Journal of Production, Operations and Systems Management

e-ISSN: 1984-2430

Open Access

Editor-in-chief: Paula de Camargo Fiorini

Received:28/01/24 Approved: 10/09/24

RISK PROCESS MANAGEMENT: A CASE STUDY IN A FINANCIAL INSTITUTION

GERENCIAMENTO DO PROCESSO DE RISCO: UM ESTUDO DE CASO EM UMA INSTITUIÇÃO FINANCEIRA

Fernando Martins Mallet [1]
Nicolle Christine Sotsek [2]
Aline Frazon[3]

ABSTRACT

Purpose: The purpose of this study is to propose a new method for controlling the product "Financial Risk Management" in a multiple bank. The focus is on addressing Model Risk, particularly in the context of financial institutions, where reliance on incorrect statistical models can pose serious problems.
Theoretical framework: Model Risk is the possibility of losses due to models with flaws, deficiencies or inadequacies in the development, implementation or use process. Model Risk is considered one of the main problems for financial institutions. With the advancement of technology and the use of more robust models, dependence on incorrect statistical models can cause serious problems for institutions, increasing the need for studies in the area.
Methodology/Approach: To conduct the research, the institution's own survey was used, being applied to the analysis of the main financial models built in the last six months in the organization. As a result, the structure of this process was evaluated, action plans and control indicators were proposed, dividing them into the areas of: Data Governance, Systems, Data Quality and Reporting. With this categorization, it was also possible to create a Control Panel for each Area or Department, improving the management necessary to control Risk.
Findings: The findings of the study involve the evaluation of the structure of the risk management process, with a particular focus on addressing Model Risk. The research proposes a new method for risk assessment within the context of "Financial Risk Management" in a multiple bank setting.
Research, practical & social implications: In terms of research implications, the study contributes by proposing a novel method for controlling financial risk in a banking environment. The practical implication is the potential improvement in risk management processes within financial institutions. Socially, this research may contribute to the overall stability and reliability of financial systems.
Originality/ Value: The originality of this study lies in its proposition of a new method for risk assessment within the domain of "Financial Risk Management" in a multiple bank setup. The value of the research is evident in addressing the critical issue of Model Risk, which can have substantial consequences for financial institutions.
Keywords: Financial Institution, Financial Risk, Process Management.

RESUMO

Objetivo: O objetivo deste estudo é propor um novo método para controle do produto "Gestão de Riscos Financeiros" em um banco múltiplo. O foco está na abordagem do Risco de Modelo, particularmente no contexto das instituições financeiras, onde a dependência de modelos estatísticos incorretos pode representar sérios problemas.
Referencial Teórico: O Risco de Modelo é a possibilidade de perdas devido a modelos com falhas, deficiências ou inadequações no processo de desenvolvimento, implementação ou utilização. O Risco de Modelo é considerado um dos principais problemas das instituições financeiras. Com o avanço da tecnologia e a utilização de modelos mais robustos, a dependência de modelos estatísticos incorretos pode causar sérios problemas às instituições, aumentando a necessidade de estudos na área.
Metodologia/Abordagem: Para a realização da pesquisa foi utilizada a pesquisa própria da instituição, sendo aplicada à análise dos principais modelos financeiros construídos nos últimos seis meses na organização. Como resultado, foi avaliada a estrutura desse processo, foram propostos planos de ação e indicadores de controle, dividindo-os nas áreas de: Governança de Dados, Sistemas, Qualidade de Dados e Reporting. Com esta categorização foi também possível criar um Painel de Controlo para cada Área ou Departamento, melhorando a gestão necessária ao controlo do Risco.
Resultados: Os resultados do estudo envolvem a avaliação da estrutura do processo de gestão de riscos, com foco particular na abordagem do Risco de Modelo. A pesquisa propõe um novo método para avaliação de riscos no contexto da "Gestão de Riscos Financeiros" em um ambiente de banco múltiplo.
Contribuições, implicações práticas e sociais: Em termos de implicações de investigação, o estudo contribui ao propor um novo método para controlar o risco financeiro num ambiente bancário. A implicação prática é a potencial melhoria nos processos de gestão de risco nas instituições financeiras. Socialmente, esta investigação pode contribuir para a estabilidade e fiabilidade globais dos sistemas financeiros.
Originalidade/Valor: A originalidade deste estudo reside na proposição de um novo método de avaliação de riscos no domínio da "Gestão de Riscos Financeiros" em uma configuração de banco múltiplo. O valor da investigação é evidente ao abordar a questão crítica do Risco do Modelo, que pode ter consequências substanciais para as instituições financeiras.
Palavras-chave: Instituição Financeira, Risco Financeiro, Gestão de Processos.

DOI: 10.15675/gepros.3009

---

[1]*Email: fermallet@gmail.com; https://orcid.org/0000-0002-3668-661X; Rua XV de Novembro, 1299 - Centro, Curitiba - PR, 80060-000*
[2] *Email: nicolleramos@ufpr.br; https://orcid.org/0000-0001-8567-5522*
[3] *Email: aliner.liveira@gmail.com; https://orcid.org/0000-0003-0705-6907*

1. INTRODUCTION

With the globalization and evolution of the interconnection between financial agents, Financial Institutions (FI's) are gradually exposed to greater risks and new types of risks, no longer focusing only on Traditional Risks (Credit, Market, Liquidity) and evolving in the identification and solutions of Risks that involve the external environment, sustainability and behaviors. The new risks are, among others: Financial Contagion, Model, Reputation (all involving the organization in general, selection and contract with the supplier network, affiliated and controlled companies, foundations, etc.) risks in order to provide security and comfort to all interested parts (stakeholders, society, customers and employees).

As a result, a type of risk associated with mathematical models emerged in the financial market, called “Model Risk”. This new risk was established based on mathematics and statistical models during the 1970s. Although Hendricks (1996) and O'Brien (2002) deal with Model Risk, studies have not yet broadly evaluated the Risks generated by the models, limiting itself to evaluating only Backtesting issues (rehearsing how an operational strategy would perform according to the previous movement already made by the market). The urgency for the elaboration of better risk models may increase the danger of financial institutions after the breakdown of the Bretton Woods system and the growing dependence on the world economy (Greene, 2008). The increase in computational capacity and leadership makes it possible to calculate the risk of these models. Model Risk management includes the function of model validation, including duties related to model governance, inventory control, risk exposure reporting, and setting policies and standards for model management across the institution. The issue of risk management has been showing increasing importance in the business context. According to him, with the increasing interdependence of markets, companies become more vulnerable to different risk factors (Jia and Bradbury, 2020).

Elevated levels of model risk should be of concern to practitioners and regulators, given their importance (Klein Jr and Reilley, 2021). The results of risk forecasting models are used as an important input in decision-making, be they portfolio or capital allocation. In order to carry out proper risk control, the company must provide well-defined processes, involving the process of identifying, evaluating, treating and monitoring the risks existing in the organization. Even with the importance of these models, there is still no standardized method for analyzing the risk of models, given that there are many models found in the literature, but each one has its limitations, such as difficulty in application and divergence between probability measures (Arrieta, 2022).

Model risk is a growing concern as artificial intelligence advances and is applied across various sectors. With increasingly complex AI models such as deep neural networks and sophisticated machine learning algorithms, challenges related to biases in training data and interpretation of model decisions are amplified (Montavon et al., 2022; Mitchell et al., 2023).

The need for transparency and interpretability in AI models has been widely discussed. Recent research emphasizes the importance of methods that make model decisions understandable, crucial for mitigating risks and enhancing confidence in their application (Doshi-Velez and Kim, 2023; Mittelstadt and Floridi, 2024).

Beyond technical challenges, ethical and social issues are critical in the AI context, including data privacy, algorithmic discrimination, and social justice concerns (Crawford et al., 2022; Selbst and Barocas, 2023).

To manage model risk, approaches such as rigorous performance testing, data audits to detect biases, and the development of regulatory frameworks are being proposed (Rudin et al., 2022; Veale and Binns, 2024). Recent case studies highlight how errors in AI systems can have

significant impacts, especially in sensitive areas such as healthcare, finance and the judicial system (Obermeyer et al., 2023; Larson et al., 2024).

Thus, it becomes necessary to develop methods for analyzing Model Risk, which can be applied in companies from different sectors, to support improvement processes and identify flaws and the criticality of each model. Thus, the present study aims to propose a method for carrying out the process of monitoring the product "Financial Risk Management" in a Financial Institution (multiple bank).

This work adds an additional layer to model risk assessment by involving both model managers and risk evaluation teams. Typically, this synergy is lacking, which hinders the analysis and development of effective action plans. With the establishment of new banks and payment institutions, we believe this study can enhance governance in financial institutions, benefiting the national financial system as a whole.

2. LITERATURE REVIEW

According to the United States Department of the Treasury, through the Office of the Controller of Currency, published in 2011, a model is a quantitative method, system or statistical approach that applies statistics, economics, finance or mathematical theories to process data and transform it into estimates. quantitative.

The difference between risk and uncertainty has different interpretations in the bibliography (Andrade, 2011). Knight (1921) defines uncertainty as an incalculable risk. The approach of Shenhar and Dvir (1996) proposes a quantitative relationship between risk and uncertainty, the greater the identified uncertainties, the greater the project risk. For Brinckmann, Liberali and de Souza (2005), there was a change in the thinking of company directors, who sought integrated risk management to increase performance.

According to Saunders (2000), we can divide the main risks to which a Financial Institution is exposed into:

• Interest Rate Risk: Effect of changes in interest rates on the value of a single asset, on the value of "portfolios" of assets or on the difference between the values of a "portfolio" of assets and the "portfolio" of liabilities that they back the assets (Carvalho, 1994);

• Market Risk: Risk arising from variations in the prices of an organization's assets and liabilities (Guasti, 2016);

• Credit Risk: Possibility of the counterparty not fulfilling contractual monetary obligations relating to monetary transactions (Jorion, 2003);

• Exchange Rate Risk: Possibility of exchange rates between currencies of importing and exporting countries moving adversely between the quotation and settlement dates (Brigs, 1998);

• Country Risk: Reflection of the economic and financial situation of a country, also reflecting political stability and historical performance in fulfilling its financial obligations (Garcia et al., 2003);

• Liquidity Risk: Occurrence of imbalances between tradable assets and payable liabilities that may affect the institution's payment capacity, taking into account different currencies and settlement periods (BACEN Resolution No. 002804, 2000).

In the face of digitalization and automation, with greater access to information and an increasing volume of data, new models need to be developed, thus increasing the assertiveness of decisions. Sources of model risk in management and evaluation models include (Kato and Yoshiba, 2000):

• Use of wrong assumptions;

• Errors in parameter estimation;
• Errors resulting from discretization;
• Errors in market data;
• Differences between the assumed distribution and the actual distribution; It is
• Errors in the model structure.

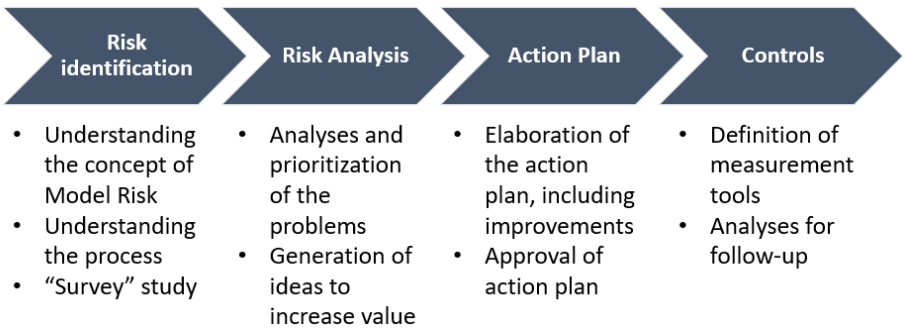
For the OCC (2011), we can define Model Risk as the possibility of losses due to models with flaws, deficiencies or inadequacies in the development, implementation or use process. According to Derman (1996), model risk arises from the sensitivity of results and decisions to the choice and uncertainty about the adequacy of the model. However, for Kato and Yoshiba (2000) model risk is defined as "the risk of not accurately estimating the probability of future losses".

Model Risk Management typically includes the function of validating models, including duties related to model governance, controlling model inventory, reporting model risk exposure, and defining policies and standards for model management across the enterprise. institution.

3. METHODOLOGY

This research is characterized as a case study, which studied a financial institution that has the objective of evaluating the construction of its risk models, developed by managers (responsible for the idea of developing and using the model) from specific areas. The approach of this study is, therefore, quantitative and qualitative at the same time. Quantitative, as the assessment instrument that the company already has will be used, a Survey (based on the Likert scale), generating a final grade and consequently a risk level for the Model. Qualitative, as it considers the profile of the respondent and the type of Model. This collection of information about the individual who developed the model and the model itself allows an analysis and the possibility of generating action plans, resulting in a Risk analysis and the construction of improvement proposals. The steps to achieve model risk are "Risk Identification", "Risk Analysis", "Action Plan", and "Controls", presented in Figure 1.

Figure 1
Methodology and expected results.



Source: authors.

The description and detailing of each stage of the model can be found in the following sections.

3.1 Risk identification

The evaluation of the model manager's profile is extracted from the bases of the Financial Institution, involving position and experience in the construction of financial models. The template sample is based on a Template Inventory. The Institution divides the Models into 3 possible Tier's, according to their relevance in decision-making: Tier I (greater relevance in decision-making), Tier II (medium relevance in decision-making) and Tier III (low relevance).

This assessment is applied in the form of a Survey. The objective of the Survey is to evaluate the risks of the Model, divided into 5 dimensions, on which the model is evaluated, addressing questions to understand the manager's perception of the risks of the model. The 5 dimensions are:

1. Methodology – aims to assess the soundness of the methodology focusing on the main model assumptions, selection of data, drivers and segments;
2. Data – aspects related to data input, availability and quality;
3. Performance – performance, robustness over time, uncertainty around estimates, and sensitivity to changes in data or the environment;
4. Technology and Information (IT) – assesses the existence of adequate IT infrastructure to implement the models and support risk management;
5. Governance – evaluates the use of the model, controls and governance, to ensure an adequate approval process and correct use of the model and its results.

This organization's standard assessment consists of 41 questions. The Survey is based on the Likert scale, and the self-assessment score is calculated by the weighted average of the answers for each dimension, as shown in Table 1.

Table 1
Dimensions, questions and weights

Dimension	N of Questions	Questions	Weight%
Methodology	9	• Soundness of Methodology • Comparison between methodologies • Limitations of the methodology	20%
Data	11	• Collection Process • Data quality • Sufficiency of historical series	20%
IT	6	• Methodology on platform under management from you • Approval process • Business continuity plan	15%
Performance	7	• Periodic review • Identification of deficiencies in the model Backtesting	30%
Governance	8	• Documentation • Model validation • Report to forums	15%

The Survey was developed with questions and weights established by the responsible team, considering the main dimensions that must be analyzed in the construction of a financial model. The final grade will be given in percentage, according to Equation 1:

$$final\ risk\ score = \frac{\sum_{i=1}^{41}(Answer\ (i) * Weight\ (i)}{100} \qquad (1)$$

After completing the Survey, a percentage is arrived at, and with the calculations, the rating classifications are defined, framed in one of the 5 categories:

- Minimal Risk (81% - 100%): model with appropriate performance and use.
- Low Risk (61% - 80%): model with appropriate performance and use.
- Moderate Risk (41% - 60%): model with appropriate performance and use.
- High Risk (21% - 40%): model with occurrences in performance or use.
- Very High Risk (0% - 20%): model without expected performance or usage.

3.2 Risk analysis

After defining and applying the Survey, a proposal was established to carry out the classification of the Models and consequently the identification of the Model Risk, carrying out the analysis to discover the causes and consequences in case the risks materialize. The proposal was, therefore, to establish a team dedicated exclusively to the management of Model Risk, so that, after identifying the Risk, carrying out the analysis of the information collected, involving the steps of: benchmarking, alternative solutions and necessary approvals.

3.3 Action plan

Then, the third step was to generate action plans, with the 5W2H Tool, a set of questions used to compose action plans quickly and efficiently. Its objective is the definition of effective tasks and their follow-up, in a visual, agile and simple way.

These answers helped defining priorities and those responsible for the tasks. With the result of 5W2H, the Model Risk management process becomes more agile and assertive, allowing the creation of a Risk Management maturity assessment Model. Action Plans are individualized by manager, allowing the same Plan to be used for other Models.

3.4 Controls

Finally, in the last stage, Control Indicators were created to monitor the measures implemented to analyze the approved models and check whether they respond to the needs and objectives for which they were programmed, such as:

- Monitoring of action plans for each model;
- Creation of Models follow-up by Area/Department;
- Performance Indicator (KPI's) of the Models.

4. RESULTS AND DISCUSSION

4.1 Operation of the company

The Financial Institution operates in several branches regarding products and services. It has a wide network of branches and services, covering a diversified customer base, capitalization bonds, credit cards, among others. It has approximately 90 thousand employees, and the Models are developed and used mainly in the departments of: Credit, Data Management, Insurance and Risk.

The Functional Organizational Chart of the Financial Institution is composed of the Executive Board, followed by the Departmental Board, Superintendent, and Departmental Manager, who coordinates 3 Analysts.

4.2 Survey result: identification

The Survey was applied for 1 month. A total of 307 models were inventoried, divided into 7 departments, representing a sample of approximately 65% of the institution's model population (475 models).

Regarding the Profile of the Respondents, the information was collected from the bases provided by the Company's HR, which includes the area of expertise, length of experience and training. It was identified that on average each manager develops 2 models per month, with Artificial Intelligence being the classification with the highest growth rate. In this research, 30 areas were identified in 7 departments, totaling 27 managers, with the following division: 87% managers and 13% specialists.

4.3 Evaluation of the models: analysis of the general survey

The models were classified according to the categories established in the Research Method of this work, performing the arithmetic mean of the Survey responses with the weights of each of the questions. The results can be seen in Table 2.

Table 2

Models Classification

Department	Minimum	Low	Moderate	High	Very High	Total	%
A	4	1	0	0	0	**5**	**2%**
B	105	26	8	0	0	**139**	**45%**
C	40	43	31	0	0	**114**	**37%**
D	1	14	0	0	0	**15**	**5%**
E	0	0	2	0	0	**2**	**1%**
F	0	1	0	0	0	**1**	**0%**
G	5	18	8	0	0	**31**	**10%**
Total	**155**	**103**	**49**	**0**	**0**	**307**	**100%**

Table 2 shows that approximately 50% obtained a minimal risk result and 34% a low-risk result. Of the 50%, the vast majority in the Department with the highest number of Models (Dept B). In Table 3, it appears that there is a proportionality in the distribution of Tier's. The most relevant (Tier I) represents 36% of the total sample, and is more present in Department C, of Credit models, which in most situations has an impact on corporate decisions. Models with Tier II (medium relevance) are equivalent to 31% of the total, while those with low relevance (Tier 3), 34% of the sample.

Table 3

Tier in each Department

Department	Tier 1	Tier 2	Tier 3	Total
A	1	3	1	**5**
B	23	42	74	**139**
C	74	34	6	**114**
D	0	8	7	**15**
E	2	0	0	**2**
F	1	0	0	**1**
G	8	7	16	**31**

Table 4 shows that of the 49 models classified as Moderate, 82% are Tier I, 8% Tier II and 10% Tier III. For the 103 models classified as Low, approximately 34% were Tier I, 31% Tier II and 35% Tier III. The 155 models classified as minimal risk had the percentage of their Tier's at 22%, 37% and 41%, respectively.

Table 4
Risk Level by Tier

Risk/Tier	Tier 1	Tier 2	Tier 3
Very high	0	0	0
High	0	0	0
Moderate	40	4	5
Low	35	32	36
Minimum	34	58	63
Total	**109**	**94**	**104**

Therefore, it can be identified that: Department B and Department C are the ones with the highest number of evaluated models; Department C has most Tier III models, which are less relevant; Department C has the highest number of models with Moderate risk.

4.4 Evaluation of models: by dimensions

At this stage, the objective is to demonstrate the results for each of the 5 dimensions that were structured by the company. It was identified that the Survey currently used by the Organization has many overlapping questions. In this way, some of them were selected to compose the evaluation by dimension, to a new Survey.

4.4.1 Methodology dimension

Department D (Loans) has the lowest average response among the departments (0.73), possibly due to the high variability of each Organization, making it difficult to compare with other techniques or methodologies. Regarding the questions, it was identified that question 3 has the lowest score (0.71), probably motivated by the development of 24 new models.

4.4.2 Data dimension

All Departments obtained a high level of scores in relation to the Data dimension. Regarding the questions, it was identified that question 6 is the one with the lowest score (0.80), probably motivated by the lack of need for reconciliation between the model data and the Organization's accounting information.

4.4.3 IT dimension

For the IT dimension, Department G is the one with the lowest grade level in relation to the IT dimension, mainly because this is the Organization's newest department, possibly still implementing all Technological issues and approvals. Regarding the questions, it was identified that question 15 has the lowest score (0.74), requiring that the subsidies be sent with regularity to supply the model.

4.4.4 Performance dimension

Department A has the lowest grade level (0.75) in relation to the Performance dimension. Regarding the questions, it was found that all have good levels of answers.

4.4.5 Governance dimension

Department A has the lowest score (0.75) in relation to the Governance dimension. Regarding the questions, it was identified that question 25 has the lowest score (0.85), probably due to the lack of need to report the results of these models, since they serve as input for other models (these generating a result to be reported).

4.5 Assessment of the risk model

After the Survey, the manager must follow pre-established processes. It is verified that the manager will have a team that will accompany him, composed of 7 people, one for each department, with the function of assisting in the execution of the action plan, making an annual schedule for the control of indicators and action plans.

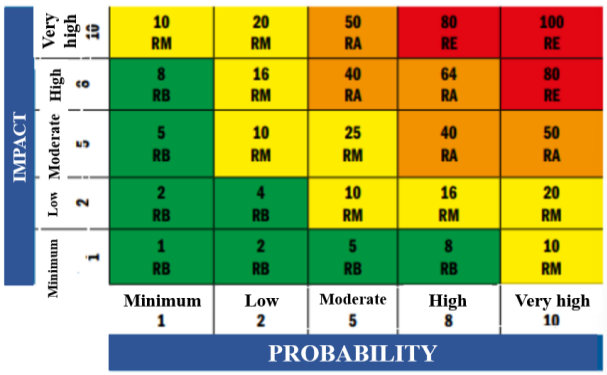
The models that need approval (Moderate, High and Very levels) will be sent to their respective competent Executive Forums, with the objective of approving the Action Plans. Models with Moderate risk should be evaluated in forums, High and Very High risks in forums with the entire Organization.

4.6 Action plan

Based on completing the Survey and calculating the grade (using Equation 1), the result will be evaluated by the responsible team. It is proposed that the results be inserted in the Risk matrix, locating each of the Departments' models, thus generating Action Plan proposals.

As mentioned, the proposal involved the use of a Risk matrix, Figure 2 (based on the guidelines for building Risk Matrices used in the Organization), to identify the urgency of treatment for each of the models. The Survey result represents the Impact axis and the Probability axis represented by the Department's history, that is, the number of models that have already been developed and the Manager's experience.

Figure 2
Risk Matrix.



Source: authors.

In the Probability Scale, the probability of occurrence of problems in the Department is considered. This scale is given by:

- Minimum: Unlikely. In exceptional situations, the event may even occur, but nothing in the circumstances indicates this possibility.
- Low: rare. Unexpectedly or casually, the event may occur, as the circumstances do not indicate this possibility.
- Moderate: possible. In some way the event may occur, as the circumstances do not indicate this possibility.
- High: likely. Even expected, the event may occur, as the circumstances strongly indicate this possibility.

In the Impact Scale, the impact of the occurrence of problems with the Model is considered, using the result of the Self-Assessment carried out by the Manager as a basis. The impact can be minimal (minimal impact on objectives), low, moderate, high (significant impact) or very high (catastrophic impact). For example, if a model is considered as a Moderate probability and a Low Impact, they will be inserted in Moderate Risk in the Risk Matrix. Therefore, according to the pre-established process, it is proposed that, after the self-assessment, the team responsible for Management insert the Risk Matrix information, later call a meeting with the managers by Department and Area, verifying the location of their models in the Matrix and seeking individual action plans for each of the models, following the criteria below:

- For models with Minimal and Low Risks – make an action plan and do not need approval from the Commission.
- Models with Moderate Risk – action plan and Commission in the Area.
- High and Very High Risks – action plan and Departmental Commission.
- The action plan will be prepared for each model/area and according to the Dimension, below are some points that can be addressed in the action plans, using the questions that make up the Survey as a basis:
- Methodology: Deepen the understanding of models in the literature, alignment of technical assumptions with specialized areas and use Backtesting;
- Data: Review the periodicity of the information, evaluate the data quality of the data and understand the history of the elements;
- IT: Alignment with the department responsible for Information Technology, training for staff qualification and development/alteration of the continuity plan;
- Performance: Improvement of Backtesting and performance of stress tests;
- Governance: Documentation review and verification of reporting standards.

Below you can see an example of 5W2H being applied, taking into account the Model Manager and the Dimension that should be the focus of improvement.

- WHAT (what will be done): Model 159.
- WHY (because it will be done): Identified that it has a Moderate Risk and problems in the Governance dimension.
- WHERE (where it will be done): department C.
- WHEN (when will it be done): June 2023 deadline.
- WHO (by whom it will be done): Analyst B under the responsibility of the Manager.
- HOW (how it will be done): Review of the Model's documentation and verification of the reporting standard.
- HOW MUCH (how much will it cost to do): $1,000.00.

4.7 Control indicators

After preparing the Action Plan, which will help identify the sense of urgency of each of the models/areas, some indicators were created, responsible for evaluating the "In Use" models and verifying the real effectiveness of the implemented Action Plan (or under implementation). The indicators were created considering the performance of the models, encompassing the 5 areas of the Survey, allowing the creation of a Control Panel for each Model, aiming at better management. In Table 5 are some Indicators that were proposed for risk control.

Table 5

Indicators proposed.

Methodology	1) % parameters considered in the methodology
Data	2) Number of data sources for each reference
	3) % data correction not applied at source
IT	4) % system available
Performance	5) % models with Backtesting
	6) Performance deficiencies that have ongoing corrective actions x total deficiencies
Governance	7) % models approved in the relevant forums
	8) % models with updated manual

- Indicator 1 – Enables the identification of how many parameters used in the model are being considered in the methodology, according to Equation 2:

$$Parameters(\%) = \frac{Parameters\ in\ methodology}{Total\ parameters} x100\% \qquad (2)$$

- Indicator 2 – Check the sources of each of the references used. The greater the number of references, the greater the reliability of the information;
- Indicator 3 – Identify the amount of incorrect information, serving as input for future action plans. The greater the number of corrections not applied at the source, the greater the risk of the Financial Model;
- Indicator 4 – Must be calculated using the total time that the system was available (uptime), taking into account the total time (uptime + downtime), this indicator serves as a basis for improvements or generating continuity plans, according to Equation 3;

$$Availability = \frac{uptime}{uptime + downtime} x100\% \qquad (3)$$

- Indicator 5 – Allows you to identify the number of models that have Backtesting, process of testing mathematical models, using time series, to predict the behavior of dynamic systems, according to Equation 4:

$$Backtesting\ (\%) = \frac{Models\ with\ Backtesting}{Total\ Models} x100\% \qquad (4)$$

- Indicator 6 – Check the progress of models that have performance deficiencies. It uses corrections in progress and the total number of models that need corrections as information, according to Equation 5:

$$Performance(\%) = \frac{Models\ with\ deficiencies\ and\ corrections}{Total\ Models\ with\ Deficiencies} \qquad (5)$$

- Indicator 7 – Evaluate the number of models that need approval by Commissions and that have already been approved by the relevant Forums, according to Equation 6:

$$Models\ Commissions(\%) = \frac{Forum\ Approved\ Templates}{Total\ Approval\ Required\ Templates} x100\% \qquad (6)$$

- Indicator 8 – Identify and monitor the models that have an updated manual, according to Equation 7.

$$Updated\ Manual\ Models\ (\%) = \frac{Models\ with\ Updated\ Manual}{Total\ Models} x100\% \qquad (7)$$

5. CONCLUSION

Globalization has, quite significantly, transformed the landscape in which financial institutions used to work. Given the more complex and competitive environment that Financial Institutions are exposed to, the increase in risks to which they incur and the possibility of generating potentially large losses, the role of risk management is an important mitigating key. On the other hand, there are still no standardized methods for analyzing the risk of models.

This work aimed to improve management, creating indicators that serve to monitor and mitigate Model Risk in an FI. Using the existing inventory of Models, direct communication with the manager was sought, identifying possible points of improvement in the use or development of each of the Models. This work improved the existing Survey, making it leaner and with less redundancy, making managers feel more motivated to achieving more assertive results. With this, it achieved its objective, as well as contributing to the academy, bringing new methods and approach to model risk analysis, of easy application, and to other companies, given that the methodology used can be expanded to other sectors, from that have models already used for data collection, which can serve as support for improvement processes, failure identification, and for other articles and case studies related to the theme.

The evolving landscape, marked by the emergence of new banks and payment institutions, underscores the importance of robust governance frameworks in FIs. This study positions itself to support these institutions by bolstering risk management capabilities, thereby fortifying the national financial system overall.

Performing the individual assessment of each model, using specific parameters, weights, and action plans according to the impact and probability of each model, is very important. This evolution in assessment allows for a deeper understanding in the defense line.

Looking forward, the proposed survey methodology shows promise for broader application across industries, reducing complexity and enhancing response accuracy. Additionally, integrating risk matrices and control indicators promises to further strengthen risk management post-financial model development.

REFERENCES

Andrade, R. P. (2011). A construção do conceito de incerteza: uma comparação das contribuições de Knight, Keynes, Shackle e Davidson. *Nova Economia*, 21(2), 171-195.

Arrieta, D. (2022). Model risk quantification based on relative entropy**.** *Journal of Risk Model Validation*, 16(3).

Berkowitz, J., & O'Brien, J. (2002). How accurate are value-at-risk models at commercial banks? *Journal of Finance*, 57(3), 977–987.

Brigs, P. (1998). *Principles of international trade and payments*. Blackwell Publishers.

Brinckmann, S., Liberali, G., & De Souza, R. (2005). Estudo de caso: Braskem: Implantação de uma gestão integrada de riscos. *Revista Melhores Práticas*.

Carvalho, A. S. (1994). Administrando risco de taxas de juros em instituições financeiras. *Caderno de Estudos*, 10.

Crawford, K., & Calo, R. (2022). There is a blind spot in AI research. *Nature.* https://www.nature.com/articles/d41586-022-00683-0

Derman, E. (1996). *Model risk*.

Doshi-Velez, F., & Kim, B. (2023). Towards a rigorous science of interpretable machine learning. *arXiv Preprint*. https://arxiv.org/abs/2304.04368

Garcia, M., & Didier, T. (2003). Taxa de juros, risco cambial e risco Brasil. *Revista Pesquisa e Planejamento Econômico*.

Gitman, L. J. (2004*). Princípios de administração financeira*. Pearson.

Gonçalves, J. E. (2000). As empresas são grandes coleções de processo. *Revista de Administração de Empresas*, 40(1), 6-19.

Greene, W. H. (2008). *Econometric analysis* (6th ed.).

Guasti Lima, F. (2016). *Análise de riscos* (2nd ed.). Atlas.

Hendricks, D. (1996). Evaluation of value-at-risk models using historical data. Federal Reserve Bank of New York Economic. *Policy Review*, 2(1).

Jia, J., & Bradbury, M. E. (2020). Complying with best practice risk management committee guidance and performance. *Journal of Contemporary Accounting & Economics*, 16(3).

Jorion, P. (2003). Value at risk: A nova fonte de referência para a gestão do risco financeiro. *Bolsa de Mercadorias & Futuros*.

Junior, P. J., & Scucuglia, R. (2011). Mapeamento e gestão por processos – BPM (*Business Process Management*). M. Books.

Kato, T., & Yoshiba, T. (2000). Model risk and its control. Monetary and *Economic Studies*.

Klein Jr., V. H., & Reilley, J. T. (2021). The temporal dynamics of enterprise risk management. *Critical Perspectives on Accounting*.

Knight, F. H. (1921). *Risk*, uncertainty and profit. Houghton Mifflin Company.

Mitchell, M., Wu, S., Zaldivar, A., Barnes, P., Vasserman, L., Hutchinson, B., Spitzer, E., Raji, I. D., & Gebru, T. (2023). Model cards for model reporting: Standardizing model reporting in NLP. In Proceedings of the 2023 *Conference on Fairness*, Accountability, and Transparency (FAccT '23), 311–324.

Mittelstadt, B. D., & Floridi, L. (2024). Why AI needs interpretability. *AI & Society*, 39(1), 17-24.

Montavon, G., Samek, W., & Müller, K. R. (2022). Explainable AI: Interpreting, explaining and visualizing deep learning. *Springer*.

Obermeyer, Z., Powers, B., Vogeli, C., & Mullainathan, S. (2023). Dissecting raciais bias in an algorithm used to manage the health of populations. *Science*, 366(6464), 447-453.

OCDE. (2011). *Avaliações da OCDE sobre governança pública*: Avaliação da OCDE sobre o sistema de integridade da administração pública federal brasileira - Gerenciando riscos por uma administração pública mais íntegra.

Office of the Comptroller of the Currency, *Federal Reserve*. (2011). Supervisory guidance on model risk.

PMI. (2008). Um guia do conhecimento em gerenciamento de projetos (Guia PMBOK, 4th ed.). *Project Management Institute*.

Pradella, S., Furtado, J. C., & Kipper, L. M. (2012). *Gestão de processos da teoria à prática* – Aplicando a metodologia de simulação para a otimização do redesenho de processos. Atlas.

Rudin, C. (2022). Stop explaining black box machine learning models for high stakes decisions and use interpretable models instead. *Nature Machine Intelligence*, 4(1), 3-5.

Saunders, A. (2000*). Administração de instituições financeiras*. Atlas.

Selbst, A. D., & Barocas, S. (2023). The intuitive appeal of explainable machines. *Fordham Law Review*, 91(1), 101-148.

Shenhar, A. J., & Dvir, D. (1996). Toward a typological theory of project management. *Research Policy*, 25, 607-632.

Sibbertsen, P., Stahl, G., & Luedtke, C. (2008). *Measuring model risk*.

Smith, P. G., & Merritt, G. M. (2002). Proactive risk management: Controlling uncertainty in product development. *Productivity Press*.

Solomon, J. F., Solomon, A., & Norton, D. S. (2000). A conceptual framework for corporate risk disclosure emerging from the agenda for corporate governance reform.

Veale, M., & Binns, R. (2024). Fairness and accountability design needs better incentives. In Proceedings of the 2024 AAAI/ACM *Conference on AI, Ethics, and Society* (AIES '24), 129-138.