been granted), and the parent institution in a Member State must comply with the own funds requirements on a consolidated basis.

Therefore, the institution at the highest level of consolidation operating within the framework of the Single Supervisory Mechanism should be able to specify:

(a) which legal entities within the group have been granted permission to use an internal model for calculating own funds requirements for market risk;

(b) the scope of application of each model permission (i.e. individual, sub-consolidated or consolidated);

(c) the risk categories listed in Article 363(1) of the CRR for which each permission has been granted.

The ECB also understands that, for institutions to calculate own funds requirements at the consolidated level by using their internal models, a permission to use their internal models at consolidated level is required under Article 363(2) of the CRR.

43. In those cases in which the scope of the permission applies at the consolidated or sub-consolidated level, institutions should be able to provide a list of legal entities included in the scope of consolidation or sub-consolidation, specifying which of those entities effectively contribute to the market risk own funds requirements determined by using the internal model. In order for the ECB to assess how the own funds requirements are determined, institutions should also be able to provide information on how each legal entity is integrated into the information system infrastructure of the risk management system and whether impediments exist to such integration.

If impediments exist to the integration of the risk numbers from individual legal entities, the ECB considers it best practice to integrate the risk numbers from these entities into the model-based own funds requirements by applying a simple sum aggregation.

44. In accordance with Article 368(1)(a) of the CRR, the internal model must be closely integrated into the daily risk management process of the institution and serve as the basis for reporting risk exposures to senior management. Therefore, the ECB understands that institutions should ensure an integrated and harmonised risk management across all legal entities included in the scope of the model permission.

45. In accordance with Article 325 of the CRR, institutions may use positions in one institution or undertaking to offset positions in another institution or undertaking only for the purpose of calculating net positions and own funds requirements for market risk on a consolidated basis, and only subject to the permission of the competent authorities. The ECB understands that this requirement applies to all

positions, in particular to intra-group transactions.[75] The offsetting of positions can be performed irrespective of the calculation approach that is applied for market risk own funds requirements (i.e. IMA or standardised approach). In order for the ECB to assess how these requirements are fulfilled, institutions should document how the offsetting of positions is performed.

46. In accordance with Article 367(3) of the CRR, an institution may use empirical correlations within risk categories and across risk categories only if the institution's approach to measuring correlations is sound and implemented with integrity. The ECB understands that for empirical correlations to be sound they should be based on reliable and observable data. If this cannot be ensured, an institution should use the simple sum aggregation of stand-alone risk numbers within risk categories or across risk categories.

In order for the ECB to assess the soundness and integrity of the implementation of the use of empirical correlations, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to provide the stand-alone VaR and sVaR corresponding to each of the following risk classes:[76] interest rate risk; equity risk; commodity risk; foreign exchange risk; and credit spread risk.

3 Regulatory back-testing of VaR models

3.1 Regulatory references

	Date of issue	Article	Paragraph/Point
Legal Background			
CRR	26/06/2013	34	
		105	(10)
		106	(3)
		352	(2)
		366	
		368	(1)
		386	(3)
Other references			
Final Draft RTS on assessment methodology for IMA and significant share	22/11/2016	40	(4), (5), (10)
		43	(4)

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[75] This interpretation is also supported by the explanation in footnote 7 of the Final Draft RTS on assessment methodology for IMA and significant share.

[76] If this is not possible, the calculation should be based on the approved risk categories in accordance with Article 363(1) of the CRR.

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IMA and significant share will become an additional relevant regulatory reference. Currently that document only exists in a final draft version.

3.2 Scope of application of regulatory back-testing

47. The scope of application of regulatory back-testing, as referred to in Article 366 of the CRR, should be clearly documented.

48. In accordance with Article 366(3) of the CRR, regulatory back-testing compares the hypothetical and actual changes in the portfolio's value ("hypothetical P&L" and "actual P&L") with the *related* one-day value-at-risk number generated by the institution's model. Therefore, the changes in value of all of (and only) the instruments and transactions entailing positions included in the scope of calculation of the VaR model should be considered in the calculation of the hypothetical P&L and the actual P&L.

49. In particular, if the institution is authorised to apply the IMA for foreign exchange and/or commodities risk positions, and the banking book positions in these risk categories are included in the scope of the internal model, the institution should include these banking book positions in the back-testing and should clearly document how the actual and the hypothetical P&L of these positions are calculated.

50. Regarding positions in the banking book that are included in the IMA, only the changes in value of market data pertaining to FX risk and commodity risk should be taken into account in the calculation of the actual and the hypothetical P&L. Only for those instruments or transactions where the separation of the positions stemming from risk categories other than FX risk or commodities risk (for example, risk of debt instruments) is operationally challenging or its effect on the total P&L is immaterial, an institution may include changes in value of market parameters pertaining to all risk categories in the actual and the hypothetical P&L. Institutions should be able to justify the immateriality or the operational challenge, if applicable. In particular, considering only the effect of FX risk in the actual and the hypothetical P&L is not deemed to be operationally challenging.

51. Positions excluded from the calculation of the own funds requirements for market risk on the basis of a permission granted by the competent authorities under Article 352(2) of the CRR (i.e. (i) positions taken in order to hedge against the adverse effect of the exchange rate on the institution's capital ratios, or (ii) positions which an institution has which relate to items that are already deducted in the calculation of own funds) should also be excluded from the scope of application of the back-testing.

52. Positions that are excluded from the regulatory trading book for the purpose of calculating capital requirements on the basis of Article 106(3) of the CRR (i.e. internal or external credit derivative hedges for banking book credit risk

exposure or counterparty risk exposure) should also be excluded from the scope of application of the back-testing.

53. In accordance with Article 386(3) of the CRR, eligible hedges that are included in the calculation of own funds requirements for credit valuation adjustment (CVA) risk must not be included in the calculation of the own funds requirements for specific risk. Therefore, the change in value of those positions that are attributable to specific risk of those eligible hedges should also be excluded from the actual and the hypothetical P&L. However, if the own funds requirements for general risk of these eligible hedges are calculated using the VaR model (see paragraph 10), the change in value of those positions that are attributable to general risk should be included in the actual and in the hypothetical P&L.

54. Hedges which under Article 386(3) of the CRR are not eligible hedges for regulatory credit valuation adjustment should be included in the VaR calculation and in the scope of calculation of the hypothetical P&L and the actual P&L for back-testing.

3.3 Historical period used to perform back-testing, definition of business days, and documentation

55. In accordance with Article 366(2) of the CRR, the addend to the multiplication factors must depend on the number of overshootings for the most recent 250 business days.

56. For the purpose of paragraph 55, institutions should define and document local and global business days according to the guidance set out in paragraphs 57 to 59.

57. The ECB considers that when the business trading unit of an institution is in operation (even with a reduced number of staff) on a given day in a given location, this constitutes a local business day for the institution in that location. Therefore, as it is a business day, it requires actual and hypothetical P&L calculation, VaR calculation and market risk monitoring and reporting. Institutions should consistently define their business days, and therefore should be able to justify any non-business days. Unchanged risk positions are a necessary but not sufficient condition to demonstrate adequately that a particular day constitutes a non-business day.

58. The ECB considers that global business days should be defined at the consolidated level (or for a national sub-group, at the sub-consolidated level), and that for the purpose of defining global business days the institution's most important trading location (the "reference location") should be used, to ensure that the most important trading activity is adequately captured in back-testing. Global business days should include at least the local business days of the reference location. If there are two or more important trading locations (of approximately the same size), the institution should choose one reference

location and is allowed to add additional global business days based on the local business days of the other important trading locations. In such a case, the rationale underlying this choice should be documented.

59. For every global business day, actual and hypothetical P&L calculation, VaR calculation and market risk monitoring and reporting are required.[77] However, if such calculations are carried out on non-global business days, these should not be used for the purpose of regulatory back-testing. The actual and hypothetical P&L used for back-testing should always be the P&L between two consecutive global business days, and should be compared with the related one-day VaR forecast for a one-day holding period between those two global business days, and be based on the composition of the portfolio on the first of those global business days.

60. Based on Article 368(1)(e) of the CRR, the ECB understands that institutions should have a documented policy and procedure describing how they calculate the actual and hypothetical P&L. The ECB considers that to be fit for purpose, the policy and procedure should include, at least, the following key information:

    (a) how the actual P&L is calculated and, in particular, the differences between the economic[78] and actual P&L;

    (b) the fees, commissions and net interest income excluded from the actual P&L;

    (c) how the hypothetical P&L is calculated and, in particular, the differences between the actual and hypothetical P&L;

    (d) the valuation adjustments not updated every day and whether or not they are included in the P&L time series.

    In order for the ECB to assess the appropriateness and implementation of the policy and procedure for the calculation of the actual and hypothetical P&L, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to provide, for a sample of transactions or portfolios, detailed decompositions of economic, actual and hypothetical P&L into their elements.

3.4 Calculation of actual P&L

3.4.1 General rules

61. In accordance with Article 366(3) of the CRR, actual P&L must be based on actual changes in the portfolio's end-of-day value. Therefore, the ECB

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[77] All positions of trading units in a location with local non-business days should be included in the calculation of the consolidated figures.

[78] As defined in the Glossary.

understands that the actual P&L should closely correspond to the economic daily P&L as reflected in the books and records of the institution, with the exception of certain elements as specified in the following paragraphs.

62. Actual P&L should include the profit and loss stemming from intraday activities as they change the portfolio's value. In accordance with Article 366(3) of the CRR, fees, commissions and net interest income must be excluded from the actual P&L. The definitions and methods used to apply this exclusion should be clearly documented.

63. In accordance with Article 366(3) of the CRR, fees, commissions, and net interest income must be excluded from the portfolio's actual value when computing the actual P&L. The ECB understands that these exclusions from the portfolio's actual end-of-day value are required by the CRR so that fees, commissions, and interest gains or losses are removed from the daily actual P&L in order to ensure that the back-testing assesses whether P&L fluctuations driven by market risk are accurately captured by the VaR model. Furthermore, the ECB acknowledges that the net interest income definition applied to banking book items accounted for at amortised cost cannot easily be transferred to the fair value items in the regulatory trading book.

The ECB considers that it is acceptable for an institution to define the net interest income in the regulatory trading book as equal to zero; this leads to no P&L component being excluded as net interest income.

The ECB considers that where an institution uses another definition for net interest income it should be able to duly justify this approach, taking into account its trading strategy. In any case, theta effects (for example, options theta) and P&L contributions of unearned credit spreads should not contribute to the net interest income, because they are susceptible to market risk.

64. The actual P&L is calculated for instruments and transactions entailing positions[79] in the regulatory trading book and banking book which are within the scope of the IMA. In accordance with Article 366(3) of the CRR, the actual P&L must be based on the actual value at the end of the subsequent day. Therefore, the ECB considers that the change in value of all market risk parameters (even those that are not modelled in the VaR) should be taken into account in the actual P&L.

65. In order to ensure that the actual P&L corresponds closely to the economic daily P&L as reflected in the books and records of the institution, the ECB considers that the pricing methods, model parametrisations and market data should be the same as those used to compute the daily economic P&L.

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[79] For the purposes of this guide, a "position" is defined as a risk position (as stated in the Glossary). For example, for a bond denominated in FX and where the scope of the IMA approval does not include FX risk, the FX risk position is not in the scope of the VaR model, while the FX risk is reflected in the actual P&L.

3.4.2   Valuation adjustments

66. Because the actual P&L should closely correspond to the economic daily P&L as reflected in the books and records of the institution, all valuation adjustments or reserves made in the economic P&L are also relevant for the calculation of the actual P&L. Therefore institutions should clearly document all such adjustments (methodology, frequencies, calculation process, etc.).

67. Except for the elements referred to in paragraphs 68 to 70 below, fair value adjustments[80] and all other valuation adjustments made in the economic P&L should be included in the actual P&L even if they are not computed on a daily basis – provided that they are in the scope of market risk.

68. The ECB considers that credit valuation adjustments (CVA) should be excluded from the actual P&L,[81] because they receive a specific regulatory treatment. The same applies to debit valuation adjustments (DVA), due to their nature as the reverse side of CVAs.

69. Additional valuation adjustments (AVA)[82] that are calculated to obtain the prudent value of the positions in the regulatory trading book should also be excluded from the actual P&L, as they receive a specific regulatory treatment under Article 34 of the CRR as an additional layer of prudence.

70. Changes in portfolio value generated by the default of a counterparty should be excluded from the actual P&L, provided that the institution demonstrates that they are related solely to counterparty credit risk; this is because the corresponding profits or losses are taken into account in the institution's counterparty credit risk framework. Conversely, profits or losses due to the default of a bond or other fixed income security are not in the scope of counterparty credit risk and should therefore be included in the actual P&L.

71. In accordance with Article 366(3) of the CRR, back-testing must be performed daily on the portfolio's end-of-day value. It could therefore be understood that changes in valuation adjustment figures should be computed daily to obtain an accurate portfolio end-of-day value. However, the ECB is aware that some valuation adjustments are not calculated daily by some institutions. In such cases, the ECB considers that changes in valuation adjustment figures should be taken into account in the actual P&L on the business day which is taken as the reference date for the calculation of the valuation adjustment. As a consequence, institutions should not apply any kind of smoothing or distribution over several dates in relation to changes in valuation adjustment figures.

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[80]   This refers at least, but is not limited to, the examples of potential valuation adjustments listed in Article 105(10) of the CRR.

[81]   This understanding is also supported by Article 40(5)(d) of the Final Draft RTS on assessment methodology for IMA and significant share.

[82]   As set out in Commission Delegated Regulation (EU) 2016/101 of 26 October 2015 supplementing Regulation (EU) No 575/2013 of the European Parliament and of the Council with regard to regulatory technical standards for prudent valuation under Article 105(14) (OJ L 21, 28.1.2016). Those categories may overlap with fair value adjustments (e.g. market price uncertainty, close out costs, etc.).

3.5 Calculation of hypothetical P&L

72. In accordance with Article 366(3) of the CRR, the hypothetical P&L is based on changes in the portfolio's value assuming unchanged positions at the end of the subsequent day. The ECB understands that the term "unchanged positions" refers to an unchanged composition of the portfolio in terms of instruments and transactions. Therefore, the P&L generated by intraday trading and by new transactions entered (or maturing transactions) during the day is not taken into account. The ECB understands that the term "subsequent day" could imply a passage of time of one business day and that this could lead to a change in the risk positions due solely to this passage of time. Therefore, institutions may choose to include the passage of time of one business day in the hypothetical P&L.

    The ECB understands from Article 366(4) of the CRR that back-testing on the hypothetical P&L is intended to focus on detecting deficiencies in the internal model. Therefore back-testing on hypothetical P&L should be used as a statistical test of the integrity of the VaR measure, allowing for a more "pure" testing of the model.[83]

73. In accordance with Article 366(3) of the CRR, the hypothetical P&L is to be based on the portfolio's value, assuming unchanged positions, while the actual P&L is to be based on the *actual* portfolio's value. Therefore, the ECB considers that any adjustments taken into account in order to obtain the actual value of the portfolio should not be considered in the hypothetical P&L, provided that they are not part of the VaR model.[84] Consequently, any other profit and loss element – such as credit valuation adjustments, debt valuation adjustments, additional valuation adjustments and any other valuation adjustments – as well as fees, commissions and net interest income, should not be included in the hypothetical P&L.[85]

74. As both the actual and the hypothetical P&L are based on the portfolio's value, they should be calculated using the same pricing framework. Therefore, the hypothetical P&L should be computed using the same pricing methods, model parametrisations and market data as those used to compute the daily economic P&L. Where an institution computes the hypothetical P&L in a system that is different from the one that is used to produce the daily economic P&L, the risk is that differences in the computations could occur. To minimise this risk, the institution should ensure that differences in market value computations at instrument or transaction level and at the total hypothetical P&L level are negligible, and should monitor the alignment frequently.

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[83] This understanding is also supported by Section 2.3.2 of the report of the Final Draft RTS on assessment methodology for IMA and significant share.

[84] This understanding is also supported by Article 40(5)(d) of the Final Draft RTS on assessment methodology for IMA and significant share.

[85] This understanding is also supported by Article 40(4)(d) of the Final Draft RTS on assessment methodology for IMA and significant share.

75. The back-testing on the hypothetical P&L should be used as a statistical test of the integrity of the VaR measure. Therefore, paragraph 74 applies to partial use models so that only the changes in market value due to changes in pricing risk factors within the risk categories in the scope of the model are considered, and the other pricing risk factors outside the scope of the model are held fixed.[86] For example, (i) if the institution is authorised to use an internal model for general interest rate risk only, the hypothetical P&L should include the changes in value of market parameters pertaining to general interest rate risk only; or (ii) if FX risk is not in the scope of the model, market value changes due to changes in the FX rate should not be reflected in the hypothetical P&L.[87]

    In the case of partial use models, only for those instruments or transactions where the exclusion of the P&L stemming from risk categories not included the scope of the internal model is operationally challenging or its effect on the total P&L is immaterial, an institution may include in the hypothetical P&L those changes in value of market parameters pertaining to all risk categories.[88] Institutions should be able to justify the immateriality or the operational challenge, if applicable. In particular, excluding the effect of FX risk in the hypothetical P&L is not automatically deemed to be operationally challenging.

76. The passage of time effect (theta effect) should be considered (or not) in the VaR and in the hypothetical P&L in a consistent manner. However, if institutions include the passage of time in the P&L and not in the VaR, or vice versa, they should be able to demonstrate that the effect of this inconsistency is not material.[89]

3.6 Counting of overshootings

77. In accordance with Articles 366(2) and 366(3) of the CRR, the back-testing addend is determined as the higher of the number of overshootings under hypothetical and actual changes in the value of the portfolio for the most recent 250 business days.

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[86] The requirement to use the market quote or pricing methods and model parametrisations used for the economic P&L takes precedence over the requirement to change only the risk factors within the risk categories in scope of the model in this case.

[87] For example, let $pv(t; p; g_t, s_t, e_t, f_t, x_t)$ be the market value of a position at time t used in the economic P&L calculation, depending on some parameter set p (not explicitly time dependent), and risk factor sets g_t, s_t, e_t, f_t, x_t for all risk categories at time t. If the specific interest rate risk s and the FX risk x are not in the scope of the model, the risk factor values in those categories do not change from the previous time t0, and the hypothetical P&L at time t should be calculated as

$$\text{HypoP\&L}(t) = pv(t_x; p; g_t, s_{t0}, e_t, f_t, x_{t0}) - pv(t_0; p; g_{t0}, s_{t0}, e_{t0}, f_{t0}, x_{t0}),\text{ where}$$

$t_x = t_0$ if VaR uses an instantaneous shock; or $t_x = t$ if VaR includes theta for consistency.

[88] In this case, if a market price that incorporates all risks is used in the economic P&L, it should also be used in the hypothetical P&L.

[89] This understanding is also supported by Article 43(4) of the Final Draft RTS on assessment methodology for IMA and significant share.

78. In accordance with Article 366(5) of the CRR, institutions must notify the competent authorities promptly, and in any case no later than within five working days, of overshootings that result from their back-testing programme.

79. If either a P&L or the VaR is not available or cannot be computed within five working days, the ECB considers that there is a risk that an overshooting may have occurred, and that in order to ensure that the number of overshootings is not misrepresented, a prudent approach would be to consider such an instance as an overshooting under hypothetical or actual changes, respectively.

80. If an overshooting has occurred due to malfunctions in the calculation of a P&L or the VaR and is notified to the ECB, and the institution demonstrates to the satisfaction of the ECB that the overshooting was caused by an acceptable reason, the institution may withdraw the overshooting notification. The explanation of the malfunction should be supported by clear and complete documentation. If malfunctions leading to erroneous calculations and overshooting notifications are recurrent, this may indicate that the internal model is not implemented with integrity as required in Article 368(1) of the CRR, and the ECB may require the institution to present a remediation plan.

81. The ECB considers that examples of acceptable reasons for withdrawing an overshooting notification could include:

    (a) errors in the calculation of the actual P&L, hypothetical P&L or VaR due to IT issues or incorrect data;

    (b) errors in the scope of positions for the calculations of the P&L or the VaR;

    (c) false or missing bookings, or incorrect positions included in the scope of the calculations;

    (d) delayed reserve releases;

    (e) temporary transmission problems between different business locations.

82. However, the ECB considers that the following reasons for withdrawing an overshooting notification would not be acceptable:

    (a) differences in pricing functions between the VaR engine and the actual and hypothetical P&L calculations (the front-office pricing functions);

    (b) losses due to the trading or transfer of large positions at a price that deviates from the market price due to the trading volumes;

    (c) the overshooting corresponds to a small difference between VaR and a P&L;

    (d) unexpected market movements;

(e)   a model deficiency that has caused an overshooting in the past has already been addressed (there is no backward adjustment of overshootings).

83.   In accordance with Article 368(1)(a) of the CRR, the internal model must be closely integrated into the daily risk management process. In order for institutions to be able to meet this requirement, the ECB considers that the VaR numbers should be available within three business days. In addition, this would enable institutions to fulfil the requirement to notify back-testing overshootings within five business days.

If delays in the VaR computation are recurrent, this may indicate that the internal model is not implemented with integrity as required by Article 368(1) of the CRR, and the ECB may require the institution to justify such delays or to present a remediation plan.

3.7   Analysis of overshootings

84.   In accordance with Article 368(1)(b) of the CRR, the risk control unit must produce and analyse daily reports on the output of any internal model, including overshootings. The ECB considers that such an analysis of overshootings should include at least the following areas, as they are the most relevant drivers of the VaR number:

(a)   identification of the set of positions responsible for the overshooting (portfolio analysis);

(b)   identification, description and analysis of the market moves contributing to the overshooting (market analysis);

(c)   identification of possible weaknesses in the internal model in the light of (a) and (b) above (analysis of the internal model).

Paragraphs 85 to 88 explain what the ECB considers are best practices in order to analyse each of the three areas referred to in (a), (b) and (c) above.

The ECB considers it best practice that for every regulatory back-testing overshooting a detailed analysis should be performed by the institution and provided to the competent authority within one month.[90]

In accordance with Article 368(1)(f) of the CRR, any internal model for market risk must have a proven track record of reasonable accuracy in measuring risks. In order to assess the track record of reasonably accuracy in measuring risk, the ECB can, on the basis of Article 10 of the SSM Regulation, request a detailed analysis (in accordance with its specific instructions) of overshootings and reporting of time series related to back-testing.

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90   This understanding is also supported by Article 40(10) of the Final Draft RTS on assessment methodology for IMA and significant share.

3.7.1 Portfolio analysis

85. The analysis of the back-testing overshooting should include a detailed description of the trading portfolio for which the one-day VaR forecast calculated was exceeded by the one-day change in the portfolio's value. If the overshooting was notified for the actual P&L, the intraday changes in the portfolio that affected the actual change should also be analysed.

86. The analysis of back-testing overshooting should be performed not only at the overall portfolio level, but also at lower portfolio levels, to identify the main positions that caused the overshooting. If specific sub-portfolios can be identified, they should be mentioned and analysed.

3.7.2 Market analysis

87. The analysis of the market should describe the market moves contributing to the cause of the overshooting and explain them on the basis of observable market data (for example, asset prices, indices, interest rates, FX rates, implied correlations and volatilities). To assess the significance of the market data movements, the market data, including those that are risk factors in the VaR, should be analysed in a historical context. The significance of the change in market data that are risk factors in the VaR, and which contributed to the P&L, should be tested against the historical 99% confidence interval of risk factor changes. Changes in the structure of correlations between the risk factors should also be analysed. In addition, the analysis should, as far as possible, include the economic reasons for the market movements.

3.7.3 Analysis of the internal model

88. The suitability of the internal model should be assessed on the basis of the two previous analyses. Where positions contributing to the back-testing overshooting can be identified, the appropriateness of the model for these particular positions should be assessed. To do this, the part of the P&L that can be explained by the model (i.e. risk factors and pricing functions) should be distinguished from the part which cannot. In addition, the reliability of the VaR calculation and of the actual and hypothetical changes in the portfolio should be evaluated. The analysis of the internal model should focus on:

    (a) the appropriateness of risk factors used;

    (b) the modelling of risk factors;

    (c) the suitability of the processes for calculating VaR, hypothetical P&L and actual P&L.

4 Aspects of internal validation of market risk models

4.1 Regulatory references

	Date of issue	Article	Paragraph/Point
Legal Background			
CRR	26/06/2013	368	(1), (2)
		369	
Other references			
Final Draft RTS on assessment methodology for IMA and significant share	22/11/2016	23	(2)

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IMA and significant share will become an additional relevant regulatory reference. Currently that document only exists in a final draft version.

4.2 Frequency of internal validation

89. Institutions are required under Article 369(1) of the CRR to conduct a validation of their internal models on a periodic basis. The ECB considers that an appropriate frequency is at least annually, as one year is a reasonable time in which significant changes in the market or in the composition of the portfolio could occur. In addition, a validation conducted at least annually would allow the institution to use the results in the review of its overall risk management process, as referred to in Article 368(2) of the CRR.

4.3 Internal back-testing of VaR models

4.3.1 Granularity of internal back-testing

90. In accordance with Article 369(1)(b) of the CRR, institutions must, in addition to the regulatory back-testing programmes, carry out their own internal model validation tests – including back-testing – in relation to the risks and the structure of their portfolios. The ECB considers that to satisfy the requirement regarding internal back-testing in relation to the risks and the structure of the portfolios, institutions should perform separate back-testing at more granular levels than the top-of-the-house level[91] on at least the hypothetical P&L (i.e. counting and analysing of overshootings under the hypothetical P&L).

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[91] See the Glossary.

(a) The ECB understands that, at a minimum, internal back-testing should be performed:

   (i) at one level below the top-of-the-house level;

   (ii) for each portfolio that is subject to a separate VaR limit established by the institution's management body.

(b) Where an institution intends to apply the revisions to the IMA as set out in the fundamental review of the trading book (FRTB) in the future, the ECB considers that it would be beneficial if the institution applied analogously the criteria established in Appendix A of the FRTB to its current portfolio structure in the regulatory trading book, identified the sub-portfolios within the current scope of the internal model that would most likely satisfy the requirements for becoming FRTB trading desks, and performed separate internal back-testing on them.

This is without prejudice to the requirement for the internal model validation function to perform back-testing on both actual and hypothetical P&L under Article 369(2) of the CRR, which the ECB understands as relating to the top-of-the-house level.

The ECB considers it best practice that the internal back-testing defined above in this paragraph is performed on a daily basis in order align it with the regulatory back-testing programme.[92]

91. The ECB understands that Article 369(2) of the CRR requires that the back-testing performed in internal validation complies with the same requirements as the regulatory back-testing regarding the calculation of actual and hypothetical P&L. Therefore, the requirements described in section 3 regarding the calculation of actual and hypothetical P&L should also be applied to internal back-testing, in order to ensure consistency. In verifying compliance with this provision of the CRR, the ECB will take into account the specific circumstances of the institution.

4.3.2 Tests to be performed in internal back-testing

92. In accordance with Article 369(1)(b) of the CRR, institutions must carry out their own internal model validation tests, including back-testing. The ECB considers it best practice that the periodic internal validation tests include the following (or their equivalent) for at least the top-of-the-house level:

(a) statistical tests on the overshootings, such as the Kupiec (1995)[93] and Christoffersen (1998)[94] tests , including an analysis of the validity of the hypotheses underlying those statistical tests;

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[92] This understanding is also supported by Article 23(2)(b) of the Final Draft RTS on assessment methodology for IMA and significant share.

(b)   a test on the uniformity of the distribution of the p-values[95] of the daily actual P&L and the hypothetical P&L in the daily forecasts of P&Ls of the VaR[96] engine, at least for the daily data of the last year. For example, a P&L value equal to the VaR at confidence level of 99% corresponds to a p-value of 0.01.

93.   In order to assess whether the periodic internal validation tests used by an institution are adequate and fit for their purpose, the ECB can, on the basis of Article 10 of the SSM Regulation, require the institution to provide the following information:

(a)   for the top-of-the-house level, the complete economic P&L, hypothetical P&L, actual P&L, and VaR time series of at least one year, but preferably three years;

(b)   for the top-of-the-house level, the number of overshootings and the corresponding dates when they occurred over at least the last year, but preferably over the last three years;

(c)   for the top-of-the-house level, for the overshootings (i.e. $-P\&L_{t+1} > VaR_t$ where $VaR_t > 0$ by convention), the time series of at least one year, but preferably three years, of the loss overshooting ratio (LOR) defined as:

$$LOR = \frac{-P\&L_{t+1} - VaR_t}{VaR_t}, \text{ where } -P\&L_{t+1} > VaR_t;$$

(d)   for the top-of-the-house level, the time series of p-values of the daily actual P&L and the hypothetical P&L in the daily forecasts of P&Ls of the VaR engine of at least one year, but preferably three years;

(e)   for the more granular levels referred to in paragraph 90:

(i)   complete economic P&L, hypothetical P&L and VaR time series of at least one year, but preferably three years;

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93   See Kupiec, P.H., "Techniques for verifying the accuracy of risk measurement models", *Journal of Derivatives*, Vol. 3, Issue 2, 1995, pp. 73–84.

94   See Christoffersen, P., "Evaluating interval forecasts", *International Economic Review*, Vol. 39, Issue 4, 1998, pp. 841-862.

95   The probability integral transformation states that for a continuous random distribution X, applying the cumulative distribution function (CDF) of X, F_X, on X yields a uniform distribution. By negation, if the resulting distribution is not uniform, F is not the CDF of X.
Given a vector of simulated P&L (used to estimate the VaR) sorted in ascending order, $x_1, \ldots, x_n$, the p-value, $p(x)$, corresponding to a given P&L, x, should be obtained in the following way:

$$p(x) = \begin{cases} \frac{x_{k+1}-x}{x_{k+1}-x_k} \cdot p_k + \frac{x-x_k}{x_{k+1}-x_k} \cdot p_{k+1} & if \ x_k \leq x \leq x_{k+1} \ for \ k = 1, \ldots n-1 \\ \frac{\left(\frac{p_1}{1-p_1}\right)^{\frac{x}{x_1}}}{1+\left(\frac{p_1}{1-p_1}\right)^{\frac{x}{x_1}}} & if \ x < x_1 \\ \frac{\left(\frac{p_n}{1-p_n}\right)^{\frac{x}{x_n}}}{1+\left(\frac{p_n}{1-p_n}\right)^{\frac{x}{x_n}}} & if \ x > x_n \end{cases} \quad \text{where } p_k = \frac{k}{n+1}.$$

96   If an institution has a model based on a mixture of approaches in several VaR model components, the most material approach should be used.

(ii) an analysis of all overshootings, including an explanation of the cause of the overshooting over the hypothetical P&L and an assessment of the model adequacy on the relevant level.

4.4 Validation on hypothetical portfolios

94. In accordance with Article 369(1) of the CRR, institutions must have processes in place to ensure that all their internal models for market risk have been adequately validated. Therefore, the requirement of Article 369(1)(c) to use hypothetical portfolios in the internal model validation refers in particular to VaR, sVaR, and IRC models.

95. In accordance with Article 368(1)(e) of the CRR, institutions must have a documented set of internal policies and controls in place concerning the overall operation of their internal models, including the internal validation. Therefore, institutions should have a policy in place that governs the overall processes related to the validation of their internal models for market risk using hypothetical portfolios. The ECB considers that in order to cover the overall process, such a policy should comprise the following aspects:

(a) portfolio definition – the processes for defining hypothetical portfolios;

(b) analysis – the processes for analysing the performance of the model based on the results of the tests performed on hypothetical portfolios, including:

(i) an assessment of the ability of the models to capture the risk of the hypothetical portfolios;

(ii) verification that the insights gained by the analysis of hypothetical portfolios are reflected in the models;

(iii) in particular, for back-testing on hypothetical portfolios, an identification of the market movements and parameters causing overshootings;

(c) reporting – the processes to ensure that the results of validation on hypothetical portfolios are reported to a management body with sufficient authority in respect of internal models.

96. In accordance with Article 369(1)(c) of the CRR, institutions must conduct validation exercises using hypothetical portfolios in order to ensure that a model is able to account for particular structural features.[97] The ECB understands that these hypothetical portfolios should have targeted compositions so that the

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[97] These hypothetical portfolios should not be limited to portfolios defined in the benchmarking exercises for market risk conducted by the EBA or the Basel Committee on Banking Supervision, as those portfolios cannot account for all relevant particular structural features. Participation in such benchmarking exercises is thus not sufficient to meet the requirements of this section of the guide.

model can be tested at a level of granularity that enables the identification and isolation of specific model performance for those structural features (for example, related to specific business lines, instrument features, and/or trading strategies).

97. As they should ensure that the risk model is validated for the institution's risk management purposes, such hypothetical portfolios should be designed in line with the business model of the institution. For example, it is not necessary to include products that are not covered by trader mandates, nor to test specific features that are not relevant for potential positions according to the institution's approved trading strategy. Consequently, an institution should review the hypothetical portfolios in the event of a change in its business model or trading strategy.

98. For the same reason, the number of hypothetical portfolios should be commensurate with the nature, scale and complexity of the activities of the institution.

4.5 Validation based on hypothetical portfolios for VaR models by internal back-testing

99. The ECB considers that the validation requirements of Article 369(1)(c) of the CRR for VaR models can be fulfilled by internal back-testing where an institution can demonstrate that it has set up internal back-testing for the VaR model using sub-portfolios at a level which is sufficiently granular to account for the particular structural features that may arise in its portfolios.

100. Where an institution performs internal back-testing on hypothetical portfolios for the VaR model, the P&L calculations for this back-testing of hypothetical portfolios should not differ from the P&L calculations for regulatory VaR back-testing as described in section 3, in order to ensure consistency. This back-testing can be conducted based on the hypothetical P&L only, as hypothetical portfolios are not part of the daily trading activity and therefore the actual P&L is not relevant.

101. As the purpose of such internal back-testing is the internal validation of the VaR model, the ECB considers that in order to ensure consistency:

(a) the comparison should be carried out using the daily hypothetical P&L and the one-day VaR;

(b) back-testing periods for hypothetical portfolios should cover at least the period used to calibrate the VaR as of the validation date, to ensure that the results are relevant for the model at that date;

(c) institutions should ensure that the particular structural feature, as referred to in paragraph 96, for which each hypothetical portfolio was selected,

continues to be in place over time and during the entire historical period for which the back-testing is performed.

5 Methodology for VaR and stressed VaR

5.1 Regulatory references

	Date of issue	Article	Paragraph/Point
Legal Background			
CRR	26/06/2013	365	
		366	(2)
		367, 368, 369, 370	
Other references			
EBA Guidelines on sVaR[98]	16/05/2012		6,10
Final Draft RTS on assessment methodology for IMA and significant share	22/11/2016	38	(1), (2)
		49	(2)

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IMA and significant share will become an additional relevant regulatory reference. Currently that document only exists in a final draft version.

5.2 General requirements

102. In accordance with Article 369(1) of the CRR, the appropriateness of any assumptions made within the internal model must be demonstrated. Therefore, institutions should demonstrate the appropriateness of any assumptions about the distribution of risk factors included in the VaR and sVaR models on the basis of observable data.[99] In order to assess the appropriateness of the distribution assumptions, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to consider different plausible distribution assumptions and compare the VaR and sVaR amounts calculated according to those different assumptions to demonstrate that the selected assumption is appropriate.

103. In accordance with Article 368(1)(f) of the CRR, an internal model must be reasonably accurate in measuring risks. Therefore when using Monte Carlo simulations, institutions should be able to demonstrate that the number of simulations used to compute the VaR and sVaR is sufficient to produce accurate and stable VaR and sVaR numbers.

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[98] EBA Guidelines on Stressed Value At Risk (Stressed VAR) (EBA/GL/2012/2), referred to in this guide as the "EBA Guidelines on sVaR".

[99] Where an institution applies historical returns in its model, the requirement refers to the choice of the specific methodology to determine the returns (for example, the use of relative or absolute returns).

104. An institution may apply different methodologies (i.e. the absolute, relative or mixed approach[100]) to calculate returns used to calibrate the VaR and sVaR models for different risk factors. The ECB has observed that the best practices used in the VaR and sVaR models are the following methodologies:

Risk factor category	Methodology used to calculate returns
Interest rate curves	Absolute or mixed approach
Bond spread	Absolute or mixed approach
CDS spread	Absolute or mixed approach
Foreign exchange rate	Relative approach
Equities spot	Relative approach
Commodities	Relative approach

As institutions are required under Article 368(3) of the CRR to apply best practices, they should be able to explain deviations from these methodologies and quantify the impact of those deviations.

Article 365(2) of the CRR requires that the calculation of the sVaR is made in accordance with the requirements for calculation of the VaR. Therefore, for a given risk factor, where a specific methodology is used in the VaR, the same methodology is expected to be used for the same risk factor in the sVaR.

As regime changes could occur between the VaR effective historical observation period and the sVaR historical period, the method should be suitable for both periods. In accordance with Article 369(1) of the CRR, the appropriateness of any assumptions made within the internal model must be demonstrated. The ECB considers that this choice of method is one of the assumptions whose appropriateness should be demonstrated.

105. In accordance with Article 368(1) of the CRR, the internal model must be conceptually sound and implemented with integrity. Therefore, it is expected that the returns are calculated on the basis of one single holding period (for example, one day or ten days) for all risk factors.[101]

106. Under paragraph 10.3(c) of the EBA Guidelines on sVaR, institutions should be able to prove that on the day of the week chosen for the sVaR calculation their portfolio is representative of the portfolio held during that week, and that the chosen portfolio does not lead to a systematic underestimation of the sVaR numbers when computed weekly; shown, for example, by using sensitivities or by proving that the VaR is not systematically lower on the day of the week chosen for sVaR.

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[100] Either of the two examples following could be considered as a "mixed approach": (i) the case where some risk factors within a given risk factor category are calculated via absolute returns while others within the same risk factor category are calculated via relative returns (e.g. interest rate curves with low interest rate levels calculated via absolute returns and interest rate curves of other currencies with higher levels via relative returns); or (ii) the case where a single methodology takes into account different regimes (e.g. return close to absolute for low levels of interest rates and close to relative for higher levels).

[101] Uniform use of a one-day holding period in VaR and a ten-day holding period in sVaR might be permissible if adequately justified by an institution.

107. In order to assess that the day of the week when the sVaR amounts are calculated does not lead to material bias, the ECB can, on the basis of Article 10 of the SSM Regulation, require an institution to recalculate the sVaR for 15 consecutive business days (including three reporting days). If it is not possible to perform this calculation in the production environment, it can be performed in a test environment that replicates the calculation of the regulatory sVaR.

108. In accordance with Article 368(1)(e) of the CRR, institutions must ensure compliance with a documented set of internal controls. In order for the ECB to assess compliance with this requirement, an institution should be able to provide an inventory of all open validation findings in relation to the VaR and sVaR models including, for each finding, a description thereof, the envisaged remedial action and the target date for closure of the finding. In addition, institutions should retain closed validation findings for at least one year after the closure date and should be able to provide a description of the remedial action implemented.

5.3 Data inputs, length of the time series used to calibrate VaR and sVaR, and quantile estimation

109. In accordance with Article 365(1)(d) of the CRR, institutions must use an effective historical observation period of at least one year for the calculation of the VaR, except where a shorter observation period is justified by a significant upsurge in price volatility. The ECB considers that this requirement can be fulfilled by taking returns referring to 250 consecutive business days[102] in order to allow alignment with the time frame referred to in Article 366(2) of the CRR. The ECB understands that an effective historical observation period of at least one year means that the average time lag[103] of the scheme used by an institution is at least the average time lag for an equally weighted observation period of one year (i.e. 125.5 days for 250 business days).[104]

110. Where the institution uses a shorter effective historical observation period (for example, by applying a weighting scheme) due to a significant upsurge in price

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[102] The observation period corresponds to the time frame between the first day of calculation of returns and the last day of calculation of returns. Where an institution uses 10-day returns, the minimum observation period is 250 business days but the time frame between the first day of calculation of the first 10-day return and the end date of the last 10-day return is 260 days.

[103] A weighting scheme is considered to be the set of weights directly or implicitly applied to observations of a risk factor, $\{w_t\}_{t=1,2,\ldots}$, where typically for giving more weight to more recent observations $w_t \geq w_{t+1} \forall t$, and t is the lag in number of business days between the (s)VaR computation date and the historical observation date. The average time lag using the most recent n observations is defined as

$$average\ time\ lag(n,w) = \frac{\sum_{t=1}^{n} t \cdot w_t}{\sum_{t=1}^{n} w_t}$$

This definition can be extended to equally weighted schemes by setting $w_i = 1$ for all dates. For an equally weighted scheme on 250 continuous business days, the formula results in 125.5 days.

The ECB may, after analysing the particular circumstances of an institution, also consider other methods of processing market data or risk factors to be a weighting scheme, and assess whether such methods provide an effective historical observation period of at least one year in accordance with Article 365(1)(d) of the CRR.

[104] This understanding is also supported by Article 38(1) of the Final Draft RTS on assessment methodology for IMA and significant share.

volatility, the ECB considers that this should not lead to a lower VaR risk number. Therefore, the institution should use the higher of the following:

(a)   the VaR amount calculated with an equally weighted historical observation period of at least one year;

(b)   the VaR amount calculated with the shorter effective historical observation period.[105]

In accordance with Article 365(1)(e) of the CRR, this comparison should be performed at least monthly, and the institution should continue to apply the resulting calibration method until the next comparison.

111.   For the purpose of the regulatory back-testing conducted under Article 366 of the CRR, the higher of the two metrics mentioned in paragraph 110 should be used for consistency with the own funds requirement calculation.

If the institution always uses a VaR calculated with the shorter effective observation period as mentioned in paragraph 110 for its risk management, the institution is allowed to perform internal back-testing of the VaR under Article 369(1)(b) of the CRR using this shorter effective observation period, in order to ensure that the model is closely integrated into the daily risk management process.

112.   In accordance with Article 365(2) of the CRR, the institution must calculate the sVaR calibrated to historical data from a continuous 12-month period of significant financial stress relevant to the institution's portfolio. The ECB considers that this requirement can be fulfilled by taking returns referring to 250 consecutive business days in order to allow alignment with the time frame referred to in Article 366(2) of the CRR.

Under paragraph 6.8 of the EBA Guidelines on sVaR, no weighting of historical data should be applied when determining the relevant historical period or when calibrating the sVaR model.[106] The ECB considers that a calibration to historical data from a continuous 12-month period implies that no weighting scheme should be applied to the historical data used to calibrate the sVaR.[107]

113.   In order to ensure that the approach for measuring empirical correlations is sound and implemented with integrity as required by Article 367(3) of the CRR, the institution should use one single observation period (i.e. with the same start date and end date, and consequently the same length of observation period) for all risk factors modelled in the VaR. This also applies to the sVaR.

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[105]   This understanding is also supported by Articles 38(1) and 38(2) of the Final Draft RTS on assessment methodology for IMA and significant share.

[106]   Under paragraph 10.10 of the EBA Guidelines on sVaR, this does not contradict the requirement that the sVaR methodology should be based on the current VaR methodology.

[107]   This understanding is also supported by Article 49(2)(h) of the Final Draft RTS on assessment methodology for IMA and significant share.

114. Consequently, if a new instrument (e.g. a single stock or credit index series) is issued, the time series corresponding to this instrument should not be used on its own for the calibration of the VaR and sVaR models until the length of the available time series reaches the length of the observation period used by the institution. In this case, because, at the least, the missing portion needs to be completed, a risk factor calibrated to this time series is considered to be proxied and the requirements for proxies should be observed (see section 5.5).

115. In accordance with Article 365 of the CRR, the VaR and sVaR are calculated as the 99th percentile, one-tailed confidence interval, and In accordance with Article 367(1)(a) of the CRR, the model must accurately capture all material price risks. In accordance with Article 368(1)(f) of the CRR, any internal model must have a proven track record of reasonable accuracy in measuring risks. Therefore, the ECB considers that for institutions using a simulation approach (either historical or Monte Carlo) in their VaR (or sVaR) model, the percentile estimation method used to obtain the 99th percentile should be based on reasonable statistical properties that ensure its accuracy – that is, it should be statistically unbiased, distribution-free, and assume that the probability of experiencing a P&L lower (or higher) than the lowest (or highest) simulated value is strictly greater than zero. For these reasons the ECB considers that the method proposed by Harrell and Davis[108, 109] is an adequate method to ensure that price risks are accurately captured when using the percentile estimation method.

The ECB considers that the following simplified method[110] is also adequate, and that although it could be argued that it is typically not unbiased, it generally implies a degree of conservatism. Consider the vector of simulated P&L of length n for the VaR (or sVaR) percentile estimation $(P\&L_1$ to $P\&L_n)$ in ascending order.[111] The result $Q(0.99)$ is obtained as the weighted average of the two subsequent P&L values $-P\&L_{Int(m)}$ and $-P\&L_{Int(m)+1}$, computed as

$$Q(0.99) = \big(m - Int(m)\big) \cdot (-P\&L_{Int(m)+1}) + (Int(m) - m + 1) \cdot (-P\&L_{Int(m)}) \, ,$$

with $m = \frac{n+1}{100}$.

For example:

for *n=250*, the percentile result of this method is
0.51 × (-P&L L3) + 0.49 × (-P&L2);

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[108] See Harrell, F.E. and Davis, C.E., "A new distribution-free quantile estimator", *Biometrika* Vol. 69, 1982, pp. 635-640.

[109] Corresponding to estimator 9 in Dielman,T., Lowry C. and Pfaffenberger, R., "A comparison of quantile estimators", *Communications in Statistics. Simulation and Computation,* Vol. 23(2), 1994, pp. 355-371.

[110] Corresponding to definition 6 in Hyndman, R.J. and Fan, Y., "Sample quantiles in statistical packages", *American Statistician*, Vol. 50, 1996, pp. 361-365.

[111] P&L_1 is the lowest P&L (i.e. the highest loss).

for $n=260$, the percentile result of this method is
$0.61 \times (-P\&L3) + 0.39 \times (-P\&L2)$.

5.4 Data quality

116. In accordance with Article 367(2)(e) of the CRR, an internal model must meet minimum data standards. This applies in particular to risk factor time series, which are fundamental inputs to a VaR model. For each risk factor time series used to calibrate the shocks of the VaR model, the institution should have a process in place to regularly check the quality of the time series. The ECB considers that an appropriate minimum frequency of such checks is quarterly, as this allows alignment with the regulatory reporting cycle. This is without prejudice to the discretion of institutions to perform certain checks on a more frequent basis if needed to meet minimum data standards. Where an institution uses different data sources for its VaR model and the daily economic P&L calculation reflected in the inventory referred to in paragraph 129, the ECB may request that the institution explain the differences between the two sets of data sources, in order to verify that they meet minimum data standards.

117. The ECB understands that the minimum data standards should ensure that the true volatility of a position or portfolio is captured. Therefore, the quality checks on the risk factor time series should, at the minimum, identify for each time series:

    (a) the number of days for which data points were initially missing and then filled using a particular methodology (e.g. interpolation and extrapolation);[112]

    (b) the number of days for which data points were initially available and were replaced using a particular methodology (e.g. interpolation and extrapolation);

    (c) the number of days with no daily changes;

    (d) the maximum number of consecutive days with no daily change.

118. Material or large numbers of changes in the time series may affect the ability to capture the true volatility of a position or portfolio. In order to monitor and ensure that the operation of the internal model is not adversely affected, institutions should maintain up-to-date documentation[113] describing any changes in the risk factor time series, including in particular any methodology for the replacement of missing data, and the list of tasks that may be performed during manual adjustments. This documentation should contain the following:

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[112] There should be no missing data points for the final time series of shocks used to calibrate the model.

[113] In accordance with Article 368(1)(e) of the CRR.

(a) a description of the methodology followed to introduce the adjustment – the description should be sufficiently detailed so that any staff member of the unit in charge is able to produce the same outcome;

(b) a description of the processes in place to ensure the appropriate implementation of a manual process in accordance with the documentation.

119. In accordance with Article 367(2)(e) of the CRR, the institution's internal model must conservatively assess the risk arising from less liquid positions and positions with limited price transparency and must meet minimum data standards. Therefore, the ECB considers that institutions should have in place documentation which defines the minimum data quality standards that risk factor time series should meet, and be able to provide justification for the use of time series that include an elevated number of consecutive business days with missing data or no daily changes. Moreover, the ECB considers that when using time series with only a low number of available data points per year institutions should provide justification that the number of data points is sufficient to reflect the true volatility of a position or portfolio.

120. In order to ensure that changes in the risk factor time series do not affect the ability to capture the true volatility of a position or portfolio, institutions should analyse how the replacement of missing data affects the volatilities and correlations of the IMA. This applies particularly where time series are used that have:

(a) the value of the same data of the previous day in the case of automatic and systematic replacement of missing data points;

(b) an elevated number of consecutive business days with missing data or no daily changes;

(c) only a low number of data points per year before any data cleaning or treatment.

Filtering of data or exclusions of outliers should not be performed unless the institution can demonstrate that the excluded data points correspond to erroneous or stale data and do not represent the real market volatility of the risk factors. As part of the requirement under Article 368(1)(e) of the CRR to have procedures for ensuring compliance with controls concerning the overall operation of internal models, the ECB considers that institutions should keep track of any exclusion made in the risk factor time series used to calculate VaR and sVaR.

121. Conversely, automatic and systematic filtering of data leading to exclusions of high or low returns should not be performed without further analysis and documentation.

5.5　Proxies, beta approximation and regressions

122. For the purposes of this guide, the ECB understands that market data are proxied in the calculation of the VaR or sVaR[114] when market data that are used as inputs in the pricing model to compute the economic P&L for an IMA position are replaced with other market data[115] (or a weighted average of market data) for the purpose of calibrating the VaR or sVaR (respectively) for that position.

    Where for the economic P&L a certain market data input (for example, the directly observable price of an instrument) is used, while the VaR model uses other market data that would lead to an equivalent price, the ECB considers that these data should not be considered as proxies.[116] Conversely, if the data would not lead to an equivalent price, they should be considered as proxies.

    In accordance with Article 367(1)(b) of the CRR, where a risk factor is incorporated into the institution's pricing model but not into the risk measurement model, the institution must be able to justify such an omission to the satisfaction of the competent authority. Therefore, the ECB considers that in the event of reduced granularity of market data inputs for curves or surfaces in the VaR or sVaR model, as compared with the economic P&L, an institution should duly justify why the data points interpolated owing to the reduced granularity should not be considered as proxies.

123. In accordance with Article 370(e) of the CRR, an internal model used for specific risk must capture name-related basis risk, and in particular be sensitive to material idiosyncratic differences between similar, but not identical, positions. The ECB therefore considers that the use of each single stock price (where available) as a risk factor in the VaR or sVaR is the best practice for modelling specific risk for equity instruments. Similarly, the direct use of idiosyncratic market data (where available) (for example, the idiosyncratic bond spread or each single-name credit default swap) as a risk factor is considered to be the best practice for modelling specific risk for debt instruments.

    However, the use of beta approximations or regressions could be accepted if they are documented and regularly validated (i.e. they are shown to lead to good model performance) as required by Articles 368(1)(e) and 369 of the CRR. Institutions with internal model approval for specific risk should be able to

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[114] For the purpose of partial use models this proxy definition should be applied only to market data inputs that fall into the approved risk categories of the model. Market data inputs giving rise to risks that are out of the scope of the approved risk categories should not automatically be counted as proxied. For example, an equity price that is modelled by a regression to an index for a general equity risk model (no approval for specific equity risk) should not be counted as proxied.

[115] If market data used for pricing and VaR calculation only differ in the source (for example, P&L pricing uses one source and VaR calculations are based on another source), the data used for risk calculation should not be considered as a proxy. In any case, the quality of the data should be checked and the sources justified by the institution.

[116] Examples that could lead to equivalent prices are: (i) where the economic P&L is computed by market instrument (yield) rates, while the VaR/sVaR is computed based on zero coupon rates; and (ii) where a price-based economic P&L is used (for example, listed options, or the direct bond price), while the VaR uses a model-based P&L.

demonstrate that the idiosyncratic volatility of equity or debt instruments with specific risk is correctly taken into account in the VaR and sVaR models.

124. The ECB considers that in order to demonstrate that the model captures accurately all material price risks as required by Article 367(1)(a) of the CRR, the institution should document and make available upon request an inventory of time series of risk factors that are proxied for the calibration of the VaR and sVaR models, together with the materiality of the corresponding risk factors.

125. The ECB considers that the requirement to have a documented set of internal policies and controls also applies to the use of proxies, as they are part of the overall operation of internal models. Therefore, institutions should have a policy in place that defines a clear process for deriving and validating each proxy for VaR and sVaR. The policy should further define a set of controls (for example, statistical analysis or comparison against alternative proxies) that should be performed to ensure the appropriateness of proxies.

126. As a control to ensure that the proxies are appropriately conservative and are reflective of the true volatility where sufficient market data are available, institutions should perform analyses to show that the proxy market data (i) are highly correlated with the market data used for economic P&L, and (ii) show a similar level of volatility for VaR and sVaR. Where analyses based on market data used for economic P&L are not feasible, institutions should at least assess alternative plausible proxy choices.

In particular, institutions which have approved internal models for specific risk of debt instruments or specific risk of equity instruments should demonstrate that the use of a proxy enables the idiosyncratic risk to be appropriately captured as required by Article 370(e) of the CRR.

127. As proxies are part of the internal models, any proxy should also be validated for VaR and sVaR at least annually in accordance with section 4.2 on the frequency of regular internal validation.

128. In order to assess that proxies are appropriately conservative and reflective of the true volatility, the ECB can, on the basis of Article 10 of the SSM Regulation, require an institution to provide, for a selection of sub-portfolios, business days, and material proxies:

(a) the hypothetical P&L used for regulatory back-testing;

(b) the hypothetical P&L calculated on the same unchanged positions but replacing, for the positions for which proxies are used in the VaR, the market data with the market data of their proxies;

(c) the hypothetical P&L calculated on the same unchanged positions but replacing, for the positions for which proxies are used in the sVaR, the market data with the market data of their proxies.

The specific information required will depend on the results of the institution's analysis of the appropriateness of the proxies.

5.6 Risk factors in the model

129. In accordance with Article 367(1)(b) of the CRR, the VaR and sVaR models must capture a sufficient number of risk factors, depending on the level of activity of the institution in the respective markets. Where a risk factor is incorporated into the institution's pricing model (referred to as "market data input" for the purposes of this guide) but not into the risk measurement model, the institution must be able to justify such an omission to the satisfaction of the competent authority.

   So that it can assess compliance with this requirement, the ECB considers that an institution should be able to provide an inventory of all the market data inputs to the economic P&L and of all the risk factors used in the VaR and sVaR models. This inventory should include a comprehensive mapping between the market data used to calculate the economic P&L and the corresponding risk factors included in the VaR and sVaR model. The inventory should contain at least the following information:

   (a) a list of the market data inputs used in the calculation of the institution's economic P&L;[117]

   (b) for each market data input, information confirming:

       (i) whether the market data input is directly modelled in the VaR engine (i.e. whether it is a risk factor of the model and involves no use of a proxy);

       (ii) whether the market data input is proxied in the VaR calculation;

       (iii) whether the market data input is modelled (or not) in the VaR engine;

       (iv) where relevant, how the market data input is proxied in the VaR calculation (for example, by one market data input or by a combination of several market data inputs in a regression approach).

   A similar inventory should be provided for the sVaR model where relevant.

130. Identical underlyings should always be mapped to the same risk factor in order to ensure consistency within the model.

131. In order to assess whether VaR and sVaR models capture a sufficient number of risk factors and to assess the materiality of missing risk factors, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to provide, for a selection of sub-portfolios, business days, and missing risk factors:

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[117] For example, inputs in institutions' pricing models for economic P&L.

(a)   the hypothetical P&L used for regulatory back-testing as defined in section 3.5;

(b)   the P&L calculated assuming simultaneously:

(i)   unchanged positions and omitting the changes in value of the missing risk factors of the VaR and sVaR;

(ii)   use of the pricing method and model parametrisation used to compute the economic P&L.[118]

5.7   Pricing functions and methods in the model

132. In accordance with Article 367(1)(a) of the CRR, models must capture accurately all material price risks. In addition, in accordance with Article 368(1)(e) and (f) of the CRR, institutions must have a set of documented procedures and controls concerning the overall operations of their internal models, and those models must have a proven track record of reasonable accuracy in measuring risks. Therefore, institutions should be able to produce and update, on a regular basis, an inventory of all the VaR and sVaR pricing functions and methods, and the pricing functions and methods used in the economic P&L. This inventory should include a comprehensive mapping between the pricing functions and methods used in VaR and sVaR and the pricing functions and methods used for the daily economic P&L. It should include the following information at the relevant level of granularity:

(a)   the pricing functions and methods, and pricing functions and methods parametrisation (for example, the number of Monte Carlo simulations) used to calculate the daily economic P&L;

(b)   the scope of instrument types covered by each pricing function and method used to calculate the daily economic P&L;

(c)   the number of individual positions, as well as the total amount of outstanding notional and market value covered by each pricing function and method used to calculate the daily economic P&L;

(d)   corresponding pricing functions and methods as well as the pricing functions and methods parametrisation (for example, the number of Monte Carlo simulations) used in the VaR engine;

(e)   a self-assessment by the institution, including a scorecard indicator (green, amber, red)[119] of the appropriateness of VaR pricing methods (VaR engine pricing versus daily economic P&L pricing).

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[118]   This should be identical to the pricing function used to calculate the hypothetical P&L under paragraph 74.

[119]   The scorecard indicators are: green – fully appropriate; amber – acceptable; red – weakness detected.

The criteria for assessing this scorecard indicator should be described in an internal policy.

A similar inventory should be available for the sVaR model, where relevant.

The ECB considers that an appropriate frequency for updating this inventory is at least annually, so that it can be used in the annual review of the institution's overall risk management process as referred to in Article 368(2) of the CRR.

133. This inventory should be reviewed at least annually by a unit independent of the one that produces it (for example, the internal audit function or internal validation function). This review should check the quality, reliability and comprehensiveness of the information provided in the inventory.

134. As for any other assumption in an internal model, the differences in the pricing functions and methods used for the calculation of the VaR and sVaR, compared with those used for the calculation of the economic P&L, should be subject to validation[120] in accordance with Article 369(1) of the CRR. This validation should include any simplifications of pricing functions and methods introduced for use for VaR or sVaR-related purposes (for example, a reduced number of parameters or simulations). The validation should be performed at least initially when a pricing method is introduced into the VaR or sVaR calculation that is not identical to the one for economic P&L purposes, and should assess the impact of the use of different pricing methods. Additionally, a regular validation should be performed in order to check that this impact remains low. The scorecard indicator mentioned above should be based on the results from this (initial and regular) validation. The institution should develop a work plan to mitigate the risk or improve the quality of any pricing functions or methods that are deemed inadequate according to the institution's assessment in the scorecard (i.e. a red indicator).

135. In order to assess the accuracy and appropriateness of the pricing functions and methods in the VaR and sVaR models, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to provide, for a selection of sub-portfolios, business days, and pricing functions/methods:

   (a) the hypothetical P&L used for regulatory back-testing as defined in section 3.5;

   (b) the P&L, calculated on the same unchanged positions, by using the pricing functions and methods used to compute the VaR and sVaR numbers with the market data input used for the hypothetical P&L.

   This information allows assessment of the isolated impact on the hypothetical P&L of using the pricing functions and methods in VaR and sVaR calculations, instead of those in the economic P&L.

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[120] The validation of pricing functions used for economic P&L purposes is expected to be regularly performed by an institution and thus is the basis for this additional requirement.

6 Methodology for IRC models focusing on default risk

6.1 Regulatory references

	Date of issue	Article	Paragraph/Point
Legal Background			
CRR	26/07/2013	4	(1)
		153, 336, 368	
		369	(1)
		370	
		372	(d)
		373	
		374	(2), (4)
		375	(1)
		376	(2), (3), (6)
Other references			
EBA Guidelines on the IRC	16/05/2012		17, 25, 29
Final Draft RTS on assessment methodology for IMA and significant share	22/11/2016	63	(4)(b)
		65	(3)
		70	(3)

Once adopted by the European Commission, the Final Draft RTS on assessment methodology for IMA and significant share will become an additional relevant regulatory reference. Currently that document only exists in a final draft version.

6.2 General requirements

136. Under paragraph 29.2 of the EBA Guidelines on the IRC, institutions should be able to prove that, on the day of the week chosen for the IRC calculation, their portfolio is representative of the portfolio held during the week and that the chosen portfolio does not lead to a systematic underestimation of the IRC numbers when computed weekly (for example, by using sensitivities or jump-to-default).

137. In order to assess that the day of the week when the IRC numbers are calculated does not lead to material bias, the ECB can, on the basis of Article 10 of the SSM Regulation, require an institution to recalculate the IRC for 15 consecutive business days (including three reporting days). If it is not possible to perform this calculation in the production environment, it can be performed in a test environment replicating the calculation of the regulatory IRC.

138. In accordance with Article 374(4) of the CRR, the IRC model must be based on the assumptions of a constant level of risk over the one-year time horizon or, alternatively, on the assumption of a one-year constant position. As with any

other modelling assumption, an institution should be able to demonstrate that the chosen assumption appropriately captures the risk of its portfolio.

In order to assess the appropriateness of that choice, the ECB can, on the basis of Article 10 of the SSM Regulation, require an institution that uses a constant level of risk assumption and liquidity horizons shorter than one year to calculate the impact of using a constant position assumption on the IRC and the default risk in the IRC[121] amounts.

139. In accordance with Article 375(1) of the CRR, hedging or diversification effects associated with long and short positions may only be recognised by explicitly modelling gross long and short positions in the different instruments, and institutions must reflect the potential for significant basis risks in hedging strategies, in particular by maturity. Therefore, the ECB considers that irrespective of whether a one-year constant position assumption or a constant level of risk assumption is used, institutions should not overestimate diversification or hedging effects, and in particular should ensure that maturity mismatches between long and short positions occurring within the liquidity horizon or within the one-year risk modelling horizon do not lead to an underestimation of risk.[122]

In accordance with Article 376(3)(c) of the CRR, as part of the annual independent review and the initial and periodic validation of its IRC model, an institution must apply appropriate quantitative validation. Therefore, the ECB considers that institutions should, as part of the annual independent review and the initial and periodic validation of their IRC models, assess quantitatively how maturity mismatches – that may lead to imbalanced positions within the modelling horizon – impact the IRC and the default risk in the IRC amounts.[123]

140. In accordance with Article 372(d) in conjunction with Article 368(1)(f) of the CRR, an IRC model must be reasonably accurate in measuring risks. Therefore, an institution should be able to demonstrate that the number of simulations used in its model to compute the IRC and the default risk in the IRC is sufficient to ensure accurate and stable IRC amounts.

141. In order to assess the accuracy of the IRC calculations, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to calculate a confidence interval of IRC estimation with a confidence level of 95%.

142. Under paragraph 17.2 of the EBA Guidelines on the IRC, institutions should use one (or, where relevant data is available, more than one) migration matrix that is

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[121] For the purposes of this document, default risk in the IRC means the risk charge calculated with the institution's IRC methodology and on the institution's current IRC portfolio, but without taking the effect of rating migrations into account. Thus, default risk in the IRC is a stand-alone risk number and not the default risk contribution to the IRC amount.

[122] This understanding is also supported by Article 63(4)(b) of the Final Draft RTS on assessment methodology for IMA and significant share.

[123] A simple way of testing the impact of maturity mismatches leading to imbalanced positions may be to scale down the probabilities of default and migration of maturing positions, taking into account the reduced time horizon until maturity.

specific to sovereign issuers (where relevant). Therefore, institutions should use a separate migration matrix for other types of issuers. Where an institution uses only one matrix for all types of issuers, it should be able to demonstrate that this leads to conservative IRC amounts.[124]

143. In accordance with Article 372(d) in conjunction with Article 368(1)(e) of the CRR, institutions must ensure compliance with a documented set of internal controls related to their IRC model. So that the ECB can assess compliance with this requirement, an institution should be able to provide an inventory of all open validation findings in relation to its IRC model, including a description of the finding, the envisaged remedial action and the target date for closure of the finding. In addition, institutions should retain closed validation findings for at least one year after the closure date and should be able to provide a description of the remedial action implemented.

6.3 Data inputs

144. In accordance with Article 376(6) of the CRR, an IRC model must meet minimum data standards. This applies in particular to time series used to calibrate the IRC model, for which the institution should have a process in place to check the quality of the time series regularly. The ECB considers that an appropriate minimum frequency for checking the quality of the time series is quarterly, as this allows alignment with the regulatory reporting cycle. Therefore the data quality requirements for VaR and sVaR models indicated in paragraphs 117 to 118 and 120 to 121 also apply to the market data used for calibration of the IRC model.

6.4 Distribution and correlation assumptions

145. In accordance with Article 376(3)(a) of the CRR, an institution must, as part of the annual independent review and the initial and periodic validation of its IRC model, validate that its modelling approach for correlations and price changes is appropriate for its portfolio, including the choice and weights of its systematic risk factors. The ECB understands that this provision requires institutions in particular to justify (i) the choice of systematic factor types (for example, region and industry) and, for each type of systematic factor, its granularity, and (ii) the full correlation structure and its calibration for the entire set of risk factors used.

146. An institution that does not calibrate the correlations of its IRC model to market data, but instead uses internal ratings-based (IRB) correlations, should demonstrate their appropriateness in relation to its portfolio. The ECB considers that owing to the nature of the regulatory trading book, the correlations as defined in Article 153 of the CRR should be used for this purpose.

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[124] The impact on the default risk in the IRC should also be provided upon request.

147. In accordance with Article 374(2) of the CRR, correlation assumptions must be supported by analysis of objective data in a conceptually sound framework. In accordance with Article 372(d) in conjunction with Article 369(1) of the CRR, institutions must perform tests to demonstrate that any assumptions made within the internal model are appropriate. In view of those two provisions, the ECB considers that any assumption for correlation modelling made by the institution should be supported by observable market data (for example, credit default swap data, equities data or rating migrations data) and justified by a quantitative analysis as part of its initial and periodic validation process. In particular, this quantitative analysis should compare the level of correlation between issuers that is derived from the institution's IRC correlation model and from observable market data. The ECB understands that this requirement also applies to those institutions using an IRB-based methodology and to those using a vendor model.

148. In order to assess the appropriateness of the modelling approach for correlations, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to provide correlations for all issuer pairs, and all relevant correlation values according to their factor model, in particular for the systematic factors.

149. In accordance with Article 374(2) of the CRR, concentrations under stressed conditions must be reflected in the correlation assumptions of the IRC model. The ECB understands that the use of a short period of data for calibrating the correlations implies the risk that stressed conditions are not appropriately reflected. Therefore, institutions should be able to justify that stressed conditions have been adequately captured and to quantify the impact of using sufficiently long time series capturing a relevant stressed period for calibrating correlations in the IRC and the default risk in the IRC. In accordance with Article 370(c) of the CRR in conjunction with Article 372(d) of the CRR, the IRC model must be robust to an adverse environment. Therefore, the ECB considers that, in order to also ensure a robust calibration of the IRC model, a time series of at least 10 years is appropriate.[125]

150. In accordance with Article 376(3)(b) of the CRR, institutions must perform sensitivity analysis and scenario analysis to assess the qualitative and quantitative reasonableness of the internal model, particularly with regard to the treatment of concentrations. Because the weights of the systematic risk factors are relevant for the modelling of concentrations, the ECB considers that institutions should – as part of the independent review, and in the initial and periodic validation process – perform sensitivity analyses for the IRC and the default risk in the IRC. In particular, the ECB considers it best practice that this sensitivity analysis includes, as a minimum, the following basic analysis, where

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[125] By using proxies if, and where, necessary.

systematic risk factor weights or correlations of risk factors[126] in the model are shifted up or down by a fixed value or set to generic values:

(a) all weights of the systematic factors per issuer, for each issuer,[127] are shifted by +10% in absolute value (not going beyond 100%);[128]

(b) all weights of the systematic factors per issuer, for each issuer, are shifted by -10% in absolute value (not going below 0%);

(c) all weights of the systematic factors per issuer, for each issuer, are set to 0;

(d) all weights of the systematic factors per issuer, for each issuer, are set to 1;

(e) all correlations between systematic factors are set to 100% (weights of issuers to their respective systematic factors remain unchanged);

(f) all correlations between systematic factors are set to 0% (weights of issuers to their respective systematic factors remain unchanged).

In order to assess the appropriateness of the sensitivity analysis and scenario analysis performed to validate the reasonableness of the internal model, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to provide the results of the sensitivity analysis as described in paragraph 150(a) to (f).

151. In order to assess the appropriateness of the modelling approach for correlations, and in particular the choice and weights of the systematic risk factors, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to calculate the IRC and the default risk in the IRC amounts based on a one-factor Merton Model (using one single global systematic risk factor) and one flat correlation with different correlation assumptions: 0%, 5%,10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 60%, 70%, 80%. All other inputs into institutions' IRC models remain unchanged.

152. In accordance with Article 374(2) of the CRR, correlation assumptions must be supported by analysis of objective data in a conceptually sound framework. In accordance with Article 376(3)(a) of the CRR, an institution must, as part of the annual independent review and the initial and periodic validation of its IRC model, validate that its modelling approach for correlations is appropriate for its portfolio. In accordance with Article 376(3)(c) of the CRR, institutions must apply appropriate quantitative validation. Under paragraph 25.2(iii) of the EBA Guidelines on the IRC, in the validation process the impact of different copula

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[126] The latent variables of the model that determine the correlation of migration and default events of the issuers.

[127] If the asset value Ai of an obligor i is written as follows in a factor model: $A_i = \sqrt{\rho_i}\, X_i + \sqrt{1 - \rho_i}\, \xi_i$ where Xi is driven by systemic contributions and ξi the idiosyncratic noise term), the weights of the issuers to their respective systematic factors corresponds to $\sqrt{\rho_i}$.

[128] Which reduces the idiosyncratic weight accordingly.

assumptions should be analysed, for example by testing the impact of different distributional assumptions. Because the copula choice is a key assumption of the modelling approach for correlations, the ECB understands that these provisions require, in particular, that institutions demonstrate the appropriateness of and validate the copula choice of the modelling approach for correlations. The copula choice refers to the copula of the joint multivariate distribution[129] of the risk factors for migration and default and of the joint systematic risk factors, where relevant.

153. In accordance with Article 376(3)(b) of the CRR, institutions must perform sensitivity analysis and scenario analysis to assess the qualitative and quantitative reasonableness of the internal model, particularly with regard to the treatment of concentrations. Because the copula choice is a key assumption of the modelling approach for correlations and is relevant for the modelling of concentrations, the ECB considers that institutions should – as part of the independent review, and in the initial and periodic validation process – perform sensitivity analyses for different copula assumptions. The ECB considers that the following are suitable choices for comparing the impact of different copulas on the IRC and the default risk in the IRC with respect to the approved model:

(a) using a Student-t copula for all issuer risk factors with 8 degrees of freedom;

(b) where relevant, using a Student-t copula for the systematic risk factors with 8 degrees of freedom;

(c) using a Student-t copula for all issuer risk factors where the degrees of freedom have been calibrated to market data;

(d) where relevant, using a Student-t copula for the systematic risk factors calibrated to market data.

This list is without prejudice to the discretion of an institution to perform additional analyses on copula choices that it deems more fitting for its particular circumstances.

6.5 Ratings, probabilities of default and recovery rate assumptions

6.5.1 Documentation requirements

154. In accordance with Article 372(d) in conjunction with 368(1)(e) of the CRR, an institution must have a documented set of internal policies and controls

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[129] Sklar's theorem (in Sklar, A., "Fonctions de répartition à n dimensions et leurs marges", *Publications de l'Institut de Statistique de L'Université de Paris*, Vol. 8, 1959, pp. 229–231) states that every multivariate cumulative distribution function of a random vector can be expressed in terms of its marginals and a copula.

concerning the overall operation of its internal models. The ECB considers that for the IRC model institutions should have in place, in particular:

(a) methodology and process documents for the determination of probabilities of default (PDs) and recovery rates (RRs), including a process and documentation concerning the fallback approaches applied;

(b) validation documents demonstrating that the assumptions relating to PDs and RRs are appropriate;

(c) a documented hierarchy of preferred sources for the determination of PDs and RRs, which are applied to all issuers and instruments within the scope of the IRC model.

155. In order to assess the appropriateness and implementation of the policies and procedures for determining PDs and RRs, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to provide on request a complete list of positions in the IRC model, together with the respective issuer or obligor ratings, the PDs of the issuer or obligor and the RRs for the positions. If the ratings, PDs or RRs have been adjusted or have not been assigned using the usual automated process (for example, by manual intervention or deviation from the usual automated process), the institution should maintain a complete list of such ratings, PDs and RRs, and provide the rationale for the adjustment, or (for example) manual intervention or deviation from the usual automated process (as applicable) in each case.

6.5.2 Validation requirements

156. In accordance with Article 376(3)(b) of the CRR, institutions must perform sensitivity analysis and scenario analysis to assess the qualitative and quantitative reasonableness of the internal model. Therefore, the ECB considers that institutions should – as part of the independent review and in the initial and periodic validation process – perform sensitivity analyses with respect to the PDs and RRs that are applied to assess the quantitative impact in terms of the IRC and the default risk in the IRC. In particular, the ECB considers it best practice that such sensitivity analysis include, as a minimum, the following basic analyses on the main drivers of the IRC model:

(a) a simultaneous 10% (absolute) up and down shift (not going beyond 0% or above 100%) of the RRs used in the portfolio. For models using stochastic RRs, institutions are expected to incorporate this impact by adjusting the mean of the RR distributions;

(b) for models using stochastic RR, a simultaneous 30% (relative) up and down shift of the standard deviation of recovery rates;

(c) for all the PDs used in the IRC calculation:

(i) a minimum value of 0.01% for all PDs;

(ii)   a minimum value of 0.03% for all PDs;

(iii) a simultaneous 10% relative upshift of all PDs;

(iv)   a simultaneous 10% relative downshift of all PDs;

(v)   a simultaneous 1bp absolute upshift of all PDs;

(vi)   a simultaneous 1bp absolute downshift[130] of all PDs.

The change in PD should be compensated for by proportionally increasing (or decreasing) all the migration probabilities belonging to the same initial rating class to maintain the cumulative 100% migration and default probability.[131]

As the sensitivity analyses listed above are part of the model validation, institutions should take them into account in detail when assessing and justifying their PDs and RRs parameters. The assessment should encompass an analysis of how the most important issuers and groups of issuers are affected by the altered PD and RR values.

In order to assess the appropriateness of the sensitivity analysis and scenario analysis performed to validate the reasonableness of the internal model, the ECB can, on the basis of Article 10 of the SSM Regulation, require institutions to provide the results of the sensitivity analysis described in paragraph 156(a) to (c).

157. In accordance with Article 376(2) of the CRR, the IRC model must be based on data that are objective and up-to-date. Therefore, the ECB considers that institutions should demonstrate, on the basis of observable data, that the PD estimates[132] are appropriate.

158. In accordance with Article 373 of the CRR, the IRC model must cover all positions that are subject to own funds requirements for specific interest rate risk, including those with a 0% specific risk capital charge under Article 336 of the CRR. In accordance with Article 372(a) of the CRR, the IRC model must give a meaningful differentiation of risk, and accurate and consistent estimates of incremental default and migration risk. Therefore, the ECB understands that all annual PDs should be risk sensitive and greater than zero[133] for all obligors. In this context, the term "greater than zero" is interpreted to mean greater than, or equal to, one basis point.

159. In accordance with Article 376(2) of the CRR, the IRC model must be based on data that are objective and up-to-date. Therefore, the ECB considers that

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[130] Not going below zero.

[131] Given an initial set of migration probabilities, $p_1, \ldots, p_n$, where p_n corresponds to the PD, the probabilities p_i for $i = 1, \ldots, n-1$ should be adjusted by $p_i' = p_i \cdot \left(1 + \frac{p_n - p_n'}{1 - p_n}\right)$ where p_n' corresponds to the modified PD.

[132] The same requirements apply to the rating agency data.

[133] In accordance with Article 65(3) of the Final Draft RTS on assessment methodology for IMA and significant share.

institutions should demonstrate, based on observable data, that the RR estimates are appropriate.

Based on its observations of the practices of the industry, the ECB considers it best practice that the RRs do not exceed the following values:

(a)   25% for subordinated debt;

(b)   55% for senior unsecured debt;

(c)   88.75% for covered bonds;

(d)   75% for any other product.

This does not exclude the possibility that higher RRs may be used, where institutions can justify them by objective and up-to-date data in accordance with Article 376(2) of the CRR. This best practice also applies to positions under the fallback approach for the RRs (i.e. for which no direct data sources are available).

6.5.3   Consistency requirements

160. In order to ensure that institutions do not use different sources for PDs and RRs for the sole purpose of reducing the overall own funds requirements for market risk, they should apply consistent sources for PDs and RRs in the IRC model. Therefore, institutions using internal ratings should use the corresponding internal RRs, and those using external ratings should use historical, market implied or market convention RRs.[134]

6.5.4   Requirements for PD fallback values

161. In accordance with Article 376(6) of the CRR, proxies must be appropriately conservative and may be used only where available data is insufficient. The ECB is aware that for positions where a reliable PD assignment is not possible due to a lack of adequate data (for example, where no internal or external ratings or liquid credit spread time series are available) institutions apply a fallback PD value. As fallback PD values are used when available data is insufficient, the ECB considers them as proxies. In order to ensure that fallback PDs are appropriately conservative, the ECB considers it best practice that the fallback PD assigned to each of those issuers and positions is at least equal to the higher of the following:

(a)   the PD that is equivalent to the worst investment grade rating applicable, according to the institution's sources for the determination of PDs – those

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[134]   This understanding is also supported by Article 70(3) of the Final Draft RTS on assessment methodology for IMA and significant share.

institutions using internal rating approaches for the assignment of PDs should use the PD that is equivalent to the worst investment grade rating in their internal rating scales;

(b) the equally weighted[135] average PD[136] of those issuers included in the IRC model which are not subject to the fallback approach.

162. In accordance with Article 372(a) of the CRR, the IRC model must provide a meaningful differentiation of risk, and accurate and consistent estimates of risk. In accordance with Article 376(2) of the CRR, the IRC model must be based on data that are objective and up-to-date. Therefore, the ECB considers that institutions should periodically assess the materiality of those issuers and positions that are assigned a fallback PD in the IRC model. The ECB considers that a suitable analysis for this purpose consists of the following:

(a) comparison of the jump-to-default risk (where applicable, by using the average of the RRs in the case of a stochastic recovery rate) of those positions that are assigned fallback PDs with the jump-to-default risk of all positions in the IRC model;

(b) calculation of the ratio of the incremental[137] IRC contributions and the incremental default risk in the IRC contributions of the positions assigned fallback PDs, to the IRC number as calculated by the IRC model:

$$\frac{IRC\,(full\,scope)\, - IRC\,(non\text{-}fallback\,for\,PD)}{IRC\,(full\,scope)}\,;$$

$$\frac{Default\,risk\,in\,the\,IRC\,(full\,scope)\, - Default\,risk\,in\,the\,IRC\,(non\text{-}fallback\,for\,PD)}{Default\,risk\,in\,the\,IRC(full\,scope)}$$

163. In accordance with Article 372(a) of the CRR, the IRC model must provide a meaningful differentiation of risk. The ECB considers that if a significant percentage of the IRC is calculated using fallback PDs, there is a risk that the IRC model may not provide the meaningful differentiation of risk required. The ECB considers that if the percentage of the IRC calculated using fallback PDs is larger than 10%,[138] the institution should investigate whether additional data sources are available to reduce the percentage of issuers subject to the fallback PD assignment.

In accordance with Article 376(3)(b) of the CRR, institutions must perform sensitivity analysis and scenario analysis to assess the qualitative and

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[135] All issuers have the same weights.

[136] The PD may be derived from the rating of the issuer by applying the migration matrix of the IRC model. In addition, defaulted positions are included in the calculation of the average with a PD equal to 100% as issuers subject to the fallback approach could be in default.

[137] Risk management literature is not uniform in the use of the terms "incremental" risk number (e.g. incremental value-at-risk) and "marginal" risk number. We adopt the convention that an incremental risk number refers to the exact finite change in a risk number when adding a finite position, whereas "marginal" risk number refers to the derivative of a risk number with respect to a position (infinitesimal change rate).

[138] This threshold of 10% is set by analogy with the CDR on materiality of extensions and changes to the IMA, which establishes 10% as the threshold for assessing materiality.

quantitative reasonableness of the internal model. In the event that the resulting percentage of the IRC calculated using fallback PDs is larger than 10%, the ECB considers that institutions should perform, as part of the independent review and validation, a sensitivity analysis for the IRC and the default risk in the IRC. In particular, the ECB understands that this requirement implies assessing the sensitivity of the IRC and default risk in the IRC amounts by assigning one rating grade higher and one rating grade lower than the one used in the fallback PD assigned on the basis of paragraph 161.[139]

6.5.5 Requirements for the calculation of losses based on recovery rates

164. In accordance with Article 372(a) of the CRR, the IRC model must provide accurate and consistent estimates of incremental default risk. Therefore, the ECB considers that the market value change following the default of an issuer should be calculated as the difference between the current market value of the position and the expected market value subsequent to default.

165. In accordance with Article 372(a) of the CRR, the IRC model must provide a meaningful differentiation of risk. In accordance with Article 375(1) of the CRR, institutions must reflect the potential for significant basis risks in hedging strategies by product, seniority in the capital structure, internal or external rating, maturity, vintage and other differences in the instruments. The ECB considers that in order to provide a meaningful differentiation of risk and to reflect the potential for significant basis risks, recovery rates should at least reflect the type of product, including the collateralisation of the position, and its seniority in the capital structure.

166. In accordance with Article 372(a) of the CRR, the IRC model must provide accurate and consistent estimates of incremental default risk. In accordance with Article 372(d) in conjunction with Article 369(1) of the CRR, institutions must demonstrate that any assumptions made within the IRC model are appropriate. The ECB considers that this applies also to RRs. An RR measures the expected market value subsequent to default of a position as a percentage of the base value (for example, notional). For a long credit position (for example, the holding of a long bond position) a default of the issuer would lead to a loss. For RRs based on notional value, a negative RR indicates a negative expected market value subsequent to default, whereas an RR above 100% indicates that the expected market value subsequent to default is higher than the notional value. The ECB is aware that RRs generally range between 0% and 100%. Recovery rates outside this range could indicate that the assumptions made within the IRC model are not appropriate – because they could imply an expected profit subsequent to default – and so institutions

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[139] When the average PD is used as a fallback approach, institutions should, by analogy, apply this requirement (i.e. identify the rating grade that is closest to the average PD and shift up and down starting from this rating grade).

should be particularly prudent in applying such RRs or be able to demonstrate that they are conservative.

6.6   Treatment of groups of connected issuers

167. In accordance with Article 374(2) of the CRR, the IRC model must appropriately reflect issuer concentrations. As defined in Article 4(1)(39) of the CRR, two or more legal persons in the same group of connected clients constitute a single risk, unless it is shown otherwise. The ECB considers that groups of connected clients are relevant for modelling issuer concentrations. Therefore, such groups should be appropriately reflected in the IRC model and their treatment in the model is subject to the same requirements as any other component of the model, in particular documentation and validation.

168. In accordance with Article 374(2) of the CRR, the IRC model must appropriately reflect issuer concentrations. As defined in Article 4(1)(39) of the CRR, a group of connected clients constitute a single risk, unless it is shown otherwise. Therefore, the ECB considers that institutions should model issuers and obligors in the same group of connected clients as a single risk (this means, for example, that in an asset value model they should be modelled as a single asset value). However, the existence of different rating grades within a group of connected clients indicates the possibility that not all of those in the group default or migrate simultaneously. Therefore, the ECB considers that a suitable method of modelling is to distinguish within a group of connected clients by sub-groups of issuers that have the same internal or external rating grade and where the default or migration of each sub-group would occur simultaneously in the IRC model – unless it is demonstrated that another treatment is more appropriate in view of the definition in Article 4(1)(39) of the CRR.

169. In accordance with Article 376(3)(a) of the CRR, an institution must, as part of the annual independent review and the initial and periodic validation of its IRC model, validate that its modelling approach for correlations is appropriate for its portfolio. Because modelling groups of connected clients is relevant for modelling issuer concentrations and the correlations amongst them, the ECB considers that validation of the modelling of groups of connected clients is part of the annual independent review and the initial and periodic validation of the institution's IRC model.

7 Risks not in the model engines

7.1 Regulatory references

	Date of issue	Article	Paragraph/Point
Legal Background			
CRR	26/06/2013	99, 103, 105	
		363	(1)
		366, 367, 368	
		369	(1)
		377	
CDR on materiality of extensions and changes of the IMA	04/03/2015	7a	(1)(c)
		7b	
		Annex III	Part II, Section 2(13)
CIR on supervisory reporting[140]	16/04/2014	5	(a)

7.2 The framework for risks not in the model engines

170. In accordance with Article 367(1)(a) of the CRR, any internal model used to calculate capital requirements for market risk must capture accurately all material price risks. In accordance with Article 367(1)(b) of the CRR, where a risk factor is incorporated into the institution's pricing model but not into the risk measurement model, the institution must be able to justify such an omission to the satisfaction of the competent authority. In accordance with Article 368(2)(d) of the CRR, the annual review of an institution's overall risk management process must consider the scope of risks captured by the risk measurement model. In accordance with Article 369(1) of the CRR, institutions must have processes in place to ensure that all their internal models for market risk have been adequately validated to ensure that they are conceptually sound and adequately capture all material risks. In accordance with Article 368(1)(e) of the CRR, the institution must have in place established procedures for monitoring and ensuring compliance with a documented set of internal policies and controls concerning the overall operation of its internal models.

Based on the provisions referred to above, the ECB considers that the risks not captured in the model[141] engines (referred to in this guide as "risks not in the model engines", or "RNIME") are a component of the IMA for market risks.

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[140] Commission Implementing Regulation (EU) No 680/2014 laying down implementing technical standards with regard to supervisory reporting of institutions according to Regulation (EU) No 575/2013 of the European Parliament and of the Council (OJ L 191, 28.6.2014, p. 1), referred to in this guide as the "CIR on supervisory reporting".

[141] In this section, the generic reference to "model" means a reference to the VaR, sVaR, IRC, and comprehensive risk measure (CRM) models for correlation trading portfolios as referred to in Article 377 of the CRR.

Therefore, institutions should develop an RNIME framework, the elements of which are further elaborated on in the following paragraphs.

171. For the purposes of this guide and in relation to the RNIME framework, the following diagram shows schematically the different components of the market risk own funds requirements and the RNIME framework.[142] The ECB considers that an internal model comprises all of the required policies, controls, validation and processes. Each internal model includes, inter alia, the following constituent elements.

    (a) An "engine" – that is, the calculation methodology for each risk number, referred to collectively as "risk engines". The ECB understands that Articles 367 and 368 of the CRR refer to an engine as a "risk-measurement model". There is one risk engine for each risk number and the risk engine is used to compute the daily risk number. Typically, an engine models and computes all risks in an integrated manner. However, it may comprise several components, for example, a main component for the bulk of the risks, and some "satellite" components, for example, for particular risks not modelled in the main component. In accordance with Article 367(3) of the CRR, institutions may, in any internal model used for market risk, use empirical correlations; where they are not used, the model uses a simple sum aggregation of these components.

    (b) An RNIME framework relating to all risk engines, in which RNIME are identified and quantified and, if appropriate, capitalised by RNIME add-ons to the own funds requirements. The process for determining RNIME add-ons is part of the RNIME framework. The ECB considers that the RNIME add-ons are outside the model engines, and are therefore not part of the risk numbers. In particular, RNIME add-ons are not part of the VaR number used for regulatory back-testing.

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[142] In order to simplify the diagram, CRM is not explicitly included. It should be treated in the same way as IRC.

Figure 4

Components of market risk own funds requirements and RNIME framework

In accordance with Article 363(1) of the CRR, institutions may calculate their own funds requirements for market risk using their internal models instead of, or in combination with, the methods of the standardised approaches for market risk. Because the positions exposed to RNIME according to the process and requirements described in this section 7 are within the scope of the IMA, they do not need to be accounted for under the standardised approaches (SA) for market risk.

Exclusions of positions from the scope of the IMA in risk categories for which the IMA is approved are subject to the requirements described in section 2.5 of this guide.

172. In accordance with Article 368(1)(e) of the CRR, institutions must have established procedures for monitoring and ensuring compliance with a documented set of internal policies and controls concerning the overall operation of internal models. Therefore, the ECB considers that an institution should have a policy and controls in place that govern the overall process for the identification, quantification and management of RNIME. In order to enable efficient monitoring of RNIME, the ECB considers that the documented policies should include a description of the different tasks and responsibilities, and the frequency of their execution. This policy and these controls constitute the RNIME framework. The ECB considers that the RNIME framework should cover the tasks described in the following paragraphs of this section.

173. In accordance with Article 368(1)(b) of the CRR, the risk control unit is responsible for the overall risk management system. Because the RNIME framework is a component of the IMA, the ECB considers that the risk control unit is also responsible for the overall RNIME framework.

In accordance with Article 368(1)(b) of the CRR, the risk control unit must conduct the initial and ongoing validation of any internal model for market risk. Therefore, the ECB considers that the RNIME framework and methodologies should be initially and periodically validated internally, and updated if necessary.

7.3 Identification of RNIME

174. A single RNIME identified refers to a distinct risk not accurately captured or omitted, and related to positions or instruments within the approved risk categories in the IMA in the VaR, sVaR, IRC or CRM models. In this section 7, the i-th RNIME is denoted by $RNIME_i$. This can refer to a single risk factor, a set of risk factors (e.g. related to a yield curve), a particular effect (e.g. volatility skew) or specific instruments.

The ECB considers that RNIME can emerge as a result of the following circumstances.

(a) Differences in the positions, risk factors and pricing methods captured in VaR, sVaR, and IRC (and CRM if applicable) engines, in comparison with those of the end-of-day valuation process for the books and records of an institution.[143] In particular, these may include risk factors that are taken into account in the economic P&L, but not in the risk measurement model as referred to in Article 367(1)(b) of the CRR.

Some examples could be: simplified pricing models or sensitivities based P&L in the risk engines; use of proxies for risk factors; calibration of pricing models in the risk engines; and risks not adequately modelled, such as basis risk between two different classes of shares.

(b) Weaknesses and limitations in the stochastic modelling of risk factors in the risk engines that are not linked to the valuation produced by the end-of-day valuation process.

Some examples could be: distributional assumptions for risk factors of both the marginal distributions and joint distributions (i.e. correlation structure); jump risks; calibration of model parameters; regression approach calibration and deviations; IRC factor model assumptions and calibration; and insufficient or unreliable data for risk factors.

(c) Other factors leading to risks not being captured accurately or being omitted from the risk engines.

Some examples could be: instruments on exotic underlyings in the IMA scope that may be treated under the RNIME framework in the manner referred to in paragraph 24 of this chapter; positions in defaulted debt, as

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[143] Those potential RNIME are different from valuation adjustments that an institution might have made in order to satisfy the fair value and prudent valuation requirements under Article 105 of the CRR.

referred to in paragraph 32 of this chapter; some risks not accurately captured due to position data not being updated daily.

175. In accordance with Article 368(1)(e), an institution must have established procedures for monitoring and ensuring compliance with a documented set of internal policies and controls concerning the overall operation of its internal models. Therefore, the ECB considers that in order to ensure a comprehensive coverage of such risks, the institution should clearly describe and document each RNIME in an inventory, as part of its RNIME framework.

In order to properly monitor each RNIME, the ECB considers that institutions should explain how each RNIME is identified and defined, and should, in particular, be able to justify the cases where a single RNIME is defined across portfolios or product classes. In order to properly assess materiality, the ECB understands that the current portfolio composition and trading strategy of the institution should be taken into account when assessing each RNIME. Unless the institution can provide justification that the effect of an RNIME is negligible in the current portfolio and will remain negligible taking into account the trading strategy, it should take that RNIME into account in its RNIME framework. The institution should be able to provide justification as to why any particular RNIME is not included in its risk engines.

176. In accordance with Article 367(1)(a) of the CRR, any internal model must capture accurately all material price risks. The ECB considers that in order to ensure an accurate capture of risks, institutions should not rely solely on the monitoring of current RNIME, but strive to identify RNIME on an ongoing basis, and as early as possible, as part of the overall risk management. The ECB considers it best practice to use existing processes efficiently to identify RNIME.

As part of such best practice, and in order to maximise efficiency, institutions should, at a minimum, use the following processes to identify RNIME:

(a) a review of the institution's trading strategy, as referred to in Article 103 of the CRR, considering, in particular, the expansion and reorientation of the trading business, given that expanding a particular business could lead to RNIME becoming significant, or to additional risks that are not currently covered in the RNIME process;

(b) the regulatory back-testing process, as referred to in Article 366 of the CRR, as part of which the institution should review the results and analyses of overshootings in order to identify RNIME;

(c) market data quality assurance processes for risk factors, as referred to in Article 367(2)(e) of the CRR, where market data display insufficient quality;

(d) initial and ongoing internal validation of internal models, as referred to in Articles 368(1)(b) and 369(1) of the CRR, at least where differences between the institution's pricing model and risk measurement model are identified (for example, risk factors that are used for the valuation of a product for the end-of-day valuation process, but not for risk

measurement), and where internal back-testing shows a high number of overshootings;

(e) introduction of new products, where the institution should analyse whether the market risks inherent in the new products and their related trading strategies can be adequately captured by the risk engines in order to ensure that these new products – which may pose additional risk factors or require methodological changes – are fully compatible with the comprehensive risk control and validation by the risk control unit, as required by Article 368(1)(b) of the CRR.

In accordance with Article 368(2)(d) of the CRR, the annual review of an institution's overall risk management process must consider the scope of risks captured by the risk measurement model. Therefore, the ECB considers that a review of the inventory of RNIME should be carried out at least once a year.

7.4   Quantification of RNIME

177. In accordance with Article 367(1)(a) of the CRR, any internal model used to calculate capital requirements for market risk must capture accurately all material price risks. In order to ensure a meaningful quantification of RNIME in relation to the internal models, the ECB considers that the risk parameters for RNIME quantification should be aligned to the regulatory specifications. Therefore, the quantification of risks not in the VaR engine should aim to reflect a loss at a 99% confidence level and a holding period of ten days. Similarly, the quantification of risks not in the sVaR engine should aim to reflect a loss at a 99% confidence level and a holding period of ten days, and be calibrated to historical data from the stressed period used to calibrate the sVaR model. The quantification of risks not in the IRC engine (or CRM engine, if applicable) should aim to reflect a loss at a 99.9% confidence interval over a time horizon of one year.

178. In accordance with Article 367(1)(a) of the CRR, any internal model used to calculate capital requirements for market risk must capture accurately all material price risks. Therefore, the ECB considers that in order to ensure that the internal models capture all material price risks, institutions should quantify RNIME in an appropriate way and document and duly justify the methodology applied. The ECB understands that the quantification of the impact of the identified i-th RNIME (RNIME$_i$) serves to assess the need to incorporate the i-th RNIME in the engine.

The ECB considers it best practice that for each RNIME$_i$ identified, the impact quantification M$_i$ should be estimated as the incremental risk number[144] where the RNIME$_i$ would be incorporated in the model engine; this is in comparison with the current engine using the same portfolio as reference,

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[144] See footnote 143 above for details.

$$M_i \overset{\text{def}}{=} \text{risk number}(\text{engine with } RNIME_i \text{ incorporated})$$
$$- \text{risk number}(\text{current engine}),$$
$$\text{risk number} \in \{VaR, sVaR, IRC, CRM\}$$

where no RNIME add-ons (or other capital add-ons) are included in the risk numbers.

The impact quantification M$_i$ is a signed number and could be negative if incorporating RNIME$_i$ were to be risk reducing.

Because the impact quantification should allow the different RNIME to be assessed individually, no diversification effect should be applied between different RNIME when quantifying the individual RNIME$_i$.

179. The impact quantification of RNIME should be accurate to the extent possible using reasonable effort. The ECB considers that a more conservative impact quantification than described in paragraph 178 could be used where this is duly justified. In particular, where an appropriate impact quantification using an incremental risk number cannot be performed, the ECB considers it a prudent approach to resort to a stand-alone impact estimation for an RNIME,

$$\widetilde{M}_i \overset{\text{def}}{=} \text{risk number}(RNIME_i \text{ as only source of risk}),$$
$$\text{risk number} \in \{VaR, sVaR, IRC, CRM\},$$

and M_i is set to $\widetilde{M}_i$ for the impact quantification.

As an illustration, in the case of the VaR, and where RNIME$_i$ can be well described as a sensitivity p$_i$ to an additional risk factor (i.e. a risk position), the impact quantification M$_i$ corresponds to its incremental VaR, i.e. the incremental effect on VaR of adding the risk position p$_i$ to the existing set of risk positions. Let p denote the set of current risk positions, and let VaR(p) denote the current VaR, then the impact quantification M_i of RNIME$_i$ interpreted as an additional risk position p$_i$ is

$$M_i = VaR(p + p_i) - VaR(p)$$

The impact quantification as incremental risk, M_i, is different from the assessment of the risk on a stand-alone basis as a sole source of risk, $\widetilde{M}_i$. In the setting above, the stand-alone risk would be $\widetilde{M}_i = VaR(p_i)$, which in general is different from $VaR(p + p_i) - VaR(p)$. If the sub-additivity property $VaR(p) + VaR(p_i) \geq VaR(p + p_i)$ holds, the stand-alone risk $VaR(p_i)$ is a conservative estimate of the incremental risk,

$$\widetilde{M}_i = VaR(p_i) \equiv VaR(p) + VaR(p_i) - VaR(p) \geq VaR(p + p_i) - VaR(p) = M_i.$$

Because VaR, sVaR, IRC and CRM are all value-at-risk-based risk measures, the same applies for those, by analogy.

180. In accordance with Article 367(1)(a) of the CRR, any internal model used to calculate capital requirements for market risk must capture accurately all material price risks. The ECB considers that in order to ensure that the

quantification of RNIME is appropriately accurate, the quantification should, where possible, make use of observable market data, even if the data quality is not sufficient to model these risks in the model engine.

In order to ensure alignment with the internal models when quantifying an RNIME – for example, by using sensitivities – the shocks applied in order to quantify it should be based on the same holding period and, in principle, on the same observation period as those for the shocks for the other risk factors used in the relevant internal model. Differences in the observation period should be duly justified. If scarce data are used to calibrate these shocks, the shocks should be estimated conservatively. This may involve relying to some extent on expert judgment.

7.5 Management of RNIME and implementation in an institution's risk engines

181. In accordance with Article 367(1)(a) of the CRR, any internal model must capture accurately all material price risks. The ECB considers that in order to ensure ongoing accurate risk capture, the risk control unit should carry out regular impact quantification and monitoring of all RNIME.

    If an institution can provide justification that an impact quantification of a VaR RNIME also applies for sVaR, the sVaR impact quantification and monitoring may be based on the VaR impact quantification. If it cannot provide such justification, or where certain RNIME have been identified specifically for the sVaR engine, a specific impact quantification and monitoring for those sVaR RNIME should be performed. Monitoring of RNIME should include, in particular, checking whether RNIME are above certain thresholds, as further detailed below in this section 7.5.

182. In accordance with Article 99 of the CRR in conjunction with Article 5(a) of the CIR on supervisory reporting, institutions must submit the information relating to own funds requirements with a quarterly frequency. Therefore, the ECB considers that in order to assess the adequacy of own funds, institutions should quantify and monitor the RNIME at least quarterly.

    The risk control unit should report the outcome of the quantification and monitoring to the committee or persons responsible for deciding on the management of RNIME in terms of identification, quantification, treatment, limitation, reporting frequency, etc.

183. In accordance with Article 367(1)(a) of the CRR, any internal model must capture accurately all material price risks. Therefore, the ECB considers that in order to ensure that the models accurately capture all material price risks including RNIME and thereby result in a sufficient level of own funds, institutions should take into account all of the following points.

(a) An RNIME$_i$, where M$_i$ < 0 does not allow the reduction of own funds requirements until the related risk has been incorporated in the relevant engine.

(b) Institutions should determine thresholds for assessing, at their own discretion, the impact of individual RNIME above which an individual RNIME is considered a "substantial" RNIME.

The ECB considers that if a single RNIME already has a 5% impact, there is a risk that the risk engine might not capture accurately all material risks. Therefore, the ECB considers as best practice that the i-th individual RNIME$_i$ is considered substantial if the impact quantification M$_i$ corresponds to more than 5% of the amount computed by the risk engine[145] (without taking into account any add-ons as they are not part of the relevant risk number).

That is, RNIME$_i$ is considered substantial if

$$\frac{M_i}{risk\ number} > 5\% \text{ , risk number} \in \text{\{VaR, sVaR, IRC, CRM\}.}$$

This is without prejudice to the discretion of an institution to set a lower threshold than 5%.

The ECB considers it best practice and prudent that any substantial RNIME$_i$ should be included in the relevant internal model capital requirements by way of an RNIME$_i$ add-on of size M$_i$, taking into account the multiplication factors (m$_c$) and (m$_s$) for VaR and sVaR as referred to in Article 366 of the CRR, until the institution has incorporated it in the engine affected. Consistent with the impact quantification, the ECB considers that there should not be any diversification effect between different RNIME$_i$ add-ons.

(c) Institutions should determine, at their own discretion, thresholds above which RNIME are incorporated in the model engines.

In accordance with Article 7a(1)(c)(ii) of the CDR on materiality of extensions and changes of the IMA, a change of 10% or more of a relevant risk VaR, sVaR, IRC, or CRM number is to be considered a material change to the IMA. Therefore, the ECB considers, by analogy, that if the cumulative RNIME impact corresponds to more than 10% of the amount computed by the risk engine, this indicates that an engine might not capture accurately all material price risks,[146] as the change needed to incorporate them in the engine could amount to a material model change.

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[145] The calculation should be made at the end of the quarter by comparing the impact quantification of the RNIME, e.g. at the end of the quarter, with the previous 60-business day average of the VaR or the previous 12-week average of the IRC or CRM amount (without any add-ons).

[146] This is without prejudice to a determination by the ECB, based on an assessment taking into account the specific circumstances of the institution, that the model does not accurately capture all material price risks.

In order to assess whether that is the case, institutions should calculate the cumulative impact quantification $CIQ_{risk\ number}$ per risk number by adding the positive impacts of RNIME related to that risk number, without taking any diversification among the different RNIME into account, and divide by the risk number computed by the model engine without taking any add-ons into account.[147] If the resulting ratio is greater than 10%, the ECB considers that the model engine might not capture accurately all material price risks,

$$CIQ_{risk\ number} = \frac{\sum_{all\ RNIME\ i\ related\ to\ risk\ number} max[M_i, 0]}{risk\ number} > 10\%,$$

$$risk\ number \in \{VaR, sVaR, IRC, CRM\}.$$

This is without prejudice to the discretion of an institution to set a lower threshold than 10%.

If it is the case that the ratio as calculated above is greater than 10% (or a lower threshold set by the institution), the institution should provide the ECB with an implementation plan for the incorporation of some or all of these RNIME in the model engine(s), such that the cumulative impacts are reduced below the threshold.

(d) The ECB considers it a prudent approach that RNIME which are to be incorporated into the relevant engine(s) are capitalised with RNIME add-ons as part of the implementation plan, until they are incorporated into the relevant engine(s). If the institution deems it convenient, the remaining RNIME may also be capitalised with RNIME add-ons.

184. With reference to the previous paragraphs in this section 7.5, the incorporation of RNIME in the model engine should be performed so that the engine complies with all relevant requirements of the CRR including, in particular, internal validation. The term "incorporation" here means the integration of RNIME into the relevant risk engine, and into its methodology and processes, typically allowing for a diversification with other risk factors. This is without prejudice to the discretion of an institution not to use empirical correlations within risk categories or across risk categories, as referred to in Article 367(3) of the CRR, by applying instead a simple sum aggregation.

185. In accordance with Article 99 of the CRR in conjunction with Article 5(a) of the CIR on supervisory reporting, institutions must submit the information relating to own funds requirements with a quarterly frequency. Therefore, the ECB considers that in order to ensure an accurate quarterly reporting of own funds requirements, the RNIME add-ons should be updated at least quarterly.

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[147] The calculation should be made at the end of the quarter by comparing the sum of impact quantification of the RNIME, e.g. at the end of the quarter, with the 60-day average of the VaR or the 12-week average of the IRC or CRM amount of the preceding quarter.

In order to enable monitoring of RNIME add-ons for own funds requirements, the ECB can, on the basis of Article 10 of the SSM Regulation, require an institution to provide an overview of RNIME add-ons in a suitable format chosen by the institution.

186. Because the RNIME framework is a component of the IMA, a change to the framework – in particular one that relates to the RNIME identification methodology, the consideration of new types of RNIME, the impact quantification methodology, or the RNIME add-on methodology – constitutes an IMA model change and should therefore be assessed in accordance with the CDR on materiality of extensions and changes of the IMA.

In accordance with Article 7b and Annex III, Part II, Section 2(13) of the CDR on materiality of extensions and changes of the IMA, any structural, organisational or operational change to the core processes in risk management or risk controlling functions requires ex ante notification to the competent authorities. The ECB considers that because the RNIME framework is a component of the IMA, a change in it should accordingly be notified ex ante to the competent authorities.

187. Ceasing to capitalise an RNIME, or capitalising an RNIME with an RNIME add-on according to the thresholds of the RNIME framework, does not constitute a model change and does not need to be separately notified as a model change, provided that it is based on the approved methodology of the RNIME framework.

188. The incorporation of an RNIME in the model engine, irrespective of whether it was previously treated as an RNIME add-on or not, and irrespective of whether it is an RNIME identified previously or is newly identified, constitutes an IMA model change and should therefore be assessed in accordance with the CDR on materiality of extensions and changes of the IMA. The materiality assessment, in accordance with Article 7a(1)(c)(ii) of that CDR, should be based on the new risk number, i.e. on the following ratios,

$$\frac{risk\ number(engine\ with\ RNIME\ incorporated)}{risk\ number(current\ engine)},$$
$$risk\ number\ \in\ \{VaR, sVaR, IRC, CRM\}.$$

For the sum of market risk requirements, the assessment of materiality in accordance with Article 7a(1)(c)(i) of that CDR should be made analogously.

189. Because the RNIME add-ons are not included in the VaR number, they should not be taken into account when performing regulatory back-testing. However, all VaR engine components that constitute the VaR engine (including, where applicable, satellite components) should be taken into account in the regulatory back-testing.

Counterparty credit risk

1   Scope of the counterparty credit risk chapter

1. The purpose of this chapter is to provide transparency on how the ECB understands a number of topics related to the principles defined for the Internal Model Method (IMM[148], as referred to in Part Three, Title II, Chapter 6, Section 6 of the CRR[149]), which have been looked at in the targeted review of internal models (TRIM). Consequently, this chapter does not contain an exhaustive list of topics relevant for compliance with IMM requirements that could be subject to review during coming internal model investigations.[150]

2. The following sections are structured in the same manner and cover those issues relating to counterparty credit risk (CCR), for which the TRIM project intends to ensure a consistent application of regulatory requirements. For each item:

    (a) references are only made to the relevant CRR provisions that require more guidance; other relevant provisions of the CRR are therefore not mentioned in the guide, but are not to be disregarded; this refers specifically to paragraphs 6, 21, 28, 39, 45, 53, 59, 66, 81 and 86;

    (b) a summary of observed practices and their variability is given aiming to motivate principles[151];

    (c) principles are expressed following CRR requirements as they are understood by the ECB.

2   Trade coverage

3. For the purposes of this section, "IMM transactions" are transactions for which the institution has approval to use the IMM to estimate the related exposure value.

4. This section refers to transactions for which the institution does not have approval to use the IMM, and IMM transactions, for which the related exposure is not fully simulated in the IMM.[152]

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[148] Note that the advanced method for the credit valuation adjustment (CVA) capital requirement is not in scope here.

[149] Articles 273-294 of Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 (OJ L 176, 27.6.2013, p. 1). For the purposes of this document, the reader's attention is also drawn to the corrigendum published on 30 November 2013 (OJ L 321, 30.11.2013, p. 6).

[150] A prominent example is data quality.

[151] The final version of the guide will not contain practices.

5.   The section also addresses potential carve-outs of transactions from the IMM scope to a non-IMM method, for example due to price differences compared with benchmarking systems[153], and the consequences of the potential creation of synthetic netting sets.

2.1   Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	273	(6)
		283	(1), (3)
		284	(1)
		293	(4)
		294	(1)(d), (l), (o)
Other references			
ECB Guide on options and discretions available in Union law	11/2016	Section II, Chapter3, paragraph 9	

6.   The regulatory provisions relating to the topic addressed in this section that require further guidance are the following.

(a)   Article 283(1) (permission to use the IMM) and 283(3) (sequential implementation of the IMM) of the CRR, further specified for banking supervision in Section II, Chapter 3, paragraph 9 of the ECB Guide on options and discretions available in Union law, form the basis for IMM approval.

(b)   Article 273(6) of the CRR requires, for all methods in Part Three, Title II, Chapter 6, Sections 3 to 6 of the CRR (Articles 274-294), that the exposure value for a given counterparty is calculated as the sum of exposure values, calculated for each netting set with that counterparty. However, these provisions do not explicitly address the case of synthetic netting sets arising from the splitting of a contractual netting set.

(c)   Article 294(1)(d) of the CRR requires that actions be taken to address the inaccuracy of the model if model validation indicates that the effective expected positive exposure (EEPE) is underestimated.

(d)   Article 294(1)(l) of the CRR requires that pricing functions be tested against an appropriate independent benchmark.

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[152]   "Fully simulated" in this context means that, for each of the simulated market data paths with a joint dependency structure at the predefined grid points, a full revaluation of the transactions is performed. All material risk drivers of the valuation routine are simulated and the pricing function is not approximated compared with the benchmarking system.

[153]   See the definition in the Counterparty credit risk glossary.

(e) Article 294(1)(o) of the CRR requires, in a general way and without further explanation, that validation "shall assess whether or not the counterparty level and netting set exposure calculations [...] are appropriate".

(f) According to Article 293(4) of the CRR, any "institution shall define criteria with which to assess its CCR exposure models and the models that input into the calculation of exposure and maintain a written policy that describes the process by which unacceptable performance will be identified and remedied". However, this provision is drafted in a general way and needs to be detailed further.

(g) Article 284(1) of the CRR requires that the exposure value at netting set level be calculated for those transactions where the institution has the permission to use the IMM in accordance with Article 283(1) of the CRR.

(h) Article 284(1)(a) of the CRR provides that the model used by the institution must "specify the forecasting distribution for changes in the market value of the netting set attributable to joint changes in relevant market variables, such as interest rates, foreign exchange rates".

(i) Article 284(1)(b) of the CRR provides that the model used by the institution must "calculate the exposure value for the netting set at each of the future dates on the basis of the joint changes in the market variables". It is not specific about excluding any exposure simulation for some transactions outside the standard joint Monte Carlo simulations.

7. The CRR does not explicitly establish a requirement regarding how to handle netting sets in cases where transactions which the institution has general approval to treat with the IMM need to be carved out from the IMM to a non-IMM method for any reason.

2.2 Practices

8. For IMM transactions for which the related exposure is not fully simulated, four different types of treatment have been observed.

(a) Exposure is simulated in the IMM, but some (material) parameters necessary for the pricing function are not stochastically diffused.

(b) Exposure is simulated, but the pricing function in the IMM is approximated compared with the pricing function used for the same transaction in benchmarking systems.

(c) Transactions are treated under an "alternative exposure calculation" in the IMM, where the resulting exposure from this treatment is finally netted with the simulated exposures in the same netting set.

(i) In some variants, a predefined exposure time profile is assigned to a given transaction. This time profile is built using two additive components:

- a first component, which is equal to the t_0 value[154] of the transaction and is kept constant over the whole lifetime of the transaction (for margined transactions this component is in some cases dropped, aiming only for the value evolution within the margin period of risk);

- a second component, which is a predefined add-on time profile to account for the transaction's estimated exposure evolution over time that:

  - either builds up *identical* second components for the exposure profiles for all simulated scenarios,

  - or builds up add-on profiles *per scenario* but independent from the IMM risk factor simulation.

(ii) Another variant observed for margined trading is based on the use of new aggregated risk factors[155] that are diffused with an own simplified stochastic process and that are uncorrelated with other risk factors in the IMM.

(d) Transactions are carved out from the IMM to a non-IMM approach, for example because market data for revaluation are not available, or a new product process has to be followed first, or differences relative to benchmarking system values are too high (with heterogeneous threshold levels), etc.

9. When carving out IMM transactions to a non-IMM method, institutions create synthetic netting sets either by netting agreement or by counterparty.

10. The various approximations and alternative exposure calculations are related to different product types and different risk factor availabilities.

2.3   Principles for ECB banking supervision

11. With regard to the coverage of the IMM, institutions should comply with Section II, Chapter 3, paragraph 9 of the ECB Guide on options and discretions available in Union law, where the IMM coverage mentioned covers transactions treated under the methods described in Part Three, Title II, Chapter 6, Section 6 of the CRR, whereas transactions treated under Section 3, 4 or 5 are excluded.

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[154] See the Counterparty credit risk Glossary for a definition of t_0.

[155] This refers to compositions of several "basic" risk factors (e.g. equity risk, foreign exchange (FX) risk and interest rate risk).

In particular, transactions which are carved out from the IMM are excluded from the IMM coverage.

12. Transactions for which there is no permission to apply the IMM in accordance with Article 283(1) of the CRR must be covered by one of the exposure methods described in Part Three, Title II, Chapter 6, Section 3, 4 or 5 of the CRR. In the view of the ECB, this includes transactions without IMM permission, to which the alternative exposure calculations as described in paragraph 8(c) are applied.

13. For cases where, for a given legally enforceable netting agreement as defined in Part Three, Title II, Chapter 6, Section 7 of the CRR, one part of the transactions is treated under the method described in Section 6 (IMM) and another part is covered by one of the methods described in Section 3, 4 or 5[156], the ECB considers, as a best practice, the creation of different synthetic netting sets, one per method. Hence, one synthetic netting set covers all the transactions under the IMM and the other synthetic netting sets cover all the transactions under each non-IMM method (one per non-IMM method).

14. It is the ECB's understanding that synthetic netting sets created for the purposes described in paragraph 13 should cover only transactions under the same contractual netting agreement; that is, Article 273(6) of the CRR (netting set-specific application of any CCR method) is understood to apply also to synthetic netting sets.

15. In relation to the requirement provided by Article 294(1)(l) of the CRR[157] and in accordance with Article 294(1)(d) of the CRR, the ECB considers that the following measures can be used to ensure that identified pricing model deficiencies (in accordance with Article 294(1)(o) of the CRR) are addressed. It would be good practice to perform a detailed assessment for all transactions meeting all of the following conditions:

    (a) the difference exceeds [€100,000];

    (b) the difference exceeds [0.5%] of the notional amount;

    (c) the difference exceeds [5%] of the absolute value of the respective benchmarking value;

    unless an institution is able to demonstrate that the above-mentioned differences occur for less than [ten business days] during the reference quarter, and where "difference" means the absolute value of the difference between the IMM transaction's t_0 value and the respective benchmarking value.

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[156] This implies that not all transactions covered by the contractual netting agreement are treated under the IMM.

[157] See paragraph 78 with regard to how to detect value differences of transactions between the IMM and the benchmarking system.

16. The ECB considers that appropriate measures to address identified model weaknesses as per the above assessment are (i) a carve-out of transactions to one of the methods described in Part Three, Title II, Chapter 6, Section 3, 4 or 5 of the CRR, and (ii) the creation of synthetic netting sets to remedy unacceptable performance of the CCR exposure model in accordance with Article 293(4) in conjunction with Article 294(1)(d) of the CRR.

Institutions may apply other criteria to identify transactions where the exposure calculation may be inappropriate or other measures than carve-outs to address model deficiencies, provided that these criteria and measures (i) can be justified and regularly validated, and (ii) meet the purpose set out in Article 294(1)(d) of the CRR of not systematically underestimating exposure, in conjunction with the purpose of Article 293(4) of the CRR of identifying and remedying unacceptable exposure model performance. This includes, in the ECB's understanding, as further explained in paragraph 78, that institutions should take all necessary remediation actions to solve the root causes creating the most significant differences between the values of pricing functions used for revaluation under the IMM and the respective benchmarking value in a timely manner.

In particular for margined netting sets, the ECB considers as compliant with the above-mentioned requirements the keeping of the transactions within one netting set to calculate future margin requirements. In this case, in order to address any unacceptable performance of the exposure model, the ECB considers that the netting benefit[158] due to not carving out should be added to the entire netting set's expected exposure (EE) time profile.

17. In the ECB's understanding, transactions carved out due to price differences with a benchmarking system should not be considered as contributing to the required IMM coverage explained in Section II, Chapter 3, paragraph 9 of the ECB Guide on options and discretions available in Union law.

18. For all transactions covered by the IMM (i.e. that are not carved out as outlined in paragraph 15 above), the ECB's understanding is that the aggregated t_0 transaction value differences of the netting set should be taken into account in the modelling of the transaction's exposure profile as an appropriate measure to remedy unacceptable performance of exposure calculation in accordance with Article 293(4) of the CRR. For all future grid points, the adjustment of the netting set value using the aggregated difference should only be taken into account if this difference increases the netting set exposure. For these grid points, the difference could be estimated using more sophisticated methods taking amortising transactions into account.

19. **OPTION 1**[159]

Article 284(1)(a) and (b) of the CRR requires that exposure values be based on

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[158] The netting benefit at t_0 is estimated as the difference between the current exposure (without collateral) based on the unsplit netting set and the sum of the current exposures (without collateral) across split netting sets. For grid points after t_0, it is good practice to estimate the netting benefit using more sophisticated methods, in particular taking maturing transactions into account.

[159] The final version of the guide will only have one option.

a forecasting distribution of joint changes in market variables. The ECB considers that any kind of alternative exposure calculation[160] that is not derived from valuations directly using forecasting distributions based on simultaneous changes of market variables with a joint dependency structure[161] does not comply with that requirement.

OPTION 2

The ECB considers it best practice to perform a full simulation[162] for all IMM transactions to comply with the requirements of Article 284(1) of the CRR. In cases where this practice is not feasible (e.g. some risk factors or a performant pricing function are not available), the ECB considers that the following approach would ensure compliance with the CRR:

(a) if other (approximate) pricing methods are used, they should be subject to the validation requirements described in paragraphs 78 and 79;

(b) if an alternative exposure calculation is used:

  (i) the institution should be able to demonstrate that the reason for an alternative exposure calculation is only pricing performance, or a performance issue related to calibrating certain transaction-specific risk factors;

  (ii) correlations with other risk factors simulated in the exposure model and joint changes of market variables should be taken into account, which would also hold in the case of new or aggregated risk factors only used for alternative exposure methods;

  (iii) the risk factor simulation should take the exposure time dependency into account, in particular regarding the time grid point to which the margin period of risk is attached for margined trading;

  (iv) for the purpose of calculating the current exposure of affected transactions, a pricing function should be implemented in the IMM or accessible from the IMM using t_0 market values as available in the IMM.

3   Margin period of risk and cash flows

20. This section refers to the modelling of the margin period of risk (MPOR),[163] including the following aspects.

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[160] See the examples in paragraph 8.

[161] Depending on the modelling of the dependency structure, this could mean using standard Pearson correlations.

[162] As described in footnote 158.

[163] Note that the modelling of collateral is addressed in section 4.

(a)   Treatment of margin call and trade-related cash flows (abbreviated in the following as "CFs") in all currencies. The trade-related cash flows include here both intermediary flows and the settlements at maturity related to trades, as well as flows in the form of a commodity or precious metal or any other asset that may be paid/received during the MPOR. Trade-related CFs *paid* by the institution to the counterparty result in upward jumps of the exposure time profile (hereinafter called "spikes").

(b)   Taking the default management process (DMP) into account when modelling CFs paid/received during the MPOR. The DMP refers to all legal and operational actions performed by the institution upon counterparty default before the institution stops paying margin call and trade-related CFs to the defaulted counterparty.

(c)   Interpolation techniques that may be applied to estimate the netting set market value at MPOR time points that do not belong to the simulation time grid used.

(d)   Mapping between each time grid point t, for which EE(t) is calculated, and the associated MPOR.[164]

3.1   Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	272	(9)
		284	(4)
		285	(2), (3), (4), (5)
		289	(5)
		292	(1)(a), (b)
		294	(1)(g), (i)

21.   The regulatory provisions relating to the topic addressed in this section that require further guidance are the following.

(a)   Article 292(1)(a) of the CRR, which requires the model to reflect transaction terms and specifications in a timely, complete and conservative fashion, but does not make explicit mention regarding trade-related CFs.

(b)   Article 292(1)(b) of the CRR, which requires that netting agreements (including actions upon counterparty default or outstanding payments of the counterparty as part of netting arrangements) be reflected.

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[164]   Due to the small distance between the adjacent grid points (t), MPORs related to the two adjacent grid points may overlap.

(c)   Article 289(5) of the CRR, which notably provides that an "institution shall estimate EE along a time profile of forecasting horizons that adequately reflects the time structure of future cash flows and maturity of the contracts and in a manner that is consistent with the materiality and composition of the exposures". However, modelling within the MPOR is not explicitly mentioned.

(d)   Article 272(9) of the CRR, which provides a definition of the MPOR: "'margin period of risk' means the time period from the most recent exchange of collateral covering a netting set of transactions with a defaulting counterparty until the transactions are closed out and the resulting market risk is re-hedged". However, this definition does not mention the trade-related cash flows.

(e)   Article 284(4) of the CRR, which specifies how to use the alpha parameter, mentioning that competent authorities may require a higher one than 1.4.

(f)   Article 294(1)(g) of the CRR, which notably requires the validation of transaction-specific information to capture the effects of margining in the model, and Article 294(1)(i) of the CRR, which requires the testing of key assumptions of the CCR exposure model, without mentioning explicitly advanced features in MPOR and CF modelling, such as the use of "Brownian Bridge"-based interpolation for additional time grid points in the MPOR.

(g)   According to Article 284(1) of the CRR, the exposure value needs to be calculated "on the basis of joint changes in relevant market variables". It does not give explicit details regarding the starting point in time of these changes.

(h)   Article 285(2) to (5) of the CRR sets the length of the MPOR. There is no special provision for its length if the MPOR is attached to (i) time grid points t after t_0 but before t_0 plus the MPOR length or (ii) time grid points at the end of the exposure time axis with t plus MPOR being later than the one-year horizon or later than the final maturity of the netting set.

(i)   According to Article 284(4) of the CRR, the "model shall estimate EE at a series of future dates t1, t2, t3, etc." The article does not specify for margined trading in which way an MPOR needs to be attached to these future dates, in particular concerning attachments close to t_0 and close to the one-year future date or the final maturity of the netting set.

3.2   Practices

22.   The following practices have been observed.

(a) Institutions use the start of the MPOR as the starting point for market value changes of the netting set. Institutions take the netting set value at the MPOR start to determine the collateral balance at the MPOR start.

(b) Most institutions consider that no margin call, either paid or received, may occur during the MPOR.

(c) Modelling of trade-related CFs is performed in various ways depending on the institution. As a result, modelling choices may result in observing more or fewer spikes in the expected exposure profile, depending on the chosen CF modelling approach. This leads to variability in the estimated EEPE.

(d) Institutions take their DMP only partially into account.

(e) MPOR modelling may require the estimation of the netting set market values at time points that do not belong to the simulation time grid. Institutions perform market value estimations at such time points in significantly different ways, involving various interpolation/extrapolation techniques, notably the use of Brownian bridges.

(f) For calculating the expected exposure $EE(t)$ at a future date t for netting sets subject to a margin agreement, institutions generally use one of the two following modelling choices for attaching the MPOR to t:

   (i) In the "backward modelling", $EE(t)$ is calculated based on the evolution of exposure (as a result of the evolution of transaction and collateral values) in the time interval $[t - MPOR, t]$, where $MPOR$ denotes the time length of the MPOR.

   (ii) In the "forward modelling", $EE(t)$ is calculated based on the evolution of exposure in the time interval $[t, t + MPOR]$. In this approach, the MPOR starts at t and ends at $t + MPOR$.

3.3   Principles for ECB banking supervision

23. The requirements of Articles 292(1)(a) and 289(5) of the CRR are also seen as being applicable to the modelling of exposure changes of margined trading within the MPOR.
The CRR term "margin arrangement", as mentioned in Article 292(1)(b) of the CRR, is understood as comprising all contractual features, the margining mechanism with margin call triggers, grace periods and close-out provisions which, according to Article 292(1)(a) of the CRR, must be reflected in the model.
In the view of the ECB, regarding the modelling of margin call and trade-related CFs within the MPOR, Article 272(9) of the CRR should be understood as providing that none of these CFs is received from the counterparty after the beginning of the MPOR. Furthermore:

(a) the counterparty is supposed to default at some time point during the MPOR, and non-payment of trade-related CFs to the defaulting counterparty may be assumed to the extent that this assumption is consistent with:

  (i) the DMP and the features of enforceable settlement mechanisms (e.g. agreements to net CFs with related margin calls or analogues to the Continuous Linked Settlement system);

  (ii) the grace period and close-out requirements specified in the netting agreement, and in particular how the close-out is affected by paid or non-paid CFs.

  It is seen as good practice and cautious modelling (for example, given that watchlists of critical counterparties include only a subset of all potentially critical counterparties) that trade-related CFs from the institution to the counterparty that are due according to the underlying contract are assumed to be paid at least for a time period after the beginning of the MPOR corresponding to the re-margining period.

(b) If the institution has no defined DMP or the DMP is not taken into account in the modelling, all trade-related CFs due by the institution should be assumed to be paid to the counterparty during the whole MPOR.

(c) Assuming that there are documented and enforceable settlement netting rules, the aggregation of netting set CFs with opposite signs falling due on the same date from different legs of the same transactions and/or from other transactions in the netting set could be integrated into the modelling of CFs within the MPOR.

  (i) If a net CF is to be received from the counterparty, this net CF should be modelled as not received.

  (ii) If a net CF is to be paid, this net CF should be modelled as being paid or not paid according to (a) and (b).

  (iii) If, in the IMM modelling, there is no reliable access to legal settlement netting agreements, no settlement netting is to be applied.

(d) A modelling different to the expected modelling described above showing discrepancies with the DMP could be accepted if it is shown that the quantitative impact of this approach on the EEPE is not material.[165]

24. If (i) an institution does not comply with the requirements of Articles 292(1)(a) and 289(5) of the CRR, and (ii) there is a material impact as referred to in paragraph 23(d), the ECB has the power to impose an appropriate and

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[165] This holds if it is shown that the difference between the EEPE as calculated with the CF modelling currently implemented by the institution and the EEPE as calculated with the expected CF modelling described above is not significant (at least for a representative sub-portfolio in the sense of counterparty credit risk Glossary).

proportionate remediation measure, which can consist – as provided by Article 284(4) of the CRR – in an increase of the alpha parameter derived from expected exposure add-ons for all margined netting sets.

(a) It is proposed that the expected exposure add-on per margined netting set (see Annex 1 for details) be equal to the average of the CF spikes.

(i) Formally, for a margined netting set n

$$addon_n = \sum_{i=1}^{min\{1\ year, maturity\}} EE_n(t_i)^{spike} \cdot \Delta t_i ,$$

where $EE_n(t_i)^{spike}$ stands for the difference between the expected exposure estimated with an MPOR CF modelling complying with the requirements of paragraph 23 and the expected exposure estimated with an MPOR CF modelling assuming that CFs are neither paid nor received during the MPOR, and with $\Delta t_i = t_i - t_{i-1}$ in analogy to Article 284(6) of the CRR.[166]

(ii) Where institutions already (partially) take paid trade CFs into account in the EEPE calculation, such paid CFs could be excluded from the add-on calculation to the extent that they are captured. This exclusion could only be done with CFs not being netted with CFs assumed to be received from the counterparty during the MPOR.
Institutions excluding certain paid CFs should clearly document and describe to what extent these CFs are already captured in the EEPE calculation and why these CFs can be excluded from the add-on calculation.

(iii) If the longest-remaining transaction maturity among all transactions in the netting set, denoted by T, is above or equal to one year, then Δt_i should be expressed in units of a year.
If T is below one year, e.g. 0.5y, then Δt_i is expressed as a fraction of T (in other words, the Δt_i are rescaled by $1/T$, in this example by $1/T = 2$).

(b) In order to obtain the alpha increase, the add-on of paragraph 24(a) would be added to the EEPE for each netting set and the overall increased exposure would be compared with the overall exposure using only the EEPE (see Annex 1).

25. MPOR modelling may require the estimation of netting set market values at time points that do not belong to the simulation time grid. It is the ECB's understanding of Article 294(1)(g) of the CRR that interpolation/extrapolation techniques used by the institutions to perform such estimations should be validated by studies showing that impacts on the EEPE, compared with full revaluation, are not material.

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[166] The $EE_n(t_i)^{spike}$ can also be directly computed.

26. In the view of the ECB, the previously defined backward and forward modelling (see paragraph 22(f)), as well as a mix of both[167], can be considered CRR compliant. In particular the following holds.

   (a) Backward modelling approach
       For time grid points t falling within the interval $[t_0, t_0 + MPOR]$, institutions should calculate expected exposure EE(t) as required in Article 284(4) of the CRR by modelling joint changes in relevant market variables mentioned in Article 284(1)(b) of the CRR starting from t_0, since Article 284(5) of the CRR defines this date as the earliest date for the calculation of exposure. The ECB understands that this may shorten the effective length of the MPOR for these grid points and considers that this will not affect the formal length of the MPOR, which is provided by Article 285(2) to (5) of the CRR.

   (b) Forward modelling approach
       When using the forward modelling approach, institutions should calculate expected exposure EE(t) as required in Article 284(4) of the CRR by taking into account close-out amounts that are determined after t within the MPOR period as given by Article 285(2) to (5) of the CRR. This applies also when t = 1 year.

       Furthermore, if t equals the maturity of the longest lasting transaction (T) in the netting set, and if no collateral is modelled as held by the institution at T for a given scenario, the effective length of the MPOR may shorten, as no close-out or re-hedging is due after maturity of the last transaction in the netting set.

   The ECB understands that the effective length of the MPOR for these grid points may be shortened and considers that this will not affect the formal length of the MPOR as provided by Article 285(2) to (5) of the CRR.

4 Collateral modelling

27. This section deals with the modelling of cash and non-cash collateral, that is, its potential value changes from the time when the last margin call at the beginning of the MPOR is settled up to the end of the MPOR. Initial margin modelling is addressed in section 5.

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[167] This includes variants of attaching the MPOR to the t of EE(t) where the t is not at the border of the time interval set by the MPOR.

4.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	223, 224, 225, 226, 227	
		285	(1), (6), (7)
		292	(1)

28. The regulatory provisions relating to the topic addressed in this section that require further guidance are the following.

   (a) Article 285(1), (6) and (7) of the CRR clarifies the modelling options under which the effects of margining can be directly recognised in the exposure value calculation.

   (i) However, these provisions do not determine whether institutions should model margin collateral in a manner consistent with the modelling of securities underlying over-the-counter (OTC) derivatives and securities financing transactions (SFTs)[168], or whether they are allowed to adopt a different modelling approach for margin collateral, on the one hand, and securities underlying the different transactions, on the other.

   (ii) The provisions of Article 285(6) of the CRR leave room for interpretation regarding the term "jointly modelled".

   (iii) The wording of Article 285(7) of the CRR[169] leads to the conclusion that this article provides an exemption to Article 285(6) of the CRR in case where an institution is not able to model collateral jointly with the exposure. In this case, and in accordance with Article 285(7) of the CRR, the institution is allowed to use volatility adjustments to recognise the effects of margining in the exposure calculation directly such that the institution does not have to apply one of the EEPE calculation measures presented in Article 285(1)(a) or (b) of the CRR.

   (iv) In addition, Article 285(1), (6) and (7) of the CRR is not specific about whether a combination of the two options (use of volatility adjustments and joint modelling) to account for margining effects is possible. Thus, it is not clear if it is possible to use volatility adjustments in line with Article 285(7) of the CRR, together with the jointly modelled risk factors in accordance with Article 285(6) of the CRR, for the collateral modelling in cases where, for some risk

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[168] See the definition in the Counterparty credit risk glossary.

[169] "If an institution is not able to model collateral jointly with the exposure [according to Article 285(6) of the CRR] it shall not recognise […] the effect of collateral […], unless it uses […] volatility adjustments […]."

factors, the institution is able to model some collateral components jointly.

(b) Article 285(7) of the CRR refers to the standards of the Financial Collateral Comprehensive Method (as set out in Article 223 of the CRR, which refers to Articles 224-227 of the CRR) in cases where an institution wants to make use of volatility adjustments to recognise the effect of margining directly in its exposure calculation. Article 223(1) sub-paragraph 3 of the CRR requires institutions to apply a volatility adjustment to reflect mismatches between the collateral currency and the settlement currency for OTC derivative transactions covered by recognised netting agreements. However, Article 223(1) sub-paragraph 3 of the CRR neither defines exactly what the settlement currency is, nor its relationship with the currency in which the exposure is denominated in the context of netting sets with attached margin agreements. In addition, the case of these currencies being different from the reporting currency is not treated explicitly.

(c) Article 292(1) of the CRR requires an institution to ensure the integrity of its modelling process by reflecting, among other things, transaction terms and specifications, which also include margining arrangements. However, it is not specified further how the future collateral composition or the reflection of the actual collateral balance in the IMM's estimated exposure for a netting set should be reflected in the IMM's assumptions.

4.2   Practices

29. The following practices have been observed:

(a) in cases where SFTs are modelled under the IMM, the modelling of the securities of the non-cash margin collateral is not always consistent with the modelling of the security leg of SFTs;

(b) some institutions use the full simulation approach and some use an approach based on volatility adjustments;

(c) assumptions about the future collateral composition (i.e. the breakdown between cash collateral and different types of non-cash collateral) over time show large differences among institutions;

(d) various approaches to the treatment of FX risk in collateral modelling have been observed;

(e) not all institutions perform a proper assessment of the modelled collateral balance at t_0 with respect to the known existing collateral balance[170] at t_0;

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[170]   This is hereinafter referred to as the "real collateral balance".

(f)   in cases where a contractual margined netting set includes both IMM and non-IMM transactions and the institution splits transactions into synthetic netting sets in accordance with paragraph 13, the assignment of the real collateral balance at t_0 to one synthetic netting set or the other is performed in significantly different ways.

4.3   Principles for ECB banking supervision

30. The ECB sees as a best practice the treatment of non-cash margin collateral in a manner consistent with the modelling of securities underlying OTC or SFT transactions, provided that the SFTs are within the IMM scope. For example, if a certain type of security is fully simulated (or if a volatility adjustment is applied) in the security leg of an SFT, then it should also be fully simulated (or a volatility adjustment should also be applied) if its use is as margin collateral. Deviating from the foregoing treatment could also be regarded as acceptable, if the institution is able to demonstrate that (i) its approach does not systematically underestimate exposures, and (ii) the quantitative impact on the final EEPE is not material.

31. In the context of Article 285(6) of the CRR, the ECB understands the provision "an institution shall model collateral […] jointly with the exposure in its exposure value calculation" as follows: the collateral value changes over time and in particular during the MPOR are determined by using the same model as for the calculation of the transactions' value changes. The use of the same model refers in particular to the IMM's general modelling features (including simulated and non-simulated risk factors, the dependency structure, pricing functions, etc.), which should be used for both the calculation of the transactions' value changes and the calculation of collateral value changes applying the same generated scenarios. If some risk factors are not required for the calculation of the transactions' value changes and are only used for the collateral modelling, these risk factors should be modelled consistently with those for derivatives and SFTs within the scope of the IMM, also regarding the dependency structure.

32. Article 285(7) of the CRR provides that, if an institution is not able to model collateral jointly with the exposure, it may use volatility adjustments to recognise the effects of margining on the exposure itself, provided the institution complies with the requirements of the Financial Collateral Comprehensive Method as per Article 223 of the CRR.

In particular, according to Article 223(1) sub-paragraph 3 of the CRR, a volatility adjustment must be applied to reflect currency mismatches. In the light of Article 220(2)(d) of the CRR, the ECB sees, as a best practice, the identification of the currency that is potentially different from the collateral currency as described below.

(a)   When Article 223(1) second sub-paragraph of the CRR uses the term "the currency in which the underlying exposure of the netting set is denominated", and when Article 223(1) third sub-paragraph of the CRR

(for OTC derivative transactions only) uses the term "settlement currency", it is the currency as determined in (b).

(b) It is the currency:

(i) agreed in the individual derivative contract if no netting has been agreed upon;

(ii) of the relevant governing master netting agreement if agreed without a credit support annex; or

(iii) of the relevant credit support annex, if agreed; or

(iv) of the close-out amount if more than one credit support annex has been defined for one master netting agreement.

33. It can be derived from Article 285(6) in conjunction with Article 285(7) of the CRR that an institution can, in order to capture directly the effects of margining in the calculation of exposure values, use:

(a) the option of joint modelling (Article 285(6) of the CRR) for the modelling of all collateral; or

(b) the volatility adjustment option (Article 285(7) of the CRR) for the modelling of all collateral.

In all other cases, the ECB is of the view that using both options would only be compliant with the above CRR articles if volatility adjustments for non-cash collateral are used, while applying the joint modelling option for the treatment of FX risk in the collateral modelling. In this context, it is considered by the ECB as good practice that the above combination can only be made by using jointly modelled FX rates for all currencies. In other words, a partial application of FX volatility adjustments alongside jointly modelled FX rates for the purpose of collateral modelling would not be considered by the ECB as consistent modelling.

34. In order to comply with the requirements laid down by Article 292(1)(a) and (b) of the CRR with respect to the terms of margining and netting arrangements, the ECB is of the view that the future composition of collateral over the lifetime of the netting set should reflect the contractual arrangements in terms of eligible margin collateral or the composition observed historically or at least the current composition of margin collateral.

35. In the view of the ECB, in order to follow Article 292(1)(a) and (b) of the CRR for both unmargined and margined cases, and in conjunction with Article 285(6) and (7) for the margined case, institutions should take into account the following in their modelling process: potential FX risk arising from currency mismatches between (i) any of the various currencies of the exposure components (e.g. various transactions with different currencies, the currency of the governing master agreement, collateral types with different currencies) and (ii) the reporting currency. The ECB considers that potential FX risk is treated in

compliance with Article 292(1)(a) and (b) of the CRR by applying either of the following:

(a) simulation of FX rates for all exposure components at all relevant points in time;

(b) the FX volatility adjustments in accordance with Article 223(1) of the CRR when using the option provided by Article 285(7) of the CRR.
Any potentially remaining FX risk between the collateral currency and the reporting currency that is not already covered by such a volatility adjustment should be taken into account by using additionally the simulated FX rates at the end of the MPOR.[171]

36. The ECB considers it compliant with Article 292(1)(b) of the CRR when the collateral balance at t_0 is "model estimated" (i.e. when the t_0 collateral balance is estimated as a function of the calculated netting set value as of t_0 – using IMM pricing functions and using modelled features of the margin agreement – and is not set equal to the real collateral balance) to benchmark the resulting modelled collateral balance against the real collateral balance at t_0. In this case:

(a) validated but still relevant differences between model-estimated and real t_0 collateral balances should be taken into account in the modelling of future time grid points so that the exposure at default (EAD) is not systematically underestimated;

(b) a full analysis of these differences should be performed at least annually in order to detect and correct the most significant discrepancies, if any.

37. When a contractual margin agreement contains transactions treated under both the IMM and a non-IMM method and therefore the contractual netting set is split into different synthetic netting sets, the ECB considers that the real margin collateral should be assigned to the synthetic netting sets in a way that also reflects their respective current exposures, as defined in Article 272(17) of the CRR. If the institution chooses a different approach (e.g. a full assignment of collateral to only one synthetic netting set), it should be able to demonstrate that its methodology:

(a) is not designed to minimise resulting exposures;

(b) does not double-count collateral;

(c) does not lead to overcollateralisation;

(d) and, therefore, does not systematically result in an underestimation of the resulting exposure values.

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[171] The additional use of simulated FX rates applies to those cases where the currency as per Article 223(1) of the CRR differs from the reporting currency.

5 Modelling of initial margin

38. Initial margin (IM) is already applied in central clearing and currently carries over to bilateral OTC agreements. The modelling issue with respect to CCR is that the IM depends on the risk profile of the future netting set in terms of the levels and volatility of simulated market risk factors and on transactions still alive, i.e. it is a variable agreement parameter.

    To be clear, it should be specified that "IM modelling" refers here to the modelling of IM under the IMM and not, for example, to the implementation of European Market Infrastructure Regulation (EMIR)[172] requirements in the institutions' collateral management in terms of calculating an appropriate level of IM.

5.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	292	(1)(b)
		293	(1)(b)

39. The regulatory provisions relating to the topic addressed in this section that require further guidance are the following:

    (a) Article 292(1)(b) of the CRR, which requires institutions to include, amongst other transaction terms, margining and netting arrangements in the model;

    (b) Article 293(1)(b) of the CRR, which notably requires the comparison of risk measures generated by the model with realised risk measures.

5.2 Practices

40. The following practices have been observed.

    (a) Some institutions keep part of their exposures subject to IM out of the IMM scope (e.g. exchange-traded derivatives, exposures towards central counterparties (CCPs). Therefore, the IM itself is kept outside the IMM.

    (b) For exposures subject to IM that are within the IMM scope, most institutions have a straightforward modelling where the IM is simply kept constant over time. More advanced approaches (e.g. dynamic modelling) have also been observed.

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[172] Regulation (EU) No 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories.

(c)   For exposures subject to IM that are within the IMM scope, most institutions set the level of the IM at t_0 in the modelling at an amount equal to the real IM at t_0.

5.3   Principles for ECB banking supervision

41.   In relation to the requirements set out in Article 292(1)(b) of the CRR, and for exposures subject to IM that are within the IMM scope, the ECB considers as good practice that institutions have an IM modelling reflecting contractual arrangements for the respective netting set.[173] In particular, if contractual arrangements provide that the IM should reflect forward variability of netting set values, the IMM modelling of the IM should take this feature into account.

42.   The ECB considers that, in order to avoid the risk of non-compliance with Article 293(1)(b) of the CRR, the level of the modelled IM at t_0 should be benchmarked on a regular basis against the real IM at t_0. Differences should be taken into account in the modelling (e.g. by using some corrective exposure level add-on if the modelling is not risk sensitive and/or may lead to non-conservative exposures). For the same purpose, the ECB considers that it would be beneficial for institutions to perform a full analysis of the differences on an annual basis so as to detect the most important discrepancies and enhance the modelling, if needed.

6   Maturity

43.   This section refers to the estimation of the parameter M used in the calculation of the risk weight for counterparties, towards which the institution has an IMM exposure and for which the institution uses the internal ratings-based (IRB) approach.

44.   The section also refers to the treatment of contingent transaction maturities, especially where there are early termination clauses (ETCs, also called break clauses) for derivatives and SFTs, and to different CRR interpretations.

Note that transaction maturities (and their changes) affect (i) the M parameter of Article 162 of the CRR, (ii) the shape of the EE(t) time profile, and (iii) the maximum transaction maturity relevant for Article 284(6) of the CRR, where (i) affects the calculation of risk-weighted assets (RWAs) for IRB institutions and (ii) and (iii) affect the calculation of the EEPE and then (via the exposure value) also RWAs.

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[173]   In cases where IM agreements include discretionary elements, institutions are still expected to consider all contractual arrangements to the extent possible when modelling the IM within the IMM, potentially also taking the history of observed IMs into account.

6.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	162	
		284	(4), (6)

45. The regulatory provisions relating to the topic addressed in this section that require further guidance are the following:

    Article 162 (defining the maturity parameter M) and Article 284(4)[174] and (6) (defining the remaining transaction maturity) of the CRR. Contingent transaction maturities and contractual arrangements for early termination are not mentioned in these articles.

6.2 Practices

46. The following practices have been observed:

    (a) institutions usually apply Article 162(2)(g) of the CRR, thus establishing an effective floor for M set at one year;

    (b) only some institutions apply this floor broadly; the others tend to reduce it, when possible, applying different paragraphs depending on whether the longest maturity in the netting set is either below or above one year;

    (c) in the case of daily re-margining, a few institutions apply Article 162(3) of the CRR, either with a floor equal to the relevant MPOR or without any floor, thus also allowing an M of one business day (for exceptional cases);

    (d) mandatory ETCs, and in some cases optional ETCs, are taken into account to shorten the transaction maturities, leading to lower M values.

6.3 Principles for ECB banking supervision

47. Article 162 of the CRR will be understood below for the exclusive purpose of applying the IMM as specified by Part Three, Title II, Chapter 6, Section 6 of the CRR. In the ECB's understanding, the article should apply in the following way:

    (a) paragraph (2)(b) should apply to unmargined derivatives subject to a master netting agreement if the longest-dated contract in the netting set has a maturity of less than or equal to one year;

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[174] Article 284(4) of the CRR stipulates: "The model shall estimate EE at a series of future dates t1, t2, t3 etc."

(b)   paragraph (2)(c) should apply to fully or near-fully collateralised derivatives subject to a master netting agreement if the longest-dated contract in the netting set has a maturity of less than or equal to one year;

(c)   paragraph(2)(d) should apply to unmargined and margined SFTs subject to a master netting agreement if the longest-dated contract in the netting set has a maturity of less than or equal to one year;

(d)   paragraph (2)(g) should apply to all transactions not subject to a master netting agreement, on the one hand, and to multiple transaction netting sets where the maturity of the longest-dated contract is greater than one year, on the other hand, unless the conditions for applying paragraph (2)(i) are satisfied;

(e)   if the conditions of paragraph (2)(i) are fulfilled, setting M to one year should apply only for those transactions or netting sets where the application of paragraphs (2)(a), (b), (c), (d), (f) or (g) would result in M being greater than one year;

(f)   the provisions of paragraph (3) regarding the floor value for M should be used in the following way: when applying paragraph (2)(c) or (2)(d) for the purpose of estimating M for a given netting set, an institution should be allowed to use the floor value provided by paragraph (3) (one business day), insofar as all paragraph (3) requirements are fulfilled.

48.   The CRR is silent on the transaction maturity that should be considered for both the calculation of the EEPE and the calculation of the M parameter in the case of open term repos or, in general, SFTs without an explicitly fixed maturity.

(a)   If the institution has the right to terminate the transaction, in the ECB's view, the transaction maturity should be set at the higher of:

(i)   the average lifetime of the transaction type under consideration in the last two years with the same or comparable[175] counterparties, subject to a cap of one year;

(ii)   five business days.

(b)   If the institution does not have the right to terminate the transaction, the ECB considers that the transaction maturity should be given by the longest past lifetime of transactions with the same or comparable counterparties, subject to a five-year cap.

49.   For derivatives with ETCs:

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[175]   In terms of credit quality (e.g. rating, credit spread) and counterparty type (e.g. government, corporate, central counterparty).

(a) it is seen by the ECB as best practice that non-mandatory ETCs are not used for the calculation of M, which corresponds to Article 162(2) of the CRR (this article aims to deal only with a non-contingent maturity);

(b) the ECB also considers it as compliant with Article 162(2) and (3) of the CRR to use mandatory ETCs for the calculation of M instead of the contractual maturity, because there cannot be any positive exposure after that date due to the provisions of Article 284(4) of the CRR.

50. Internal analyses by the institutions should be able to justify, as the case may be, choices of values of M shorter than:

- five business days for netting sets consisting only of SFTs;

- ten business days for all other netting sets, including the derivative instruments listed in Annex II of the CRR.

In accordance with Article 162(3) of the CRR, provisions for prompt liquidation need to be in place in order to use short M values. If these provisions are different for the M parameter referred to in Article 162 of the CRR than in the IMM exposure modelling of margined trading, the appropriateness of shorter close-out periods would also have to be demonstrated.

51. The ECB sees, as best practice, the estimation of the maturity of physically settled options on derivatives (e.g. swaptions, used for the purpose of calculating the parameter M and for the calculation of the EEPE) on the basis of the maturity date of the underlying derivatives (e.g. the swap underlying the swaption).

7 Granularity, number of time steps and scenarios

52. This section refers to the chosen time grid for the future exposure calculation and the number of scenarios generated. More specifically:

(a) the number and density of time grid points have an impact on the accuracy of EE profiles and thus also on the accuracy of the EEPE;

(b) the number of scenarios and the type of random number generator determine the numerical accuracy of the calculations and thus the statistical error of expected exposures.

7.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	284	(4), (5), (6)
		292	(1)(a), (b)
		293	(1)(a), (c)
		294	(1)
		368	(1)(f)

53. The regulatory provisions relating to the topic addressed in this section that require further guidance are the following.

    (a) In accordance with Article 292(1)(a) of the CRR, an institution must ensure that the model reflects transaction terms and specifications in a timely, complete and conservative fashion. Article 292(1)(b) of the CRR specifies that these terms must include at least the contract notional amounts, maturity, reference assets, margining arrangements and netting arrangements. However, it stays silent on the number of grid points necessary to take cash flows resulting from these terms into account.

    (b) In accordance with Article 284(4) of the CRR, EE must be calculated for time grid points $t_i = 1, 2, 3, \dots$ The output, $EE(t_i)$, is used in the EEPE calculations (Article 284(5) and (6) of the CRR). However, there is no specific requirement as to how to set these t_i values.

    (c) Article 293(1)(c) of the CRR requires an institution to carry out initial and ongoing validation of its CCR exposure model, while Article 294(1) states the requirements that need to be met by the institution's validation programme. While there is no explicit requirement regarding the number of scenarios in Article 294 of the CRR, Article 368(1)(f) of the CRR (which is included in the reference to Part Three, Title IV, Chapter 5 of the CRR made by Article 293(1)(a) of the CRR) requires the internal model to have a proven track record of "reasonable accuracy" in measuring risks.

7.2 Practices

54. The following practices have been observed.

    (a) The number of time grid points used differs across institutions. Most institutions only use static grid points. A few institutions match part of the trade-related cash flows (including final payment at maturity) with dynamic grid points (in addition to static ones) that are specific to each netting set.

    (b) The number of scenarios also differs across institutions, and the resulting numerical errors of the exposure values are estimated at different levels of accuracy and within different validation frameworks.

7.3 Principles for ECB banking supervision

55. Since the modelling process has to reflect transaction terms, as required by Article 292(1)(a) and (b) of the CRR, in the understanding of the ECB the density and location of grid points as defined in Article 284(4) of the CRR should capture intermediate and final transaction-related cash flows depending on notional amounts, maturities, etc. that influence the shape of the exposure profile. The ECB also considers that, if the EEPE calculated with a very dense time grid[176] is more than 5% above the EEPE as calculated by the institution using its standard set of grid points for the whole portfolio or representative sub-portfolios as defined in the counterparty credit risk Glossary, then the ECB can increase the alpha parameter following the process described in section 11.[177]

56. The ECB is of the view that, in order to fulfil the requirements set out in Article 368(1)(f) of the CRR, the estimation and monitoring of the numerical error of the EEPE should be part of the regular validation programme mentioned in Articles 293(1)(c) and 294(1)(d) of the CRR. If the numerical error[178] is more than 5% of the EEPE for the whole portfolio or representative sub-portfolios as –defined in the counterparty credit risk Glossary, the ECB can increase the alpha parameter following the process described in section 11.[179]

8 Calibration frequency and stress calibration

57. The calibration frequency is relevant both for regulatory reporting and for internal risk management (line consumption, etc.) in accordance with Article 286 of the CRR, also in the light of the use test requirements set by Article 289 of the CRR:

    (a) for Pillar 1 purposes, the minimum quarterly frequency required by Article 292(2) of the CRR may be increased to reflect (important) changes in market conditions;

    (b) for internal risk management purposes, the calibration frequency also affects the quality of exposure numbers used for the institution's day-to-day risk management process.

58. To compute own funds requirements for CCR, the ECB considers that institutions should use two different calibrations: one based on current market data and one based on a stress period.

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[176] The expression "very dense time grid" means here a daily grid, unless the institution can show that all cash flows are captured with a coarser time grid.

[177] For example, if the difference is more than 5%, the alpha parameter could be increased by at least 0.05, etc.

[178] See Annex 2 for a description of how to derive the statistical error at a 95% confidence level.

[179] For example, if the error is more than 10%, the alpha could be increased by at least 0.1, etc.

8.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	6	(1)
		284	(3)(b)
		289	(1)
		292	(2), (3), (4)

59. The regulatory provisions relating to the topic addressed in this section that require further guidance are the following.

    (a) Article 289(1) of the CRR requires among other things "that the distribution of exposures generated by the model used to calculate effective EPE is closely integrated into the day-to-day CCR management process of the institution", without further specifying the meaning of "closely integrated".

    (b) According to Article 6(1) of the CRR, "institutions shall comply with the obligations laid down in Parts Two to Five and Eight [of the CRR] on an individual basis".

    (c) In accordance with Article 284(3)(b) of the CRR, institutions must compute the EEPE using a stress calibration. This provision should be read in the light of Article 292(2) of the CRR, which sets out the requirements of the stress calibration, and Article 292(3) of the CRR, which sets out the requirements for the stress period determination.

    (d) In accordance with Article 292(4) of the CRR, the EPE model must use data – implied or historical – that include the data from the stressed credit period and must use such data in a manner consistent with the method used for the calibration of the EPE model to current data. It does not further specify the meaning of "consistent".

60. However, the CRR does not specify the level of a banking group at which the single stress calibration in accordance with Articles 284(3)(b) and 292(2) of the CRR has to be performed for solo capital requirement calculations, if the IMM is applied for different legal entities of a banking group.

8.2 Practices

61. The following practices have been observed:

    (a) a wide use of historical calibration, with recalibration frequencies ranging from daily to yearly;

    (b) the identification of a stress period and the corresponding stress calibration are performed at legal entity level or only at group level;

(c)   some parameters (e.g. drift and mean reversion) are not always calibrated with data from the identified stress period only, but are:

       (i)   kept as under current conditions;

       (ii)   calibrated with longer time series (corresponding to the window length used for the current calibration);

       (iii)   set to particular values or set to satisfy certain boundary conditions.

8.3   Principles for ECB banking supervision

62.   The ECB considers that Article 289(1) of the CRR should be understood as implying that the exposure distribution used for internal risk measurement in the day-to-day CCR management process should be sufficiently up to date for daily line consumption calculations. Accordingly, the revaluation of current exposure for internal risk management purposes should also be performed on a daily basis. The frequency of the recalibration of the parameters of the underlying stochastic processes (such as drift, volatility and correlation) for internal risk management should be at least monthly unless the institution is able to demonstrate that the minimum quarterly frequency required by Article 292(2) of the CRR for the calculation of capital requirements is sufficient to reflect changes in market conditions in an appropriate manner.

63.   Following the requirements of Article 6(1) of the CRR, the ECB is of the view that, if a single stress period is determined in accordance with Article 292(3) of the CRR at group level for the different legal entities that have approval to use the IMM for solo capital requirement calculations, each legal entity should assess the suitability of this single stress period for its own IMM scope.

64.   In order to comply with Article 292(2) and (4) of the CRR, the ECB considers the following as best practice.

(a)   Volatility and correlation parameters pertaining to the stochastic processes underlying the EEPE simulation should be calibrated with the data from the stressed period (i.e. in the case of historical data using the exact three years of data corresponding to the stress period) using the same estimation method as that applied for the current calibration.

(b)   Other parameters underlying the stochastic processes of the EPE model should also be calibrated with the data from the identified stress period (i.e. with the exact three years of data corresponding to the stress period in the case of historical data) using the same estimation method that is applied for the current calibration. An alternative stress calibration method for these parameters would be accepted by the ECB, if the related institution is able to demonstrate that its approach is consistent with its current calibration and does not systematically underestimate exposures.

9 Validation

65. This section refers to the validation framework set up by institutions to assess the performance of the CCR exposure model, in particular back-testing methodologies, the validation of pricing functions and further checks on key modelling assumptions.

9.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	287	(2)
		292	(1)(a), (g), (6)(a)
		293	(1)(b), (c), (4)
		294	(1)(c), (d), (e), (g), (h), (i), (j), (l), (o)

66. The regulatory provisions relating to the topic addressed in this section that require further guidance are as follows.

(a) Article 287(2) of the CRR states that the risk control unit is expected to be responsible for the initial and ongoing validation of the model. Furthermore, Article 293(1)(c) of the CRR provides that the validation and review must be independent of model development, which needs to be reconciled with Article 287(2) of the CRR given that model development is usually also done within the risk control unit.

(b) Article 293(4) of the CRR requires, among other things, that institutions "maintain a written policy that describes the process by which unacceptable performance will be identified and remedied", without further describing what constitutes unacceptable performance and what the remedies might be.

(c) According to Article 292(6)(a) of the CRR, "an institution shall subject the model to a validation process that specifies the kind of testing needed to ensure model integrity and identify conditions under which the assumptions underlying the model are inappropriate and therefore result in an understatement of EPE". However, the CRR does not further specify which assumptions should form part of the validation process.

(d) Article 293(1)(b) of the CRR requires institutions to conduct "a regular programme of back-testing", but does not further specify the frequency of the back-testing.

(e)   Regarding the requirements laid out with respect to back-testing levels[180] and methodologies, Article 294(1)(c) of the CRR provides that "an institution shall back-test the performance of its CCR exposure model and the model's relevant risk measures as well as market risk factor predictions", without mentioning any restrictions. Article 294(1)(h) of the CRR requires the model validation process to "include static, historical back-testing on representative counterparty portfolios that are actual or hypothetical", not specifying whether the "or" in this sentence is an inclusive or exclusive "or". According to Article 294(1)(i) and (j) of the CRR, "back-testing shall be designed to test the relevant risk measures" and furthermore "be appropriate and capable of identifying poor performance in an EPE model's risk measure".

(f)   Article 294(1)(g) of the CRR states that "as part of the initial and on-going validation of its CCR exposure model and its risk measures, an institution shall ensure that the CCR exposure model includes transaction-specific information to capture the effects of margining", without specifying any further details of the expected validation tasks.

(g)   Article 292(1)(a) of the CRR requires that the model reflect transaction terms and specifications in a timely, complete and conservative fashion (also regarding pricing and the market data to be used). Article 292(1)(g) of the CRR requires ongoing processes for reconciliation between the model and source data, which verify that transaction terms and specifications are reflected correctly or at least conservatively.

(h)   Article 294(1)(e) of the CRR provides that, as part of the initial and ongoing validation process, an institution "shall test the pricing models used to calculate CCR exposure for a given scenario of future shocks to market risk factors", as well as regularly testing these pricing models against appropriate independent benchmarks in accordance with Article 294(1)(l) of the CRR.

(i)   As outlined in Article 294(1)(o) of the CRR, "the initial and on-going validation of CCR exposure models shall assess whether or not the counterparty level and netting set exposure calculations of exposure are appropriate". Article 294(1)(d) of the CRR provides that "if the model validation indicates that effective EPE is underestimated, the institution shall take the action necessary to address the inaccuracy of the model". Both requirements are set out in a general way and therefore need further guidance.

(j)   Article 292(1)(a) of the CRR requires the model to reflect transaction terms which must be ensured by formal reconciliation processes between the model and source data in accordance with point (g) of the same article.

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[180] Back-testing levels refer to the risk factor level, the transaction level, and the actual and/or hypothetical portfolio level.

9.2   Practices

67. The following practices have been observed.

   (a) In most cases, various teams within the institution contribute to model validation.

   (b) Looking at validation frameworks in general, back-testing still seems to be the activity to which most attention is given, compared with work regarding the validation of stochastic processes, pricing functions or margining. Further validation of all kinds of modelling assumptions is not systemically in place.

   (c) Frequencies of validation, especially for back-testing, differ greatly across the institutions, but also depend on the kind (e.g. statistical measure or prediction horizon) and level of back-testing analysis. Back-testing is mainly conducted on a quarterly basis, but within a range that goes from weekly to every 1.5 years.

   (d) While back-testing at the risk factor and actual portfolio levels is common practice, further analysis at the level of actual or hypothetical transactions and of hypothetical portfolios is not conducted in every institution. Moreover, the number and the share of back-tested risk factors, transactions and portfolios vary significantly. It was observed that back-testing coverage ratios (i.e. shares of back-tested risk factors, transactions and portfolios) were estimated using very different approaches and definitions of these ratios.

   (e) Some institutions build back-testing samples with forecasts over fully overlapping time periods (i.e. distinct variables over the same forecasting period are tested simultaneously) or partly overlapping time periods (i.e. tests built on a single variable and different successive but overlapping observation periods). It was observed that only some of the institutions account for these dependencies by adapting the respective back-testing test statistic.

   (f) While a couple of institutions use the IMM pricing functions to compute back-testing realisations, most take realised values from benchmarking systems.

   (g) Concerning the risk measures and metrics used in the back-testing approaches, it was observed that some of the institutions only perform back-testing on the market value at portfolio level, while others extend the analysis to exposure distributions and/or metrics, such as EE or potential future exposure (PFE) or even EPE. With respect to margined trading, meaningful back-testing techniques to assess the exposure (taking into account the collateral balance and margin mechanism) are not yet common practice.

(h)　All institutions have established a benchmarking of IMM pricing functions on an ongoing basis. Furthermore, it was observed that some institutions use benchmark prices before the independent price verification (IPV) process.

(i)　It was observed that for IMM transactions whose related exposure is not fully simulated (e.g. due to the use of approximated pricing functions or alternative exposure calculations), dedicated validation tasks are not systematically in place.

9.3　Principles for ECB banking supervision

68.　In accordance with Article 293(1)(c) of the CRR, validation/review and model development must be independent, that is, the validation function must be effectively separated from model development. Hence, the ECB considers that for cases where operational parts of the validation framework, e.g. back-testing runs or benchmarking of IMM pricing functions, are conducted by staff also responsible for model design and development, the above-mentioned requirement provided for by Article 293(1)(c) of the CRR would be fulfilled if all of the following practices were implemented:

(a)　the respective validation task is conducted on behalf of the validation function;

(b)　a regular, independent and effective challenging of the underlying methodological aspects of the respective validation task comprising scope, data samples, tools, etc., is performed by the validation function;

(c)　the assessment of the outcomes of the analysis (e.g. the evaluation of back-testing traffic lights or pricing deficiencies detected in the benchmarking) and the judgement regarding respective remediation measures are the responsibility of the validation function only.

Moreover, the ECB considers that the organisational requirements of the risk control unit (see Article 287(2) of the CRR) should be regarded as fulfilled when (part of) the initial or ongoing validation of the model is conducted by staff not belonging directly to the risk control unit, but for instance to a separate validation unit.[181]

As part of the process by which unacceptable performance will be identified and remedied in accordance with Article 293(4) of the CRR, the ECB considers that it is good practice to ensure a comprehensive view of all the findings, problems, weaknesses and limits of the exposure model, identified by all staff contributing to the validation and review of the exposure model.

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[181]　Please refer to section 2.6 of the general topics chapter of this guide regarding the expectation that the internal audit function should not be responsible for validation.

69. The validation framework is expected to cover the kind of testing needed to ensure model integrity and the appropriateness of assumptions underlying the model in accordance with Article 292(6)(a) of the CRR. The ECB considers as best practice the inclusion of various types of analyses on the key modelling assumptions in a regular validation schedule. In particular, it is the ECB's understanding that the key modelling assumptions refer to the validation of the grid point setting, the chosen stochastic processes in the event of poor back-testing results, the monitoring of the Monte Carlo error of the EEPE (see paragraph 56), an assessment of expert-set parameters and boundaries in use (such as caps and floors for risk factor paths) and modelling features regarding the MPOR setting.

70. In order to comply with Article 293(1)(b) of the CRR, the ECB sees it as best practice if back-testing is performed and reported on at least once a year.

71. In accordance with Article 294(1)(c) of the CRR, back-testing of risk factor levels is mandatory. In the ECB's view, not all key assumptions of the CCR exposure model (mentioned in Article 294(1)(i) of the CRR) can be captured when back-testing is only conducted on hypothetical portfolios, in particular when looking at non-plain vanilla transactions. Hence, in the view of the ECB, Article 294(1)(h) of the CRR should be read as also including back-testing of actual portfolio levels.

72. In order to support the analysis of portfolio back-testing and mitigate the risk of breaching Article 294(1)(e) and (i) of the CRR, it is recommended and seen as good practice to include back-testing at single transaction level in the regular framework.

73. According to Article 294(1)(h) of the CRR, back-testing samples[182] must be representative and chosen on the basis of their sensitivity to material risk factors as well as their combinations. As stated in paragraph (j) of the same article, the institution's back-testing programme must be capable of identifying poor performance of an EPE model's risk measures. As a result, the ECB considers that back-testing samples should allow for a meaningful assessment of the CCR exposure model and that institutions should ensure a comprehensive coverage of their back-testing framework by calculating back-testing coverage ratios, at least at risk factor and actual portfolio levels. In particular:

    (a) next to a simple number-based[183] approach, institutions should take into account different weighting schemes like sensitivities and exposure metrics;

    (b) at risk factor level, in addition to the full risk factor set[184], coverage ratios should also be provided by asset class;[185]

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[182] Comprising the subset of risk factors, transactions or portfolios used for the purpose of back-testing.

[183] This means, for example, the number of risk factors, the number of portfolios that are covered, etc.

(c)   whenever ratios are less than [50%], institutions should be able to provide an explanation justifying the level of the ratio.

Such coverage ratios should form part of the back-testing reports.

Furthermore, it is the ECB's understanding that in order to comply with the representativeness requirements stated in Article 294(1)(h) of the CRR, SFTs should be included in the back-testing samples if they are within the IMM scope.

74.   The ECB considers that statistical tests used for back-testing should be adapted when back-testing samples contain forecasts over fully or partially overlapping time periods (compared with standard versions of statistical tools applicable for the case of non-overlapping forecasts) to account for dependencies in the sample and therefore serve as a proper indicator of the model performance. In the view of the ECB, this practice would avoid the risk of being in breach of Article 294(1)(j) of the CRR.

75.   Where back-testing relies only on IMM pricing functions for both predictions and realisations (i.e. realised prices derived from benchmarking systems are not taken into account), the attention given to the assessment of the adequacy of IMM pricing functions (as provided for by Article 294(1)(e) and (l) of the CRR and further described in paragraphs 78 and 79 of this chapter) is seen to be even more important. Consequently, in the view of the ECB, institutions should strengthen their validation of IMM pricing functions accordingly.

76.   In order to ensure appropriate back-testing practices as required by Article 294(1)(j) of the CRR, the ECB sees it as good practice to pay special attention to the consistency of predictions and realisations in the case of actual portfolio back-testing; in other words, changes of the portfolio composition during the observation period (e.g. due to new or closed-out transactions) should be handled accordingly.

77.   In accordance with Article 294(1)(c), (e) and (g) of the CRR as understood by the ECB in paragraphs 71 and 72 of this chapter, the ECB sees benefit in back-testing different relevant risk measures, including the market value[186] at transaction level, the market value of netting sets[187] as well as the exposure at netting set level.[188] If direct back-testing of the exposure of margined netting sets is not feasible, institutions should have a separate validation of the margining process, of collateral value changes and of netting set market value changes over the relevant time horizons.

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[184]   Note that the set of risk factors should include all underlying risk factors/drivers that are integrated into the IMM exposure model (not differentiating between whether risk factors are directly or implicitly diffused).

[185]   It should be noted that for a sensitivity-based approach, coverage ratios by asset class only are sufficient.

[186]   Market values can be either positive or negative.

[187]   This means the sum of all transaction market values within that netting set. This sum can be positive or negative.

[188]   Exposure should always take into account the collateral balance and margin mechanism. In the case of unmargined netting sets, the collateral is zero.

78. In order to reduce the risk of breaching Article 292(1)(a) and (g) of the CRR, and based on the requirements of Article 294(1)(l) of the CRR, institutions should compare the values of pricing functions used for revaluation under the IMM with values from a benchmarking system on a regular basis. The ECB understands Article 294(1)(o) of the CRR as requiring a corresponding full analysis of the differences and their root causes so as to detect and correct, when needed in accordance with Article 294(1)(d) of the CRR and with paragraph 15, the most significant discrepancies.

79. Following the purpose of Article 294(1)(e), (l) and (o) of the CRR and in accordance with the understanding of the ECB described in paragraphs 78 and 19, the ECB views it to be best practice if institutions assess the following within their validation framework.

    (a) Whether deviations from a full simulation[189] are documented and justified.

    (b) Whether the effect of using approximated pricing functions instead of those from any reliable benchmarking system is not significant.

    (c) Whether, for all approximated pricing functions, the value changes due to risk factor changes occurring in IMM simulated paths are reliable compared with value changes from non-approximated pricing functions (from any reliable benchmarking system) for the same transaction type.

    [If OPTION 2 in paragraph 19, point (d) also holds:]

    (d) If alternative exposure calculations are used, the ECB considers that the items mentioned in paragraph 19(b) of this chapter should also be met. Furthermore, validation should ensure that alternative exposure methods are applied in a way that does not lead to a systematic underestimation of exposures compared with the standardised methods of Part Three, Title II, Chapter 6 of the CRR and with the full simulation for the affected transactions.
    In the ECB's understanding, transactions treated with alternative exposure methods should be included in the back-testing framework. In order to fulfil the requirements set in Article 294(1)(o) of the CRR, the ECB sees benefit in also analysing affected transactions separately rather than mixing effects when back-testing is only conducted at actual portfolio level. Additionally, the netting benefits (numerical impact) when using any type of alternative exposure method should be assessed by comparing the results with:

        (i) the splitting of the transactions into synthetic netting sets differentiating between the "standard" IMM calculation and the alternative exposure method;

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[189] As described in footnote 158.

10   Effective expected positive exposure

80. This section refers to the normalisation of weights Δt_k that are used in the calculation formula for the EEPE.

10.1   Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	284	(6)

81. The regulatory provisions relating to the topic addressed in this section that require further guidance are the following:

The calculation formula for the EEPE, which appears in Article 284(6) of the CRR.

82. If the Δt_k weights are always expressed in units of one year, also for cases where the duration of the longest-lasting transaction in a netting set (T) is either greater or lower than one year, then the EEPE is underestimated for the netting sets where T < 1 year, since

$$\sum_{k=1}^{min\{1\ year, maturity\}} \Delta t_k < 1, \qquad if\ T < 1 year\ .$$

10.2   Practices

83. Different practices can be followed and capital underestimations can happen if T is less than one year.

10.3   Principles for ECB banking supervision

84. In the view of the ECB, Article 284(6) of the CRR should be understood as requiring that the sum of the weights is equal to one:

$$\sum_{k=1}^{min\{1\ year, maturity\}} \Delta t_k = 1$$

using the CRR notation, i.e. if the Δt_k weights are originally expressed in units of a year but if the longest maturity of the netting set is less than one year (e.g. T =

0.5 year), then all Δt_k weights should be rescaled (enlarged) with $1/T > 1$ (in this example by $1/T = 2$).

11 Alpha parameter

85. The alpha multiplier affects all netting sets and thus all counterparties and should be considered as intending to capture extra risk arising from the fact that exposures are correlated with credit drivers (e.g. probability of default, loss given default) and to address general deficiencies in the IMM framework. Alpha is the only parameter besides capital buffers that can be increased explicitly to account for such deficiencies.

11.1 Relevant regulatory references

	Date of issue	Article	Paragraph/Point
Legal background			
CRR	26/06/2013	284	(4)
		293	(1), (2)

86. The regulatory provisions relating to the topic addressed in this section that require further guidance are the following:

   (a) Article 284(4) of the CRR defines the exposure value as the product of alpha and the EEPE with "α = 1.4, unless competent authorities require a higher α or permit institutions to use their own estimates in accordance with paragraph 9 [of Article 284 of the CRR]";

   (b) Article 293(2) of the CRR, based on Article 284(4) of the CRR, links the level[190] of the supervisory alpha setting to the degree with which the institution meets the requirements for the risk management system as set out in Article 293(1) of the CRR;

   (c) Article 293(1) of the CRR refers in particular to overall validation, adequate processes, integration into the day-to-day risk management process and limit utilisation (use test), documentation and independent reviews.

11.2 Practices

87. It was observed that only one country within the scope of the Single Supervisory Mechanism (SSM) made use of the possibility to increase alpha

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[190] This refers to levels higher than the floor value of 1.4 for the non-modelled and 1.2 for the modelled alpha parameter in accordance with Article 284(4) and (9) of the CRR.

(pre-SSM) to higher values than the floor of 1.4 in the event of model deficiencies.

11.3   Supervisory actions

88.   In accordance with Article 284(4) of the CRR, the ECB can increase the alpha parameter in a proportionate and appropriate way for either an interim or an undefined period to address model, risk management or governance deficiencies identified by the ECB. In particular, targeted deficiencies may include (i) model deficiencies, which lead or may lead to an underestimation of the EEPE as defined in Article 284(5) and (6) of the CRR and Article 285 of the CRR for margined trading, or (ii) deficiencies in the validation framework.

It should be noted that:

(a)   both supervisory alpha increases related to an interim period and those related to an undefined period require explicit supervisory decisions;

(b)   if alpha is increased for an interim period, the decision will specify the length of the interim period or the condition when it ends.

89.   The ECB can base the amount of a potential alpha increase above the floor values to the extent possible on an available impact analysis.

(a)   The analysis assesses[191] the impact on the EEPE as calculated without the identified model deficiency.

(b)   As this deficiency is obviously related to the standard configuration of the IMM, which contains this deficiency, an impact calculation based only on a subset of the relevant portfolio could be accepted for this purpose. This calculation can be performed in a well-defined developer area for representative) sub-portfolios (as defined in the counterparty credit risk Glossary).

(c)   Some non-exhaustive examples of how identified model deficiencies can increase alpha are discussed in this document (see for example paragraphs 24, 55 and 56), where the general alpha increase (applied to all netting sets) reflects whether the identified deficiencies possibly affect only a part of the netting sets (e.g. only the margined ones).

(d)   The ECB considers that increases should be in multiples of half a decimal point. For example, if alpha = 1.4, alpha becomes at least 1.45 if an increase is deemed necessary.

If no impact calculations are available, the ECB may estimate the amount of the alpha increase in a conservative way using all other available information.

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[191]   This assessment can also include less precise estimations, where needed.

90. If there is evidence that the final alpha parameter after applying an alpha increase could become higher than [2.0], the ECB may instead propose to apply one of the standardised exposure methods in Part Three, Title II, Chapter 6 of the CRR as described in Section 3 or 5 for all CCR exposures; in other words, the ECB may withdraw the model approval for the IMM, because in that case the ECB may not be satisfied that the requirements of Section 6 are still fulfilled.

Annexes

1 Calculation of exposure spikes

This annex specifies how the capital add-on mentioned in paragraph 24 can be calculated. It starts by assuming that exposure spikes can be calculated for all counterparties and all netting sets. At the end of this annex, this assumption is relaxed and a method to obtain an overall capital add-on is shown given that spike calculations can be done only for some representative netting sets.

The following definitions are given for margined netting sets:

> the *full exposure metric*, $EE_{full}(t)$, is the EE time profile resulting from a CF modelling that complies with the requirements of paragraph 23;

> the *smooth exposure metric*, $EE_{smooth}(t)$, is the EE profile resulting from a modelling assumption that no CFs are paid or received within the MPOR;

> the *spike exposure metric*, $EE_{spike}(t)$, is the net profile including only the jumps in exposure that are caused by CFs.

A daily time grid for exposure calculations up to the one-year time horizon should be implemented when possible. The ECB recommends the application of full revaluation (avoiding interpolation techniques). The application of any interpolation or proxy valuation method rather than full revaluation would require a dedicated validation task.

Two possible options, A and B, to calculate $EE_{spike}(t)$ are presented here.

Option A: Calculate the two exposure profiles defined above: $EE_{full}(.)$ and $EE_{smooth}(.)$. Both profiles are then estimated on the same time grid. The $EE_{spike}(.)$ profile is defined as follows: Per grid point t:

- $EE_{spike}(t) := EE_{full}(t) - EE_{smooth}(t)$.

Option B: Calculate the (net[192]) paid CFs for each simulated path (scenario vector for all simulated risk factors) using the same back-office data as for $EE_{full}(t)$ on CF dates and for types of CF (fixed coupon, floating coupon, option exercise, final maturity, etc.) and estimate $EE_{spike}(t)$ for each daily grid point t as the expected value of the (net) paid CFs using all simulated scenarios. Note that this daily grid would need only daily risk factor simulations, and no full netting set revaluations (or interpolations). Simplified price functions can be used for those transactions contributing a net paid CF in the MPOR related to a certain grid point t to get, for example, a floating swap coupon or option payout at maturity. Option B requires the use of the length of the period where net paid CFs occur for all Δt_i values in the add-

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[192]   This depends on enforceable settlement netting; the rules of paragraph 23 apply.

on formula in paragraph 24(a)(i), normalised as described in paragraph 24(a)(iii). For option A, the smooth exposure profile, $EE_{smooth}(.)$, can be obtained from at least one of the following three variants,[193] which ignore the (usually small[194]) ageing effects due to time elapsing ("theta" effect) and discounting effects within the MPOR:

(a) Variant 1: Freeze the respective netting set composition (in terms of transactions still alive and regarding paid vs. not-yet-paid CFs) as of the end time of MPOR, t_{end}, implicitly assuming that any CF paid or received during the MPOR is properly settled. Let $PV^{t_{end}}(t_{start+i})$ denote the PV of the netting set with portfolio composition as of t_{end} revalued using the market data as of $t_{start+i}$,[195] where t_{start} is the start time of the MPOR; the simulated smooth netting set PVs during the MPOR are given by:

$$\{PV^{smooth}(t_{start}), PV^{smooth}(t_{start+1}), \dots, PV^{smooth}(t_{end})\}$$
$$= \{PV^{t_{end}}(t_{start}), PV^{t_{end}}(t_{start+1}), \dots, PV^{t_{end}}(t_{end})\}.$$

(b) Variant 2: Freeze the netting set composition as of the start time of the MPOR, t_{start}, implicitly assuming that any CF paid or received during the MPOR is not settled. Let $PV^{t_{start}}(t_{start+i})$ denote the PV of the netting set with composition as of t_{start} revalued using the market data as of $t_{start+i}$; the simulated smooth netting set PVs during the MPOR are given by:

$$\{PV^{smooth}(t_{start}), PV^{smooth}(t_{start+1}), \dots, PV^{smooth}(t_{end})\}$$
$$= \{PV^{t_{start}}(t_{start}), PV^{t_{start}}(t_{start+1}) \dots, PV^{t_{start}}(t_{end})\}.$$

(c) Variant 3: This variant assumes that full netting set PV revaluations are available during the MPOR. It uses the netting set composition as of the respective day within the MPOR, but corrects for CFs either paid or received between t_{start} and t_{end}. This can be achieved, for example, by obtaining the CF status at the beginning of the MPOR, option (a), or the one at the end of the MPOR, option (b). For any day s within the MPOR, $s \in [t_{start}, t_{end}]$, the expression TF(interval) denotes the sum of all due[196] CFs accrued over the interval with interval ≥ 1 business day and seen from the institution's perspective, i.e. CFs paid have a positive sign (they increase exposure) and CFs received have a negative sign. The simulated smooth netting set value at day s is then given by:

(a) $PV_{t_{start}}^{smooth}(s) = PV^s(s) - \begin{cases} TF([t_{start}, s - 1bd]), & t_{start} < s \leq t_{end} \\ 0, & s = t_{start} \end{cases}$,

(b) $PV_{t_{end}}^{smooth}(s) = PV^s(s) + \begin{cases} TF([s + 1bd, t_{end}]), & t_{start} \leq s < t_{end} \\ 0, & s = t_{end} \end{cases}$.

The expected smooth exposure, $EE_{smooth}(t)$, is calculated by averaging over the positive part of the smooth netting set PVs per scenario.

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[193] Institutions can decide on a different approach.

[194] This is not the case, for example, for options shortly before maturity.

[195] This equals t_{end} if the index, which counts the number of business days after t_{start}, is the length of the MPOR.

[196] "Due" means that these CFs would be paid or received in the absence of a default. For the purpose of calculating TF, all paid and received CFs of the whole netting set need to be netted.

Institutions are asked to give a documented rationale for the option/variant they have chosen to calculate the spike exposure metric.

If the **spike add-on** as defined in paragraph 24 for one netting set **can only be calculated for representative margined netting sets** (rather than for all sets), the following process to obtain proxy add-ons applies.

Definitions:

- the *spike-reduced sample add-on value*, $SUMaddon_{SRS}$, is the sum of all spike add-ons in accordance with paragraph 24(a)(i) calculated by the bank for a subset of or all netting sets;

- the exposure value of the reduced sample, EAD_{SRS}, is the exposure value added across all representative netting sets also used for the spike calculation in $SUMaddon_{SRS}$ based on the current model;

- $EAD_{current\,i}$ is the exposure value of netting set *i* of the current model.

Algorithm to obtain spike add-ons for all margined netting sets in the form of pseudo code:

If netting set $i \in$ of the reduced sample, then

> use the already available $addon_i$ of paragraph 24(a)(i)

else

$$addon_i = factor_i \cdot SUMaddon_{SRS}$$

> with

$$factor_i = 1.1 \cdot \frac{EAD_{current\,i}}{EAD_{SRS}}$$

end if

Note that $factor_i$ may also use information from other counterparties, depending on the extent to which other counterparties contribute to $SUMaddon_{SRS}$. This is done intentionally to improve its quality. It is increased by a safety margin of [10%] to compensate for the fact that certain netting sets are not in the "accurate" sample.

For all **un-margined netting sets**: $addon_i = 0$.

For the purpose of calculating a potential alpha increase, the following algorithm applies to all the netting sets that the institution has.

Definitions:

- $effective\,EPE_i$ is the effective EPE (EEPE) for netting set *i*;

- $\Delta\alpha$ is the alpha increase (to be added to the current alpha).

Then $\Delta\alpha$ is calculated as:

$$\Delta\alpha = \alpha \cdot \frac{\sum_i addon_i}{\sum_i effective\ EPE_i},$$

where the sum runs over all netting sets (of all counterparties) that the institution has. The resulting $\Delta\alpha$ is, in general, subject to rounding.

2 Calculation of the Monte Carlo error

This annex presents how the numerical error on the effective EPE (EEPE) estimation, referred to in paragraph 56, could be calculated in the case of a pseudo Monte Carlo (MC) simulation as a statistical error.

The MC error on the EEPE is defined as an aggregation of the MC error on the different netting sets. At netting set level, the MC error on the EEPE is defined as half the length of the 95% two-sided confidence interval centred around the sample estimated EEPE.

Two methods are proposed for the calculation performed at the netting set level. These are described in the "Method 1" and "Method 2" sections. How the MC error should be inferred for a whole portfolio consisting of several netting sets is detailed below in the "Aggregation" section.

Note that the methods below apply to banks that use a pseudo Monte Carlo simulation method and not to banks that apply a quasi Monte Carlo simulation method. In this context, a pseudo Monte Carlo simulation method is defined as a method that utilises a random number generator based on an algorithm creating a sequence of desired length N of numbers that mimic independent samples drawn from a uniform distribution. A quasi Monte Carlo simulation method is defined as a method that utilises a low-discrepancy sequence of numbers, which is deterministically uniformly distributed (e.g. Sobol).

An institution using a quasi Monte Carlo simulation method should provide an alternative analysis showing that its approach uses an adequate choice of low-discrepancy sequences and an appropriate number of scenarios to achieve a reasonable accuracy as required by Article 368(1)(f) of the CRR (as referenced by Article 293(1)(a) of the CRR). This analysis should include an assessment of convergence and an error estimation.

In the following, "MC run" refers to a pseudo MC simulation with N scenarios calculated with one particular set of random numbers.

Method 1

Let $\widehat{EEPE_N}(\alpha)$ denote the estimator of the EEPE for one given netting set α obtained from one MC run with N simulations (e.g. $N = 2000$).

The institution can estimate an MC error on $\widehat{EEPE_N}(\alpha)$, on the basis of a 95% confidence level, by using a set of several MC runs. In what follows, notations are

simplified: $\widehat{EEPE_N}(\alpha)$ is replaced by $\widehat{EEPE}$; α and N are dropped since the calculations detailed below are performed on the same netting set α and with the same number of simulations per MC run, N.

Furthermore, let m denote the size of the set of MC runs (e.g. $m = 50$). The different MC runs are obtained by running the MC simulation with different random numbers (e.g. by using different seeds).

The MC error on $\widehat{EEPE}$ calculated with method 1 is defined as:

$$\widehat{error}_{M1}\left(\widehat{EEPE}\right) := \Phi^{-1}(0.975) \cdot convAdj(m) \cdot \sqrt{\widehat{var}_{M1}\left(\widehat{EEPE}\right)}$$

$$\simeq 1.96 \cdot convAdj(m) \cdot \sqrt{\widehat{var}_{M1}\left(\widehat{EEPE}\right)} \, ,$$

with

$$\widehat{var}_{M1}\left(\widehat{EEPE}\right) := \frac{1}{m-1} \sum_{k=1}^{m} \left(\widehat{EEPE}^k - \frac{1}{m}\sum_{l=1}^{m}\widehat{EEPE}^l\right)^2 ;$$

- $\widehat{EEPE}^k$ denoting the estimation of $EEPE$ using the k-th run of the MC run set;

- Φ^{-1} standing for the inverse cumulative function of a standard normal distribution.

By using $\Phi^{-1}(0.975) \approx 1.96$, we arrive at the following error formula:

$$\widehat{error}_{M1}\left(\widehat{EEPE}\right) := 1.96 \cdot convAdj(m) \cdot \sqrt{\frac{1}{m-1} \sum_{k=1}^{m} \left(\widehat{EEPE}^k - \frac{1}{m}\sum_{l=1}^{m}\widehat{EEPE}^l\right)^2}$$

The rationale of this formula is as follows.

If we assume that $\widehat{EEPE}$ follows a normal distribution, $\widehat{error}_{M1}\left(\widehat{EEPE}\right)$ can be interpreted as half of the length of the 95% two-sided confidence interval centred around $\widehat{EEPE}$. More precisely, it is estimated through a three-step approach:

1. $\Phi^{-1}(0.975)\sqrt{var\left(\widehat{EEPE}\right)}$ is half of the length of the 95% two-sided confidence interval centred around $\widehat{EEPE}$, since we have:

$$P\left(EEPE \in \left[\widehat{EEPE} - \Phi^{-1}(0.975)\sqrt{var\left(\widehat{EEPE}\right)} \, , \right.\right.$$
$$\left.\left. \widehat{EEPE} + \Phi^{-1}(0.975)\sqrt{var\left(\widehat{EEPE}\right)}\right]\right) = 95\% \, .$$

2. $\sqrt{var\left(\widehat{EEPE}\right)}$ being unknown, it is approximated by $\sqrt{\widehat{var}_{M1}\left(\widehat{EEPE}\right)}$. The length of the two-sided 95% confidence interval, $\Phi^{-1}(0.975)\sqrt{var\left(\widehat{EEPE}\right)}$, is then approximated by $\Phi^{-1}(0.975)\sqrt{\widehat{var}_{M1}\left(\widehat{EEPE}\right)}$.

3. However, one must take into account that whenever m is too small (e.g. $m < 50$), $\widehat{var}_{M1}\left(\widehat{EEPE}\right)$ may not have properly converged to $var\left(\widehat{EEPE}\right)$.

Finally, $\Phi^{-1}(0.975)\sqrt{var\left(\widehat{EEPE}\right)}$ is estimated by

$$\Phi^{-1}(0.975) \cdot convAdj(m) \cdot \sqrt{\widehat{var_{M1}}\left(\widehat{EEPE}\right)},$$

where $\cdot$ $convAdj(m)$ takes into account the fact that $\widehat{var_{M1}}\left(\widehat{EEPE}\right)$ may not have properly converged to $var\left(\widehat{EEPE}\right)$.

Details of $convAdj(m)$:

The parameter $convAdj(m)$ is chosen such that

$$P\left(\sqrt{var\left(\widehat{EEPE}\right)} < convAdj(m)\sqrt{\widehat{var_{M1}}\left(\widehat{EEPE}\right)}\right) = 95\%$$

holds. More precisely, still under the assumption that $\widehat{EEPE}$ has a normal distribution, one can write:

$$\frac{m-1}{var(\widehat{EEPE})}\widehat{var_{M1}}\left(\widehat{EEPE}\right) \sim \chi^2_{m-1} \qquad (1)$$

where χ^2_{m-1} denotes a standard chi-squared distribution with $m-1$ degrees of freedom.

From (1), we get $P\left(var\left(\widehat{EEPE}\right) < convAdj(m)^2\ \widehat{var_{M1}}\left(\widehat{EEPE}\right)\right) = 95\%$ with

- $convAdj(m) = \sqrt{\dfrac{m-1}{q(m-1;97.5\%)}}$,

- $q(m-1;97.5\%)$ is such that $P(q(m-1;97.5\%) \leq Z) = 97.5\%$ with $Z \sim \chi^2_{m-1}$.

Here are the values of $convAdj(m)$ for a subset of possible values of m:

m	$convAdj(m)$
10	1.83
16	1.55
20	1.46
50	1.25

Method 2

As in the previous section, we denote $\widehat{EEPE}_N(\alpha)$ as the estimator of the EEPE for one given netting set α obtained from one MC run with N simulations (e.g. $N = 2000$) and, as in the previous section, we simplify the notation $\widehat{EEPE}_N(\alpha)$ as $\widehat{EEPE}$.

The second method to estimate the error on $\widehat{EEPE}$ is a method where only one MC run is needed (contrary to method 1 where a set of m MC runs was needed).

Before presenting the method for the estimation of the MC error, let us detail some definitions and notations. For any time point t_k of the time grid used for exposure

calculations, we denote $E(t_k)$ as the netting set exposure at time t_k and $EE(t_k)$ as its expected value. Let $\widehat{EE}(t_k)$ be the estimator of $EE(t_k)$ based on the MC run, i.e.

$$\widehat{EE}(t_k) = \frac{1}{N} \sum_{j=1}^{N} E_j(t_k),$$

where $E_j(t_k)$ stands for the netting set exposure level at time t_k for scenario j.

The following equations holds if the EEPE is not dominated by the current exposure $E(t_0)$, meaning there is at least one t_k below one year with $E(t_0) < \widehat{EE}(t_k)$ – otherwise the numerical error of the EEPE is in any case zero. For the sake of simplicity, it is also assumed that $EE(t_0) < \widehat{EE}(t_1)$.

The *effective reference dates* are the subset of dates t_k among the simulation dates $(t_h)_{h>0}$ such that

$$EE(t_k) > \max_{0 \leq h < k} EE(t_h) \,.$$

Let us denote $(s_u)_u$ these effective reference dates with

$$s_1 < s_2 < \cdots < s_u < \cdots < s_p \leq t_{1y} \,,$$

i.e. p dates.

For the given MC run, the estimated effective reference dates are the subset of dates t_k among the simulation dates $(t_h)_{h>0}$ such that :
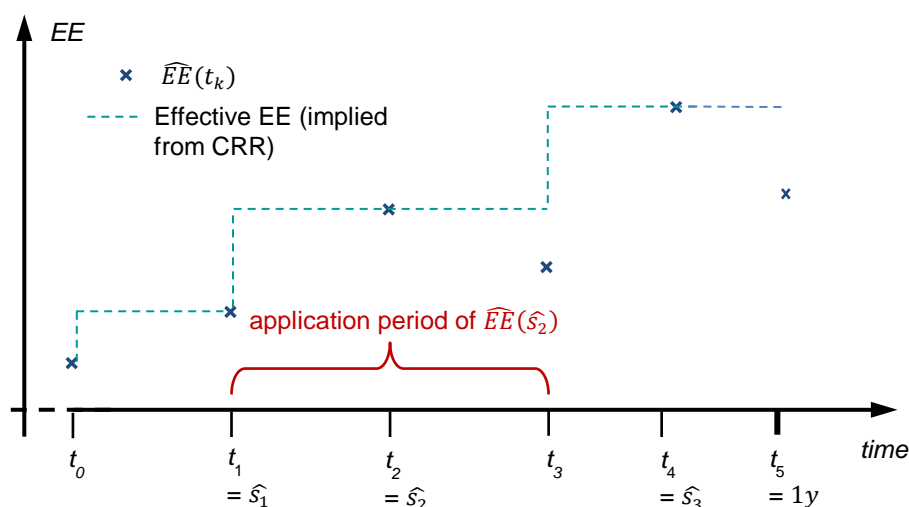
$$\widehat{EE}(t_k) > \max_{0 \leq h < k} \widehat{EE}(t_h)$$

Let us denote $(\widehat{s_u})_u$ these estimated (i.e. as resulting from an MC simulation) effective reference dates with:

$$\widehat{s_1} < \widehat{s_2} < \cdots < \widehat{s_u} < \cdots < \widehat{s_{\hat{p}}} \leq t_{1y}$$

i.e. $\hat{p}$ dates.

$\widehat{EEPE}$ depends only of the $\left(\widehat{EE}(\widehat{s_u}) \right)_u$ and the time profile of effective EE values as defined in Article 284(5) of the CRR. More precisely, it is fully determined by $\widehat{EE}(\widehat{s_u})$ as can be seen by the following schematic graph:

The method below relies on the assumption, which should be checked by the institution when applying the method, that N is large enough such that all $\widehat{EE}(t_k)$ are "sufficiently close" to their true values $EE(t_k)$ and that, as a consequence, the effective reference dates are properly identified, i.e. $(\widehat{s_u})_u = (s_u)_u$.

Under the complementary assumptions that $s_p \neq t_{1y}$, and considering, as previously mentioned, that $(\widehat{s_u})_u = (s_u)_u$, $\widehat{EEPE}$ is given by:[197]

$$
\begin{aligned}
\widehat{EEPE} &= \sum_{u=1}^{p-1}(v_u - v_{u-1})\widehat{EE}(s_u) + \left(t_{1y} - v_{p-1}\right)\widehat{EE}\left(s_p\right) \\
&= \frac{1}{N}\sum_{j=1}^{N}\left[\sum_{u=1}^{p-1}(v_u - v_{u-1})E_j(s_u) + \left(t_{1y} - v_{p-1}\right)E_j\left(s_p\right)\right]
\end{aligned}
$$

Where $(v_u)_u$ are the "application period dates": they are such that $[\,v_{u-1},\,v_u\,]$ is the period $\widehat{EE}(s_u)$ is applied to. For instance, for the case illustrated in the graph above, $\widehat{EE}(s_2)$ is applied on $[t_1,\,t_3]$, and thus $v_1 = t_1$ and $v_2 = t_3$.

Let us define, for each scenario j from 1 to N:

$$
D_j := \sum_{u=1}^{p-1}(v_u - v_{u-1})E_j(s_u) + \left(t_{1y} - v_{p-1}\right)E_j\left(s_p\right)
$$

By definition of D_j, we have $\widehat{EEPE} = \frac{1}{N}\sum_{j=1}^{N}D_j$.

For $D := \sum_{u=1}^{p-1}(v_u - v_{u-1})E(s_u) + \left(t_{1y} - v_{p-1}\right)E\left(s_p\right)$, the variance of D can be estimated by:

$$
\widehat{var}(D) = \frac{1}{N-1}\sum_{j=1}^{N}\left(D_j - \frac{1}{N}\sum_{k=1}^{N}D_k\right)^2 = \frac{1}{N-1}\sum_{j=1}^{N}\left(D_j - \widehat{EEPE}\right)^2 .
$$

---

[197] This assumes the longest lasting transaction in the netting set has a maturity equal to or higher than one year and all time differences in the above formulas are expressed in units of a year – otherwise the correction as described in paragraph 84 needs to be applied.

Note : cases where $E(t_0) \geq \widehat{EE}(t_1)$ and/or $s_p = t_{1y}$ are not derived in the annex. However similar equations can be obtained.

An estimator of the variance of $\widehat{EEPE}$ is then given by:

$$\widehat{var_{M2}}(\widehat{EEPE}) = \frac{1}{N}\widehat{var}(D) = \frac{1}{N(N-1)}\sum_{j=1}^{N}\left(D_j - \widehat{EEPE}\right)^2.$$

As mentioned in the first footnote of paragraph 56 requiring a statistical error at a 95% confidence level, the estimation of the MC error on $\widehat{EEPE}$ should be calculated according to the following formula:

$$\widehat{error_{M2}}(\widehat{EEPE}) := \Phi^{-1}(0.975)\sqrt{\widehat{var_{M2}}(\widehat{EEPE})}$$

$$\simeq 1.96 \cdot \sqrt{\frac{1}{N(N-1)}\sum_{j=1}^{N}\left(D_j - \widehat{EEPE}\right)^2}$$

The rationale of the formula is the same as that outlined in method 1, with a different estimator of the variance of $\widehat{EEPE}$ and without a convergence adjustment. If we assume that $\widehat{EEPE}$ follows a normal distribution, then $\widehat{error_{M2}}(\widehat{EEPE})$ can be interpreted as half of the length of the 95% two-sided confidence interval centred around $\widehat{EEPE}$. No adjustment (similar to $convAdj(.)$ in the first method) is needed, since for usual values of N, we have $convAdj(N)$ close to 1, e.g. $convAdj(500) \simeq$ 1.067 and $convAdj(1000) \simeq 1.046$.

Other methods

Institutions may apply a distinct own method to estimate the numerical error as part of their validation framework. Institutions should then check whether the own method complies with paragraph 56. However, in the view of the ECB institutions should also have the ability to estimate the numerical error under one of the 2 methods suggested in this Annex upon request by supervisors.

Aggregation across netting sets

a) When risk factors are simulated all together (no "silo"), the MC error of the estimator of the EEPE for the full scope should be calculated in a similar way to that described for a single netting set, except that $\widehat{EEPE}_N$ should be understood as the sum of the estimators of the EEPE related to all netting sets belonging to the institution's portfolio. Assume that a set of n netting sets $A = \{\alpha_1, \ldots, \alpha_n\}$ is available for the MC error analysis.

This means for **method 1** that

$$\widehat{var_{M1}}(\widehat{EEPE}_N) = \frac{1}{m-1}\sum_{k=1}^{m}\left(\sum_{\alpha_i \in A}\widehat{EEPE}_N^k(\alpha_i) - \frac{1}{m}\sum_{l=1}^{m}\sum_{\alpha_i \in A}\widehat{EEPE}_N^l(\alpha_i)\right)^2$$

should be inserted into the equation for $\widehat{error_{M1}}(\widehat{EEPE})$.

For **method 2**, the addition needs to happen at the netting set-specific D term.

$$D_j = \sum_{\alpha_i \in A} D_j(\alpha_i)$$

should be inserted into the equation for $\widehat{var}_{M2}(\widehat{EEPE}_N)$ to calculate the variance, then this should be inserted into the equation for $\widehat{error}_{M2}(\widehat{EEPE}_N)$.

b) When risk factors are not simulated all together (in cases where exposures are estimated through "silos", e.g. one per asset class), the MC error should be derived from the MC errors of $\widehat{EEPE}_N$ per silo. Using either method 1 or 2 for computing the MC error per silo as explained immediately above (item a), the error on the total portfolio is then given by:

$$\widehat{error}_{M1/M2}\left(\widehat{EEPE}_N \text{ of total portfolio }\right) = \sqrt{\sum_{i=1}^{S}\left(\widehat{error}_{M1/M2}\left(\widehat{EEPE}_N \text{ of } silo_i\right)\right)^2},$$

where

- S is the total number of silos,

- $silo_i$ is a sub-portfolio of the institution's total portfolio corresponding to all the netting sets simulated in silo i.

3 Glossary

Credit risk

BCBS
Basel Committee on Banking Supervision

CCF
Conversion factor

CRR
Capital Requirements Regulation

EAD
Exposure(s) at default

EBA
European Banking Authority

EBA GL on PD and LGD
EBA Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (EBA-GL-2017-16)

EL$_{BE}$
Expected loss best estimate

Final Draft RTS on assessment methodology for IRB
EBA Final Draft Regulatory Technical Standards on assessment methodology for IRB

GDP
Gross domestic product

IRB
Internal ratings-based

LGD
Loss(es) given default

LRA
Long-run average

MoC
Margin of conservatism

NUTS
Nomenclature of territorial units for statistics

PD
Probability of default

RDS
Reference dataset

RTS
Regulatory Technical Standards

RWEA
Risk-weighted exposure amounts

SME
Small and medium-sized enterprises

SRM
Shadow rating model

TRIM
Targeted review of internal models

Market risk

Actual P&L The daily actual changes in the portfolio's value, as defined in Article 366(3) of the CRR.

Economic P&L The daily changes in the portfolio's value (or profit and loss, P&L) calculated on the basis of end-of-day mark-to-market or mark-to-model (depending on the instruments) values of the

books and records of the institution, taking into account the independent price verification (IPV) process. It is generally calculated using front-office systems (position data, pricing models, valuation methods, pricing parameters, end-of-day market data, etc.).

Fundamental review of the trading book (FRTB) The document entitled "Minimum capital requirements for market risk" issued by the Basel Committee on Banking Supervision (BCBS) in January 2016.

Hypothetical P&L The daily hypothetical changes in the portfolio's value, as defined in Article 366(3) of the CRR.

IMA The internal model approach for the calculation of own funds requirements for market risk.

P&L The daily changes in the portfolio's value (or profit and loss).

Position Understood to be a risk position. A risk position is a non-identically-zero sensitivity to a risk factor. Holding securities or entering into transaction contracts entails having a position. When defining a position, neither hedging nor netting should be considered.

Top-of-the-house level Both (i) the legal entity for which an approval for the IMA approach has been granted, and (ii) (within the scope of the IMA) the highest level of the portfolio structure.

Counterparty credit risk

Benchmarking system In the context of pricing functions mentioned in the guide, this means the respective front-office pricing functions, pricing functions of accounting systems or other benchmarks with which front-office prices are frequently compared (at least quarterly, as for CCR purposes). Values taken from such benchmarking systems are values after independent price verification (see Article 4(70) of the CRR) without any valuation adjustments beyond the default-free value (such as the credit valuation adjustment).

IMM Internal Model Method for counterparty credit risk.

Pricing function A dedicated implementation of a pricing model taking into account:
- the input data used in this particular implementation (e.g. the input market data needed, day-count conventions, etc.);
- the parametrisation of the implemented pricing model including the method for its calibration;
- the numerical method used (e.g. binomial tree, finite difference, Monte Carlo, etc.).

Pricing model The quantitative, mathematical model (e.g. a Black 76 swaption) that is used to determine the market value of a transaction for a given (current or future) date and specified market conditions/scenarios.

Representative sub-portfolios Representative counterparties or netting sets, for which the following two conditions hold:
- the sub-portfolios should be representative in terms of transaction types, underlying risk factors, margined/unmargined netting sets, short/long positions and the netting set structure;
- the institution should be able to demonstrate to supervisors that the chosen sub-portfolios are sufficiently representative in terms of the above item and meaningful regarding the purpose for which the portfolio has been selected.

Securities financing transactions (SFTs) This term covers repurchase agreements, margin lending and borrowing agreements, as well as securities and commodities lending and borrowing agreements. It thus encompasses all products covered by Article 272(25)(a) and (b) of the CRR.

t_0 The first date of the simulation time grid in the IMM and the reporting date for which the EEPE is calculated. It is thus equal to the "current date" referred to in Article 284(5) of the CRR.