

Vendor Analysis: SAS

Model Risk Management:
Governance and Validation Solutions, 2023



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- Operational risk and governance, risk management and compliance (GRC).
- Market risk.
- Asset and liability management (ALM) and liquidity risk.
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- Cyber risk management.
- Insurance risk.
- Regulatory requirements.
- Wealth advisory.
- Asset management.

Chartis focuses on risk and compliance technology, giving it a significant advantage over generic market analysts.

The firm has brought together a leading team of analysts and advisors from the risk management and financial services industries. This team has hands-on experience of developing and implementing risk management systems and programs for Fortune 500 companies and leading consulting firms.

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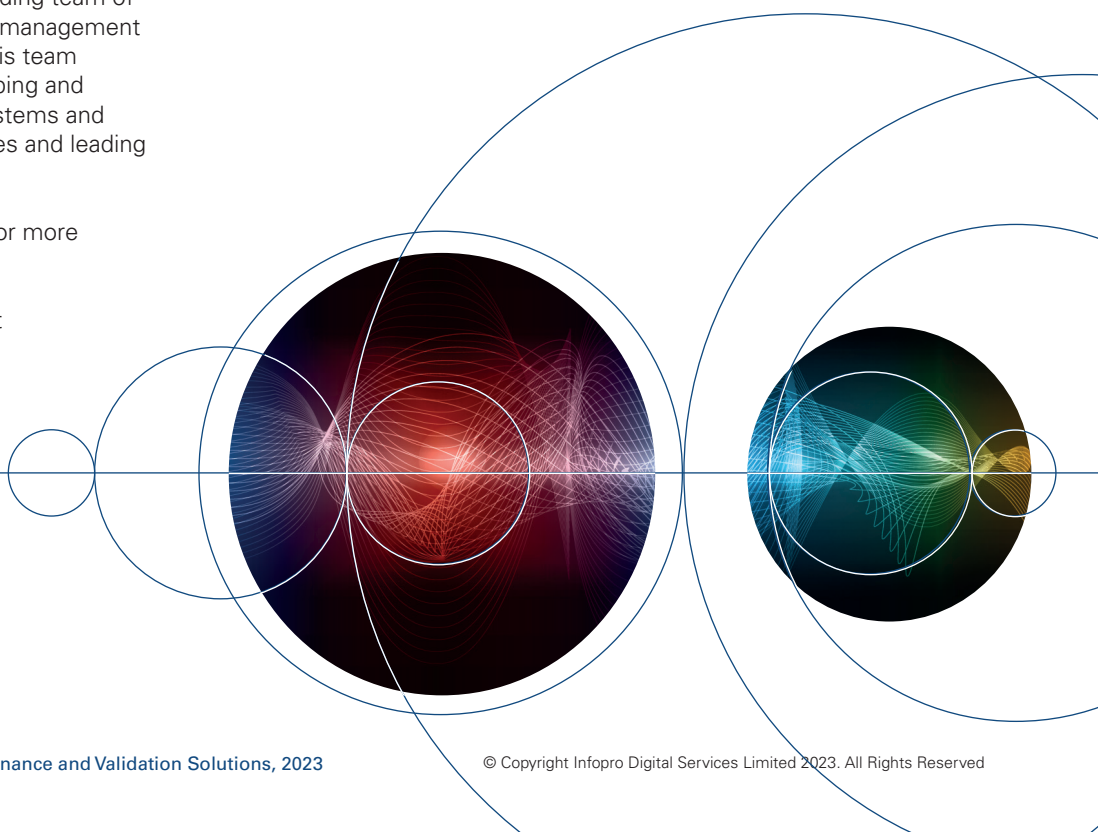


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1. Report context

This Vendor Analysis is based on the Chartis quadrant report *Model Risk Management: Validation Services and Tools, and Governance Solutions, 2023; Market and Vendor Landscape* (published in March 2023). This section summarizes the key theses in that report; subsequent sections take a detailed look at SAS' quadrant positioning and scoring, and Chartis' underlying opinion and analysis.

Key thesis

Chartis has split model risk management (MRM) into two broad segments to reflect the different types of vendor functionality in the market, which have evolved from overlapping but distinct user requirements. Nevertheless, elements of model validation and governance are increasingly converging, as firms invest in automated validation tools, which – along with validation services – are built on the quantitative and qualitative tools used to test the appropriateness, robustness and accuracy of models.

Whereas model governance solutions have traditionally represented the functionality used for several capabilities (including managing the model lifecycle, tracking risk thresholds and maintaining inventories), these governance frameworks highlight the conceptual clarity that has emerged as MRM as a practice has matured. Within the broad governance, risk management and compliance (GRC) universe, model risk governance remains something of an outlier. Although governance practices are formalized in regulatory guidelines and business practices, they are also tightly coupled with underlying theoretical modeling frameworks. As a result, model risk governance requires specialist tools such as inventory management and regulatory intelligence, which are not covered by general GRC workflow tools.

Consequently, two types of technology vendor largely operate in the model risk governance space: conventional GRC vendors and quantitative modeling vendors that have developed an additional governance solution.

A key feature of vendor competition in the governance space is the unique requirements of different modeling paradigms – including tracking and prioritizing specific compliance demands. For validation solutions and services, however, domain expertise is paramount. Vendors are bounded by the risk area in which they have historically competed and have expertise in servicing. The mechanics of models are defined by the theoretical frameworks from which they are derived (such as statistical frameworks, optimization frameworks or partial differential equation [PDE] solvers), which

are unique to different risk management areas, including credit risk, derivatives and fixed income. And in addition to a model's theoretical foundation and methodology, other factors, including analytical tractability, historical data availability and model replicability, can shape validation practices.

As a result, vendors and financial institutions alike rely on experienced quantitative experts to validate models, but training and retaining staff can be expensive, especially as models become more complex. Specific validation tools that can be used by practitioners to standardize and automate tests can ease some of the burden, and these are becoming more popular.

Vendors that develop models often have a set of best practices, tools and documentation, along with staff who can provide considerable support throughout the model validation cycle. For a variety of reasons, however, these vendors often restrict such services to their own models. As a result, we have color-coded and distinguished between service-provider vendors and those vendors with modeling capacity.

Demand-side takeaways

Although MRM, model governance and model validation are closely related activities, they can be viewed through distinct lenses:

- **Model risk governance.** This is characterized by the leveraging and analysis of market data, market conditions and volatility data, how volatility data in the markets shifts and the nature of how volatility manifests itself. If the nature of that manifestation changes, the model assumptions, structure, etc., need to change. But that must all be documented, controlled, made transparent and queried. People should be able to find out who has changed what, when and why they changed it, and how the assumptions changed, with links to external documents, theoretical papers, internal papers, regulatory documents, etc. – all of which suggest the background context and environment in which these changes manifested themselves.

- **Model validation.** This is essentially the process of testing whether the assumptions that have gone through a model are correct, whether the coding of the model has been appropriately and properly developed, and whether the model's results are being generated in the correct and appropriate context.

A vast field

MRM in the financial services industry is now a vast and broad field, characterized by distinct vertical sectors that involve deep domain knowledge. The quantitative modeling methodologies and risk management practices in different segments of the financial services sector evolve according to their own specific market contexts and drivers. Demand for MRM tools, which is shaped by unique model validation requirements, is amplified by regulation, emerging technologies and industry standards. In the past, model risk in the derivatives markets attracted considerable attention from industry players and regulators, and, as a result, the underlying calculation methodologies are now relatively stable.

This historical focus on the model risk of OTC derivatives by the financial industry has broadened across all asset classes and industry segments. Regulators, senior managers and quants are now considering the risk of all models that are part of an institution's business, notably those concerning credit and market risk. Operational risk, regulatory capital and stress-testing regimes are also areas of increased scrutiny from regulators around model risk.

Differing requirements and challenges

The unique requirements of different modeling regimes can create a broad range of challenges for institutions. Large banks, for instance, need to manage the various modeling demands that arise across their many business lines. All aspects of an institution's business are critically impacted by the modeling assumptions and frameworks that govern them. Yield curves, options pricing, value at risk (VaR) and the statistical analysis of time series, correlation and Copula methods are just a few examples of model classes with their own risk management methodologies.

Fundamentally, models represent a worldview of the state of the market and its structure. Different views rely on embedded assumptions that often change over time, alongside new constraints on cost and greater demands on scale. One

of the central challenges that institutions must confront is the lengthy task of generating model documentation that is consistent over time and detailed enough to meet regulatory guidelines.

New tools and complexities

The implementation of machine learning (ML) techniques across a range of use cases means that firms must now contend with new modeling paradigms. These come with their own validation and governance challenges, and a relative lack of industry consensus around how to manage them. The implementation of neural networks can simplify computationally expensive simulations with a high volume of path dependencies. But these projects come with their own complexities, as banks need to plan appropriate timelines that enable adequate testing for regulatory approval. Many of the mechanisms for testing, validating and managing the lifecycle of ML models have been developed in non-financial industries.

More models and more complexity

Despite compliance demands and an awareness of the need for MRM, institutions often struggle to manage model risk in-house. The ubiquity and nuances of model risk mean that model validation is a process that requires experts, but at scale – creating costly demand for suitably qualified people. The model validation process is also split across different phases (such as internal and external) and levels (such as code and calculation), and these phases can also require dedicated personnel. And although model documentation is viewed by many firms as a tedious afterthought, maintaining consistent and accurate documentation is a challenging, time-intensive process.

Technology advances, such as digitalization and expanding IT infrastructures, have made it easier for institutions to monitor models, integrate policies and centralize pricing and development libraries. However, advances and improvements in the availability of technology (including open-source frameworks, flexible programming languages such as Python and R, and end-user applications) are helping to create control and governance issues. End-user computing issues are increasingly cited in various regulatory guidance and framework documents, and institutions are responsible for assessing the impacts and implications of these systems on data integrity and model risk.

Supply-side takeaways

Expertise is vital

Success for vendors of model validation solutions has been dictated by domain-specific expertise, and there has been a history of 'services-led' solutions. The extent to which vendors have 'operationalized' their validation functionality varies according to their business model. Vendors that provide pricing libraries, for example, often in the derivatives pricing and valuation space, do not have model validation as a service as their core focus. Rather, these pricing vendors provide validation support as part of their broader offerings, and to create additional value for their customers in line with demanding regulatory and market conditions.

Validation firms: mixed offerings

The development of validation and governance tools enables validation teams to improve the efficiency of their MRM frameworks, and ever more firms are investing in and rolling out sophisticated validation tools across a broad range of use cases to gain a competitive edge. Technology vendors are not subject to the same model stewardship and compliance requirements as the clients they serve; nevertheless, their competitive success relies on firms having confidence in the accuracy and robustness of the models they provide and validate. The degree to which these vendors provide validation varies substantially, from benchmarking models to full validation, compliance and auditing.

Chartis has observed that, in spite of the expansion in model risk requirements across financial institutions, vendors tend to specialize in model validation in one business class or one asset area, and tend not to be as strong in model validation in other areas. Sometimes, validators may be able to cover two or three business classes, but generally this is not the case.

Model validation is a services business. It is carried out by a range of different service providers, including large accountants, consultants, systems integrators, specialized model validation service providers and sometimes even software firms (providers of core software tools for pricing and modeling). Some model providers also offer validation services, although often they only provide validation services for their own models, rather than third-party ones. Others provide validation capabilities for their own models in terms of framework and structure, but don't necessarily offer the full 'human-resource' services required.

Governance – a distinct activity

Currently, model governance remains a somewhat distinct activity. Vendors of model governance solutions often tend to be providers of the models themselves (so, for example, model governance for credit risk is often provided by vendors that provide credit risk models). But there is also a large group of GRC providers that offer workflows, case management and the infrastructure to provide appropriate model governance across a large class of models.

The key questions for financial institutions are what they really want to become involved in, what their area of focus is and where they should target their activities.

Key dynamics in the landscape

For financial institutions, model risk progressively has become more of a critical concern. But they are not necessarily seeking to invest in expanding costly internal validation teams. Banks' big regulatory projects, with new data and modeling requirements, are incredibly resource-intensive and require a team of experts that services companies can provide. In addition to acquiring 'knowledge services' provided by experienced and highly skilled subject-matter experts across all levels of validation, these firms are looking to automate aspects of the model risk process. Some vendors also provide platforms with analytics and data management capabilities alongside consulting.

Technology vendors are also seeking to invest in relevant tools, but, for the most part, these projects are smaller and less mature. For services firms, specialist experience in certain asset classes, risk types and regional markets is a key dimension of their competitive approach. Indeed, while services firms are seeking to automate aspects of the model risk process, the validation market continues to be dominated by those with domain expertise.

2. Quadrant context

Introducing the Chartis RiskTech Quadrant®

This section of the report contains:

- The Chartis RiskTech Quadrants® for model validation solutions (credit) and model governance solutions, 2023.
- An examination of SAS' positioning and its scores as part of Chartis' analysis.
- A consideration of how the quadrant reflects the broader vendor landscape.

Summary information

What does the Chartis quadrant show?

The Chartis RiskTech Quadrant® uses a comprehensive methodology that involves in-depth independent research and a clear scoring system to explain which technology solutions meet an organization's needs. The RiskTech Quadrant® does not simply describe one technology option as the best model validation/governance solution; rather, it has a sophisticated ranking methodology to explain which solutions are best for specific buyers, depending on their implementation strategies.

The RiskTech Quadrant® is a proprietary methodology developed specifically for the risk technology marketplace. It takes into account vendors' product, technology and organizational capabilities. Section 4 of this report sets out the generic methodology and criteria used for the RiskTech Quadrant®.

How are quadrants used by technology buyers?

Chartis' RiskTech and FinTech quadrants provide a view of the vendor landscape in a specific area of risk, financial and/or regulatory technology. We monitor the market to identify the strengths and weaknesses of different solutions, and track the post-sales performance of companies selling and implementing these systems. Users and buyers can consult the quadrants as part of their wider research when considering the most appropriate solution for their needs.

Note, however, that Chartis Research does not endorse any vendor, product or service depicted

in its research publications, and does not advise technology users to select only those vendors with the highest ratings or other designation. Chartis Research's publications consist of the opinions of its research analysts and should not be construed as statements of fact.

How are quadrants used by technology vendors?

Technology vendors can use Chartis' quadrants to achieve several goals:

- Gain an independent analysis and view of the provider landscape in a specific area of risk, financial and/or regulatory technology.
- Assess their capabilities and market positioning against their competitors and other players in the space.
- Enhance their positioning with actual and potential clients, and develop their go-to-market strategies.

In addition, Chartis' Vendor Analysis reports, like this one, offer detailed insight into specific vendors and their capabilities, with further analysis of their quadrant positioning and scoring.

Chartis Research RiskTech Quadrant® for model governance solutions, 2023

Figure 1 illustrates Chartis' view of the model governance vendor landscape, highlighting SAS' position.

Quadrant dynamics

General quadrant takeaways

The demand for model risk governance solutions continues to grow, driven by innovative modeling paradigms and regulatory pressure (in the form of both principle-based and validation requirements). Despite the growth in demand for governance solutions, compared to other GRC markets, competition to provide model risk governance solutions has not experienced the same rapid increase. The enormous variety of models and specialist requirements (such as model inventories and lifecycle management) require both technical and domain expertise.

Figure 1: RiskTech Quadrant® for model governance solutions, 2023



Source: Chartis Research

For vendors approaching the market without specialist knowledge in terms of either a modeling product or services background, providing strong governance across a wide variety of asset classes is a challenge. The model risk governance quadrant reflects the specialist nature of the model risk solutions industry, as it features relatively few vendors outside the category leader position.

Within the category leader section of the quadrant, historically strong players feature alongside some relatively new market entrants. There is a clear cluster of best-in-class vendors in the category leader position. These firms differentiate themselves based on the strength of their core governance functionality, level of documentation detail and automation, as well as their ability to integrate their offerings with validation tools.

Vendor positioning in context – completeness of offering

SAS' category leader position reflects a combination of features and functionality across the whole model lifecycle. Its model risk governance solution is hosted on SAS Viya, a cloud-based platform that allows for regular updates and enables users to deploy models at scale. Viya also allows users to integrate multiple data sources and supports an application programming interface (API)-centric architecture and a modular framework. The solution also enables the management of disparate data sources and the tracking of data lineage through the model lifecycle – key challenges in MRM. Collected data points can be visualized to illustrate the distribution of model risk throughout an organization.

SAS achieved a high score for its model inventory capabilities, reflecting the company’s broad governance coverage across model types (including tools) and its centralized inventory. SAS’ governance features cover the full model cycle, from implementation details to compliance and policy monitoring. Its overarching governance approach includes the continuous updating of models’ status, with automated model-usage documentation, version monitoring and control implementation.

SAS has also developed governance tools for ML models and their unique governance requirements. The company’s ‘model cards’ feature allows users to conduct various activities, including collecting and monitoring contextual information and acquiring performance and benchmarking metrics.

Table 1 shows Chartis’ rankings for SAS’ coverage against each of the completeness of offering criteria.

Chartis Research RiskTech Quadrant® for model validation solutions (credit), 2023

Figure 2 illustrates Chartis’ view of the model validation (credit) vendor landscape, highlighting SAS’ position.

Quadrant dynamics

General quadrant takeaways

International Financial Reporting Standard 9 (IFRS 9) and Current Expected Credit Losses (CECL) are transforming credit modeling in the banking book, triggering greater model complexity and a broader set of validation requirements. The credit risk model validation space includes both services firms and traditional credit solution providers. Product companies’ solutions generally have governance features, illustrating the growing convergence of governance and validation solutions. Product companies in the category leader space also have experience in providing credit models and use this expertise to approach the validation market.

Vendors in the point solutions category adopt various approaches to the market, including extended GRC offerings or ML models/code optimization.

Table 1: Completeness of offering – SAS (model governance solutions, 2023)

Completeness of offering criterion	Coverage
Model coverage	Medium
Governance	High
Data management	High
Model inventory	High
Dashboarding	High
Visualization	Medium

Source: Chartis Research

Vendor positioning in context – completeness of offering

SAS’ category leader positioning in the quadrant reflects its experience as a product company that provides deep analytics and sophisticated credit modeling. Its credit risk management offerings cover a wide set of calculations, pricing methods and lending product types across the credit lifecycle. The company also has built-in capabilities to test, benchmark and manage credit models within the product platform; additional functionality includes back-testing, challenger model functionality and a broad range of statistical testing.

Alongside teams with deep modeling experience, SAS also provides a powerful base on which clients can test frameworks and models. In addition, the company has subject-matter expertise in consumer credit modeling, as well as broad compliance and validation experience. This expertise, combined with the company’s Kamakura acquisition, was a key factor in SAS’ positioning as a category leader. Its risk modeling platform offers visualizations that support the model testing/ experimentation and validation process, while the ability to share parameters and integration with in-house development helps to create an efficient validation environment. SAS’ integrated solution and in-memory processing also supports efficient and flexible model development and validation.

Figure 2: RiskTech Quadrant® for model validation solutions (credit), 2023



Notes: Yellow dots indicate services companies; blue dots indicate companies that primarily offer products, although we acknowledge that many companies offer a mix of both products and services.
 The credit risk quadrant focuses on banking book credit.
 Source: Chartis Research

Table 2 shows Chartis’ rankings for SAS’ coverage against each of the completeness of offering criteria.

Vendor positioning in context – market potential

SAS has a reputation in the market as a consistently strong player that continues to upgrade and develop its MRM solution. The company has maintained competitive deployment levels for its solution across different regions and global systemically important banks (G-SIB). SAS’ high score for its model governance solution contributes to its positioning as a category leader in this space. In addition, the completeness of its model risk governance features and functionality, as well as investment in specific ML governance frameworks, have helped it achieve a high score for its business model in both market segments. SAS’ partnerships and MRM-related events also reinforce its position and reputation as a leader in the market.

The launch of Viya and SAS’ long-standing expertise in risk and finance, alongside its sophisticated credit risk modeling, supports its status as a category leader in both model risk governance and model validation. SAS’ ‘common platform’ architecture strategy for its risk solutions gives the company a competitive advantage, as product integration is an essential aspect of MRM. Crucially, SAS users can integrate model data from the Model Implementation Platform to the Model Risk Management platform.

SAS’ integration approach and links to other systems also play key roles in its compliance support across a range of risk areas that intersect with model validation requirements.

SAS achieved a high score for its business model in both the model governance and model validation quadrants, reflecting the scalability of its solutions. The company’s acquisition of Kamakura has enabled it to enhance and expand its modeling and analytics expertise. Kamakura’s market-leading credit models, risk solution and cross-validation functionality reinforce SAS’ position as a category leader and domain expert in this space.

Tables 3 and 4 show Chartis’ rankings for SAS’ coverage against each of the market potential criteria in both analyses.

Table 2: Completeness of offering – SAS (model validation solutions [credit], 2023)

Market potential criterion	Coverage
Organizational depth and personnel	Medium
Supporting tools	Medium
Methodological frameworks and structure	High
Data handling/approach	Medium
Dashboarding	Medium
Visualization	Medium

Source: Chartis Research

Table 3: Market potential – SAS (model governance solutions, 2023)

Market potential criterion	Coverage
Market penetration	High
Growth strategy	High
Financials	High
Business model	High

Source: Chartis Research

Table 4: Market potential – SAS (model validation solutions [credit], 2023)

Market potential criterion	Coverage
Market penetration	Medium
Growth strategy	Medium
Financials	High
Business model	High

Source: Chartis Research

3. Vendor context

Overview of relevant solutions/ capabilities

Table 5 provides a summary of the vendor and its solutions.

Table 5: SAS – company information

Company	SAS
Headquarters	Cary, NC, US
Other offices	<p>Total number of countries where SAS has R&D offices: 7 (US, UK, China, Denmark, India, Japan, Republic of Korea)</p> <p>Total number of countries where SAS has offices: 56</p> <p>Total number of SAS regional offices in the US: 12 in 10 states</p> <p>Total number of SAS offices in the US (including executive suites and training centers): 44 in 20 states</p>
Description	<p>SAS' continued development of next-generation risk solutions will emphasize a cloud-first and API-first architecture based on SAS Viya 4, an artificial intelligence (AI), analytics and data management platform. With more than fifteen years of building enterprise governance solutions, SAS aims to use its expertise and services-based framework to meet clients' needs across a range of ever-changing risk and compliance requirements.</p>
Solution	<p>SAS has spent a decade simplifying MRM via feedback from its large client base, and now delivers the following capabilities:</p> <ul style="list-style-type: none"> • Model risk card. • Best-in-class APIs – simplifying integration with open source, data governance and risk systems. • Automated documentation. • Enterprise system of record that supports regional variations. • One-click model attestation. • Business-user configuration. • Out-of-the-box reporting for areas and functions including board-level, business unit and model owner. • AI governance toolset. • Cloud-tuned offering with monthly cadence, with client requests and regulation updates. • Best-in-class model and MLOps. • Automated performance monitoring.

Source: SAS

SAS Model Risk Management

As regulators expand their oversight of MRM, banks need to improve their governance around building, validating, deploying and managing models at scale.

Key questions for banks to answer include:

- Can we prove that our model inventory is complete and accurate?
- How do we know that all our models are being employed for their intended uses?
- Are we sure that all our models have been validated and verified for those uses?
- Can we demonstrate that all our models are being executed and monitored consistently?
- Are we confident that our model governance can adapt as regulations evolve?

Forward-thinking banks are already looking to get ahead of the game by standardizing and simplifying their model lifecycle management across the organization. By eliminating complexity, banks can scale model-driven decision-making effectively as business demands and regulatory requirements evolve.

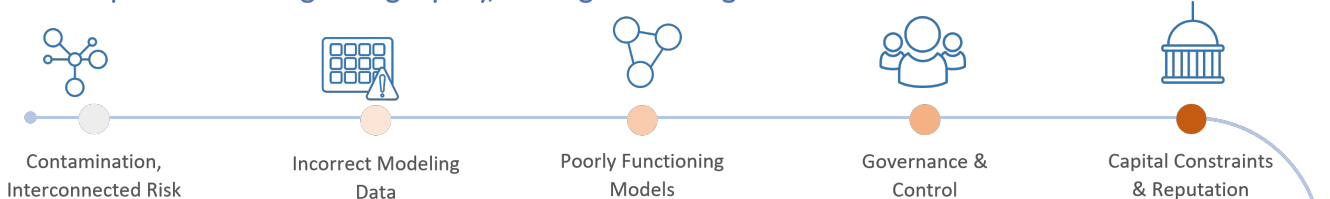
SAS' solution allows banks to create an integrated ecosystem that provides complete model lifecycle management and end-to-end traceability (see Figure 3). A bank's model-building team can continue to use the languages, frameworks and tools it prefers. SAS helps firms to standardize downstream processes, including model validation, approval, deployment, execution and monitoring. By increasing the level of automation, focusing resources on the most critical models and applying consistent model governance throughout the model lifecycle, firms can respond to regulators in a more efficient and agile way. The ability to develop and operationalize models more efficiently leads to decreased time to market for new or revised products linked to these models.

A decade of enabling G-SIBs with global regulations

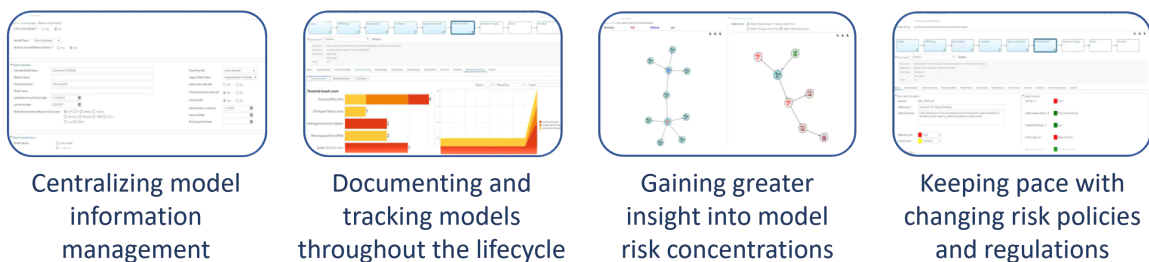
SAS is a long-standing partner of leading banks, including G-SIBs. Its cloud-based solution for model lifecycle management and MRM can scale to thousands of models and provide both the robust governance and the agility a bank's modeling communities need to meet regulatory requirements while accelerating model deployment (see Table 6).

Figure 3: Mitigating model risk

Models in production are growing rapidly, leading to challenges for banks...



With SAS Model Risk Management (MRM) you can better mitigate model risk by....



Source: SAS

Table 6: SAS MRM – an overview

Model identification and model risk classification	<p>SAS MRM offers a one-click model inventory attestation.</p> <ul style="list-style-type: none"> • Assesses the accuracy and completeness of the model inventory. • Includes a 'one-button' feature to kick off a project to attest an organization's entire model inventory. • Identifies and corrects gaps. <p>Repeatable and systematic assessments for regional regulations.</p> <ul style="list-style-type: none"> • Defines a model, a model inventory and a risk-based tiering approach to categorize models.
Governance	<p>Provides board level-reporting and real-time model cards across an entire organization.</p> <ul style="list-style-type: none"> • Out-of-the-box reporting for all levels of an organization. • Flexible. • Agnostic (VA, Power BI, etc.) <p>MRM Viya will introduce a model risk card that can be called by external applications. The configurable card will contain information that communicates model risk status across an organization.</p>
Model development, implementation and use	<p>ModelOps and MLOps integrate with open-source platforms while enforcing MRM policy.</p>
Independent model validation	<p>Orchestrates three lines of defense. Numerous continuous monitoring and automated documentation features.</p>
Model risk mitigants	<p>Reduce time to establish and measure via continuous monitoring and automation.</p>

Source: SAS

Vendor leading practices

SAS' MRM solution enables banks to organize a centralized model inventory – complete with model candidate assessment – that supports theoretical and assumption documentation, model limitation scoring, validation results, criticality ratings and model interdependence relationships (see Figure 4). Its features include the ability to import the attributes and metadata from any type of model developed in any technology into the model inventory. To help organize model sets, SAS' solution can classify and report on models by lineage, business unit, model owner or customized factors to meet a bank's needs.

Configurable, capable and comprehensive

SAS MRM is an 'out of the box' configurable solution. It includes a browser interface, application and data logic, workflow automation, model risk card (providing real-time model risk data) and a database structure with comprehensive reporting capabilities.

MRM offers the option of a 'quick start' rapid implementation methodology that enables customers to achieve pilots in 8-12 weeks.

SAS MRM is built around three core design principles:

- A configurable, capable and comprehensive offering.
- The 360-degree linking of models, documentation and all relevant attributes.
- Auditable workflow-controlled processes and interaction between operational, control and business-managed change processes.

MRM solution features and capabilities

Managing global vs. regional customizations

A singular model library enables users to register and maintain a single model library that covers global and regional (regional customizations where required) regimes, all model types and classes, and all business units.

Automation

Automates model validation by executing standardized tests based on model type and regulatory regime.

Automates documentation for both validation and performance monitoring, using templates and controls, including light-touch edits for executive summaries.

Integration with model execution platform

Connects into existing model execution platforms and prevents execution of models upon the rejection of model use approval.

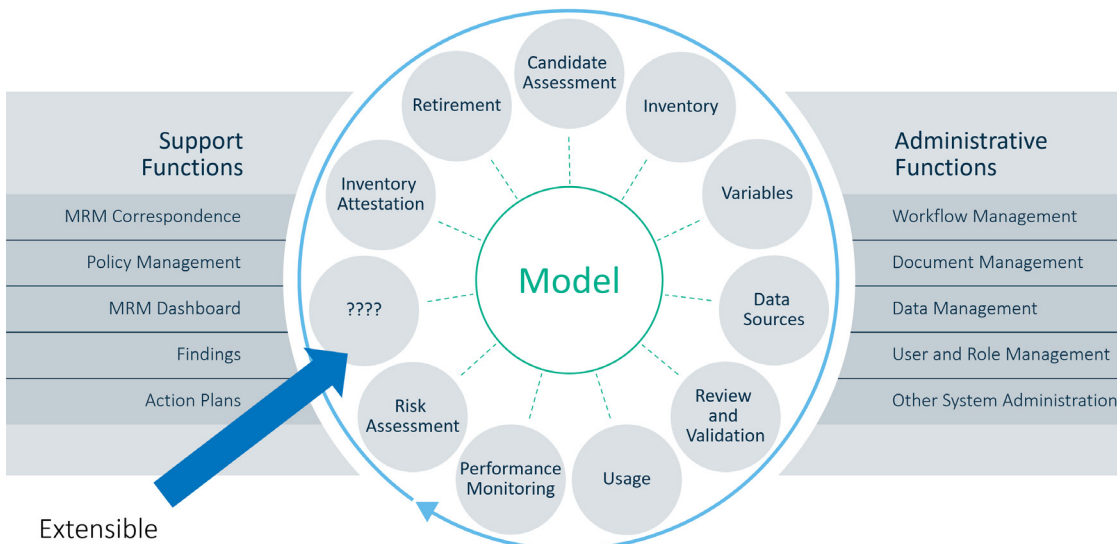
Connects into existing model execution platforms and conducts automated performance monitoring for any model type.

Best practices in the cloud

MRM application updated monthly.

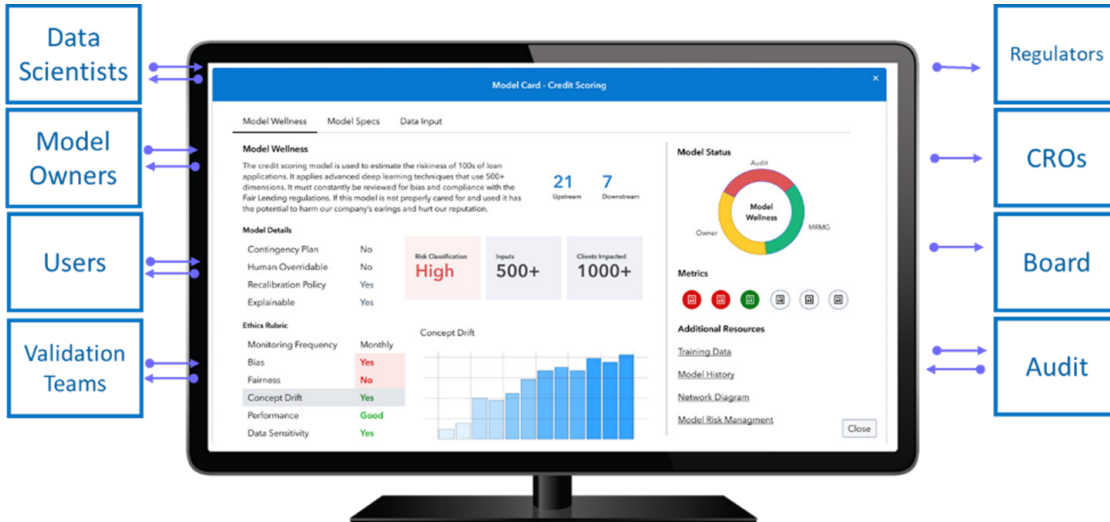
New features/best practices defined by customers at virtual quarterly prioritization webinars.

Figure 4: SAS Model Risk Management architecture



Source: SAS

Figure 5: Distributing MRM data



Source: SAS

Prioritized and delivered by SAS.

Ability to configure and merge added content with customizations.

Model cards

Model risk cards operate at a business level and can be called by external applications. The configurable card will contain information that communicates the model risk status across an organization (see Figure 5). Externalizing MRM data is possible via API-callable cards that are relatively straightforward to interpret. SAS is attempting to create a common language that

can communicate model health to model users, owners, executives, auditors and interns.

Support for AI and ML models

Supports and integrates with existing systems to automate explainability, bias, fairness and performance monitoring, including model/data drift.

Responsible AI – consolidating and communicating via model risk card.

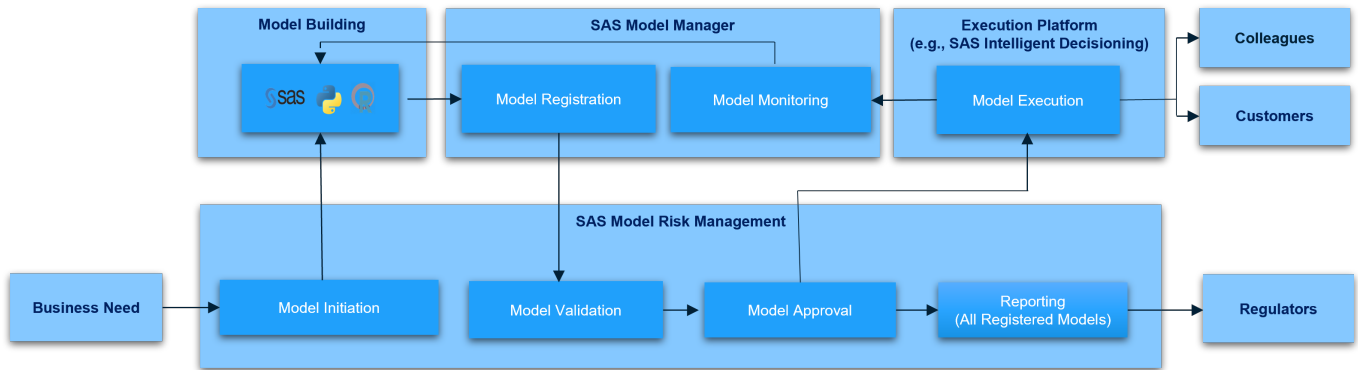
Model cards can extend into and provide context for AI- and ML-specific models (see Figure 6).

Figure 6: Example model card for AI/ML models



Source: SAS

Figure 7: Integrated ModelOps environment



Source: SAS

Model lifecycle: a unified approach

When a bank’s modeling communities identify the need for a new model, a unified approach allows the process to flow seamlessly through an integrated ModelOps environment (see Figure 7). By taking a unified approach, a bank can radically simplify and streamline the way it works with models to:

- Ensure control, transparency and responsible decisioning with comprehensive governance.
- Empower data scientists to build models in any language and execute them anywhere.
- Reduce time-to-value by getting models validated, approved and into production faster.
- Simplify model management, eliminate manual handoffs and reduce the risk of errors.

Model initiation

SAS’ solution helps the community to determine and automatically document the key characteristics for the new model – identifying the data, techniques and methodologies, use cases, materiality and risk tiering.

Model building

The community builds the model using whichever modeling languages, frameworks and tools it prefers – SAS or open source, in the cloud or on-premise. Once built, models created in SAS, R, Python and other languages can be executed directly without recoding, saving time and rework for technical teams.

Model registration

The model is registered in the model catalogue, together with automatically generated metadata and documentation. This ensures full traceability and robust governance throughout the lifecycle of the model.

Model validation

The model is automatically tested and validated to ensure accuracy and freedom from bias. Champion/challenger tests, for example, can be used to confirm whether the model outperforms existing ones.

Model approval

Automated MRM acts as a gatekeeper, ensuring that the new model has passed all necessary approval checkpoints before it moves into execution, and capturing a full audit trail.

Model execution

SAS Viya provides a cloud-based execution environment for models, and also integrates with external data processing engines such as Apache Spark. The results of running the model can then be integrated into business processes to support colleagues and customers.

Model monitoring

Model performance is automatically monitored in production with real-time dashboards, and alerts are raised whenever results fall outside the limits defined and signed off by the governance team. This then prompts data science teams to rebuild or replace models when necessary.

Reporting and compliance

SAS Model Risk Management provides comprehensive, out-of-the-box reporting capabilities for all levels of an organization, including board level, line of business and MRM team. Regional data can then be aggregated, giving a global view of the model risk an organization faces.

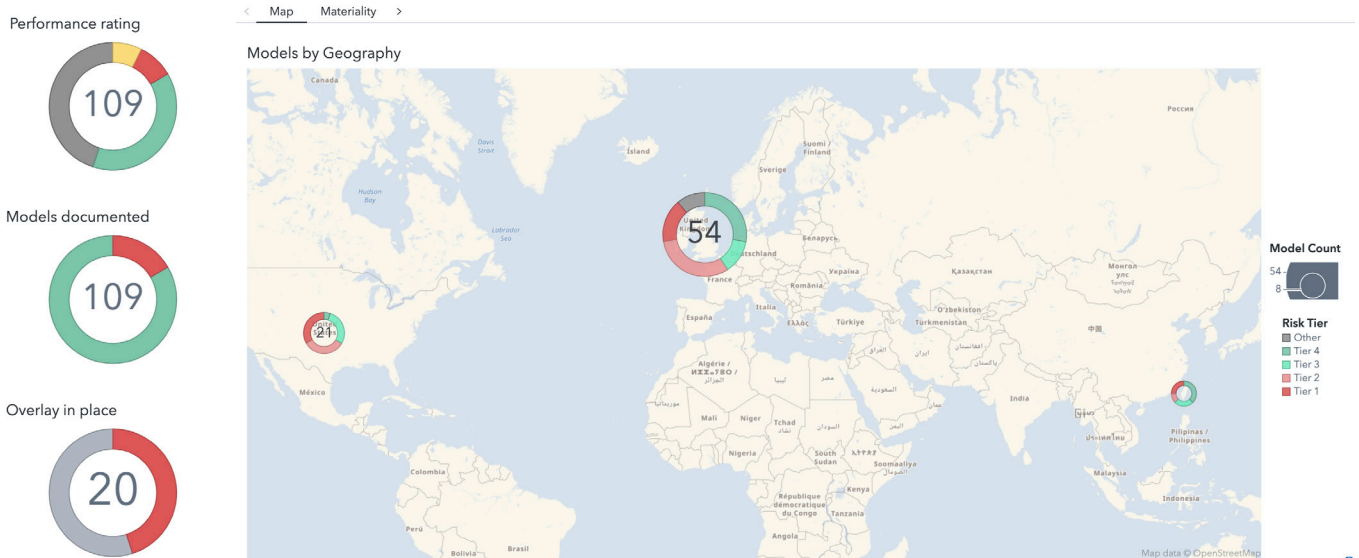
Since all data and metadata throughout each model's lifecycle are fully captured by SAS MRM, the solution makes it easy to explain and audit models, and automatically generates comprehensive reports for management and regulators (see Figure 8).

Deploying SAS Model Risk Management provides:

- A complete model governance and MRM solution as required by the business and regulators.
- A central model inventory and model assessment capabilities.
- ML capabilities.
- Streamlined model validation activities.

- The communication of model risk 'wellness' across the organization.
- Centralized model information for enhanced management.
- Documentation and tracking of models throughout the model lifecycle and across model types and technologies.
- Greater insight into model risk concentrations and contagions.
- A model governance and MRM solution that can keep pace with changing risk policies and regulations.

Figure 8: Explaining and auditing models



Source: SAS

4. Methodology

Overview

Chartis is a research and advisory firm that provides technology and business advice to the global financial services industry. Chartis provides independent market intelligence regarding market dynamics, regulatory trends, technology trends, best practices, competitive landscapes, market sizes, expenditure priorities, and mergers and acquisitions. Chartis' RiskTech® and FinTech™ quadrant reports are written by experienced analysts with hands-on experience of selecting, developing and implementing financial technology solutions for a variety of international companies in a range of industries, including banking, insurance and capital markets. The findings and analyses in our quadrant reports reflect our analysts' considered opinions, along with research into market trends, participants, expenditure patterns and best practices.

Chartis seeks to include RiskTech and FinTech vendors that have a significant presence in a given target market. The significance may be due to market penetration (e.g., a large client base) or innovative solutions. Chartis uses detailed 'vendor evaluation forms' and briefing sessions to collect information about each vendor. If a vendor chooses not to respond to a Chartis request for information, Chartis may still include the vendor in the report. Should this happen, Chartis will base its opinion on direct data collated from technology buyers and users, and from publicly available sources.

Chartis' research clients include leading financial services firms and Fortune 500 companies, leading consulting firms and financial technology vendors. The vendors evaluated in our quadrant reports can be Chartis clients or firms with whom Chartis has no relationship.

Chartis evaluates all vendors using consistent and objective criteria, regardless of whether they are Chartis clients. Chartis does not give preference to its own clients and does not request compensation for inclusion in a quadrant report, nor can vendors influence Chartis' opinion.

Briefing process

We conducted face-to-face and/or web-based briefings with each vendor.¹ During these sessions,

¹ Note that vendors do not always respond to requests for briefings; they may also choose not to participate in the briefings for a particular report.

Chartis experts asked in-depth, challenging questions to establish the real strengths and weaknesses of each vendor. Vendors provided Chartis with:

- A business update – an overview of solution sales and client satisfaction.
- A product update – an overview of relevant solutions and R&D roadmaps.
- A product demonstration – key differentiators of their solutions relative to those of their competitors.

In addition to briefings, Chartis used other third-party sources of data, such as conferences, academic and regulatory studies, and publically available information.

Evaluation criteria

We develop specific evaluation criteria for each piece of quadrant research from a broad range of overarching criteria, outlined below. By using domain-specific criteria relevant to each individual risk, we can ensure transparency in our methodology, and allow readers to fully appreciate the rationale for our analysis. The specific criteria used for model validation and governance solutions are shown in Table 7.

Completeness of offering

- **Depth of functionality.** The level of sophistication and number of detailed features in the software product (e.g., advanced risk models, detailed and flexible workflow, domain-specific content). Aspects assessed include innovative functionality, practical relevance of features, user-friendliness, flexibility and embedded intellectual property. High scores are given to firms that achieve an appropriate balance between sophistication and user-friendliness. In addition, functionality linking risk to performance is given a positive score.
- **Breadth of functionality.** The spectrum of requirements covered as part of an enterprise risk management system. This varies for each subject area, but special attention is given to functionality covering regulatory requirements,

Table 7: Evaluation criteria for Chartis’ model validation and governance solutions report

Completeness of offering	Market potential
<p>Model governance:</p> <ul style="list-style-type: none"> • Model coverage • Governance • Data management • Model inventory • Dashboarding • Visualization <p>Model validation (credit):</p> <ul style="list-style-type: none"> • Organizational depth and personnel • Supporting tools • Methodological frameworks and structure • Data handling/approach • Dashboarding • Visualization 	<ul style="list-style-type: none"> • Market penetration • Growth strategy • Financials • Business model

Source: Chartis Research

multiple risk classes, multiple asset classes, multiple business lines and multiple user types (e.g., risk analyst, business manager, CRO, CFO, compliance officer). Functionality within risk management systems and integration between front-office (customer-facing) and middle/back office (compliance, supervisory and governance) risk management systems are also considered.

- **Data management and technology infrastructure.** The ability of risk management systems to interact with other systems and handle large volumes of data is considered to be very important. Data quality is often cited as a critical success factor and ease of data access, data integration, data storage and data movement capabilities are all important factors. Particular attention is given to the use of modern data management technologies, architectures and delivery methods relevant to risk management (e.g., in-memory databases, complex event processing, component-based architectures, cloud technology and software as

a service). Performance, scalability, security and data governance are also important factors.

- **Risk analytics.** The computational power of the core system, the ability to analyze large amounts of complex data in a timely manner (where relevant in real time) and the ability to improve analytical performance are all important factors. Particular attention is given to the difference between ‘risk’ analytics and standard ‘business’ analytics. Risk analysis requires such capabilities as non-linear calculations, predictive modeling, simulations, scenario analysis, etc.
- **Reporting and presentation layer.** The ability to present information in a timely manner, the quality and flexibility of reporting tools, and ease of use, are important for all risk management systems. Particular attention is given to the ability to do ad hoc ‘on-the-fly’ queries (e.g., ‘what-if’ analysis), as well as the range of ‘out-of-the-box’ risk reports and dashboards.

Market potential

- **Business model.** Includes implementation and support and innovation (product, business model and organizational). Important factors include the size and quality of the implementation team, approach to software implementation, and post-sales support and training. Particular attention is given to 'rapid' implementation methodologies and 'packaged' services offerings. Also evaluated are new ideas, functionality and technologies to solve specific risk management problems. Speed to market, positioning and translation into incremental revenues are also important success factors in launching new products.
- **Market penetration.** Volume (i.e., number of customers) and value (i.e., average deal size) are considered important. Rates of growth relative to sector growth rates are also evaluated. Also assessed are brand awareness, reputation and the ability to leverage current market position to expand horizontally (with new offerings) or vertically (into new sectors).
- **Financials.** Revenue growth, profitability, sustainability and financial backing (e.g., the ratio of license to consulting revenues) are considered key to scalability of the business model for risk technology vendors.
- **Customer satisfaction.** Feedback from customers is evaluated, regarding after-sales support and service (e.g., training and ease of implementation), value for money (e.g., price to functionality ratio) and product updates (e.g., speed and process for keeping up-to-date with regulatory changes).
- **Growth strategy.** Recent performance is evaluated, including financial performance, new product releases, quantity and quality of contract wins, and market expansion moves. Also considered are the size and quality of the sales force, sales distribution channels, global presence, focus on risk management, messaging and positioning. Finally, business insight and understanding, new thinking, formulation and execution of best practices, and intellectual rigor are considered important.

Quadrant construction process

Chartis constructs its quadrants after assigning scores to vendors for each component of the Completeness of Offering and Market Potential criteria. By aggregating these values, we produce total scores for each vendor on both axes, which are used to place the vendor on the quadrant.

Definition of quadrant boxes

Chartis' quadrant reports do not simply describe one technology option as the best solution in a particular area. Our ranking methodology is designed to highlight which solutions are best for specific buyers, depending on the technology they need and the implementation strategy they plan to adopt. Vendors that appear in each quadrant have characteristics and strengths that make them especially suited to that particular category, and by extension to particular users' needs.

Point solutions

- Point solutions providers focus on a small number of component technology capabilities, meeting a critical need in the risk technology market by solving specific risk management problems with domain-specific software applications and technologies.
- They are often strong engines for innovation, as their deep focus on a relatively narrow area generates thought leadership and intellectual capital.
- By growing their enterprise functionality and utilizing integrated data management, analytics and business intelligence (BI) capabilities, vendors in the point solutions category can expand their completeness of offering, market potential and market share.

Best-of-breed

- Best-of-breed providers have best-in-class point solutions and the ability to capture significant market share in their chosen markets.
- They are often distinguished by a growing client base, superior sales and marketing execution, and a clear strategy for sustainable, profitable growth. High performers also have a demonstrable track record of R&D investment, together with specific product or go-to-market capabilities needed to deliver a competitive advantage.

- Because of their focused functionality, best-of-breed solutions will often be packaged together as part of a comprehensive enterprise risk technology architecture, co-existing with other solutions.

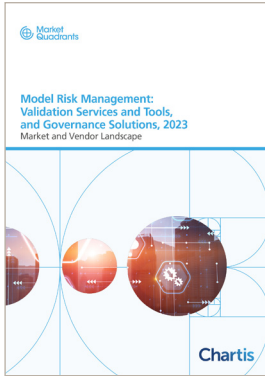
Enterprise solutions

- Enterprise solution providers typically offer risk management technology platforms, combining functionally rich risk applications with comprehensive data management, analytics and BI.
- A key differentiator in this category is the openness and flexibility of the technology architecture and a 'toolkit' approach to risk analytics and reporting, which attracts larger clients.
- Enterprise solutions are typically supported with comprehensive infrastructure and service capabilities, and best-in-class technology delivery. They also combine risk management content, data and software to provide an integrated 'one stop shop' for buyers.

Category leaders

- Category leaders combine depth and breadth of functionality, technology and content with the required organizational characteristics to capture significant share in their market.
- They demonstrate a clear strategy for sustainable, profitable growth, matched with best-in-class solutions and the range and diversity of offerings, sector coverage and financial strength to absorb demand volatility in specific industry sectors or geographic regions.
- They will typically benefit from strong brand awareness, a global reach and strong alliance strategies with leading consulting firms and systems integrators.

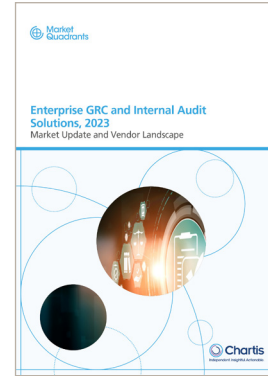
5. Further reading



Model Risk Management: Validation Services and Tools, and Governance Solutions, 2023; Market and Vendor Landscape



Spotlight on Model Risk Management



Enterprise GRC and Internal Audit Solutions, 2023; Market Update and Vendor Landscape



GRC Solutions, 2021; Market Update and Vendor Landscape



Model Validation Solutions, 2019



RiskTech100 2023

For all these reports, see www.chartis-research.com