Polish Financial Supervision Authority

Recommendation W

on model risk management in banks

Warsaw, July 2015

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I. Introduction

This Recommendation is issued on the basis of Article 137(5) of the Act of 29 August 1997 – the Banking Law (Journal of Laws of 2015, item 128).

Having regard, on the one hand, to the fact of increasing the use of models for internal purposes, and on the other hand, the limited scope of supervisory regulations that determine the standards of model risk management in a comprehensive and detailed way, this issue of Recommendation W is intended, among others, to define standards for the model risk management process, taking into account the needs to identify the framework for the process, including the principles of models development and assessment of the quality of their performance, while ensuring appropriate solutions within corporate governance.

Recommendation W is issued mainly in order to:

- clearly define the supervisory expectations in the scope of the model risk management process, including those resulting from Article 85(1) of the CRDIV[1], indicating to the bank the need to introduce a systemic approach to model risk management that would establish standards binding for the whole institution (taking into account external models, including group models), compliance with which shall ensure adjustment of the risk of the models used by the bank to the bank's tolerance of that type of risk,
- present to the banks good practices in the scope of an effective model risk management process at all its stages and, as a result, improvement of the model risk management quality and development of high market standards,
- adjustment of the actions undertaken by the banks in the scope of model risk management to the model risk level (the principle of proportionality),
- reducing the level of exposure of the banking sector to model risk and preparation of the banks for efficient undertaking of the right remedial and corrective measures in the event of materialisation of model risk in the future.

It should be stressed that improvement of the quality of model risk management, which is a natural consequence of thorough adjustment of the course of bank's internal processes to the requirements set out in this Recommendation, contributes to the development of the potential for possible use by the bank of internal methods[2], especially thanks to:

- introduction of mechanisms that facilitate the process of risk measurement at the bank,
- adjustment of model risk management actions to the nature, scale and degree of complexity of the models,
- covering important models with the validation process,
- development at the bank of expertise in the scope of model risk management,
- carrying out actions aimed at improvement of the quality of data used by models.

In view of the foregoing, as well as having regard to the content of motive 42 of Regulation CRR[3] and Article 77(1) and (3) of the CRDIV, the Polish Financial Supervision Commission expresses the expectation that, as a consequence of implementation of the Recommendation and improvement of

1 Directive 2013/36/EU of the European Parliament and the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC.

2 That is the methods used, after prior obtaining an authorisation from the supervision authority, to calculate the capital requirements for credit, market and operational risk.

3 Regulation 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 6482012.

model risk management, the banks will undertake actions leading to more widespread use of internal risk measurement models also within the framework of calculation of capital requirements for regulatory purposes with the aim to ensure greater cohesion between the levels of capital requirements and the bank risk level.

This document contains 17 recommendations divided into the following areas:

- principles and organisation of the model risk management process,
- model risk management process,
- model management,
- validation.

What is an important issue from the viewpoint of the efficiency of the model risk management process, beside regulation of that process from the formal and organisational side, is appropriate adjustment of the actions undertaken by the bank to the level of risk generated by models. The risk level of a given model is determined by means of two components: the materiality of the model and the degree of susceptibility to model risk. Model materiality shall be mostly associated with the scope of application of the model at the bank – the higher the share of a given model in the processes and decisions made at the bank, the greater its materiality.[4] As regards the degree of susceptibility to model risk, it influences the broadly understood model quality – starting from the quality of data, through methodological aspects related to the process of its development and the regularity of its implementation to the banking systems and processes, to rational use of its results in the processes and decisions made at the bank. Therefore, model risk management should mainly focus on active measures that reasonably reduce the degree of susceptibility to model risk of material models, and thus the model risk level to values consistent with the bank's level of tolerance of that type of risk.

The right way to reduce the degree of susceptibility to model risk is the application of appropriate control mechanisms, directed at reducing the level of residual risk (in the case of already functioning models) and inherent risk (in the case of models under development) of models. This is achieved by introduction by the bank of model management principles, which – if used effectively – reinforce the efficiency of control mechanisms on all stages of the model life-cycle and contribute to gradual increase in the model performance quality. Because of the complex and multi-stage nature of the actions related to model management, the Recommendation incorporates them in a separate chapter. At the same time, what should be considered a key element of the set of rules and a highly effective control mechanism is the fact of functioning at the bank of a separate validation unit – supervisory expectations in the scope of the conditions of functioning of the unit at the bank are presented in the last chapter of this Recommendation.

Taking into account the specification of the issues related to model risk management and the differences in the scope of the circumstances, the scale of activity, the level of risk of specific banks and the role which is played by the models in them, the way of implementation of the recommendations and the goals identified in them may differ. Therefore, descriptions and comments included along with specific recommendations should be treated as a set of good practices, which should be applied with observance of the principle of proportionality. This means that the use of the practices should depend, among others, on the degree to which they are suitable for the relation of the costs of their development to the benefits they yield. In particular, in the case of selected recommendations, there are defined specific requirements, which should be met in the case of the existence of material models at a bank – this concerns in particular the expectation related to the application of a complex approach to model risk management and the functioning at

4 In the case of banks in which no material models have been identified – which shall be associated with low level of exposure to model risk – expectations as to the complexity of the process of managing their risk are limited. This is reflected, among others, through lack of requirement to define the degree of susceptibility to model risk and the level of risk of the models and tolerance to model risk.

the bank of a validation unit. At the same time, the supervision authority expects that the decisions concerning the scope and manner of introducing the solutions indicated in the Recommendation will be preceded by an in-depth and documented analysis, supported by a relevant argumentation.

All banks should comply with the recommendations set forth herein, with the reservation that the supervision authority expects that, at least at the banks that have a large and complex scale of activities, the process of model risk management will be shaped in a way that minimises the bank's dependency on solutions provided by external entities (including mother companies) – i.e. mainly in the scope of development and ongoing model performance quality assurance, taking into account the need to have a validation unit with resources characterised by high qualifications and competences.

In addition, in the case of cooperative banks, the supervision authority expects associating banks to support the process of implementation of this Recommendation, having regard to the scale and specificity of the operations of a given cooperative bank, applying the principle of proportionality. The scale of operations and the solutions used with reference to models should determine the scope and degree of adopted solutions. The process of implementation of those solutions at cooperative banks, despite an active role of the associating bank, may not, however, be inconsistent with the scope of responsibilities defined in specific recommendations and the responsibility of statutory bodies of associated cooperative banks.

The Financial Supervision Commission expects that Recommendation W concerning the principles of model risk management at banks will be adopted not later than until 30 June 2016.

II. Glossary

Degree of susceptibility to model risk – a measure reflecting the cumulated impact of all identified model risk categories on the regularity of generation by it a correct result in the production environment, used in the processes or decisions made at the bank.

Development environment – the IT environment, in which a model is developed and tested.

External data – all data used in the process of model or model risk management, which are not internal data.

External model – a model used by the bank, in the development of which an important role was played by another entity.

Group model – an external model used by the bank, in the development of which an important role was played by an entity from the bank's capital group.

Inherent model risk – a level of model risk which exists before control mechanisms have been or may potentially be undertaken.

Internal data – all data used in the process of model or model risk management, the source of which are bank's systems and databases.

Internal model – a model used and developed by the bank.

Internal model stakeholders – the bank's organisational units, teams, committees and bodies, which have influence on the course of the process of model risk management or are under its influence.

Material model – a model which has been classified by the bank as one of the models which play an important role in the key processes or decisions made at the bank, including because of the amount of exposure covered by the model.

Model – a tool used to develop a limited (to the most important dimensions) description of a selected aspect of reality (identifying and approximating the relations existing in it on a theoretical or empirical basis), the use of which entails a risk of incurring by the bank a loss due to errors in the development, implementation or use of that tool.

Model life-cycle – a period during which a model goes through subsequent phases of its life, from the moment of commencement of development and implementation works (i.e. the conceptual phase, development of the model and verification of its quality, technical and process implementation, usage of the model and periodical verification of its quality, introduction of changes), until the moment of withdrawal of the model from use or replacing it with a new one.

Model log – a set of information which enable obtaining key (from the viewpoint of model risk management) information about the model, ordered in a way enabling third parties to fully reconstruct the history of actions related to the model and logic behind them.

Model materiality – a feature of a model, which is determined by the bank, taking into account at least the importance of the process, within which the model is used, and the role of the model in that process, as well as the amount of exposure covered by the model.

Model materiality assessment – a measure which reflects model materiality, used to assign a model to at least two classes of model materiality, as specified by the bank (material model/non-material model).

Model monitoring – verification of the efficiency of the model performance, carried out by the bank's unit responsible for the model performance, usually on the basis of statistical measures.

Model owner – the bank's organisational unit directly responsible for model development and ensuring proper model operation quality.

Model process implementation – actions, as a result of which a model, after transfer into the production environment, can be applied in processes and decisions made at the bank in accordance with its intended use; it covers, in particular, necessary modifications of internal processes and regulations and training of model users.

Model register – a list containing the most important, current information concerning all models used by a bank, ordered in accordance with a single format.

Model risk – a potential loss which may be incurred by the bank as a result of a decision which could basically be based on data obtained through the application of internal models,[5] as a result of errors in development, implementation or use of such models.[6]

Model risk categories – identified by the bank, specific and separated areas which affect the degree of susceptibility to model risk (e.g. broken down by: inherent model limitations; data risk; assumption/methodology risk; administration risk; interdependence risk).

Model risk level – established on the basis of the bank's internal criteria, as objective as possible assessment of model risk, which results from model materiality and the degree of susceptibility to model risk.

Model risk tolerance – the permissible level of model risk, accepted by the bank.

Model technical implementation – the process, under which a model (along with input and output components) is transferred from the development environment to the production environment, keeping its integrity and functionality.

Model user – the bank's organisational unit which carries out the activities related to direct servicing and generation of model results or using its results within implementation of its tasks.

Non-material model – a model which has not been classified by the bank as one of material models.

Principle of proportionality – a principle, according to which model risk management is conducted with the use of outlays suitable for the model risk level, which are needed for achieving the intended purpose.

Production environment – the IT environment, in which a model is aimed to be implemented and used operationally.

Recommendation – Recommendation W.

Recommendation D – *Recommendation D – regarding management of information technology and IT environment security in banks.*

Residual model risk – the level of risk which remains despite the application of control mechanisms and follow-up measures resulting from them.

Validation – assessment of the efficiency of operation of a model, carried out by the bank's unit not related to the process of model development and use, usually in a manner more comprehensive than within monitoring, including: adequacy of the concept and assumptions of a model to the process or decision-making mechanism, in which the model is used, and correctness of its development and implementation from the substantive and formal perspectives.

5 In this context, they are all models used by a bank in internal processes, regardless of the origin of the model (an internal or external model, including a group model).

6 Model risk definition according to the definition resulting from Article 4(1)(12) of the CRR.

III. List of recommendations

Principles and organisation of the model risk management process

Recommendation 1

The bank shall develop and implement a model risk management policy, consistent with the internal risk management strategy.

Recommendation 2

The bank's supervisory board should oversee the model risk management process, while the bank's management board should ensure its proper and efficient performance.

Recommendation 3

Significant aspects of functioning of models should be approved by the bank's management board or a dedicated committee.

Recommendation 4

Organisational solutions and human resources dedicated to the model risk management process should be adequate to the model materiality and should enable efficient and timely implementation of measures under the process.

Recommendation 5

The bank should have formalised principles that determine the roles and scopes of responsibility of the participants of the model risk management process and standards in the scope of the development, implementation, use and verification of the operation and documentation of models, as well as a process of preparation of data serving to develop and feed models on an ongoing basis.

Recommendation 6

Reporting on the model performance at the bank and significant measures undertaken within model risk management should form an integral element of the management information system.

Recommendation 7

The model risk management process should be subject to periodical, independent audits.

The model risk management process

Recommendation 8

The bank should cover all models it uses with the model risk management process, regardless of model materiality, origin and type of data used.

Recommendation 9

The model risk management process in place at the bank, integrated with the bank's whole risk management system, should cover actions related to identification, estimation, control, monitoring and reporting of model risk.

Model management

Recommendation 10

The bank should have a register of models, and a model log for each of the models.

Recommendation 11

The bank should determine the principles of model management at all phases of their life-cycle.

Recommendation 12

The bank should ensure that data used at all phases of the model life-cycle are of high quality.

Recommendation 13

The bank should ensure that the models it applies are of appropriate quality at each phase of their life-cycle, which requires their use and effectiveness to be subject to regular verification, with a frequency adjusted to their specificity.

Recommendation 14

There shall be in place at the bank a transparent process of escalation of negative results of model performance quality verification that ensures undertaking efficient and appropriate remedial and corrective measures.

Validation

Recommendation 15

The bank which has material models should have an independent unit responsible for their validation.

Recommendation 16

The scope of actions performed during validation and its frequency should be adjusted to the specificity and risk level of a model.

Recommendation 17

The validation process should involve – in a complementary manner – both quantitative and qualitative techniques to ensure full knowledge about the model performance quality.

IV. Principles and organisation of the model risk management process

Model risk management policy

1. Recommendation 1

The bank shall develop and implement a model risk management policy, consistent with the internal risk management strategy.

1.1. Model risk, as a specific element of operational risk, should be considered by banks which apply models in their everyday operations as one of the risks inherent in the conduct of banking activities. As a consequence – just like other types of risk – model risk should be covered by the management process on the basis of formally established principles that enable proper identification of the model risk and its reliable assessment, as well as ensure that there are in place proper control mechanisms and tools for active management of model risk exposure, incorporating an efficient reporting process.

1.2. The bank should develop in writing and implement a model risk management policy, which shall be aimed, among others, at:

- ensuring proper, adjusted to the importance of model risk in the bank's activities, quality of model risk management and enhancing the transparency of the course of the whole model risk management process, both for operational and control purposes,
- adequate adjustment of the organisational structure to the scale and nature of the performed activity the existing model risk through introduction of solutions to ensure an appropriate division of tasks and assignment of official reporting and scope of responsibilities,[7] taking into account the principle of proportionality, by ensuring dynamic adjustment of the scope and type of the tasks performed in the model risk management process to the specificity of the models or their risk level,
- introduction of mechanisms to ensure efficient remedial and corrective measures to prevent the use of models that do not meet specific quality standards or characterised by excessive risk level,

and in the event that the bank has not only non-material models:

- standardisation of the model risk management process through determination of the course of selected subprocesses and appropriate unification of the solutions applied at the bank level,
- establishment of an acceptable model risk level at an aggregate level (model risk tolerance level).

1.3. The provisions of the model risk management policy should ensure, among others:

- coverage of all models used and planned to be used in the bank by the model risk management process,
- introduction of formal principles of management of models and their risk on all stages of their life-cycle,
- appropriate documentation of each models used,

7 The detailed way of meeting this requirement should be determined in the appropriate regulations of a lower order than policy, in a way not giving rise to any doubts concerning the scope of tasks and responsibilities, at the same time guaranteeing lack of overlap of obligations and responsibilities of particular organisational units, positions or groups of positions in the scope of the model risk management process.

- promotion of high standards in the scope of model risk management,
- that it is updated on a regular basis, at least once per year,

and in the event that the bank has not only non-material models:

- having by the bank current and full knowledge about the risk level of particular models – also in aggregate.

1.4. When formulating the framework for the model risk management process and shaping the infrastructure to support that process (personnel and IT resources), the bank should be guided by the principle of proportionality through adjustment of the size and type of allocated resources to its own specificity, especially in the context of: the amounts and types of exposure, the nature of the conducted activity, as well as the complexity and scope of model use. It means that a bank, in which the scope of model use is limited and the models used are classified as non-material, will be able to confine itself to determination of the general framework of the model risk management system, while on the other hand, a bank shall be obliged to undertake appropriate measures with respect to models identified, on the basis of the classification principles developed at the bank, as material, even if the model risk level in the bank in aggregate is not high.

1.5. In order to ensure the possibility to carry out an effective internal model identification process, the bank, for internal purposes, should make the universal definition of a model presented in the Recommendation more precise, taking into account the specificity of the conducted activity.

1.6. In the process of identification of the models used, the bank should analyse in particular the following potential areas of model application:

- risk measurement (assessment of credit rating and creditworthiness, loan loss provisions calculation, calculating capital requirements, estimation of internal capital, calculation of supervisory liquidity measures, carrying out stress tests, determination of the value-at-risk, detection of credit fraud cases),
- pricing (financial instruments pricing, modelling real property prices, valuation of other physical collateral).

Roles of the management board and the supervisory board

2. Recommendation 2

The bank's supervisory board should oversee the model risk management process, while the bank's management board should ensure its proper and efficient performance.

2.1. The supervisory board should:

- exercise supervision over the compliance of the bank's model risk management policy with the bank's risk management strategy,
- at least once per year, evaluate the effectiveness of model risk management by the bank,

and when the bank has not only non-material models, also:

- approve the bank's model risk tolerance level and oversee the management board's compliance with it.

2.2. The bank's management board shall be responsible for implementation of effective functioning of the model risk management process at the bank, taking into account the appropriate division of roles, the principles of cooperation and responsibility of particular process participants.

2.3. The bank's management board should manage model risk in an active manner, making use of all available information.

2.4. The final liability for proper functioning of models (regardless of their source of origin and the data used) shall rest on the bank's management board, which should have the necessary knowledge about the models used at the bank.

2.5. The bank's management board should ensure that all model risk management process participants have access to appropriate trainings, professional literature, IT infrastructure (hardware and software) and data necessary for effective performance of entrusted tasks.

3. Recommendation 3

Significant aspects of functioning of models should be approved by the bank's management board or a dedicated committee.

3.1. With respect to model risk management, the bank's management board or a dedicated committee should be responsible in particular for:

- determination of the structure of the model risk management process, consistent with the risk management system in place at the bank,
- approval of model risk management policy and carrying out its annual review to ensure its being tailored for the current circumstances, priorities and directions of change in the organisation of processes,
- assessment of the regularity of the course of the model functioning quality assessment process,
- determination of the bank's approach to the scope of application of external models,

and in the event that the bank has not only non-material models, also for:

- determination of the model risk tolerance level,
- controlling the model risk level with respect to the risk tolerance level.

3.2. With respect to material models, the bank's management board or a dedicated committee[8] should be responsible for:

- approval of the results of model validation,
- approval, withdrawal and introduction of changes to models,
- approval and monitoring the introduction of suitable remedial and corrective measures.

Organisational solutions and human resources

4. Recommendation 4

Organisational solutions and human resources dedicated to the model risk management process should be adequate to the model materiality and should enable efficient and timely implementation of measures under the process.

4.1. The bank's organisational structure should ensure the existence of an appropriate level of independence between the model owners, model users and people responsible for model validation. In selected cases, properly justified by the bank, when there is no risk of the occurrence of conflict of interest between model owners and model users for objective reasons, combination of the roles shall be permissible.

8 With regard to specific models, binding decisions in their scope may be taken by committees dedicated to management of specific risk types – this requires, however, appropriate delegation from the bank's management board.

4.2. The bank should ensure that the employees who fulfil specific roles in the model risk management process have appropriate qualifications, competences and experience that allow them to reliably perform their tasks.

4.3. The bank should appoint a management board member directly responsible for supervision over the area related to model risk management.

4.4. Among the bank's management, there should be an employee responsible for:

- coordination of actions in the scope of model risk management,
- obtaining all necessary information from internal stakeholders and their proper aggregation, including for the needs of development of management information,
- ensuring relevance of the model register and model materiality assessments,

and in the event that the bank has not only non-material models:

- ensuring the use of an integrated approach to management of that risk with reference to all models used at the bank,
- ensuring relevance of model risk level assessments,
- ongoing monitoring of model risk level in aggregate in the context of the adopted risk tolerance level.

4.5. The principles and level of remuneration of employees responsible for model risk management should be proportional to the degree of complexity and importance of the tasks performed by them and should motivate to a constant growth of their competences and involvement in that area.

4.6. The bank should minimise the personnel risk related to excessive cumulation of knowledge in the scope of model risk management important for a narrow group of bank employees. Therefore, the bank is expected to promote such organisational solutions within which each bit of knowledge in the scope of model risk management will be possessed by at least two bank employees. On the one hand, this is indispensable to apply an efficient control mechanism of 'two pairs of eyes,' and on the other hand, to ensure continuity of the course of processes in the event of absence of the bank's employee directly responsible for their course.

4.7. The management should in particular:

- exercise direct supervision over the correctness of the course of operational processes resulting from the model risk management principles binding at the bank (including being responsible for the development of appropriate lower order regulations, ensuring proper course of the model risk management process),
- have appropriate knowledge in the scope of the structure and functioning of models,
- regularly report on assessment of efficiency of the application of model risk management principles to the management board or a dedicated committee and inform about identified model risks,
- initiate undertaking of appropriate remedial and corrective measures in the scope of models, in order to ensure continuous proper operation of models.

Internal regulations

5. Recommendation 5

The bank should have formalised principles that determine the roles and scopes of responsibility of the participants of the model risk management process and standards in the scope of the development, implementation, use and verification of the operation and documentation of models, as well as a process of preparation of data serving to develop and feed models on an ongoing basis.

5.1. Model risk management at the bank shall be carried out on the basis of procedures concerning identification, estimation, monitoring, control and reporting of that sort of risk. The methodologies concerning the development, implementation (process and technical), use and verification of the performance quality of models used by the bank, as well as other documents that describe the course of specific stages of the model risk management process, should be developed in a way so transparent as to enable third parties with appropriate competences to trace back the course of the process defined by the documents, and make an assessment of their substance. The degree of advancement and detail of specific procedures and methodologies should correspond to the specificity and materiality of models which they concern.

5.2. Appropriate internal regulations should be known to the bank's employees who participate in the model risk management process. The way of their development should ensure transparency and unambiguity of the issues presented therein, enabling its recipients to fully understand the essence of the submitted information – reducing both the personnel risk (low quality of documentation hinders accumulation of knowledge at the bank), and model risk (appropriate documentation ensures easy access to information). Procedures should be subject to regular verification in order to adjust them to changes in the organisational structure and risk level at the bank and in the business environment, in which the bank operates.

5.3. The bank, in its regulations, should stress the roles of specific participants of the model risk management process and identify the scope of tasks assigned to them at particular stages of model risk management. As a rule, the principles shall include:

- development of internal regulations related to model risk management, determining the frequency and organisational units responsible for carrying out the reviews,
- preparation of a project schedule for (re)development/replacement/withdrawal of a model,
- ensuring, at the stage of model implementation, of appropriate: funds, human resources and IT tools,
- defining business needs and initiating the commencement of model use in processes or decisions made at the bank,
- defining the scope of model application, the way of its use and the conditions, in which the use of the model can be abandoned (or the results can be overwritten),
- identification of types and sources of data used by the model, ensuring access to the right data at the stages of development, use and performance quality verification of the model,
- collection, processing and supplying necessary input data to the model,
- determination of model performance quality acceptance criteria,
- construction of a model in the development environment, its documentation and performance of an assessment of its conformity with internal and external requirements,
- approval of a model for use and implementation into the production environment,
- the process of model implementation in the production environment and documenting the

performed implementation tests,

- approval of the results of model implementation tests in the production environment that confirm that the model has all intended functionalities and operates fully like the version implemented in the development environment,
- carrying out model validation,
- approval of model validation results,
- carrying out model monitoring and documenting it,
- approval of monitoring results,
- drawing up a model log,
- development of model register,
- initiation of undertaking specific remedial or corrective measures in the case of deterioration of model performance quality,
- carrying out assessment of model materiality, degree of susceptibility to model risk, and the model risk level,
- making a back-up copy of the model (model source code),
- granting authorisation to access the code to a narrow group of dedicated specialists,
- ensuring recording of all changes introduced in the model code (change author, its scope and date),
- formation of the process of selection of external suppliers of services in the scope of models and the scope of services provided by them (including in particular adjustment of external model functionality to the bank's specific needs),
- controlling the quality of the services provided by external suppliers,
- preparation of management information.

5.4. The bank should apply a consistent system of versioning of the documentation concerning model risk management, i.e. there should be identified for each document:

- the name and type of document,
- the number of document version and date of its creation/revision/approval,
- author/s of the document and the people who approved it,
- a log of the scope type of changes introduced in comparison to prior versions.

Management information system

6. Recommendation 6

Reporting on model performance at the bank and significant measures undertaken within model risk management should form an integral element of the management information system.

6.1. Reporting on models that function at the bank and important actions undertaken within model risk management should form an integral element of the management information system and should be presented with a frequency appropriate for: the internal stakeholder's position in the hierarchy, the scale of model use in processes and decisions made at the bank, and the dynamics of changes in the area of model risk management.

6.2. The supervisory board should regularly receive, observing the principle of proportionality with respect to the frequency and detail level of the information, yet at least once per year, in particular:

- management board reports containing information on implementation of the model risk management policy (including a list of the most important measures undertaken in the scope of management of the risk and assessment of their effectiveness),
- other information important from the viewpoint of exercising efficient supervision over the actions of the bank's management board in the scope of model risk management.

6.3. When the bank has not only non-material models, the supervisory board should additionally be informed at least once per year about,

- the level of risk of specific material models, including the directions and causes of its changes over time,
- the level of risk of models in aggregate in the context of the adopted tolerance level for that risk.

6.4. Within the management information system, the bank's management board or a dedicated committee should, at least twice per year, receive current information covering no less than:

- a list of models used at the bank along with their materiality and risk level (in the case of material models), as well as changes in the values of the categories over time (trends),
- changes in the number of models used, their scope of application and causes of the changes,
- a list of planned measures in the scope of management of models and their risk,
- other information important from the point of view of possibility of effective performance of the tasks entrusted to the bank's management board in the scope of model risk management.

6.5. The bank's management board or a dedicated committee should, when the bank has not only non-material models, be additionally informed at least once per quarter about the schedule of tasks for a given period in the scope of model risk management along with assessment of its performance and any possible delays with respect to material models about:

- the level of risk of particular material models, including the directions and causes of changes over time,
- key findings of performed monitoring, model validation and internal audits,
- the status of recommendations (from monitoring, validation and audit) issued in the previous periods and the effectiveness of the undertaken remedial and corrective measures,

  assessment of the level of the bank exposure to model risk in aggregate in the context of the adopted risk tolerance level.

Role of internal and external audit

7. Recommendation 7

The model risk management process should be subject to periodical, independent audits.

7.1. The internal audit unit should carry out periodical revisions of the model risk management system, taking into account the actions undertaken by participants of that process at all phases of model life-cycle.

7.2. The internal audit unit should perform its control function in the area of model risk taking into account the specificity of that risk.

7.3. Within the performed internal audit of the model risk management process, particular attention should be paid to:

- the necessity to use all important sources of information about the bank's model risks,
- adequacy and currency of the model risk management policy with respect to the risk of the models in place at the bank,
- the division of tasks and independence of the processes of development, validation and use of models,
- complexity of lower order internal regulations and compliance of the course of the model risk management process with the provisions contained therein,
- use in practice of internal regulations in the scope of model risk management with special attention paid to the model risk management policy,
- completeness and quality of the documentation developed by specific participants of the model risk management process,
- completeness and currency of the model register with particular attention paid to assessments of model materiality and model risk level,
- covering all models with the model risk management process, in accordance with the principle of proportionality,
- the way of managing access rights to model codes and model change management,
- the quality of managerial information in that area and effectiveness of the actions undertaken on its basis (with special attention paid to reporting information concerning negative results of verification of model performance quality),
- areas where higher risk models exist.

7.4. The bank should ensure that the internal audit unit has suitable human resources with the necessary knowledge in the scope of model risk management. In the case of banks with material models, the auditors' knowledge should in particular enable them to analyse the quantitative aspects of the models, issues related to data quality assessment and the quality of the unit responsible for validation, both at the level of the process layer, and the substantive layer. In addition, it is advisable that the level of their knowledge should enable implementation by the internal audit unit also of advisory function with respect to selected elements of the model risk management process.

7.5. Internal audit of the model risk management process should be carried out on a regular basis. The frequency, scope and a detailed schedule of audits should result from the model risk level related to specific areas/processes and fully take into account the principle of proportionality in the model risk management process. At the same time, it should be ensured that audits will cover – with appropriate frequency – all aspects of functioning of the model risk management process.

7.6. Having regard to the specialised nature of the aspects of functioning of models (i.e. mainly issues of quantitative nature), it may be considered permissible to adopt a solution, in which independent verification and revision are performed – in a complementary manner – by an internal audit unit or another, comparable, independent entity (e.g. the validation unit), with the use of the division of tasks appropriate for the substantive competences of those individuals, with the reservation that the activity of the validation unit shall be subject to independent evaluation by internal audit.

7.7. It is advisable that the delegated representative of the internal audit unit should fulfil the role of observer on the committee participating in the model risk management process.

7.8. Entrusting additional audits to professional external institutions that specialise in examination of the areas of model risk management is a factor which may significantly reinforce control over the risk related to that area. Nevertheless, such actions should be only of supportive nature. Therefore, the bank should analyse the justifiability, and take an appropriate decision on that basis with respect to supplementing the actions of the internal audit with external audits carried out by such entities, especially in the scope of areas of high model risk level.

V. Model risk management process

Model classification

8. Recommendation 8

The bank should cover all models it uses with the model risk management process, regardless of model materiality, origin and type of data used.

8.1. Classification of models into materiality classes shall be based on approved principles and clearly defined criteria that enable cohesive, consistent, and reliable differentiation of materiality between models. When the scope of application of models in the bank is limited, and the dependence of the course of processes or decisions made at the bank is low, there may exist only models classified as non-material. The classification is made at least once per year, and each time after the occurrence of circumstances that make a change of class of a given model likely (e.g. a change in the scope of model application).

8.2. It is expected that the model risk management process will cover all models used by the bank, i.e. regardless of:

- the origin of the model: internal and external models (including group models),
- the phase of model life-cycle: used in the bank's operations or planned for implementation,
- the sources of the data used: based on internal or external data,
- the model development method used,
- model materiality assessment.

8.3. The bank should identify the source of origin of each of the models it uses, i.e. classify them into the following sets:

- an internal model,
- an internal model developed with the support of an external entity,
- an external model (not a group model),
- a group model,
- other (to be defined in case of existence).

8.4. In the event that the bank uses sources of data other than only internal ones, in the event of using data from commercial suppliers, the bank should strive at obtaining information about their quality (including the applied mechanisms of control and validation of data quality, as well as periodical results of data quality audits) and representativeness for the area of model application at the bank, taking into account the requirements set forth in recommendation no. 8 of Recommendation D.

8.5. In the event of the use of an external model, under an agreement with an external supplier, the bank shall ensure that it has access to[9]:

- model technical documentation (containing at least a description of: the sources and scope of data used to develop the model and assess their representativeness for the areas of model application at the bank; assumptions of the model and the way of their verification; the model construction method used; all model components, the way of their construction,

9 In those cases, in which the scope of services provided by an external entity is of substitutive nature with respect to the bank's actions related to a given model.

parametrisation and calibration; model selection criteria; assessment of model performance quality, in this comparison to alternative models; justification that the selected model will meet the bank's business criteria),

- a description of the results of model implementation tests,
- information about the frequency and scope of model performance quality testing,
- periodical results of model performance quality assessment (including the reports from performed monitoring, validation, and internal audit),
- appropriately early information about any changes introduced into the model or an intention to withdraw the model from use, along with a description of the principles of introducing changes into the model,
- training in the scope of handling and operation of the model,
- ongoing user support.

8.6. It is expected that the bank using an external model will have appropriate justification for the use of the external model instead of an own model (e.g. lack of appropriate data or resources), including it will present alternative solutions, which it considered while selecting an appropriate approach.

8.7. The bank shall be obliged to manifest high level of its own knowledge concerning the principles and details of functioning of an external model, including:

- unambiguous determination of the scope and principles of application of the model and its results in processes and decisions made at the bank,
- knowledge of the assumptions and type of the method used to construct the model,
- having a complex and current knowledge about the model performance quality and its adequacy for its area of application (especially in the context of adequacy of the data, on which it was parametrised or calibrated),
- having information about the ways of ensuring continuity of operation of the processes, within which the model is used,

and with reference to a model classified as material, having also information about:

- advantages, disadvantages and limitations resulting from the assumptions adopted for the model (taking into account expert choices),
- the scope of input data processed by the model,
- the way of adjusting the assumptions and structure of the model to the local specificity of the bank or the macroeconomic situation of Poland.

Elements of the model risk management process

9. Recommendation 9

The model risk management process in place at the bank, integrated with the bank's whole risk management system, should cover actions related to identification, estimation, control, monitoring and reporting of model risk.

9.1. The bank should manage model risk in a way that enables avoiding the use of models that fail to meet the measures of quality and performance defined by the bank, and in the case of banks that have not only non-material models, the bank's exposure to model risk should not exceed the level corresponding to the model risk tolerance. The goal shall be implemented mainly through limitation

of the risk level of specific models, especially those that have a significant impact on the total model risk level and in the case of which there is a lot of room for limiting that risk (related to the difference between the inherent risk level and the potential residual risk level).

9.2. The process of management of risk of a given model, implementing the principle of proportionality, should be fully adjusted to the model materiality, and the specific actions undertaken with respect to the model should depend on the current degree of susceptibility to model risk.[10]

9.3. Depending on the materiality, type and area of application of a model, the bank should determine the way, in which it differentiates its approach to management of its risk, with special attention paid to risk management areas like:

- the architecture and complexity of the model risk management process, taking into account the number of participants and the scope of roles and responsibilities assigned to them in the process (adjustment of the degree of comprehensiveness of the approach to the model specificity),
- the division of decision-making competences with regard to management of a given model,
- the level of detail of the model development methodology,
- the scope and level of detail of the model-related documentation,
- the scope of internal regulations that concern the way of using the model,
- the requirements concerning the minimum values of the model approval criteria,
- the requirements concerning the quality of data used by the model,
- the frequency of performance of model monitoring and the scope of analyses performed within it,
- the frequency of carrying out model validation and the scope of analyses performed within it,
- the scope and level of detail of documenting model technical implementation,
- the permissible scope and type of corrections of the results given by the model,
- the scope of the production environment in which the model is to operate,
- the complexity and frequency of carrying out model risk estimation,
- the scope and level of detail of management information on model operation,
- the scope of potential remedial and corrective measures,
- readiness to incur investment expenditure on possible model modification.

9.4. In the process of material model risk identification, the bank should verify what risk categories a given model is sensitive to. With regard to each of the applied material models, the bank should assess possible exposure of the model to:

- the risk related to inherent limitations in modelling a given phenomenon – depending on the specificity of each phenomenon, models are objectively characterised by a different expected effectiveness, so what should be the starting point for formulation of expectations concerning model performance effectiveness is an assessment of feasibility of a given phenomenon/process to be modelled,

10 While it should be demonstrated that, with respect to models classified as non-material – due to lack of requirement to estimate their risk level – actions related to controlling, monitoring and reporting model risk can be deemed sufficient.

- data risk – resulting from: lack of access to required data; low quality input data; deficiencies of the processes of obtaining, processing, aggregating and storage of data; insufficient sample size; inadequate length of time series; inappropriate frequency of feeding the model with data; insufficiency of the accessible range of data to describe the course of the modelled process,
- assumption risk – resulting from: erroneous logic of model operation; limited model functionality in the context of the goals it is to achieve; negative results of verification of adequacy of the assumptions made in the course of the modelled process in the real world (including in particular those concerning the dynamics of the process and the statistical distributions which describe it); low quality of the process of adequacy of the model assumptions; inadequacy of the method/tools/techniques to the modelled process; incompleteness of the model in the context of taking by it into account of all important factors influencing the formation of the modelled phenomenon; lack of appropriate balance between the level of complexity of the model and the degree of its resistance to the effect of model overfitting; the fact of using excessive simplifications or complications with respect to the nature, scale or complexity of the modelled phenomenon; inadequacy of expert assumptions or corrections; lack of stability of model estimates; use of non-observable variables or parameters; inappropriate way of taking into account estimation errors in model estimates,
- administration risk – resulting from: lack or low quality of internal regulations concerning management of the model or its risk; low quality of documentation; errors in model implementation (concerning in particular programming errors and insufficient precision of calculations); failure to use or erroneous use of the model; inappropriate change of scope of model application; use of the model for purposes other than intended; lack, incomplete or erroneous information about the current quality of model performance; mistakenly set values of limits serving to control model performance quality; ineffective process of escalation of negative results of model functioning; untimely undertaking of measures; the occurrence of a conflict of interest in model risk management which could lead to concealment of negative information about the actual model performance quality; introduction of unauthorised changes to the model; negative assessment of the model functionality or performance quality by users; excessive scale of overriding model results,

and in the process of estimation of aggregate risk level, the following should also be taken into account:

- interdependence risk – resulting from: being based on the same data sources, model development methodologies, model assumptions or model testing techniques; using dependent variables or results of some models as input data/independent variables in other models.

9.5. The process of model risk level estimation is of measurable nature. Within the process of material model risk level estimation, the bank should take into account, among others, the following conditions:

- making assessment of the risk level of each model, taking into account the degree of susceptibility to model risk (while that factor should play the role of booster),
- having precise principles of making the assessment of exposure of models to the identified risk categories and combining the assessments into an aggregate model risk assessment,
- separating out at least three risk levels (e.g. low, medium, high),
- assessing risk level in aggregate (risk of model groups/all models), whereas the aggregation methodology for specific models should be sensitive to the existence of possible interdependences between models.

9.6. In order to ensure appropriate model risk control, the bank should appropriately apply, in particular, the following control mechanisms:

- determination of the model performance quality acceptance criteria and the related escalation process covering remedial and corrective measures,
- careful documentation of the model development process,
- starting to use the model after obtaining approval of model implementation test results for production environment that confirm that the model has all the intended functionalities and operates fully consistently with the version implemented in the development environment,
- making a back-up copy of the model,
- granting authorisation to access the code to a narrow group of specialists,
- ensuring that all changes introduced in the model code are recorded (change author, its scope and date),
- verification whether the way and circumstances of model use are consistent with the adopted principles,
- management of the model at all phases of its life-cycle, based on high-quality, approved standard procedures,
- controlling model risk at all levels of the organisational structure,
- carrying out documented model monitoring,
- in areas important from the viewpoint of model risk, an efficient control mechanism of 'two pairs of eyes' should be implemented, whereas both involved persons should have substantive knowledge in the area,

and with respect to a model classified as material – when justified – also:

- starting the process of testing the regularity of model performance already at the stage of its specific modules, and only then its final form,
- comprehensive tests of model performance (approach – quantitative/qualitative, methods – parametric/nonparametric/graphic, detail level – general/detailed),
- not ignoring even small inconsistencies/discrepancies between the development and production versions of the model in order to avoid accumulation of the effects of possible errors (the so-called 'snowball effect'),
- on an ongoing basis, adjusting the nature of the model to the scale and complexity of the problems subject to modelling and ensuring that they allow for the newly identified risk sources,
- applying a broader range of control mechanisms and at a higher level of detail with respect to areas key from the viewpoint of generating risk by the model,
- regular up-dating of the model risk level, including after each occurrence of circumstances that justify lowering the rating, yet not less frequently than once per year.

9.7. In the process of model risk monitoring, the bank should, among others:

- analyse model performance quality, the direction and dynamics of changes in the level of that quality, allowing for the impact of the type and scope of control actions regarding it,
- verify whether appropriate remedial or corrective measures are undertaken and analyse the status of the previously undertaken measures,

- monitor the effectiveness of the control mechanisms in place,
- apply a transparent management information system,

and with respect to a model classified as material, also:

- analyse, based on current results of model risk estimation, the direction and dynamics of changes in the level of that risk, allowing for the impact of the type and scope of control actions performed with respect to it,
- apply as uniform, over time, as possible methods of model risk estimation, maintaining cohesion of the results.

9.8. In the process of model risk reporting, the bank should, among others:

- adjust the nature and scope of presented information to the type of recipient, reliably presenting the actual model risk level,
- indicate the scope, nature and justifiability of potential remedial or corrective measures with respect to the model,

and when the bank has not only non-material models, also:

- indicate the causes that affect the current model risk level and inform about the efficiency of the hitherto undertaken measures.

VI. Model management

Model register

10. Recommendation 10

The bank should have a register of models, and a model log for each of the models.

10.1. The bank should have a model register, containing – for each model – information concerning at least:

- the name, number and version of model,
- the source of origin, scope of application and purpose of the model,
- model materiality assessment,
- location of source documents related to the model,

and for material models:

- assessment of the risk exposure level and the model risk level,
- schedule of future actions related to the model.

10.2. What should be the basic source of information for the model register are the logs of specific models. The data included in the register should be up-to-date, complete and integrated with the data included in the logs of specific models. The register should be updated with a frequency adjusted to the actions implemented under model management, yet no less frequently than quarterly.

10.3. For each of the models used, the bank should develop a model log and update it on an ongoing basis. The log should contain the history of the most important events related to a given model (and its prior versions, if applicable). The detailed scope of collected information should be adjusted to the specificity of a given model, but it should contain at least:

- the metrics of the current and previous versions of the model (name, version number, model type; source of origin, scope of application and purpose of the model; model status; list of the types of decisions and processes, within which the model results are used; the way of using the model results; the date of approval of the model for use; the starting date of operational use of the model; references to the location of source documents related to the model; the model owner; the person/committee/body that approved the model for use; model users),
- model materiality assessment,
- reference to the location of source documents related to model risk management (containing, among others: information on the control actions carried out wit respect to the model and the process of its use; summary of the current quality statistics along with their substantive assessment).

and with respect to material models, additionally information covering at least:

- information about the control actions carried out with respect to the model (a list of any undertaken remedial and corrective measures),
- a specification of high-priority recommendations/instructions concerning the model and the process of its use (the nature, entity issuing the instruction/ current status),
- the current values of the most important model performance quality statistics,
- an assessment of the degree of susceptibility to model risk and the model risk level,

- reference to the location of documents that contain the plan of actions related to the model (including any pending escalation measures, dates of planned control actions, expected date of model updating).

10.4. The model log should be developed in a way that enables third parties to fully trace back the history of actions related to that model and their logic.

Model life-cycle phases

11. Recommendation 11

The bank should determine the principles of model management at all phases of their life-cycle.

11.1. The bank should establish formal rules in the scope of:

- documentation of the process of model development and preparation of data serving to develop and feed models on an ongoing basis,
- model implementation (the principles of model implementation in the IT environment and inclusion to the processes implemented at the bank),
- updating/replacing models.

In the event of material models, the formal principles should concern also the approach to model development (model development methodology).

11.2. The bank's actions carried out in specific phases of model life-cycle should be carefully documented in a manner that ensures the existence of complete, current and auditable documentation, the level of detail of which should correspond to the materiality level of the model it concerns.

11.3. As regards the construction and preparation of data serving to develop a model and feed it on an ongoing basis, the following elements should be documented,[11] as long as their existence can be applied to a given model:

- the purpose of model development and description of the need it is to satisfy,
- determination of the scope of application of the model with respect to the kinds and types of exposure or instruments,
- determination of the processes, within which the model or its results are used, information concerning the links between the current model version with the previous ones,
- the source of origin of the model, i.e. indication whether the model was built inside the bank (if the bank used support from an external entity, the scope of cooperation should be determined), or outside of the bank (by an external entity or within a group),
- model type, i.e. indication whether the model is theoretical, statistical, expert, or hybrid, with justification of the choice,
- a list of the assumptions forming the basis for model construction, an analysis of the degree of fulfilling them in reality and any possible threats resulting from failure to fulfil them,
- a description of the model structure with specification of the component parts and links between them,
- a description of the applied sources of data with indication, whether the data are internal or external (in which case, their source, their objective and temporal scope, and their country/ies

11 Not all the elements have to be included in one document, as long as inclusion of the elements in separate documents does not lead to a loss of information integrity.

of origin should be identified), their location in IT systems and description of the way of ongoing feeding the model with data,

- the type of data along with information on the quality of the data in the context of the requirements posed by the model (having regard to the requirements specific for the data quality assurance process, as presented in recommendation no. 8 in Recommendation D),
- a description of the way of combining data coming from different sources,
- an assessment of cohesion of the definition of variables (especially the dependent variable), in the period covered by the sample,
- a description of possible exclusions from the sample for model development with a breakdown by cause and number of cases,
- a description of the applied approach in the scope of proceeding with erroneous data, missing data, outliers, as well as data whose definition of categorisation has changed over time,
- a description of the applied transformations of input data, their causes along with analysis of the intuitiveness of the received results,
- the time horizon and sample size,
- a division of the data set into independent and dependent variables,
- a description and justification of the selection of specific independent variables and their weights along with an assessment of the sufficiency/completeness of the incorporated data range in the context of their information value,
- information on the identified weaknesses of the model, its limitations, and circumstances, in which the model is ineffective,
- the applied criteria of assessment of model performance quality along with justification and assessment of the degree to which the criteria are met by the final form of the model,
- an assessment of the intuitiveness of the estimates produced by the model,
- a description of the elements of conservatism included in the model, including the scale and degree of the applied possible expert corrections and their causes,

an in the case of material models, also:

- an analysis of the representativeness of the data used to construct the model to the current data structure (including in particular justification for the selection of time series of certain length),
- an assessment of the impact of technological changes resulting from possible migration of data between the bank's IT systems (if it took place during the period covered by the sample) on the quality of the data included in the data repository and the model estimates,
- the technical requirements referring to the IT infrastructure serving the model (including the maximum time for computing the model results, the guaranteed accessibility of the model or the functionality of user interface),
- references to the model development methodology along with indication of the scope of possible divergences and their causes,
- information on the areas, on which the model could be improved in the future,
- an assessment of the model performance quality in comparison to alternative models taken into consideration,
- an assessment of the model's resistance to producing improper estimates in stress conditions,

- a description of the process of consultation of the model assumptions and performance with business experts (users) along with assessment of the impact of those consultations n the final form of the model.

11.4. In the event of application of models whose production environment is end-user software (the so-called EUC), the bank shall be obliged to undertake actions leading to ensuring the safety of the such application,[12] as well as to cover the model with the appropriate control mechanisms to minimise the risk of its improper implementation, proportional in intensity and scale to model materiality.

11.5. As regards the process of technical implementation of models to the dedicated production environment, the bank should ensure that:

- implementation tests have been performed and their results indicate full compliance of the model's operation and the scope of its functionality with the version implemented in the development environment, which shall include: examination of the compliance of the implemented model formulas with its technical documentation; covering numerous combinations of model parameters with test cases, including in particular extreme values; analysis of compliance of the results obtained from the production system with the results of transformation of data outside of the system; verification whether the data migration to and from the model works properly; assess whether the user interface provides access to all intended model functionalities and is sufficiently intuitive to operate for the user,
- possible errors detected at the production stage of model functioning are recorded and corrected, without undue delay as a rule, but at a time not shorter than proportional to their impact on the model risk level and its proper functioning,

and in the case of material models, also that:

- the model implementation process is based on an approved implementation plan (covering, among others: the end goals/products; tasks; scope of responsibility of the technical implementation expert, the model owner and the model user; an implementation schedule taking into account the involvement of all internal stakeholders) and taking into account any difference that may exist between the model development environment and the production environment,
- the type, scope and scenarios of implementation tests are clearly determined and adjusted to the nature of operation of a given model and the production system, in which it is to be implemented,
- the implementation process prepared as a detailed report (in the event that, during technical implementation, there were introduced some simplifications and the model in the production environment is not a true reflection of the model from the development environment, and the report shall include a list of all differences and an assessment of their impact on model risk).

11.6. As regards the process implementation of the model, the bank should ensure that:

- the bank's internal regulations that determine the role, principles and way of using the model in the processes and decisions made at the bank are updated along with the changes introduced in models or processes of their application (this pertains in particular to the “model user handbook” and the “instruction on the use of model results in the processes and decisions made at the bank”),
- all internal stakeholders receive information concerning the current model status at the bank,

12 With the use of EUC software, the recommendations set forth in recommendation no. 17 in Recommendation D shall be complied with.

- the model users have been comprehensively trained on the principles of operating it in the system, in which it has been productively implemented,
- the model users (excluding the users involved in the process of sale and renewal of exposure) have current knowledge about the structure and principles of operation of the model,
- users know the principles of model use (including in particular the principles of using departure from model use or making corrections in the produced results),
- in the case of a decision to withdraw a model from use, the process of its replacement by a new model should run in a way ensuring that the bank keeps continuity of the functionalities that need to be provided by the model (i.e. among others ensuring continuity of the process, within which it is used),
- there is at the bank an effective communication channel for comments from model users to model developers aimed at limitation of the weaknesses and risks of the models identified in the course of their regular use.

11.7. The principles of updating models introduced at the bank should ensure that the scope of changes in the introduced models would be unambiguously identifiable and that the new version of the model would be characterised by an increase in its clarity compared to the previous version (as long as the update does not result from causes external to the bank – e.g. a regulatory change) at a level justifying financial viability of the performance of the process of updating (e.g. a slight growth in the model performance quality measure may not be a sufficient cause to justify increased financial expenditure on implementation of its new version), whereas as regards material models, as far as possible, the following conditions should also be met:

- along with gaining experience in model management, the bank shall strive at perfection of the principles, techniques and methods used in model management and commensurate increasing the minimum model approval thresholds (which means, among others, making justified updates also of those models, which meet the minimum quality criteria),
- periodically, when obtaining new data, the bank should verify the justifiability of updating the model on the basis of a new sample of observations,
- in the event of intention to cover with the hitherto applied model of a new area of application (e.g. the types of products or exposures), the existing model should be properly adjusted (e.g. reparametrised or recalibrated) to the new area of application.

11.8. The material model development methodologies in place at the bank should:

- take into account the current state of knowledge about the solutions for modelling a specific phenomenon used in the banking practice, whereas reference to the current academic literature of the subject should also be made,
- indicate the bank's preferred methodological approach to model development in specific areas,
- introduce a terminological base consistently used in the bank's practice,
- include a detailed description of specific solutions along with identification of their disadvantages and advantages, as well as indicate the optimum solution in certain conditions (e.g. due to the volume of available data),
- present in detail and chronologically the stages of model development and the actions to be taken at each of the stages (including a detailed description of the issues related to obtaining and processing data),
- point out possible difficulties in model construction and indicate possible ways of acting to

reduce their negative impact on the model performance quality,

- indicate the necessary (and potential) tests or calculations which should be made at the model development stage, and the applied measures of model performance quality assessment,
- unambiguously and transparently present (e.g. in the form of examples) the right way of indicating the measures used in the process of model development and interpretation of their values,
- establish the principles of exemplary model documentation,
- with the assumption that they are properly applied, reduce significantly the risk of arising of low quality performance of models.

Data quality

12. Recommendation 12

The bank should ensure that data used at all phases of the model life-cycle are of high quality.

12.1. Using by the model of high-quality data is key from the viewpoint of its ability to generate proper results, so the bank shall be required to undertake actions aimed at continuous increase in the data quality.

12.2. Management of the quality of the data used for the purposes of the models should be carried out on the basis of approved standards of operation, consistent with the general principles resulting from recommendation no. 8 in Recommendation D.

12.3. The bank is expected to intensify control activities in the area of data quality management when:

- the effectiveness of the hitherto applied methods of ensuring high-quality data was limited,
- the level of automation of data processing is limited,
- the bank uses numerous data sources (especially when their architecture is not fully coherent),
- data can be modified manually,
- some of the data are obtained from outside of IT systems.

12.4. When the process of feeding a model with data is automatic, it should be ensured that:

- there is performed ongoing monitoring concerning the data sources, aimed at verification if the scope/layout of variables and the way they are coded has not changed (when such changes are intended, the data obtaining process should be adjusted appropriately in advance),
- unambiguous rules of response of the model to data of improper quality have been established (e.g. deficiencies of specific data or changes in their format) to prevent a situation, when data are treated by the model as correct,
- the identified errors in data have been recorded and communicated to the relevant recipients.

12.5. When the data are entered into a model manually, it should be ensured that:

- appropriate control rules have been implemented to significantly reduce the risk of entering data that do not meet the set quality criteria,
- the person entering data have strictly followed specific instructions that regulated, among others: the layout, format and range of permissible values adopted by the data,
- the quality of entered data has been independently monitored.

12.6. The bank should have at its disposal a current and complete information on the quality of the data used by specific models, and take into consideration the impact of the data quality on model risk level.

12.7. Before commencement of verification of the quality of model estimates, it should be checked whether the data that are to be the object of the analyses are of desired quality. The criteria and measures of data quality should be defined by the bank.

Model performance quality

13. Recommendation 13

The bank should ensure that the models it applies are of appropriate quality at each phase of their life-cycle, which requires their use and effectiveness to be subject to regular verification, with a frequency adjusted to their specificity.

13.1. The bank should have formalised principles of carrying out model performance quality assessment (including making assessments on the basis of approved methodologies of such examination), taking into account, on the one hand, the materiality and specificity of the model, and on the other hand, the possible division of tasks among model owners and the validation unit organised in a way that ensures obtaining full current knowledge on model performance quality.

13.2. The bank should regularly verify model performance quality, including in particular it should have current information concerning the degree of meeting by a given model the performance quality criteria defined for it.

13.3. Each time, model performance quality should be assessed by taking into consideration: the purpose of its application, the business requirements and current economic conditions.

13.4. For each of the models used, the bank should develop a set of minimum approval criteria (thresholds measures), which would refer to key areas of assessment of model performance quality. The types and threshold values of the applied measures should be adjusted to the specificity of particular models, the phase of their life-cycle, and respect the principle of proportionality (i.e. the requirements concerning the scope of testing and minimum model quality level, the requirements concerning the scope of testing and the minimum model quality level should take into account the importance of the model for the bank, whereas the most important models should be covered by a broader scope of testing and should be characterised by the highest quality) and – in the case of material models – allowing for the impact of statistical measurement errors (resulting from a limited number of observation sample) on the values of measures.

13.5. Coherent measures should be the basis in the assessment of the model performance quality in order to maintain comparability of assessments among different models over time.[13] Interpretation of the values of the measures should be supported also with expert opinion.

13.6. The assumptions and conditions of applicability of statistical tests should be recognised in order to avoid methodological errors in model assessment (e.g. the assumptions of independence or linear nature of the dependence between variables, or their specific statistical distribution).

13.7. The scope of adopted verification methods and model performance quality should be adjusted to its specificity and potentially cover:

- historical verification (backtesting) – which enables making an absolute assessment of model performance quality and serves to verify the degree of conformity of model estimates with their empirical realisation; there should be used various complementary tests adjusted to the

13 The said recommendation is not aimed at limiting the number of measures used by the bank in the process of model performance quality assessment and only indicates that at least some of the measures were used in a consistent manner over time.

specificity of the model performance specificity and the most important dimensions of its quality (each test has assumptions and specific weaknesses, and using only its results as the basis is risky); each time, tests results should be assessed critically, taking into consideration the impact on their results of model assumptions,

- sensitivity analysis (single and multiple factor) – directed at drawing conclusions in the scope of adequacy of the strength of reactions of model result to changes in the values of independent variables and sensitivity of model results to the change in parametrisation of model assumptions (including assessment whether the level of variability of the results generated by the model is appropriately sensitive to the variability of the actually observed values of the dependent variable),
- stress-tests – used to verify adequacy of model specification (especially with reference to the functional form of the relation between independent variables and the dependent variable) in the case of significant changes in the levels of input variables,
- benchmarking – enables making a relative verification of model performance quality, used especially in the case of the occurrence of limitations in availability of data that enables effective backtesting; benchmarking should be applied in particular at the stage of making decisions on the choice of model and updating/replacement of the model (the so-called 'champion-challenger' method),
- qualitative analysis – directed mainly at assessment of adequacy of concept of the model to the current situation and the currency of its assumptions to the changing external and internal environment, as well as identification of the potential causes of specific results of model qualitative analyses; in its course, there are also analysed possible user comments concerning the model structure and its performance.

13.8. As a minimum, in the scope of carrying out verification of non-material model performance quality, there should be highlighted the need to perform by the bank – with reference to the models used, in particular their assumptions – internal assessment taking into account testing and backtesting, which should be identified with the basic version of monitoring – the frequency of such examination should be, as a rule, annual, lower in justified cases (e.g. because of limited data availability), yet no smaller than once per three years. As the scope of use of models in risk management resulting from banking activity is growing, such verification – through increasing its scope (e.g. through the use of a broader range of tests within a specified testing area or the use of a broader range of testing methods) and frequency – should be moving towards regular and comprehensive model monitoring. As regards material models, the frequency of such examination should not be lower than annual, and when data are available, correspondingly higher.

13.9. In the case of finding out that model estimates can present a picture of the examined phenomenon in an insufficiently precise manner, it is recommended to supplement the estimates with the conservatism margin.

Process of escalation of negative results of model performance quality verification

14. Recommendation 14

There shall be in place at the bank a transparent process of escalation of negative results of model performance quality verification that ensures undertaking efficient and appropriate remedial and corrective measures.

14.1. It is expected that the process of escalation of negative results of model performance quality verification, in place at the bank, will cover both the remedial measures (initiated in response to

earlier symptoms testifying to the possibility of a growth in model risk level), and corrective measures (initiated in response to clear signals testifying to a growth in model risk level).

14.2. The process of escalation of negative results of model performance quality verification, in place at the bank, should ensure efficient and timely undertaking of the right remedial and corrective measures on a scale and of a nature proportional to the importance of the detected weaknesses in the model performance.

14.3. When defining the catalogue of appropriate remedial and corrective measures, the bank should also take into account the scope of premises indicating justifiability of undertaking the specific measures and adjust them to the specificity of the model, which they concern. The choice of measures that can be used can potentially include:

- increased observation of the trend in a given dimension of model performance,
- carrying out in-depth ad-hoc analyses (or model validation) providing more extensive information about the causes of deterioration of the model performance quality (including the incorporation of comprehensive verification of adequacy of model assumptions),
- ongoing benchmarking of model results with respect to alternative models,
- increase in the frequency or scope of typically performed control actions,
- starting to incorporate the estimation error in model results (or increasing the applied confidence level for the identified estimation error in the case of prior incorporation of the estimation error in model results) or imposition of other prudential add-ons, appropriate for the identified weaknesses (e.g. for poorer input data quality),
- a change in the selected model assumptions,
- initiation/acceleration of works on modification/updating/replacement of the model,
- a change in the principles of taking the model results into account in decisions made at the bank (e.g. a change in the cut-off point),
- limitation of the scope of application of the model,
- temporary increase in the scale of permissible overriding of model results,
- temporary/permanent exclusion of the model from use.

14.4. A developed catalogue of remedial and corrective measures should differentiate them at least into optional and obligatory measures to be undertaken in response to the occurrence of specific circumstances with respect to a given model.

VII. Validation

Independence of the validation unit

15. Recommendation 15

The bank which has material models should have an independent unit responsible for their validation.

15.1. In banks that have material models, there should function an independent (at least with respect to the bank's organisational units that fulfil the role of model owners and users) validation unit. The number of people involved should be proportional to the number and nature of the models subject to validation.[14] In the case of non-material models, covering them with an independent validation process shall depend on an individual, performed by the bank, assessment of justifiability of the undertaking.

15.2. What is the basic purpose of the validation of models, which should be ensured by the bank, is reduction of the model risk level through:

- verification of the correctness and assessment of the efficiency of model performance and the way of its functioning,
- identification of areas, in which justified improvements can be introduced, concerning both the model directly and the process of its application,
- formulation of appropriate recommendation and assigning the appropriate priority levels to them,
- verification of the quality of implementation of the formulated recommendations,
- promotion of high standards of model management.[15]

15.3. In order to avoid conflicts of interest and to protect the validation unit against potential negative impact of other bank organisational units (i.e. those that fulfil the roles of the owner or user of the model that constitutes the object of control by the validation unit) on the nature of validation findings, it is recommended that the validation unit should administratively and functionally be directly subject to the management board member responsible for supervision over the area related to model risk management. In addition, the validation unit should have undisputed right to issue binding recommendations – in this regard, it is recommended that reporting position of the validation unit should ensure that their recommendations have an appropriate priority and guarantee involvement of appropriate resources for the purpose of their efficient implementation.

Strengthening the functional independence of the validation unit shall be carried out by undertaking the following actions:

- non-participation of the people/units subject to assessment by the validation unit within the control activities performed by it in the process of appraisal of the employees of the validation unit or the levels of remuneration resulting from that assessment,
- non-performance by employees of the validation unit of tasks, the performance of which will be subject to assessment by that unit,

14 In justified cases, it may include only one employee, and it shall be permissible that the person will perform other, besides validation – tasks, while ensuring appropriate independence of the validation function taking into account recommendation 15.3.

15 The very fact of functioning of a validation unit exerts an additional pressure on the participants of the model risk management process to perform their tasks with due diligence and high quality.

- ensuring that, in the case of performance of internal recruitment to the validation unit, the employee of the validation unit is not responsible for making an assessment of the actions he or she carried out – under the prior role – for at least a year,
- locating workstations in a way that ensures the possibility to make an impartial and objective assessment of the activity of the controlled units
- ensuring turnover in the scope of assigned models for assessment by specific employees of the validation unit in such a way that a given employee does not assess the same model three times in a row.[16]

Scope of validation

16. Recommendation 16

The scope of actions performed during validation and its frequency should be adjusted to the specificity and risk level of a model.

16.1. The bank should have a written validation methodology to determine the goals and course of the validation process and the applied procedures, methods, and tools, as well as justification that the use of the procedures, methods and tools contributes to achievement of the intended goals. In particular, the specification of particular model performance quality tests, performed by the validation unit, should be consistent with the bank's model risk tolerance level.

16.2. When forming the validation process, one should remember that there is no universal approach to validation, which would always be well embedded in the bank's specificity and the range of the models used there – therefore, the way of implementation of tasks resulting from the validation methodology (and sometimes exceeding the strictly specified framework) should each time be flexibly adjusted to the nature of the model.

16.3. In order the carry out control activities assigned to the validation unit in an effective manner, the validation process (maintaining an appropriate adjustment to the scope of tasks to the type of validation) should cover all model risk categories identified by the bank, i.e. the validation process should in particular be directed at analysis of such aspects of model risk management as:

- use of the model in the processes and decisions made at the bank,
- correctness of implementation,
- logical and coherent theoretical concept,
- appropriate quality of data feeding the model,
- adequacy of the assumptions and assessment of model weaknesses/limitations,
- assessment of the statistics concerning model performance quality,
- assessment of alternative solutions,
- compliance with internal and external requirements,
- the process of reporting model results,
- the process of implementation of validation recommendations,
- the quality of documentation,
- assessment of changes in models.

16 Except when the validation unit comprises one employee.

16.4. Each time, a report on the validation process shall be prepared, which shall clearly indicate the components of the model and its application which were examined by the validation unit (in accordance with the validation schedule), and which were not – due to lack of technical capacity (e.g. missing data), and which – for other reasons (e.g. low materiality).

16.5. As a rule, each material model should be covered by an annual validation cycle. For some types of material models, if this results directly from the specificity of their functioning, validation may be performed less than once per year (yet not less frequently than once per three years). Cases of such models should be clearly justified, treated in a coherent and consistent way over time and they should be appropriately included in the validation unit schedule of work in advance.

16.6. In justified cases, it shall be permissible that the scope of validation should be narrowed down, or the date of particular validation should be deferred,[17] as long as at least one of the following additional conditions have been met:

- a sufficient quantity of data required for carrying out standard testing on the basis of quantitative measures has not been gathered for a given year (this pertains in particular to models for the so-called low-default-portfolio segment),
- the model is being redeveloped and shall soon be withdrawn (i.e. the time between the date of the last model validation and the date of its planned withdrawal from use should not be longer than 24 months),
- the results of the last validation did not reveal significant weaknesses of the model, its current risk level is not high, the results of monitoring indicate its high quality, users do not dispute the model quality, the process forming the object of the modelled phenomenon is characterised by stability and all possible high-priority recommendations of the validation units and the audit have been implemented.

It should be remembered, however, that the decision on not performing validation or narrowing down its scope should be each time made by the management board member who oversees the activity of the validation unit.

16.7. The validation unit shall perform its tasks on the basis of an established work schedule, at least one year ahead. The schedule should:

- assume covering each material model with the validation process, in accordance with the established cycle,
- incorporate time for carrying out prevalidation[18] for new models and validation of their implementation,[19]
- allow for time needed for verification of the progress in implementation of previously issued recommendations (verification of the compliance of the process of implementing recommendation with its schedule),
- incorporate temporal dispersion of the actions performed with regard to specific models (e.g.

17 Taking into account the recommendation set out in recommendation 16.5, aimed at preventing a situation when any material model is validated with a frequency lower than once in 3 years.

18 At least with regard to material models, the decision on their production implementation should be preceded with a positive assessment by the validation unit concerning the correctness of their idea and regularity of the construction process (both in qualitative and quantitative terms, as long as quantitative techniques were used in the construction process of a given model). In the case of introducing changes in existing models, detailed principles of procedure shall be set out by the bank (including the circumstances when specific changes are to be subject to validation).

19 The way of implementing the model into the production system should be subject to the validation process, as a rule during the first 3 months of the date of production model implementation. The scope of actions undertaken within validation should be sufficient for the validation unit – or a different bank's organisational unit with appropriate competences – to perform a reliable and independent assessment of the quality of the implementation.

strive at coordination of the actions with the owners of specific models, so as the dates of monitoring and validation of a given model would be appropriately spaced),

- provide for an appropriate time buffer for ad-hoc validations.

16.8. An efficient validation process shall require involvement of personnel with holistic knowledge and competences – as a rule, an appropriate level of scientific knowledge (the need to understand the mechanisms of functioning of particular models, knowledge concerning the optimum model testing methods, the ability to critically assess model assumptions) is needed, but also the ability to use IT tools (especially those that are used by model owners), an in-depth understanding of the specificity of the processes in place at the bank (an assessment of the model use process) and appropriate communication skills (frequent interaction with many participants of the model risk management process).

16.9. When designing the structure of resources of the validation unit, smooth replaceability of people delegated to the performance of specific tasks should be ensured.

16.10. In the case of external models, the scope of validation assigned to specific validation units (local or group/external) should be defined precisely, whereas in the case of carrying out validation by an external entity, under contracts with external suppliers, the bank should strive at ensuring the possibility to co-define the scope of validation for itself, so as to cover all important risks.

Validation techniques

17. Recommendation 17

The validation process should involve – in a complementary manner – both quantitative and qualitative techniques to ensure full knowledge about the model performance quality.

17.1. In the process of quantitative validation, the techniques and principles of examination that form the object of recommendation 13 should be used accordingly.

17.2. Each model is based on specific assumptions. Some of them cannot be modified within the functioning of a specific method, as they form its integral part (e.g. the assumption concerning the type of statistical distribution or the method of estimation of parameters), while others result from certain expert decisions. The validation unit should examine the reasonability and adequacy of the expert decisions within the assessment of model performance, as well as verify whether the application of another (alternative) method based on different assumptions would be more adequate as a description of the examined phenomenon.

17.3. The validation unit should verify whether the model documentation contains information on the assessment of the behaviour of the model during adverse market conditions and should independently verify the presented results. This is tantamount to examining whether the causal relations described with the models are stable in various market conditions.

17.4. There should be applied various, complementary validation techniques – e.g. instead of measuring the discriminatory power with various methods, it is better to measure that power with one statistics, but used in different cross-sections:

- subpopulation (e.g. industries),
- time (a period of enhanced growth or recession),
- single characteristics (stability),
- estimation errors (confidence intervals for statistics).

17.5. The validation unit should examine whether the model estimates are:

- prospective (they incorporate expectations concerning the future situation), or retrospective,

- static, or dynamic (new information influence model estimates), as well as whether this is consistent with the requirements concerning the principles of functioning of a given model.

17.6. With regard to model components which are key from the viewpoint of model risk, especially if they produce unintuitive results, the validation unit should consider replication of the process of construction of these components.

17.7. In the process of drawing conclusions on the basis of quantitative validation, the following principle must always be kept in mind: "few observations → low power of the statistical test → low efficiency of identification of an erroneous model → potentially higher error of the value or relation estimated by the model."

17.8. Prognostic models, aimed at anticipating the course of a given process in the future, are calibrated to historical data. The validation unit should examine whether that assumption is adequate in the context of current market conditions.

17.9. The validation unit should verify whether the model assumptions are close to reality and whether lack of full correspondence of the model to the real world is not manifested in underestimation of the level and variability of risk. Similar course of action should be adopted with reference to whether all weaknesses and limitations of a model have been identified at the stage of its development. In the event of identification of deterioration of the model performance quality, the validation unit should strive at precise determination of the cause of that deterioration, i.e. whether it was determined by factors external to the model, or a specific model risk category related to a weakness of a specific model component materialised.

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