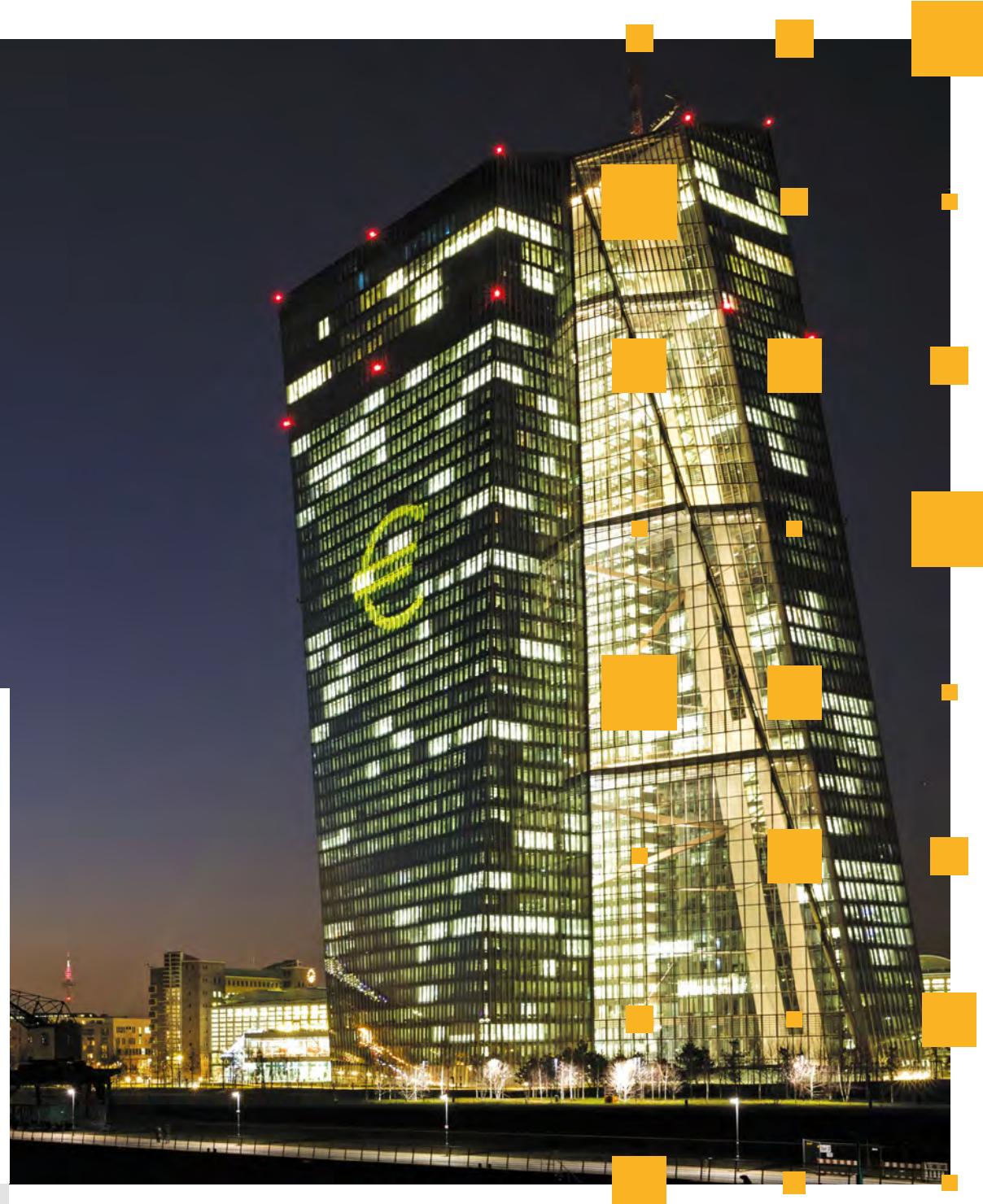


# Risk Management & Modelling



[www.pwc.cz/rmm](http://www.pwc.cz/rmm)



# Introduction



Dear Risk professional,

Thank you for your interest in the PwC Risk Management & Modelling team's products and services. In this catalogue, we present our main areas of focus (as defined by regulation) and support that we can deliver to our clients.

The focus of our team is on financial institutions, predominantly banks and insurance companies; however, we are ready to support investment firms or large corporates as well.

The catalog is organised into 4 chapters:

■ **Services** – There are different ways to help you improve your current risk management practises. The individual techniques are described in this chapter - they apply to all topics equally.

Thanks for your time and interest in reading our catalog.

Please don't hesitate to [contact us](#), if we could be of help to you and your institution.

■ **Core topics** – The universe of regulation is continuously growing. The topics covered by the team are described in the chapter together with the key regulation. Each topic is owned by a Subject Matter Expert monitoring market practise, new regulation, and supervising delivery to our clients.

■ **Tools** – Automation in risk management through the use of modern technologies is our key differentiator. Explore our set of innovative Tools that will help you digitise your risk-related processes.

■ **Team** – Subject Matter Experts representing and developing the team's expertise in the respective topic.



Rostislav  
Černý  
Partner



Ondřej  
Glatz



Jiří  
Mach

# Table of Contents

01

## Services

Pages 4 – 7



02

## Core Topics

Pages 8 – 48



03

## Tools

Pages 49 – 64



04

## Team

Pages 65 – 70



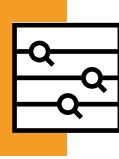
# 01

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## Services



# Services



## Model Validation

► To achieve higher performance standards, banks and other financial institutions are forced to continuously implement a growing number of complex models. These models are mostly created with advanced-analytics techniques. According to the regulatory requirements, models must be under strict control. Regulators and auditors expect institutions to have a robust model risk management framework to identify, eliminate, and minimise risks. Poorly designed models can have significant financial consequences and damage a bank's reputation and market position. An effective model validation framework must be built to provide not only evaluation and constructive feedback on a particular model but also to help maximise the model's performance.

The validation process can be challenging; to help our clients, PwC validation experts remain attuned to the ever-changing regulatory landscape to deliver high-performing solutions that reflect the latest requirements. Our team offers a high level of expertise, experience, and modern technology services to achieve desirable results and align with the best market practices.



## Model Development

► Model development has turned into a core quantitative activity. Many institutions have a dedicated department whose purpose is to ensure models are conceptually sound and implemented as expected.

Our risk modelling experts are able to cover the clients' needs in most of the quantitative risk management areas. We have strong experience in particular in credit risk model development (scoring models, IRB models, loan loss provisioning), stress testing (CCAR/DFAST, EBA, ...), and complex derivatives pricing.



## Quality Assurance

► Our team's knowledge is based on the hands-on experience of Subject Matter Experts with CV records from financial institutions. Knowledge of regulation, often the driver for risk-related projects, is thus accompanied by knowledge of products and processes.

We can support you by performing quality checks on the project's outputs, soundness of implementation of regulatory requirements, or by providing consultation regarding observed market practice.



## Automation

- Model development, recalibration and validation are one of any financial institution's main activities concerning its models. But the need for more up-to-date models, more frequent quantitative assessments and more detailed reports increases the pressure on teams performing these activities. As a result, it becomes essential to speed up and enhance respective processes by automating repetitive tasks.

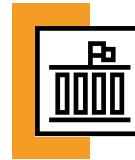
We provide our clients with a service that automates their development or validation processes from data quality controls to final report export to address this challenge. A result is an interactive tool that allows for an end-to-end modelling activity. By automating the repetitive tasks, we save time and resources. The focus of the validation and development teams can thus be shifted to analysing discovered issues rather than preparing inputs and writing reports.



## Benchmarking

- Benchmarking against observed or leading market practise is a standard tool for upskilling existing practises of financial institution. Our team possesses Subject Matter Experts with long-term records in the banking industry, knowledge and hands-on experience of banking products and services. Due to the delivered projects we have gained additional experience on existing approaches around the Europe, Eurasia, or even US markets.

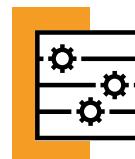
The benchmarking results in an assessment of the maturity level of risk management practice, identification of improvement opportunities and formulation of recommendations. Recommendations can be further aggregated into projects based on implementation synergies.



## Regulatory Implementation

- New financial regulations can affect various departments and processes across the institution, which makes its implementation a complex task. Non-compliance can lead to fines imposed by regulators, litigation, loss of reputation on the market and other unfavourable consequences for the entity.

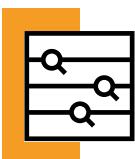
Our team can support you in end-to-end implementation starting from preparation of an operational gap analysis and proposal of a local implementation plan and budget. This is followed by execution of financial impact assessments, development of local methodology, creation of target operating models of processes, implementation of new IT solutions allowing for the new regulatory requirements and their UAT to be reflected.



## Project Management

- Projects are vital for implementing ideas and transforming them into respective outputs. The benefits of a well-organised and controlled project are that the required outputs are delivered in a specified time and within an approved budget. In FSRR, the management of projects is our daily agenda. We combine our project management experience with expert knowledge of the topic to deliver the best experience for the client.

We can support your projects by appointing a project manager with expertise in the topic addressed by your project. Our contribution is also in the transfer of knowledge.



## Due Diligence

- Conducting a comprehensive due diligence is an integral part of any business combination transactions. When financial institutions are involved in a transaction, along with typical topics such as financial, legal, tax, IT, HR, etc., there are at least two additional important areas to be covered by specialists: risk and capital.

We offer a team of risk management experts with specialised knowledge in the areas of credit risk modelling & management, capital requirement calculations and related standards and regulations. Using our experience from audit engagements, we are able to assist the buy-side in analysing the target's loan portfolio quality, gap assessment of the provisioning models, review of the risk-weighted asset calculations (both SA and IRB), or in assessing the ICAAP and other risk-related policies.



## Audit

- Providing support to our PwC colleagues from Audit is one of the most common activities of our team. We are experienced in performance of audit procedures, as we often act as the auditors' experts, e.g. in the area of loan loss provisioning. We communicate with the core audit teams, as well as with the clients.

Given our knowledge and experience, we are efficient in seeking the potential issues and analysing them. We can offer both qualitative and quantitative analyses, with respect to the relevant standards and the needs of individual clients. We are able to provide our own back testing or challenger models if needed. We are also experienced in documenting the audit results and findings, as the outcome of our work contributes to the final audit reports.



## Education

- Transferring knowledge is at the core of the added value our team brings its clients. We utilise various platforms to ensure coherent knowledge sharing. Our subject matter experts regularly deliver workshops on specific topics requested by the client. We are also prepared to provide ad-hoc support via focused calls. Furthermore, to create a long-term and replicable impact, we can develop custom-made e-learning to fit the needs of the client. We will closely cooperate with our colleagues from PwC Academy, a branch of PwC and a training organisation recognised worldwide, to achieve excellence not only in the content of the e-learning but also in the effectiveness of the knowledge transfer.

# 02

## Core Topics

<b>1</b>	<b>Risk Appetite Framework</b>	<b>9</b>
<b>2</b>	<b>Risk Culture</b>	<b>10</b>
<b>3</b>	<b>Integration of Climate and Environmental Risks</b>	<b>11</b>
<b>3.1</b>	<b>ESG Quantitative Modelling</b>	<b>13</b>
<b>3.2</b>	<b>Green and Sustainability Issuance</b>	<b>14</b>
<b>4</b>	<b>Model Risk Management</b>	<b>16</b>
<b>5</b>	<b>Internal Ratings-Based approach</b>	<b>17</b>
<b>6</b>	<b>Predictive Models and Machine Learning</b>	<b>18</b>
<b>7</b>	<b>Capital Management</b>	<b>20</b>
<b>7.1</b>	<b>Synthetic Securitization</b>	<b>22</b>
<b>7.2</b>	<b>Economic Capital</b>	<b>24</b>
<b>7.3</b>	<b>Regulatory Stress Testing</b>	<b>25</b>
<b>7.4</b>	<b>Internal Stress Testing</b>	<b>26</b>
<b>8</b>	<b>Risk Based Pricing</b>	<b>28</b>



<b>9</b>	<b>Credit Risk Management</b>	<b>30</b>
<b>9.1</b>	<b>Loan Origination and Monitoring Process</b>	<b>32</b>
<b>9.2</b>	<b>Expected Credit Loss Benchmarking</b>	<b>34</b>
<b>9.3</b>	<b>Credit scoring</b>	<b>35</b>
<b>10</b>	<b>Loan Loss Provisioning</b>	<b>36</b>
<b>11</b>	<b>Recovery Planning</b>	<b>37</b>
<b>12</b>	<b>Resolution Planning</b>	<b>38</b>
<b>13</b>	<b>Liquidity Risk Management</b>	<b>39</b>
<b>13.1</b>	<b>Funds Transfer Pricing</b>	<b>40</b>
<b>14</b>	<b>Market Risk Management</b>	<b>41</b>
<b>14.1</b>	<b>Interest Rate Risk in the Banking Book</b>	<b>42</b>
<b>15</b>	<b>Data Quality and Consistency Review</b>	<b>43</b>
<b>16</b>	<b>Asset Quality Review Preparation</b>	<b>45</b>
<b>17</b>	<b>Asset Quality Review Audit</b>	<b>48</b>

# 1 Risk Appetite Framework



Institutions shall have robust governance arrangements, which include a clear organisational structure with well defined, transparent and consistent lines of responsibility, effective processes to identify, manage, monitor and report the risks they are or might be exposed to, adequate internal control mechanisms...that are consistent with and promote sound and effective risk management.

(Article 74 DIRECTIVE 2013/36/EU)

A sound Risk Appetite Framework aligns Business Strategy, Risk Appetite, and Risk Management Strategy for the sustainable long-term growth of the bank. It defines the maximum amount of risk the bank is able to bear (risk capacity) and the amount of risk the bank is willing to accept (risk appetite) to achieve its business objectives.

The Risk Appetite Framework defines the overall approach through which the risk appetite is established, communicated, and monitored. The framework is designed to capture and consider all material risks to the bank and the bank's reputation vis-à-vis policyholders, depositors, investors, and customers.

## Risk Appetite Framework

The framework sets the roles and responsibilities of stakeholders, ownership of risks amongst 1st and 2nd Lines of Defense, embedding mechanisms for sound risk culture. It determines the general framework in which Internal Capital Adequacy Assessment Process and Internal Liquidity Adequacy Assessment Process are conducted. At the same time, the results and outputs of the ICAAP



Jiří  
Mach



Silvia  
Majlingová

and ILAAP are also channeled back into the framework. The framework defines the process of cascading and embedding Risk Appetite Statement throughout the bank.

The framework interconnects remuneration policies, individual risk management policies (credit/ market/liquidity risk), policy on the creation of limits, and other procedures are aimed at securing the appropriate balance between risk and rewards.

### Relevant regulations

- Basel II, III, IV
- CRR/CRR 2, CRD 5
- Upcoming CRR 3, CRD 6
- EBA/GL/2021/05 Guidelines on internal governance under Directive 2013/36/EU
- BCBS Guidelines Corporate governance principles for banks (2015)
- FSB Principles for An Effective Risk Appetite Framework (2013)



Risk culture ... the institution's norms, attitudes and behaviours related to risk awareness, risk taking and risk management.

(FSB Guidance on Supervisory Interaction with Financial Institution on Risk Culture, 2014)

**Risk Cultures vary across financial institutions. However, certain common fundamental elements determine a sound Risk Culture within the institution, such as:**

- Effective risk governance
- Effective risk appetite framework
- Compensation practices that promote appropriate risk taking behaviour

PwC's globally recognised methodology for assessment of Risk Culture recognises six focus areas - Leadership, Governance and Organization, Communication, People Management, Incentivization and Accountability.

The initiative is focused on assessing Risk Culture attributes in each focus area via specialised tools, ensuring consistent deployment of the methodology. There are four techniques for

observing the attributes – a **Risk Culture Survey** for all employees, **desktop research** aimed at policies and procedures, **interviews with the key stakeholders**, **focus groups** on dedicated risks.

The assessment is both qualitative and quantitative. Unified, widely recognised terminology for maturity level evaluation is not available. Still, there is consensus that there are five levels of maturity. In PwC methodology, there are five maturity levels - Basic, Developing, Defined, Managed, Optimised.

For attributes assessed as "Defined" and below, the qualitative assessment is used to define **improvement opportunities** and **formulate recommendations**.

### Sound Risk Culture

- Consistently supports appropriate risk awareness, behaviors, and judgments about risk-taking within a robust risk governance framework
- Bolsters effective risk management, promotes sound risk-taking, and ensures that emerging risks or risk-taking activities beyond the institution's risk appetite are recognised, assessed, escalated, and addressed on time



[pwc.cz/risk-culture](http://pwc.cz/risk-culture)

**There are six key focus areas when creating and sustaining an effective risk management culture**



### Relevant regulations

- FSB Guidance on Supervisory Interaction with Financial Institutions on Risk Culture (2014)
- FSB Principles for An Effective Risk Appetite Framework (2013)
- EBA/GL/2021/05 Guidelines on internal governance under Directive 2013/36/EU
- BCBS Guidelines Corporate governance principles for banks (2015)



Peter  
Tuchyňa



Jan  
Muchna

Moving to a greener and more sustainable economy is good for job creation, good for people, and good for the planet. Today we are making sure that the financial system works towards this goal. Our proposals will allow investors and individual citizens to make a positive choice so that their money is used more responsibly and supports sustainability.

(First Vice-President of the European Commission Frans Timmermans, during presentation of the EU Action Plan for Sustainable Finance)

## Background

Binding climate protection regulations are slowly being imposed on the financial sector under the EU Action Plan. Its targets, based on the Paris agreement and UN sustainable development goals, are seeking to decarbonise the EU economies by 2050, and reduce GHG emissions by 55% by 2030 compared to 1990 levels. To be compliant with these rules, the institution should formulate its sustainable business strategy, governance, risk management and sustainability targets. That way, they can seize opportunities for sustainable development, set themselves apart from the competition, and make sure their business model is ready to react to climate change challenges.

## Preparing for the climate challenges

**Integrating climate and environmental risks into bank's governance, business strategy and risk management should include:**

- Reviewing the current status of the sustainability activities, and mapping them to climate-related and environmental (C&E) risks, opportunities and trends on the market
- Incorporating best practices into the company's ESG area, namely into:
  - Governance: the integration of C&E risks into roles and responsibilities of the management, risk reports, risk appetite statement, and C&E data needs and plans

- Business strategy: setting strategy, business environment monitoring and key performance indicators
- Risk management: the integration of C&E risks into credit risk sector lending policies, underwriting procedures, continuity of its operations, and conduct of an (ad-hoc) C&E-related stress testing or sensitivity analysis
- Identifying the main strengths and weaknesses in the company's C&E disclosures
- Creation and promotion of green products and services by formulating:
  - responsible financing policy
  - developing sectoral heat-maps
  - creating tools for relationship managers that can help them talk to their clients about their C&E approach and goals

## Relevant regulations

- European Green Deal
- ECB Guide on climate-related and environmental risks
- EBA report on management and supervision of ESG risks for credit institutions and investment firms
- Principles for Responsible Banking (Framework by UNEP-FI)

### 3 Integration of Climate and Environmental Risks (2/2)

#### Challenging questions in the integration of climate and environmental risks

When thinking about and integrating C&E risks into bank's processes, financial institutions must tackle the following questions:

- How to incorporate C&E risks into business processes such as financing decisions, investment advisory processes, and disclosure requirements?
- How is the governance of C&E risks incorporated into the bank's roles and responsibilities?
- Does the company have C&E goals? How do they promote those goals across the organisation?
- Does the company have, or does it plan to introduce decarbonisation plans and pathways for specific industries and clients?
- How do they measure their carbon footprint, and that of their suppliers and clients? Do they disclose such information on a regular basis?
- How do C&E risks and opportunities impact the business strategy and governance of the bank, and risk management & client relationship management more specifically?
- Is risk management working on incorporating C&E risks into its governance and processes? Are credit risk, market risk, liquidity risk and operational risk units aware of and ready to integrate the climate-related and environmental risks into their daily management processes?
- Does the company perform C&E-related stress testing or scenario analyses?
- How to use the bank's approach to C&E risks in issuing debt and capitalising on the demand for green debt?



## 3.1 ESG Quantitative Modelling

ESG (Environmental, Social and Governance) risks have fallen under increased regulatory scrutiny putting pressure on banks' modeling teams to include these new risks within their credit risk models - both transactional and portfolio. Current requirements are limited to managing these risks: (i) during the loan origination process, via (ii) special purpose stress-testing tools and (iii) through specialised disclosures, but in the future, these risks will have to be included within Basel and IFRS frameworks. Furthermore, banks that do not prepare for these tasks in advance, could be subject to increased capital requirements under Pillar 2 within Basel III and, more formally, within Basel IV. Notwithstanding regulatory pressures, ESG modelling also represents a significant business opportunity (green and brown), if the framework is adapted well to the bank's business model.

### ESG modelling poses significant modeling challenges as:

- Many of these risks have not yet materialised, and thus traditional model calibration is not possible
- Physical and transitional risks behave differently and have different transmission channels
- Dynamic balance-sheet assumptions require more sophisticated calculation methods otherwise calculation times are very long
- Lack of data and infrastructure for data collection is particularly problematic

In PwC, we are prepared to help with these issues comprehensively in order to enable the bank to appropriately assess risks associated with ESG issues and demonstrate its ability to do so to all stakeholders.

Jan  
Muchna



Ondřej  
Šedivý



### Relevant regulations

- Sustainable finance disclosure regulation (SFDR)
- EU Taxonomy
- CRR 2, CRD 5
- EBA/ITS/2022/01 Final draft implementing technical standards on prudential disclosures on ESG risks in accordance with Article 449a CRR
- EBA/GL/2020/06 - Guidelines on loan origination and monitoring
- Upcoming CRR 3/CRD 6
- ECB Guide on climate-related and environmental risks



## 3.2 Green and Sustainability Issuance (1/2)



Peter  
Tuchyna

“ If some companies and industries fail to adapt to the transition to a low-carbon economy, they will fail to exist.

(Mark Carney,  
Governor of Bank of England;  
François Villeroy de Galhau,  
Governor of Banque de France)

Demand for green debt has been soaring since market inception, with over \$1.6tn issued to date, of which over \$500bn was issued in 2021 alone, and 2022 expected to see the first annual trillion, according to Climate Bonds Initiative (see chart on next page). Likewise, pricing advantages are expected to show endurance during a changing economic landscape, driven largely by heavy demand outstripping the supply as asset managers look to address climate risk in their portfolios.

Harnessing the bond investors' preference for green and sustainable investment opportunities, green issuance is another tool to further solidify the sustainability strategy of banks in the eyes of investors, rating agencies and clients. By setting up a framework aimed at defining sustainable project categories with either environmental and/or social aspects, financial institutions get financing for their customers' sustainable activities, and they show a commitment towards their sustainability targets.



### Relevant regulations

- EU Taxonomy (Regulation 2020/852)
- ICMA Sustainable Finance principles (Green Bond Principles, Social Bond Principles, Sustainability Bond Guidelines, Sustainability-Linked Bond Principles)
- European Green Deal

## 3.2 Green and Sustainability Issuance (2/2)

### Green Issuance Options

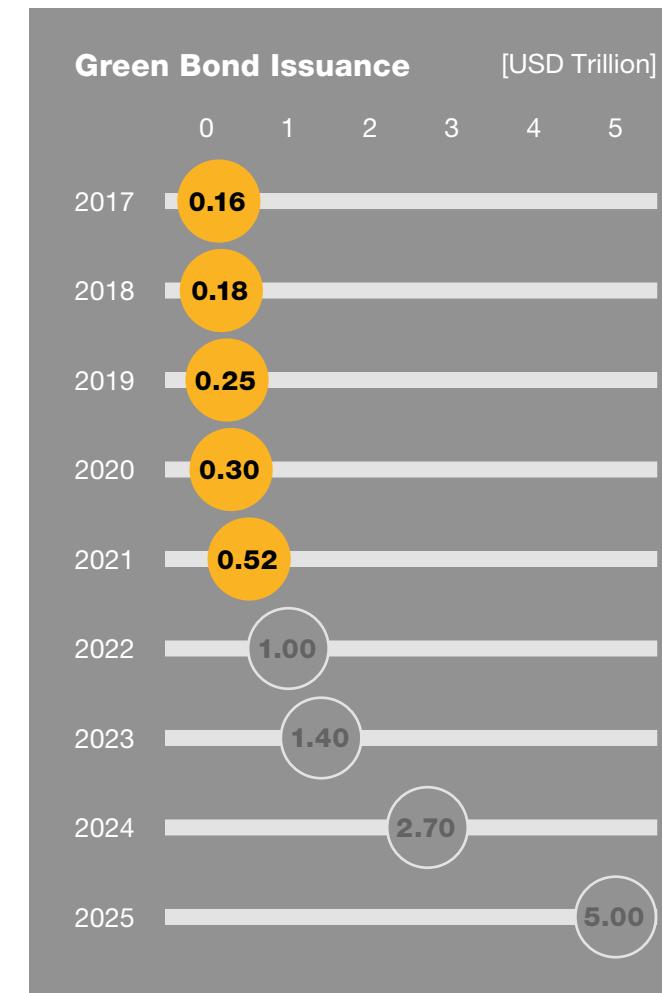
When deciding on getting financing for their ESG projects, financial institutions must consider several aspects:

- How will they set up the Sustainable finance framework, with links to the overall sustainability strategy of the company?
- What projects they want to finance/refinance with their Green issuance, and according to which classification system will they report their green/sustainability compliance (e.g., ICMA principles, EU taxonomy, their own green definitions)
- Whether they need a second party opinion on:
  - The whole company, and/or
  - The sustainable finance framework, and/or
  - Some specific areas (such as green portfolio reporting, their ESG strategy, etc.)
- Through what channels will they promote and underwrite the issue (selection of bookrunners, lead managers, lead arranger, etc.), including setting up the roadshow and investor calls
- Which investor types / specific investors do they want to target (Green / Dark green investors, mainstream investors, what proportion of each type, etc.)

- What incentive structures (if any) do they want to embed into the offering, such as financial and/or structural characteristics depending on whether the issuer achieves predefined Sustainability/ESG objectives?
- Who and how often will verify the issuer's sustainability claims and promises made in the offering?
- How and in what frequency will they disclose and report their sustainability targets and green portfolio performance?

### The time for action is now

What lies ahead of humanity in order to limit global warming (well) below 2°C compared to pre-industrial levels is a (very) challenging task. It will require cooperation from all economic stakeholders around the world. What is positive is that, according to the latest report by the Intergovernmental Panel on Climate Change, we still have a chance to achieve this target, but we will have to significantly reduce carbon dioxide emissions in the next five to ten years. In order to secure a liveable future, financing sustainable projects is one piece of the puzzle.



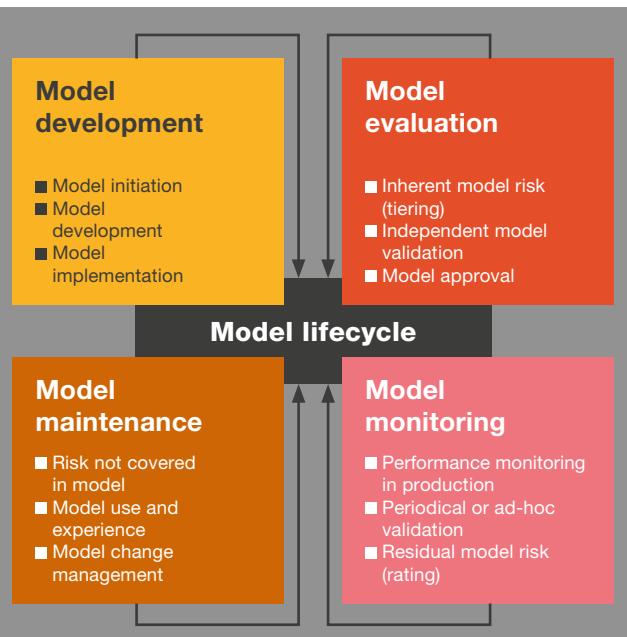
# 4 Model Risk Management

David  
Dolejší



Banking organisations should be attentive to the possible adverse consequences (including financial loss) of decisions based on models that are incorrect or misused, and should address those consequences through active model risk management.

(Supervisory Guidance on Model Risk Management, SR Letter 11-7, FED)



Model risk is associated with the use of models during their entire lifecycle. It arises from various sources. It can originate from incorrect identification, erroneous model implementation in a system; unreliable or incomplete data; uncertainties about statistical and mathematical methods in place; inaccurate calibrations; model misuse; incorrect interpretation of model results; inappropriate assumptions stemming from the use of upstream and downstream models; incomplete or inaccurate model inventory and so on.

To manage and remediate associated risks, a financial institution needs to establish and implement the formal set of standards, policies, and processes known as model risk management. Hence, model risk management is the control framework that supports the business and decision process around the use of all models in an institution. The framework should be built on controls along the phases of the model lifecycle.

## Model lifecycle phases:

- Model development
- Model evaluation
- Model monitoring
- Model maintenance

Formalised requirements on model risk management are part of industry practice and part of the regulation. Authorities such as the European Central Bank, US Federal Reserve System, or Canadian Office of the Superintendent of Financial Institutions require supervisees to set up proper governance around model risk.

PwC assists financial institutions across the globe with implementing a model risk management framework. We are helping to establish group-wide minimum standards for inventory, development, validation to align and harmonise the current processes with market practice and regulatory requirements.

## Relevant regulations

- CRR/CRR 2, upcoming CRR 3
- ECB Guide to internal models
- Delegated Regulation on RTS on assessment methodology for IRB approach under CRR
- EBA/GL/2018/03 - Guidelines on SREP (and upcoming revised version - EBA/CP/2021/26)
- PRA Supervisory statement: Model risk management principles for stress testing (SS3/18)

## Tools

- Model Risk Manager



Ondřej  
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Ondřej  
Šedivý



David  
Dolejší

Deepening banks' experience with credit risk modelling, increasing portfolio size and availability of historical portfolio data might lead to a decision by a bank to move from a standardised approach to more sophisticated credit risk internal rating-based (IRB) models for the purpose of regulatory capital calculation. Transition to more complex IRB models introduces additional costs due to increased demand for more qualified and experienced staff, strict requirements on data quality and other conditions set out by regulation. On the other hand, the IRB approach should lead to a level of capital requirements that is sensitive to the riskiness of the portfolio, improve management of credit risk and should deliver model-based risk parameters applicable also in areas of the banks' activities outside of the regulatory scope. In the European setting, modelling itself is considerably dependent on the implementation of Basel rules in the form of CRR 575/2013 and further supported by EBA guidelines and regulatory technical standards.

## Typically, the IRB modelling involves the following steps:

- 1 Data Processing, Data Quality Checks, Construction of Reference Datasets
- 2 Development of Ranking Mechanism for LGD and EAD parameters or Scoring for PD
- 3 Calibration to Long Run Average
- 4 Margin of Conservatism
- 5 Downturn (LGD and EAD)

Naturally, the transition to the Foundational or Advanced IRB approach does not end with the development of the model. The model must be initially and periodically validated and, if needed, recalibrated or redeveloped when its performance is not satisfactory or not compliant with any newly imposed regulatory requirements.

### Relevant regulations

- CRR 575/2013
- EBA guidelines (EBA/GL/2017/16, EBA/GL/2016/07, EBA/GL/2019/03,...)
- EBA regulatory technical standards (EBA /RTS/2018/04, EBA/RTS/2016/03, ...)
- ECB Guide to Internal Models
- Instructions for reporting the validation results of internal models

### Tools

- [Credit Risk Modeling Suite](#)



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Glatz



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Šedivý



David  
Dolejší

Predictive analytics uses methods of mathematical statistics, data mining, and artificial intelligence to predict likely future outcomes with the aid of historical data. In the financial sector, predictive models help institutions optimise their business strategies, automate processes and reduce costs.

Nowadays, a plethora of predictive models is used in banking practices ranging from traditional statistical approaches (e.g., linear or logistic regression, principal component analysis, hierarchical clustering) to modern methods of machine learning (e.g., random forests, neural networks, genetic algorithms). Typically, various approaches are tested and compared, eventually combined to achieve an optimal solution.

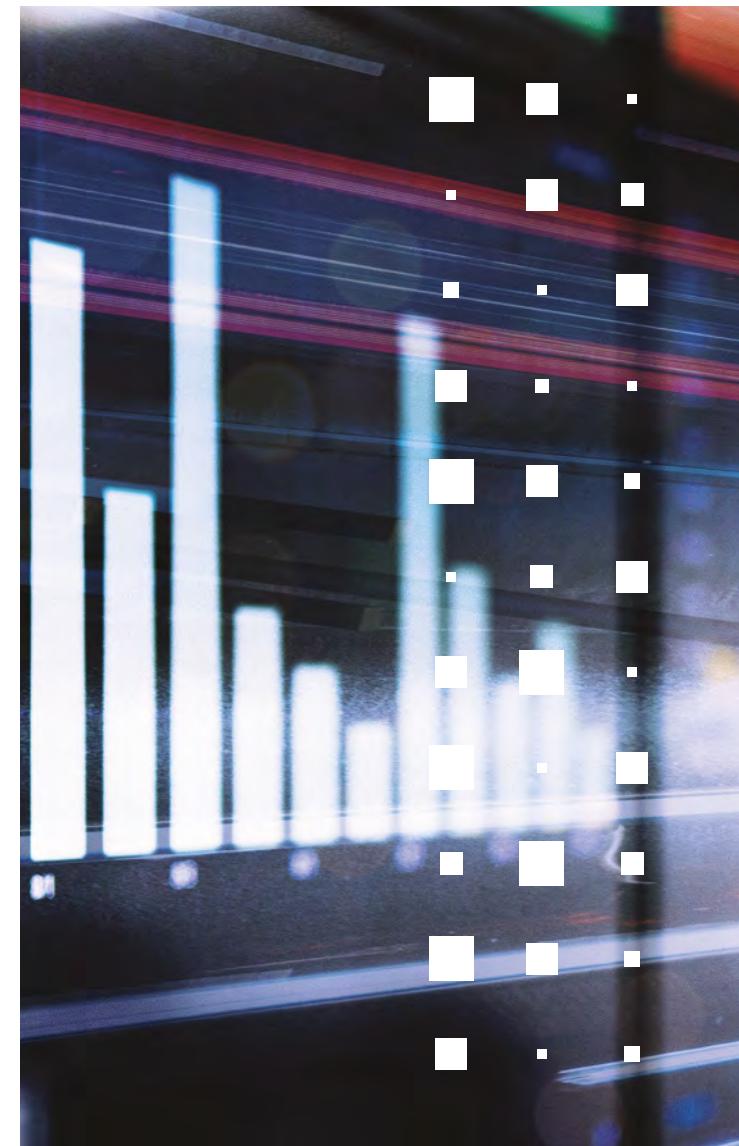
**Predictive models are employed by financial institutions in many different areas including:**

- [Credit Scoring](#)
- [IRB Modelling](#)
- [Loan Loss Provisioning](#)
- [Internal Stress Testing](#)
- [ESG Quantitative Modelling](#)
- [Risk Based Pricing](#)

## Artificial intelligence and machine learning (AI / ML)

Methods of machine learning are becoming increasingly important in the financial industry as they can bring competitive edge. Many financial institutions have already utilized these advanced techniques for assessing creditworthiness of the customers and predicting their future behavior. In the underwriting process, loan providers aim to assess as efficiently as possible the applicants' ability to repay which directly affects profitability of their business. Later in the loan lifecycle, information on customers' habits is a substance for estimating their behavioral credit score. Machine learning has also proven to be useful for KYC/AML or fraud detection. Loan providers can basically use any available data relevant for a given purpose (telco data, transactional data, geolocation data, social media); this is often accompanied with the integration of big data.

In the regulatory world the application of machine learning models is rather limited due to strict requirements on clear interpretation of the functional model form and individual risk drivers. However, the shift towards acceptability of AI mindset is visible, as EBA points out in the discussion paper on machine learning for IRB models: „...ML models might prove to be useful in improving IRB models, even helping them to meet some prudential requirements“.



## 6 Predictive Models and Machine Learning (2/2)

### Explainability



The most widely acknowledged challenge of ML models is the difficulty in understanding why and how the model generates results, generally described by the term 'explainability', associated with a number of important risks.

(Artificial Intelligence, Machine Learning and Big Data in Finance: Opportunities, Challenges, and implications for Policy Makers. OECD, 2021.)

Although the machine learning methods are generally more difficult to interpret, it does not mean they are a pure black box. There is a clear mathematical background and formulas defining the model outcomes. Expansion of artificial intelligence is accompanied with the development of methods for interpretation of the models leading to trusted and explainable AI. Statistics describing the impact of individual drivers on the model outcomes should be an integral part of the model documentation.

Furthermore, predictive models are usually required to be unbiased. This can often be translated in practical terms as that no groups in the population should be discriminated due to deficiencies in data sample selection or model development process; this property is also referred to as fairness. Notably in the banks' services, fairness of models applied to customer segments is scrutinized by the regulators.

#### Relevant regulations

- EBA discussion paper on machine learning for IRB models
- EBA report on big data and advanced analytics

#### Tools

- [Credit Decision Engine](#)
- [Credit Risk Modeling Suite](#)



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The institution is expected to maintain a robust, up-to-date capital plan that is compatible with its strategies, risk appetite, and capital resources. The capital plan is expected to comprise baseline and adverse scenarios and to cover a forward-looking horizon of at least three years. The institution is also expected to take into account the impact of upcoming changes in legal, regulatory, and accounting frameworks.

(ECB Guide to the internal capital adequacy assessment process)

## Introduction

The capital requirements for the bank consist of three main elements - minimum capital requirements (Pillar 1), an additional capital requirement (Pillar 2), and buffer requirements. Both minimum and additional capital requirements are binding (TSCR), and the bank should maintain the applicable TSCR, at all times in an adverse scenario.

**The large banks are expected to implement the normative perspective complemented by the economic perspective:**

- Normative perspective – multi-year assessment of the bank's ability to fulfill all of its capital-related regulatory and supervisory requirements
- Economic perspective – the bank is expected to identify and quantify all material risks that may cause economic losses and deplete internal capital

On top of the amounts regulators and supervisors demand, the bank is expected to assess and maintain capital that it considers adequate to cover the nature and level of the risks it is or might be exposed (ICAAP).

The regulatory changes (Basel IV, CRR 3, BRRD 2) in capital quality, capital eligibility and composition, and RWA calculation significantly impact capital needs and capital ratio calculations. The bank shall consider the impact of regulation changes and analyze the possible impact on its overall risk profile, future regulatory own funds, or the TREA.

## Relevant regulations

- Basel III and Basel IV
- CRR 2 and upcoming CRR 3
- EBA Guidelines and ECB Guides

# 7 Capital Management (2/2)

## Capital management process

Measures to maintain sufficient capital (under a baseline/adverse scenario) are essential areas in capital management.

### The bank needs to specify arrangements on:

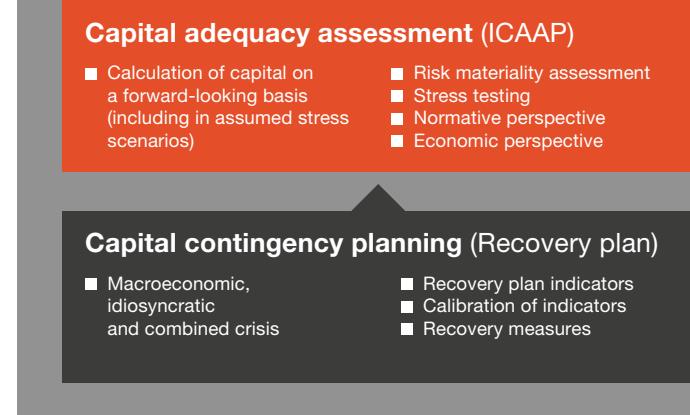
- The internal capital adequacy assessment (ICAAP) methodology and its periodic reviews
- The scenarios for stress testing exercise
- The monitoring method of capital adequacy
- The process of calculating the capital adequacy ratio
- The monitoring of regulatory changes in capital, capital eligibility and composition, and RWA calculation
- The capital planning, recovery&resolution planning process

## Potential business benefit impact

Capital management has become a critical factor in value creation for banks - the issue is using rational methods (management of the business and correlated risks) from the viewpoint of capital consumption and producing profit on a forward-looking basis.

## The bank can benefit from capital management improvement in the following areas:

- Risk-adjusted performance metrics (RAROC)
- Effective capital allocation and optimisation of regulatory capital structure (types and composition of capital, synthetic securitization as a way to boost regulatory capital – see next topic)
- Risk-based pricing (and product design)
- Active capital management (diversification benefit, quantified “bank specific” capital requirement, strategic capital planning, etc.)
- Demonstrate strong risk management capabilities to regulators, rating agencies, and other stakeholders



## Synthetic Securitisation:

Strengthening Bank Capital Ratios at Favourable Costs

Banks are utilising innovative ways of transferring credit risk to third parties, thus releasing capital at favourable costs. This way banks can achieve two objectives: (i) support business growth, and (ii) reduce risks. Structuring and advising banks on end-to-end implementation of such synthetic risk transfer can help them in widening their risk management capabilities and bring them a useful capital management tool.

## Deep dive

The transfer of credit risk related to the loan portfolio takes place by the use of a risk-hedging instrument – an unfunded financial guarantee. An outside investor assumes a large part of the credit risk of some portfolio of loans of the originating bank, thus significantly decreasing unexpected losses. According to CRR, if a so-called Significant Risk Transfer occurs, this results in a decrease in risk-weighted assets and thus higher capital ratios (CET1, Tier 1 and Total capital ratios). When executing using best market practice, the costs of capital released are much lower than the usual equity costs required on capital markets.

## Relevant regulations

- CRR Art. 244, 245
- A general framework for securitisation and creating a specific framework for simple, transparent and standardised securitisation (Regulation 2017/2402)
- EBA Report 2020/32 on significant risk transfer
- ECB Public guidance on the recognition of SRT

## Three options to achieve higher capital ratios

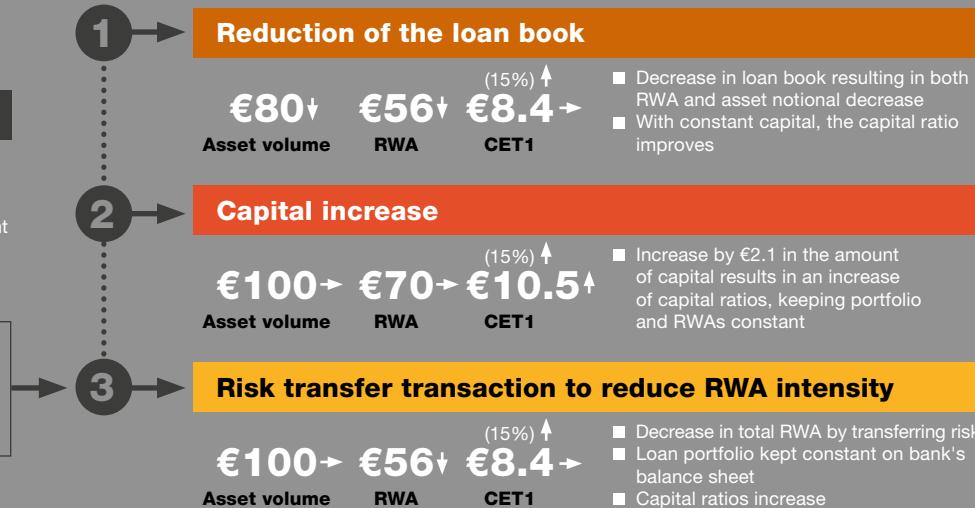
### Starting point

€100 Asset volume    €70 RWA    €8.4 (12%) CET1

Assumptions:  
 ■ 70% risk weight  
 ■ 12% Pillar I minimum CET1 requirement

### Risk Transfer Transaction:

- Provides an efficient way on risk reduction and thus regulatory capital release
- Strengthen bank's resilience in time of increased risk weights (regulatory, business)
- Enable further business growth thanks to capital release



# 7.1 Synthetic Securitization (2/2)

## Key transaction highlights

1

### Financial guarantee

- The transfer of credit risk occurs by the use of a hedging instrument – unfunded financial guarantee
- The reference portfolio remains on the originator's balance sheet and the business relationship between the originator and its clients is kept intact

2

### Benefits of the transaction

- Lower costs of capital released than traditional equity costs, even after taking into account all transaction and maintenance costs
- No involvement of rating agencies required - Supervisory formula used for the calculations
- Reference portfolio protection against adverse economic scenario
- Support for new business generation – part of the saved costs of capital can be passed on to the business lines for new business generation

3

### Reference portfolio

- The reference portfolio remains on the originator's balance sheet and will not be sold on to a third party
- As the loan portfolio remains with the originator, business relationship between the originator and its clients is kept intact
- All interest income and fees and commissions remain at the originator

4

### Loss guarantee

- Under the financial guarantee, the originator is reimbursed for a range of losses from the reference portfolio
- Potential losses from the reference portfolio are divided into tranches, whereas the originator retains first loss (junior) tranche and only losses above this level are passed on to the investor (mezzanine tranche)

5

### Significant risk transfer

- Significant Risk Transfer (SRT) acc. to CRR Article 244 is fulfilled by the transfer of the mezzanine securitisation positions to the investor
- Regulator has to recognise the SRT after a comprehensive review
- Significant risk-weighted assets (RWA) reduction is achieved by replacing the reference portfolio's RWA with the RWA of the retained tranches

## 7.2 Economic Capital



Jan  
Muchna

Economic capital is a term coined by the Basel committee with reference to Pillar 2 requirements, where each institution should estimate the amount of risk it faces (usually described by some “quintile”) and hold sufficient equity against it.

Compared to the regulatory capital models, there are no prescribed requirements or formulas, and each institution is free to adopt any available technology.

Although many risk practitioners point to the fact that for the most part economic capital requirements are lower than regulatory ones, and therefore they lack justification to invest in the topic as no capital savings can be derived; a key benefit of implementing economic capital is its specificity to the business model of the bank.

### ■ For credit risk, in case of IRB institutions, many regulatory assumptions can be relaxed:

- No single-name concentration (fully granular portfolios)
- Infinitely large portfolio
- Predefined term-structure
- Predefined asset correlation structure
- No correlation between PD and LGD
- Use of down-turn LGD in all scenarios

... which all influence not only the credibility of the regulatory capital requirements towards its stakeholders, but also its usefulness for risk-management, pricing purposes and portfolio steering.

### ■ In case of STA institutions, a need for an internal capital model is even more pronounced as the standardised method is not risk-sensitive at all, as it basically treats all clients within one exposure class as similar, leading to it being unusable for any internal use.

Credit risk capital models are usually built using either the Vasicek model (also used in the IRB framework: probability of loss on loan portfolio) or using correlated binomial models. The key difference to the stress-testing models is an emphasis on the repeatability and reproducibility of the calculation and lack of interest in a specific scenario.

Apart from the credit risk, market risk and operational risk capital models, economic capital models also assign equity requirements for business risk, strategic risk and IRRBB.

The key benefit of the economic capital model is that it can be drilled down to the level of a client or transaction with a risk-consistent approach, which means that each transaction is assigned a capital requirement, which corresponds to its contribution to the tail risk the institution faces. This way, it can be used to measure and report the real risk that is on the bank's books. It can be used to identify problematic clients or sectors and price them accordingly. Economic capital can also encompass ESG risks, where it can act as a simple and powerful means to implement it through the bank, even in pricing, without introducing unnecessary new risk/price category.

## 7.3 Regulatory Stress Testing

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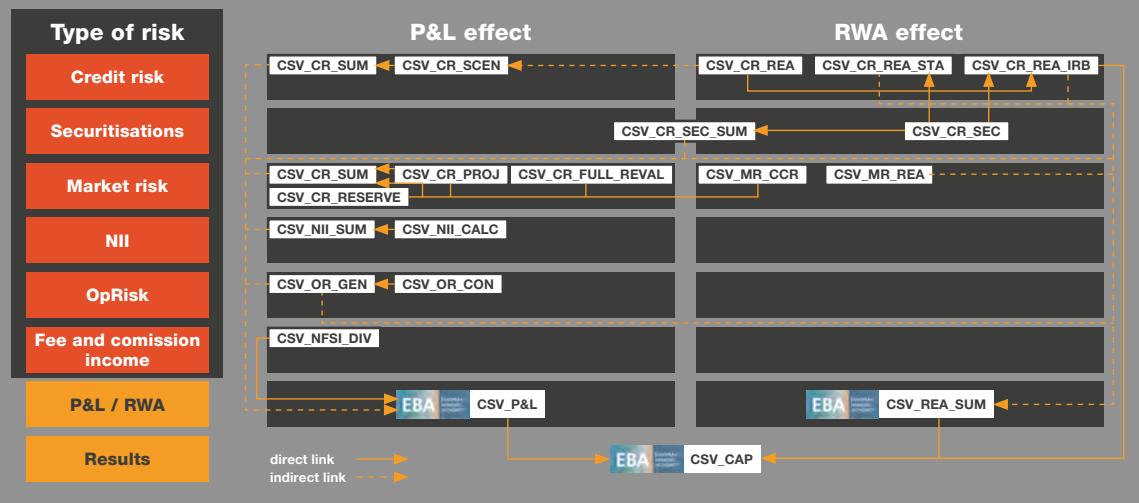
Jaroslav  
Nedvěd



One of the responsibilities of the national supervisory authority is to ensure the orderly functioning and integrity of financial markets and the stability of the financial system. The primary tool for such an analysis is a stress test exercise. Its aim is to assess the resilience of financial institutions to adverse market developments and to contribute to the overall assessment of systemic risk in the financial system.

The stress test is based on the baseline and adverse scenarios, projected via transmission mechanisms into the defined areas of risks. The mechanisms are developed by individual banks depending on the complexity of their products and the portfolio structure.

Reporting  
templates  
EBA:



### Stress test deliverables

Stress tests are delivered via qualitative and quantitative information provided by each bank to the regulator. The qualitative information offers insight into transmission mechanisms, including the reasoning of possible deviations from the prescribed scenarios and/or limitations set by the scenarios.

Quantitative information focuses on the delivery of a stressed income statement and balance sheet of the financial institution. The stress test is performed over a 3-year horizon and focuses on the institution's prudential requirements (capital adequacy).

The impacts of the scenarios are monitored via credit risk, market risk, operational risk and "other income" areas. The challenging part is simulating the Net Interest Income (NII) as the core input into the capital adequacy calculation. When performing the NII calculation, the institution can use its existing engine provided that it meets the constraints and mechanics set up by the stress test. In case the bank does not possess such an engine, PwC developed a NII projection tool, which fulfills the static balance sheet assumption and can be tailored to meet the specifics of the bank and the particular stress test scenarios.

In 2021, the regulatory stress test was enhanced by the "Environmental, Social and Governance" aspects (ESG) as these are the new emerging risks. The ESG should not create a new category of risks, but rather should be embedded in the traditional risk areas (credit, market, operational).

### Relevant regulations

- Methodological note issued by respective regulator
- Guidance to templates



[pwc.cz/stress-testing](http://pwc.cz/stress-testing)

## 7.4 Internal Stress Testing (1/2)



Apart from the regular regulatory stress-testing exercises, institutions are required under Pillar 2 to perform internal-stress tests at least once a year for all risk types of risk: credit, market, operational and liquidity. Additionally, many institutions decided to go beyond these minimum requirements and regularly use stress-testing methods to explore possible situations where it could endanger the going-on principle. They also capture business risk, strategic risk, interest-rate risk in the banking book, and funding risk.

Many of these situations are in the form of the materialisation of concentrations in the portfolio, either sectoral or single-name, in some cases also by the wrong-way risk (a situation where collateral value is negatively correlated with a borrower's credit worthiness).

Compared to the regulatory stress tests, with a "one size fits all" approach, internal stress tests are able to focus on those areas that specifically match the institution's risk profile, while not requiring unnecessary regulatory conservatism (e.g., zero net profit assumption); therefore, they are generally much more useful for the top management. Their only negative is that they are not very comparable across the market.

Normal outputs revolve around possible PL impacts for the institution and capital/liquidity requirements.

**Standard market practice revolves around three approaches, all being very powerful tools, having unique traits. They are distinguished mainly by the way a scenario was generated:**

### 1 Sensitivity analysis

Outputs of sensitivity analyses show the degree of an institution's vulnerability to specific risks and possible PL impacts. The standard scenarios explore specific problems like sovereign distress, mortgage crisis, sectoral ESG transition risk, represented by tangible and simple key risk indicators: decrease in sovereign credit rating by 2,4 or 6 notches; decrease in real-estate prices by 10%, 20% or 30% while increasing unemployment by 50%, 200% and 500%; increase in carbon price by 500%, 1000%, 2000%. These scenarios do not need to have their occurrence probabilities attached to them; they should be severe, but plausible.

### 2 Stress-testing

Stress-testing exercises are broader in the sense that they work based on (usually narrative-rich) scenarios and are overarching across all portfolios, with scenario narratives being defined separately per each risk type, although they could be loosely connected. We note that scenarios should have some 'probability of occurrence' attached to them.

### 3 Integrated stress-testing

Integrated stress tests represent the highest level of modelling efforts as they are built on fully fledged scenarios across all risk types. Generating those scenarios is usually a very challenging task, since it requires consistent predicting of all key risk indicators. Such scenarios are usually obtained from external sources, or via internal macro/micro-economic models.

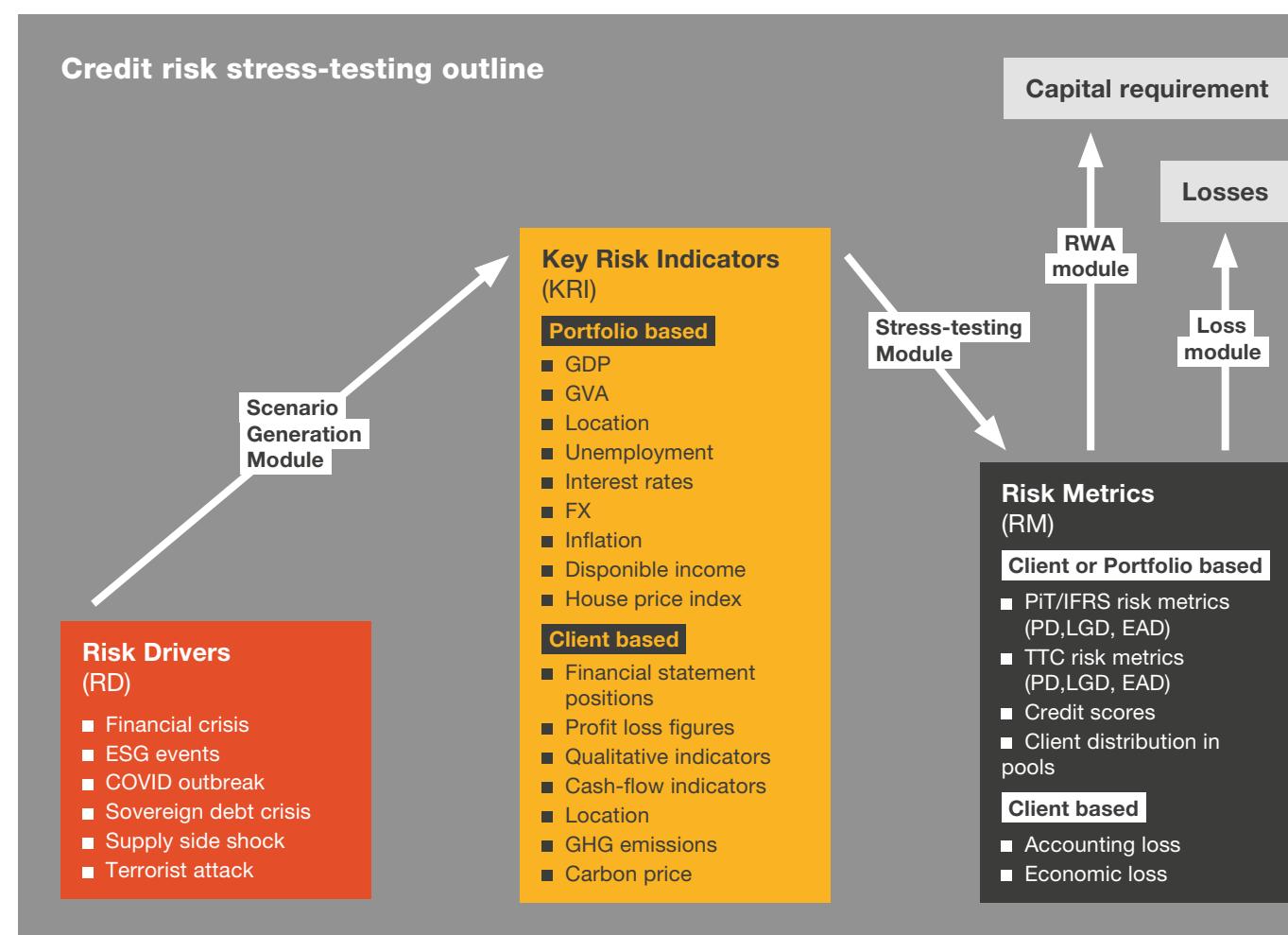
#### Relevant regulations

- Overview of Pillar 2 supervisory review practices and approaches
- Stress-testing principles
- Final report on Guidelines on institutions stress testing (EBA-GL-2018-04)

## 7.4 Internal Stress Testing (2/2)

The sophistication of the stress-testing models revolves not only around how scenarios are generated or how the risk drivers are defined in the Scenario Generation module, but also by the stress-testing models that are employed. They could be specific for that exercise, be general tools or use IFRS models that are already available in a bank. These models are used to capture transmission mechanisms from the Key Risk Indicator to a particular risk metrics that are used for the calculation of possible loss. The calculation level of these models can be client, sector or portfolio specific. Lower granular calculations provide more precise calculations, but there is a requirement for homogeneity in the modelling sample, so in many cases it's driven by the narrative itself. The "PD model level" is often considered the minimum calculation level.

Not to be confused with the calculation level, the last thing which should be considered is the application level: being portfolio based (top-down) or transaction/client based (bottom-up). Bottom-up application levels are highly recommended, as sufficiently granular application levels ensure that available collateral is not averaged across all clients, even to those, where they are not applicable.



Traditionally, the pricing topic has been a domain of business departments, seen as largely driven by market forces, where the bargaining power of an individual institution was often disputed. Within their responsibilities, business lines came up with intuitive and, in many cases, simple pricing models that somewhat reflected the riskiness of their clients, but such schemes were often disconnected from the rest of the banks' risk management, which potentially led to pricing inconsistencies and to a decrease in profit via mispricing, both in terms of the credit risk not correctly pricing, but also in not accepting clients that could still be profitable.

On the other hand, the ability to come up with risk-consistent pricing models has been, in the past, hindered by the lack of (i) risk data and (ii) risk-pricing knowledge in the institutions, but now with more or less developed ICAAP and IRB frameworks, the data gaps are closed, however low awareness and risk-pricing knowledge remain the main inhibiting factor for implementations.

**Pricing effectiveness can be measured on different granularities. Once it's measured on the bank level, the most common metric is ROE, which has three drawbacks:**

- It cannot be drilled down, so institutions often lack knowledge of what transactions or business lines contribute to ROE and by how much. Many transactions or even segments can have long-term negative ROEs without being even noticed by the top management. And even for profitable transactions, the capital associated with them could be so high such that the cost of capital outweighs interest income and fees, leading to ROEs much lower than Cost of Equity, being effectively loss making from shareholders' view.
- ROE can be influenced by the macroeconomic factors outside the control of the management (COVID crisis, financial crisis, sovereign debt crisis or by positive events by long-term relaxed monetary policy stance) and, therefore, it is hard to judge what the real contribution of the management was to the net profit. From the shareholders' and often also regulatory perspective, this is not a desired feature as management could get rewarded for the good years in the economy, and punished for crisis years through their KPIs, even though it managed to go through the downturn periods much better than peers, effectively contributing to the shareholders' value.

■ It cannot be calculated ex-ante (it is built on the observed data), and as such its usefulness for ex-ante pricing purposes is hindered.

**These drawbacks can be overcome by three of the following metrics...**

- RORAC - Return on risk-adjusted capital (Point-in-time metric)
- RAROC - Risk adjusted return on capital (Though-the-cycle metric)
- EVA - Economic value added (Though-the-cycle metric)

... which can be measured on all granularities: transaction, client, segment, business-line, bank as well as ex-ante (used for pricing) and ex-post (used for reporting and analyses and setting of effective KPIs, where the KPI objective has especially been proven by banks to be very efficient in managing Net Profit).

### Relevant regulations

- Guidelines on loan origination and monitoring
- Credit risk regulation (CRR)
- Credit risk directive (CRD)
- IFRS 9

While the first two metrics are relative, the second one is measured in units (of currencies) and can be compared to the Net Profit, and its main benefit is that it is fully additive, meaning that the sum of all EVAs on all clients is the bank's total EVA. EVA can help to spot important sectors, clients or transactions from the Net Profit point of view, while RAROC and RORAC can be comparable across any loan sizes and portfolios.

The main idea behind these metrics is to take Cost of capital and Though-the-cycle cost of risk into account. In best-in-class implementations, the average RAROC across multiple years will equal ROE.

**It is proven by industry practice that implementing risk-adjusted-pricing techniques for pricing and/or setting KPIs brings significant benefits to the**

- Risk-cost awareness  
(stops Après moi, le déluge thinking)
- Capital awareness (stops capital wastage)
- Reduces volatility of Net profit  
(by pricing though-the-cycle)
- Removes arbitrariness from the evaluation process
- Helps to promote fair, just and transparent pricing and shines the light on possible price manipulation and/or outliers

The need for risk-based pricing is embedded deep in the IFRS9 staging rules, which are at the moment being ignored by most banks, thus creating development liabilities for the future. We think that ignoring these requirements substantially weakens IFRS performance in terms of its ability to timely and adequately capture credit risk in (stage 2) loan impairments.

Needless to say, the implementation of these metrics in IRB (or equivalent) banks is easier, but by no means is IRB status required. The main challenge of the implementation actually lies in the alignment of the base of the finance, controlling and risk data.

**The standard comprehensive implementation comes in three phases (not all have to be done):**

- Institutions should start with the implementation in the ex-post world (reporting to the top management and business-lines). As problematic and crucial follow-up segments are identified, and an action plan is prepared (retention or change in strategy/pricing).
- Once the institution internalises numbers and can work and interpret the reports, the ex-ante (pricing) aspect is implemented, where all metrics should be embedded within credit decision-making standards for underwriting.
- Lastly, the KPI aspect should be implemented for both senior management and business lines, to set correct incentives for the long term.



A goal of the credit risk management is to align credit risk strategy with the overall Risk Appetite Framework of a bank. Within the credit risk strategy a bank targets the risk that a borrower is not going to repay its obligations to a desirable level. A bank can achieve this by implementing a credit risk management framework which consists of policies and procedures, methods for risk measurement (e.g. credit scoring) and defining roles and responsibilities within the bank.

## The credit risk management involves multiple roles across various departments:

- 1** It starts with the sales department, which is responsible for the communication with the client and preparation of the credit proposal.
- 2** Next, the assessment of the credit proposal is performed by a credit analyst, who conducts the financial analysis of the client and verifies the completeness of the proposal.

- 3** The final decision is granted by an underwriter, who assesses all aspects of the loan (credit conditions, covenants, purpose of the loan, etc.). In case the credit proposal exceeds the underwriter's approval limit or is not in line with standard credit granting process, it must be assessed by the bank's credit committee.
- 4** In case the borrower defaults on its obligations, the process continues with the collection department which aims to minimize the losses related to the defaulted loans by following its collections strategy.



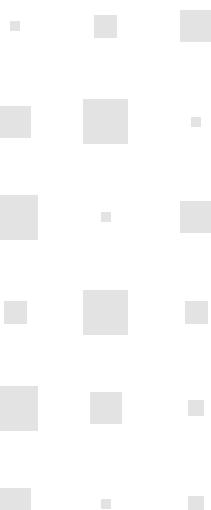
# 9 Credit Risk Management (2/2)

## Independent review of credit risk management

A bank can benefit from an independent review of its credit risk policies and procedures.

### This is usually performed in 3 steps:

- 1 Review of internal policies compliance with the regulatory framework.
- 2 Review of internal policies against market leading practice.
- 3 Review whether the internal policies and procedures are appropriately followed by a bank staff.



### The following areas are usually covered in the first and second steps of the independent review:

- Compliance with the EBA guideline on loan origination and monitoring or other regulations and guidelines.
- The underwriting process which includes credit approval process, such as financial analysis, creditworthiness and profitability assessments, setup of covenants, etc.
- Loan monitoring process which includes annual client review process as well as early warning indicators framework.
- Detection and evaluation of a group of connected clients incl. implementation of the EBA guidelines.
- Management and monitoring of forbore clients.
- Credit scoring process (see the [Credit Scoring](#) topic for more details)
- Review of IFRS 9 models and policies (see [Loan Loss Provisioning](#) and [Predictive Models](#) for more details).
- Definition and performance of the bad-debt collections strategy.

The third step of the review is usually customized for individual purposes or issues of a bank. Typically, a sample of credit files is created and completeness of the loan application and credit files is compared against the requirement of the internal policies and procedures.

## Early warning indicators

Nowadays, banks expand their client monitoring framework by embedding a system of early warning indicators (EWI). EWI are defined as a set of triggers designed to identify changes in the borrower's creditworthiness that might affect its credit risk.

Banks develop, maintain and regularly evaluate relevant quantitative and qualitative EWI that are supported by an appropriate IT infrastructure. They aim to timely detect an increase in credit risk in their aggregated loan portfolios as well as in sub-portfolios, industries, geographical locations and also for individual exposures.

## Group of connected clients

Detection and evaluation of the groups of connected clients is a crucial part of the loan approval process as well as client monitoring process. It allows a bank to track exposure limits and therefore manage its credit risk strategy. The ability to correctly evaluate borrower's connections plays a significant role in the creditworthiness assessment as it can prevent a domino effect – a transfer of financial problems from the controlling entity to the controlled entity, and vice versa.



Institutions and creditors should have sufficient, accurate and up-to-date information and data necessary to assess the borrower's creditworthiness and risk profile before concluding a loan agreement.

(EBA/GL/2020/06 Guidelines on loan origination and monitoring)

Loan origination and monitoring in the retail as well as commercial (SME and corporate) segments is a comprehensive procedure, consisting of various steps and diverse participants from several departments. The goal of a bank is not to eliminate credit risk, but based on all available information, measure and manage credit risk with the aim to maximise risk adjusted return. A bank must take an optimal mix of the portfolio view in managing risk on one side and on the detailed assessment of individual transactions on the other side.

## Milestones in loan origination and monitoring process

**The following tasks are directly associated with the loan origination and monitoring process:**

- Credit analysis which involves an analysis of financial statements (balance statement, income sheet, cash flow statement, all with historical overview), financial ratios analysis, and the analysis of many other qualitative inputs (strategy, business plan, transaction setup, competitiveness, quality of management, market or industry situation).

- Creditworthiness assessment which is an analysis of the ability (capacity) of the borrower to repay its debt (usually expressed in covenant DSCR – debt-service coverage ratio), assessed based on cash flow models and financial statements.
- Analysis of collateral and guarantees which should cover more than a simplified comparison measurement of loan-to-value (LTV) covenant (e.g. assessment of the liquidity of collateral, application of value haircuts, etc.).
- Monitoring and evaluation of groups of connected borrowers by which a bank is able to control exposure limits imposed on individual borrowers as a part of fraud prevention.



# 9.1 Loan Origination and Monitoring Process (2/2)

The results of the quantitative and qualitative analysis are usually summarised in the scoring model. Based on the scoring results, clients are segmented in one of the rating categories. Consequently, banks achieve division of clients into several segments with certain risk characteristics (e.g. different probability of default buckets).

Regular portfolio review also plays an important role in credit risk management. Correct exposure classification to performing/non-performing as well as implementation of early warning signals should be an integral part of monitoring in the lending process. A bank should have in place a process to validate that the periodical loan monitoring process is performed and that all early warning signals are properly considered.

## Exceptional grip ready to the exceptional cases

Special attention should be paid to the specific types of commercial loans. Some parts of the above mentioned process might vary for each particular type of loan. E.g., an investment loan has a different cash flow model than project financing or real estate development financing. Hence, the approach to their assessments should be appropriately adjusted and taken into account during the loan approval process as well as during the loan monitoring process.

## Measuring of credit risk

The quality of a bank's credit portfolio affects the amount of credit risk the bank is facing. In other words, the portfolio quality is indicated by the reliability of repayments of every individual client and of the whole portfolio as well. The basic instrument for measurement is the probability of default (PD), meaning that the client will not be able (partially or in full) to meet its obligations. Other parameters like loss given default (LGD) and exposure at default (EAD) are used to estimate the client's credit risk.

The LGD defines the loss that a bank realises when the client defaults as a percentage of the defaulted

exposure. The LGD is supplemented with the recovery rate (RR), thus it assumes that, in the case of default, a bank is able to recover part of its receivables. The RR is influenced by numerous factors related to the collections that might vary from bank to bank. The goal is to precisely estimate its RR because it enables a bank to predict future losses on its defaulted portfolio.

The assessment of the client's credit risk is further impacted by the estimation of the EAD. Considering that the EAD in the future could be higher than the current exposure it is essential to estimate correctly its possible size, hence, to estimate the exposure amount of the defaulted portfolio.

### Relevant regulations

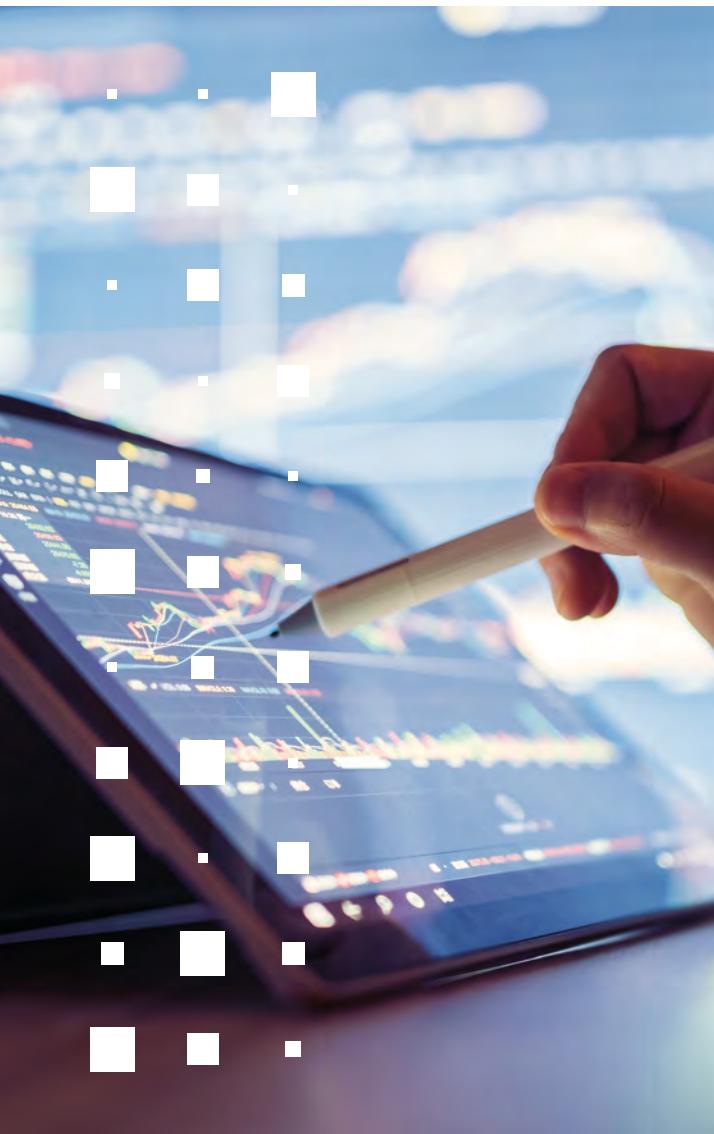
- IFRS 9
- Basel III
- CRR/CRR 2/CRD 5
- EBA/GL/2020/06 – Guidelines on loan origination and monitoring
- EBA/GL/2017/15 – Guidelines on connected clients under Article 4(1)(39) of Regulation (EU) No 575/2013

### Tools

- [Credit Decision Engine](#)

## 9.2 Expected Credit Loss Benchmarking

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Banks are facing increasing risks due to the current turbulent situation on the markets and because of that regulators are inclined to assess the health of the commercial banks that they are overseeing. One of the potential approaches is to review the appropriate level of the IFRS 9 Expected Credit Losses (ECL) by applying the prudential approach of the Asset Quality Review (AQR) methodology. This one-size-fits-all approach allows central banks to compare the modelled ECL with prudential approach towards the ECL calculation as well as to compare the level of ECL between banks.

The AQR introduces the concept of a Challenger Model, which calculates ECL based on the standardized prudential methodology (a standardized set of input data is required).

### The Challenger Model:

- Reclassifies IFRS 9 stages based on the predefined thresholds for Significant Increase in Credit Risk (SICR).
- Recalculates the PDs using the historically observed migration matrices and forward-looking indicators.
- Recalculates the LGDs based on the historically observed collections.
- Challenges the shape of the EAD rundown curves.
- Combines all the calculation parameters into the resulting "AQR" ECL which is distributed into multiple segments.

The results allow comparing the ECL parameters derived by the prudential approach with the ones modelled by a bank for various segments and subsegments. Thus it is possible to point out "weak spots" of the models (e.g., the AQR ECL is significantly higher than the bank ECL) and to identify the potential drivers behind this difference.

### What are the benefits for a bank?

Performing the exercise before a regulatory one will help a bank to understand the sufficiency of its provisioning level from the perspective of a central bank. A bank can start a remediation process, correct in-time weaknesses identified, and thus decrease costs that the regulatory exercise would trigger.

The ECL benchmarking results may serve the bank management as an independent evaluation of their provisioning models and as a basis for further strategic decisions.

## 9.3 Credit scoring

Good credit scoring model is a key prerequisite for correct assessment of the customers' creditworthiness. Costs invested in the development of a scoring model often turn out to be marginal compared to the amount spared by timely and accurate prediction of future credit losses. That's why scoring models lie in the heart of the lending business.

There are several steps in the scoring implementation process, starting from a gap analysis / feasibility study, throughout model development, and ending with full underwriting process implementation and regular maintenance.



Ondřej  
Glatz

Ondřej  
Šedivý

### 1 Scoring Feasibility Study

- Use available data and investigate if there is sufficient discriminatory power
- Identification of additional possible data, recommendations regarding regulatory compliance

### 2 Credit scoring model development

Includes full modelling pipeline from data quality checks to final model testing and application guidelines as shown on the scheme

### 3 Underwriting process implementation

- Methodology & implementation of the loan underwriting process (see more in Commercial Credit Lending Process topic)
- Decision making such as K.O. criteria, limit setting, strategies for sub-segments

### 4 Periodic validation, recalibration

- Review and backward testing of scorecard performance
- Recalibration, eventually redevelopment of the scorecard due to low performance or for business reasons



#### Data Quality

- Data completeness, accuracy and consistency
- Comprehensive basis of available risk drivers
- Profiling and outlier investigation
- Data Quality and Consistency Review



#### Univariate Analysis

- Discriminatory power, weight of evidence
- Short listing
- Visualization



#### Model Candidates

- Estimation technique (logistic regression, random forest, xgboost, neural networks)
- Selection algorithm (forward/backward stepwise, K.O. criteria, cost function, correlation threshold)



#### Model Selection & Testing

- Performance – out of sample / out of time validation
- Stability – stability of coefficients, population stability
- Explanation – contribution of individual components



#### Strategy & Pooling

- PD cut-offs for approval / investigation / rejection based on the business expectation and risk appetite
- Definition of rating based on score cut-offs

# 10 Loan Loss Provisioning



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**Ondřej  
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A loan loss provision is an income statement expense set aside to allow for uncollected loans and loan payments. In order to ensure that banks are presenting an accurate assessment of their overall financial health, they will account for potential loan defaults. In this context, the loan loss provision represents the expected credit losses.

The level of provisioning is influenced by a variety of factors, which include the supervisory requirements. In Europe, the requirements on loan loss provisions are set by the International Financial Reporting Standard 9 – Financial Instruments (IFRS 9) issued in July 2014 by the International Accounting Standards Board (IASB). In the US, the similar role plays Accounting Standards Update (ASU) No. 2016-13, Topic 326, Financial Instruments – Credit Losses (CECL) issued in June 2016 by the Financial Accounting Standards Board (FASB). Under both IFRS 9 and CECL, banks are required to recognise expected credit losses taking into account past events, current conditions and forecast information. The main difference between IFRS9 and CECL is that under IFRS 9, the credit deterioration affects the amount of allocated expected credit loss.

In order to ensure the overall adequacy of Loan Loss Provision levels and compliance with the relevant standards, suitable models need to be developed, validated, implemented and monitored. Furthermore, the IFRS 9 and CECL models and their outcomes will be periodically reviewed by external auditors. Any discovered deficiencies will be addressed by making model adjustments, recalibrations or redevelopment.

## Relevant regulations

- IFRS 9
- CECL (FASB standard)

## Tools

- [IFRisk 9 Calculator](#)
- [CECL Calculator](#)



Recovery Plan is a key element of the crisis management framework. The Plan shall set out the arrangements and measures a bank would adopt to restore long-term financial viability in case of severe distress. The regulatory Technical Standards and EBA Guidelines provide details on the key part and information that must be included in Recovery Plan to be drafted by banks as requested by the Bank Recovery and Resolution Directive (BRRD).

The compliance of recovery plans with the regulatory requirements is crucial for all key elements of The Recovery Plan – governance, recovery plan indicators, stress scenarios, strategic analysis including recovery options and preparatory measures, communication and disclosure plan.

We are ready to fully support you to understand and apply all the requirements thanks to our vast knowledge of the regulation, experience in Recovery Plan projects and implementation (also in view of COVID-19 pandemic) including direct interaction with the regulators.

## Our Services

We cover all aspects of the Recovery Plan revision and preparation process from the review of the current state and gap analysis, through the plan development to the support during the submission to the regulator:

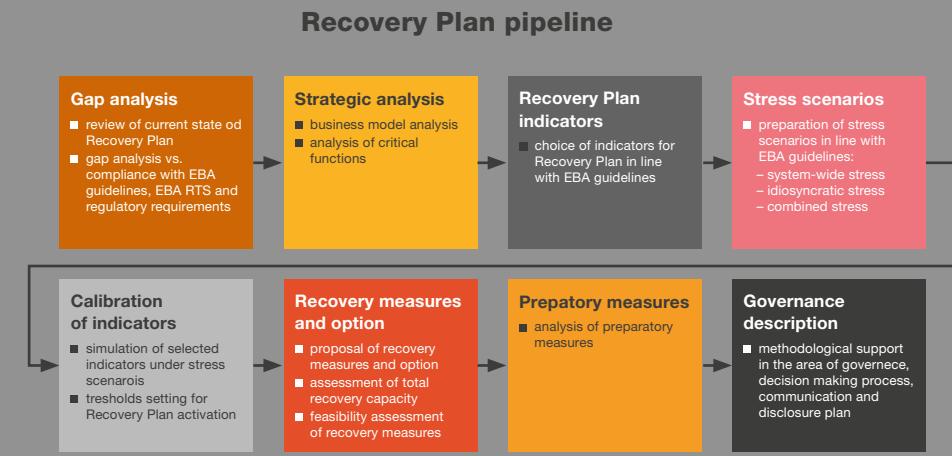
- **Preparation** – complete preparation of the Recovery Plan covering the review of the current state, quantitative analysis and document drafting
- **Revision** – quality assurance, gap analysis vs compliance with EBA guidelines, RTS and local regulatory requirements
- **Update** – methodological support in the recovery plan update process as a response to the supervisor's feedback, including gap analysis and quantitative analysis
- **Seminars & Workshops** – open and in-house seminars and workshops on recovery plans, best practice sharing

## Relevant regulations

- RTS on the content of recovery plans – Commission Delegated Regulation (EU) 2016/1075
- EBA/GL/2021/11 Guidelines on recovery plan indicators under Article 9 of Directive 2014/59/EU
- EBA/GL/2014/06 Guidelines on the range of scenarios to be used in recovery plans
- EBA/GL/2015/07 Guidelines on failing or likely to fail

## How do we proceed with Recovery Plan?

The process of Recovery Plan preparation / update / revision consists of several parts. Throughout the whole process, we actively communicate with you and agree on the next steps.



“ This new set of rules for bank bailouts is a major shift from the public means, from the taxpayer if you will, back to the financial sector itself which will now become for a very, very large extent responsible for dealing with its own problems, (Dutch finance minister, Jeroen Dijsselbloem, after the approval for establishing Europe's so-called banking union)

Stability and trust are integral parts of local, regional and global financial systems. However, in today's increasingly interconnected world, failing financial institutions can threaten the stability of financial systems. Costly public bailouts of 'too-big-to-fail' banks during the 2008 financial crisis highlighted the need to address the moral hazard posed by systemically important financial institutions.

Resolution plan, or "living will" of Financial institutions, helps regulators and banks ensure important areas are resolution-proof, should an idiosyncratic shock lead to insolvency.

## Failing or likely to fail: Resolution

The resolution plan shows what an institution would do if it fails, and addresses the financial, legal and operational obstacles to resolution. This enables the regulator to make an assessment of the potential effects on financial stability and then determine whether the plan is acceptable.

A sound resolution plan should enable regulators to understand a bank's ownership structure and exposures to, and connections with, other affiliated and unaffiliated entities, markets and payment infrastructures. The plan should also include an understanding of the legal structure as it will help regulators identify structural and operational issues relevant to the separation of significant entities.

It is also important to understand the scale of each economic function and the potential impact of closing any of the economic functions. This will provide details of which legal entity or entities each function sits within, and how to deal with them in case of crisis.



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## Single Resolution Board

(SRB, the EU Resolution watchdog) and National Resolution Authorities focus on the following 7 dimensions of the resolvability process:

- 1 Governance
- 2 Loss absorption and recapitalisation capacity
- 3 Liquidity and funding in resolution
- 4 Operational continuity in resolution and access to financial market infrastructure
- 5 Information systems and data requirements
- 6 Separability and restructuring
- 7 Communication

### Relevant regulations

- Bank Recovery and Resolution Directive, BRRD II
- Single Resolution Mechanism Regulation, EU and national Deposit insurance frameworks
- EBA/GL/2022/01 – Resolvability Guidelines
- SRB Expectations for Banks, and related thematic Guides

# 13 Liquidity Risk Management

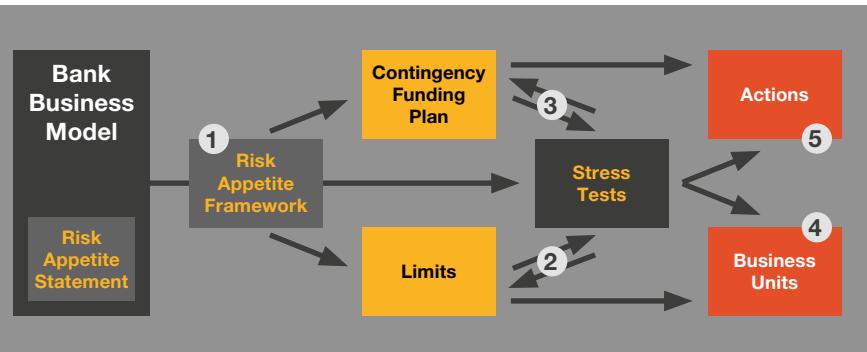
Sound liquidity management is not only required by the regulation but also contributes to PnL of the institution and thus ensures the sustainability and resilience of the institution's business model going forward (BSBS Sound Principles for Sound Liquidity Risk Management and Supervision, 2008)

Liquidity management is a core activity performed by the financial institution on a daily basis. The sound liquidity management framework is in the center of the attention of different stakeholders – depositors, shareholders, and regulators. The 2008 crisis brought liquidity management to centre stage for regulators and lawmakers.

## ILAAP\*: Linking the principles

The ILAAP is a core process ensuring that liquidity risk management principles are regularly monitored, assessed and enhanced.

\* ILAAP = Internal Liquidity Adequacy Assessment Process



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## Among others sound liquidity management framework supports:

- Senior Management effort to reach Business Plan objectives within approved risk appetite
- The ability of efficient liquidity management via reduction of costs
- Process of selecting the most advantageous funding or placement of options
- Institution comfort during a period of stress

Liquidity risk management policy follows principles listed in points 1–6. It can also state approaches to modelling of non-maturing deposits, loans prepayments, early withdrawal of term deposits, loan drawdown or other material B/S items. ALM manages liquidity risk in its 1st Line of Defense role. Market risk performs the role of 2nd LoD. The Treasury has the role of securing access to financial markets – handling orders from ALM.

## Relevant regulations

- BCBS Sound Principles for Sound Liquidity Risk Management and Supervision (2008)
- Basel III
- CRR/CRR 2
- EBA Guidelines on LCR disclosure to complement the disclosure
- EBA Guidelines funding plans

A Bank should incorporate liquidity costs, benefits and risks in its product pricing, performance measurement for all significant business activities.

(Principles of sound liquidity management, 2008)

Funds transfer pricing (a mechanism that allocates liquidity costs, benefits and risks) is part of the effective risk management framework of an institution. As such, the mechanism should be consistent with the framework of governance, risk tolerance and the decision-making process.

(CEBS/EBA Guidelines on Liquidity Cost Benefit Allocation, 2010)

## An effective FTP

- Provides input into the product pricing process
- Contributes to the desired long-term sustainable and profitable Balance sheet
- Secures a margin of a business unit throughout the lifetime of the transaction, transfer the FX, interest rate and liquidity risk to the central unit (Treasury/ALM)
- Enables profitability measurement on a deal level
- Transfers the cost of liquidity to liquidity consumers, in other words FTP rewards providers of liquidity by defining a transfer price for the funds invested (assets) and acquired (liabilities)
- Provides essential input for risk-adjusted profitability measurement (RAROC, RORAC)

## FTP framework

- Description of FTP methodology including construction of FTP Curves
- FTP formulas on the level of products
- Principles of splitting revenues from the transactions (business unit vs. central unit)
- Roles and responsibilities of stakeholders
- Implementation – FTP rates communication, recalculation frequency

## FTP curves

- Currency-specific
- Used to derive FTP for products, on the level of particular transactions
- FTP curve consists of several components
- Market observable (for example mandatory reserves at the central bank)
- Bank-specific – related to the business objectives of the Bank, complexity and scale of the Bank's business, clients portfolio (for example Contingency Liquidity Buffer)

### Relevant regulations

- Basel III
- CEBS/EBA Guidelines on Liquidity Cost Benefit Allocation (2010)
- FSI Liquidity transfer pricing: a guide to better practice (2011)



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Market risk is defined as the risk of losses in on and offbalance-sheet positions arising from movements in market prices.

The market risk arises from the volatility of market rates and the sensitivity of the market risk positions to them. The market risk can materialise into both profit and loss for the financial institution.

(Basel Committee on Banking supervision)

Market Risk Management includes management of Interest Rate Risk, Equity Risk, Exchange Rate Risk and Commodity Risk. In managing the risk, it is necessary to distinguish between Banking Book and Trading Book.

The last Basel Committee reform focused also on capital requirements for market risk arising from the Trading Book. The market risk as such is present in all of the three Basel Pillars.

The Market Risk Management is defined by the organisational framework of the financial institution (Three Lines of Defense model) establishing the Market risk management department/division.

Market risk management framework should focus on identifying, measuring, mitigation, monitoring and reporting of market risks.

### A sound framework defines:

- Organisational structure, roles and responsibilities of functions
- Measurement and analysis methods (techniques, assumptions, etc.)
- Monitoring method – Value at Risk, sensitivities calculation
- Stress Testing scenarios
- Policy on Key limits, ensuring alignment with the Risk Appetite Statement



- Market value calculation
- Trading Book and Banking Book boundaries
- Internal reporting system (Board of Directors, Asset-Liabilities Committee).

### **Sound Market Risk Management Framework is an assumption for effective management of the market risks and supports:**

- Early identification of risks and in-time treatment of risk (decreasing the cost of risk mitigation).
- Decision-making process based on relevant, and accurate information.
- In-time reporting of matters that would seriously affect the financial institution
- Risk profile is within the risk capacity of the financial institution and in line with the shareholders will for risk to be accepted.
- Institution comfort during a period of stress

### **Relevant regulations**

- CRR/CRR 2/CRD 5
- Upcoming CRR 3
- BCBS Fundamental Review of the Trading Book /Minimum capital requirements for market risk/ (2019)

# 14.1 Interest Rate Risk in the Banking Book



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All banks must be familiar with all elements of IRRBB, actively identify their IRRBB exposures and take appropriate steps to measure, monitor and control it.

(BCBS Interest rate risk in the banking book, 2016)

## Introduction

IRRBB refers to the risk, both current and forward-looking, to the capital and earnings of the bank arising from interest rates shifts. It stems from two types of mismatches that are at the core of the business of most banks. First, banks are exposed to IRRBB due to the maturity mismatch (i.e. long-term assets are funded by short-term liabilities). The second cause of IRRBB is the rate mismatch (i.e. fix rate loans are funded by variable rate deposits). Banks need to identify the IRRBB in their products & activities and take appropriate steps to ensure the risk is adequately measured, monitored, and controlled. The treatment of IRRBB is an integral part of the broader risk management framework of the bank via ICAAP.

## Measurement

Measurement of IRRBB is based on two pillars; change in Economic Value of Equity ( $\Delta$ EVE) and change in net interest income ( $\Delta$ NII). When interest rates change, the cash flows of the bank are affected. Cash flows are slotted into time buckets; regulation defines a minimum granularity of the buckets. Different time horizons and assumptions are applied to EVE (B/S run-off) and NII (1-3YR horizon, constant B/S).

For EVE, the Basel standard prescribes 6 interest rate shock scenarios, the results of which need to be disclosed. Behavioral options, such as loan prepayments, deposit early withdrawal, or non-maturity deposits, have to also be included.

## Mitigation

The most common tool to minimise the mismatch described above is hedging. The bank needs to identify appropriate debt and derivative instruments and strategies to mitigate the risk, such as interest rate swap. Due to the different measurement methods, hedging of NII opens the position as measured by EVE and vice-versa.

## Relevant regulations

- BCBS Interest rate risk in the banking book (2016)
- CRD 4/CRD 5
- EBA/GL/2018/02 - Guidelines on the management of interest rate risk arising from non-trading book activities
- Upcoming regulation (under development): RTS on IRRBB supervisory outlier tests, RTS on IRRBB standardised approach, EBA Guidelines on IRRBB and CSRBB

“ The long-term benefits of improved risk data aggregation capabilities and risk reporting practices will outweigh the investment costs incurred by banks.

(BCBS Principles for effective risk data aggregation and risk reporting, 2013)

High level of data quality is essential for successful development, calibration and validation of models as well as to be compliant with the BCBS 239 standards. Mechanisms to ensure the data quality should be implemented and regularly reviewed as any potential inconsistency might significantly affect results of the models or ability to make use of them.

A complex data quality review brings the opportunity to enhance data reliability and hence improve overall performance of the risk management function. In order to effectively help banks to improve the data quality, PwC developed a Data Quality and Consistency Review process accompanied by a Data Integrity Validation Tool which are based on the internationally recognized methodology developed by the ECB.

## Data quality checks

This review consists of a series of data quality and consistency checks that can be used to obtain management information on the quality of finance and risk data. The process is organised around 4 types of data checks:



The checks are performed by the Data Integrity Validation Tool which automatically performs over 100 checks and generates a report with overview of findings in Power BI and excel report with details on identified data issues.

# 15 Data Quality and Consistency Review (2/2)

## Data set

The reviewed data set covers two snapshot periods and contains fundamental data attributes which are used in credit risk management and modelling as well as which are relevant for the finance department.



## The process involves 2 phases:

### 1 Initial phase

During the initial phase of the review, the analysis of the data set is performed. It consists of the following steps:

1. Collecting required portfolio dataset.
2. Performing initial review of the data structure.
3. Performing data quality checks.
4. Preparation of a report with overview of data quality findings.

### 2 Follow-up phase

The review continues with a follow-up phase in which the process needs to be customised based on the results of the initial review and on the bank's preferences. Depending on the results the following options might be considered by the banks:

1. Set up a remediation process which can be either sourced internally by the bank or requires external support.
2. Define specific data quality rules and indicators and implement those to the current DWH process.
3. Setup a periodical data quality and consistency review in order to monitor progress with the remediation process.

By undergoing Data Quality and Consistency Review, banks obtain a specific list of data issues that can be prioritized for the following remediation process and as a result, banks would have more reliable data for modelling and financial reporting.

### Relevant regulations

- BCBS 239
- Asset Quality Review methodology

### Tools

- [Data Integrity Validation Tool](#)

The Asset Quality Review (AQR) is a supervisory mechanism created by the European Central Bank (ECB) for reviewing the quality of a bank's assets, including the adequacy of assets, collateral valuation and expected credit losses.

The AQR is a comprehensive assessment that covers a variety of areas such as a review of internal policies, extraction of client data, performing a credit file review, or modelling of collective provisions. While the AQR usually has tight deadlines, it is essential that a bank prepares itself in advance because each area requires significant involvement of bank staff to prepare the requested documents in the required quality and within a given timeline.

A bank should primarily focus on the AQR work blocks summarised in the chart below, which require significant bank involvement. The chart also shows interdependencies between the individual AQR work blocks. The next sections describe a “best practice” preparation approach for each considered work block.

## A Processes, policies and accounting review (PP&A)

PP&A review is focussed on ensuring that the bank has a robust set of clearly defined policies and processes for correctly interpreting accounting rules or other applicable industry standards. The review covers thematic areas related to key

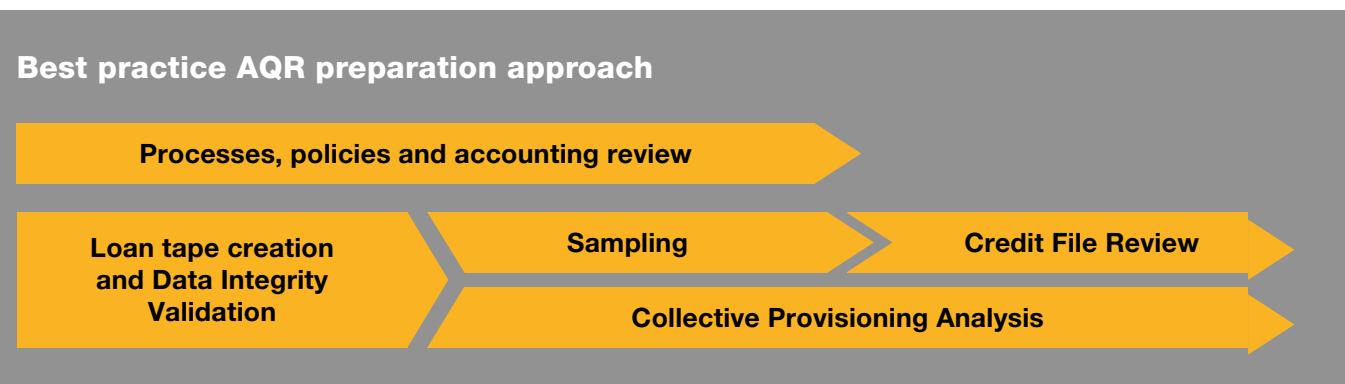
accounting decisions, e.g., classification of financial instruments, provisioning methods, impairment staging criteria, NPE definitions, forbearance and restructuring, collateral valuation, and disposal processes, etc.

### AQR preparation process consists of:

1. Explanation of the PP&A requirements and templates.
2. Collections of internal policies and procedures as defined in the AQR methodology.
3. Review of the collected documentation, communication of findings and definition of remedial actions.

A proper preparation process will result in the availability and completeness of the documentation.

### Best practice AQR preparation approach



## B Loan Tape creation and Data Integrity Validation

AQR methodology requires the creation of a “loan tape” which is a dataset that includes basic account information about clients and exposures. To achieve the transparency of bank balance sheets, it must be ensured that the provided data is correct, meets defined requirements and is of sufficient quality.

# 16 Asset Quality Review Preparation (2/3)

Hence, a set of tests is performed on the data which is called Data Integrity Validation (DIV). Since the required format and terminology differ from the bank's internal one, banks usually struggle with providing all requested information.

**PwC developed the following approach to assist banks with these tasks:**

1. Explanation of the loan tape data requests, structure, and format. Sharing best practices for loan tape creation and common DIV errors. Optionally, assistance with the extraction of data from a bank's source system(s).
2. Performance of DIV checks in several DIV iterations using the DIV Tool.
3. Explanation of DIV findings and their potential impact on the AQR assessment.
4. Definition of remedial actions reflecting the identified DIV findings.

As a result, banks are prepared to deliver loan tapes of high quality and mitigate any potential gaps identified by DIV.

## C Sampling

The sampling process is an intermediate step between the creation of a loan tape and the credit file review and results in a set of debtors (sample) which is subject to the credit file review. In the sampling process, debtors are segmented into risk classes and exposure classes based on the portfolio's characteristics, hence sample sizes may differ between banks and portfolio types.

**During the AQR preparation, the sampling is performed using the internally developed Sampling tool in order to:**

- Assess overall sample sizes per portfolio;
- Assess concentration of debtors in particular risk and exposure classes and understand the underlying drivers; and
- Create a sample of debtors that will be subject to credit file review.

One of the challenges for a bank during the AQR audit is to prepare the requested credit files of selected debtors (in a very short period of time). The estimation of the sample size should be properly projected into a project plan, hence underestimation of staff capacities might be avoided.

## D Credit File Review (CFR)

The CFR focusses on the assessment of misclassification and under/over-provisioning of sampled debtors.

**The CFR approach is performed in the following steps:**

1. **CFR data preparation** – understanding of the CFR templates and related data requests. Alignment of which documents should be included in the credit file of a debtor. Reconciliation of the data in the credit files against the data in the loan tape and assessment of the data quality.
2. **Classification review** – assessment of whether exposure is correctly classified by a bank from different perspectives (evidence of impairment, NPE classification, regulatory exposure classifications, AQR asset segmentation and related party classification). Based on this assessment a new classification might be determined.
3. **Review of provisions** – individual provisions are recalculated for the non-performing debtors which involve using the “going concern” / “gone concern” AQR approach.

# 16 Asset Quality Review Preparation (3/3)

Particular attention should be dedicated to potential differences and data gaps between the loan tape, templates, and credit files, as well as to significant differences in provision levels of a bank and those calculated using the AQR approach.

## E Collective provisioning

During the collective provisioning analysis (CPA), the level of provisions of a bank is assessed against the so-called Challenger Model – a standardised statistical model that estimates expected credit losses based on the provided data inputs.

### Steps performed

1. Explanation of the CPA data requests, structure, and format. Sharing best practice for accurate calculation of the CPA data inputs (e.g., contractual repayment schemes; debt collection data; sales log of repossessed assets, etc.).
2. Analysis of data quality and consistency to ensure that collected data are of sufficient quality.
3. Creation of the Challenger Model using the CPA Tool which processes the reviewed CPA data inputs and loan tape data.

4. Interpretation of the Challenger Model results which quantify the impact of each parameter on the final results. This output can be further used to identify “weak spots” and potential gaps in the CPA data inputs as well as in a bank’s provisioning models.

The above-mentioned tasks help the bank to identify required sources for CPA data inputs and might identify potential weak spots in the prepared data. This will enable the bank to investigate any deteriorations and, if necessary, set up a mitigation process.



The objective of the Asset Quality Review (AQR) is to ensure the proper valuation of a bank's assets and that a bank has sufficient capital to absorb losses on existing delinquent assets.

The AQR exercise is the most comprehensive methodology available globally for reviewing the asset quality of a banking institution and covers all areas from accounting policies to loan classification, impairment, collateral valuation, repossessed assets valuation to capital impacts (see the chart below). Subjectivity is minimised. Rules are followed.

Such an exercise is much wider than any internal or external audit. Most banks have not experienced this type of review and the pressure that goes along with it with tight deadlines and hundreds of files to be provided to an external reviewer.

**To successfully complete the AQR audit, the AQR auditor needs to have:**

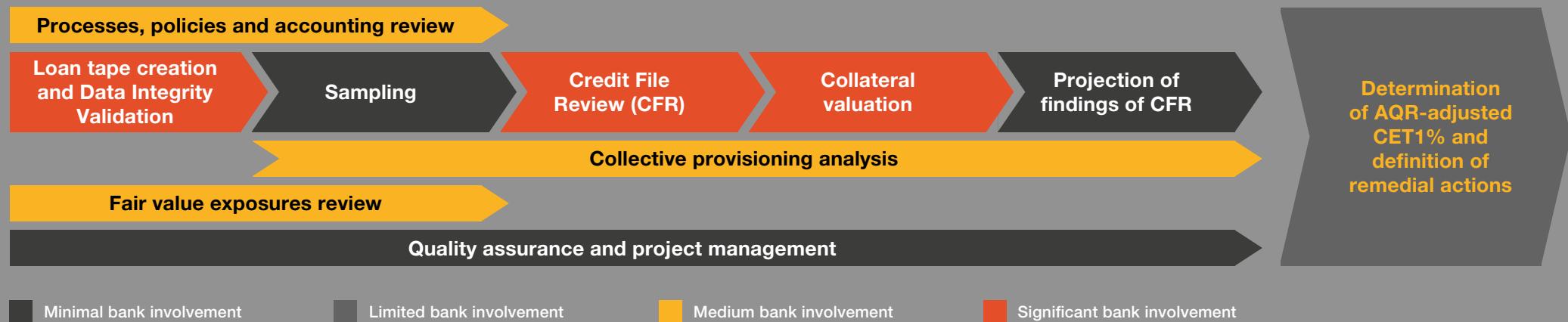
- Good understanding of the methodology and have hands-on experience with delivering AQR audits.
- Automated solutions and tools for repetitive tasks within the AQR process, such as filling out the standardised AQR templates.

- Effective communication channels with a bank to share a large number of files and monitor the status progress.
- A sound multi-level quality assurance process.
- A robust project management structure.

## Tools

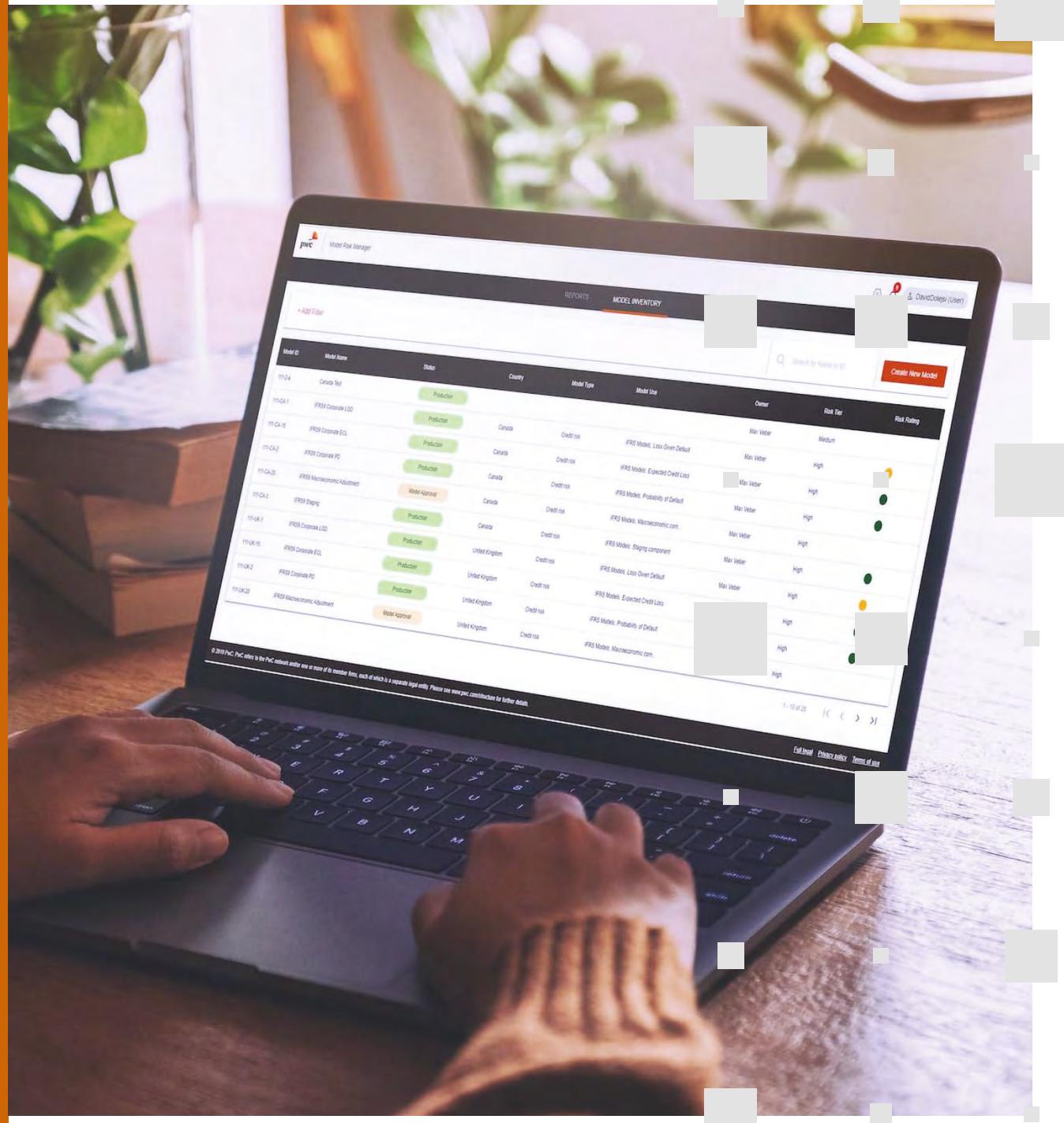
- [Data Integrity Validation Tool](#)

### Workflow of the AQR work blocks with determination of level of bank involvement



# 03

## Tools



# 1 FTP Tool



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The **FTP Tool** is an MS Excel-based calculator assigning an FTP rate to individual transactions following a maturity-matched approach. FTP rate is based on the value of FTP components representing the cost for liquidity and interest rate hedging. It can be used as a Minimum Viable Product when developing an internal FTP solution or solely as a challenger model to verify outputs from the internally developed solution.

The tool is coded in VBA to optimise calculation time. MS Excel sheets are used for data inputs and outputs.

## The required inputs take into consideration:

- Market data available
- Typical structure of data in DWH of banks
  - transactions are broken down into a set of cash flows

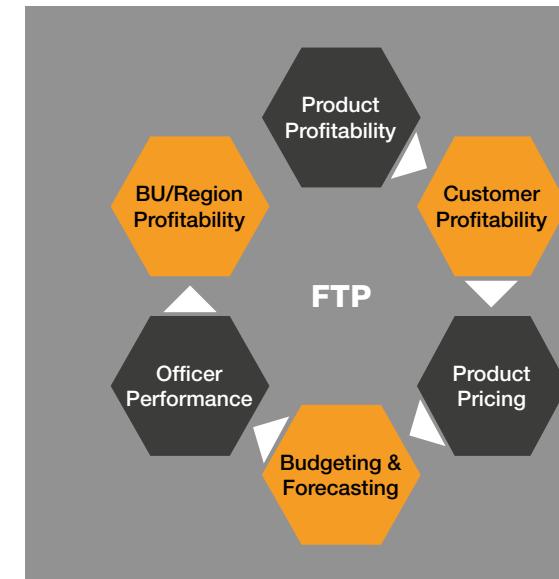
There is no unified FTP methodology recognised as a standard by the market. The tool is based on leading market practices as observed by PwC Subject Matter Experts. Implementing the methodology into practice brings some challenges. As a result, the tool is accompanied by an Implementation Manual describing in more detail how to treat the calculation of the FTP rate per product.

The tool is fully functional; however, it needs to be connected to relevant data sources and feeder models (for example, bootstrapping the IRS curve into a zero-coupon yield curve).

## At present, the tool is configured to treat typical banking products:

- Fixed & Floating loans (both bullet and amortising)
- Mortgages
- Credit cards and working capital loans
- Deposits placed & taken
- Non-Maturing Deposits (current accounts, saving accounts)
- Bonds issued and bought

The tool is fully scalable and enables the adding of products simply by defining the respective FTP formula (aggregation of FTP components relevant to the product).



## 2 CECL Calculator (1/2)



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### CECL Calculator is a simple off-the-shelf solution for CECL calculation and analysis

The **PwC CECL Calculator** has been developed to support financial institutions with the CECL calculation. Powerful engine together with simple interface enable users to quickly evaluate and compare CECL under different scenarios.

#### CECL in three clicks

##### 1 Drag & drop your data

All inputs necessary for the CECL calculation are provided in the form of Excel or CSV text files.

Simply drag & drop the required files to the application window to instantly upload them into the tool.



##### 2 Validate the inputs

Calculator implements over hundred validation procedures that are executed upon the upload of inputs.

These checks ensure data consistency across inputs and allow for smooth CECL calculation.

#### Our approach



##### Quick deployment

PwC provides Calculator as a service accessible on the PwC-managed cloud. Or it can be deployed in your environment.



##### Easy access

Application is easily accessible via a web browser without the need for any installations by end users.



##### Scenario analysis

Fast calculation engine also makes Calculator a great tool for various scenario analyses and quick impact calculations.



##### Flexible calculation

Thanks to general inputs, Calculator can handle most of the common CECL methodologies as it is.

##### 3 Calculate the results

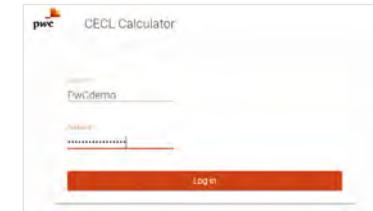
Provided no validation errors were encountered, the user is free to calculate the CECL.

After the successful calculation, the results are presented in a neat dashboard and a detailed report is made available for download.

## Calculation workflow

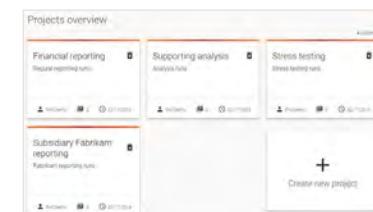
### 1 Log-in

- Regular user and admin user roles available.
- User management is fully in client's hands.
- Every client is provided with their own copy of Calculator with a separate database and allocated resources.



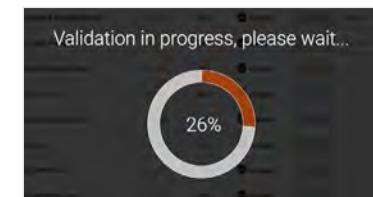
### 2 Create new calculation

- Calculations can be freely organized into "projects".
- The project usually groups similar calculations for different reporting dates or other types of related calculations.



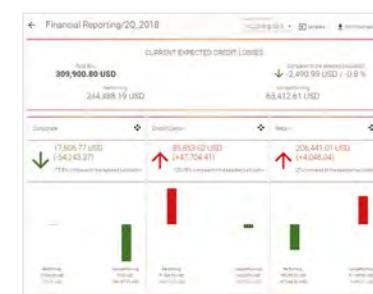
### 3 Upload & validate data

- When a new calculation is created and input data uploaded, the validation step can be executed.
- Over hundred validation checks are evaluated within a few seconds.
- In case the input data doesn't pass validation, user can replace incorrect files and rerun the validation process.



### 4 Calculate & download results

- Result dashboard shows a comparison with selected previous calculations.
- Detailed results can be downloaded as CSV.
- Breakdown of change in CECL on loan level can be generated and downloaded.



### 3 Credit Risk Modelling Suite (1/2)



Ondřej Glatz



#### CRMS automates credit loss modelling under various frameworks (IFRS 9 / CECL / IRB)

The **PwC Credit Risk Modelling Suite** (CRMS) showcases the possibilities of automation and standardisation in credit risk modelling. With a methodology adjustable to your needs it covers all stages of model development from modelling of individual components to the final impact analysis. compare CECL under different scenarios.

#### Interactive modelling process

##### 1 Analyse portfolio

In CRMS you can analyze the historical behaviour and trends observed in various segments of your portfolio. In this step, multiple segmentations can be created for further use during modelling.



##### 2 Evaluate and compare

CRMS allows you to quickly calculate the impact for any selected combination of model components and evaluate the performance of the model.

Thus, you can compare different models and understand how individual modelling choices impact provisions or capital requirements.

#### Our approach

##### Efficient

Integration of modelling steps (exploration, estimation, evaluation) within a single interactive tool enables rapid model development.



##### Versatile

Apart from regular model development, the tool is also suitable for quick ad-hoc analyses needed for impact studies, scenario analyses, etc.



##### Standardized

Integrated modelling suite ensures integrity and consistency of all developed models with defined modelling methodology.



##### Customizable

Within the general workflow the particular modelling approach can be adapted to the provided modelling guideline.

##### 3 Estimate the models

The CRMS enables you to fit multiple models to each of the credit loss components (PD, LGD, EAD, ...) to explain observed data.

Underlying flexible database takes care of storing and versioning all the created models.

## Principal components

### 1 Leverage comprehensive data model

Underlying SQL database allows you to store multiple versions of models for each risk component. Changing the assumptions and comparisons with previous models is just a few clicks away.

### 2 Develop the application or current rating

The rating simulation component employs Logistic regression or a Random forest ML algorithm to develop a scoring model and an automatic WoE binning method ensures that rating grades are defined in a meaningful way.

### 3 Model forward-looking risk measures

CRMS comprises a time-series analysis and simulation component (ARIMA, VAR), which can be used to forecast macro-economic factors impacting the probability of default.

### 4 Make the most of scenario analysis

Thousands of forward looking scenarios are generated by the Monte-Carlo method and are used to determine representative scenarios and their weights for the final loss calculation.

### 5 Apply robust segment-tailored PD models

Combine historical information with predictions of macroeconomic development using the Cox hazard model, or transition matrices with Vasicek/Merton z-shift to estimate PD at the account level.

### 6 Anticipate exposure and loss

EAD depends on repayment schedules and CCF estimates. LGD reflects the expected collateralization and unsecured recovery rates estimated by Kaplan-Meier method.

### 7 Benefit from complex stage classification

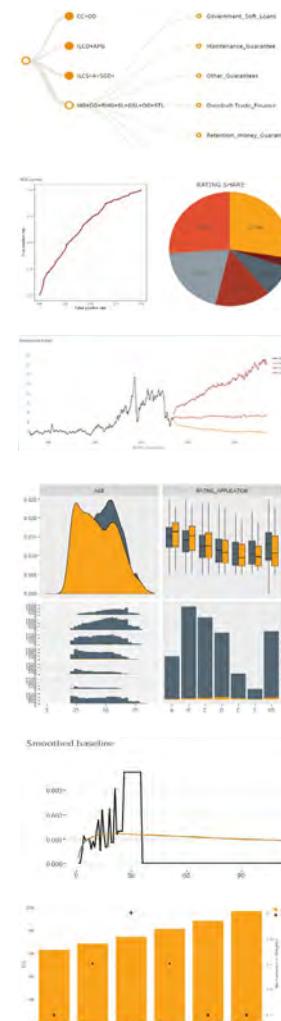
The IFRS 9 staging algorithm uses both qualitative and quantitative criteria as well as a comparison of current and origination PD curves.

### 8 Gain insight into expected credit loss

In the final calculation stage, any combination of prepared model components and related segmentations can be selected and evaluated.

### 9 Test your assumptions and see their effects

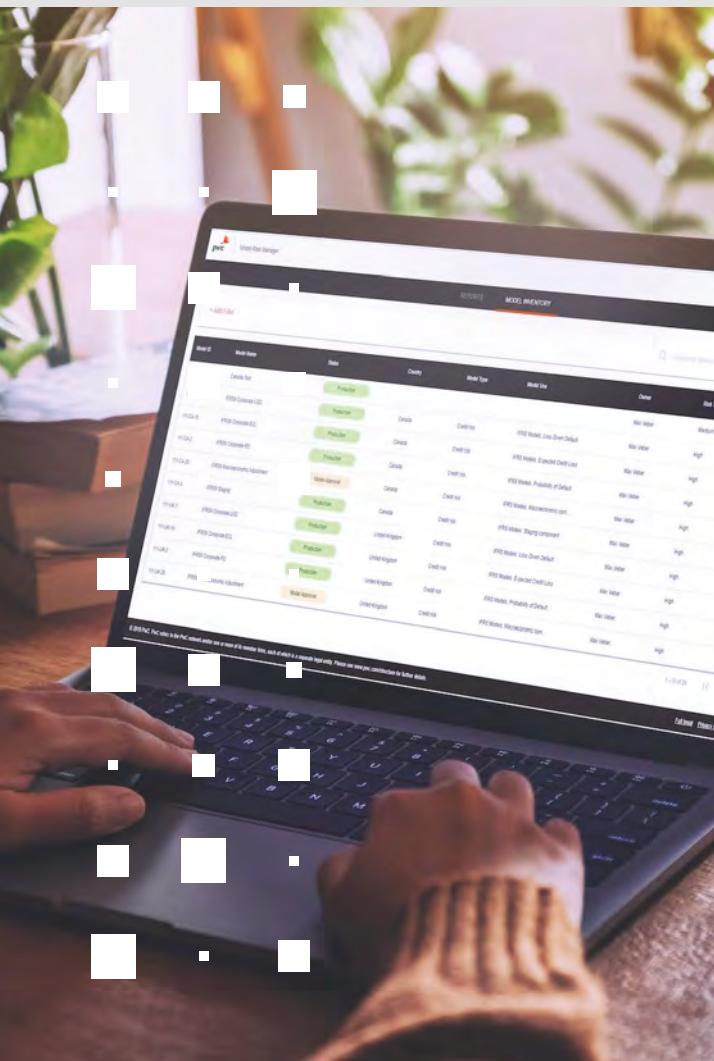
Computation, visualization and comparison of the results help to quickly assess the impacts of assumptions behind the credit loss calculation.



# 4 Model Risk Manager (1/2)



**David  
Dolejší**



## The tool tracks, documents and monitors the lifecycle of the risk model for you.

The **PwC Model Risk Manager** serves your institution as a control framework around the management of models. With this application, your financial institution can organise, evaluate and monitor all the models used across the organisation in a user-friendly environment.

### All-in-one box

#### 1 Model Inventory

The Model Inventory serves as a structured and powerful database of your models with more than 200 attributes in the off-the-shelf version and the possibility of customisation per your specific needs. Its main purpose is to assist banks, insurance companies and other financial institutions in storing, supervising and documenting their models using a user-friendly dashboard.



#### 2 Model Workflow

The Model Workflow provides the key functionality to support the whole model lifecycle, including the flexibility to be adjusted per individual models. Workflow enables multiple user roles to be set up and supports a four-eyes principle.

### Our approach



#### All-in-one box

The MRM platform combines the Model Inventory, Model Workflow and Reporting functionalities all-in-one box.



#### Easy access

The user connects to the MRM through an interactive web application.



#### Efficient

The MRM saves you time and resources by automating the governance processes surrounding your models.



#### Compliant

The MRM tool complies with regulatory requirements, follows market practices, and the information stored in the tool has an auditable track.

#### 3 Reporting

The MRM tool visualises the distribution of attributes across a bank's portfolio of models either in the form of build-in reporting functionality, customisable reports or usage of third-party reporting platforms.

## Main functionalities

### 1 Model Inventory

#### Model Typology

- A structured database of all models available in your institution
- Stores key model information with regard to model risk management

#### User Roles

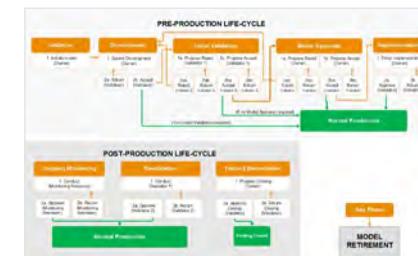
- For each model, the inventory supports multiple roles such as model owners, developers and validators

#### Finding Tracker

- List of key findings and resolutions from audits and validations

#### Auditability

- All relevant actions performed on models are stored



### 2 Model Workflow

- Essential logic of the model lifecycle is enforced through core phases in predefined relationships
- Possibility to set up a simpler workflow by omitting certain phases in the tool's standard settings
- Automatic notifications and a four-eyes principle (key actions reviewed by particular independent users)

### 3 Reporting

- The tool provides management with a standardised report on the aggregated level
- Summary of predefined subsets of models
- High-level information regarding model risk and model lifecycle phase
- For custom reporting, the tool is linkable with third-party reporting tools such as PowerBI or Tableau



## 5 IFRiSk 9 Calculator (1/2)



Ondřej  
Glatz



### IFRiSk 9 Calculator is a simple off-the-shelf solution for IFRS 9 ECL calculation and analysis

The **PwC IFRiSk 9 Calculator** has been developed to support financial institutions with the IFRS 9 ECL calculation. Powerful engine together with simple interface enable users to quickly evaluate and compare ECL under different scenarios.

#### ECL in three clicks

##### 1 Drag & drop your data

All inputs necessary for the ECL calculation are provided in the form of Excel or CSV text files.

Simply drag & drop the required files to the application window to instantly upload them into the tool.



##### 2 Validate the inputs

Calculator implements over 140 validation procedures that are executed upon the upload of inputs.

These checks ensure data consistency across inputs and allow for smooth ECL calculation.

#### Our approach



##### Quick deployment

PwC provides Calculator as a service accessible on the PwC-managed cloud. Or it can be deployed in your environment.



##### Easy access

Application is easily accessible via a web browser without the need for any installations by end users.



##### Scenario analysis

Fast calculation engine also makes Calculator a great tool for various scenario analyses and quick impact calculations.



##### Flexible calculation

Thanks to general inputs, Calculator can handle most of the common ECL methodologies as it is.

##### 3 Calculate the results

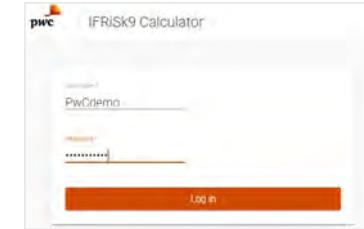
Provided no validation errors were encountered, the user is free to calculate the ECL.

After the successful calculation, the results are presented in a neat dashboard and a detailed report is made available for download.

## Calculation workflow

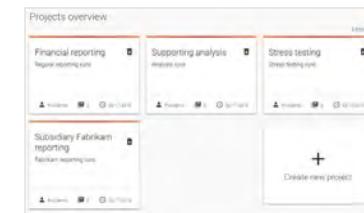
### 1 Log-in

- Regular user and admin user roles available.
- User management is fully in client's hands.
- Every client is provided with their own copy of Calculator with a separate database and allocated resources.



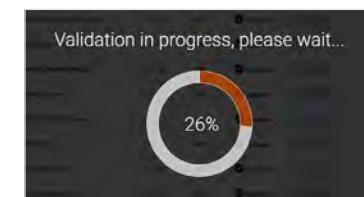
### 2 Create new calculation

- Calculations can be freely organized into "projects".
- The project usually groups similar calculations for different reporting dates or other types of related calculations.



### 3 Upload & validate data

- When a new calculation is created and input data uploaded, the validation step can be executed.
- Over 140 validation checks are evaluated within a few seconds.
- In case the input data doesn't pass validation, user can replace incorrect files and rerun the validation process.



### 4 Calculate & download results

- Result dashboard shows a comparison with selected previous calculations.
- Detailed results can be downloaded as CSV.
- Breakdown of change in ECL on loan level can be generated and downloaded.



## 6 Validation Automation Service (1/2)



**David  
Dolejší**



We can help you automate repetitive model validation and model monitoring so that you can focus on risk analysis and decision making. Most resources will be saved when your institution uses similar models across portfolios and for regular ongoing monitoring tests.

### 1 Upload Data and Perform Checks

Data quality checks are implemented in order to verify that the used data have all necessary fields, no missing values or outliers.



### 2 Run Model Validation Tests

Selection of predefined validation tests is run using the unified interactive environment. This allows user to change input parameters such as thresholds, tested variables, etc.

### 3 Automatically Generate Validation Report

The structure and format of the validation report is set in advance. All the test results and user comments are automatically exported in this report.

## Our approach



### End to end framework

We provide a service that automates your model validation or monitoring process from data quality controls, to final report export. Including validation methodology based on your demands, regulations and industry standards.



### Flexible and scalable framework

Our solution is not a black box. Our platform will be tailored to your needs. We use open source programming languages such as Python and R and provide full access and control of the codes and rights to further modify them on your side.



### Save time and focus on important issues

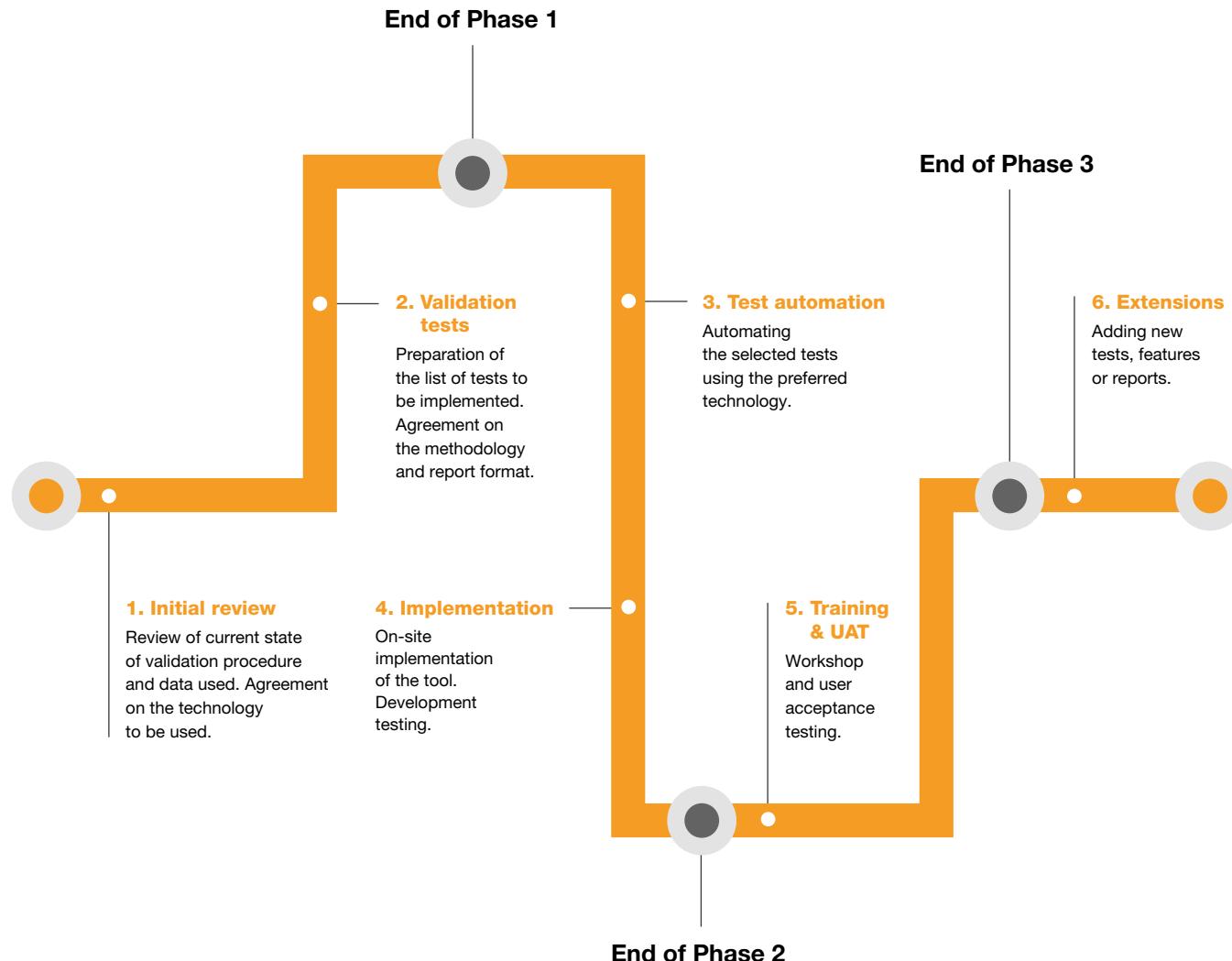
By automating the repeating tasks such as data quality checks, validation tests setup and final report preparation we save the time and resources. Focus can be thus shifted to analysing discovered issues rather than preparation of the reports.



### Clear methodology and versioning

Avoid having multiple versions of the script for the same test. The platform can always include the master version. Test methodology will be transparently published.

## Step by step process of model testing automation in your institution



## Illustrative charts

### 1. Test Setup



### 2. Test Results



### 3. Tool Generated Word Report



## 7 Credit Decision Engine (1/2)



**Jan  
Muchna**



**Online lending is the answer for credit institutions aiming to increase their market share (not only) under the pandemic, but also comes with specific challenges**

- A fully digital credit decision system is required, able to easily integrate even a very complex scoring strategy, scoring model, data sources etc.
- Decision engine must be flexible and modular, allowing continuous integration and deployment.
- There are specific requirements of consumer protection. Using data typically available in online channels, it may be more difficult to conduct creditworthiness checks.
- Higher fraud incidence and resulting need for more comprehensive automated hard checks.
- Need to flexibly evolve the decision process based on rapidly changing conditions under the pandemic (payment holidays, COVID rebounds, population changes).

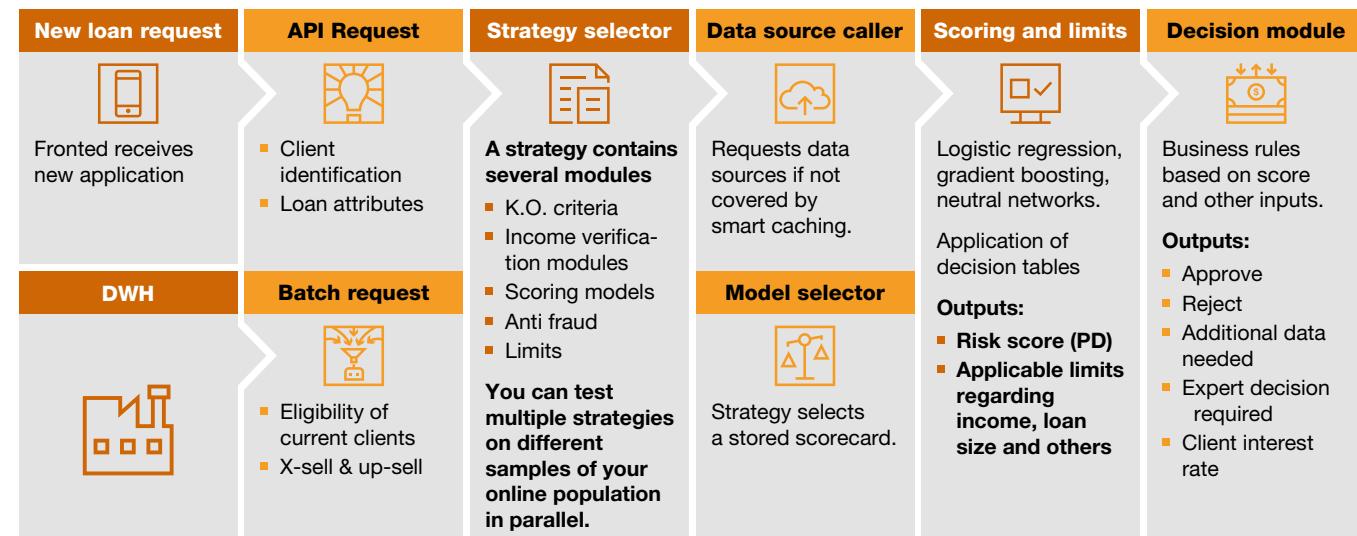
Together with our partner TaranDM, we provide a full scope real-time decision manager based on a modern open source technology stack. It provides an unique ecosystem for integration of your data sources, development of your scoring strategy and orchestration of your scoring requests.

### Functionalities:

- Credit approval
- Limit management
- Risk measurement
- CRM – segmentation, strategy, next best offer, real time offer, dynamic pricing

### Technology:

- Can be deployed in cloud as well as on-prem
- Core decision manager – Python
- APIs – OpenAPI – FastAPI
- PwC's instance running in Azure / Kubernetes
- DevOps – Azure DevOps
- PostgreSQL



## Why the PwC Solution?

Online lending is the answer for credit institutions aiming to increase their market share (not only) under the pandemic, but also comes with specific challenges



### Modular and flexible

- Highly modular and flexible.
- Set-up a custom strategy for your approval process from available modules.



### Cost effective

- Cost-effective – smart caching of external and costly data source in the data caller.
- New data are only requested when needed.



### Multiple strategies

- Multiple scoring strategies for benchmarking and/or segmentation of the loan approval process.



### Anti-fraud module

- Anti fraud check based on info from antifraud DB such as device ID, IP address.
- Built-in libraries for collecting technical data from the device.



### Auditable, transparent

- Every input and output is saved and every historical decision is replicable and deterministic.
- Interactive reporting module over SQL database for monitoring your online population and basis for upgrades.



### Real-time and batch

- Real-time and batch scoring in one unified engine – real time for BAU application process and batch for campaigns on existing population.



### Smart pricing and x-sell

- In-built cross-sell and up-sell capabilities based on defined strategies.
- Supports risk based pricing and/or propensity based smart pricing.



### Modern tech stack

- Open source tech mitigating vendor lock-in.
- Easy deploys virtually independent on IT department.
- A license type enabling you to modify the code and develop on top of it for your purposes.



### Easy to maintain

- Analytical utilities – suite of utilities for data scientist working with TaranDM.
- Extract predictors for analytical work.
- Predictor form and binning embedded in strategy.

## 8 Data Integrity Validation Tool (1/2)



Jaroslav  
Nedvěd



**Data Integrity Validation Tool (DIV Tool)** is an automated solution for testing of data quality and consistency of data sets that are used for risk modelling and financial reporting in banks. The testing approach is based on the internationally recognized Asset Quality Review (AQR) methodology developed by the ECB which is broadened by a series of additional checks that are based on PwC's long-term experience with data quality testing.

### This tool:

- Uses fundamental data attributes such as **client risk information** (exposure value, residual maturity and classification, performing status, PDs, internal ratings, DPDs, etc.), **client qualitative information** (regulatory segmentation, location, financial statements, etc.) as well as **collateral information** (collateral value, location, type, etc.).
- Performs a series of data checks which covers full-scale review starting with **technical checks** (verification that data attributes fulfill predefined conditions), **cross-field logical tests** (comparisons between various risk indicators, e.g. comparison of DPDs, IFRS 9 stage and performing status) as well as **cross-time plausibility checks** (e.g. cross-time comparison of DPDs, IFRS 9 stage and forbearance flag).
- Provides results via Power BI dashboards that point out main data issues and their potential drivers, accompanied by comprehensive report in MS Excel, which lists all identified issues together with all necessary details

The purpose of the tool is to point out the currently existing data issues and their potential drivers. Based on the report, a bank is able to prioritize the data

### Our approach



#### Standardization

Standardized data structure allows effective deployment of the tool for any bank.



#### Automation

Data import, performance of data checks and results reporting are fully automated.



#### Customization and flexibility

Data model and data checks can be easily tailored for the purposes of individual banks.



#### Results visualization

Results are reported in easy-to-follow Power BI dashboards.



#### AQR templates add-on

Module for automated reporting of results into the official ECB's AQR templates.

issues and it can set up an appropriate remediation process. Afterwards, the tool can be used for regular monitoring of the progress of the remediation process as it allows a comparison of the numbers of identified issues between the individual review iterations.

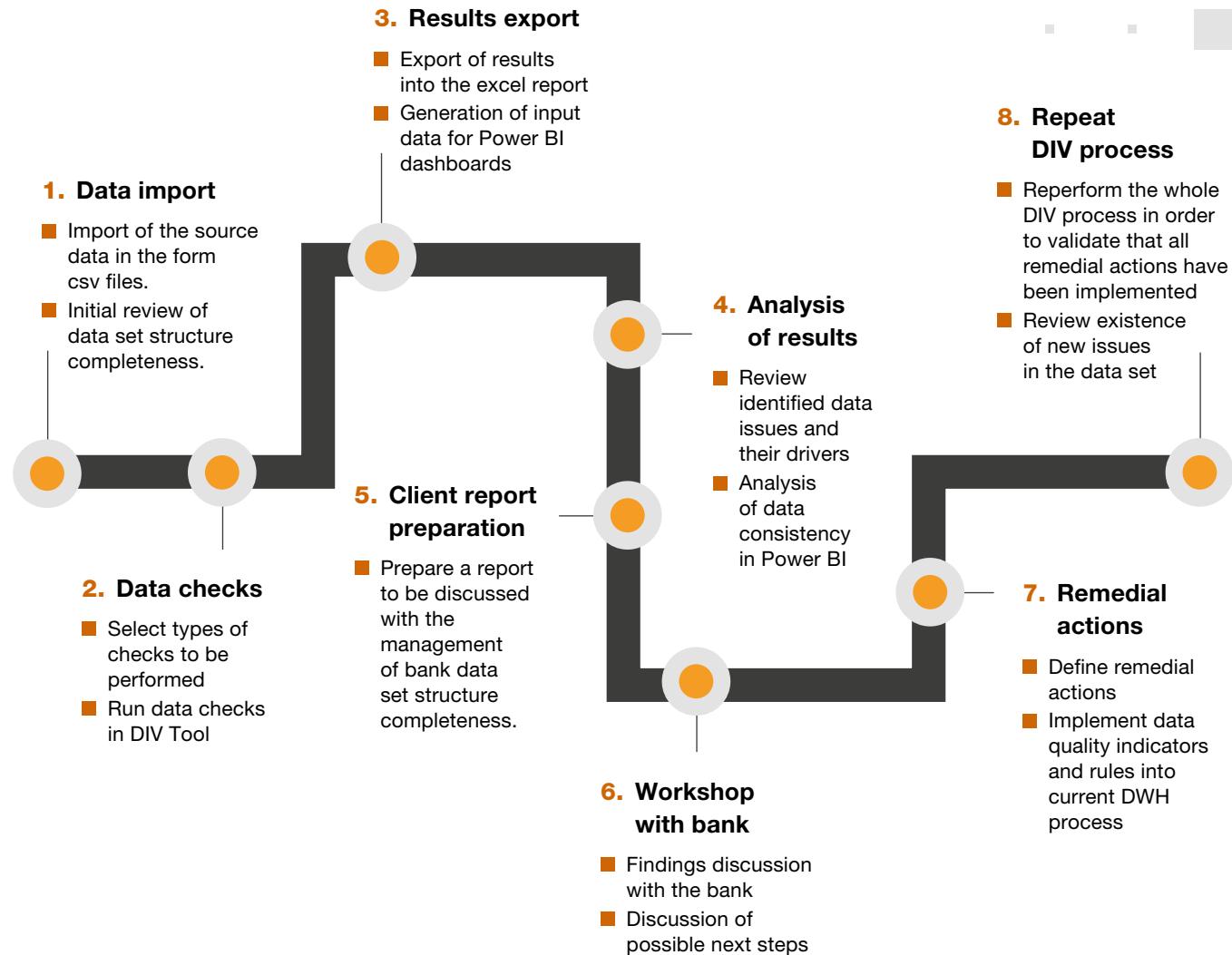
The DIV Tool should help the banks to identify and eliminate a majority of data quality issues related to data attributes that are commonly used across multiple risk model data sets as well as financial reporting data sets.

## 8 Data Integrity Validation Tool (2/2)

### Examples of Power BI reports



### Data Integrity Validation workflow



# 04

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## Team



# Team



**Rostislav  
Černý**  
Partner

## Experience summary

Rostislav is a Consulting Partner and Basel IV Leader leading the Risk Management & Modelling team.

He has 18 years of experience in various positions in FS risk consulting with main focus on quantitative risk modeling. He worked on engagements across Europe, Asia and the US.

He worked on several consulting engagements dealing with review and optimization of calculation of both the capital requirements (SA and IRB) and loan loss provisioning for banks in central Europe.

He led a team developing a methodology concept and actual estimation of PD, LGD and EAD parameters used for capital requirements for a major CEE operating banking group.

He participated in the model validation project for the largest US banks in model validation under CCAR stress testing exercise (econometric top down and bottom up net charge-off rate models, using e.g. hazard rate and ARIMAX modelling techniques). He was also involved in validation of Fair Landing practices for US banks.

In PwC, Rostislav and his teams provide mainly services in the area of implementation and audit of IFRS9 (end CECL) methodologies and provisions calculation, and support clients in the process of (re)development of their capital risk parameters. The team works on international assignments, supporting clients also with a complete Risk governance setup from Risk appetite statement, capital management, through credit, market, liquidity and operational risk management. The team has a strong reference in the Model Risk Management framework setup including its fully in-house developed solution Model Risk Manager.

Recently, the team worked on projects incorporating ESG and climate risk into the bank's risk process including assessment of portfolio carbon footprint and methodology design and calculation of related stress test.

## Contact

[rostislav.cerny@pwc.com](mailto:rostislav.cerny@pwc.com)



**Jiří  
Mach**  
Senior Manager

## Experience summary

Jiří is a Senior Manager in the Risk Management & Modelling team based in Prague. Prior to joining PwC, Jiří worked for another Big 4 and had over 18 years of rich risk management experience in consulting and financial services industry including role of Director of Trading & ALM of the bank, CEO and BoD role in Central Bank regulated financial institution.



**Ondřej  
Glatz**  
Senior Manager

## Experience summary

Ondřej leads the risk modelling agenda of the Risk Management & Modelling team in PwC CEE. He has more than 10 years of experience in quantitative modelling from both PwC and a multinational bank. He delivered multiple IFRS 9 and IRB projects across the world taking part in both model development as well as modelling related client trainings. He is also responsible for development of PwC IFRS 9 calculation software.

## Areas of expertise

- Risk Appetite Framework
- Risk Culture
- Liquidity Risk Management
- Funds Transfer Pricing
- Market Risk Management
- Interest Rate Risk in the Banking Book

## Contact

[jiri.mach@pwc.com](mailto:jiri.mach@pwc.com)

## Areas of expertise

- Internal Ratings-Based Approach
- Predictive Models and Machine Learning
- Credit Scoring
- Loan Loss Provisioning

## Contact

[ondrej.x.glatz@pwc.com](mailto:ondrej.x.glatz@pwc.com)



**David  
Dolejší**  
Manager

## Experience summary

In PwC, David leads credit risk model validations and risk management for PwC Risk Management & Modelling team in Prague. He is skilled in credit risk model development, validation, audit and methodology design under various regulations including ECB Guidelines, Basel II and IFRS9. David also has experience in leading end to end development of complex model risk solutions. He is currently a product owner for the CEE PwC model inventory solution Model Risk Manager.



**Jaroslav  
Nedvěd**  
Manager

## Experience summary

Jaroslav is a manager in the Risk Management & Modelling team and has worked in the Advisory department of PwC Czech Republic for 6 years. He specialises in bank credit risk management and has broad experience with the Asset Quality Review projects and IFRS 9 impairment models. Further, he also has strong project management skills as he was responsible for delivering complex international projects in eastern Europe and east and central Asia. Jaroslav also specialises in data analytical projects, data visualisation and automatisation of BI processes. He is skilled with Power BI, Tableau and other data visualisation software.

## Areas of expertise

**Model Risk Management**

**Internal Ratings-Based Approach**

**Predictive Models and Machine Learning**

**Loan Loss Provisioning**

## Contact

[david.dolejsi@pwc.com](mailto:david.dolejsi@pwc.com)

## Areas of expertise

**Regulatory Stress Testing**

**Credit Risk Management**

**Loan Origination and Monitoring Process**

**Data Quality and Consistency Review**

**Asset Quality Review Preparation**

**Asset Quality Review Audit**

## Contact

[jaroslav.n.nedved@pwc.com](mailto:jaroslav.n.nedved@pwc.com)



**Silvia  
Majlingová**  
Senior  
Regulatory Expert

## Experience summary

Silvia is a Senior Regulatory Expert in PwC Consulting in Czech Republic. Silvia is an experienced banking professional in Risk management, Banking regulations and Internal Audit domains. Silvia has more than 25 years of experience and knowledge in risk management and prudential regulations. Prior to joining PwC, she was leading the team of internal auditors (focusing on risk and regulation) in Ceska Sporitelna (Erste Group) and Komercni banka (Societe Generale Group) and leading Liquidity and Risk management, ALM, and Treasury departments in CSOB bank (KBC Group) in Czech Republic and Slovakia.



**Peter  
Tuchyňa**  
Manager

## Experience summary

Peter has over 14 years of experience in risk management from management positions in a large banking group as well as a co-founder in a peer-to-peer lending start-up. His areas of expertise are credit risk management, capital management, recovery & resolution planning and incorporating climate and environmental risks into banks' standard risk management processes.

## Areas of expertise

**Risk Appetite Framework** **Capital Management**  
**Regulatory Stress Testing** **Recovery Planning**  
**Resolution Planning** **Liquidity Risk Management**  
**Market Risk Management**  
**Interest Rate Risk in the Banking Book**

## Contact

[silvia.majlingova@pwc.com](mailto:silvia.majlingova@pwc.com)

## Areas of expertise

**Integration of Climate and Environmental Risks**  
**Green and Sustainability Issuance**  
**Capital Management** **Synthetic Securitization**  
**Resolution Planning**

## Contact

[peter.tuchyna@pwc.com](mailto:peter.tuchyna@pwc.com)



**Jan  
Muchna**  
Manager



**Ondřej  
Šedivý**  
Manager

## Experience summary

Jan has more than 10 years of experience in Credit risk management and underwriting from a major European banking group. He was responsible for development of Basel II and III across the group, Credit risk regulatory compliance, CVA methodology and calculations as well as deployment of RAROC/EVA calculation. In underwriting, he was responsible for managing the largest clients in the EMEA territory (sovereigns, banks, NBFIs, SOEs).

## Areas of expertise

**Integration of Climate and Environmental Risks**

**ESG Quantitative Modelling**

**Capital Management**

**Economic Capital**

**Regulatory Stress Testing**

**Internal Stress Testing**

**Risk Based Pricing**

## Contact

[jan.muchna@pwc.com](mailto:jan.muchna@pwc.com)

## Experience summary

Ondřej is an expert in credit risk modelling with more than 5 years working record in the Risk Management & Modelling team in Prague. He has wide experience with model development, validation, and audit. His domain of expertise includes regulatory models (IRB, IFRS 9), scoring and rating models, and recently also ESG quantitative modelling and stress-testing. Furthermore, Ondřej specialises in the development of analytical tools for both clients' and internal use (Python, Dash, R, Shiny).

## Areas of expertise

**ESG Quantitative Modelling**

**Internal Ratings-Based approach**

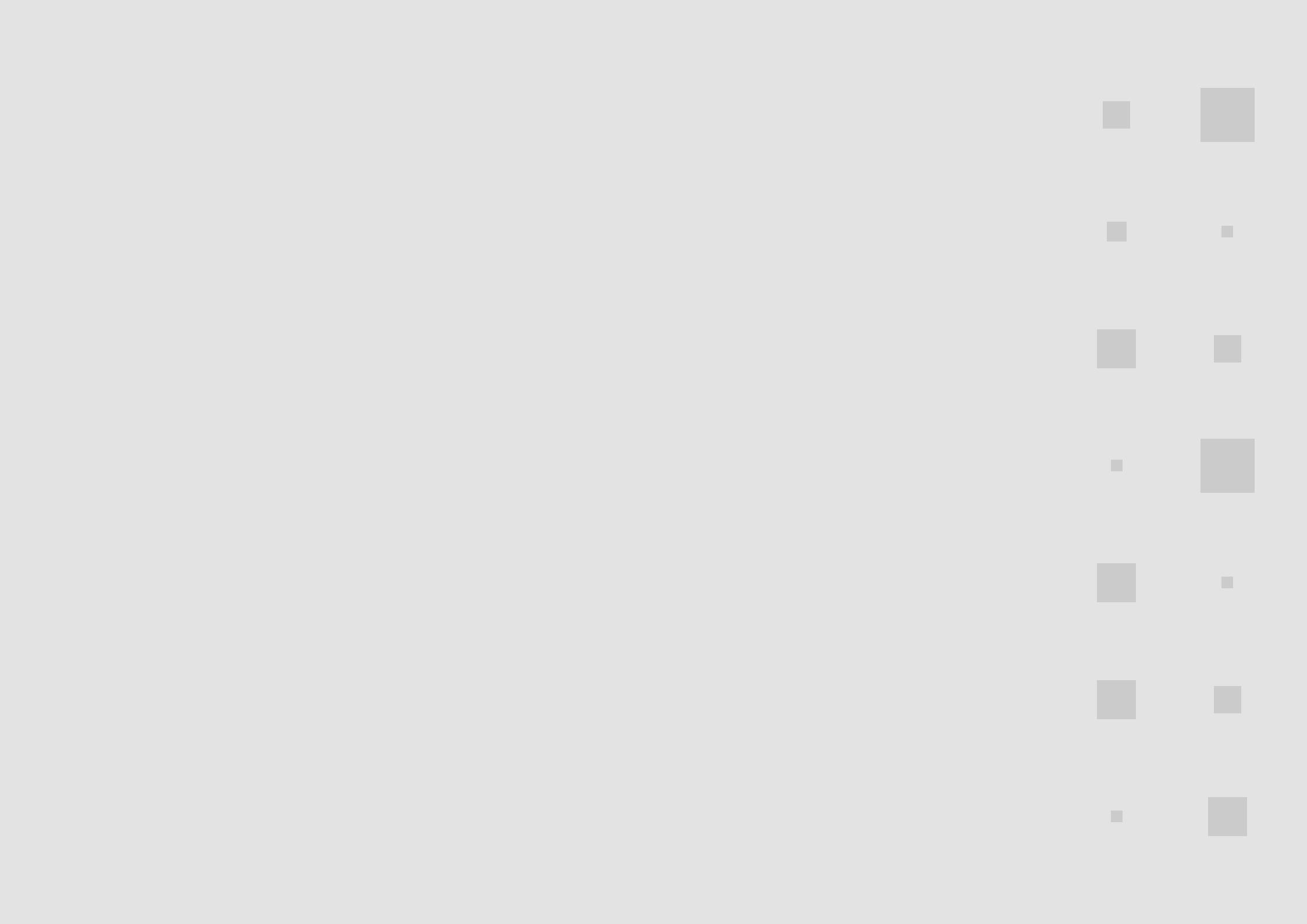
**Predictive Models and Machine Learning**

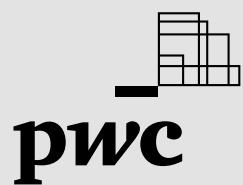
**Credit Scoring**

**Loan Loss Provisioning**

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