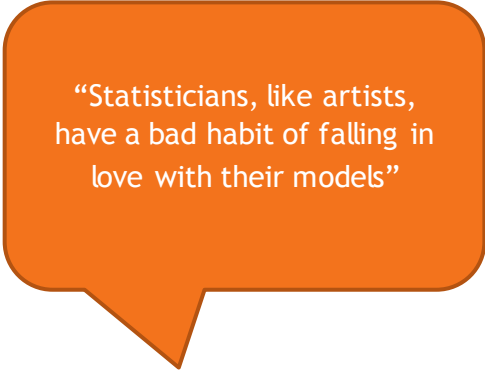




# Observations on Model Risk

How financial institutions deal with the risk their models create

An orange speech bubble with a white border and a tail pointing downwards and to the left. Inside the bubble, the text reads: "Statisticians, like artists, have a bad habit of falling in love with their models".

“Statisticians, like artists,  
have a bad habit of falling in  
love with their models”

George Box, Statistician

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## 1. EXECUTIVE SUMMARY

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Five years ago the US Office of the Comptroller of the Currency (OCC) published its SR 11-7 Guidance on Model Risk Management (MRM), a cornerstone of regulation which established a new standard for MRM.

This report assesses the progress that financial institutions have made since then in creating a more rigorous governance regime and consolidated management function for MRM. It identifies trends and provides insight from practitioners and experts.

The research was carried out by risk management consultancy Fintegral on behalf of the International Association of Credit Portfolio Managers (IACPM).

### KEY FINDINGS



Practice of MRM shaped by regulatory framework



Emergence of global standard of governance



CCAR banks more confident in practice of MRM



US regulators more prescriptive than European



Concerns about lack of resources



No standard practice for aggregating model risk

MRM is of great interest to the financial markets community.

SR11-7 has emerged as a global standard of MRM governance, but there are important differences between US and European banks. This is a function of regulatory development, in that Europe has been slower to embrace SR11-7.

The way in which MRM is conducted at IACPM member organisations varies significantly. It is influenced by the size, type and geographical location of the financial institution.

Effective set-ups for managing model risk include a centralised MRM function of which model validation is a constituent. The driver for this centralised MRM is the requirement for enterprise-wide visibility of model risk.

There are strong arguments for aggregating risk across models and this is an area where there is scope for gains from a quantitative angle. Model risk should be viewed throughout the model life cycle. A complete and structured inventory of models and their main assumptions is required. This is a difficult task, which is why we observe the frequent use of score card models that allow a mix of quantitative and qualitative measures.

Significantly more headcount is allocated to model development than to the review functions. The number of model validations has risen, as has demand for model validators.

Resources are a challenge. Big regulatory exercises like the Comprehensive Capital Analysis and Review (CCAR) by the US Federal Reserve have persuaded some banks to allocate more to MRM. This will increase.

## 2. INTRODUCTION

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### 2.1 WHAT IS A MODEL?

Models underpin the modern financial system.

In its landmark Guidance on MRM (SR 11-7) in 2011 the US Office of the Comptroller of the Currency (OCC) provided a defining standard in model governance. The document describes a model as

**“a quantitative method, system or approach that applies statistical, economic, financial or mathematical theories, techniques and assumptions to process input data into quantitative estimates.”<sup>1</sup>**

In terms of their application, models are

**“used for analysing business strategies, informing business decisions, identifying and measuring risks, valuing exposures, instruments or positions, conducting stress testing, assessing adequacy of capital, managing client assets, measuring compliance within internal limits, maintaining the formal control apparatus of the bank, or meeting financial or regulatory reporting requirements and issuing public disclosures.”<sup>2</sup>**

However there is still inconsistency among financial institutions in the definitions they employ. As regulators have become more prescriptive so banks have extended the range of methods that they now classify as models. That in turn has greatly expanded the MRM function.

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<sup>1</sup> SR 11-7 Guidance on MRM, April 4 2011, Board of Governors of the Federal Reserve System.

<sup>2</sup> Ibid.

## 2.2 WHAT IS MODEL RISK?

Given the ubiquity of models within the financial system, it is important to accurately assess the risk that models themselves create. SR 11-7 describes model risk as

“the potential for adverse consequences from decisions based on incorrect or misused model outputs and reports. The risk is created by a model being unfit for its intended purpose, or incorrectly employed. The risk increases as the model becomes more complex, the inputs and assumptions more uncertain, the use of the model more extensive, and its potential impact greater.”<sup>3</sup>

“Model risk occurs primarily for two reasons: (1) a model may have fundamental errors and produce inaccurate outputs when viewed against its design objective and intended business uses; (2) a model may be used incorrectly or inappropriately or there may be a misunderstanding about its limitations and assumptions.”<sup>4</sup>

The European Banking Authority addresses model risk in its Guidelines on Common Procedures and Methodologies for the Supervisory Review and Evaluation Process (SREP). Model risk is not considered a standalone risk type, but is included in the operational risk category. It is the

“risk of losses relating to the development, implementation or improper use of any (...) models by the institution for decision-making (e.g. product pricing, evaluation of financial instruments, monitoring of risk limits, etc.).”<sup>5</sup>

MRM cannot eliminate all risk but its purpose is to introduce a systematic approach to measure and mitigate it.

Effective model risk frameworks include:

- A complete and structured inventory of models and their main assumptions
- A view of model risk throughout the model life cycle
- All four lines of defence<sup>6</sup>
- A centralised MRM function with model validation as a part thereof

In recent years practice at banks has reflected this, with increasing numbers creating a consolidated model risk management function.

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<sup>3</sup> SR 11-7 Guidance on MRM, April 4 2011, Board of Governors of the Federal Reserve System.

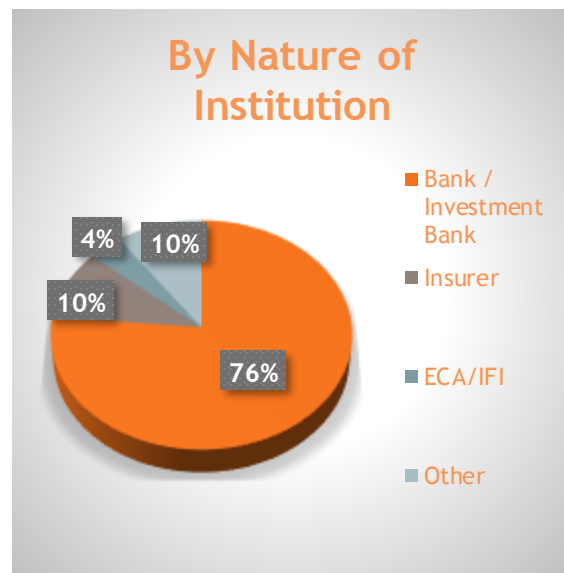
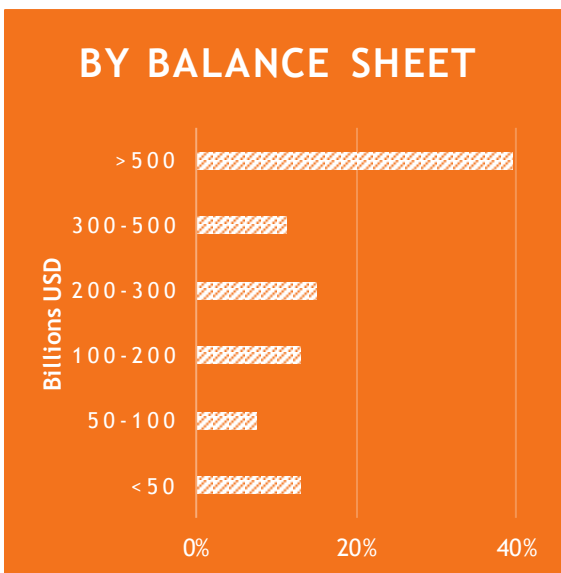
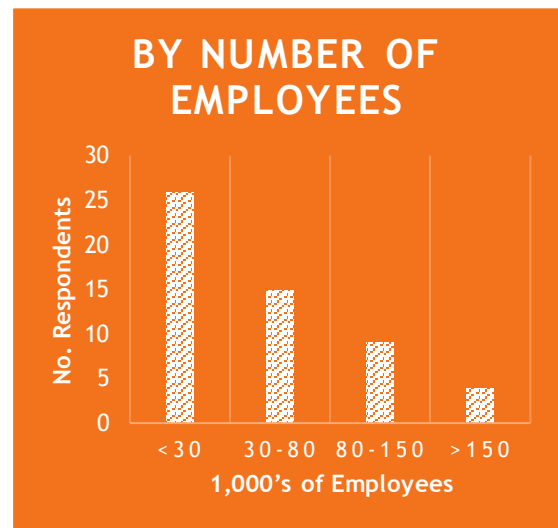
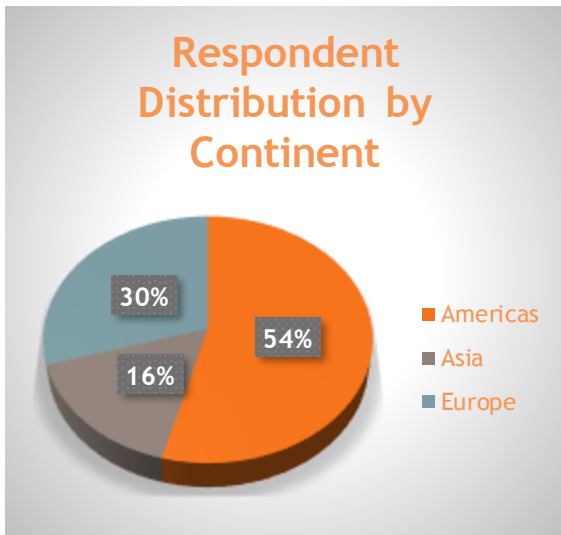
<sup>4</sup> Ibid.

<sup>5</sup> Guidelines on Common Procedures and Methodologies for the Supervisory Review and Evaluation Process (SREP), December 19 2014, European Banking Authority

<sup>6</sup> To the traditional three-lines-of-defence model (business units, risk management, internal audit) is added a fourth: external audit/regulators.

### 3. SURVEY DEMOGRAPHICS

This survey was conducted by Fintegral on behalf of the IACPM during March and April 2016. The respondents were representatives of 54 financial institutions across a broad spectrum of size, region and speciality - including Tier 1 global banks, the financial services unit of a corporate and a number of supnationals (for example International Financial Institutions (IFIs) or Export Credit Agencies (ECAs)).





The level of engagement with the survey was impressive. Model risk is considered an important topic worthy of deliberation, creative thinking and an increasingly systematic approach. However, some banks feel they need to bring their practices up to date, and in certain quarters there are concerns that they lack the resources to do so effectively.

The survey contained 67 questions split into 3 categories:

1. Scope, Process and Methods
2. Governance and Reporting
3. Regulatory

We expected to see distinctions between institutions principally along the lines of size, regulator, geography and specialism. Hence our peer comparison analyses defined the following groups:

Global Systemically Important Banks (G-SIB) vs non G-SIB	<i>Used as a proxy for size. G-SIB institutions are generally larger (17 G-SIB's).</i>
CCAR vs non CCAR	<i>Regulatory pressure is considered to be highest in the US (23 CCAR banks).</i>
Geographic location	<i>Americas, Europe and Asia.</i>
Type of financial institution	<i>Bank, insurance, supranational, corporate.</i>

After the responses were analysed, follow-up interviews were conducted with a number of participants to gain further insight into how they apply MRM in the context of their organisation, regulation and quantitative methodology.

## 4. SCOPE OF MRM

There are marked variations in how individuals and organisations define both models and model risk.

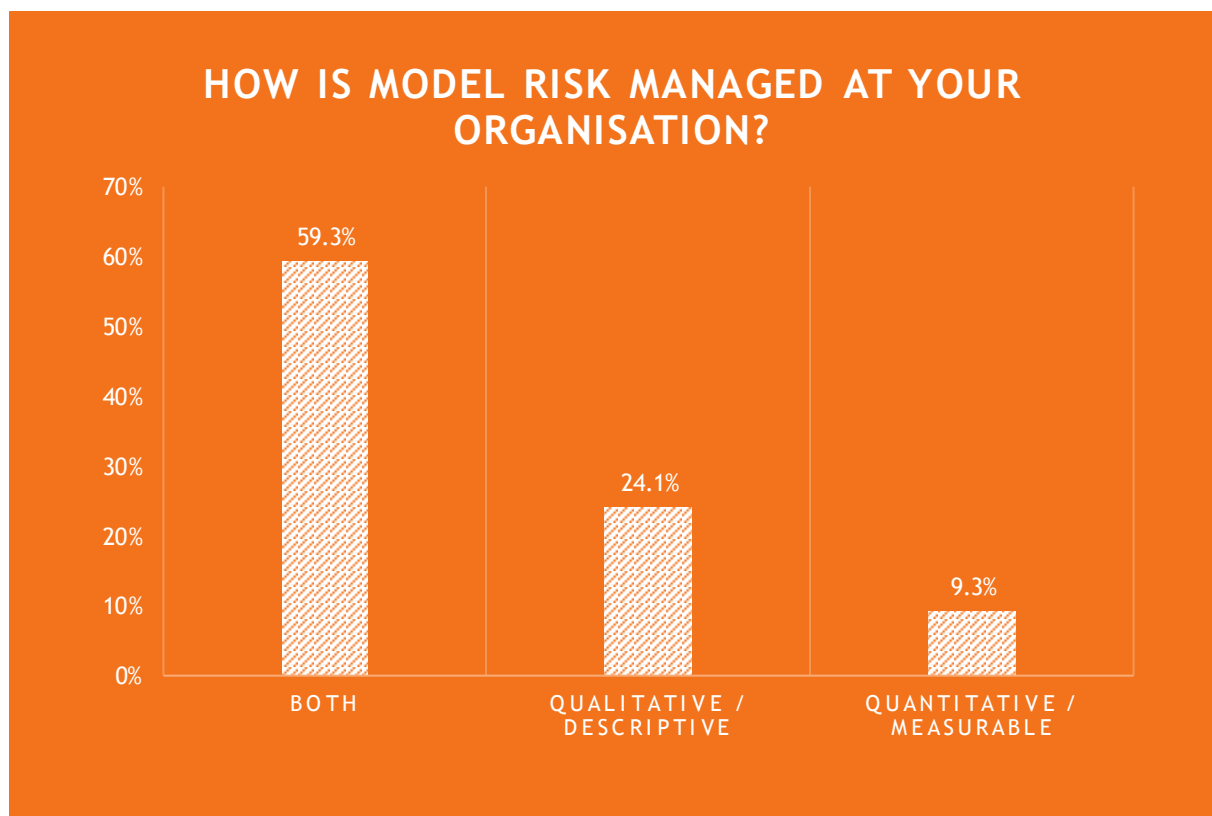
Asked which types of models fell within the scope of MRM, survey participants provided a broad spectrum of answers. They ranged from the obvious, such as pricing models, to less obvious such as fraud, marketing or HR processes.

Credit models dominate the picture, followed by market risk models and operational risk models. Other model types cited were:

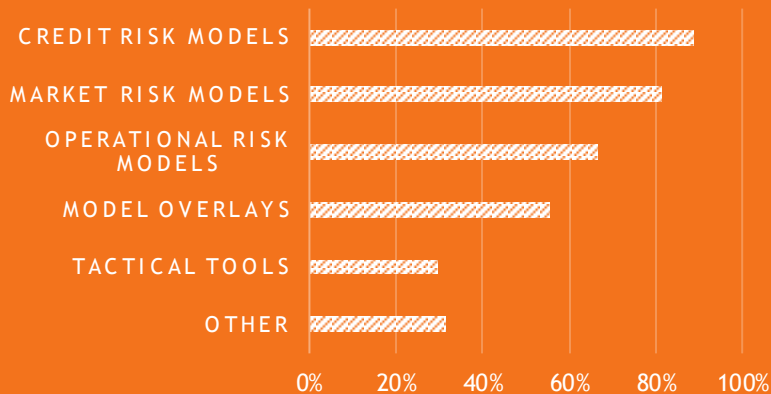
- marketing and product management
- balance sheet
- business planning/financial
- investment management
- fraud

This reflects both the breadth of MRM as a topic and the diversity of opinion about its definition.

While models themselves are quantitative, the assessment of model risk itself is a qualitative discipline too. In fact, of the institutions surveyed a larger number described their MRM as solely qualitative than those that described it as solely quantitative. A quantitative approach works for statistical aspects, but encounters difficulties with, for example, errors of interpretation which are much harder to quantify.



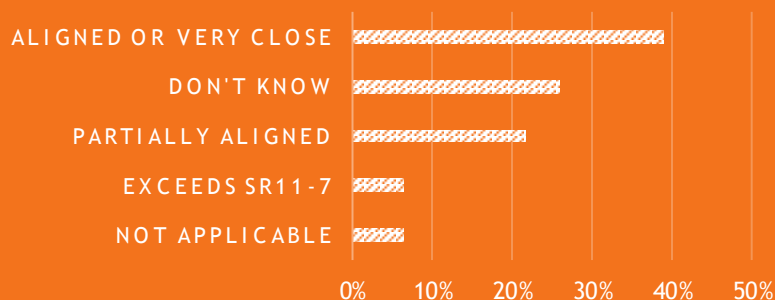
## WHAT DOES MRM REVIEW?



Discussions with survey participants suggested that the definition of a model was highly correlated with its function within the organisation. Those involved in model validation are more likely to apply a broader definition than, for example, those involved in business decisions. Model validation teams need to ensure that regulatory requirements are met and tend to err on the side of caution by validating more, rather than fewer, models.

40% of our participants state that their model definition is very close to the SR11-7 definition. 6% say that their criteria exceed that definition.

## MRM POLICY RELATIVE TO SR11-7



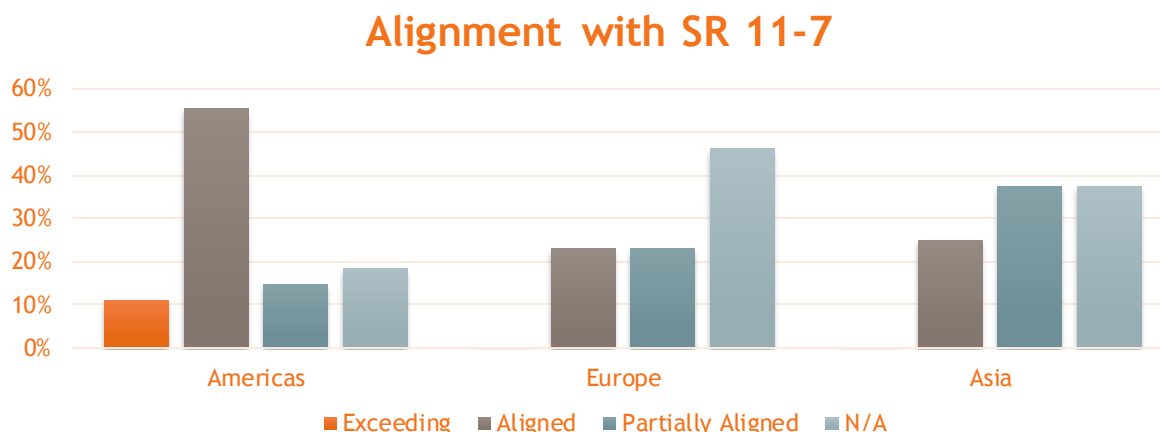
## “OTHER” INCLUDES:

- Marketing models
- Pricing and balance sheet management amongst others
- Residual Value Models
- Counterparty Credit Risk models
- Valuation models
- Marketing and product management
- Financial Models
- PPNRs models (Pre Provisions Net Revenues forecasting)
- Asset Management and Pricing Warehouse models
- Treasury valuation models and Treasury economic capital model
- Fraud models
- Stress testing models

*“our internal policy is above and beyond SR 11-7”*

*“goes beyond it in terms of integrating model risk into the broad organisation”*

There is also a clear geographical breakdown, with a much higher proportion of US firms reporting high levels of alignment to SR 11-7:



This is not surprising given SR 11-7's geographical origins. Follow-up discussions with practitioners and regulators inside the EU confirm that similar standards are emerging in Europe.

## 5. ORGANISATIONAL SET-UP

There is a definitional distinction between MRM and model validation. Model validation deals with the actual build of a model and its parameterisation. MRM is a broader task that covers not just the quantitative aspects of a model but also the processes and governance around use of the model. At many firms it also deals with the data quality and accuracy processed by their models.

In practice, however, the separation between model risk management and validation is indistinct. In many institutions the two are closely related (56%) and often one function is contained within the other (43%). A clear separation exists at some firms although this is rarer (26%).

An overwhelming majority (80%) of respondents states that model risk is reported up to board level. Only 55% report it at business unit head level and 15% below that level. It features little in day-to-day business management.

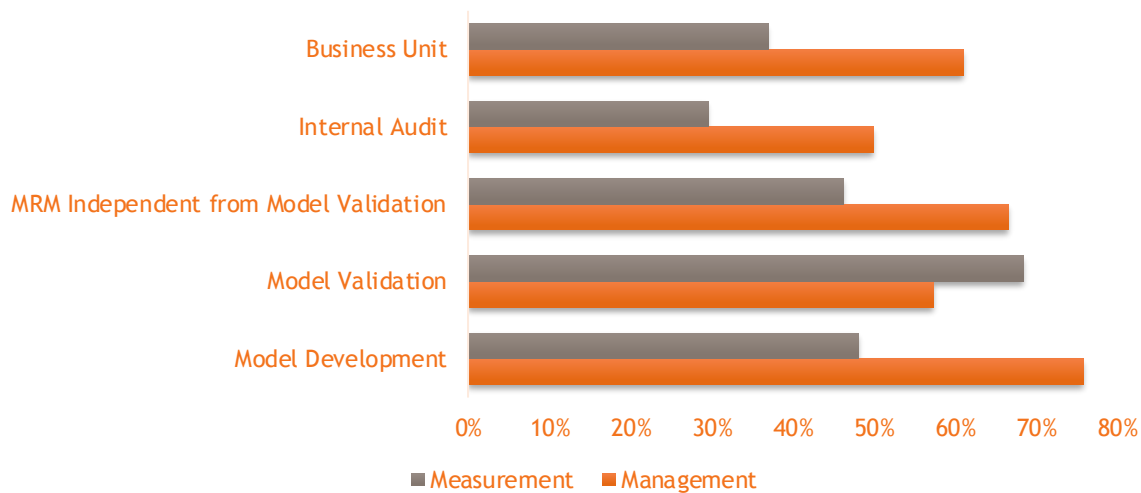
The strategic role of model risk is underlined by reporting frequency. In the main (two thirds of respondents) it is quarterly. There are organisations who report it more frequently, but this is less common. The low reporting frequency conforms to the perception of MRM as a strategic rather than everyday management activity.

For firms where MRM and model validation is not divided between separate teams, we would historically expect responsibility for validation to rest within the larger MRM function. This is the case for a majority of firms that combine both activities in one reporting line. There is a smaller number (10%) where this is reversed. This runs counter to the notion of model risk as a task broader than model validation.

One respondent suggested that MRM was performed by different areas within the organisation, but not as a dedicated function. Others described MRM as being governed by an enterprise-wide policy or framework - an effective approach.

Where we do find a difference between model validation and MRM is in the actual management of model risk as opposed to measurement. Just under 60% of respondents see management as part of the model validation function. The *management* responsibility is more commonly attributed to the model development team (78%), an independent MRM team (69%) or the business unit (63%). The *measurement* of model risk is very clearly seen as a model validation responsibility: 70% share that view, rather than 50% who see measurement as the responsibility of an independent MRM function. Our interpretation is that there is some confusion about this matter as a result of how MRM has developed. Individual banks have traditionally devised their own ways of defining MRM tasks and their allocation; SR11-7 is introducing a clarity and standard into the governance structure.

### Mapping Function to Role



*“currently in the process of developing Model Validation and MRM functions”*

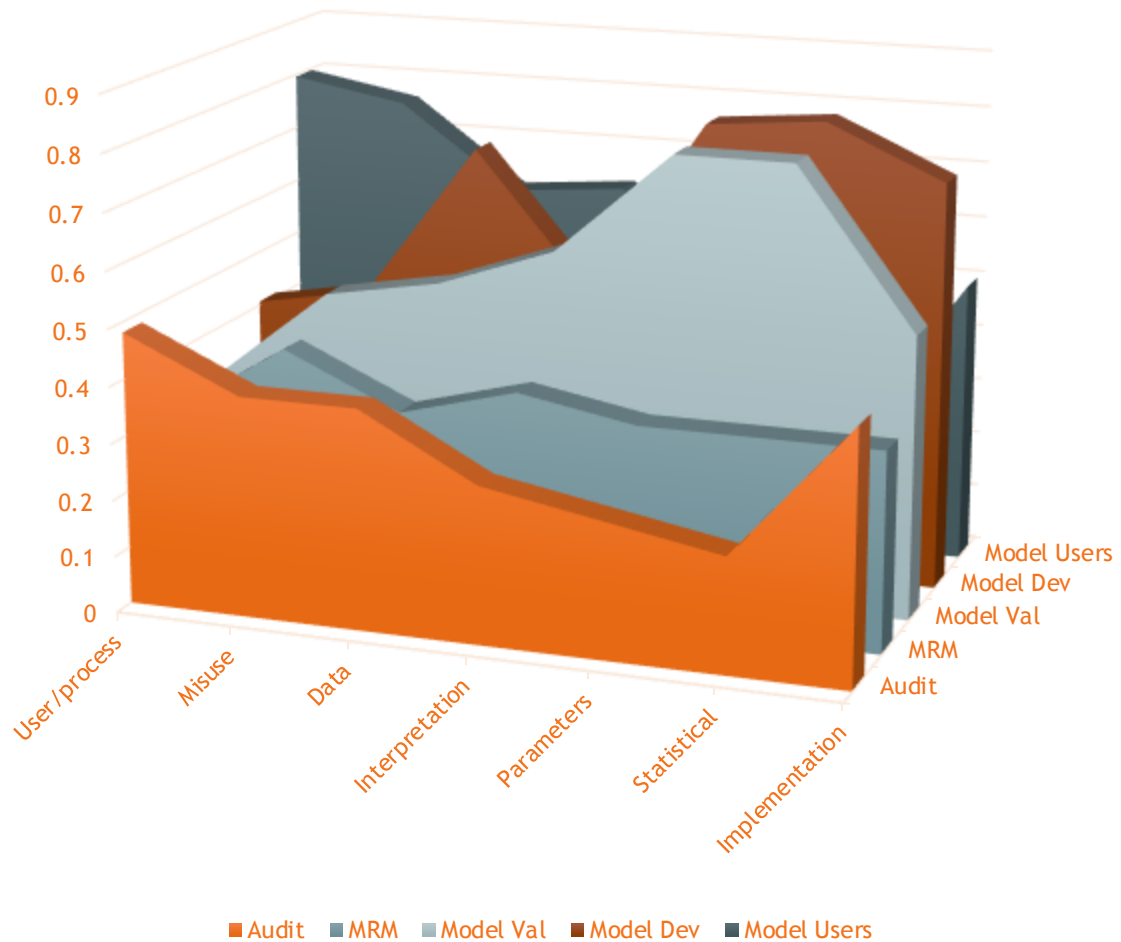
*“there are no independent MRM measurements”*

*“the model validation is outsourced”*

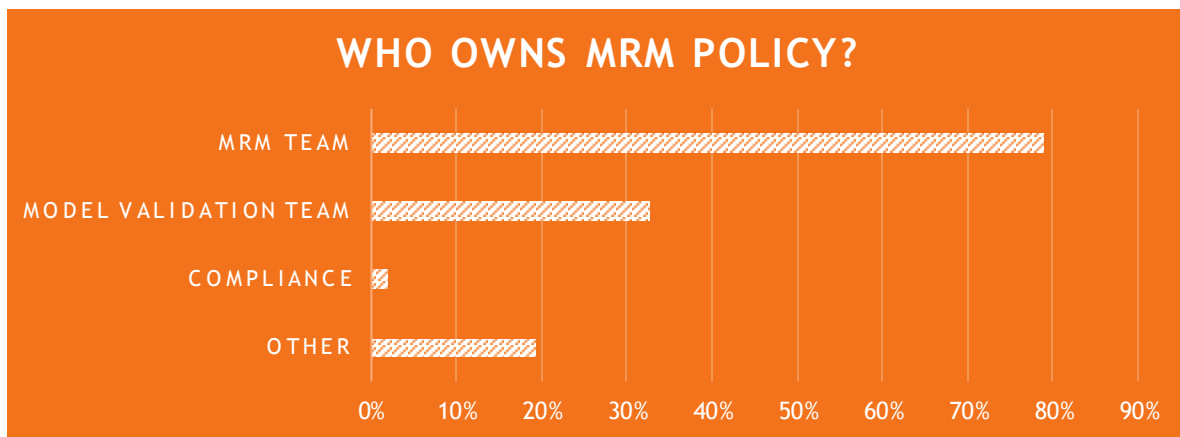
This raises the question of what MRM as an activity actually is. A classic risk management function often does not actively manage the risk. Market risk for example is managed by the business unit of a bank but controlled by the market risk management department.

We observe a similar phenomenon with MRM. When asked which roles (model development, MRM, model validation, audit or model users) manage the various types of model risk, most respondents identified the model development function (risk types - data, parameters, statistical and implementation) or the model users (majority on risk types user/process, misuse and interpretation). This is shown in the following graph, where the percentage for a given role indicates the share of participants that view the management responsibility for a given model risk type as resting with that role (e.g. 80% of the participants see Model Users as responsible for the management of user or process error risk). The graph shows that model validation assumes a management responsibility similar to the model development function.

## Management Responsibility by Model Risk Type



We conclude that there is an overlap between validation and management (or governance) functions created by the evolution of differing practices prior to SR 11-7. We witness the emergence of an industry standard which places MRM at the apex of various model risk tasks, such as model validation.



A similar picture emerges when it comes to ownership of the model inventory. Two-thirds consider it within the MRM function, of which half assert joint ownership with the validation function. There is even a minority of cases (10%) where the business unit owns the inventory.

In general banks see MRM as a holistic practice best served by a distributed approach. An overarching model risk or model governance function may well track models throughout their lifecycle. But as the models pass through that lifecycle, a number of different teams are involved in the process, with precise responsibilities allocated differently from bank to bank. Model developers, for example, are more likely to be involved in estimating uncertainty and benchmarking against alternative models, while independent validators check assumptions and implementation. Model risk management is considered too complex an activity to be allocated to a single function.

## 6. RELATIVE SIGNIFICANCE OF MODEL RISKS

Model risk has become a board level issue. But while the board is by far the most frequently mentioned destination for reports on model risk, governance is not solely an internal process. It increasingly attracts regulatory attention: 56% of respondents say that they regularly report model risk findings to their regulator. This is not the only external party to whom it is reported. A small percentage (7%) even report it to their shareholders.

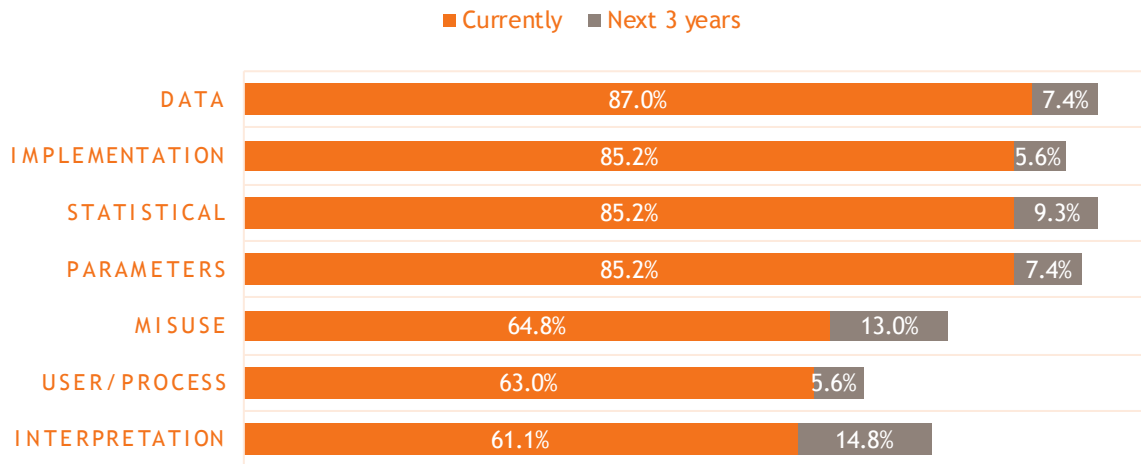
The most commonly analysed risk types are

- **Data:** incomplete, corrupt or missing data
- **Implementation:** errors introduced by incomplete or wrong implementation
- **Statistical:** uncertainties within the methodology employed (e.g. convergence of Monte Carlo simulation or standard error of a regression)
- **Parameters:** limitations or uncertainties introduced by wrong or incomplete model assumptions

Almost 90% of respondents say they examine these risk types. This reflects our view of good practice in this area. An effective in-house classification scheme would capture those elements by splitting model risk between procedural, statistical and assumption-based errors and uncertainty.

Two other important risk types were mentioned: incorrect interpretation of the results, or model misuse (with a focus on how models are protected against deliberate manipulation). These currently attract the attention of more than 60% of respondents. They are also the areas upon which organisations feel they need to focus more.

## TYPES OF MODEL RISK ANALYSED



A majority of banks currently cover most of the proposed risk types. One apparent exception is that only a third of non-CCAR banks cover the risk of incorrectly interpreting the actual model output. Another third plans to do so within the next three years.

Survey participants were asked to assign scores to these risk types (from Low = 1 to Very High = 4) in terms of their relevance to the categories of:

- P&L
- Regulatory Capital
- Economic Capital
- Reputation
- General Attention

### Relevance Scores of Risk Types

	General Attention	Profit & Loss	Regulatory Capital	Economic Capital	Reputation
Data	2.7	3.0	3.0	2.5	2.3
Implementation	2.8	2.9	3.0	2.4	2.4
Statistical	2.4	2.7	2.8	2.3	2.1
Parameters	2.6	2.7	2.9	2.4	2.2
Misuse	2.7	2.8	2.8	2.3	2.5
User/process	2.3	2.6	2.7	2.1	2.2
Interpretation	2.4	2.6	2.6	2.2	2.3

The highest scores were for P&L and regulatory capital. Reputational issues were considered less relevant.

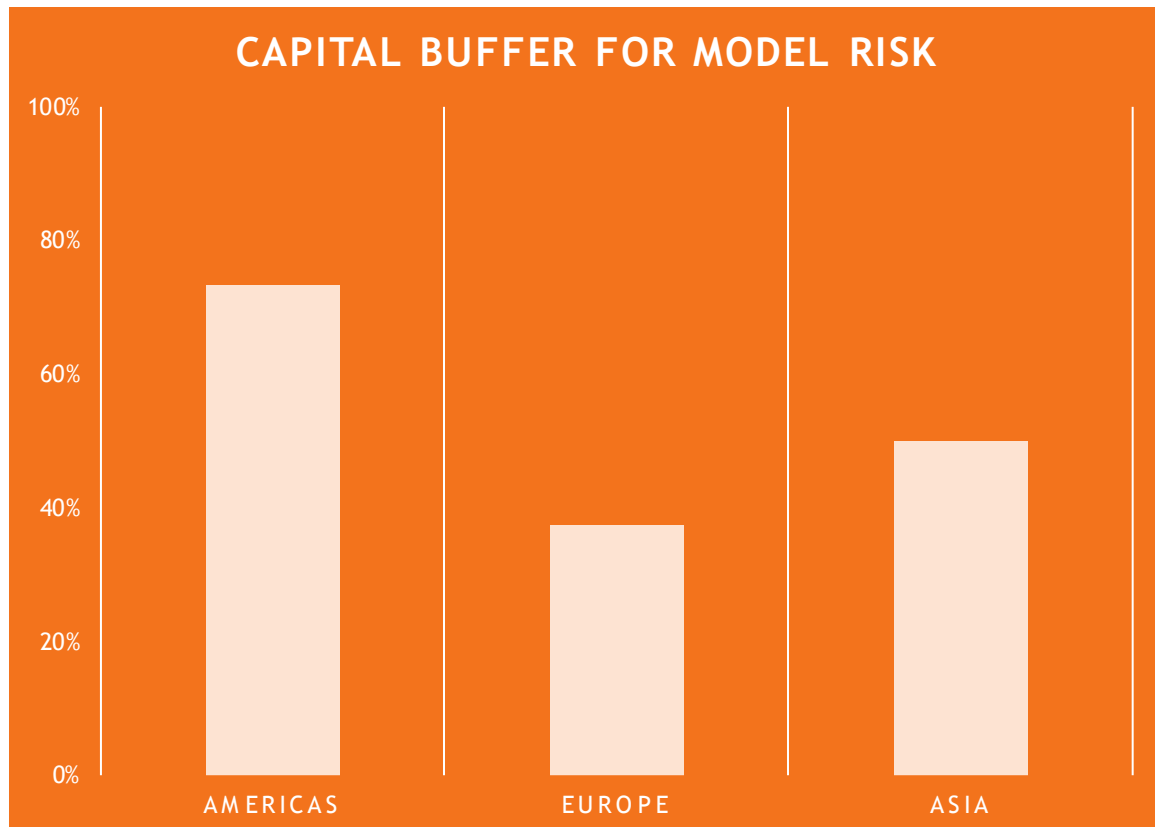
Economic capital does not score highly either. This could be the result of a slight bias introduced by the fact that most survey participants focus on credit risk and in particular credit portfolio models. Under Pillar 1 of the Basel accord internal models are not commonly used and therefore regulatory capital is not aligned with economic capital.



The risk types that resonate most with practitioners are those most frequently assessed: data and implementation errors.

Large banks, especially those regulated by CCAR, assign greater importance to all categories. On average, they classify risk one notch higher than others, and this strongly suggests a correlation with regulation. European banks see risk as less relevant to the areas of P&L, regulatory capital, economic capital and reputation.

The vast majority of American banks surveyed said that they also include a capital buffer, as opposed to only a half of the institutions outside America.

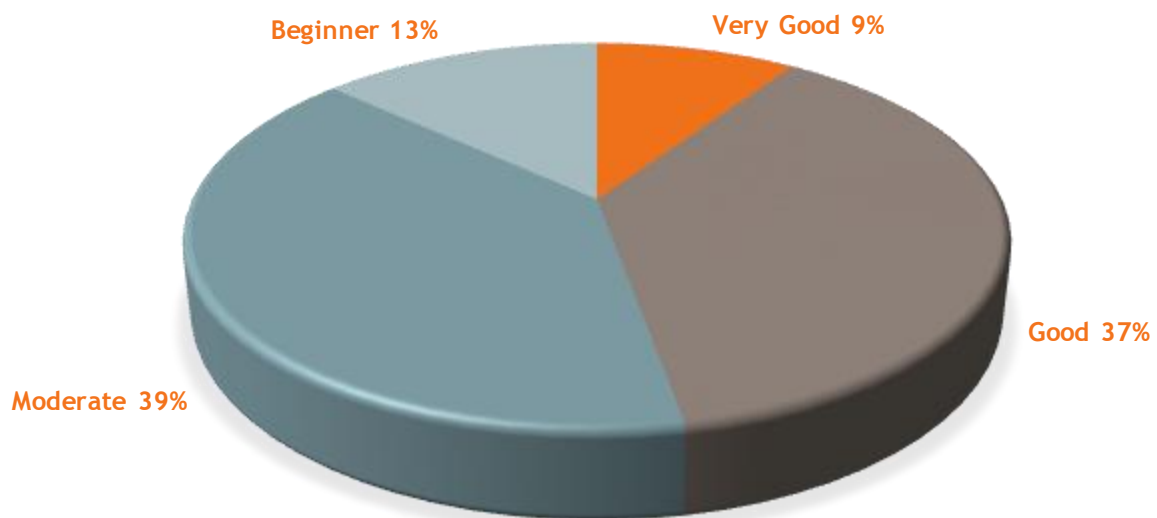


However, when questioned more closely, a loose definition of “buffer” emerges. Respondents refer not to an explicit buffer for model risk, but rather the application of conservatism to the capital calculation. In other words, model risk is “factored in” to buffer calculations. This reflects the absence of specific requirements by regulators for model risk. Nevertheless the majority of banks disclose their efforts to manage and mitigate model risk to their regulator (see section 11).

## 7. RISK, SIZE AND THE REGULATOR

Most of the financial institutions in this study consider their understanding of model risk to be either good or moderate.

### HOW DO YOU JUDGE YOUR ORGANISATION'S UNDERSTANDING OF MODEL RISK?



*“very good but limited by the availability of data”*

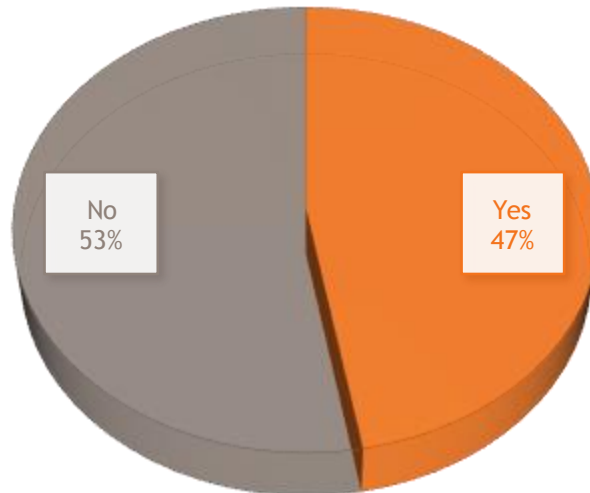
*“a maturing program with high visibility among senior leadership”*

*“the frontline is still maturing in areas like data treatment, documentation and errors threshold”*

*“there is not a quantitative assessment of model risk at present. This is currently under review”*

A small majority of participants (53%) feel that they are inadequately resourced to deal with model risk:

### RESOURCES ADEQUATE TO DEAL WITH MODEL RISK?



*“We are light in resources”*

*“need to build out capability and infrastructure in MRM and model validation”*

*“need additional internal validation staff”*

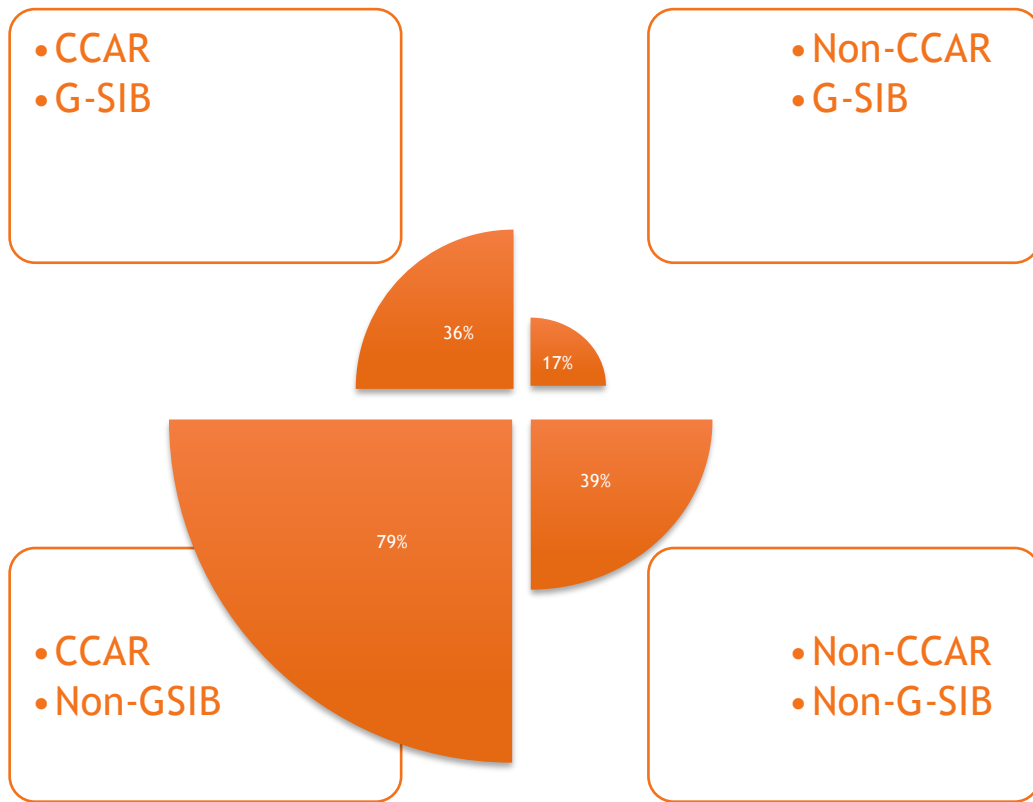
*“staffing is inadequate. Expertise is not quite there yet”*

However, US and/or CCAR banks consider themselves more effective in this field than other institutions. This is reflected in the fact that nearly two thirds of CCAR banks consider themselves to have appropriate resources to deal with model risk. Only a third of non-CCAR institution make such an assertion.

Given the large number of G-SIB’s who fall within CCAR, one might therefore expect G-SIB’s to have more confidence than smaller banks in the level of resources that they devote to MRM. However, this is not the case: a clear majority of G-SIB’s consider their resources for MRM inadequate.

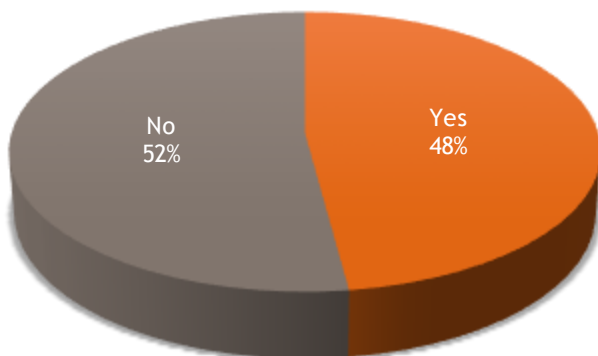
Further investigation reveals that many banks in fact consider SR 11-7 as setting a *global* benchmark for MRM. European banks with relevant operations in the US are reforming their MRM practices internationally and enterprise-wide, as a consolidated function. That in turn has increased demand for resources. The number of model validations has risen dramatically within larger banks, more extensive documentation is required and the search for relevantly experienced personnel has intensified.

Percentage of institutions stating they have adequate resources for model risk - by size and regulatory environment



Despite this apparent strain on resources, half of our research participants said that they had not suffered the consequences of any unidentified model risk, by which we mean risk not captured by a firm’s MRM procedures. This result is surprising: it is near impossible to ensure complete identification.

Have you suffered the consequences of unidentified model risk?



*“not that I know of, however this is very hard to assess, especially for risk models”*

*“financial loss due to model error”*

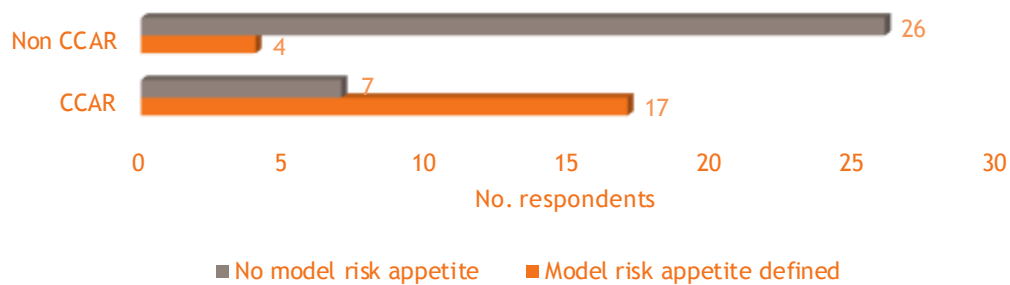
*“model breakdown or misuse, but caught by detective controls”*

*“asset management arm had several lawsuits in the past that were settled”*

## 8. RISK APPETITE AND AGGREGATION

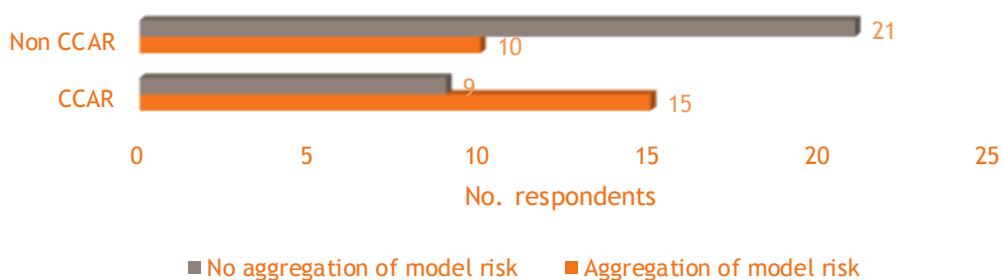
Attitudes towards appetite for model risk vary widely. Again, the role of the regulator is evident: over 70% of CCAR banks define a risk appetite level, while only 13% of non-CCAR institutions do so. Most banks use a pragmatic approach based on scorecards to measure model risk. Most G-SIB's use a combination of benchmarking, back testing and sensitivity analyses, while smaller banks rely only on one or two of these measures.

### Definition of Model Risk Appetite



For a model risk appetite to be useful it must be compared against some aggregated measure of model risk. This is a challenging process because of the interconnected nature of models, and because the underlying metrics upon which uncertainty is measured will vary according to model type. It is difficult, for example, to aggregate the model risk associated with regulatory capital with that which arises from pricing models. Rigorous approaches to aggregation might include pass-through sensitivity calculations - where a range of inputs are fed into a model to observe the impact on outputs - or an error propagation approach based on partial derivatives. Most banks in the survey said that they performed some type of risk aggregation. On closer questioning however, it appears that where institutions perform this more quantitative form of aggregation at all, it is usually confined to certain risk types or reporting metrics. A bank might, for example, aggregate the pricing uncertainty in their trading book on a standalone basis. Higher level aggregation, where it exists, is more likely to take the form of a scorecard or RAG (Red Amber Green) analysis, tracking the number of high risk models in different areas of the bank.

### Aggregation of Model Risk



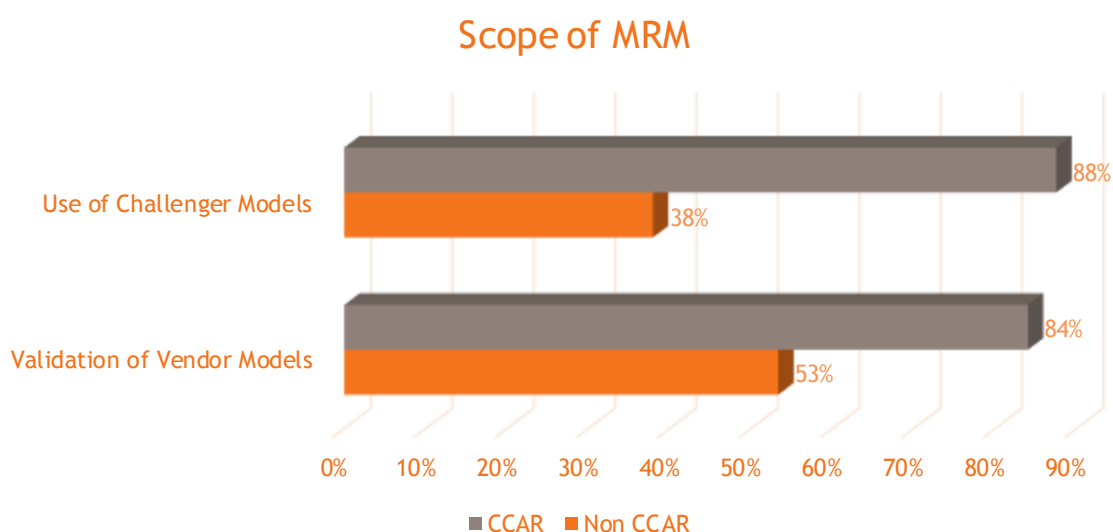
The use of aggregation techniques is sometimes an indicator of sophistication in the context of model risk. However, we discover that where aggregation is performed, it rarely is assigned a dollar value and is often not performed across all model risk types. The same is true for risk appetite: while it may be defined by metrics such as the number of high risk models or model rejections, more often it is expressed qualitatively.

Aggregation is a more appropriate approach for quantitative elements than for qualitative. Indeed, some practitioners question the value of aggregating model risk, arguing that the techniques may themselves create risk.

## 9. CCAR IMPACT ON SCOPE AND DOCUMENTATION

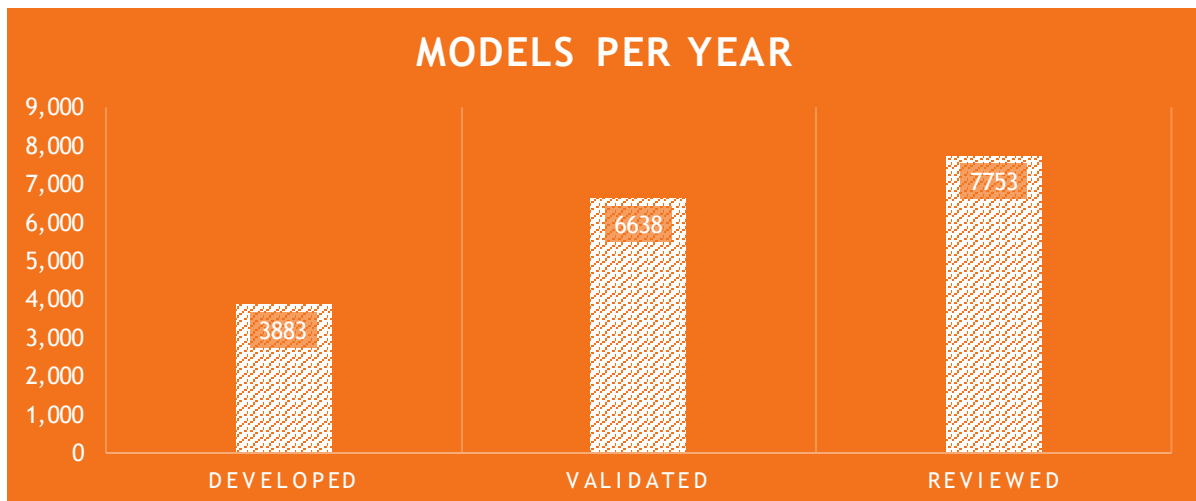
CCAR is a significant factor in the scope of model risk analysed and the tools used. While most CCAR banks use challenger models to ensure they use the most appropriate model for a given task, this is only the case for 40% of non-CCAR banks. Almost all CCAR banks produce risk reports for vendor models, while only half of non-CCAR banks analyses vendor models in-depth. This finding may be skewed by non-CCAR banks having less vendor models in place.

The ratio of the length of validation documents to the length of model documentation varies significantly in the evaluated sample, but is clearly lower for CCAR banks. Our experience in this field suggests that this is because CCAR banks produce more extensive model documentation and not that their validation documents are shorter in absolute terms.



## 10. RESOURCE ALLOCATION

To gauge the workload of a typical model risk or validation function we examined the number of models reviewed or developed per head count per annum. This assessment was provided for the MRM, model validation and model development functions. There is no significant difference between the output of the MRM and the model validation activities. The median is 10 models reviewed per person per year. However the maxima are quite different. Model validators reach 48 models, while model risk managers manage 83. This again confirms that MRM is an activity of broader spectrum than model validation. MRM encompasses more models and a wider range of model types, but in less detail. In contrast, model developers produce a median of 2 models per person per annum. In model development work there is often more than one person working on any new model. The maximum here is 8 models. This also means that staffing levels in model development outnumber validators and model risk managers. On average the ratio of model developer to the sum of model validator and model risk managers is 3.4:1. The maximum for one organisation is 10:1.



39% of respondents indicate that they currently outsource simple model validation exercises and another 13% plan to do so within the next two years. 13% of firms outsource more than 50% of their validation of the simpler models. There is a trend to employ external service providers for model validation and the review of simpler and more commoditised model types. This outsourcing has accelerated with the arrival of new entrants into the banking industry. Where they have a leaner organisational structure, they are predisposed to outsource risk management.

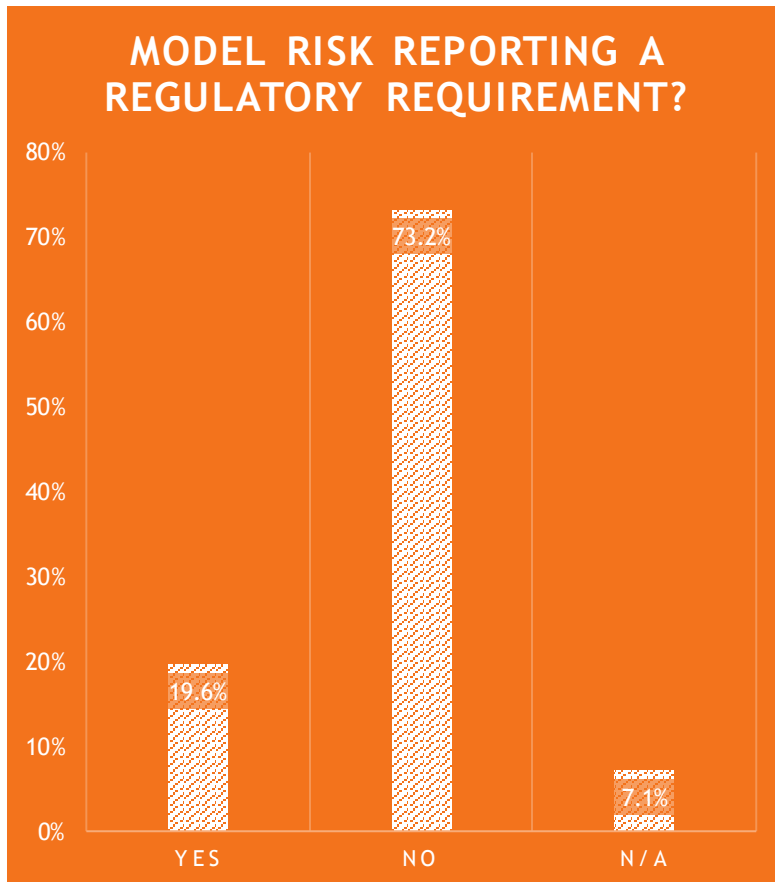
## 11. REGULATORY FRAMEWORK

Model risk is a regulatory issue. This is particularly true of the US.

Around 40% of respondents state that they report model risk to the regulator, but 79% say that the regulators do not prescribe such reporting. 59% include a buffer for model risk in their capital (regulatory or economic) calculations despite there being no requirement.

A number of banks say that they only perform MRM to satisfy their regulator.

### BIGGEST REGULATORY CHALLENGES IN NEXT THREE YEARS



- “keep pace with regulatory capital changes”
- “evidencing control over the data management processes”
- “ability to concentrate on material issues”
- “Basel 4 floors (and flaws!), CCAR/DAST, SR11-7, IFRS9”
- “aggregate model risk”
- “implement regulation which can be inconsistent”

Respondents expect to face more scrutiny from regulators in the field of model risk. They are particularly concerned about the cost and resource implications, and whether the task of implementing models into systems can keep up with the speed of regulatory change.



Understanding of regulatory requirements is in general well developed. A large proportion of respondents (76%) already perform a gap analysis between regulatory requirements and their current practice for model risk. 80% of firms are confident they have a good understanding of the relevant regulatory requirements, although 11 participants say they do not.

Comments from European financial institutions suggest there is less clarity there than in the US. Our research indicates that European regulators are more interested in clarifying the technical aspects of model risk, while the Fed places a greater emphasis on governance. Practitioners frequently describe the European approach as principles-based, and the American as prescriptive. This is reflected in the CCAR requirements, which contain more detailed instructions than comparable ECB texts.

## EUROPEAN BANKS' UNDERSTANDING OF REGULATORY REQUIREMENTS

“the US (regulator) is more prescriptive than Europe; that means it’s easier to display compliance”

“we consider ourselves as good but not sure regulatory requirements are well enough prescribed to say we understand”

“EU requirements remain unclear”

“current lack of definition in regulation”

“there is no mandatory requirement for now”

“we feel we understand the requirements broadly, however this is a new area with much still to be developed on the specifics”

“the Fed is more helpful in providing feedback; here (in Europe), the only way of assessing if the regulator is happy is when they stop asking questions”

“outside the US there is less recognition of model risk as a standalone risk type, but that gap is slowly closing”

## 12. CASE STUDY: A SOUND EXAMPLE OF MRM

Here we provide an example from this study of an effective though imperfect MRM function. This institution states that it has not suffered the consequences of unidentified model risk and is confident about its understanding of regulatory requirements.



### Institution

- This is an international tier 1 bank



### Organisational Model

- There is an MRM department that includes responsibility for model validation and covers the entire life cycle of models
- It reports directly to the Chief Risk Officer



### Responsibility

- There is a specific MRM department which covers a wide range of models
- It is a pure control function which reviews and assesses model risk, but delegates its management to model developers and users
- MRM owns model risk policy but the model inventory is owned by the business unit
- There is a rigorous process for validation, monitoring, restrictions and model overlays



### Methods

- The bank defines risk appetite for model risk according to a scoring system which allows aggregation across model types
- The framework is well structured and allocates to each model a specific risk class (high/medium/low)
- The model definition details exceed those of SR 11-7



### Reporting

- Reporting is extensive: both qualitative and quantitative
- The board and business units receive quarterly reports
- The Chief Risk Officer is informed on a monthly basis



### Resources

- The bank invests \$10-50m pa in model risk
- 25% of model validation is outsourced
- The development documentation is comprehensive
- There is a 10:1 ratio of model developers to model risk managers
- On average each model risk manager reviews 5 models/year
- There is a plan to double the headcount for model risk



### Regulation

- There is no regulatory requirement specifically targeted at model risk
- There is no capital buffer for model risk

## 13. CONSIDERATIONS FOR THE FUTURE

### Focus sharpens on governance

- A global standard of governance has emerged which has at its core an enterprise-wide model risk management function
- The speed and extent of its adoption varies significantly among practitioners
- The principal challenge of MMR is the identification of an entire universe of risk types around a model - a huge task

### Development of an effective framework

- Institutions agree on the need for an effective model risk framework that ensures the inclusion of all relevant risks and provides consistent quality across the entire financial sector.
- There are good examples of this. Some banks achieve it by using software which breaks down models into digestible elements. These are then assessed by the model risk manager according to certain criteria defined by the software, given model specifications and model type. The output of this process is a control review which comprises a model map and assessment of the model elements. It highlights any core risks which are not being managed by the specific model.

### A standard for aggregating risk

Techniques for aggregating quantitative model risks exist and are used by a number of financial institutions.

Individual model risk can be measured by combining information about the model's uncertainty (e.g. regression error) with sensitivities to the model's input factors. These risk measures can be aggregated, ideally with reference to a correlation structure of the different sub-models.

Still, the effective aggregation of model risk is an ideal in the pursuit of which which no single solution has triumphed. Our conversations with survey participants suggest that standardisation is a goal they are actively pursuing.

### Four lines of defence

- Financial institutions vary in the way they approach MRM. A core of progressive players is developing forward-looking practices anchored in a four-lines-of-defence approach. Others adopt a simpler approach which is often a function of both their regulatory environment and business context.
- Firms that go beyond the regulatory requirements often have the keenest awareness of the business case for MRM. They view it strategically rather than reactively.

Fintegral is a specialist consultancy which provides risk and capital management solutions to banks and insurance companies. It combines academic excellence with decades of experience in the financial services industry. Fintegral operates in London, Zurich, Frankfurt and New York, working with some of the world's best known financial institutions to develop solutions in quantitative finance.

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