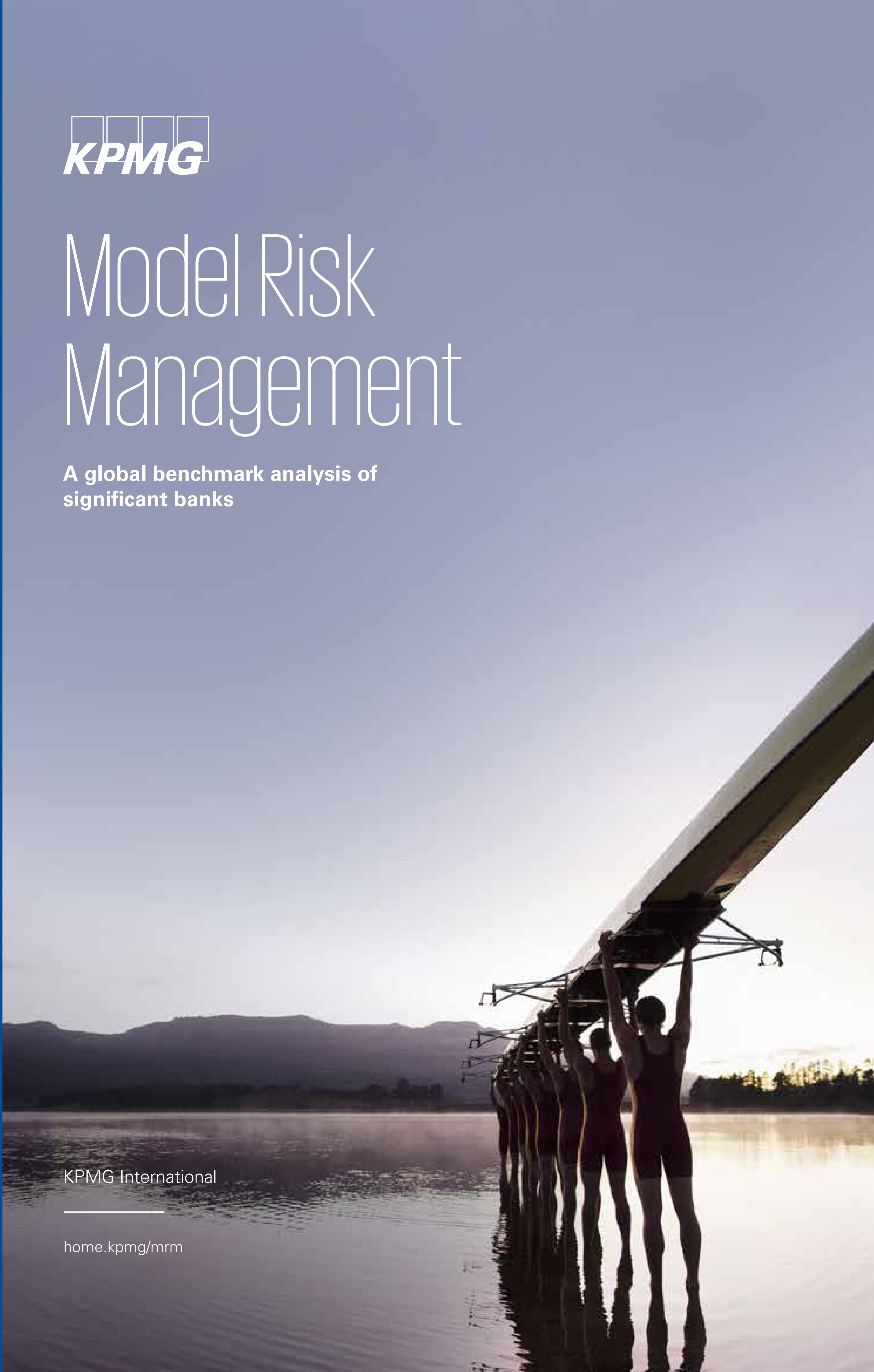


Model Risk Management

A global benchmark analysis of significant banks

KPMG International

home.kpmg/mrm

Table of contents

Key findings 6

MRM: Why does it matter? 8

Turning up the regulatory light 9

Balancing the model risk appetite equation 10

Theory into practice: Operationalizing MRM 12

Governance from the top through senior engagement 17

Into the future — Artificial Intelligence and Machine Learning 20

Automation of MRM 21

Conclusion 23

Introduction

Banks are highly dependent on credit, market and behavioral models. These are used for a wide variety of purposes across nearly all functions in a bank and have become a key component of operational efficiency and risk management. Banks use models to evaluate risks, assess capital adequacy, define funding requirements, understand customer behavior, manage data analytics and make investment decisions.

Indeed, the use — and importance — of models is only set to grow as the rapidly proliferating trend of digitalization and the incorporation of artificial intelligence (AI), machine learning (ML) and big data increases the number and complexity of models even more. The correct use of sophisticated models is key to making the right decisions for the future. Failures in model implementation and usage can cause both direct financial losses and reputational damage — while the suddenness with which model risk issues can occur is also significantly increasing.

As a consequence of this, supervisory and regulatory scrutiny of models is intensifying. More extensive and rigorous sets of requirements have started to appear. While most banks implement their approaches to Model Risk Management (MRM) based on the requirements of the US Federal Reserve/OCC's SR11-7 guidelines, other significant recent initiatives include the European Central Bank's Target Review of Internal Models (TRIM) and papers from the Bank of England (BOE) and Prudential Regulation Authority (PRA).

The imperative for banks to effectively manage and monitor their MRM activities is only growing; therefore, model risk management has become a matter of strategic importance, as well as one with capital implications, given that buffers may be needed where model performance or governance is deemed to be poor.

Matthias Peter
Partner
KPMG in Germany

MRM also matters because it is an area attracting significant spend. Based on market observation and client engagement, KPMG estimates that the operational and salary costs of maintaining and developing a MRM framework and team could come to more than US$100 million annually for a large global bank.

However, there is a risk of models being incorrectly designed or implemented, being used in the wrong way or becoming less fit for purpose over time. This is especially the case as AI and ML algorithms become more widely incorporated into models.

Therefore, sound life cycle management, effective inventory keeping, a clear validation framework, strong governance that includes senior management/board involvement and effective use of technology all become key features of robust MRM.

Against this backdrop, KPMG member firms have conducted a survey of significant banks to assess the MRM landscape, which includes answers to the following fundamental questions.

— What are the key challenges facing banks?

— Are the regulatory requirements and guidelines clear and understood?

— Where do banks' efforts need to be focused to strengthen and improve their MRM further?

We find that the great majority of banks have a systematic MRM framework in place, with most banks following the SR11-7 guidelines as a template. But to ensure the emerging and increasing challenges of model risk are under control, most banks have more work ahead of them.

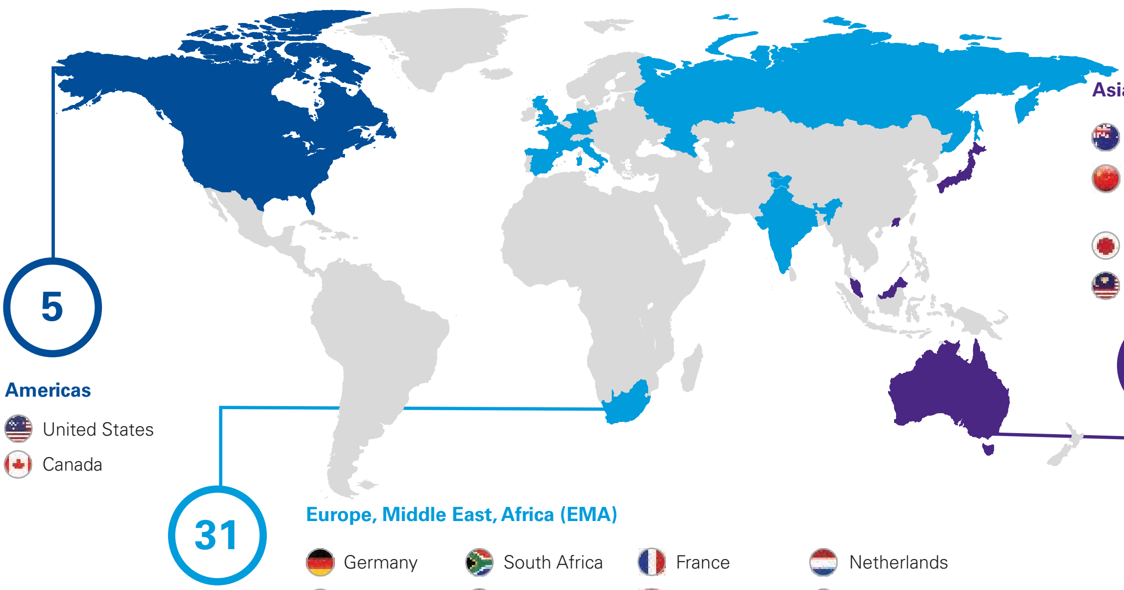
“Digitization will make model risk management a major risk category for banks in the future, however today compliance and efficiency are the leading subjects of debate.”

About the survey

KPMG's research was conducted between June and August 2019 among 48 significant banks representing 16 countries globally. Of these, 31 were based in the Europe, Middle East and Africa (EMA) region, 12 in Asia-Pacific (ASPAC) and 5 in the Americas. Nearly a third (29 percent) of the banks participating were global systemically important banks, while just under half (48 percent) were domestic systemically important banks. There was a range of asset sizes, from less than US$50 billion to over US$500 billion. Twenty of the 48 participating banks (42 percent) have assets in excess of US$500 billion.

Purpose: The MRM global benchmarking survey ("survey") intended to collect insights on the range of model risk management practices, along with related regulatory aspects of significant banks globally, in order to perform a benchmark analysis for participating banks.

Scope: The survey was conducted between June 2019 and August 2019 among model risk management executives from **48 significant banks** ("banks") representing **16 countries/regions/jurisdictions** globally.



Asia-Pacific (ASPAC)

- Australia
- Hong Kong (SAR), China
- Japan
- Malaysia

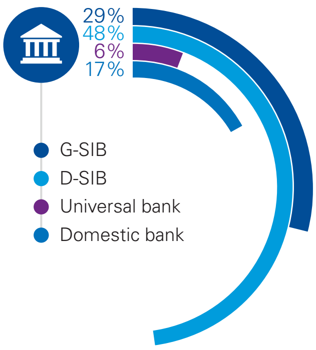
Americas

- United States
- Canada

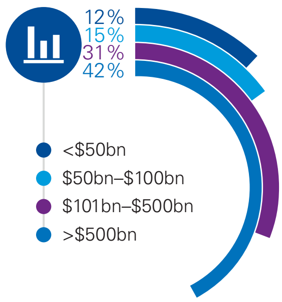
Europe, Middle East, Africa (EMA)

- Germany
- Italy
- India
- South Africa
- Spain
- Russia
- France
- Switzerland
- Netherlands
- United Kingdom

Types of Banks



Assets size of banks (USD)



Source: Model Risk Management Survey, KPMG International, 2019

Key findings

Many of the banks surveyed proactively use the SR 11-7 definition of a model:
The model definition prescribed in the guidance is applied by the majority of respondents irrespective of size, complexity and geographical footprint. Fifty-eight percent of respondents use SR 11-7 definition of a model exactly as written or with some modifications.

Regulatory or supervisory initiatives for MRM are increasing:
A third of respondents have undergone a regulatory exam/inspection relating to MRM in the past, and this rises to 55 percent of larger banks with assets over US$500 billion. The majority have had an exam within the last year.

Many banks are looking for further regulatory clarity:
The most common areas where respondents would welcome extra guidance are model risk appetite, model definition and scope of MRM and model tiering methodology. Ninety-six percent of respondents require clarity from regulators on various aspects of MRM.

Two-thirds of respondents have not established a model risk appetite and associated limits:
Only 38 percent of respondents have done so. In addition, less than a third of respondents (31 percent) allocate capital for model risk and establish a reserve/buffer or provision in some form.

Many of the banks surveyed either estimated a 2:1 (specifically larger banks) or 5:1 (specifically smaller banks) ratio of developers to validators in their bank.

Insufficient model documentation, inadequate model performance, poor data quality and model methodology are the most common sources of findings raised as a result of model validation:
Seventy-five percent of respondents cited model documentation as the most common validation findings.

Board of directors' involvement varies widely:
At more than half of banks, the board of directors (BoD) is involved in reviewing or challenging the highest-risk tier models. But the BoD is not involved at all in 37 percent of banks.

Around two-thirds of large banks have a Chief Model Risk Officer or Head of Model Risk (or equivalent):
64 percent of smaller banks do not.

AI and ML are increasingly being used in models:
Half of banks already consider Artificial Intelligence (AI) or Machine Learning (ML) techniques as part of their internal definition of a model. New types of model such as those utilizing AI or ML are seen as one of the top factors in contributing to the need for MRM to evolve.

Only half of banks surveyed are investing in automation of their MRM framework:
Although this rises to 60 percent of larger banks. Workflow management is most commonly seen as the area where automation can bring benefits. The great majority of banks believe that regulators are neutral or receptive to the use of automation in MRM.

Our research also highlights that banks in the Americas tend to be the most advanced in their MRM approaches, followed by banks in EMA, with banks in ASPAC somewhat further behind. The lead position of banks in the Americas is unsurprisingly caused by regulatory pressure — given that the US Federal Reserve published its SR11-7 guidelines several years ago, prompting US banks to focus on the topic, followed by the publication of the Canadian OSFI E-23 guidelines in 2017. However, we can expect banks in other regions to begin closing the gap as the regulatory focus on MRM increases around the world.

At the same time, the single most important determinant of the sophistication of a bank's MRM approach is whether or not they are subject to US Federal Reserve supervision. Those banks who are subject to supervision by the Federal Reserve have the most developed MRM frameworks and practices, regardless of where they are located.

MRM: Why does it matter?

Before we explore these findings in detail, it is worth briefly stepping back to consider why MRM is becoming a top priority issue for banks.

Here are five key reasons.

1 **Banks' dependence on models is increasing**

Models have become integral to making decisions and interacting with clients across almost all areas of a bank. Based on market observation, more models are in wider use than ever before.

2 **The complexity of models is growing**

This is particularly fueled by the ever-expanding incorporation of AI and ML based algorithms into models to identify specific predictors in data sets that go beyond human thinking or to set more detailed and complex thresholds.

3 **Poor MRM can lead to financial losses for an organization**

Inadequate practices regarding model development and usage may lead, among other things, to suboptimal lending decisions and pricing, hitting a bank's financial performance.

4 **Regulators are increasing their focus on MRM.**

Regulatory inspections and exams connected to MRM are on the rise and more regulators are publishing new guidance. MRM is also working its way into major regulatory initiatives such as Basel IV, where supervisors are trying to constrain model risk through standardized modeling.

5 **Stakeholders are demanding improved risk management**

Whether it's the board of directors, senior management, regulators or shareholders, the expectations of sophisticated risk management at an enterprise level across capital, liquidity and credit and loss forecasting are only rising.

For all of these reasons, those responsible within a bank for risk management are likely to come under increasing pressure to demonstrate that the institution's MRM is fit for purpose and, at the very least, comparable to that of its peers.

Turning up the regulatory light

A wide number of regulatory agencies are in-scope for the banks surveyed, due to their presence in various geographies. These agencies commonly include the US Federal Reserve System (FRS)/the Office of the comptroller of the currency (OCC); the European Central Bank (ECB)/the European Banking Authority (EBA); the Canadian Office of the Superintendent of Financial Institutions (OSFI); the UK Bank of England and the Prudential Regulation Authority (PRA); and the Hong Kong Monetary Authority (HKMA).

Along with their local regulatory requirements on MRM, many banks (nearly 40 percent) proactively adhere to Fed/OCC SR11-7 guidelines.

40%

of banks proactively adhere to Fed/ OCC SR11-7 guidelines

Fed/OCC were the first regulators to pay special attention to MRM, publishing their SR11-7 guidelines in 2011. They are also the most active regulator in terms of inspections: 83 percent of banks subject to the Fed/ OCC have had a supervisory exam. By contrast, only 17 percent of non-Fed banks have had one.

Overall, around a third of banks surveyed have had a supervisory exam, mostly within the last year — a sign that the regulatory focus on MRM is growing.

1/3

of banks have had a supervisory exam

As a result, many banks have conducted a self-assessment of their practices relative to relevant supervisory guidance. This is leading to change: model governance, inventory and risk reporting are the top three areas where banks are making or planning to make changes to align with supervisory guidance.

A range of regulatory initiatives and developments such as IFRS 9 (especially for smaller banks), ECB TRIM, changes to Libor and Basel IV are commonly seen as necessitating MRM changes.

There remain a number of areas where banks would welcome further clarity from regulators, including model risk appetite, scope of MRM and model tiering methodology.

KPMG view

Clearly, regulators in the Americas have been the most active in setting the pace on MRM and providing guidance that they expect banks to follow. In other regions such as Europe, MRM has perhaps been a secondary priority with other initiatives such as Libor, Basel IV and IFRS 9 more to the fore.

We can expect regulators in Europe and further afield to increase their focus on MRM in the coming years. Inspections that include an MRM element are on the rise. The direction of travel is clear: regulators internationally are putting MRM on their radars, and as a result banks will need to continue to develop and mature their approaches.

Balancing the model risk appetite equation

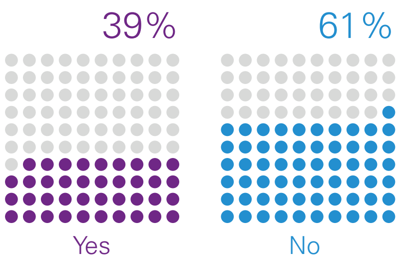
Establishing a model risk appetite and, from that, allocating capital for model risk are two of the most advanced and difficult features of MRM.

It is therefore notable that over a third of banks (37 percent) have established a clear model risk appetite. Those respondents that have established a model risk appetite and associated limits primarily use both quantitative as well as qualitative approaches to measure their model risk appetite.

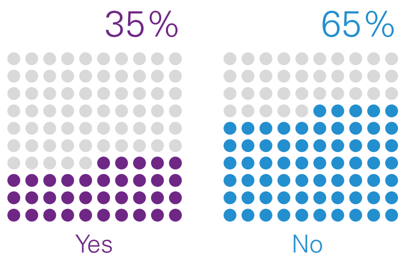
Has a model risk appetite and associated limits been established within your bank?

Total responses

Banks with total assets < US$500bn



Banks with total assets > US$500bn



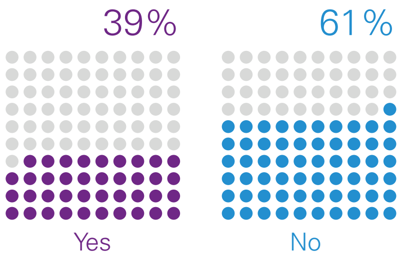
Source: Model Risk Management Survey, KPMG International, 2019

Does your bank allocate capital for model risk?

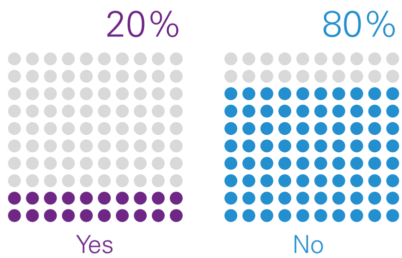
Total responses

Source: Model Risk Management Survey, KPMG International, 2019

Banks with total assets < US$500bn



Banks with total assets > US$500bn



A slightly lower proportion (31 percent) allocate capital for model risk in the form of a reserve/buffer or provision.

While these figures are commendable, this still leaves a majority of banks who are yet to develop their approaches in this area.

Those banks that do allocate capital use a mixture of quantitative and judgmental qualitative approaches, with the main models included being economic and valuation models.

The data also reveals that a relatively high proportion of banks in EMA have established a model risk appetite and allocated capital to model risk.

31% **allocate capital for model risk in the form of a reserve/ buffer or provision**

The issue of model risk appetite and capital allocation is a key area where more explicit regulatory guidance would be useful, as current guidance says little about it.

KPMG view

The issue of model risk appetite is a topic currently in development at many banks and it is likely that a market standard will emerge in time. Which regulators a bank is subject to once again plays an important role here, with around 50 percent of those banks subject to Federal Reserve supervision having established a model risk appetite.

50% **of banks are subject to Federal Reserve supervision**

The question of capital allocation is quite different, however. It is unlikely that many banks hold a separate buffer specifically for model risk — the capital held will be part of a broader risk provision. The market consensus for banks under Federal Reserve supervision is that they do not have to allocate separate capital for model risk.

Essentially, it remains an open question as to how you quantify or put a ‘dollar amount’ on model risk. No single approach dominates at the moment. Allocating capital shows regulators that you are taking the subject seriously; but on the other hand, the more banks invest in developing strong MRM, the less they might need to allocate.

Theory into practice: Operationalizing MRM

Model risk management cannot be a one-off process, applied once and then forgotten: a whole life-cycle management process needs to be created. This should encompass such areas as model definition; the tiering of models; the development and validation of new models; and maintaining and updating an inventory.

Key findings from our research around these 'bread and butter' issues of operationalizing MRM are:

Model definition

Ninety-four percent of banks have a definition of a model, and in the majority of cases it is based on SR 11-7. The main reason for changing a model definition is to keep in line with regulatory requirements (circa 80 percent).

94% **of banks have a definition of a model**

What are the main reasons for changing the model definition or scope of MRM?

Total responses

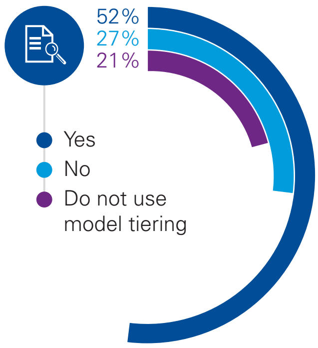
Source: Model Risk Management Survey, KPMG International, 2019

Model tiering

Half of banks apply tiering consistently across the business, and this is mostly assigned by the independent MRM function (or the model validator in smaller banks). The majority review tiering periodically or upon significant market changes.

Is the model tiering (i.e., model risk rating) method consistently applied across your bank?

Total responses



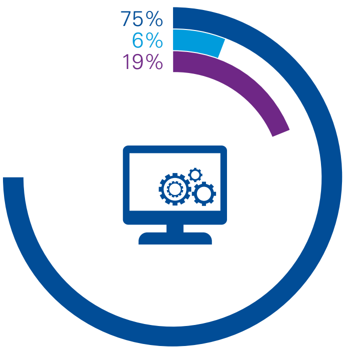
Source: Model Risk Management Survey, KPMG International, 2019

Model development

The majority of banks use some vendor models and make specific adjustments where needed. Six in 10 banks outsource some model development activities with a lack of skilled internal resources being the most commonly cited reason; cost considerations are the main obstacle here. The most commonly used programming languages are SAS, R and Python.

Does your bank make use of models developed and provided by external vendors?

Total responses



- Yes — we use vendor models and make specific adjustments where required
- Yes — we use vendor models without any adjustments
- No — we only develop our models in-house

6/10 of banks outsource some model development activities

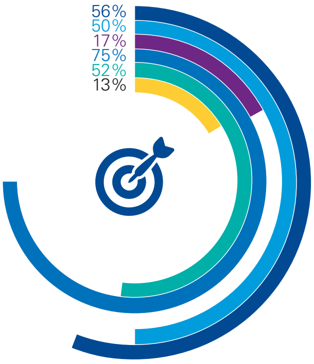
Source: Model Risk Management Survey, KPMG International, 2019

Model validation

Most banks validate all models. For the majority of banks, insufficient model documentation is one of the major findings that came up during model validation (cited by circa 75 percent). Half of banks outsource some validation activities, with a lack of skilled resources and new regulatory requirements being the main reasons, followed by segregation of duties and management of workload as quoted by some of the other survey respondents. Further, most of the banks have indicated cost considerations as the main barrier to outsource model validation activities.

What are the most common sources of findings raised as a result of model validation?

Total responses



- Model performance
- Model methodology
- Adherence to regulation
- Insufficient model documentation
- Poor data quality
- Others

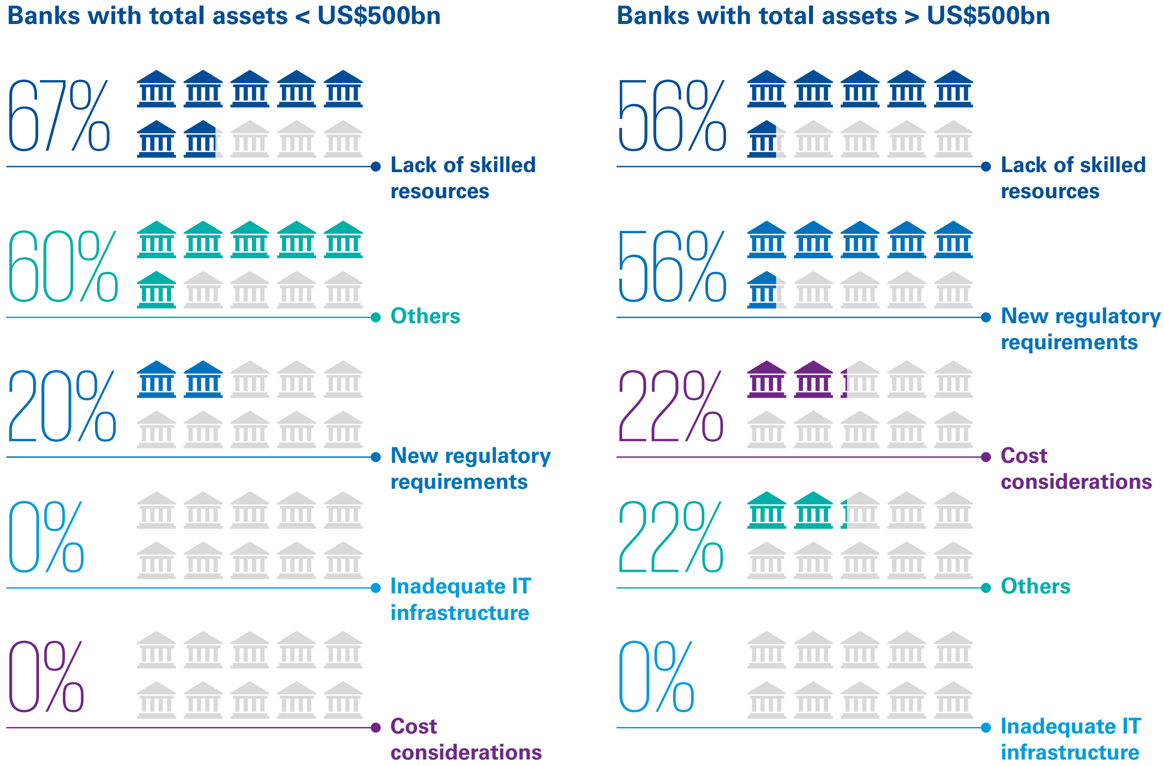
Source: Model Risk Management Survey, KPMG International, 2019

Does your bank outsource any model validation activities?

Source: Model Risk Management Survey, KPMG International, 2019

50% **of banks outsource some validation activities**

What are the key reasons for outsourcing validation activities?

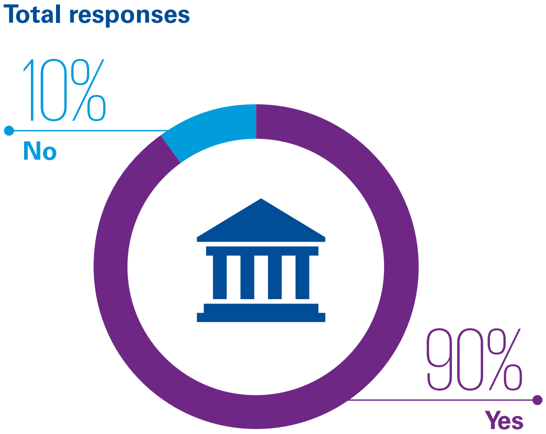


Source: Model Risk Management Survey, KPMG International, 2019

Model inventory

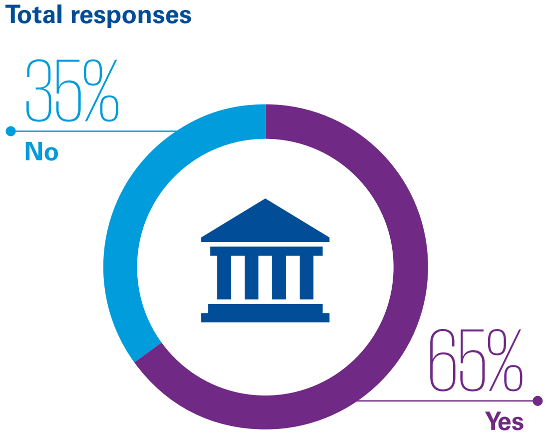
Ninety percent of banks have a firm-wide model inventory. Most banks utilize in-house proprietary tools, databases or spreadsheets to facilitate model inventory management. However, over a third have no regular attestation process. Only a minority of banks describe the sophistication of their inventory management as 'high'.

Does a firm-wide model inventory exist at your bank?



Source: Model Risk Management Survey, KPMG International, 2019

Does your bank have a regular attestation process covering accuracy and completeness of records in the firm-wide model inventory?



Source: Model Risk Management Survey, KPMG International, 2019

Governance from the top through senior engagement

With MRM being an area of such growing importance, strong governance — and engagement at a senior level — is clearly an imperative.

Our research finds that the board of directors is involved in reviewing or challenging the highest-risk tier models at more than half of banks. However, the board is not involved at over a third (37 percent) of banks.

Does your bank's board of directors understand, review and challenge the outputs and limitations of models?

Total responses

Source: Model Risk Management Survey, KPMG International, 2019

Two thirds of large banks have a dedicated Chief Model Risk Officer or Head of Model Risk (or equivalent) — but 69 percent of smaller banks do not. Where there is no dedicated Model Risk leader, responsibility will usually be assumed by head of model validation as part of their role.

Does your bank have a Chief Model Risk Officer/Head of Model Risk (or equivalent)?

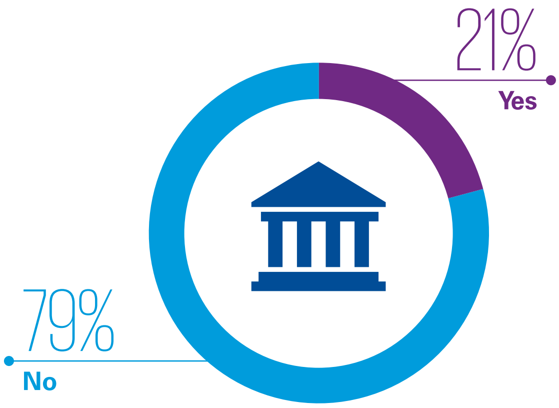
Source: Model Risk Management Survey, KPMG International, 2019

In terms of controls processes, almost all banks have clear separation between model developers and validators. However, around half of banks have a waiver process that allows a model to be used without being validated — clearly, careful controls are needed here (as per SR 11-7 guidance). The ratio of developers to validators varies widely, with larger banks likely to have a 2:1 ratio, while at smaller banks it tends to be nearer 5:1. Factors that influence this tend to include the scope of models in use within the bank, the scope of expected validation work and the extent to which outsourcing of model development is in play.

Only a minority of banks outsource any internal audit work related to MRM, and for large banks this represents less than 10 percent of internal audit MRM work.

Does your bank outsource any internal audit activities (as a model life cycle component)?

Total responses



Source: Model Risk Management Survey, KPMG International, 2019

Most banks (63 percent) do not allocate MRM costs to specific business units — perhaps unsurprisingly given the very cross-functional nature of models in use.

Does your bank charge the cost of its dedicated MRM function to business units involved in model development or use?

Total responses

Source: Model Risk Management Survey, KPMG International, 2019

Most banks say that they try to embed a culture of active MRM through frequent review of policies, structured communications and periodic training for staff.

Most banks have a system of model input data governance that is a combination of policies, procedures, governance and IT infrastructure.

KPMG view

Every bank is different and therefore there is no one-size-fits-all solution to the governance of MRM. The size, structure and footprint of a bank will all have an influence. Clearly though, given the importance of the area, senior involvement is essential. The way it is organized may differ from one bank to another.

Validation of models is an interesting area that is growing in importance as models become more complex. ECB expectations around model validation, for example, have increased. Validation is therefore taking up more time and effort. But many banks are struggling to find sufficient internal resourcing for the work while there is also pressure on profitability, which means they need to find cost-efficient alternatives. As a result, many are discussing whether to outsource more of their validation work. At the moment, only a small proportion of work is outsourced but given the scale effects and cost optimization that is possible we may see this increasing over time.

Into the future — Artificial Intelligence and Machine Learning

As we have noted, AI or ML algorithms are increasingly being integrated into models and this presents new challenges for banks to manage.

Data from our research shows that half of banks already consider AI or ML techniques as part of their internal definition of a model, and new types of models such as those utilizing AI or ML are seen as one of the top factors in contributing to the need for MRM to evolve.

We are only at the beginning of this journey, with the use of AI and ML expected to dramatically increase.

As Federal Reserve Governor Lael Brainard said, "The pace and ubiquity of AI innovation has surprised even experts … We would expect firms to apply robust analysis and prudent risk management and controls to AI tools, as they do in other areas … It is important for firms to recognize the possible pitfalls and employ sound controls now to prevent and mitigate possible future problems."[1]

Models based on AI and ML techniques tend to perform more accurately than models built on the basis of human knowledge and expertise. AI and ML algorithms are better able to identify specific predictors in data sets that go beyond human thinking and are also able to set more detailed thresholds. In the customer sphere as an example, the result can be faster and more accurate decisions based on AI customer credit scoring models.

While these new models open up new opportunities, they also introduce new types of risks such as the following.

— **Explainability risks:** The risk of an algorithm, and its resulting model, being so complex (e.g., deep learning or support vector machines) that it becomes very difficult or, in fact, impossible to determine how a certain outcome was achieved.

— **Resilience risks:** The risk of a model starting to evolve inappropriately, for example because of inaccurate feedback loops or unexpected changes in the algorithm's environment.

— **Fairness risks:** The risk of a model producing results that have a certain bias. For example when one subgroup is structurally favored over the other without good reasons.

KPMG view

AI and ML models will be a key success factor for banks in the future. But to control these techniques and use their full potential, the need has become pressing to evolve a holistic MRM framework that includes the specific risks they create. Controls must be in place to ensure that these specific models work as intended.

As far as possible, AI and ML models needed to be explainable, fair and technically robust. A model risk framework that considers the specific characteristics of AI and ML is key to operatively handle and control these new techniques, as well as to demonstrate compliance to supervisors and regulators.

However, there is little doubt that in such a fast-evolving and complex area, more work is needed between the industry and regulators to establish workable and provable thresholds and standards for the use of AI and ML. For banks to unlock the full value of AI and ML with confidence, this must become a real focus in the coming years.

[1] Governor Lael Brainard. *What Are We Learning about Artificial Intelligence in Financial Services?* Fintech and the New Financial Landscape conference, 2018.

Automation of MRM

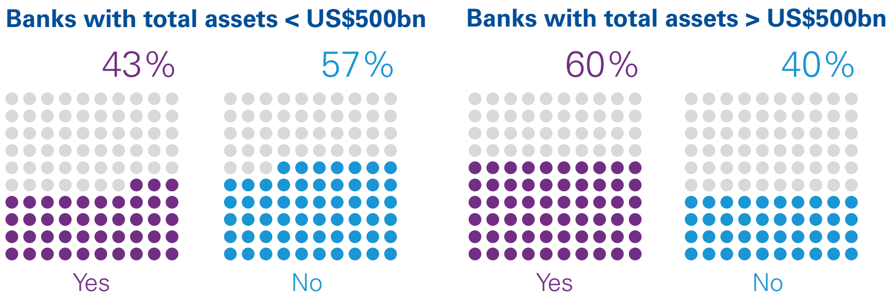
Another feature of today's rapidly developing technology landscape is the ability to automate processes through techniques such as robotic process automation (RPA). Clearly, in an area with high amounts of process embedded such as MRM, there is strong scope for automation to introduce efficiencies.

However, our research finds that many banks have not yet begun this process. Only half of banks are currently investing in the automation of parts of MRM — although this rises to 60 percent of larger banks.

The most commonly targeted area for automation is workflow management, followed by using automation to improve reporting and aspects of validation. Some banks are also using it to enhance their documentation processes.

Is your bank investing in automated solutions or new technologies to improve model risk management?

Total responses



Source: Model Risk Management Survey, KPMG International, 2019

KPMG view

Automation holds strong possibilities for MRM, improving the efficiency of frameworks and reducing the demand on MRM teams. With most banks believing that regulators are neutral or receptive to automation in this sphere, we can expect to see its penetration rise. New model validation reporting requirements in Europe could also stimulate further investment as banks look to use technology to ease the burden.

Some may be surprised that the percentage of banks investing in automation is not higher already — but automation tends to come towards the end of projects to optimize frameworks once they have been established. Nevertheless, if banks are intending to introduce more automation, the earlier they start planning it the better. Otherwise there is the risk of undoing work already done or running out of budget. Factoring automation in early will increase the efficiency and cost effectiveness of the project.

Conclusion

Our research shows that as MRM becomes an increasingly important area to regulators, many banks are stepping up their focus and professionalizing their approach to it.

But MRM is difficult — many of the banks surveyed say it is labor intensive and time consuming with a lack of skilled internal resources. MRM is also entering new territories through the use of AI and ML, introducing new challenges that must be confronted as an industry.

In KPMG's view, here are the five clear priorities that emerge from our survey.

- **Senior Board engagement** needs to increase given the strategic significance of MRM.
- **More regulatory clarity** is needed around certain key areas such as risk appetite and capital allocation.
- **Banks not supervised by the Federal Reserve** tend to be much further behind and will need to catch up quickly as other regulators increase their scrutiny.
- **AI and ML** should be included in model risk frameworks considering the specific risks arising from these technologies — more specific guidance is needed.
- **Automation in MRM** is currently underutilized — there is scope for banks to do more here to optimize the efficiency of their frameworks.

Digitalization and new technologies such as AI and ML are changing the face of banking. New digitally-enabled fintech entrants are putting increasing pressure on traditional banks. The result of these factors is that ever more complex models will be created to manage businesses and gain competitive advantage — bringing new risks. To control these risks, and the costs associated, more sophisticated model risk management will be key.

The scene is set for the continuing rise of the importance of MRM. It is very likely to become a key determinant in the future operational success of banks.

For more information visit home.kpmg/mrm

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