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Forum Paper

Global perspectives on operational risk management and practice: a survey by the Institute of Operational Risk (IOR) and the Center for Financial Professionals (CeFPro)

Gareth W. Peters,[1,3] George Clark,[2] John Thirlwell[2] and Manoj Kulwal[2]

[1]Department of Actuarial Mathematics and Statistics, Heriot-Watt University, Edinburgh EH14 4AS, UK; email: garethpeters78@gmail.com

[2]Institute of Operational Risk, Pelmark House, 11 Amwell End, Ware SG12 9HP, UK; emails: gclark@ior-institute.org, info@johnthirlwell.co.uk, mkulwal@ior-institute.org

[3]Scottish Financial Risk Academy, Colin Maclaurin Building, Gait 1, Heriot-Watt University, Edinburgh EH14 4AS, UK

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ABSTRACT

This survey represents a comprehensive perspective on operational risk practice, obtained from practitioners in a wide range of countries and sectors. It was developed and executed by two leading organizations in operational risk in the financial services industry: the Institute of Operational Risk (IOR) and the Center for Financial Professionals (CeFPro). This academic paper is a more detailed analysis of the industry report that was jointly created by these organizations. The goal of the survey and its subsequent analysis was to develop an understanding of the dynamic and evolving nature of operational risk management practice from the perspective of industry practitioners. We sought out a large cross-section of industry sectors to capture a truly global view of the discipline's responses. In this regard, we focused

Corresponding author: G. W. Peters

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on developing a survey that would facilitate a greater understanding of the following core aspects of operational risk practice, both at present and with regard to future possible directions:

- the current best practices and approaches to operational risk;
- the tools and skills being applied in practice;
- the discipline's current status in different regions and sectors; and
- the directions the discipline may go in future.

The survey was designed by the authors of this paper on behalf of the IOR and facilitated and collated by CeFPro.

Keywords: operational risk; risk management; machine learning; clustering; artificial intelligence; regulatory technology.

1 SURVEY CONTEXT

Operational risk (OpRisk) practice is going through a process of continual change in a range of areas of the discipline. The significance of OpRisk losses continues to grow in importance as continued large losses are experienced by institutions across the globe. Further, the risk types and categories of most significance to OpRisk modeling and capital management are also evolving, especially with the onset of cyber risk and cyber-related crimes.

Further, there have been significant updates to the regulatory requirements for OpRisk modeling and capital quantification. For instance, the approach that all banks should take with regard to quantifying their Pillar 1 capital has recently been modified. The Basel Committee on Banking Supervision proposed to replace all approaches, including the advanced measurement approach (AMA), for OpRisk capital with a simple formula referred to as the standardized measurement approach (SMA). For a more detailed discussion on the quantitative and practical aspects of this proposed SMA model framework change, see, for instance, Peters *et al* (2016a).

These significant changes may have far-reaching effects on the discipline of OpRisk as well as the perspectives of the practitioners implementing and managing OpRisk on a daily basis. In the presence of such substantial changes in OpRisk management and practice, we have decided to survey practitioners to understand their perspectives on the current state of OpRisk practice and how they see it emerging in the future. In order to achieve this, a joint initiative between the Institute of Operational Risk (IOR) and the Center for Financial Professionals (CeFPro) was established to conduct a global survey in order to gather information about the future

of the OpRisk discipline and possible emerging directions of practice. The highlights and the results of the survey are analyzed in depth in this paper, and an industry summary with the same name has been created for practitioners, providing insights on the following:

- the current best practices and approaches to OpRisk;
- the tools and skills being applied in practice;
- the discipline's current status in different regions and sectors; and
- the directions the discipline may go in future.

The survey was completed as an online questionnaire with 32 questions. It featured 749 respondents from more than 60 countries, with a significant proportion of the respondents coming from the United Kingdom and the United States. The respondents were drawn from IOR and CeFPro members and attendees of CeFPro events between October 2017 and December 2017. The leading countries in terms of response proportion were the United Kingdom, with 29.02%; the United States, with 27.98%; and Canada, with 6.74%. Further, the countries boasting four or more different organizational responses included Mexico, Luxembourg, Italy, Ghana, Denmark, Switzerland, Malaysia, Sweden, India, China, Australia, Singapore, Germany, Belgium, France, Greece, Nigeria, Ireland and the Netherlands. In terms of question-response rates, the typical response rate was greater than 75% for all survey questions, which means the data is of sufficient quality for a detailed analysis. The complete list of respondent countries and number of institutional respondents is provided in Table 1.

We believe that such a significant cross-section of OpRisk practitioners represents one of the most comprehensive surveys on OpRisk practice undertaken to date. Consequently, we believe the findings should shed important light on the differing perspectives in this discipline.

2 SURVEY DESIGN AND QUESTIONS

In this section, we outline the survey questions that were posed to practitioners. The following summary of the question types indicates the classes of response we sought from practitioners. The survey questions were designed to seek a range of response types, including scored ordinal responses and categorical responses as well as quantitative (numerical) and qualitative (descriptive) responses. We indicate the question-response type sought in brackets after the question using the following labels: num – numerical response; cat – categorical response; ord – ordinal response; and des – descriptive response.

TABLE 1 Respondent countries of OpRisk practice.

Country	Proportion (%)	NOR	Country	Proportion (%)	NOR
UK	29.02	168	US	27.98	162
Canada	6.74	39	Netherlands	3.28	19
Ireland	2.59	15	Nigeria	2.42	14
Greece	2.25	13	France	1.55	9
Belgium	1.38	8	Germany	1.38	8
Singapore	1.38	8	Australia	1.21	7
China	1.04	6	India	1.04	6
Sweden	1.04	6	Malaysia	0.86	5
Switzerland	0.86	5	Denmark	0.69	4
Ghana	0.69	4	Italy	0.69	4
Luxembourg	0.69	4	Mexico	0.69	4
Chile	0.52	3	Norway	0.52	3
Poland	0.52	3	Romania	0.52	3
Saudi Arabia	0.52	3	South Africa	0.52	3
Brazil	0.35	2	Czech Republic	0.35	2
Lebanon	0.35	2	Malta	0.35	2
Qatar	0.35	2	Ukraine	0.35	2
UAE	0.35	2	Zimbabwe	0.35	2
Albania	0.17	1	Algeria	0.17	1
Argentina	0.17	1	Botswana	0.17	1
Bulgaria	0.17	1	Costa Rica	0.17	1
Cyprus	0.17	1	Finland	0.17	1
Hungary	0.17	1	Israel	0.17	1
Japan	0.17	1	Kenya	0.17	1
Liechtenstein	0.17	1	Mongolia	0.17	1
Nepal	0.17	1	New Zealand	0.17	1
Pakistan	0.17	1	Peru	0.17	1
Portugal	0.17	1	Sri Lanka	0.17	1
Sudan	0.17	1	Uganda	0.17	1
Vietnam	0.17	1			

NOR denotes “Number of respondents”.

(1) What industry do you work in? [cat]

(2) How many years of experience have you had in similar or related roles to the current role you are performing? [num]

(3) Please specify which country you work in. [cat]

(4) How would you classify your role with regard to categories such as: business focus; IT and development; quantitative modeling; risk management; actuarial and capital management; accounting and audit; legal and compliance; data analytics; or other roles? [cat]

(5) Rate your familiarity with regulatory guidelines for OpRisk. [cat]

(6) How many employees work in the OpRisk function in your organization? [num]

(7) Which of the following risk categories are included within your organization's OpRisk framework: conduct risk; cyber risk; financial crime risks; regulatory compliance risks; business continuity risks; technology risks; and legal risks. [cat]

(8) What is the status of OpRisk in your organization: nonexistent; design phase; implementation phase; in use; mature? [cat]

(9) Describe your organization's approach toward OpRisk frameworks and toolkits from the perspectives of: meeting minimum regulator requirements; aligning to practice within your own industry; aligning to practice across a range of industries; developing a bespoke solution specific to your business practice; seeking to innovate in modeling, data collection and management in OpRisk. [cat]

(10) How is OpRisk management perceived within the organization by board and senior executives? [cat]

(11) OpRisk in my organization is: not understood; a subset of another risk; all about controls; understood as a people, process and systems risk; or operated in silos of risk (cyber, fraud, information, ...). [cat]

(12) What is the governance structure for OpRisk management in your organization? [cat]

(13) What are the core objectives of your approach to OpRisk? [cat]

(14) What key attributes are sought from candidates when recruiting OpRisk resources? [cat]

(15) What is the importance of OpRisk data in your management decision processes? [ord]

(16) In your experience, how important is the role played by scenario analysis in OpRisk management? [cat]

(17) In your experience, how important is the role played by key performance indicators, key risk indicators or key control indicators (BEICFs) in OpRisk management? [cat]

(18) Rate the significance of OpRisk model outputs to your risk management decision process. [ord]

(19) Comment, based on your experience, how the collection of OpRisk data (internal, external, scenario analysis and BEICFs (KRIs, KPIs, KCIs)) might be enhanced. [des]

(20) In your experience, list the three most significant sources of loss in the Basel II OpRisk event types and business units in your institution at present. [des]

(21) Choose the option that best describes how OpRisk resources in your organization might evolve over the next five years. [cat]

(22) Rank in order of significance the following categories that you foresee an OpRisk manager having mastery of in five years' time: business functionality and processes; interpersonal skills; quantitative skills (statistical or stochastic modeling); data analytics skills (data mining, data analysis and machine learning); regulatory and legal expertise; audit and capital management expertise (actuarial or accounting); and IT and technology skills (including hardware and software). [ord]

(23) Rank the following categories from most significant to least significant for your organization over the next twelve months: developing the OpRisk skills and knowledge of employees; improving OpRisk frameworks and processes; enhancing OpRisk data collection, scenario developments and BEICFs (KRIs, KPIs, KCIs); meeting regulatory obligations; reporting and analysis for OpRisk; and technology solutions. [ord]

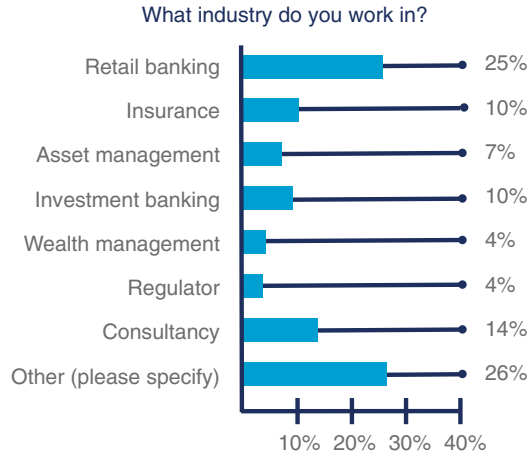
(24) Comment on what you think the discipline of OpRisk will look like in five years' time. [des]

(25) Does your organization encourage attainment of professional certifications in risk management?

(26) Does your organization encourage participation in OpRisk workshops or conferences?

(27) How would you want a professional body (such as IOR, the Institute of Risk Management, the Risk Management Association, the Office of the Registrar of Indigenous Corporations, the Global Association of Risk Professionals, etc) to contribute to the development of the OpRisk discipline?

FIGURE 1 Industry sector decomposition of respondents.



3 DESCRIPTIVE DATA ANALYSIS OF RESPONSES

We begin our data analysis with a basic descriptive summary of the survey responses. In particular, we begin with a question-wise summary of the responses that outlines the basic attributes and outcomes of the responses obtained. Further, we compare whether the results were statistically different between the three main populations of respondents, grouped as the United Kingdom, the United States and the rest of the world.

3.1 Summary of the surveyed population

In Figures 1 and 2, we show the breakdown of responses received by industry.

Within the significant number of "Others" (26%), there were also responses from the financial services industry and related areas such as financial technology (FinTech), payment and services, microfinance, central banks, mutual funds, legal, pensions, clearing and settlement, tax, audit groups, software and IT, and ratings agencies. Outside of financial services, a relatively small number of respondents came from travel and hospitality, education, manufacturing, medical and not-for-profit organizations. Respondents therefore represented a wide cross-section of industries, with the vast majority coming from financial services.

The results in Figure 3 demonstrate that we also captured a broad spectrum of experience, ranging from those relatively new to the area of OpRisk through to established career professionals in senior roles.

FIGURE 2 Distribution of respondents in (a) retail banking, (b) insurance and (c) investment banking.

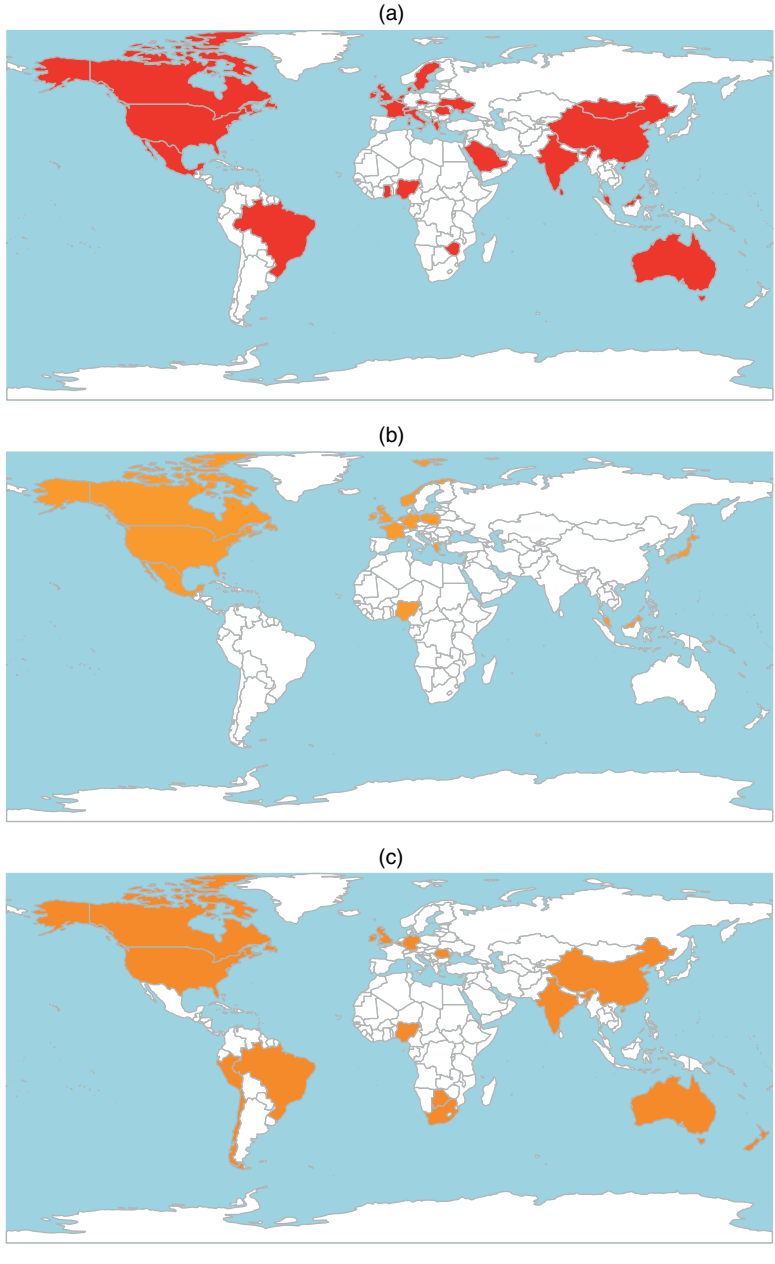
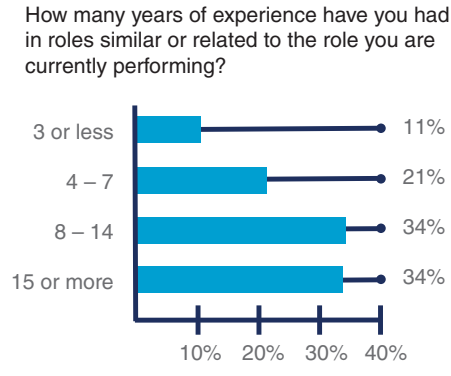


FIGURE 3 Years of experience in OpRisk management.



Given this discipline really only started just over twenty years ago, it is impressive that a third of respondents had been in OpRisk for more than fifteen years, and that a further third had been in OpRisk for more than eight years.

In Figure 4, we outline the roles of the respondents by core areas or disciplines of practice area. Respondents were asked to classify their roles by practice area. The vast majority of respondents (67%) were risk management professionals, followed (a long way behind) by business-oriented roles.

In Figure 5, we summarize responses on the importance of understanding regulatory requirements. Given the importance of OpRisk professionals understanding regulatory requirements, it is not surprising that, when asked about their familiarity with regulatory guidelines for OpRisk, approximately half of the sample of respondents said they were very familiar with OpRisk regulations and requirements, while the other half said they had at least basic familiarity.

Only a very small number of respondents answered no or said that such regulations were not relevant to their role.

We also demonstrate in Figure 6 that the distribution of respondents with roles requiring expert knowledge on the regulation of OpRisk practice is not concentrated in certain jurisdictions. This is a positive indication of the importance that regulation plays globally in understanding OpRisk practice and management.

3.2 Summary of the respondents' operational risk work environments

In this section, we highlight the characteristics of the workplaces and OpRisk environments in which respondents operate. In Figure 7, we demonstrate the size of

FIGURE 4 Discipline of practice.

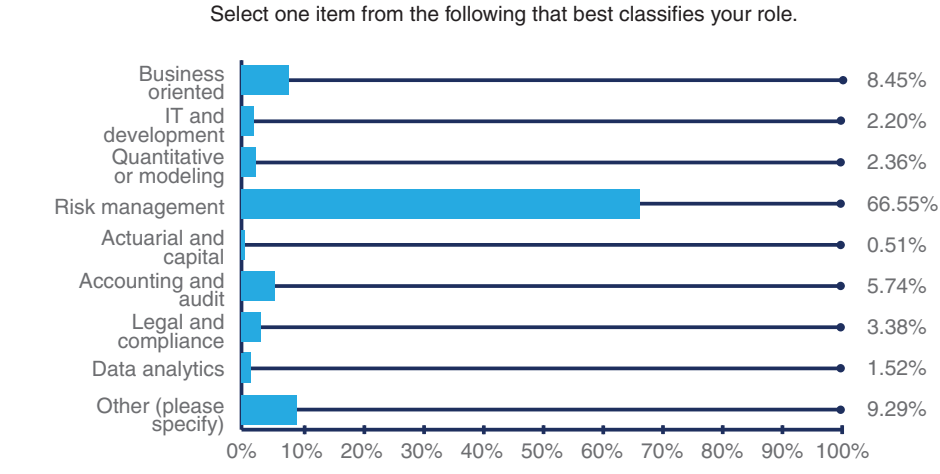
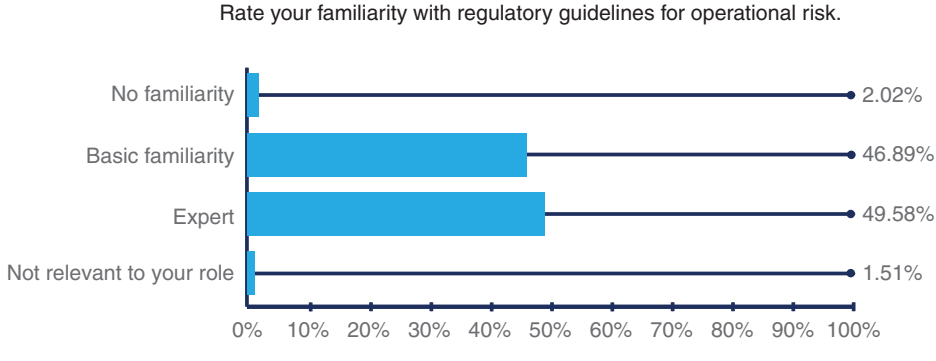


FIGURE 5 Regulation knowledge and familiarity.



the OpRisk function in the respondents' workplaces via the number of full-time employees dedicated to OpRisk management and practice.

Then, in Figure 8, we consider the range of practices in each respondent's organization, with regard to OpRisk core areas. This allows us to gauge the scope and breadth of OpRisk practices in each respondent's work environment. We allowed those surveyed to provide more than one response to this question, and we see that a wide range of practice areas is represented by the respondents' workplaces.

FIGURE 6 Distribution of respondents requiring (a) expert knowledge of regulations in OpRisk and (b) basic knowledge.

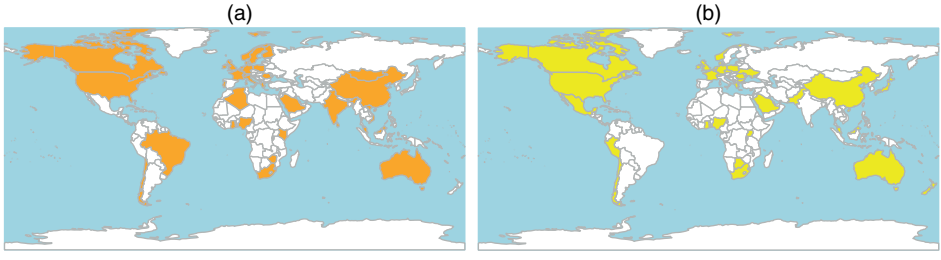


FIGURE 7 Number of full-time employees dedicated to OpRisk management and practice per respondent's workplace.

In Figure 9, we highlight the development status of OpRisk management and practice. The majority of respondents reported that OpRisk systems, practices and risk management were in play at their institutions, while the remaining respondents were approximately equally divided between those in development phases and those reporting a mature environment. Later, we will see in a cluster analysis (where we look at multiple attributes together) whether there is in fact a geographical distinction in this regard between the respondents.

We learn from Figure 10 and the subsequent cluster analysis performed in Section 4 that there is a range of stages of development of OpRisk systems in North America. However, other developed countries generally consider their OpRisk systems to be either in use or mature. Interestingly, some of the countries with the oldest OpRisk systems in development, such as Australia, consider their systems to be

FIGURE 8 Breadth of practice and scope of discipline coverage in each respondent's work environment.

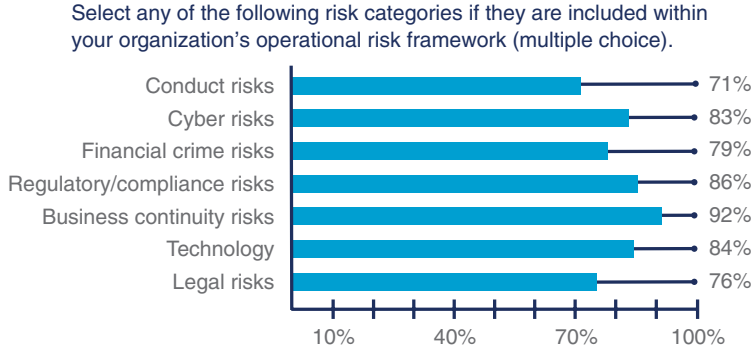
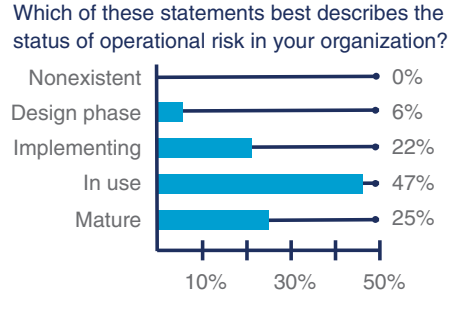


FIGURE 9 Development status of OpRisk modeling and management.

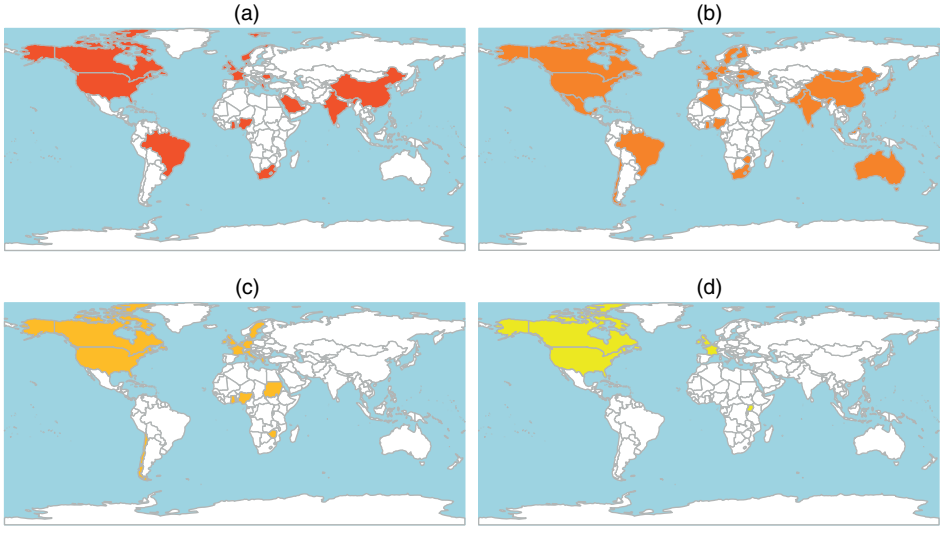


in use and not mature, whereas other countries with perhaps less advanced developments in OpRisk modeling practice may consider their OpRisk systems to be mature. We speculate that this is due to the fact that they have not gone through the various stages of AMA approval and subsequent model and system adjustments, which are ongoing in such a process, that occurred in countries such as Australia for the last fifteen-plus years.

3.3 Summarizing operational risk levels of industry innovation

The survey also sought to understand the respondent firms' approaches to OpRisk innovation as opposed to basic regulatory compliance. In Figure 11, we see that the majority of respondents reported that their firm's primary objective is to align

FIGURE 10 Distribution of respondents reporting that their OpRisk model is (a) mature, (b) in use, (c) being implemented and (d) being designed.



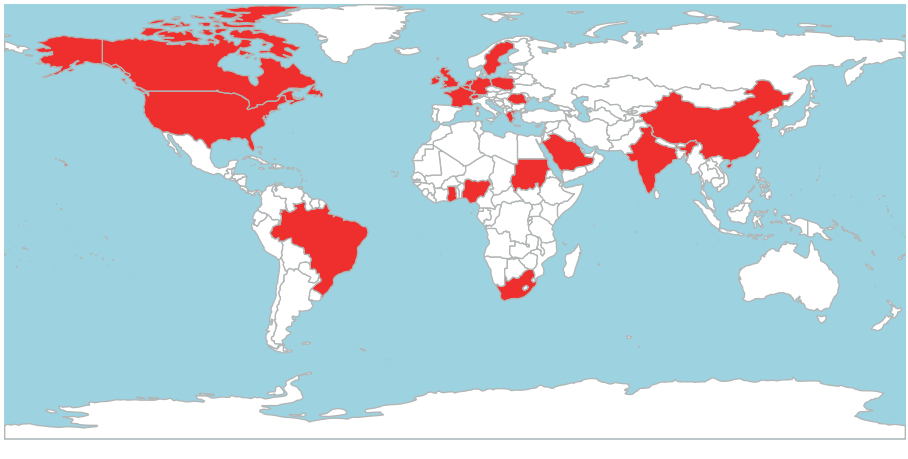
with standard practice within their industry, which, given the breadth of industries represented, could indicate a diversity of practice.

However, the second-highest response (26%) showed that respondents were aiming to innovate and be leaders in terms of industry best practice. This and the next largest response, which relates to "developing bespoke solutions", show that a generally outward and innovative approach is taken by practitioners. In Figure 12, we demonstrate the distribution of respondents by country that identified their institution's practice as being innovative in the area of OpRisk management and modeling. There appear to be no problems with concentration in particular countries in this regard, as institutions across the globe are seeking to innovate what is considered best practice. This bodes well for diversity in development as well as understanding of OpRisk management and modeling, as suggestions will be coming from a diverse range of personnel.

It is also important to gauge the significance given to OpRisk management and practice at the senior executive level of our respondents' firms. In Figure 13, we demonstrate responses to this topic. The majority of respondents felt that their senior executives believed OpRisk should comply with regulation and form an active input in terms of value creation. This indicates that, in many areas, OpRisk has moved beyond the phase of simple regulatory compliance, becoming a valued component

FIGURE 11 Decomposition of institutions according to their target practice in OpRisk management and modeling objectives.

FIGURE 12 Distribution of institutions that seek to innovate and be leaders in industry best practice in OpRisk management and modeling.



of decision-making practice and a tool to guide and facilitate the setting of firms' risk appetites.

In a related strand of questioning, we also tried to discern additional perspectives on OpRisk's role in respondents' institutions. Here, they were permitted to select more than one category pertaining to perceptions of OpRisk and its main priorities in practice. The specific selections offered and responses are provided in Figure 14.

FIGURE 13 OpRisk perceptions by the board and senior management executives.

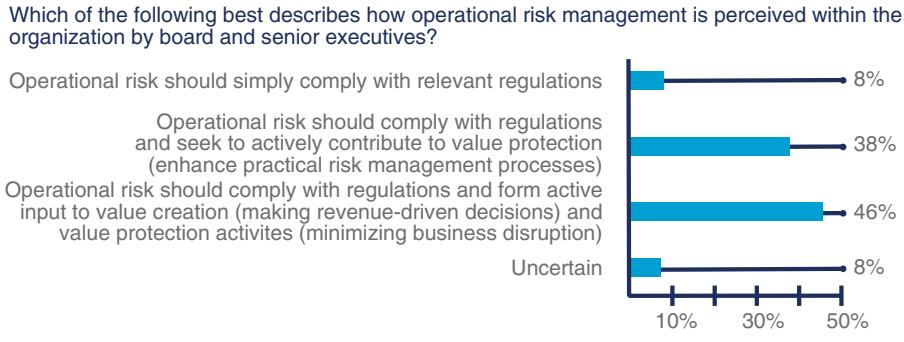


FIGURE 14 General perceptions of OpRisk in respondents' institutions.

The clear majority of respondents identified their organization's perception of OpRisk as focused primarily on people, processes and system risk. The next most dominant categories selected were that OpRisk is a control-driven discipline and that it is often operated or implemented in practice in silo-based structures, rather than uniformly integrated across an institution. This is an interesting point to raise regarding change management and governance structures.

In Figure 15, we see that the respondents who believe their institution develops OpRisk systems using a silo-based approach are located in a range of countries including the United Kingdom, France, Germany, North America, China and Australia. However, one also finds that, reassuringly, many respondents in other institutions in these countries also identified with more integrated approaches to OpRisk. For instance, in Figure 15(b) we see the countries in which respondents identified

FIGURE 15 Distribution of respondents reporting that their OpRisk model is (a) developed in silos or (b) understood as about people, processes and systems risk.

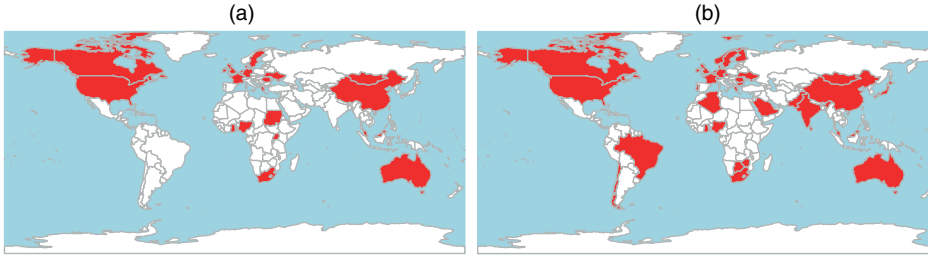
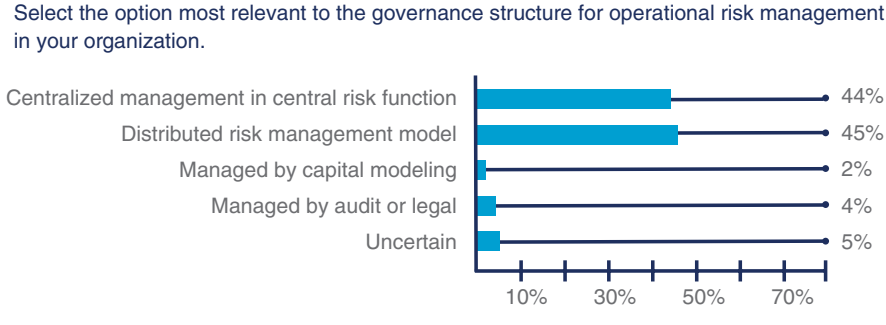


FIGURE 16 OpRisk governance structures.



with the more unified perception that OpRisk is understood as addressing people, processes and systems risk. This indicates that there is not necessarily a concentration of silo-based management practice in any one major economy when it comes to OpRisk management practice.

In the next questions, we sought to learn about the governance structure of respondents' organizations and how they are structured with regard to OpRisk (see Figure 16). The majority of respondents identified their governance structure as one of two structures: the most common was one with a central risk functionality, while the second most common was one that was distributed throughout the organization. In Figure 17, we demonstrate the distribution of governance structures, by country, that are either centralized or distributed. We see that there is a healthy range of practices in most developed economies, and we suspect that the distinguishing factor is largely due to the size of respondents' organizations.

FIGURE 17 Distribution of respondents reporting that their OpRisk model governance structure is (a) centralized and (b) distributed.

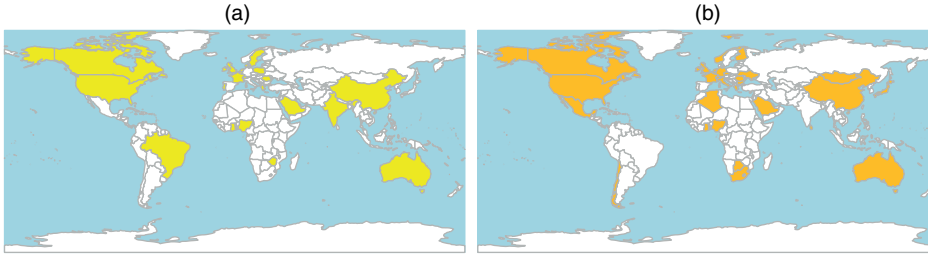


FIGURE 18 Institutions' objectives for OpRisk management practice.

In Figure 18, the respondents were given the option to select one or more categories for their response, as relevant to their OpRisk environment. The question sought responses regarding the core objectives of their approach to OpRisk. The leading category was process improvement and efficiency, closely followed by meeting regulatory requirements and improving decision making.

The survey also allowed for an analysis of the skill sets that respondents identified as highly desirable in individuals they would seek to hire in an OpRisk role in their organization. The responses in Figure 19 demonstrate that most respondents said the leading skill they required was knowledge of OpRisk theory and concepts, followed by knowledge of how to work with and influence people. The answers of the 465 respondents, who ranked the attributes from 1 to 5, are also provided in Table 2.

Further, approximately 30% of respondents indicated that OpRisk was highly significant in their decision-making processes and business practices, with only 3%

FIGURE 19 Desirable attributes required from new recruits in OpRisk.

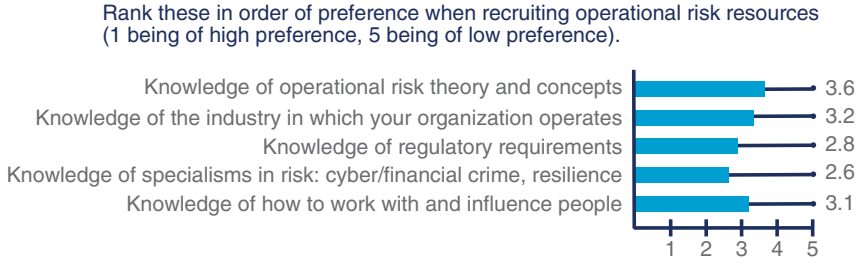


TABLE 2 Rankings from respondents related to the desirable attributes they seek to enhance or develop in order to better perform their roles in risk management.

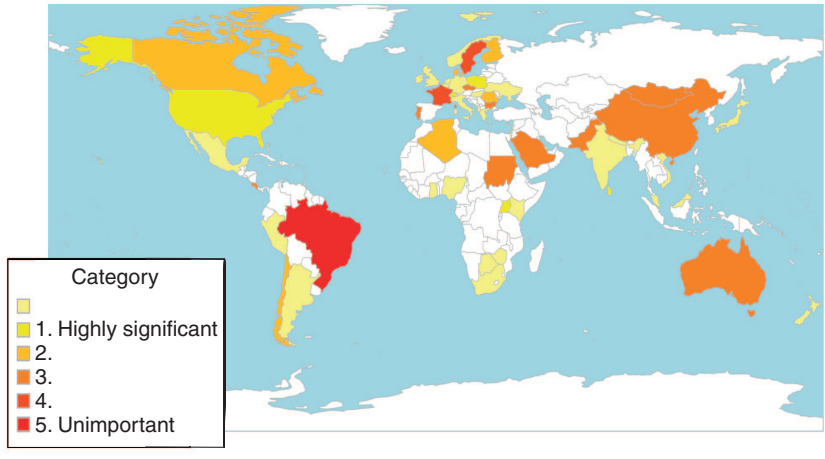
Attribute	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
OpRisk theory and concepts	143	77	72	160	43
Knowledge of your industry sector	89	93	94	77	47
Knowledge of regulatory requirements	56	74	97	106	84
Specialities in OpRisk: cyber, financial crime, ...	46	70	93	94	125
Ability to work with and influence people	93	115	82	70	93

of respondents indicating that OpRisk was unimportant for such decision-making processes.

3.4 Significance of data collection, analysis and modeling

In this section, we explore the perspectives of data collection, data use and modeling in the respondents organizations. In Figure 20, we provide a spatial distribution of the importance placed on data by institutions managing and modeling OpRisk throughout the world. We see that, surprisingly, some large European countries such as France and the Netherlands had respondents who – compared with other major economies such as the United Kingdom, the United States, Asia and Australia – ranked the importance of data relatively low in their institutions. One may speculate that this is driven by a concern in these countries that reflects the status of the

FIGURE 20 Significance placed on utilization of data in OpRisk management practice.



changes occurring at present with the SMA, which requires no detailed data capture for capital evaluation (see discussions in Peters *et al* (2016a) on this point).

Next, we aim to explore in more depth the role played by the four major types of data in OpRisk practice, according to Basel II/III, namely, the BEICFs, scenario analysis, and internal and external data. In Figure 21, we show the surveyed respondents' views on the role played by scenario analysis in their OpRisk management. The majority of respondents clearly identified that at this stage scenario analysis is only used indirectly in decision-making processes. However, over a quarter of respondents seem to use scenario analysis directly in decision-making processes. Concerningly, a little under a quarter identified that scenario analysis was not considered at all. In Figure 22, a spatial distribution of respondents that answered with direct, indirect or no use of scenario analysis is presented.

We see that, of the respondents who claim that scenario analysis has not been used in their experience of OpRisk management or modeling, the major economies that had respondents in this category also had a healthy mix of direct and indirect utilization of scenario analysis, indicating no systemic failure in the use of this core piece of OpRisk data.

With regard to BEICFs and the role of key performance indicators, key risk indicators and key control indicators, 43% of respondents identified that these were used directly in decision-making processes.

FIGURE 21 Significance and role of scenario analysis in OpRisk practice.

In addition, approximately 15% of respondents claimed that models used to quantify OpRisk were directly used in OpRisk management practice and decision-making processes. A further 25% and 29%, respectively, indicated that OpRisk model outputs were applicable to some degree in their risk management practices, rather than simply for capital quantification. However, approximately 14% of respondents indicated that in their opinion the output from OpRisk modeling had no bearing on management practices or decision-making processes, indicating clear communication gaps between the quantitative, risk management and business units in these organizations.

When respondents were asked to comment, based on their experience, on how the collection of OpRisk data (internal, external, scenario analysis and BEICFs (KRIs, KPIs, KCIs)) might be enhanced, an interesting array of responses was received. A key selection of the received responses is summarized as follows according to three main themes:[1]

- classification and collection frameworks;
- automation and standardization of indicators; and
- regulator guidance and requirements.

Several respondents said it would be beneficial to have a core set of factors, including BEICFs, incorporated by all banks. This aligns with discussions on this topic in Peters *et al* (2016a) and Peters *et al* (2016b) that were raised in response to the SMA.

The following types of KRI categories can be considered in developing a core family of factors (see Chapelle 2013).

[1] Minor rewording of responses is performed to improve grammatical structure.

FIGURE 22 Distribution of respondents' utilization of scenario analysis: (a) directly used, (b) indirectly used and (c) not in use.

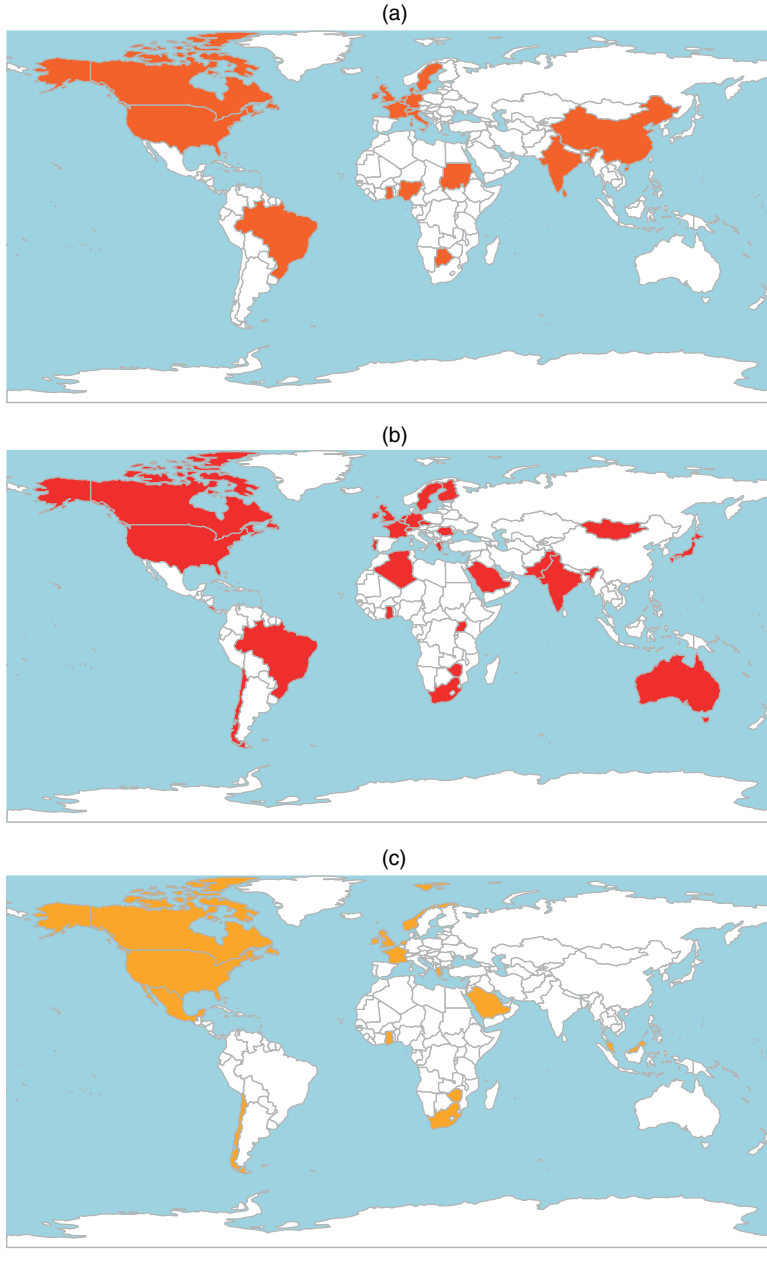
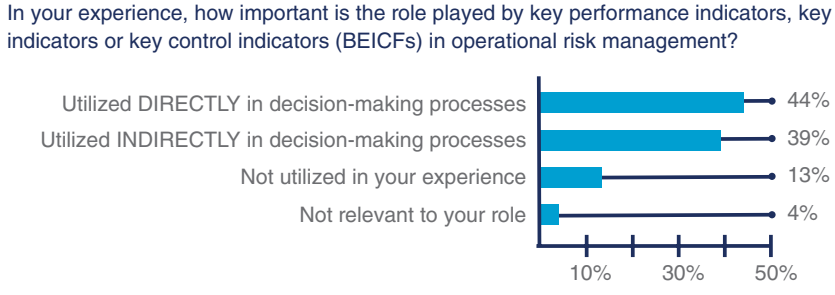


FIGURE 23 Significance of the role of BEICFs in OpRisk management and practice.



Exposure indicators. Any significant change in the nature of the business environment and in its exposure to critical stakeholders or critical resources. Flag any change in the risk exposure.

Stress indicators. Any significant rise in the use of resources, whether human or material, by the business. Flag any risk arising from overloaded humans or machines.

Causal indicators. Metrics capturing the drivers of key risks in the business. The core of preventive KRIs.

Failure indicators. Poor performance and failing controls are strong risk drivers. Failed KPIs and KCIs.

3.4.1 Classification and collection frameworks

A number of survey respondents identified an increased need for organizations to focus on improving the classification and collection frameworks for such OpRisk data, such as indicators relevant to KRI collection. In particular, there were many responses relating to taxonomy and the classification of processes as well as the resulting indicators that may be collected. In order to distill this information into recommendations for industry focus, we highlight some key points raised from these responses that should lead to directly actionable outcomes in industry practice. We also highlight the steps that are currently being taken by relevant industry parties to address such concerns.

3.4.1.1 Centralized repository and taxonomies of OpRisk. A recurring theme that resonates throughout practitioners' responses is a desire to be able to access more centralized and automated databases for the collection of OpRisk data, particularly

aspects of scenarios and KRIs. There were several requests for improved IT infrastructure in order to create the ability to automatically extract data from a range of disparate systems that the OpRisk discipline should monitor. This would require management to reconsider priorities with regard to IT infrastructure in institutions not already in the process of developing such architectures. However, risk managers and modelers clearly perceive a significant value-add in such expenditures with regard to their ability to enhance reporting for decision making.

It is also worth noting that other commercial data providers have picked up on this sentiment from practitioners in OpRisk management, and have subsequently begun to develop their commercial product offerings to address this concern, at least with regard to external data provision. For instance, the Operational Riskdata eXchange (ORX) consortium of 100 financial institution members in twenty countries has begun to evolve their data provision capabilities to address such concerns from practitioners in both banking and now also the insurance sector.[2]

Note that it is not simply the ability to collect data in a central repository that is important in these considerations. Based on respondents' opinions, it is also critical that consideration be given to the type of data collected, the frequency of data collection and the availability and verifiability of data in a timely and cost-effective manner. Further, we note that, in practice, raw data collection may not be perceived as directly useful in terms of decision making or as a model input; therefore, the best manner in which to summarize the core statistical features of the data should be considered. If undertaken properly, this will strike the right balance between keeping the costs of storing massive data sets and conducting audits down and improving the ability to use the data in practice. A large movement is currently underway in risk management and the banking and insurance sectors in general to address questions of machine learning and feature extraction from massive disparate data sets in order to better provide summary data for practitioners' use (see the discussions in Peters (2017) for more details on such methods).

Further, since 2014, industry forums such as the CRO Forum (www.thecroforum.org) have been developing recommendations for best practice with regard to minimum data standards for reporting loss events to an OpRisk loss data repository. These standards are also being adopted for new, emerging data sources such as KRIs in conjunction with groups such as ORX. The main issue here is to do with the uniformity of centralized repositories.

This should help to overcome the concerns voiced by survey respondents regarding the lack of consistency in type, quality and classification of OpRisk data that often occurs internally as well as in vendor solutions. As the CRO Forum observed in their industry standard report (https://bit.ly/2NrbQow):

[2] See https://managingrisktogether.orx.org/research/future-loss-information.

> Currently, the practice is that different providers for loss database services use their own standards. The CRO Forum has an interest of compatibility of operational loss data at the level outlined is this document, in order to allow for a potential industry wide view on operational risk events. The purpose of the minimum standards is to ensure compatibility between different loss databases with different database providers. Different providers can create additional standards and guidelines, but are asked to adhere to the standards described here to ensure that the data is mutually exchangeable.

However, this report was authored in 2014, and the industry in general has evolved significantly since this time. The report also does not address the insurance sector. Based on the responses to the survey, it is time for a reappraisal of such standards.

Further, the standards at the time this report was written were based on the now-classical but still regulatory standard Basel II fifty-six-cell risk- and business-type OpRisk taxonomy. One concern raised by survey respondents was that such a classical taxonomy may not be able to meet the needs of emerging classification for risk types such as cyber risk, second/third party vendor risk and reputational risk. Such concerns, coming directly from a large collection of industry professionals who are facing classification difficulties using the current taxonomy of OpRisk, should also be addressed in establishing centralized databases to ensure the data is suitable for purpose. This is an evolving debate that is being played out at present regarding taxonomy considerations.

We complete the remarks on this important aspect of our survey by noting that other groups, such as the large FinTech company Broadbridge (www.broadridge.com), are also beginning to offer the ability to implement and monitor relevant KRIs for industry practitioners in OpRisk. They provide outsourced centralized implementations of data analytics to facilitate the collection of such data for risk management practice. Such solutions also offer an alternative to in-house developments or a complementary supplement.

3.4.2 Regulatory guidance and requirements

A second theme we identified from respondents was related to their perception of a need for regulators to be more specific on guidance regarding BEICFs and their standardization, collection and use in models.

3.4.2.1 Enhanced understanding of analytics and reporting. The respondents highlighted the need for improving the way data analytic ideas and machine-learning methods were integrated into industry practice, particularly decision-making practice. One could infer from the responses that there is still a divide between the development of these new methods, which is advancing at a record pace in the industry,

and the practice of applying these tools to real and meaningful practical risk management decision making. A greater awareness is required of the features of such data analytic methods as well as what these methods can and cannot be used to analyze, how reliable they are in practice from a reproducibility perspective, and how robust they are when changing data sources. This is an inherent problem in the adoption of all new industry technologies, although it is one that is being addressed at present in the risk and insurance industry. This means we will hopefully avoid such methods being treated as "black boxes", except by specialized quants, and then misused or inappropriately interpreted.

Avoiding problems such as the above involves enhancing the education surrounding these emerging methods. As a result, many groups are responding to this new wave of analytic tools and methods. For instance, the IOR (www.ior-institute.org) is in the process of drafting sound practice guidance documents that address aspects of machine learning and data analytic methods for OpRisk practitioners to alleviate the concern that such methods are simply treated as black boxes. In Cruz *et al* (2014), the authors outline several data analytic methods applicable to emerging trends in data analytics specifically for OpRisk practice.

Further, several high-level reports have been commissioned in the last year to further promote the importance of addressing such considerations. For instance, the Royal Statistical Society (RSS) in the United Kingdom commissioned a report on machine-learning data analytics as input for a UK government report on artificial intelligence and how it affects a range of industry areas, including banking and insurance practice (see Royal Statistical Society 2017).

The key findings of this report are consistent with the above considerations. Below, we quote the relevant points voiced by the RSS report:

> [Recommendations of the Royal Statistical Society report...]
>
> - Introducing funded Masters courses in Machine Learning to develop a pool of informed users of machine learning across business, industry, and research sectors
> - Increasing training at PhD level and beyond to invest in the next generation of research leaders in machine learning
> - Integrating machine learning into the government's industrial strategy to help businesses make effective use of this technology
> - Continuing to build on the UK's track record of open data and safe sharing of data.

Further, the Bank of England has also developed reports on machine-learning methods, one of which was published in January 2018 (Fletcher 2017). This report focuses on understanding and explaining how best to use different machine-learning tasks for practical applications, in this case, in central bank data analytic tasks. For a more

detailed and complete mathematical treatment in both risk and insurance contexts, see Peters (2017) and the references therein.

In the insurance sector, the Institute and Faculty of Actuaries is taking the emerging machine-learning trend very seriously (https://bit.ly/2QJQKQf). It has introduced a new syllabus so that practical actuarial qualifications now contain a new module for machine learning as relevant to insurance and risk management (www.actuaries.org.uk/documents/syllabus-2019).

In particular, the new syllabus will address core competencies in CS2: Actuarial Statistics 2, which requires sound understanding of core areas such as

- describing and using statistical distributions for risk modeling,
- describing and applying the main concepts underlying the analysis of time series models,
- describing and applying Markov chains and processes,
- describing and applying techniques of survival analysis, and
- describing and applying basic principles of machine learning.

For a detailed textbook review for OpRisk practitioners that covers each of these core components from first principles, see Cruz *et al* (2014).

3.5 Summary of future perspectives on operational risk practice and management

In this section of the survey, we sought the perspectives of respondents regarding their future expectations of the development directions that OpRisk may take as well as the impact it may have in the future. This is particularly relevant, as there is a growing perception among industry practitioners that OpRisk is perhaps becoming more significant than more traditional sources of risk such as market and credit risk, which are more established and understood. Therefore, we thought it important to gauge the opinions of practitioners on key attributes of OpRisk in the next five years.

In Figure 24, we summarize the perspectives on OpRisk resources in respondents' organizations. It is clear that most respondents believe the number of OpRisk resources will increase in future. This is consistent with the general perception of the emergence of OpRisk as a core risk class that may surpass market and credit risk in terms of significance. This was followed by the belief that specialist risk resources will increase.

In Figure 25, we explore what participants believed were critical skill sets for OpRisk managers in the next five years. The leading attribute identified by respondents, who were asked to rank their selections, was an understanding of business

FIGURE 24 Future perspectives of OpRisk resource requirements in the next five years.

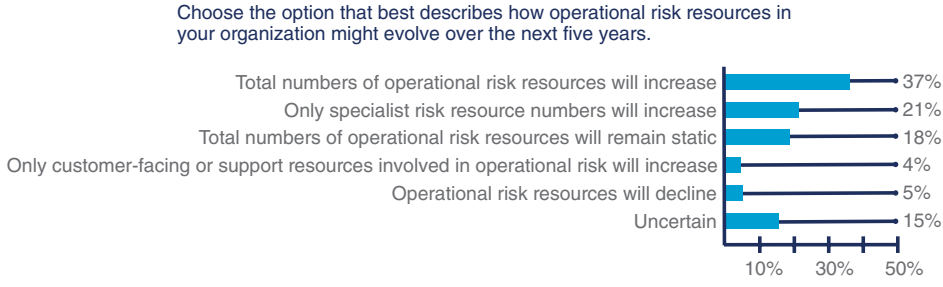
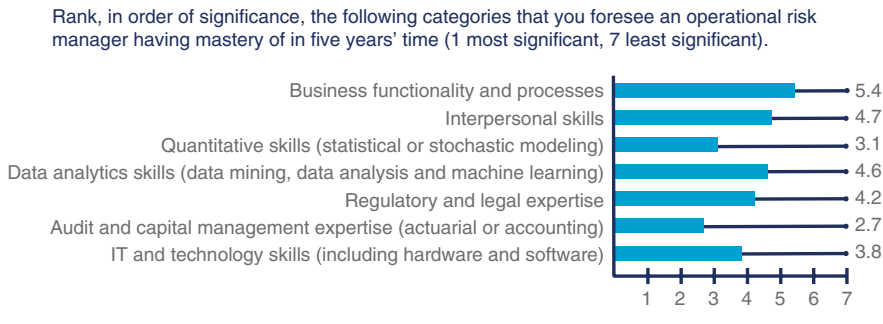


FIGURE 25 Major attributes and skills required for future OpRisk managers.



functionality and processes. This was followed by interpersonal skills and data analytic skills, which included aspects of machine learning and statistical data analysis. Aspects of regulatory and legal expertise were ranked third, followed by IT and technology skill sets.

In Figure 26, we sought the perspectives of OpRisk development in the near future, looking at a twelve-month horizon, and asked respondents to, again, rank their views on key imperatives for OpRisk development in their organizations. The leading focus for the next year was primarily continued development of operational skills and knowledge of employees, followed closely by improvement in OpRisk frameworks and processes. Meeting regulatory requirements over the next year was systematically downranked by respondents, a surprising outcome given the significant changes that are occurring in OpRisk regulation with the proposal of the SMA: see discussions in Peters *et al* (2016a).

FIGURE 26 Perspectives on OpRisk major developments in the next twelve months.

Next, respondents were given the option to share their perspectives on the discipline of OpRisk in the next five years of practice. A selection of the core responses received are itemized below.[3] The general themes identified were as follows:

- proactive suggestions and perception of growth and development of OpRisk practice, particularly in perspectives of data, machine learning, and data analytics and automation; and
- perceptions of the consolidation of OpRisk as a discipline.

3.5.1 Proactive suggestions and perception of OpRisk growth: data, analytics and automation

The vast majority of respondents who expressed views on the next five years of OpRisk development across the multiple countries and sectors surveyed highlighted that people perceive that big data, data analytics and machine learning will play a dominant role in transforming the automation and interpretation of OpRisk data.

In addition, many conceptualized a risk universe in which automation by such methods would feed more directly into risk processes and management as well as the setting of risk appetites, from the top executive level through to the day-to-day business decisions and actions of risk managers.

There was a sense from the responses received that practitioners perceived OpRisk practice to be moving from a discipline operating in a responsive mode, so-called fire-fighting, to one involving more proactive approach in terms of the OpRisk management practices and models adopted.

There were also concerns, which we feel were positive considerations, related to how best to source and incentivize the most appropriately talented and ambitious

[3] Minor rewording of responses is performed to improve grammatical structure.

practitioners into OpRisk roles in future. Such practitioners should have adequate business expertise in OpRisk management practice as well as be savvy with regard to emerging data analytic and machine-learning methods.

Numerous responses highlighted the importance of making further progress in consolidating a global view of OpRisk. This would include greater discipline integration in practice for emerging risks, such as cyber risk, and technology risks, such as vendor risks, in order to develop an enhanced strategic decision-making framework.

The automation of services was also stressed numerous times, and the perspectives voiced were aligned in terms of how best to use automation frameworks to enhance risk management data collection and facilitate this data's use in risk management reporting. Further, there were several responses that highlighted the need for considered thought on how automation should be designed to fit the existing governance and reporting frameworks of institutions as opposed to being mapped directly to IT and other processes, as is often current practice. This is discussed further, particularly in the context of cyber risk, in Peters *et al* (2018a) and Peters *et al* (2018b).

Opinions regarding the verifiability of outputs from machine learning and artificial intelligence data analysis were also noted. These naturally led to thoughts on the regulation of outputs from machine learning and artificial intelligence when used routinely in risk management decision making.

Such sentiments reflect a growing belief among regulators that there is a need to provide guidance on best practice use as well as expectations of understanding and interpretability of outputs from such tools.

A recent report by the Financial Stability Board, which comprises an international collection of national and regional banking supervisors, proposed expanding the scope of financial stability regulations into areas such as artificial intelligence and machine learning.

A risk that may emerge from the widespread adoption of machine-learning methods in sectors such as banking and insurance is that they could compromise financial stability as a result of the potential for interconnectedness, directly or indirectly, between firms using technology from a small collection of technology companies, which are largely unregulated at present.

It is generally believed that, for OpRisk, the applications that may arise from the RegTech industry's use of machine learning will help improve regulatory compliance and subsequently reduce the propensity for fines. However, the applications of such methods to capital quantification and risk decision making will require informed practice guidance as well as verifiable and interpretable relationships between resulting model outcomes and risk experts' opinions and practical experience. It will also require guidance on what level of detail is needed when reporting to regulators and external auditors on such models.

3.5.2 Perceptions of the consolidation of OpRisk as a discipline

Further, responses were also received that revealed thoughts on the consolidation of OpRisk as a discipline. These are briefly summarized in this section. Several respondents felt that OpRisk as a discipline would begin to incorporate a marriage of modeling and management with regulatory and compliance center functions, with some suggesting this might lead to a subset of OpRisk groups. Others said that they believe OpRisk will begin to work more closely and in a more cohesive manner with business strategies in order to determine the risk–reward balance when creating or establishing new business activities. This integration would further show the maturing of the discipline in practice.

Many respondents perceived that OpRisk as a discipline will continue to be seen as a critical component on both board and senior management agendas. However, with the onset of automation in mind, there was also a perception that perhaps OpRisk teams will converge to become a more consolidated, perhaps smaller, core team in most institutions. Such a team would consider aspects of the OpRisk framework and policy development by risk type. In conjunction, OpRisk skills would be embedded into the business-as-usual approach, which would be more heavily focused on controls in business practices. Such a consolidation, several respondents suggested, could involve, from a quantitative perspective, the merging of advanced data analytics and risk assessment functions.

In order to foster knowledge-exchange, guidance on best practice and awareness of emerging issues, we requested that respondents identify whether their organization supports or encourages participation in industry initiatives such as OpRisk workshops and conferences. Just over 50% of respondents replied affirmatively.

This completes the discussion on individual data analytics for each survey question. In the following section, we look at respondents' positions from a multivariate perspective. We collected all of the attributes from each question into a high-dimensional feature vector summarizing each respondent's outcome for all questions. We then looked for patterns or similarities between responses using a multivariate nonlinear clustering perspective. This required the use of some advanced machine learning and data analytics techniques, which are briefly outlined below and in the online appendix. For more details on how such techniques work, see the detailed lecture series and textbook referred to in Peters (2017).

4 MACHINE-LEARNING-BASED KERNEL CLUSTERING OF MULTIVARIATE SURVEY RESPONSES

An unsupervised cluster analysis of the survey responses in multivariate space was performed to understand the patterns and commonalities between respondents from

a multiple-response, ie, multivariate, perspective. This allows us to discern commonalities, if they are present, that cannot be readily obtained from simple question-by-question descriptive statistics. The methodology used to study this data is outlined in Technical Appendix 1 (available online).

All of the analysis in this section was completed using the software R (Stable release 3.4.3 (Kite-Eating Tree), November 30, 2017). The package used for the kernel-based cluster analysis was the `specc` toolbox from the toolbox `kernlab v0.9-25`. The preliminary studies undertaken to select aspects of the clustering methodology adopted were as follows. We tested a range of cluster sizes, from $K \in \{1, 2, 3, 4, 5, 6\}$, as well as a range of kernel maps from the following classes: linear, polynomial quadratic, square exponential, tanh and Matern. From the analysis, we trained the hyper-parameters of the kernels using the default settings in the package. We eventually selected $K = 3$ and the Matern kernel after a preliminary analysis of optimal cluster selections based on statistical criteria outlined in Peters (2017).

4.1 Why is it useful to study this type of data and perform spectral nonlinear clustering?

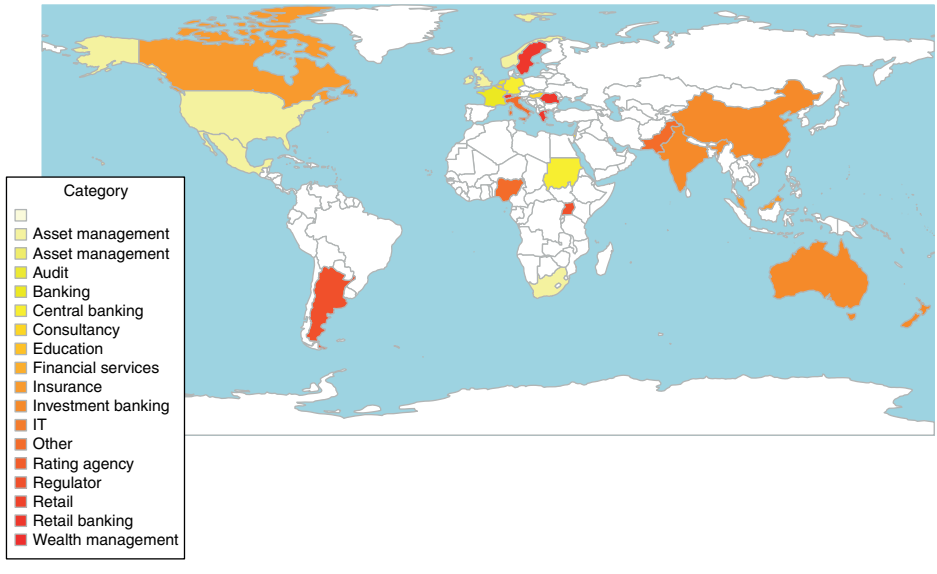
The reason we study these data sets and undertake the machine-learning analysis we perform is because we want to obtain information that will aid in answering questions such as the below.

- Are particular regions of the world more likely to be aligned in particular approaches or perspectives on OpRisk practice?
  - *This would have implications for regulation, development and education.*
- Are particular organization types or sectors more sophisticated or OpRisk focused?
  - *This could affect the way OpRisk development occurs geographically.*
- Are there different patterns to OpRisk and the regulation of OpRisk regionally?

4.2 Cluster groupings by region against sector, experience and role

In this section, we outline a summary of the results created in this analysis. For each set of results, we show a decomposition of the cluster groupings across all of the question attributes of each respondent. We do so in the three cluster classes decomposed over the regional view versus the attribute being studied.

FIGURE 27 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and sector for each cluster grouping (cluster 1).



4.2.1 Cluster groupings by region against sector

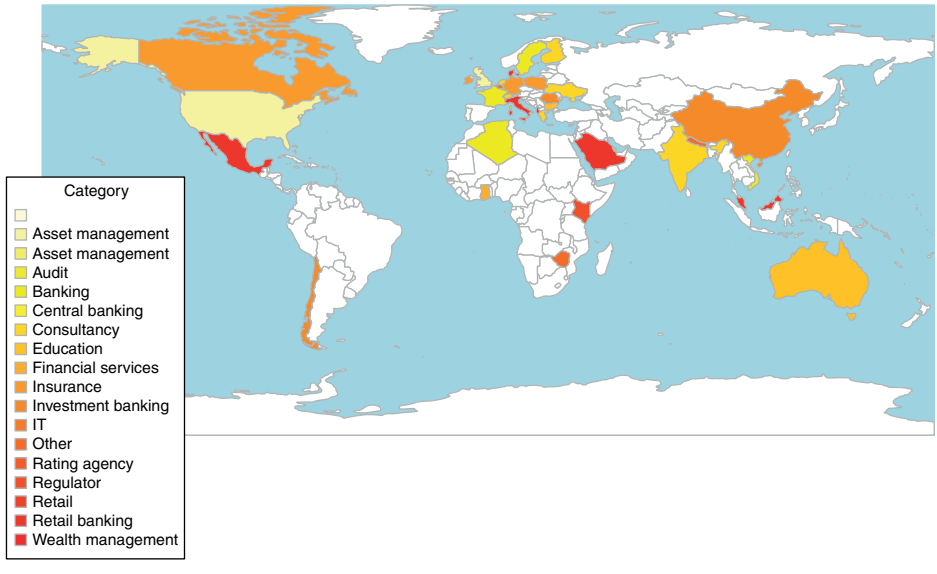
The results displayed in Figure 27, Figure 28 and Figure 29 demonstrate the cluster outcomes as a cross-section of region versus sector.

The outcomes of this visualization of the cluster partitions of all attributes as viewed by region and sector show that there was consistency in the views held by financial services and banking in the Americas between classes 1 and 2 of the cluster groupings. Similar stability was seen in Australia and China (and Asia overall) for the financial services, insurance and investment banking sectors.

The distinguishing differences between clustered groupings appeared between cluster group 1 (retail banking and wealth management), with differences in perspective between these sectors, as well as cluster group 2 (insurance and asset management) and cluster group 3 (investment banking and financial services). The differences in these sectors' perspectives on OpRisk are largely appearing in emerging economies evident in South America and Africa.

Further, the results indicate that America is largely aligned across the sectors in terms of the perspectives on OpRisk captured by the survey. Australia, China and North America are also more aligned in terms of practitioners' perspectives across all

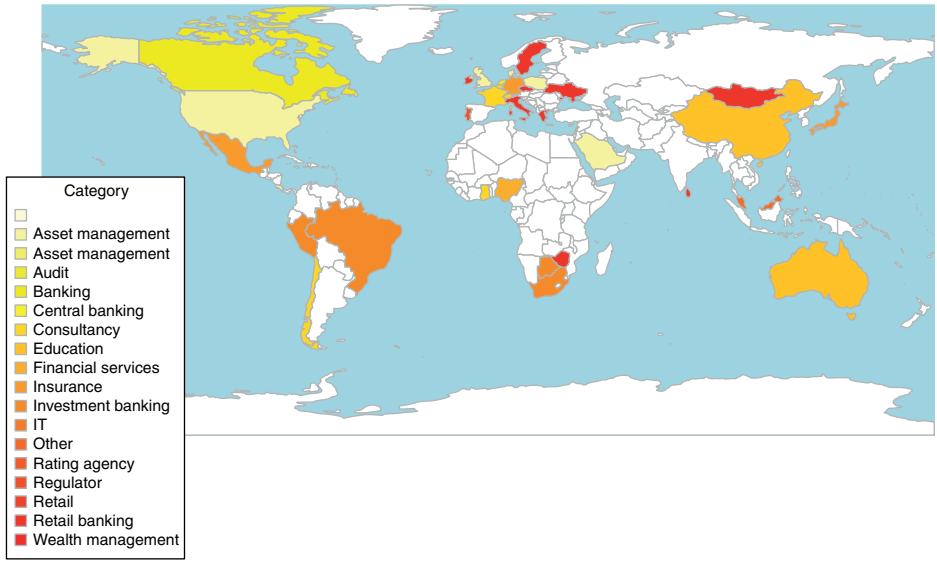
FIGURE 28 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and sector for each cluster grouping (cluster 2).



sectors compared with developing countries, as indicated by the groupings observed in the cluster analysis.

4.2.1.1 Recommendations arising. The findings indicate that there is a greater heterogeneity in opinions of OpRisk as a discipline and its maturity and evolution in developing economies that are beginning to adopt OpRisk best practice and principles. The alignment achieved and the processes adopted to facilitate this alignment in several major economies across the range of industry sectors should therefore act as guidance for emerging economies when deciding how best to implement or develop OpRisk best practice. Further, the results suggest that, in order to facilitate further coherency in developing economies' OpRisk practice and development across industry sectors, it may serve these economies well to adopt or develop in tandem compliant sound practice guidance, both from a regulatory and a practitioner perspective. This could involve working with groups such as the IOR, ORX and CRO Forum as well as promoting participation in local chapters of the statistical societies in each country, along with other educational and professional bodies, such as the Institute and Faculty of Actuaries, which also maintain active groups in most countries, including developing countries. The advantage of this would be guidance and

FIGURE 29 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and sector for each cluster grouping (cluster 3).



exposure to consistent sound practice that has resulted in coherency across industries in other major economies, avoiding as much as possible the repetition of mistakes made in the processes already developed in those economies.

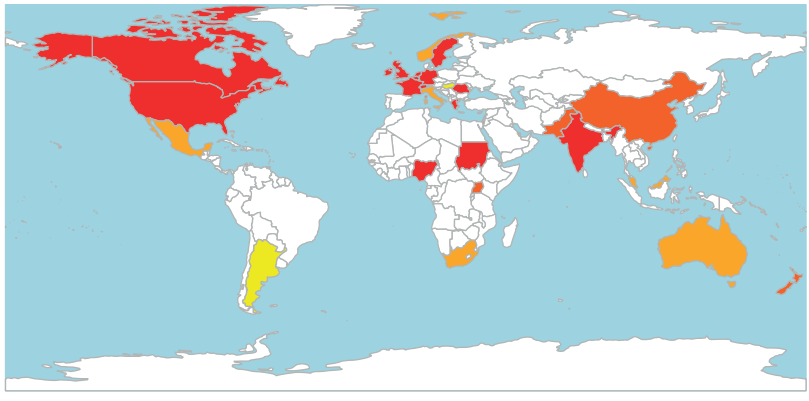
4.2.2 Cluster groupings by region against experience

The results displayed in Figure 30, Figure 31 and Figure 32 demonstrate the cluster outcomes as a cross-section of region versus years of industry experience in OpRisk modeling, measurement and practice.

We learn from this analysis that Australia and the Americas are largely comprised of experienced OpRisk practitioners, whereas the developing areas of South America and Africa demonstrate responses from respondents holding a range of junior to senior OpRisk positions. China, interestingly, was split into two groups, with clusters 1 and 3 comprised of experienced OpRisk practitioners, while cluster 2's results tended to reflect more junior practitioners.

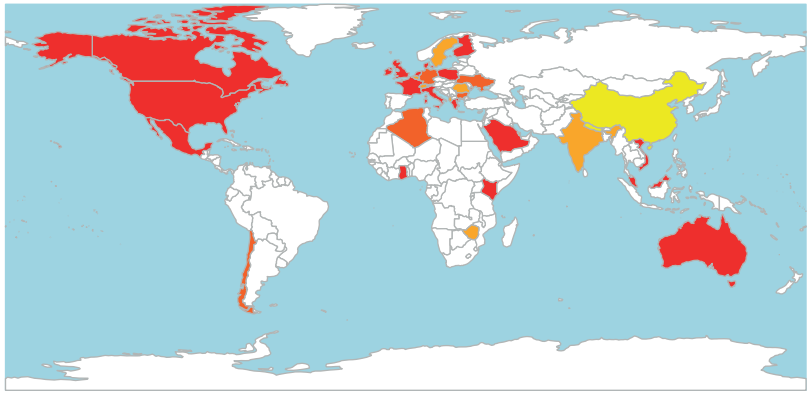
4.2.2.1 Recommendations arising. Perhaps the most interesting outcome of this part of the analysis and its subsequent recommendations is that in the major economy that is China there are clearly two subpopulations of practitioners in terms of years of

FIGURE 30 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and experience for each cluster grouping.



This plot shows cluster 1. *Note:* colors go from light to dark with increasing years of experience in OpRisk.

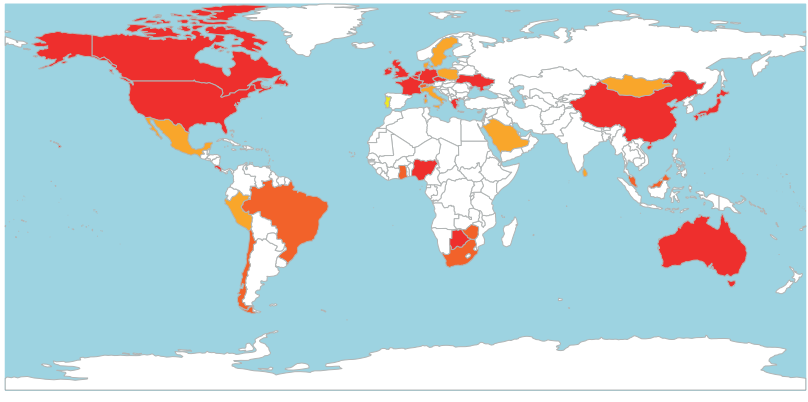
FIGURE 31 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and experience for each cluster grouping.



This plot shows cluster 2. *Note:* colors go from light to dark with increasing years of experience in OpRisk.

experience. The perspectives and approaches to OpRisk management and practice, as captured by the survey questions, deviate between experienced and less experienced groups in China in a more pronounced fashion than is evident in the responses from other countries. It is important to consider the implications of such differences for

FIGURE 32 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and experience for each cluster grouping.



This plot shows cluster 3. *Note:* colors go from light to dark with increasing years of experience in OpRisk.

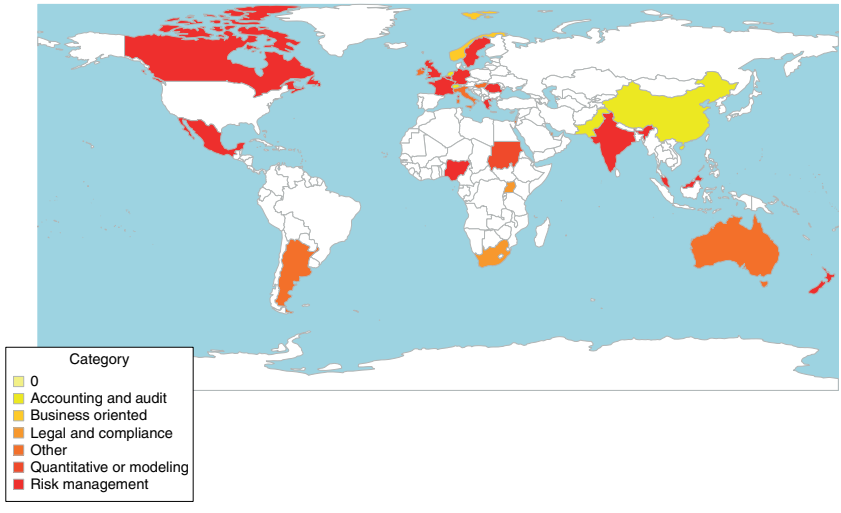
such a major economy in terms of best practice and perceptions of OpRisk in this country. Heterogeneity in a population of risk practitioners in any major economy can be good for innovation and creative solutions to the challenges faced by OpRisk; however, when such heterogeneity is only present as a result of experience in the role of OpRisk management, modeling or practice, this is perhaps more of a concern.

Therefore, the guidance here would be for regulators and professional bodies in China to share experiences, place greater emphasis on educational opportunities, and participate in more industry-wide conferences and training events. For instance, the OpRisk North America and OpRisk Europe conferences have facilitated dynamic discussions that have helped to close such gaps between young professionals and industry experts. These discussions could be facilitated in China: with the capacity of the market growing rapidly, there is a clear indication from this analysis that there is ample opportunity to develop a interactive environment in this economy between experienced and less-experienced OpRisk professionals. This should reduce such gaps between perceptions on OpRisk and allow the innovative voices of young professionals to be heard by industry experts, who possess the knowledge to help put these ideas into practice.

4.2.3 Cluster groupings by region against role

The results displayed in Figure 33, Figure 34 and Figure 35 demonstrate the cluster outcomes as a cross-section of region versus role. We see from these plots that the North American and Australian sectors of risk management, quantitative modeling,

FIGURE 33 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and role for each cluster grouping (cluster 1).



and legal and compliance are largely consistent in their perspectives across each cluster grouping. However, we see a divergence in perspectives between legal and compliance, accounting and audit, and risk management in China and regions of South America and Africa.

4.2.3.1 Recommendations arising. Again, the divergence between sectors surveyed in China that is seen in the responses is more pronounced than that recorded for the large economies of Europe and North America. The fact that respondents holding accounting, audit, and legal and compliance roles differed significantly in their perspectives on OpRisk management and practice, as captured by the survey questions, when compared with risk management and modeling groups could indicate multiple differing aspects of OpRisk practice and may be caused by multiple reasons to do with the legal and commercial operating environment in China compared with Western economies.

However, irrespective of speculation regarding the possible reasons for such divergence in sectors' perspectives on OpRisk, the result does indicate that, perhaps, international accounting and audit professions as well as actuarial and risk management professional bodies have a role to play in facilitating greater communication between professionals in each sector in the Chinese market. This would at the very least

FIGURE 34 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and role for each cluster grouping (cluster 2).

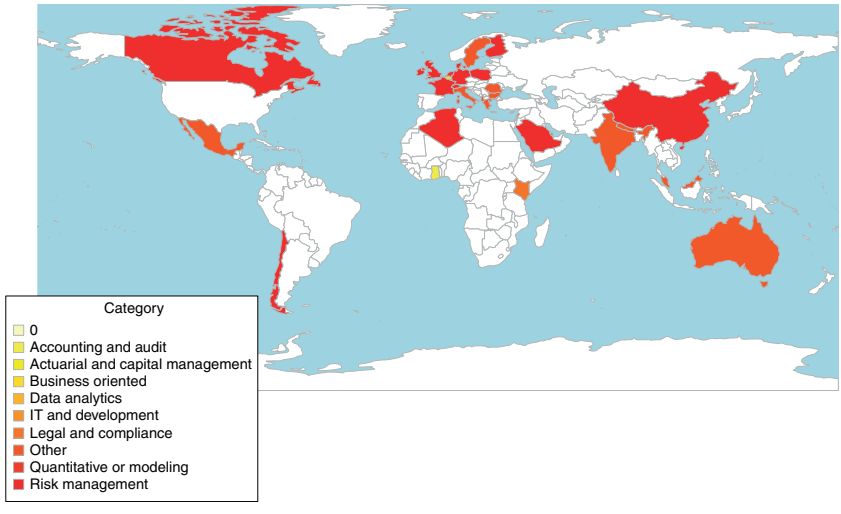


FIGURE 35 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and role for each cluster grouping (cluster 3).

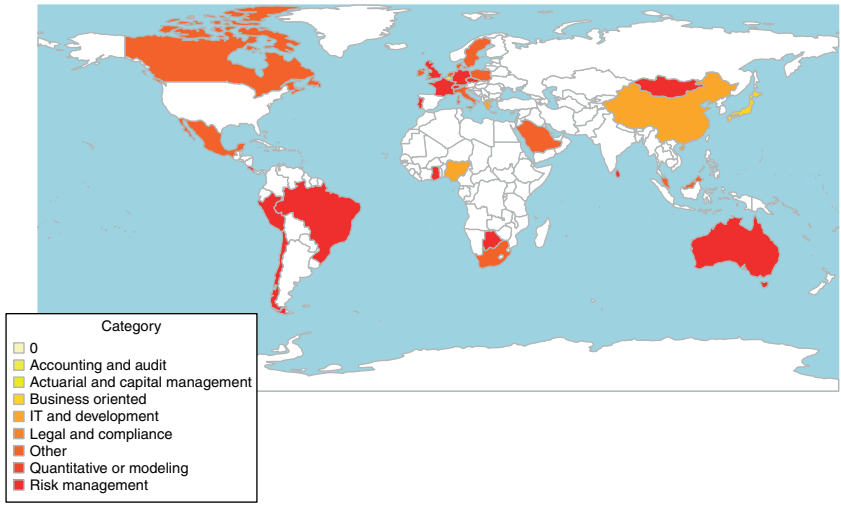
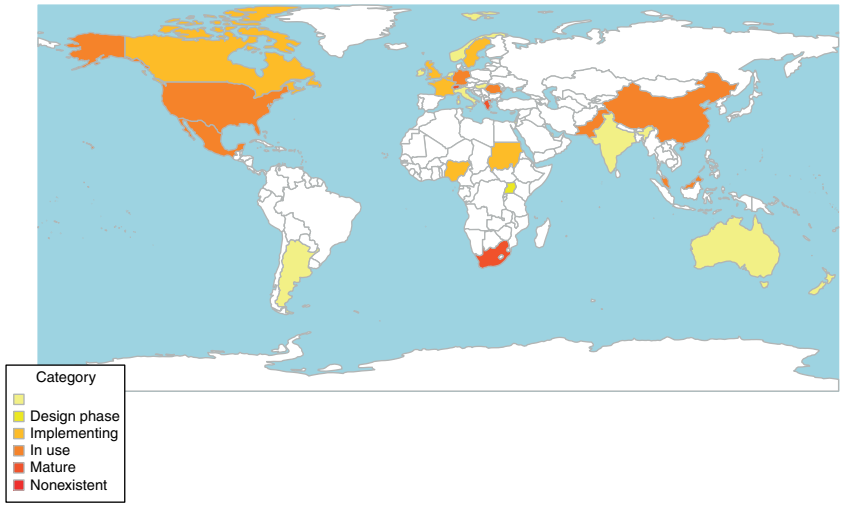


FIGURE 36 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and status for each cluster grouping (cluster 1).



resolve any issues to do with a lack of awareness of evolution of best practice in each discipline that may result in such divergence of opinion.

4.3 Cluster groupings by region against status of OpRisk

In Figure 36, Figure 37 and Figure 38, we explore the regional decomposition of attributes in the clustering analysis as partitioned according to the status of OpRisk per region. We see that the general response of clusters 1 and 2 was that most countries represented were in either a design or a development phase. The respondents assigned to cluster 3, meanwhile, were largely associated with more mature OpRisk management and processes in their respective sectors.

5 CONCLUSIONS

As regards the current status of and approach to OpRisk, it is evident that this has gone well beyond regulatory compliance. OpRisk is seen by senior management, including boards, as a value-add discipline, helping to improve and make processes more efficient and decision making more informed.

What is also encouraging to see is the impetus for innovation and seeking best practice guidance beyond practitioners' own industries. OpRisk professionals are outward looking and are keen to develop their discipline.

FIGURE 37 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and status for each cluster grouping (cluster 2).

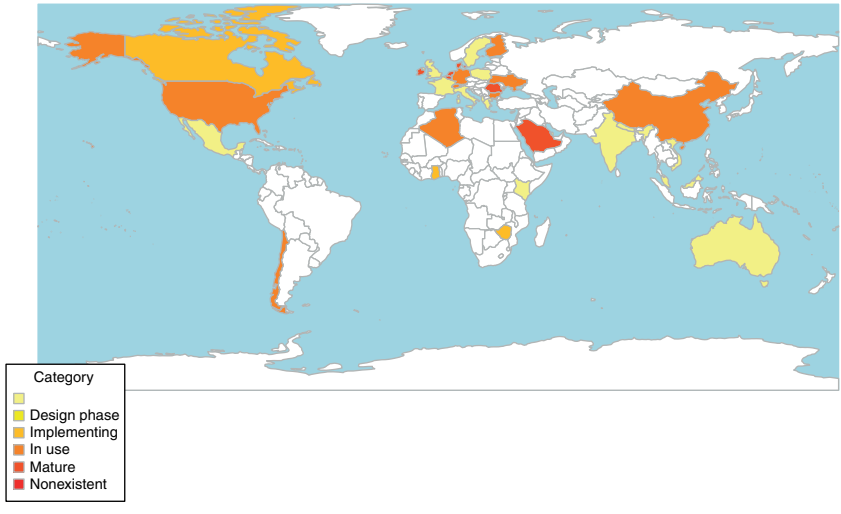
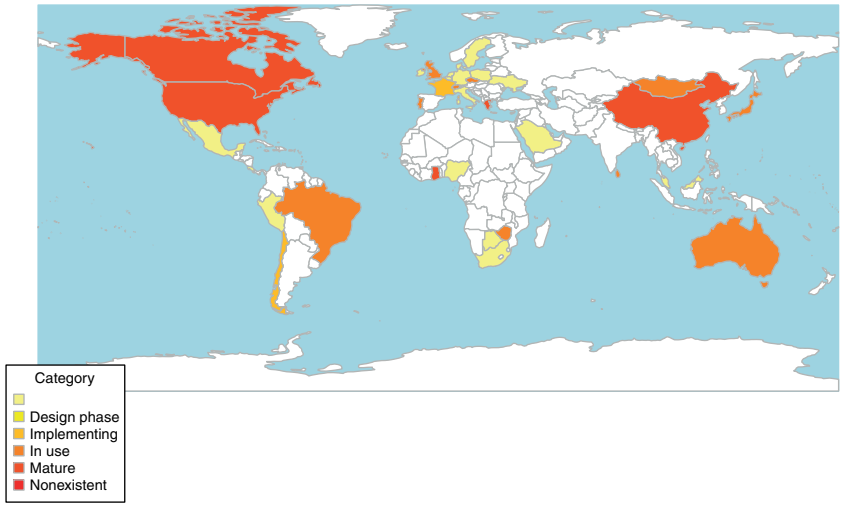


FIGURE 38 Clustering of all features, $K = 3$, Matern kernel, separated into cluster classes and plotted as region and status for each cluster grouping (cluster 3).



When it comes to data and inputs, there is a clear sense that more consistency in terms of taxonomies is needed. There need to be more conversations within the discipline and, to an extent, with regulators on this.

The collection of data is also a current priority. The comments about the future of artificial intelligence, machine learning, data analytics and automation point to a solution, but they also raise a number of interesting points and questions, not least of which is the need for more sharing of information.

Looking to the future, there seems to be a general consensus that OpRisk will consolidate a number of risk areas and, as a result, play a more important role in both senior management and boards, driving strategic decision making.

A number of respondents highlighted the fact that the environment is continually changing and OpRisk professionals need to be nimble and constantly scanning the horizon. As has been said a number of times in this analysis, OpRisk is a people risk. OpRisk professionals also need people skills to be able to communicate effectively, influence others and make the opportunities outlined above turn into actions.

The report also recognizes the need for OpRisk practitioners to be skilled, knowledgeable and credible, with the growing complexity demanded of practitioners driving a desire for the attainment of formal qualifications.

We believe that future work, which should arise as a result of the findings of this survey and subsequent analysis, will involve developing coherent and globally consistent sound practice guidance on the emerging trends in machine learning and artificial intelligence, and looking at how they can best be adopted and used to improve OpRisk practice into the future.

It is also clear from the findings that continued professional development in data analytics and machine-learning automation should be provided by academia, professional bodies, regulators and risk management institutes such as the IOR to ensure that adequate skill sets are in place to handle the transition to a more general use of such methods in the banking and insurance sectors.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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