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**A RISK MANAGEMENT MATURITY MODEL PROPOSAL FOR BRAZILIAN
PUBLIC ORGANISATIONS**

Recife

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A risk management maturity model proposal for Brazilian public organisations

Thesis presented to the Postgraduate Program in Production Engineering at the Federal University of Pernambuco, as a partial requirement for obtaining the title of Doctor of Science in Production Engineering.

Research area: Production Management.

Supervisor: Prof. Dr. Ana Paula Cabral Seixas Costa.

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ABSTRACT

Drawing on the literature concerning the contingency theory, maturity models, enterprise risk management and the fuzzy set theory, this thesis proposes a new maturity model to assess risk management (RM) implementation in Brazilian public organisations. In this sense, three main studies are presented. The first one explores RM implementation in Brazil through the support of government policymakers in 6 Brazilian states. Qualitative content analysis provides evidence that the policymakers employ strategies to approach public organisations with the aim to operationalise RM as contingent variables are perceived. These strategies are expected to attenuate the difficulties in progressing RM maturity due to some generally weak support from public top managers. The second study investigates which attributes and contingent factors are crucial to develop a public sector RM maturity model. Accordingly, a path of multivariate statistical techniques (CATPCA, K-modes, and multinomial logistic regression analysis) was used to analyse the data collected from 330 survey responses. Results reveal that 12 statistically significant variables explain 5 different levels of public sector RM maturity. The third study is a complement to the second one and proposes the PRisk-MM, a public sector RM maturity model that contains 5 levels of maturity and 23 maturity attributes related to 15 dimensions. The model was elaborated following the scientific rigour found in the literature on maturity models, being divided into 2 main phases: the development of the model and its validation in 3 public organisations of one state government. The assessment procedure of the model uses triangular fuzzy numbers to better treat the subjectivity and ambiguity of human judgement when analysing maturity dimensions and their attributes. This thesis has important practical implications as it demonstrates that RM is not always easily implemented in the public context, and higher levels of RM maturity are difficult to achieve. Therefore, the PRisk-MM was developed as a government tool that policymakers can use to assess the public organisations' maturity status and compare their performance in implementing RM. Moreover, the PRisk-MM is adaptive to governments' contexts and, once applied, presents prescriptions on what organisations must do to develop their RM practices.

Keywords: public sector risk management; contingency theory; multivariate statistics; maturity models; fuzzy set theory.

RESUMO

Com base na literatura relacionada à teoria de contingência, a modelos de maturidade, a gestão de riscos corporativos, e à teoria de conjuntos *fuzzy*, esta tese propõe um novo modelo de maturidade para avaliar a implantação da gestão de risco (GR) de organizações públicas brasileiras. Neste sentido, são apresentados três estudos principais. O primeiro explora a implementação da GR no Brasil através do apoio de formuladores de políticas governamentais em 6 estados brasileiros. Através da análise qualitativa do conteúdo, evidências demonstram que os formuladores de políticas empregam estratégias para abordar organizações públicas com o objetivo de operacionalizar a GR a partir da percepção de variáveis de contingências. Espera-se que essas estratégias atenuem as dificuldades em progredir na maturidade da GR devido ao apoio, geralmente fraco, dos mais altos gestores públicos. O segundo estudo investiga quais atributos e fatores de contingência são cruciais para desenvolver um modelo de maturidade de GR para o setor público. Assim, técnicas estatísticas multivariadas (CATPCA, K-modes, e análise de regressão logística multinomial) foram usadas para analisar os dados coletados de 330 questionários aplicados. Os resultados revelam que 12 variáveis estatisticamente significativas explicam 5 níveis diferentes de maturidade de GR no setor público. O terceiro estudo é um complemento do segundo e propõe o PRisk-MM, um modelo de maturidade de GR para o setor público que contém 5 níveis de maturidade e 23 atributos de maturidade relacionados a 15 dimensões. O modelo foi elaborado seguindo o rigor científico encontrado na literatura sobre modelos de maturidade, sendo dividido em 2 fases principais: o desenvolvimento do modelo, e sua validação em 3 organizações públicas de um estado brasileiro. O procedimento de avaliação do modelo utiliza números triangulares *fuzzy* para melhor tratar a subjetividade e ambiguidade do julgamento humano ao analisar as dimensões de maturidade e seus atributos. Esta tese tem importantes implicações práticas por demonstrar que a GR nem sempre é facilmente implementada no contexto público, e que níveis mais altos de maturidade são difíceis de alcançar. Portanto, o PRisk-MM foi desenvolvido como uma ferramenta governamental que pode ser usada para avaliar o status de maturidade das organizações públicas e comparar seu desempenho na implantação da GR. Além disso, o PRisk-MM é adaptável aos contextos dos governos e, uma vez aplicado, apresenta prescrições sobre o que as organizações devem fazer para desenvolver suas práticas de GR.

Palavras-chave: gestão de riscos do setor público; teoria da contingência; estatística multivariada; modelos de maturidade; teoria dos conjuntos *fuzzy*.

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LIST OF ACRONYMS

CATPCA	Categorical Principal Component Analysis
CGDF	Controladoria Geral do Distrito Federal
CGE-MG	Controladoria Geral do Estado de Minas Gerais
CGU	Controladoria Geral da União
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
COG	Centre of Gravity
COSO	Committee of Sponsoring Organisations of the Treadway Commission
CRO	Chief Risk Officer
ERM	Enterprise Risk Management
GPM	Government Policymakers
ICT	Information and Communication Technology
IIA	The Institute of Internal Auditors
ISO	International Organisation for Standardisation
LIC	Local Internal Controller
MCDA	Multicriteria Decision-making Analysis
MM	Maturity Model
NPM	New Public Management
PCA	Principal Component Analysis
PSRMMM	Public Sector Risk Management Maturity Model
RM	Risk Management
SCGE-PE	Secretariat of Comptroller General of Pernambuco
SEI	Software Engineering Institute
SGOV	State government
TCU	Tribunal de Contas da União
TFN	Triangular Fuzzy Number

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1 INTRODUCTION

Organisations in the public sector perform in a particularly complex environment, in which several factors exert influences that differ from those found in the private sector. Such a challenging environment involves issues related to the political climate, public interest, legal requirements, budget restrictions, technological shifts, constant changes in leadership, etc. (BOZEMAN, 2004; RAINEY; CHUN, 2005). Meanwhile, multiple stakeholders expect more than the mere delivery of public services; they are interested in whether actions are executed with efficiency, effectivity, and integrity, counting on the enhancement or maintenance of the well-being of citizens. In this context, risk management (RM) has increasingly been incorporated into the routine of public organisations to face the wide range of uncertainties they have to deal with in response to society. Such introduction is fostered by the evolution of government regulation requiring corporate governance and internal control systems to be in place, taking the management of risks into account as a promising strategy (SUBRAMANIAM *et al.*, 2013; WOODS, 2022).

Particularly, RM has also been seen as an organisational-oriented tool derived from the business-like paradigm found in the New Public Management - NPM (POLLIT; BOUCKAERT, 2017; GEORGE; VAN DE WALLE; HAMMERSCHMID, 2019). Accordingly, it has also been used as an approach to improve the quality of public services and mirror the private sector enterprise risk management (ERM). Nonetheless, the contingent factors that surround public organisations are so peculiar that require adaptations to ERM, bringing more significant challenges to the public sector (WOODS, 2022). For this reason, this thesis uses the term “public sector RM” to reflect the ERM features but considering the contextual aspects that distinguish the public sector from the private one (RAINEY; CHUN, 2005; WOODS, 2009).

Risks are conceived as “the effect of uncertainty on objectives” (ISO 31.000:2018). Such effect can be positive, negative, or even both, fostering opportunities or threats for the organisations. They are generally expressed in terms of risk sources, risk events, their consequences and likelihood (ISO 31.000:2018). Kaplan and Mikes (2012) classify risks into preventable, strategic, and external. The preventable risks are derived from operational breakdowns or from unethical and illegal behaviour; the strategic ones emerge from strategic decisions or plans; and the external risks arise from events that cannot be controlled by the organisations. Therefore, as public sector organisations face risks in all their activities, they need to manage those risks classified into all types as described by Kaplan and Mikes (2012).

For instance, in the public context, it is possible to find risks that are strategic *per se*, others are operational as they are related to the delivery of public services, and others are related to integrity such as fraud, corruption, nepotism and further unethical behaviour. Regarding the external risks, examples in the public sector may refer to risks derived from climate changes, from decisions taken by leaderships from other countries, and so on.

The adhesion to the public sector RM has been observed worldwide. Countries such as the UK, the USA, Australia, Canada, and Korea are good examples already described in the literature (WOODS, 2009; KIM, 2014; PALERMO, 2014). Following this international tendency, the Brazilian federal government started to intensify requirements regarding the public sector RM implementation, having fostered a growing surge of interest among the federal public organisations since 2016. Hence, not only has the legislation been used to formally demand RM implementation, but also the federal internal control audits, performed by the Comptroller General of the Union (CGU – *Controladoria Geral da União* in Portuguese), started to rise more concerns about the organisational risks and how they are supposed to be systematically managed. In addition, the Brazilian Federal Court of Accounts (TCU – *Tribunal de Contas da União* in Portuguese), exerting the external control in the federal government, and the CGU started to publish online versions of their own RM methodologies and of other documents in the same way to stimulate the public organisations to develop and implement RM frameworks.

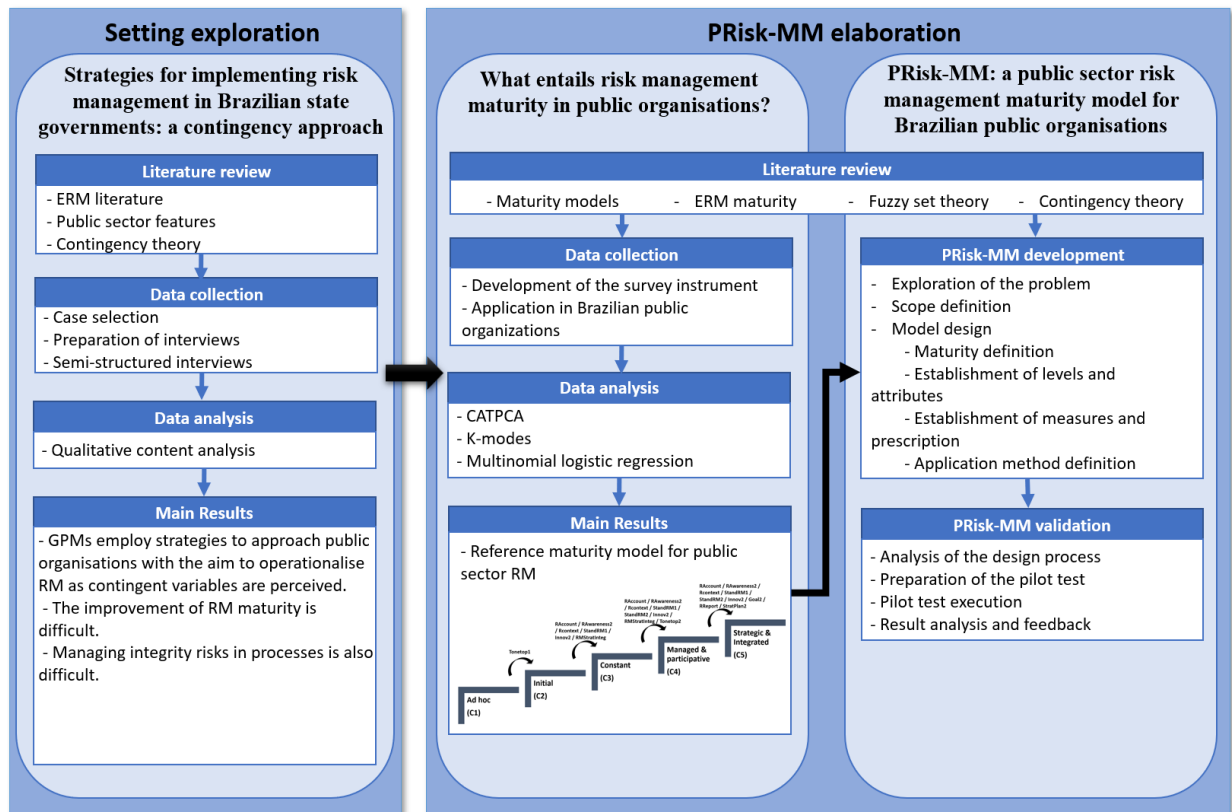
Likewise, some Brazilian state governments rapidly began to follow the same federal logic by introducing more and more regulations into their own jurisdictions, as well as by publishing online guidelines regarding the public sector RM. Therefore, in face of such a movement in Brazil, general questions have arisen: “Are the Brazilian public organisations successfully implementing the public sector RM?” “How mature are the organisations regarding the public sector RM implementation?” “Do government policymakers (GPMs) face problems to stimulate RM adoption? If so, which ones and why?”. These questions were the starting point of this thesis, with a research path beginning to emerge.

Therefore, the first research problem of this thesis comprised the need to investigate how the Brazilian governments were implementing the public sector RM and which contingent factors influenced their RM practices, both positively and negatively. For this purpose, it was necessary to explore the Brazilian setting through a qualitative approach. In this sense, the first study of the thesis was conducted based on the contingency theory, the ERM literature, and the public sector features. This study employed the qualitative content analysis method to investigate semi-structured interviews with GPMs from 6 state governments. The selection of

such governments is the result of a previous search with the aim to identify which of the Brazilian governments had enacted specific legislation demanding RM implementation. At first, 12 state governments were identified, but 6 were excluded from the final sample because neither did they answer telephone calls or e-mails, nor did they have empirical initiatives at that moment, or they only focused on Integrity/Compliance Programmes, demonstrating no interest in a wider public sector RM. Data were triangulated with further public documents and website contents. The main results suggested that the GPMs of those governments employ three distinct strategies to approach the public organisations and operationalise the public sector RM because of the generally weak support from public top managers; consequently, these GPMs perceive a great difficulty to improve RM maturity. Further contingent variables influencing the strategies were risk types and the innovation-oriented culture.

Considering these results, the fact that the governments have difficulty to reach higher levels of RM maturity has drawn attention, and the need to find a solution that could contribute to enhancing the Brazilian public organisations' RM maturity has become the second research problem of this thesis. Therefore, among the actions at government level that can be taken to attenuate this problem, the idea of elaborating a maturity model (MM) directed for Brazilian public organisations to develop their own public sector RM arose, being named PRisk-MM. The process of elaborating the PRisk-MM was robust and involved two different studies: the creation of a reference model to build public sector risk management maturity models (PSRMMM), and the development of the PRisk-MM *per se*. For both, it was necessary to deepen knowledge on maturity models, ERM maturity, the fuzzy set theory and the contingency theory. The development of the reference model to build a PSRMMM was based on three multivariate statistical analyses: CATPCA (Categorical Principal Component Analysis), K-modes, and the multinomial logistic regression; the development of the PRisk-MM followed the design science research, thus becoming a complement to the previous reference model. Figure 1 depicts the connections among the studies developed for this thesis.

Figure 1 - The studies of this thesis



Source: The Author (2023).

In this introductory chapter, this thesis is presented as comprising the three main studies and interconnections above. Moreover, the reader may find the Brazilian context as regards the public sector RM implementation, the description of the methodology performed, as well as the presentation of the thesis structure.

1.1 PUBLIC SECTOR RISK MANAGEMENT INITIATIVES IN BRAZIL

Brazil is a country composed of 26 states plus the Federal District, being divided into three tiers of government (the federal government, the states and the municipalities), and three distinct branches (the executive, the legislative and the judiciary). This thesis analyses the public sector RM implementation in the Brazilian executive branch, with a focus on the federal and state governments. Municipalities were discarded because the movement to implement RM is not yet well widespread among them.

The public organisations of the executive branch are classified as direct and indirect administration bodies (BRAZIL, 1988). The organisations pertaining to the direct administration provide services directly to the citizens on behalf of the governments. These

organisations are subordinated to the President or to the State Governors (e.g.: ministries and secretariats, respectively). On the other hand, the organisations of the indirect administration provide services to citizens indirectly through the establishment of autarchies, foundations, public enterprises, or mixed-economy companies. The two former types are more dependent on public budget and have similar characteristics to organisations of the direct administration, with the difference that they are created for specialised purposes, while public enterprises and mixed-economy companies are regulated by private law and can explore economic activities. All these public organisations operate in several different types of industries in Brazil, such as education, health, police, tourism and culture, economy, etc.

In terms of legislation in the federal government, it has been a long time since Brazil demonstrated interest in enhancing public trust, strengthening internal controls, and increasing the quality of public services. For instance, one of the main actions was the creation of the Public Ethics Committee in 1999, with the duty to implementing the Federal Code of Conduct of High Administration and to coordinate decentralized ethics initiatives (OECD, 2012). In 2006, the CGU developed operational RM methodologies that were piloted in a small number of organisations with indirect public administration, such as public commercial banks. One year later, the government introduced the National Strategy to Combat Money Laundering (OECD, 2012). The year 2013 was marked by anticorruption law 12.846/2013, which strengthened requirements from regulators and established sanctions against firms that practice illegal acts in contracts with the public administration. In 2015, decree 8.420/2015 established objective liability for such firms, considering the existence of integrity programs to attenuate penalties.

Nonetheless, the specific efforts devoted to promoting RM have increased substantially since 2016. Three important examples may be given: the CGU and the Federal Ministry of Planning, Budget, and Management jointly released Normative Instruction 01/2016 requiring the establishment of risk-based internal controls, the enhancement of governance, and the systematization of RM in the federal public administration. In the same year, Law 13.300/2016 was issued specifically for public enterprises and mixed capital societies on all tiers of government, requiring their respective statutes to observe rules of governance, transparency, as well as RM and internal control practices. One year later, Decree 9.203/2017 stipulated that the governance policy for organisations under the direct federal administration, autarchies and foundations would have to establish integrity management as one of the main pillars of public governance and determine the implementation of risk-based internal controls, the integration of RM to strategic planning, and its use for the continual improvement of processes. Also in 2017, the federal government released Normative Instruction 05/2017 stipulating procedures for

contracting services through the incorporation of RM analysis. Moreover, in 2018, the CGU and the TCU also issued several guidelines addressing topics such as the RM maturity assessment and the RM process model (e.g.: BRAZIL, 2018a; 2018b; 2018c; 2018d, 2018e). In the same direction, similar initiatives started subsequently to arise in Brazilian state governments, with some of them issuing their own regulations based on the federal examples.

In Brazil, the GPMs supposed to articulate RM implementation are public auditors generally based in the General Comptrollerships of the governments. Among other activities related to transparency, corruption prevention, the defence of public assets, internal control and auditing, ombudsmanship, correction, and fraud deterrence, their role also comprises the enactment of central government policies, RM being an example of these. Some of their duties regarding RM includes the elaboration of an RM methodology, the definition of structural arrangements in the governments, as well as formally determining responsibilities and boundaries for the public organisations. Moreover, Brazilian GPMs provide guidance through training programmes, consulting services, and formally monitoring or auditing RM implementation depending on the status of maturity of the organisations (DE LORENA, *et al.* 2022). Hence, these auditors, as GPMs, have roles related to providing either consulting services when the idea is to concentrate efforts to improve the RM system, or to the assurance on RM implementation when it becomes more embedded in the organisation (IIA, 2009).

1.2 METHODOLOGY

This session is divided into “Research definition”, “Research type and methods” and “Research justification”. In the first subsection, the reader will find the research questions along with the primary and secondary objectives. Next, the research type and the methods that have led to the elaboration of the PRisk-MM will be exposed. Lastly, the theoretical and practical justifications of the study will be presented.

1.2.1 Research definition

For the two problems discussed in the introductory text of this chapter, there is a research question with a primary and a secondary objective connected to each.

- **Research question 1**: regarding the setting exploration, the research question was: “What contingent factors contribute to and hinder RM implementation in the Brazilian public sector, and what are the consequences?”

Primary Objective: To identify the contingent factors that influence RM practices performed by Brazilian governments as well as the respective consequences in the setting.

Secondary Objectives:

- To identify the contingent variables that positively influence RM implementation in the Brazilian public sector.
 - To identify the contingent variables that negatively influence RM implementation in the Brazilian public sector.
 - To identify and analyse the consequences of the identified contingent variables.
- **Research question 2:** regarding the PRisk-MM elaboration, the research question was “How to assist the Brazilian public organisations to improve the maturity of their RM systems?”.

Primary Objective: To propose a PSRMMM to evaluate the status of the organisations’ maturity in implementing RM and to provide improvement prescriptions.

Secondary Objectives:

- To investigate which attributes and contingent factors are statistically significant to develop a PSRMMM.
- To identify, in the literature, which steps are considered state-of-the-art to develop an MM.
- To identify which measures can satisfactorily treat subjective judgements for the attributes.
- To identify which practices are important to be prescribed and to improve the RM attributes.
- To validate the PSRMMM.

1.2.2 Research classification

The studies of this thesis are classified according to their nature, purpose, approach, strategy, and methods. Table 1 brings an overview of the research classification, and to facilitate the discussion of this subsection, the studies are referred to as Study A (“Strategies for implementing risk management in Brazilian state governments: a contingency approach”), Study B (“What entails risk management maturity in public organisations?”), and Study C

(“PRisk-MM: a public sector risk management maturity model for Brazilian public organisations”).

Table 1 – Research classification

Research elements	A - Strategies for implementing risk management in Brazilian state governments: a contingency approach	B - What entails risk management maturity in public organisations?	C - PRisk-MM: a public sector risk management maturity model for Brazilian public organisations
Nature	Fundamental	Applied	Applied
Purpose	Exploratory	Explanatory	Prescriptive
Methodological choice	Qualitative	Quantitative	-
Strategy	Multi-case study	Survey	
Methods	Qualitative content analysis	CATPCA, K-modes, and multinomial logistic regression	Design Science

Source: The Author (2023).

Regarding the research nature, Study A is considered fundamental or basic because it aims to understand how Brazilian governments implemented the public sector RM, that is, it neither intervened nor transformed the reality in the settings (BARROS; LEHFELD, 2007). Studies B and C were considered applied studies because they contributed to the empirical world, aiming to propose a solution to a real-world problem (BARROS; LEHFELD, 2007; DEB; DEY; BALAS, 2019).

Regarding the research purpose, Study A is considered exploratory because it brings more familiarity to the setting and makes it more explicit, understanding, but not necessarily describing or explaining the setting (GIL, 2010). Through such exploration, it was possible to identify the contingent factors that influenced the Brazilian governments as regards RM implementation, as well as to understand their reflections in the form of strategies, since RM maturity was difficult to achieve. Study B is considered explanatory because it aimed to identify which variables could statistically explain the existence of clusters that represented the levels of RM maturity. Through this study, it was possible to deepen the understanding of what actually constituted maturity in the public sector RM (GIL, 2010). Alternatively, Study C is prescriptive, characterising the employment of design concepts and thus representing the development of the PRisk-MM as a practical solution to help mature the public sector RM implementation in the Brazilian public organisations (DRESCH; LACERDA; ANTUNES JR, 2015).

Concerning the methodological choice and strategy, Study A is qualitative and uses a multiple-case study as 6 Brazilian governments were analysed, counting on semi-structured interviews and other official documents for triangulation. This strategy is considered convenient in cases where previous findings are not enough to formulate concrete hypotheses and the limits between the phenomenon and the context are not clearly perceived (YIN, 2018). On the other hand, Study B is quantitative and based on a survey instrument that was conducted in federal and state public organisations all over Brazil to identify which attributes and contingent factors were relevant to develop a path of maturity for the public sector RM. For this purpose, based on the literature review, a set of variables related to ERM attributes and contingent factors in the public sector were operationalised for investigation (GIL, 2010). As Study C complements Study B, it indirectly follows the same quantitative methodological choice through the survey strategy to establish the levels, attributes, measures, and prescriptions of the PRisk-MM.

Finally, regarding the methods used to analyse the collected data, in Study A the “qualitative content analysis” method was chosen inspired in the protocol recommended by Schreier (2012), with further methodological observations found in Krippendorff (2013). With this method, it was possible to systematically describe the meaning of qualitative material by assigning thematic categories to the data under investigation (SCHREIER, 2012). Considering that one of the challenges in multiple case studies is the management of a big amount of data (MERRIAM; TISDELL, 2016), the Atlas.ti software was selected to perform the qualitative content analysis because it provides higher reliability and greater speed during analysis, making the process more manageable and productive (SCHREIER, 2012). Contrastingly, given the quantitative approach found in Study B, a statistical path analysis was performed by using the CATPCA, K-modes and multinomial logistic regression methods. These methods were especially chosen because they treat categorical data and were manipulated by using the *R* programming language.

Differently from the other studies, Study C is pragmatic and rooted in the Design Science Research method, which aims to suggest solutions to a practical and specific problem to help achieving better organisational results (DRESCH; LACERDA; ANTUNES JR, 2015). This method considers the understanding of a problem, and then constructs and evaluates artifacts that enable the transformation of situations into desirable status. Moreover, the Design Science Research is recognised for reducing the possible gaps between theory and practice because it produces knowledge that can be perceived as a reference of the improvement of existing theories (DRESCH; LACERDA; ANTUNES JR, 2015). Therefore, this method was

used to develop and validate the PRisk-MM, considering the typical phases proposed by Mettler (2011) and De Bruin et al. (2005) to properly design an MM.

1.3 JUSTIFICATION

The first study of this thesis is justified by a lack of investigation into what factors may hinder RM implementation in the public sector. In general, academics put efforts into exploring successful examples (e.g.: LEUNG; ISAACS, 2008; WOODS, 2009; PALERMO, 2014; KIM, 2014; Hinna et al., 2018), leaving aside the challenges that may exist. The public context has features that are distinctive from the private one (RAINEY; CHUN, 2005; WOODS, 2009); consequently, the RM principles are considered equal for both sectors, but the empirical challenges for public organisations are significantly higher (WOODS, 2022). Therefore, in this study, RM implementation is found as a difficult endeavour, and strategies may be developed by GPMs to approach public organisations mainly due to the generally weak tone from public top managers. As a result, further analysis indicates that it is difficult to reach mature levels of RM implementation.

Considering such difficulty, the second and the third studies together elaborate the PRisk-MM as a PSRMMM that can be used by GPMs to assess the RM implementation of the public organisations under their jurisdiction (DE LORENA; COSTA, 2023a), as this is part of the controlling role they exert over such organisations (WOODS, 2009; DE LORENA, *et al.*, 2022). This idea was endorsed by the fact that no previous PSRMMM has been found in the literature focusing on the public sector RM implementation like the PRisk-MM does. In this sense, one stream of researchers generally devotes attention to the contingent factors that contribute to ERM implementation (e.g.: GORDON; LOEB; TSENG, 2009; WOODS, 2009; PAAPE; SPEKLÉ, 2012), while another investigates the value creation of ERM when higher levels of maturity are achieved (e.g.: FARRELL; GALLAGHER, 2015; BEASLEY; BRANSON; PAGACH, 2015). Nonetheless, no study has explored the process by which RM may advance in the public sector, being an opportunity to understand how MMs may help.

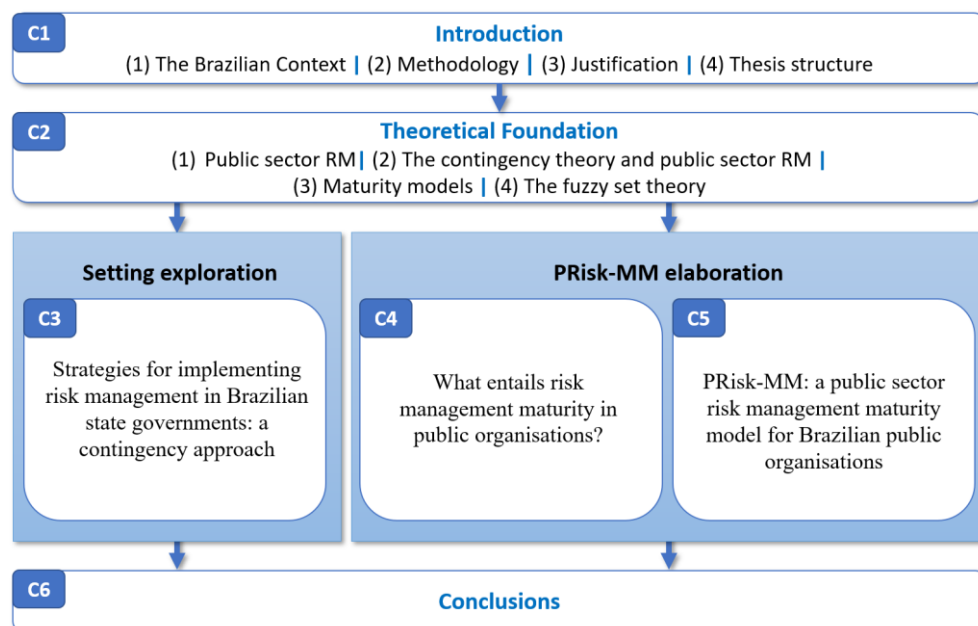
Accordingly, through a path of statistical analysis, the second study of this thesis focuses on explaining how the maturity levels of a PSRMMM behave considering the ERM attributes and contingent factors. Thus, the identification of statistically significant variables *per* maturity level highlights the originality of the PRisk-MM, contributing to the development of prescriptions for improvement. Subsequently, in the third study, the PRisk-MM is developed and validated contemplating features that are highlighted by academics as crucial for building

an effective MM. Such features consist of the provision of prescriptions, empirical validation and a sound theoretical foundation (WENDLER, 2012; SANTOS NETO; COSTA, 2019). Hence, the PRisk-MM can be used as a government tool with a clear and objective assessment procedure, being adaptative to governments through the assignment of weights to the PRisk-MM's dimensions and facilitating the comparison of the RM performances of several public organisations.

1.4 THESIS STRUCTURE

This thesis is mainly composed of one exploratory study and two main studies that together elaborate the PRisk-MM, one of which was published in the Journal of Risk Research (DE LORENA; COSTA, 2023a). These studies are interconnected as depicted in Figure 1, resulting in the development of the PRisk-MM, an RM-related tool created for Brazilian public organisations. Each study is organised as demonstrated in Figure 2.

Figure 2 - Thesis structure



Source: The Author (2023).

As described in Figure 2, this thesis starts with the introduction chapter, explaining the Brazilian context, the methodology, the justification for the studies and the presentation of the thesis structure. The second chapter presents the theoretical foundations that support this thesis, divided into the following subsections: (1) “Public sector RM”, where the reader will find the

ERM concept, what constitutes maturity in ERM, and what the literature has already explored regarding the contingent factors of the public sector RM; (2) “Maturity models”, which describes their concept, argues their benefits, and how they are supposed to be developed; finally, (3) “the fuzzy set theory”, describing its concept, features and benefits.

The third chapter represents a study entitled “Strategies for implementing risk management in Brazilian state governments: a contingency approach” (DE LORENA; COSTA, 2023b). In this study, the Brazilian setting was explored aiming to identify which contingent factors influenced their RM practices in both positive and negative ways. For this purpose, a qualitative content analysis was performed in semi-structured interviews involving GPMs from 6 state governments. Results revealed that GPMs employ three distinct strategies to approach public organisations and operationalise the public sector RM: “Gaining staff commitment”, “Centralising the RM process”, and “Managing general risks in integrity/compliance programmes”. These strategies are positively influenced by the “innovation-oriented culture” and “public top managers’ weak tone” variables, and are negatively influenced by the “risk types” variable. Moreover, it was also found that it is difficult to improve the maturity of RM in public organisations or to manage integrity risks in processes. These findings fostered reflections about which hints at government level could be provided to GPMs to facilitate RM implementation, the employment of a PSRMMM being an example of those.

Chapter 4 starts the process of the PRisk-MM’s elaboration and refers to the article “What entails risk management maturity in public organisations?” (DE LORENA; COSTA, 2023a). In this study, the main idea was to understand what in fact contributes to the public sector RM maturity and to develop a reference model that could be used to build future PSRMMMs. Thus, a survey instrument was conducted in the Brazilian setting, considering both federal and state public organisations. Data analysis was a composition of three multivariate statistical methods: (1) CATPCA contributed to the selection of which variables demonstrated a good fit for the public sector RM maturity, reducing the initial number of variables; (2) *K*-modes was used to identify the clusters that could represent the levels of RM maturity; and (3) the multinomial logistic regression contributed to the verification of which specific variables were statistically significant to explain the levels of maturity.

Presenting the final idea of this thesis, chapter 5 refers to the study named “PRisk-MM: a public sector risk management maturity model for Brazilian public organisations” (DE LORENA; COSTA, 2023c), becoming a complement to the study presented in chapter 4. This study, based on De Lorena and Costa (2023a) and validated in one Brazilian state government,

describes how the PRisk-MM was developed. The steps taken for its elaboration followed all the scientific rigour an MM must contain, inspired in the Design Science Research. Hence, the PRisk-MM may become a government tool and be used by GPMs to assess the public organisations' status of RM maturity, providing prescriptions on which actions the organisations can take in order to enhance their RM implementation.

Finally, chapter 6 presents the conclusions of this research, discussing how the studies solved the problems described in the introductory text of this thesis. Moreover, the main contributions as well as the limitations and ideas for future studies are detailed.

2 THEORETICAL FOUNDATION

This chapter introduces the theoretical background of the three studies in this thesis. It starts by discussing what public sector RM is supposed to be, and then it presents the literature on MM by providing concept, benefits, criticism advocated by academics and what has been found in the literature regarding the ERM domain. Next, the fuzzy set theory is presented, demonstrating its concept, features and benefits.

2.1 PUBLIC SECTOR RM

As explained in chapter 1, the term “public sector RM” is used in this thesis to reflect the ERM features when considering the contextual aspects of the public sector. Therefore, this session is divided into three parts: the concept of ERM, the aspects that need to be present to make ERM implementation mature, and how the contingent factors of the public context distinguish ERM practices from the public sector RM.

2.1.1 What is Enterprise Risk Management?

The management of risks arose fragmentedly within the organisations, involving a silo-based process of identifying, assessing, monitoring, and reporting risks, with little formality, structure, or centralisation in top management (LUNDQVIST, 2015; BROMILEY *et al.*, 2015). Such fragmentation occurred because different functions within an organisation would be concerned with their respective and specific risk events (ARENA; ARNABOLDI; AZZONE, 2011; BROMILEY *et al.*, 2015), especially in financial departments (VERBANO; VENTURINI, 2011), giving rise to what is recognised as traditional RM.

Over time, practitioners have perceived more benefits when risks are managed enterprise-widely, displaying a holistic view. This new wave is known as ERM, employing a proper structure that would be able to manage all kinds of risks in a coordinated and integrated way (ISO 31000:2018). This evolution entails the encouragement of a risk-awareness culture throughout the organisations, breaking down the traditional RM barriers to face various risk events (VERBANO; VENTURINI, 2011). Further features associated with ERM are the management of a portfolio of risks, board report, ERM policies, response plans, the existence of a board committee, a central department to lead ERM, risk appetite, the assumption of strategic risks, and so on (BROMILEY *et al.*, 2015; LUNDQVIST, 2015). Moreover, chief executive officers (CEO) play a significant role in ERM implementation as their influence and

control over governance decisions determine further steps towards leaving the traditional RM to introduce ERM (LUNDQVIST, 2015).

2.1.2 The maturity aspects of ERM

The basic attributes of ERM MMs are the ones that represent the RM process. According to COSO (2017) and ISO 31000:2018, it contains cyclical steps that involve the risk context regarding the internal and external environments of the activity under evaluation; the identification and analysis of risks, implying the understanding of their nature and considering the likelihood of occurrence, as well as the consequences; risk treatment decisions with the implementation of controls to mitigate risks through action plans; and the regular and formal report of risks to top managers, describing the organisations' top risk exposures (LUNDQVIST, 2015; BEASLEY; BRANSON; PAGACH, 2015; WOODS, 2022). Previous literature advocates that the frequency of risk reporting is considered an important factor to achieve more ERM maturity (PAAPE; SPEKLÉ, 2012; BRAUMAN, 2018). Finally, ERM implementation is supposed to be monitored with the aim to verify its effectiveness for the organisational performance (OLIVEIRA *et al.*, 2019; COSO 2017; ISO 31000:2018).

Considering the governance features, the presences of a Chief Risk Officer (CRO) and of a board committee accountable for overseeing ERM implementation are associated to its maturity (PAAPE; SPEKLÉ, 2012; LUNDQVIST, 2015), especially when the risk-based committees consist of top executives who provide guidelines to subordinate leaders (BEASLEY; BRANSON; PAGACH, 2015). Alternatively, CROs are experts that emphasise the commitment of top managers to ERM as change agents who put ERM into practice and assume a leadership role that emphasises communication rather than authority (KIM, 2014; PALERMO, 2014). Such a “focal point” facilitates the integration of information and formalises ERM, thus contributing to a successful implementation (OLIVEIRA *et al.*, 2019; LUNDQVIST, 2015). However, in the Brazilian context, the federal government refers to this agent as “Internal Control Special Advisor” (BRAZIL, NI 01/2016), whereas in the state governments, it is generally called “Local Internal Controller”. In both cases, these agents normally perform further activities and do not have exclusive attention to public sector RM. This is the reason why in this thesis they are not referred to as CROs, but as RM specialists.

The next attribute reflects the need of adopting a standardised RM process, including not only the identification and evaluation of risks, but also the communication of the control activities and the monitoring of measures. The provision of explicit RM guidelines fosters RM

process standardisation and provides greater solidity (KLEFFNER; LEE; MCGANNON, 2003; BEASLEY; BRANSON; PAGACH, 2015; WOODS, 2022). Such guidelines are generally formulated by the organisations' CRO and/or top managers and are disseminated to the operational level representing risk governance (JEAN-JULES; VICENTE, 2020; WOODS, 2022). In governments, guidelines may be provided by policymakers as recommendations to public organisations (WOODS, 2009; KIM, 2014). Nonetheless, they may become an anchor when the public organisation is required to follow rules and comply with orientations. Hence, despite the benefits, government standardised RM guidelines may represent constraints to organisational procedures (RAINEY; CHUN, 2005; WOODS, 2009).

Another important attribute is the perception of risk awareness at all hierarchical levels (ISO 31000:2018). To achieve proper awareness, top managers' active participation in appreciating and communicating the importance of ERM is deemed as paramount (KLEFFNER; LEE; MCGANNON, 2003; BRAUMANN; GRABNER; POSCH, 2020). Risk-aware employees tend to identify and analyse the key risks, thus incorporating the RM process into their working mode (BRAUMANN, 2018; OLIVEIRA *et al.*, 2019). Therefore, employees feel accountable for managing the risks of the activities under their responsibility (ZOU, CHEN; CHAN, 2010; WOODS, 2022), being assigned as risk owners (HOSEINI; HERTOOGH; BOSCH-REKVELDT, 2019; YEO; REN, 2009).

In terms of strategic alignment, ERM is also expected to be integrated into the strategic planning and objectives of the organisation (COSO 2017). For example, the consideration of risk information in a strategic decision-making process is observed in both private and public sector literatures (e.g.: BRAUMANN, 2018; WOODS, 2009; PALERMO, 2014). Another strategic attribute is the risk appetite - researchers advocate that more mature organisations have top managers who establish a risk appetite in alignment with the strategy, incorporate it into the strategic plan, and communicate it within the organisation (BEASLEY; BRANSON; PAGACH, 2015; BRAUMANN, 2018).

2.1.3 Contingent factors in the public sector RM

Management accounting researchers have devoted attention to the contingent factors that contribute to ERM implementation (e.g.: GORDON; LOEB; TSENG, 2009; WOODS, 2009; COLLIER; WOODS, 2011; PAAPE; SPEKLÉ, 2012; MIKES; KAPLAN, 2013). In this sense, ERM has been recognized as a control system that can have different designs according to those factors to best contribute to the firm's performance. Hence, the contingency theory has

been evoked with the aim to find such contingent factors. In essence, proponents of this theory advocate that there is not a unique best way to manage organisations, and their structures may vary according to contextual factors that require adaptation to achieve optimal performance (BURNS; STALKER, 1961; LAWRENCE; LORSCH, 1967; WOODWARD, 1965). Therefore, organisational effectiveness becomes the result of the fit between the organisational structures (including the ERM system) and their contingent variables (DONALDSON, 2001).

Considering that the *modus operandi* of public organisations is different from that of the private sector, public sector RM may differ (WOODS, 2022). A crucial distinctiveness is that formal authorities have greater political support to obtain appropriations for financial resources and authorisations before specific actions (RAINEY; CHUN, 2005), which, in turn, may cause higher political pressures. Consequently, such pressures reverberate in the behaviour of public top managers who have a more political and expository role that figures a “life-in-a-goldfish-bowl” stereotype (BOZEMAN, 2004), and whose steps are under the watchful eye of the mass media, interest groups and political authorities. Therefore, it is plausible to consider that the political environment is a potential contingent variable to influence public sector RM systems, in addition to the behaviour of public top managers being executives that perform a role that is not only managerial, but also political. Nonetheless, studies that have investigated the direct impact of political environment on organisational structures did not find sufficient support for positive conclusions (GREENWOOD; HININGS, 1976; HININGS; GREENWOOD; RANSON, 1975).

Regarding the behaviour of actors, “tone from the top” is a contingent variable that is largely mentioned by researchers and international bodies as essential for ERM development both in public and private sectors (e.g.: COSO 2017; ISO 31000:2018; OSMAN; LEW, 2021; JEAN-JULES; VICENTE, 2020). In short, it is conceived as a powerful form of cultural control that originates from the top managers’ ability to actively manage the behaviour of employees (BRAUMANN; GRABNER; POSCH, 2020). Such cultural control can be observed in a top-down fashion through the communication of the commitment and behavioural expectations regarding ERM, and in a bottom-up movement through encouraging employees to report risk issues (KLEFFNER; LEE; McGANNON, 2003; FARRELL; GALLAGHER, 2015; BRAUMANN; GRABNER; POSCH, 2020). Top managers’ support is deemed to be so important that, without it, ERM evolution is destined to fail (LUNDQVIST, 2015; OLIVEIRA *et al.*, 2019; JEAN-JULES; VICENTE, 2020).

Another possible variable that deserves attention is the organisational culture. Investigating not-for-profits’ organisations, Chen, Jiao and Harrison (2019) find that previously

settled outcome-oriented and innovation-oriented cultures positively influence the maturity of RM implementation because these cultures are supposed to shape RM practices. Outcome-oriented cultures are understood as representing the extent to which an organisation expects performance and emphasises the achievements and results. Alternatively, innovation-oriented culture indicates creativity, innovation, risk-taking behaviour, willingness or preparedness to experiment, receptivity and adaptability to change (WYNEN *et al.*, 2014; CHEN; JIAO; HARRISON, 2019). According to Chen, Jiao and Harrison. (2019), innovation culture influences the RM system because it emphasises the organisation's preparedness to develop the new management practice and accept the changes it may provide. In this sense, it is paramount that the organisational culture does not feed feelings of fear or blame in reporting risks (WOODS, 2022). Further public sector studies have found that innovation-oriented culture positively affects the performance of public organisations (TRAN; NGUYEN; HOANG, 2022), and that employees demonstrate innovation potential and do not differ from private sector employees in terms of receptivity to change and willingness to experiment (RAINEY; CHUN, 2005; BYSTED; HANSEN, 2015).

Organisational size, information and communication technology (ICT), and financial constraints are also found exerting a positive influence on RM. In Paape & Speklé (2012), size is measured regarding the amount of budget public organisations have, whereas in Woods (2009), it is related to the number of employees, considering that larger organisations use more formalised RM processes and employ specialists. Woods (2009) also observed ICT influences in two different ways: directly because it was integral to RM process, that is, using a software to run RM steps and to register risks; and indirectly as ICT was used to collect performance information. Hence, ICT is viewed as a “building block” because it supports RM integration to other corporate processes and systems (BRACCI *et al.*, 2021). Finally, financial constraints were identified by Oulasvirta & Anttiroiko (2017) as negatively influencing the degree of RM implementation. The authors suggested financial problems hinder the possibility of purchasing consulting services and a formal RM software.

Still, the central government policy is considered the most powerful contingent variable for public sector RM (WOODS, 2009) because it is responsible for determining details and setting guidance rather than control over RM implementation. This variable may represent a centralised performance monitoring according to a set of criteria, considering risk assessment and management procedures as a component that is judged for resource provision. Consequently, local authorities have limitations on strategic freedom, on setting service standards, and on controlling government policy changes (WOODS, 2009). Alternatively,

Paape and Speklé (2012) identified that regulatory pressure to implement ERM for specific listed organisations generally differs in intensity; that is, some corporate governance codes are mandatory, whereas others are suggestive. In this respect, when the enforcement is not compulsory it is easy to ignore, making regulatory pressure a driver for ERM implementation when the organisations are listed under the mandatory regime.

Further contingent factors regard organisational practices. Firstly, training programmes are recognised as a formal means to boost ERM maturity by involving both employees and senior executives (BEASLEY; BRANSON; PAGACH, 2015), as they are a strategy to promote risk awareness. In the public sector, RM training may be purchased from private professionals or provided by policymakers to give the guidelines that help standardise and support public sector RM (WOODS, 2009). Secondly, job autonomy is recognised as an unusual practice in the public sector because managers generally give less decision-making autonomy and flexibility to employees. This is explained by institutional constraints and external political influences that make public managers have greater reluctance to delegate and maintain higher levels of reviews and approvals (RAINEY; CHUN, 2005). In contrast, more recent research has discussed the importance of public employees' autonomy to foster innovative behaviour through employees' empowerment in executing tasks and finding solutions when problems arise (e.g.: FERNANDEZ; PITTS, 2011; BYSTED; HANSEN, 2015), although further findings discuss that job autonomy is significant to provide job satisfaction in the private sector (ANDRADE; WESTOVER, 2022). Job autonomy seems to be a helpful practice to public sector RM as employees make more accurate decisions to treat risks because more information is available (ANDERSEN, 2010).

Finally, formalisation in public organisations is presented as having more administrative control and being more intense and elaborate, especially when the activities are determined by external agencies (RAINEY; CHUN, 2005). Formalisation represents the organisation's use of rules and routines to achieve efficiency and quality in service provision and may provide employees with enough knowledge to spend less time on solving problems (KIRKHAUG, 2010). RM uses the formality of risk control (documents to record policy statements, principles, methodologies and tools) to enable its implementation, being frequently reviewed by policymakers in the public sector (WOODS, 2009). Moreover, documenting RM roles and responsibilities is important because it reduces the stress of the organisational change (YARAGHI; LANGHE, 2011). Hence, formalisation seems to play a positive role in RM in the public sector.

Variables related to strategic management are also paramount to ERM development as it considers strategic integration (COSO 2017). For instance, strategic planning is conceived as a set of concepts, procedures and tools used by organisations to develop their strategic direction (ELBANNA; ANDREWS; POLLANEN, 2016). In the public sector, strategic decisions, such as the allocation of resources, are more likely to have interventions or interruptions, and generally have greater involvement of external authorities and interest groups (RAINEY; CHUN, 2005; GOMES; OSBORNE; LISBOA, 2022). Hence, a formal strategic planning in public organisations not only conceives strategic objectives but also enables a better stakeholder management (ELBANNA; ANDREWS; POLLANEN, 2016), especially considering that stakeholders may influence top managers' decisions in allocating resources (GOMES; OSBORNE; LISBOA, 2022). Moreover, the involvement of managers in formal strategic planning enhances their commitment to organisational priorities, in addition to helping them acquire knowledge to implement decisions (ELBANNA; ANDREWS; POLLANEN, 2016). Therefore, strategic planning in the public sector may develop long-term objectives and assume organisational commitment, thus being able to achieve higher levels of RM implementation.

Further variables comprise goal clarity and output measures. Public organisations are usually described as having greater vagueness and difficulty in measuring goals as they are more debatable; hence, it is common to find greater multiple goals that may be conflicting and involve more trade-offs (RAINEY; CHUN, 2005). Recent research found goal clarity and output measures contributing to the moderation of the relationship between performance measurement systems and performance of public organisations (SPEKLÉ; VERBEETEN, 2014). Moreover, concerning risk aspects, Bozeman and Kingsley (1998) found that a risk-oriented culture needs to be nurtured by clear communications of goals and tasks, and George, Van de Walle and Hammerschmid (2019) argue that public executives working in organisations with goal clarity are more likely to use management tools, including RM, for example. Therefore, despite the supposed difficulties of public organisations in establishing goal clarity and appropriate output measures, these variables are considered as being able to support public sector RM.

From the set of contingent variables discussed, in the first study of this thesis, the influence of the innovation-oriented organisational culture and the public top managers' tone were found to directly affect the GPM's strategies to implement RM. Additionally, in Chapter 3, risk types are also discussed as a variable that, although deriving from the private sector literature, was also observed as influencing one specific strategy of the first study.

2.2 MATURITY MODELS

MMs are tools to evaluate the maturity or level of sophistication of a selected domain, considering a comprehensive set of criteria (DE BRUIN *et al.*, 2005). The main idea consists of increasing the capability of such domain within the organisation, implying an evolutionary progress to accomplish a target from an initial stage to a desired end stage (METTLER, 2011), representing a path of improvement that guides the organisations (SANTOS-NETO; COSTA, 2019). Therefore, every type of maturity model displays a set of levels that represents the progression of the domain, as well as measured objects that are commonly known as capabilities or attributes (WENDLER, 2012).

MMs present various benefits to the organisations. To begin with, they are a simple and effective way of measuring the quality of the organisations' processes (WENDLER, 2012; SANTOS-NETO; COSTA, 2019). Secondly, they enable organisations to understand their current level of maturity and identify the necessary steps to reach higher levels of maturity through planning specific actions (MACGILLIVRAY *et al.*, 2007a; SANTOS-NETO; COSTA, 2019). Moreover, they strengthen businesses by ensuring the organisations have the operational conditions to manage the desired changes (SANTOS-NETO; COSTA, 2019). Furthermore, they may boost greater levels of organisational learning by making the staff reflect about their work practices and communicate the gaps and needs for change (BITITCI *et al.*, 2014). Finally, they can be used for benchmarking purposes, enabling organisations to compare themselves to others from the same industry (MACGILLIVRAY *et al.*, 2007a).

The concept of MMs emerged in the 1970s in the information systems literature to control the performance of systems (METTLER, 2011). The founders were Gibson and Nolan (1974) through the development of an MM that used computational resources in organisations. In 1986, the Software Engineering Institute (SEI) of Carnegie Mellon University developed a capability maturity model (CMM) that was based on the principles and practices of total quality previously developed by Crosby (1979), thus intensifying the popularity of MMs (DE BRUIN *et al.*, 2005; METTLER, 2011). Thereafter, the SEI introduced the CMM Integration (CMMI) to incorporate the existing CMMs (WENDLER, 2012).

Since then, the interest in maturity and MMs has proliferated across many different domains, especially during the last decade, given the growing number of related articles (SANTOS-NETO; COSTA, 2019). No surprisingly, most publications focus on software engineering and on information technology/system management as MMs were first thought within the information systems literature (WENDLER, 2012; SANTOS-NETO; COSTA,

2019). Nonetheless, regarding the specific RM domain, few studies have been proposed in comparison to the number of MMs already published (SANTOS-NETO; COSTA, 2019). Yet, when it comes to the notion of ERM, the number of articles is still lower, as demonstrated in Table 2.

Table 2 - ERM MMs found in the literature

Reference	Application scope	ERM MM aspects						
		Development process	Description of levels	Description of attributes	Assessment procedures	Prescription	Validation	Application
Feitosa, Carpinetti and Almeida-Filho (2021)	Supply chain	X	X	X	X			X
Oliva (2016)		X	X	X	X		X	
Zhao, Hwang and Low (2013, 2014)	Construction projects	X		X	X		X	X
Hoseini, Hertogh and Bosch-Rekvelde (2019)		X	X	X	X		X	
Zou, Chen and Chan (2010)		X	X	X		X	X	X
Von Känel, <i>et al.</i> (2010)	General firms	X	X	X				
Domanska-Szaruga (2020)		X	X	X	X			X
Macgillivray <i>et al.</i> (2007a, 2007b)	Water utility sector	X	X	X	X	X	X	X

Source: The Author (2023).

Table 2 compares the technical aspects of eight ERM MMs found in the literature. The first conclusion is that no MM has been thought specifically for RM in the public sector, endorsing the arguments found in De Lorena and Costa (2023a). Conversely, these MMs were developed focusing on supply chain, water utility sector, construction projects, and firms in general. For instance, Domanska-Szaruga (2020) advocates that her model suits both private and public organisations without distinction, with the argument that all organisations need to mitigate risks despite their different objectives. Therefore, this MM focuses specifically on the development of the ERM culture. Nonetheless, this view has been contradicted by the argument that RM principles are identical for both sectors, but that in practice the challenge for the public sector is more substantial as different features are observed (RAINEY; CHUN, 2005; WOODS, 2022).

The second conclusion implies that all ERM MMs describe the development process of the models, as well as the levels and attributes. Exceptionally, only Zhao, Hwang and Low

(2013) do not describe a set of maturity levels because their model uses the fuzzy set theory to calculate a global index of maturity to position the firm. Most articles in Table 2 apply a top-down approach to design their ERM MMs. Within this approach, levels are defined first, and then the measures are developed to fit such definitions (DE BRUIN *et al.*, 2005). Oliva (2016), on the other hand, performs the bottom-up approach, in which the requirements and measures are established first, and then the definitions are written as a reflection of those (DE BRUIN *et al.*, 2005).

Regarding the assessment procedures, Zou, Chen and Chan (2010) and Von Känel, *et al.* (2010) do not reveal how their models classify the organisations into a maturity level. The remaining articles use simple measures such as weighted scores (HOSEINI; HERTOUGH; BOSCH-REKVELDT, 2019; DOMANSKA-SZARUGA; 2020), and more elaborate measures such as fuzzy numbers that can be combined with Multicriteria Decision-making Analysis (MCDA) (ZHAO; HWANG; LOW, 2013; FEITOSA; CARPINETTI; ALMEIDA-FILHO, 2021), and multinomial logistic regression (OLIVA, 2016).

Moreover, five ERM MMs mentioned to have been empirically validated, five were applied, and only two provided prescriptions. The lack of validation and prescriptions is strongly criticised by Wendler (2012) and Santos-Neto and Costa (2019) after conducting Systematic Literature Reviews. Prescriptive MMs are deemed relevant because they indicate how to approach maturity improvement of the evaluated domain (SANTOS-NETO; COSTA, 2019). Alternatively, the lack of validation is a crucial point before the application, demonstrating weakness in the MMs; hence, this is possibly the reason why several developed MMs have demonstrated little use in practice (WENDLER, 2012). The MMs listed in Table 2 were validated by interviewing experts and/or by being tested in case-studies. Regarding the application of the models, Zhao, Hwang and Low (2013, 2014) and Macgillivray *et al.* (2007a, 2007b) published their MMs in two articles - one for the development, and the other for the application, while others preferred to describe the development and application in the same article as pilot tests (ZOU; CHEN; CHAN, 2010; DOMANSKA-SZARUGA, 2020; FEITOSA; CARPINETTI; ALMEIDA-FILHO, 2021).

Yet, but not found in the literature, the TCU released a PSRMMM directed to public auditors of Brazil (BRAZIL, 2018a). Despite such a great initiative for the country, TCU's model does not provide prescriptions for improvements, nor does it mention previous validation. Therefore, it does not demonstrate to follow all the rigour that an MM elaboration deserves.

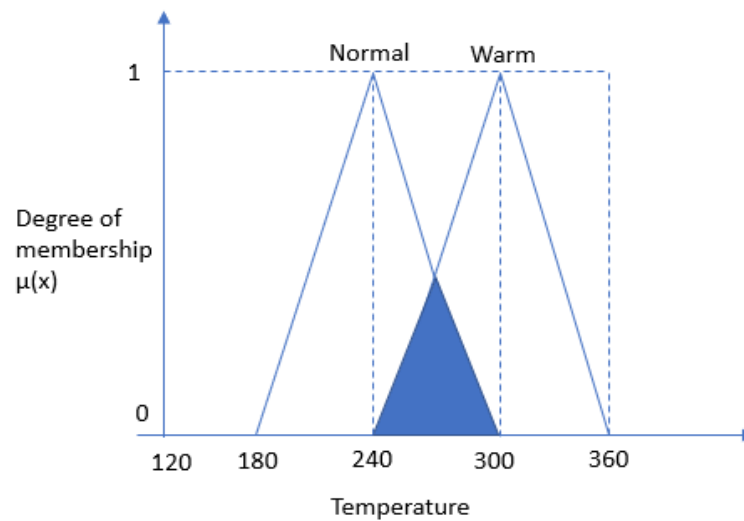
2.3 THE FUZZY SET THEORY

The fuzzy set theory was conceived by Zadeh (1965), in which he described the mathematics of fuzzy sets and fuzzy logic. The author argues that the classes of objects from the real physical world are not accurately defined; that is, they do not have precise criteria of membership functions. For instance, the set of “tall people” and the set of “beautiful people” do not constitute classes in the usual mathematical sense of the terms but play an important role in nonnumerical human thinking. Hence, a fuzzy set is understood as a "class" with a continuum of grades of membership, being efficient to deal with ambiguity, imprecision, and uncertainty (ZADEH, 1965). Therefore, this theory has been used in various ways to model inexact concepts of human reasoning (PECKOL, 2021). The fuzzy logic is based on a calculus of compatibility, describing the characteristics of properties with varying values whose partitions are associated to semantic labels such as “few” and “some” (COX, 1994). The descriptive power of fuzzy logic defines that semantic labels can overlap, corresponding to the transition from one state to another. These transitions represent the ambiguity associated with the intermediate states of such semantic labels (COX, 1994).

To make it clear, supposing that a fuzzy set A in X (space of objects) is characterised by a membership function $\mu_A(x)$ which associates a number in the interval $[0,1]$ in each element of X , the value of $\mu_A(x)$ at x representing the grade of membership of x in A (ZADEH, 1965): the nearer $\mu_A(x)$ is to 1, the higher the grade of membership of x in A . On the other hand, in the usual mathematical sense, $\mu_A(x)$ is binary, that is, it can only have two values (1 or 0), meaning that x either does or does not belong to A .

A fuzzy number provides a better set than the corresponding crisp value (PECKOL, 2021), being generally classified into three different ways: triangular, trapezoidal, and shouldered. In this thesis, the triangular fuzzy number (TFN) was chosen because it is considered simpler to specify and easier to visualise (COX, 1994). A triangular fuzzy set is created by using three numbers that represent truth values spread across a domain, and the membership function with absolute truth is placed at the midpoint of this domain; that is, the apex of the triangle (COX, 1994). The left and right edges of a TFN specify a linear decay from the centre to the points where the memberships become zero. When there is a collection of triangular fuzzy regions, the triangles overlap and must vary between 10% and 50% (COX, 1994). An example is depicted in Figure 3, demonstrating the fuzzy region of the “normal” and “warm” temperatures with 50% overlap.

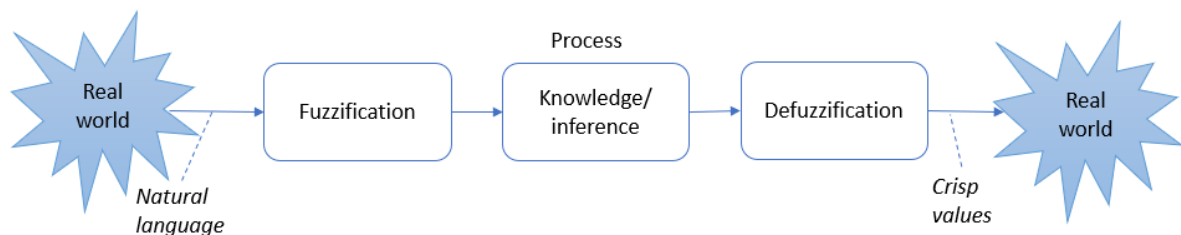
Figure 3 - The triangular fuzzy region with 50% overlap



Source: adapted from Cox (1994).

In this sense, the systems that incorporate fuzzy rules and membership functions are called “fuzzy systems” (NEGNEVITSKY, 2005). In a fuzzy system, firstly, it is necessary to associate a linguistic expression of a problem to a fuzzy subset, giving rise to a fuzzification process; secondly, the fuzzified data are processed through a collection of fuzzy rules (or inferences) and means of manipulating such rules based on previous knowledge; finally, the fuzzy solution is defuzzified by using methods to transform the final fuzzy set into a crisp set, thus representing the real world again (PECKOL, 2021). Figure 4 below depicts a simplified fuzzy system.

Figure 4 - A simplified fuzzy system



Source: adapted from Peckol (2021).

The most common defuzzification methods include the “max criterion”, the “mean of maximum”, and the “centre of gravity (COG) or centroid” (COX, 1994; NEGNEVITSKY, 2005; PECKOL, 2021). According to Peckol (2021), no systematic procedure has been found to choose the best method. The “max criterion” represents the point with maximum truth;

however, when this maximum point is inconclusive, for instance lying along a plateau, the “mean of maximum” is used to solve this conflict by averaging the values and finding the centre of the plateau. Alternatively, the COG finds the balance point of the fuzzy region by calculating the weighted mean, as well as finding a vertical line that would slice the fuzzy set into two equal masses (COX, 1994). The MM presented in this thesis uses the COG to defuzzify the fuzzy results because it is the most widely used technique, being easy to calculate and generally providing consistent results (COX, 1994; NEGNEVITSKY, 2005), thus satisfying the objectives of the PRisk-MM.

Some of the benefits of using fuzzy systems in decision support are described by Cox (1994). The first benefit comprises the ability to model complex problems because fuzzy numbers can approximate the behaviour of systems with poorly understood and/or nonlinear properties. Second, they directly model imprecise information by reducing overall cognitive dissonance in the modelling process. Third, with fuzzy numbers it is also possible to model systems involving multiple experts. Fourth, fuzzy models require fewer rules than traditional systems, being closer to the way knowledge is expressed in natural language. Finally, fuzzy logic provides a more consistent and more mathematically sound method of handling uncertainties.

Given the theoretical background presented in this chapter, it is possible to understand the development of the three studies that compose this thesis (chapters 3, 4 and 5). In this sense, while the “public sector RM” subsection upholds all studies, the “maturity models” subsection supports the study of chapters 4 and 5, and “the fuzzy set theory” subsection supports only the study of chapter 5. Therefore, these chapters present their own contextualization, the details on the methodologies applied in each study, as well as their corresponding results.

3 STRATEGIES FOR IMPLEMENTING RISK MANAGEMENT IN BRAZILIAN STATE GOVERNMENTS: A CONTINGENCY APPROACH

This chapter reflects the research developed by De Lorena and Costa (2023b), and refers to the first study of this thesis, consisting of the exploration of the Brazilian context regarding RM implementation. It addresses the first research question: “What contingent factors contribute to or hinder RM implementation in the Brazilian public sector, and what are the consequences?”. Thus, this chapter attends to its three secondary objectives: “to identify the contingent variables that positively influence RM implementation in the Brazilian public sector”; “to identify the contingent variables that negatively influence RM implementation in the Brazilian public sector”, and “to identify and analyse the consequences of the identified contingent variables”. In this sense, this study finds three different strategies that are operationalised by GPMs with the aim to facilitate RM implementation in 6 Brazilian state governments. Such strategies are designed by considering the influence of contingent variables that hinder or contribute to their effectiveness. Due to the influence of the variables, maturing RM implementation in the settings is observed to be difficult. More details are given below.

3.1 CONTEXTUALISATION

Organisations in the public sector perform in a particularly complex environment, in which several factors exert influences that differ from those found in the private sector. Such a challenging environment involves issues related to the political climate, public interest, legal requirements, budget restrictions, technological shifts, constant changes in leadership, etc. (BOZEMAN, 2004; RAINEY; CHUN, 2005). Meanwhile, multiple stakeholders expect more than the mere delivery of public services; they are interested in whether actions are executed with efficiency, effectivity, and integrity, counting on the enhancement or maintenance of the well-being of citizens. Accordingly, RM in the public sector has been considered a promising strategy to meet such expectations, becoming a recurring theme within the process of corporate governance (SUBRAMANIAM *et al.*, 2013; WOODS, 2022). Particularly, RM has also been seen as an organisational-oriented tool derived from the business-like paradigm found in the NPM (POLLITT; BOUCKAERT, 2017; GEORGE; VAN DE WALLE; HAMMERSCHMID, 2019), used as an approach to improve the quality of public services.

The Brazilian public sector has adhered to RM especially in the executive branch. In the federal government, efforts devoted to promoting RM have increased substantially after 2016.

Three important examples may be given: the Comptroller General of the Union and the Federal Ministry of Planning, Budget, and Management jointly released Normative Instruction 01/2016 requiring the establishment of risk-based internal controls, the enhancement of governance, and the systematization of RM in the federal public administration; in the same year, Law 13.300/2016 was issued specifically for public enterprises and mixed capital societies on all tiers of government, requiring their respective statutes to observe rules of governance, transparency, as well as RM and internal control practices; one year later, Decree 9.203/2017 stipulated that the governance policy for organisations under the direct federal administration, autarchies and foundations would have to establish integrity management as one of the main pillars of public governance and determine the implementation of risk-based internal controls, the integration of RM to strategic planning, and its use for the continual improvement of processes. In the same direction, similar initiatives started to arise in Brazilian state governments afterwards. Some of them issued their own regulation based on the federal examples, and GPMs began to lead RM implementation providing guidance, training programmes and supervising execution in their respective state public organisations.

Considering the particularities of the public sector (RAINEY; CHUN, 2005; WOODS, 2009), RM systems are expected to be quite different. Woods (2022) explains that while principles of RM are equal for both public and private sectors, the empirical challenges for public organisations are significantly higher due to such particularities. However, the literature investigating how governments implement RM generally provides successful cases (e.g.: LEUNG; ISAACS, 2008; WOODS, 2009; PALERMO, 2014; KIM, 2014; SCAROZZA; ROTUNDI; HINNA, 2018) and such challenges are not deeply explored.

Given this gap in the literature, this study uses the contingency theory as background to investigate what contributes to and hinders RM implementation in the public sector. State-level governments were analysed, and interviews focused on GPMs because they are the agents responsible for introducing government policies such as RM (WOODS, 2009). As a result, content analysis made evident that the settings strive to implement public sector RM by using strategies in face of the contingent variables GPMs perceive, mainly due to the public top managers that are not always supportive in the organisations and exert a weak tone from the top. Consequently, the difficulties in progressing RM maturity are enormous and recognized by GPMs. Further results address issues related to the difficulty GPMs have in stimulating the management of integrity risks in processes.

3.2 METHODOLOGY OF THE STUDY

This study adopted a multi-case study research design, convenient for cases where previous findings are not enough to formulate concrete hypotheses (YIN, 2018). Therefore, the qualitative content analysis method was used as it systematically describes the meaning of data, particularly fitting the case study research (KOHLBACHER, 2006).

3.2.1 Case selection and data collection

Our first step was to identify which Brazilian state governments had RM initiatives between 2016 and 2019. Geopolitically, the country is composed of 26 states plus the Federal District. From this total, our search revealed that 12 states had enacted specific legislation exposing the organisations that were leading RM implementation in the governments. Most of them were also implementing Integrity/Compliance Programmes at the same time, alluding to the management of integrity risks. The following step was to reach the GPMs in those organisations through telephone calls and e-mails. One state was unreachable and two mentioned they had no empirical initiative at that moment, despite the enacted legislation. From the remaining 9 states, three were excluded as they focused exclusively on Integrity/Compliance Programmes and demonstrated no interest in a wider public sector RM. Hence, our sample comprises 6 state governments and, due to the COVID-19 pandemic at the time of the interviews, video appointments were arranged. Meanwhile, legislation and website contents were reviewed carefully, providing familiarization with the contexts of the cases as shown in Table 3 (BOWEN, 2009). The state governments were codified as SGOV1, SGOV2 ... SGOV6 to provide anonymity once the interest is in aggregating evidence and demonstrating similar patterns (YIN, 2017).

Table 3 – Context of the cases

State Governme nts	Political party position	Organisations leading public sector RM	Starting Year	Team size	N° of public organisations in the governments*	N° of public organisations with RM initiatives
SGOV1	Left-wing	General Audit	2018	5	69	8
SGOV2	Right-wing	General Comptrollerships	2018	5	64	10
SGOV3	Centre-right		2019	22	49	43
SGOV4			2017	55	51	51
SGOV5	Centre		2016	5	95	27
SGOV6	Right-wing		2018	4	65	15

Source: De Lorena and Costa (2023b).

*This total number was found on the “transparency portal” websites of the SGOVs.

Table 3 brings three main interpretations. Firstly, no tendency is observed towards the political parties of the executive branch of the investigated Brazilian state governments because these governments were all implementing RM despite their different political positions. Next, all organisations leading RM implementation perform the internal control function despite their varied status (five General Comptrollerships, and one General Audit). Hence, they generally concentrate efforts in activities related to transparency, corruption prevention, auditing, ombudsmanship, correction, and fraud deterrence. Finally, the GPMs' team members are auditors designated for this task. Their team size varies significantly and demonstrates implications on the strategies GPMs decide to apply and on the speed with which they approach the public organisations.

Interviews were critical in this study because they produced information regarding issues that are not publicly released. The sole use of official documents would not present sufficient details to derive the interpretations sought for this article because they are likely to only provide information regarding policies, procedures, and reports on successful actions (BOWEN, 2009; YIN, 2017). In total, 12 semi-structured interviews were conducted resulting in 707 minutes of recorded videos as displayed in Table 4. To avoid bias, interviewees were informed that the questions were exploratory for academic interest, and that no judgement would be pronounced. The questions were based on the contingency theory and the RM literature (Appendix A). Hence, the aim was to understand the details regarding the way they operationalised public sector RM with special attention to the roles and responsibilities of different actors. Moreover, questions about the drivers and barriers that motivated them to make such decisions were addressed.

All informants were GPMs. Some of them were so enthusiastic in talking about their realities that information was provided without the need to follow the order of the questions or even to ask them all, enriching content with further details and demonstrating theoretical knowledge and empirical experiences by referring to examples. Except for SGOV1, all the other governments also implemented Integrity/Compliance Programmes. In SGOV2, SGOV3 and SGOV5, a single team was responsible for implementing both public sector RM systems and Integrity/Compliance Programmes, whereas in SGOV4 and SGOV6 they were in different teams.

Table 4 – Interviews

State Governments	Informants	Duration in minutes	Month/Year
SGOV1	State General Auditor	24	April 2020
	Manager leading the public sector RM (1st)	86	June 2020
	Manager leading the public sector RM (2nd)	20	June 2020
SGOV2	State Comptroller General	36	April 2020
	Manager leading the public sector RM and the Integrity/Compliance Programme	41	June 2020
SGOV3	Manager leading the public sector RM and the Integrity/Compliance Programme	66	June 2020
	Senior manager leading the public sector RM and the Integrity/Compliance Programme	36	July 2020
SGOV4	Senior manager leading the public sector RM	118	June 2020
SGOV5	Manager leading the public sector RM and the Integrity/Compliance Programme (1st)	100	April 2020
	Manager leading the public sector RM and the Integrity/Compliance Programme (2nd)	83	June 2020
SGOV6	State Comptroller General	34	June 2020
	Manager leading the public sector RM	63	June 2020

Source: De Lorena and Costa (2023b).

3.2.2 Qualitative content analysis

The qualitative content analysis process performed in this study was mainly inspired in the protocol recommended by Schreier (2012), with further methodological observations found in Krippendorff (2013). Considering that one of the challenges in multiple case studies is the management of a big amount of data (MERRIAM; TISDELL, 2016), the Atlas.ti software was used because it provides higher reliability and greater speed during analysis, making the process more manageable and productive (SCHREIER, 2012).

The steps for coding and categorizing data started with the establishment of a set of concept-driven categories and subcategories that inspired the semi-structured interview guide and constituted the first version of a coding frame (SCHREIER, 2012). Next, the second version was developed by going through the responses of one interview after another in four transcripts. Consequently, data-driven subcategories started to emerge from a subsumption process whenever additional details were mentioned. Afterwards, this second version of the coding frame was reviewed and piloted in three more transcripts followed by a consistency check of subcategories, which generated few more adjustments in a third version which was finally applied to the overall material. As a result, this final coding frame presented three categories (“strategies”, “RM design components” and “contingent variables”), twelve subcategories, and sixty thematic codes. After one month, all the material was recoded to test the reliability and stability of the coding frame (SCHREIER, 2012).

Next, within-case analysis was performed to better understand the RM practices of each SGOV separately, followed by a cross-case analysis through a replication logic by comparing the evidence to find patterns of convergences and divergences among the cases. During this process, the relationship between the strategies and the contingent variables inductively emerged from content analysis, being subsequently taken back to the interviewees to provide validation on the plausibility of the findings (MERRIAM; TISDELL, 2016).

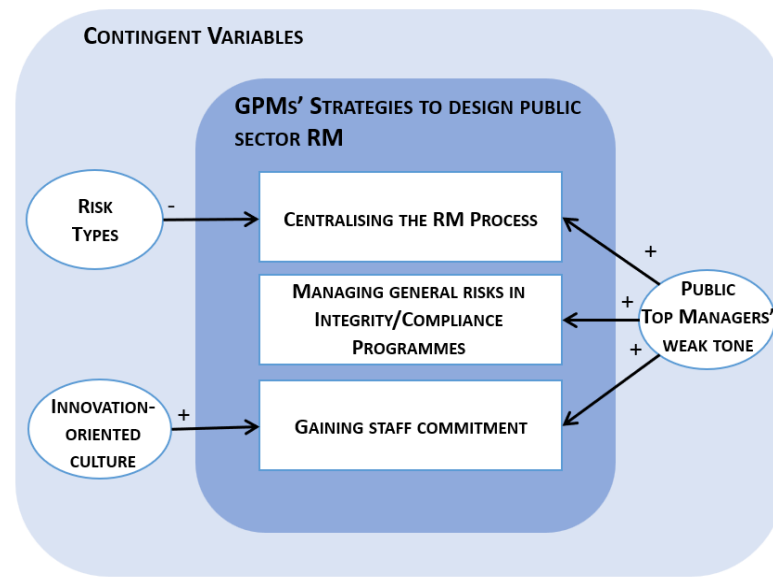
3.3 THREE STRATEGIES FOR IMPLEMENTING PUBLIC SECTOR RM IN GOVERNMENTS

All the settings have embarked on public sector RM through the strategies GPMs developed. Such articulation makes GPMs *per se* the main contingent variable of this study, thus reflecting the “central government policy” variable found in Woods (2009). In summary, they elaborate an RM methodology generally inspired by international frameworks such as ISO 31000:2018 and/or COSO (2013; 2017), define structural arrangements and formally determine duties and boundaries for the public organisations. Moreover, GPMs provide guidance through training programmes whose content vary according to the strategies. At last, they formally monitor or audit RM implementation depending on the maturity of the organisations. However, the way they exert authority and influence the public organisations differs from case to case throughout the strategies, thus confirming that this variable is situation-specific (COLLIER; WOODS, 2011). Such variations regard the way GPMs perceive further contingent variables.

In general, GPMs count on the aid of local internal controllers (LIC) who are based in the public organisations and serve as the extension of the internal control function of the organisations GPMs represent. LICs are public employees with the duty to perform the technical activities GPMs require as well as the administrative activities formally demanded by top managers. Their role cannot be associated with that of a CRO because they are not exclusively dedicated to RM activities; rather, they are the main connection between GPMs and the public organisations.

Figure 5 illustrates the relationship found between contingent variables and GPMs' strategies.

Figure 5 - Relationship between the contingent variables and the public sector RM design strategies



Source: De Lorena and Costa (2023b).

Public top managers are agents that hold the highest seat of the organisational hierarchy in the public organisations. Their function is naturally political as they are elected or appointed by governors, their behaviour being directly affected by the latter and by other political authorities (BOZEMAN; BRETSCHEIDER, 1994). In some organisations, public top managers demonstrate to welcome public sector RM, being advised to preside local committees to oversee RM, and are expected to be supportive, to provide guidance internally (BEASLEY; BRANSON; PAGACH, 2015) and to make governance decisions in favour of RM (LUNDQVIST, 2015). Nevertheless, interviewees mentioned several problems that hinder the necessary support to mature RM in the organisations, thus demonstrating that the fit between the “public top managers’ weak tone” variable and the three strategies is represented by a general positive influence because the weak tone from the top makes GPMs find strategies to implement RM in public organisations.

The “risk types” variable was observed with a strong influence on the “centralising the RM process” strategy. Risk types influence RM design choices because organisations may use different processes and actions to manage risks according to their categories (KAPLAN; MIKES, 2012). Hence, risks can be classified into preventable (when derived from operational breakdowns or from unethical and illegal behaviour), strategy execution risks (when they emerge from strategic decisions or plans), and external (arising from events that cannot be controlled). During data analysis, interviews and public documents showed that GPMs are

mainly concerned with preventable risks, clearly separating the risks derived from unethical behaviour, the “integrity risks”, from the remaining operational risks.

Regarding the “innovation-oriented culture” variable, data analysis presented it as exclusively affecting the “gaining staff commitment” strategy. Therefore, signs of this type of organisational culture were found, indicating that the RM implementation process flows more easily when the staff is already receptive, prepared and willing to change the way they currently work (WYNEN *et al.*, 2014; CHEN; JIAO; HARRISON, 2019). Features related to risk-taking behaviour and creativity were not mentioned.

3.3.1 Gaining staff commitment

The main characteristic of this strategy is the belief that the staff in public organisations are the key actors to execute public sector RM and maintain its continuity. GPMs aim to embed a risk culture at the operational level of the organisations regardless of how supportive public top managers are. Therefore, they provide training programmes and perform intense consulting services demonstrating a special proximity to the staff. Moreover, there is an urgency to prove the benefits of RM to the staff and conquer their commitment. GPMs provoke interactive face-to-face meetings until the RM process (risk identification, analysis and treatment) of a subject is completed. The idea is to keep the consulting services and reduce contact over time, just giving support as the staff demonstrates maturity and commitment to RM (IIA, 2009).

“When I have a top manager ‘buying the idea’, demanding results and work delivery, and the staff understands the RM benefits, the work gets done. If I have a supportive top manager and the staff is not very willing, the work will get done, but it won't be so nice. But if I have a top manager that says ‘GPMs are here bothering me, but that's ok, we have to do it’, and the staff is involved, the work gets done anyway. That is why I give training, because I want to involve these people.” (SGOV6)

“We need to quickly start showing results. The organisations where we had more success were the ones that had staff active participation and we quickly started to show the usefulness of RM”. (SGOV1)

This strategy is mainly motivated by the fact that some public top managers demonstrate political interests, provoke turnover in the workforce, and perceive RM as more bureaucracy.

“He (top manager) was intending to apply for congressman, something like that... he said: ‘I'm not going to put this here (RM) as my brand!’”. (SGOV5)

“... you have a person (LIC) that you spend the whole year training, he takes courses and courses and courses, and then at the end of the year the top manager changes, then the person changes, and then everything is lost” (SGOV2)

“There are some top managers who insist on understanding that RM is more of a bureaucracy and that it will give them more work to do”. (SGOV3)

In this strategy, GPMs think that once public top managers are changed, the staff is deemed to be able to maintain RM at least operationally. Therefore, there is a special concern to conquer staff commitment.

“Let's suppose a new top manager comes in. But if he sees that the environment, that all those sectors are already working with RM, it is difficult to say ‘no’, you see? [...] that's why I want to build an environment so that anyone who comes in later won't be able to change it.” (SGOV6)

Such intense and direct interaction between GPMs and the staff provides the perception that RM depends on the organisational culture through the recognition of some features related to an innovation-oriented behaviour, especially the receptivity, involvement, and willingness to improve procedures (WYNEN *et al.*, 2014; CHEN; JIAO; HARRISON, 2019).

“If the team is not involved, the work dies. The jobs that didn't work out were because of the operational team, the first line of defence that was not very involved.” (SGOV6)

“It's a crazy thing! The need for attention and solutions, to have tools, to see the difficulties of management! It's very big! So, anyone who goes there with a support helps a lot!” (SGOV5)

In this strategy, few elements of risk governance are observed (LUNDQVIST, 2015; ISO 31000:2018), although they are not equally demanded among the SGOVs. Nonetheless, the presence of these elements is not sufficient to demonstrate that RM maturity is developed in the settings. For instance, SGOV1, SGOV3 and SGOV5 require an institutional RM policy and a formalised board committee to oversee the risks in public organisations; SGOV6, in turn, only requires the formation of a board committee and the publication of an RM policy after the public top manager demonstrates to be convinced of the RM benefits. Their argument is that, without real support, the policy would be no more than a mere formality and the committee would not be effective. Concerning this aspect, SGOV2 does not require a board committee in the organisations but counts on a government-level committee to oversee major risks that are reported by GPMs. Moreover, in SGOV3, the board committee is supposed to report the critical risks to a government-level committee. Like in SGOV2, the risks reported to this latter committee are transversal among organisations and are perceived to damage the government image if concretised, thus stimulating a discursive use of RM and reflecting a “corporate governance” rationality to maintain external assurance and a reputation of trust (RAINEY; CHUN, 2005; ARENA; ARNABOLDI; AZZONE, 2010; 2011).

3.3.2 Centralising the RM process

This strategy is distinguished for centralising the RM process in GPMs' activities, that is, the staff does not participate in risk identification, analysis, and treatment decisions. The main reason for adopting this strategy is related to a strong belief that the organisations would not provide quality information regarding their risks. SGOV4 performs this strategy mainly considering the preventable risks (MIKES; KAPLAN, 2013), whereas SGOV3 only centralises the integrity risks, reflecting the influence of the "risk types" variable. GPMs in SGOV3 reported identifying these risks during consulting meetings and registering them in a different risk matrix with their own evaluation; then, they decide which controls should be executed and recommend them to the organisation.

"I don't believe that they would do it (RM) with reliability [...] here, they think that having more risk controls would hold up the process flow." (SGOV4)

"What we will take to the organisations, but in terms of activity in RM, is the adoption of measures to mitigate the risks [...]; but the risk assessment and identification process should not leave our auditors." (SGOV4)

"... who registers whether the risk is associated with corruption or not is our own consultancy, not the organisations. [...] because if I leave it to the organisations, I think it can generate resistance in registering those risks." (SGOV3)

GPMs also revealed concern with public top managers. As in the first strategy, turnover problems and demands on extra activities for LICs were mentioned.

"When the top manager leaves, the whole 'chain' is disassembled." (SGOV4)

"The law does not require that the unit (LIC) has to be exclusive for internal control. [...] So, you have an employee that is performing a work within an organisation, sector 'x', and he also needs to split part of his time to perform a service within the control". (SGOV4)

Three consequences are derived from this strategy. Firstly, centralising the RM process in GPMs' activities does not provide the public organisations with the chance to mature RM. In this strategy, the staff does not acquire knowledge on how to identify, assess and treat risks, and public top managers are not instilled to use RM tools (LUNDQVIST, 2015). Secondly, the decision to centralise the RM process also demands a bigger team of auditors (see Table 3) to provide proper attention to each public organisation. Finally, the boundaries between the lines of defence are extremely blurred since GPMs execute the RM process especially by assessing and deciding on risk responses, in addition to monitoring risk controls and process improvements (IIA, 2009). Thus, interviewees believe that the Lines of Defence Model

advocated by IIA (2022) do not necessarily apply to all situations. This strategy illustrates the concern of a group of scholars that have investigated the involvement of internal auditors in RM implementation with regards to the loss of objectivity and independence that is supposed to be present in the internal auditors' role (e.g.: FRASER; HENRY, 2007; DE ZWAAN; STEWART; SUBRAMANIAM, 2011; WHITE; BAILEY; ASENOVA, 2020).

3.3.3 Managing general risks in integrity/compliance programmes

This strategy implies the predisposition to manage operational risks within the Integrity/Compliance Programmes the SGOVs promote. Theoretically, these programmes are supposed to exclusively embrace integrity risks, being also related to ethics management, including RM as one of their pillars. Nonetheless, this strategy uses its name politically to attract public top managers and thus manage general risks because some top managers are usually perceived to embrace Integrity/Compliance Programmes rather than RM. This strategy is also considered complementary to the first two, that is, GPMs can adopt this idea and opt for either centralising the RM process or focusing on staff commitment concomitantly, as observed in SGOV2 and SGOV3.

“We make them (top managers) do RM before they even understand what RM is. [...] To summarize, he (top manager) will create a structure to help him with his risks, which he will manage, but within the integrity framework. So, if I approach the manager and say, ‘Let's do risk management!’, he won't come out with such an aptitude to do it! But if I say, ‘Let's do Integrity/Compliance!’, it will work.” (SGOV2)

“Here it is called Integrity/Compliance Programme for political reasons... but the purpose is the same. The fact is that we don't identify only integrity risks, we identify any type of risk that can somehow affect the objective. So, we try not to focus.” (SGOV3)

This behaviour is explained by the political position public top managers hold. They need to focus on public interests and thus operate under greater public scrutiny, facing more intense expectations for fairness, honesty, transparency, and public accountability (RAINEY; CHUN, 2005). They are seen as “sellers” of policies and programmes as they need to not only deliver satisfactory services, but also to convince the public that the work is being accomplished (BOZEMAN, 2004). Consequently, in the settings, there is a perception that some public top managers are more attracted to the Integrity/Compliance Programmes as these immediately represent values of ethics and anti-corruption image that they want to be recognised as a “political flag” of their management periods.

“I think that the receptivity of the Integrity/Compliance Programme is better because it is a flag that everyone wants to carry, you know? They are values that the (top) managers

here want to carry and when you think only of risk management, many people still think this is too bureaucratic.” (SGOV6)

3.4 DISCUSSION

Following the contingency perspective, GPMs of all settings demonstrated to operationalise RM in the governments with strategies in mind, becoming the main contingent variable for RM implementation, similarly to previous findings discussed by Woods (2009). The distinctiveness of this study is that GPMs perceive generally weak tone from public top managers in the organisations, thus strategically operationalising RM implementation with the aim to attenuate the negative effects by using their formal authority and representing the governments’ internal control (RAINEY; CHUN, 2005). Data analyses bring evidence of their perception that most public top managers neither embrace RM, nor perceive that it may facilitate effective management, losing the opportunity to become champions and enablers through their leadership (LUNDQVIST, 2015). Therefore, the strategies emerge as relevant solutions for GPMs to stimulate RM implementation at any rate.

In the “gaining staff commitment” strategy (SGOV1, SGOV2, SGOV3, SGOV5 and SGOV6), GPMs try to involve the staff as much as possible and keep the hope that a risk culture emerges with time, regardless of the current head in the organisation. For this reason, GPMs perceive that an innovation-oriented culture influences this strategy positively, indicating that the success of the strategy depends on a pre-existent receptive culture in the organisation, with employees willing to change. In the “centralising the RM process” strategy (SGOV3 and SGOV4), contrastingly, GPMs believe that the organisations would not provide quality information regarding their own risks, a fact that is clear when it comes to the management of integrity risks in processes as employees and public top managers show resistance, thus representing the influence of the “risk types” variable. In the public sector literature, this issue is not easily addressed. An example of a similar situation is found in Van der Wal, Graycar and Kelly (2016), who stated that the surveyed agencies had difficulties in seeing corruption risks as affecting the service delivery. Lastly, in the “managing general risks in Integrity/Compliance Programmes” strategy (SGOV2 and SGOV3), GPMs try to politically attract public top managers and manage general risks under the umbrella of the Integrity/Compliance Programme because they observe a better receptivity to these programmes.

A common feature among all SGOVs is the fact that, independently of the type of strategy they adopt, mature levels of RM implementation in the organisations seem to be a

difficult endeavour as the support of public top managers is essential (LUNDQVIST, 2015; ISO 31000:2018; COSO, 2017), but not always present. Hence, despite presenting risk governance elements such as an RM policy and a formalised board committee to oversee the risks in public organisations (LUNDQVIST, 2015), without the proper tone from public top managers these elements become superficial and just officialised, not working effectively in practice. Moreover, the lack of maturity is even worse in the SGOVs that adhere to the “centralising the RM process” strategy because they do not permit the staff and top managers of public organisations to develop knowledge on the RM system, and thus work with lines of defence that are extremely blurred (FRASER; HENRY, 2007; IIA, 2022; DE ZWAAN; STEWART; SUBRAMANIAM, 2011; WHITE; BAILEY; ASENOVA, 2020).

This study is an example that is not always easy to follow all the international frameworks’ guidelines (e.g. ISO 31000:2018; COSO, 2017; IIA, 2022), also implying that not all the tools derived from the private sector, as advocated in the NPM approach (POLLITT; BOUCKAERT, 2017; GEORGE; VAN DE WALLE; HAMMERSCHMID, 2019), are easily adapted to the public sector reality, since not always do public top managers welcome the RM system (SUBRAMANIAM *et al.*, 2013). Aiming to mitigate the problems discussed in this article, useful government-level hints are presented below as suggestive actions for GPMs to better enable RM implementation.

1. Require top management participation in RM training as a prerequisite for taking an executive position or remaining in the position.
2. Provide ongoing training and/or consultancy services to better develop employees’ risk awareness and skills at all levels of the organisation.
3. Promote government workshops to exchange experiences of successes and failures in RM implementation, requesting the active participation of top managers.
4. Create government smaller committees composed of the public organisations’ top managers to periodically discuss specific risks with greater magnitude.
5. Create a committee at government level to frequently discuss the most critical risks for the government and/or cross-cutting risks among the various public organisations.
6. Require the development and monitoring of risk indicators, emphasising integrity risks not only at governance level, but also at operational level.
7. Consider the organisations’ RM performance outputs as items to be analysed during the government allocation of resources.
8. Give transparency and publicly congratulate the public organisations that have had excellent performance in RM. An award system could be created at government level.

9. Legally require the establishment of a department in the public organisations exclusively for RM.
10. Legally align employees' performance in RM to the organisation's performance evaluation system.
11. Require that the organisation's strategic planning is aligned to the government's strategic planning, clearly highlighting the organisational risks that affect the government's strategy.
12. Require RM information as the basis for justifying possible reprioritisations of resource allocation when turnover occurs in top managers' position.
13. Require the periodical application of a PSRMMM, so that top managers and the staff can identify what actions are needed to develop RM.

3.5 FINAL CONSIDERATIONS

This article identifies strategies performed by GPMs to stimulate RM implementation in 6 Brazilian state governments. These strategies are thought under the interference of contingent variables such as “innovation-oriented culture” and “public top managers' weak tone”, which demonstrate a positive influence, whereas “risk types” generally shows a negative influence. Such strategies are expected to attenuate the difficulties in implementing RM in public organisations and highlight the behaviour of GPMs as the main contingent variable in the public sector RM. Besides, further results made evident that the management of integrity risks in processes may also be a concern, making GPMs centralise their management.

This article constitutes an example that is not always RM easily adapted to the public sector reality. Although GPMs design their respective RM systems based on international guidelines (e.g.: ISO 31000:2018; IIA, 2022; COSO, 2013; 2017), the contingent variables of their contexts may limit decisions. Therefore, future studies may investigate what alternatives could be employed to better deal with the challenges pointed out in this article. Besides, more in-depth investigation on why public employees and managers generally avoid considering integrity risks in processes could also be carried out with more focus on politicised contexts, and/or on psychological and cultural aspects.

4 WHAT ENTAILS RISK MANAGEMENT MATURITY IN PUBLIC ORGANISATIONS?

This chapter is based on the article by De Lorena and Costa (2023a), published in the *Journal of Risk Research*. This study starts the process of the PRisk-MM elaboration in order to attend to the second research question of this thesis: “How to assist the Brazilian public organisations to improve the maturity of their RM systems?”. For this purpose, in this study 12 variables are identified with statistical significance to explain 5 levels of maturity in public sector RM, thus being able to answer the first secondary objective of the second research question: “to investigate which attributes and contingent factors are crucial to develop a PSRMMM”.

4.1 CONTEXTUALISATION

RM has increasingly been incorporated into the routine of public organisations as a tool to face the wide range of uncertainties they have to deal with in response to society. Such introduction is fostered by the evolution of government regulation requiring corporate governance and internal control systems to be in place, taking the management of risks into account. Countries such as the UK, the USA, Australia, Canada, and Korea are examples of the public sector worldwide adhesion to RM (WOODS, 2009; KIM, 2014; PALERMO, 2014). Therefore, the requirement of implementing RM as a managerial model reflects the NPM paradigm in renewing theories and practices in the public sector (GEORGE; VAN DE WALLE; HAMMERSCHMID, 2019), thus mirroring the private sector ERM.

In general, researchers in both public and private sectors have devoted attention to the contingent factors that contribute to ERM implementation (e.g.: GORDON; LOEB; TSENG, 2009; WOODS, 2009; PAAPE; SPEKLÉ, 2012). Alternatively, another stream of research has gone deeper by investigating the value creation of ERM when higher levels of maturity are achieved (e.g.: FARRELL; GALLAGHER, 2015; BEASLEY; BRANSON; PAGACH, 2015). Nonetheless, despite the interest in investigating the implications of ERM maturity, few researchers have explored the process by which ERM may progress. Such investigation is even scarcer in the public sector context. One solution for this gap is to consider the logic of MMs.

MMs demonstrate a gradual and systematic development and/or improvement of processes or structures of an organisation and can be applied to different areas (METTLER, 2011; SANTOS-NETO; COSTA, 2019). They present a progressing set of maturity levels and attributes that are used to evaluate the status of the organisations. Hence, they strengthen

businesses by offering orientation and ensuring the organisations have the operational conditions to manage such improvements (SANTOS-NETO; COSTA, 2019). Regarding the MMs related to ERM, few studies have been proposed when compared to the number of MMs already published in further domains (SANTOS-NETO; COSTA, 2019). Some of the ERM MMs found in the literature were developed focusing on supply chains, water utility sectors, construction firms, and projects; others generalise their application (e.g.: MACGILLIVRAY *et al.*, 2007a; YEO; REN, 2009; ZOU; CHEN; CHAN, 2010; HARTONO; WIJAYA; ARINI, 2014; OLIVA, 2016; HOSEINI; HERTOOGH; BOSCH-REKVELDT, 2019; DOMANSKA-SZARUGA, 2020; FEITOSA; CARPINETTI; ALMEIDA-FILHO, 2021). Nevertheless, no PSRMMM was found in the literature, providing us with an opportunity for investigation.

This study aims to investigate which attributes and contingent factors of public sector RM are relevant to develop a path of maturity in public organisations. Therefore, the purpose of the study is not to provide a PSRMMM *per se*, but to be a scientific reference for the creation of future models. A literature review was carried out considering the ERM research and specific public sector factors to identify the key variables that composed the questionnaire released to Brazilian public organisations of the federal and state governments. Data analysis considered 330 answers and was statistically reasoned on a methodological path involving three multivariate statistical methods: CATPCA, K-modes, and multinomial logistic regression. As a result, a set of 12 variables is proposed and distributed into five different maturity levels.

4.2 METHODOLOGY OF THE STUDY

Following the research objectives, a series of methodological steps were performed. First, a literature review was conducted considering the ERM literature (especially the contingent factors and maturity models), as well as further factors which were specific to the public sector research. Two source and citation databases were used to pursue the articles: Scopus and Web of Science. The output of this step was a list of RM attributes and contingent factors. Next, a survey instrument was developed and applied to Brazilian public organisations of the federal and state governments. The questionnaire was divided into three parts and contained a total of 39 closed questions. The first part of the instrument comprised 17 questions related to 13 RM attributes, whereas the second one contained 16 questions related to 8 further contingent factors. These questions represented variables based on a 7-point Likert scale, ranging from “does not apply” to “fully applies”, except for variables RMspec and RMcomm that were dummies. These variables are described in Appendix B. The third part consisted of the remaining 6 questions

designed to acquire more information about the organisations, such as the government tier, the industry type, whether the RM specialist performed extra activities, the legal nature, the position of the respondents and since when they were working in the organisations.

Before data collection, it was necessary to identify the total number of organisations each government had. For this purpose, each government transparency portal was examined to find the list of organisations. Next, to reach the key-respondents (the ones accounted for leading the RM implementation), government policymakers were approached and asked to provide a list of contacts containing names, e-mail addresses, and their respective organisation. Not all policymakers could provide such a list, the reason why it was necessary to google for the website of some organisations and pursue the information. Finally, from a target population of 1,916 public organisations, 1,714 were indeed reached (313 were federal and 1,401 were at state level). Afterwards, the survey was carried out over two months, being completed in August 2020. Reminding e-mails to nonrespondents were sent every week in the first month and two more times in the second month. A response rate of 20.24% was achieved ($n=347$), albeit 17 answers had to be discarded because the respondents answered the questionnaire in less than 5 minutes or provided blind answers (repeating the same answer to all questions). As a result, 330 answers were considered valid, representing 19.25% of the reached public organisations.

Table 5 shows how the organisations are structured in terms of RM. Despite legal requirement, only 60.23% of the federal organisations revealed to have an RM specialist and, out of those, only 21.70% informed to work exclusively with RM. Besides, 59.66% affirmed to have a formal risk-related committee. The numbers representing the state governments do not reveal a much different situation, disclosing a general difficulty in formally establishing the role of both leaderships internally. Moreover, 38.48% of the respondents held the position of managers, 26.67% being advisors to top managers and 20.91% holding a directorship (see Table 6).

Table 5 - Public organisations with an RM specialist and a risk-related committee

Government tier	Presence of an RM Specialist		RM Specialist working exclusively for RM		Presence of a risk-related Committee	
	N° of public organisations	%	N° of public organisations	%	N° of public organisations	%
Federal	106	60.23%	23	21.70%	105	59.66%
State	102	66.23%	17	16.67%	81	52.60%

Source: De Lorena and Costa (2023a)

Table 6 - Respondents' positions

	Federal	States	Total	%
Managers	73	54	127	38.48%
Top Management Advisors	39	49	88	26.67%
Directors	47	22	69	20.91%
Chief Internal Auditors	10	24	34	10.30%
Superintendents	7	5	12	3.64%

Source: De Lorena and Costa (2023a)

Data analysis consisted of three multivariate statistical techniques especially chosen to treat categorical data (MEULMAN; VAN DER KOOIJ; HEISER, 2004; LINTING *et al.*, 2007; FÁVERO; BELFIORE, 2019); all analysed in *R* programming language. First, the CATPCA was used to select the variables with good fit to advance the analysis (LINTING; VAN DER KOOIJ, 2012). This method reduces the number of variables to a smaller number of uncorrelated principal components, thus demonstrating which variables provide information that is of interest to explain public sector RM maturity. Next, the *K*-modes analysis was performed with the purpose to identify clusters (HUANG, 1997; 1998) which, in turn, would represent the maturity levels of a PSRMMM. Finally, multinomial logistic regression was used to verify which variables would indeed explain the probability of a public organisation to be classified at a specific level of maturity (FÁVERO; BELFIORE, 2019). CATPCA and *K*-modes are specifically equivalent to PCA and *K*-means respectively, but with the main difference that the latter ones are ideal to treat numerical data, which is not the case of this study. Likewise, the multinomial logistic regression is a method used when multiple outcome variables are categorical, that is, being more adequate to this study than other generalised linear models. Therefore, given the qualitative nature of the analysed data, these methods were deemed satisfactory to find a proper reference model to build future PSRMMMs. Further details about them are explained in the result analysis section.

Lastly, the results were validated by experts. We sought to conduct meetings with one auditor from the CGU, and two auditors from two different State Comptrollerships. Additionally, the results were also presented to two academics who research and teach ERM in

two federal universities. During the meetings, improvement tips were collected and incorporated into the research. In general, the results were considered valid to compose a future PSRMMM.

4.3 RESULT ANALYSIS AND DISCUSSION

4.3.1 Selecting variables

The aim of using CATPCA in this study was to identify which variables present a good fit for public sector RM maturity. This procedure is an extension of principal component analysis (PCA), also known as “nonlinear PCA” (LINTING; VAN DER KOOIJ, 2012). Like the PCA, the CATPCA has the objective to reduce the dimensionality of original variables into a smaller set of uncorrelated principal components which, in turn, represent the exact variables of interest in a determined study. The main advantage of CATPCA over PCA is that the former explores not only numeric, but also nominal and ordinal variables, being able to discover nonlinear relationships, as well as treating variables at their appropriate measurement level (LINTING *et al.*, 2007).

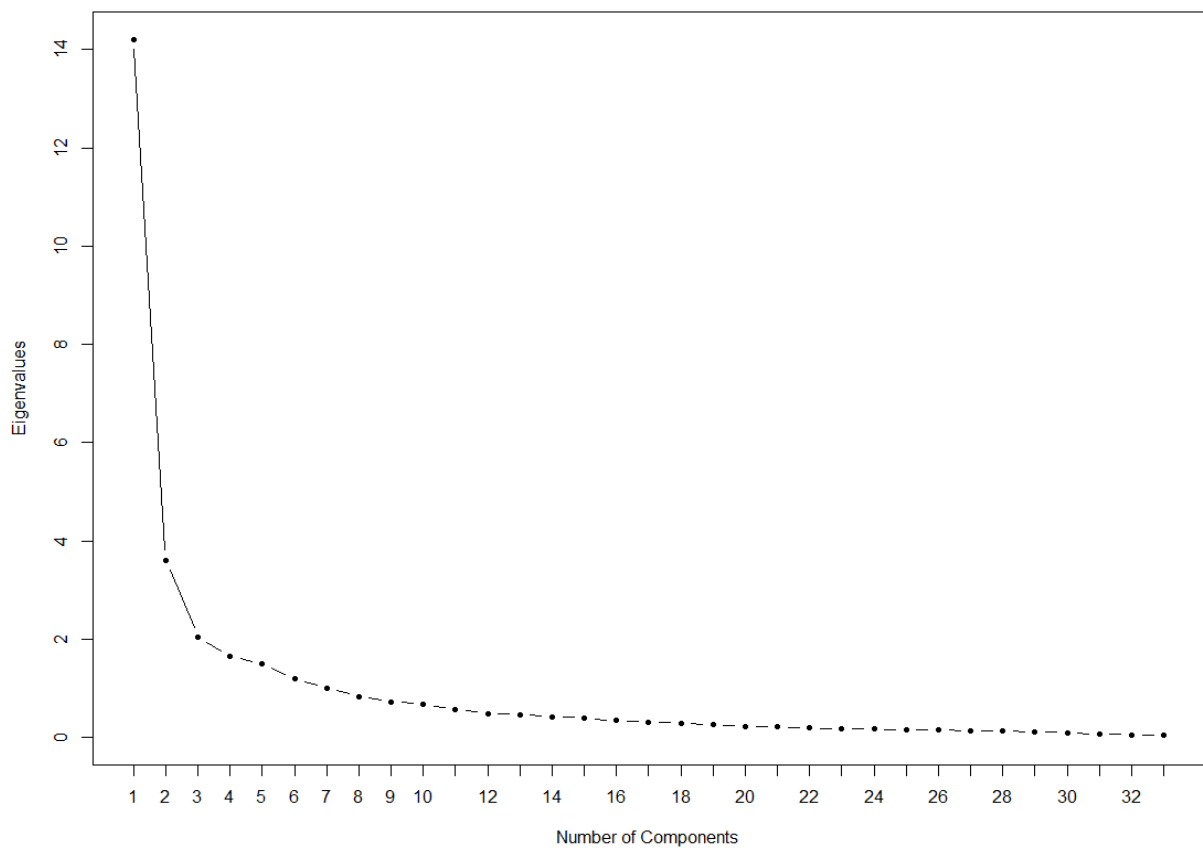
In this method, every variable is treated as categorical, and every value is referred to as a category. CATPCA transforms category numbers into numeric values through an optimal quantification process (LINTING *et al.*, 2007; MEULMAN; VAN DER KOOIJ; HEISER, 2004) in which transformations are optimal for the fitted model, implying that the first components explain as much as possible of the variance in the transformed variables (LINTING; VAN DER KOOIJ, 2012). Hence, the numeric values are called category quantifications, and the correlation matrix in CATPCA is computed considering the quantified variables and the analysis level (LINTING *et al.*, 2007). As this study uses ordinal data, the optimal quantification level only contained grouping and ordering information in the transformation process.

Initially, data were examined through the creation of a scree plot (Figure 6) for the 33 variables. The graph demonstrates the components on the x-axis and the associated eigenvalues on the y-axis. The scree plot showed a considerable break after the first component, indicating that within a unique component it is possible to account for a considerable amount of variance in the data (LINTING *et al.*, 2007). Therefore, the analysis proceeded regarding one component.

The component loadings in CATPCA are similar to the factor loadings in PCA and indicate a Pearson correlation between the quantified variables and the principal components with values ranging between -1 and 1 (LINTING *et al.*, 2007; LINTING; VAN DER KOOIJ, 2012). The sum of the squared loadings is the variance accounted for (VAF) of a variable,

providing the squared length of the vector (communality). Hence, VAF is the most important indication of fit for both principal components and quantified variables; for this reason, it should be considered the main criterion to select variables (LINTING *et al.*, 2007; LINTING; VAN DER KOOJ, 2012). We adopted Comrey's (1973) rules of thumb for VAF in a variable, which means that a VAF equal to 10% is poor, to 20% is fair, to 30% is good, to 40% is very good, and to 50% is excellent. Therefore, we opted to consider variables with VAF over 0.30, indicating that at least 30% of the variance in a quantified variable is explained across the principal component. Based on this criterion, 4 variables were excluded in the following methods: "RMspec", "RMcomm", "JobAut1", and "JobAut2" (see Table 7).

Figure 6 - Scree plot for CATPCA



Source: De Lorena and Costa (2023a)

Table 7 - CATPCA results

Variables	Component Loadings	VAF
RMspec	- 0.011	0.0001
RMcomm	0.031	0.0009
RAwareness1	- 0.639	0.4088
RAwareness2	- 0.678	0.4591
Rcontext	- 0.734	0.5381
Ridentif	- 0.727	0.5280
Ranalysis1	- 0.769	0.5913
Ranalysis2	- 0.719	0.5163
Rtreat	- 0.783	0.6124
Rmonit	- 0.776	0.6023
RReport	- 0.757	0.5723
StandRM1	- 0.716	0.5123
StandRM2	- 0.774	0.5996
RMStratInteg	- 0.750	0.5623
Rapetite1	- 0.742	0.5510
Rapetite2	- 0.785	0.6166
RAccount	- 0.767	0.5887
Tonetop1	- 0.781	0.6095
Tonetop2	- 0.719	0.5165
RMTrain	- 0.670	0.4493
JobAut1	- 0.443	0.1964
JobAut2	- 0.485	0.2356
Form1	- 0.634	0.4017
Form2	- 0.606	0.3666
Form3	- 0.608	0.3694
StratPlan1	- 0.603	0.3632
StratPlan2	- 0.676	0.4568
Goal1	- 0.609	0.3709
Goal2	- 0.617	0.3807
Output	- 0.670	0.4487
Innov1	- 0.572	0.3274
Innov2	- 0.613	0.3763
Innov3	- 0.554	0.3064

Source: De Lorena and Costa (2023a)

The “RMspec” and “RMcomm” variables had the worst performance with the lowest VAF. In the setting, some organisations did not formalise the existence of an RM specialist or a risk-related committee (see Table 5). Therefore, considering that the two variables related to tone from the top resulted in a high VAF, RM in these organisations seems to be overseen by top managers with the support of a not formally conceived “focal point”. Regarding “JobAut1”

and “JobAut2” variables, their low performance in the component is supposedly related to the perception of low decision-making autonomy and flexibility (RAINEY; CHUN, 2005).

The overall goodness-of-fit index (the overall VAF) was 43.74%, with the eigenvalue equal to 14.43. It represents the sum of the eigenvalues of the principal components divided by the total number of variables. Then, we examined the Cronbach’s Alpha, and it demonstrated internal consistency of variables reaching 95% for the single component (MEULMAN; VAN DER KOOIJ; HEISER, 2004).

4.3.2 Identifying RM maturity levels

The *K*-modes clustering algorithm was chosen to identify clusters regarding the 29 variables that presented good fit in CATPCA. Such clusters are supposed to represent the public sector RM maturity levels. The advantage and suitability of *k*-modes for this study is that it extends the *k*-means method by introducing the analysis on categorical domains, as *k*-means is only appropriate to numeric values. Therefore, the main idea of *k*-modes is to partition a multivariate data set into homogeneous groups (or clusters) so that the observations in one cluster are more similar to each other than to those in other clusters (HUANG,1997).

K-modes uses a simple matching dissimilarity measure to cluster categorical data. It replaces means of clusters with modes, and uses a frequency-based method to update such modes in the clustering process to minimize the cost function (HUANG, 1997; 1998). Huang (1998) advocates that the *k*-modes algorithm is generally faster than the *k*-means one because it needs fewer iterations to converge. The dissimilarity measure between two categorical data objects $d(X,Y)$ is defined by their total mismatches considering a determined amount of m attributes. In this study, the 29 variables were the attributes, and the 330 public organisations were the objects. The fewer the number of mismatches, the more similar the public organisations, thus contributing to the creation of a cluster. Considering that maturity models in general are based on 5 levels of maturity (DE BRUIN *et al.*, 2005), we performed the *k*-modes algorithm using 5 clusters ($k=5$). According to Huang (1997), the total mismatches are formally calculated by:

$$d(X,Y) = \sum_{j=1}^m \delta(x_j, y_j) \quad (1)$$

where

$$\delta(x_j, y_j) = \begin{cases} 0 & (x_j = y_j) \\ 1 & (x_j \neq y_j) \end{cases} \quad (2)$$

Considering the frequencies of the categories, the dissimilarity measure is defined as

$$d_{x^2}(X, Y) = \sum_{j=1}^m \frac{(n_{x_j} + n_{y_j})}{n_{x_j} n_{y_j}} \delta(x_j, y_j) \quad (3)$$

where $d_{x^2}(X, Y)$ is the chi-square distance, and n_{x_j}, n_{y_j} are the number of objects in a data set containing categories x_j and y_j for attribute j .

The procedure consisted of 4 steps (HUANG, 1997): (1) a random selection of the initial modes, one for each cluster; (2) the allocation of data objects to the cluster whose mode is nearest according to the dissimilarity measure; (3) the retesting of the dissimilarity of objects against the current modes and reallocation of such objects when necessary; and (4) the repetition of step (3) until no object changes clusters after a full cycle test of the whole data set. Nonetheless, the sensitiveness of k -modes to the choice of the initial cluster modes is considered a drawback as random choices may lead to non-repeatable clustering results. To solve this issue, we executed a loop code for the cluster analysis which ran the k -modes algorithm numerous times automatically, thus providing us with a meaningful result.

Tables 8, 9 and 10 demonstrate the distribution of public organisations per cluster considering three different aspects: government tier, legal nature, and industry. The clusters are presented progressively (C1 has the lowest maturity and C5 has the highest). In Table 8, it can be observed that there are more state-level organisations with low RM maturity and more federal organisations with higher RM maturity. This result makes sense as the movement to implement RM in Brazil started in the federal government and then was followed by the states.

Alternatively, Table 9 demonstrates that the organisations from the direct administration present mid-low level of maturity (concentration in C2 and C3), whereas the ones from the indirect administration have more maturity (especially the public enterprises and mixed-economy firms). Table 10, in turn, shows that public organisations operating in “education” and “technology/research” industries are well distributed among the clusters, while the organisations in “bank/insurance” and “mining/energy” industries support previous studies by

presenting more maturity (KLEFFNER; LEE; McGANNON, 2003; BEASLEY; CLUNE; HERMANSON, 2005). Moreover, organisations within the “police/defence” industry are concentrated in C5, possibly because the nature of this industry leads with risks most of the time.

Table 8 - Number of public organisations per cluster and government tier

Government Tier	Clusters					Total
	C1	C2	C3	C4	C5	
Federal	16	38	29	43	50	176
States	29	32	34	29	30	154
Total	45	70	63	72	80	330

Source: De Lorena and Costa (2023a)

Table 9 - Number of public organisations per cluster and legal nature

	C1	C2	C3	C4	C5	Total	%
Direct Administration	15	28	26	17	16	102	30.91%
Indirect Administration	30	42	37	55	64	228	69.09%
Autarchies	17	21	20	20	31	109	33.03%
Public Enterprises	2	10	8	19	18	57	17.27%
Foundations	10	9	7	9	7	42	12.73%
Mixed-economy Companies	1	2	2	7	8	20	6.06%

Source: De Lorena and Costa (2023a)

Table 10 - Number of public organisations per cluster and industry

Industry	C1	C2	C3	C4	C5	Total	%
Education	16	23	14	21	17	91	27.58%
Police/Defence	2	7	4	4	13	30	9.09%
Health	5	5	4	7	5	26	7.88%
Legal/Controlling Affairs	4	5	7	2	6	24	7.27%
Agribusiness	3	5	5	5	2	20	6.06%
Technology/Research	3	4	4	3	5	19	5.76%
Mining/Energy	0	2	2	6	6	16	4.85%
Water Resources	1	1	3	5	3	13	3.94%
Banks/Insurance	1	4	0	1	6	12	3.64%
Environment	2	2	4	2	2	12	3.64%
Transportation	1	4	1	2	4	12	3.64%
Culture/Tourism	1	1	2	3	1	8	2.42%
Treasury/Planning	2	0	2	1	3	8	2.42%
Social Assistance	1	1	3	0	2	7	2.12%
Construction	0	1	0	3	0	4	1.21%
Others	3	5	8	7	5	28	8.48%

Source: De Lorena and Costa (2023a)

4.3.3 Analysing RM maturity

The multinomial logistic regression was used to verify which variables explained the probability of classifying a public organisation into one of the five levels of RM maturity (FÁVERO; BELFIORE, 2019). This method was chosen because it is suitable to treat qualitative dependent variables with multiple categories, which is the case of the five clusters identified in *K*-modes. It allows us to identify what key independent variables *X* best fit each category of dependent variable *Y* (HOSMER JR.; LEMESHOW; STURDIVANT, 2013; FÁVERO; BELFIORE, 2019). The calculus for the probabilities of occurrence follows the equations below:

$$p(y=C1)= \frac{1}{1+e^{Z_1}+e^{Z_2}+e^{Z_3}+e^{Z_4}} \quad (4)$$

$$p(y=C2)= \frac{e^{Z_1}}{1+e^{Z_1}+e^{Z_2}+e^{Z_3}+e^{Z_4}} \quad (5)$$

$$p(y=C3)= \frac{e^{Z_2}}{1+e^{Z_1}+e^{Z_2}+e^{Z_3}+e^{Z_4}} \quad (6)$$

$$p(y=C4)= \frac{e^{Z_3}}{1+e^{Z_1}+e^{Z_2}+e^{Z_3}+e^{Z_4}} \quad (7)$$

$$p(y=C5)= \frac{e^{Z_4}}{1+e^{Z_1}+e^{Z_2}+e^{Z_3}+e^{Z_4}} \quad (8)$$

where the logits of the multinomial logistic regression are given by:

$$Z_1 = \alpha_1 + \sum_{i=1}^n \beta_{1i} x_{1i} \quad (9)$$

$$Z_2 = \alpha_2 + \sum_{i=1}^n \beta_{2i} x_{2i} \quad (10)$$

$$Z_3 = \alpha_3 + \sum_{i=1}^n \beta_{3i} x_{3i} \quad (11)$$

$$Z_4 = \alpha_4 + \sum_{i=1}^n \beta_{4i} x_{4i} \quad (12)$$

Considering that the model initially had 29 independent variables to be tested, *n* in this case can be any number not higher than 29. In this method, C1 is held as a reference category, being the basis for the calculations.

The procedure started with a backward stepwise analysis conducted to eliminate the statistically non-significant variables (HOSMER JR.; LEMESHOW; STURDIVANT, 2013). The analysis involved further tests to compare similar combinations of variables to reach the best goodness of fit considering the literature as background. Therefore, the final model was reduced to 12 independent variables (*n*=12): Tonetop1, Tonetop2, RAccount, RAwareness2,

Rcontext, StandRM1, StandRM2, Innov2, RMStratInteg, Goal2, RReport, and StratPlan2. This model suggests that these variables are important attributes to determine the level of maturity that classifies a public organisation. Nonetheless, it does not mean that a PSRMMM must avoid other attributes; for instance, risk identification, analysis and treatment were not statistically significant but are inherent to the RM process and, for this reason, must be asked anyway. In short, this set of variables is deemed as critical to level up maturity in a PSRMMM.

To verify the model's significance, the X^2 test was performed presenting a p-value almost equal to 0, thus indicating that at least one of the independent variables is statistically significant to explain the probability of occurrence in at least one of the clusters (FÁVERO; BELFIORE, 2019). The model presented a log likelihood of -225.369 and the Akaike Information Criterion (AIC) was 554.738. The explanatory power of the model was considered high as the Nagelkerke Pseudo- R^2 was equal to 0.874. Moreover, we identified that out of the 330 public organisations, the model classified 231 organisations correctly according to the calculated clusters in *K*-modes, that is, 70%. Table 11 shows the statistically significant results of the multinomial logistic regression per cluster.

The odds ratio represents the chances of a public organisation to be classified at a determined RM maturity level given its exposure to an independent variable when compared to level C1. For instance, at C2, only Tonetop1 demonstrated to be statistically significant by providing 99% more chances to reach this maturity level in comparison to C1. At C3, 6 variables were important under the same logic (RAccount, RAwareness2, Rcontext, StandRM1, Innov2 and RMStratInteg). At C4, these variables remained important with the addition of StandRM2 and Tonetop2. Finally, at C5, Goal2, Rreport and StratPlan2 demonstrated to be statistically significant. Figure 7 illustrates how these variables were related to the clusters, thus becoming a reference for the development of future PSRMMMs.

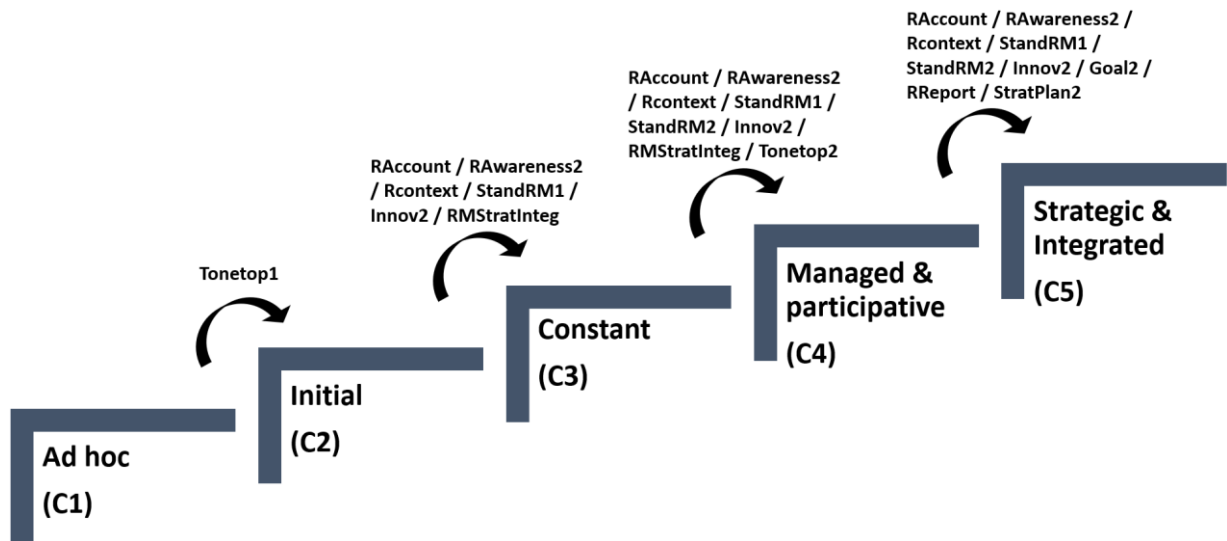
Table 11 - Multinomial logistic regression

Variables	C2				C3				C4				C5			
	Coefficients	Stand. Error	Z(Wald)	Odds ratio	Coefficients	Stand. Error	Z(Wald)	Odds ratio	Coefficients	Stand. Error	Z(Wald)	Odds ratio	Coefficients	Stand. Error	Z(Wald)	Odds ratio
Intercept	-4.56***	1.31	-3.49		-20.52***	3.21	-6.40		-34.62***	4.02	-8.613		-48.83***	4.79	-10.20	
Tonetop1	0.69*	0.33	2.06	1.99												
RAccount					0.92**	0.30	3.05	2.51	0.72*	0.337	2.126	2.05	1.06**	0.364	2.90	2.88
RAwareness2					0.80*	0.35	2.26	2.23	1.22**	0.398	3.072	3.39	1.23**	0.419	2.93	3.41
Rcontext					0.65**	0.25	2.58	1.92	0.97***	0.288	3.377	2.65	1.21***	0.312	3.89	3.36
StandRM1					0.59*	0.25	2.38	1.81	1.06***	0.282	3.759	2.88	1.41***	0.312	4.51	4.09
Innov2					0.65*	0.29	2.21	1.91	0.89**	0.327	2.736	2.44	0.94**	0.359	2.63	2.57
RMStratInteg					1.09**	0.38	2.87	2.98	0.88*	0.403	2.192	2.42				
StandRM2									1.25*	0.490	2.554	3.50	1.19*	0.511	2.34	3.30
Tonetop2									0.93*	0.362	2.559	2.53				
Goal2													1.42**	0.463	3.06	4.13
RReport													1.22**	0.410	2.98	3.40
StratPlan2													0.77*	0.393	1.97	2.17

*, **, *** indicate $p < 0.05$, $p < 0.01$, and $p < 0.001$, respectively.

Source: De Lorena and Costa (2023a)

Figure 7 - Maturity levels for a PSRMMM



Source: De Lorena and Costa (2023a)

Cluster 1 shows an *ad hoc* level of maturity at which RM is still traditional, silo-based and with little formality. The organisations classified in this cluster do not have any type of support from top managers, do not understand the importance of RM properly, and employees may perform RM when they reckon it is necessary in specific situations with no formal guidance or standardisation provided by the organisation. Besides, risk report is not required by top managers. In short, it is not possible to mention the existence of a structured public sector RM at this level.

Cluster 2 upgrades the first cluster by demanding that top managers actively communicate the importance of considering risks in business routines (BRAUMANN; GRABNER; POSCH, 2020). Concomitantly, risk awareness is expected to start to concretise the infancy of an RM culture and to foster the notion of accountability for the RM process. Despite not being statistically significant to reach this level, an RM structure is recommended to start being planned and materialised (e.g.: the assignment of leaderships, the adoption of guidelines, and the experimentation of RM in few units of the organisation). At this level, RM features start to rise with some elements in place, although a proper implementation is not yet observed. Therefore, Cluster 2 demonstrates an *initial* step to public sector RM with a primitive engagement.

Cluster 3 requires an established public sector RM structure and a *constant* and cyclical RM process in the organisation. The first attribute is the presence of a standardisation process to identify and evaluate risks, indicating that guidelines, training and/or consultancy services were provided (WOODS, 2009). The second one represents the systematic environment

analysis of the activities under evaluation. The third one relates to a risk-thinking culture which is naturally incorporated by employees in their work modes, assuming the presence of some level of risk awareness (BRAUMANN, 2018; OLIVEIRA *et al.*, 2019). In the fourth one, employees are expected to demonstrate accountability for their actions and decisions regarding RM. In the fifth one, top managers should start to consider the information on the main risks in the strategic planning process (BRAUMANN, 2018). Finally, employees must demonstrate an innovation-oriented culture by frequently searching out new work methods, techniques, or instruments (WYNEN *et al* 2014; BYSTED; HANSEN, 2015), thus becoming more receptive to RM practices (RAINEY; CHUN, 2005; BYSTED; HANSEN, 2015).

Clusters 4 and 5 also demand the presence of the following attributes: risk awareness, risk context, accountability, standardised identification and evaluation of risks, as well as the strategic integration of RM. Moreover, the employees' behaviour towards the receptivity of new methods, techniques and instruments also remains important at such levels. The additional requirement for C4 is that it emphasises the top managers' support by introducing variable Tonetop2, implying that they should not only communicate the importance of RM, but also put special emphasis on ensuring that the corporate culture encourages employees to signal potential risks, thus exerting tone from the top in a bottom-up direction (BRAUMANN; GRABNER; POSCH, 2020). Moreover, this level also includes variable StandRM2, in which control activities and monitoring measures in public sector RM must be standardised. Given these features, cluster 4 seems to represent a *managed and participative* level of RM maturity.

Followingly, C5 is distinguished by incorporating more *strategic and integrated* features into public sector RM. First, this cluster requires organisational commitment to the strategic plan, which implies that involving managers in strategic planning would contribute to the performance of RM strategic decisions and priorities (ELBANNA; ANDREWS; POLLANEN, 2016). Consequently, although the RM strategic integration attribute is not statistically significant in this cluster, its presence is considered implicit. Another significant contingent factor is the organisational need to have specific and detailed goals demonstrating that their communication supports strategic RM. Moreover, this cluster requires that the evaluated risks are reported regularly to top management (PAAPE; SPEKLÉ, 2012; BRAUMANN, 2018). These variables clearly demonstrate a high commitment of middle and top managers to RM practices and to preparing the organisation for a more strategic and governance view.

4.4 FINAL CONSIDERATIONS

This chapter adapted the article by De Lorena and Costa (2023a), and started the elaboration process of the PRisk-MM. The main motivation for this study regards the finding that the governments investigated in chapter 3 demonstrated to have difficulties in stimulating RM maturity in the public organisations of their jurisdiction, mainly due to some generally weak support from public top managers. Moreover, the literature has not devoted efforts to investigate the process by which a public sector RM may progress. Therefore, this study aimed to understand what indeed entails RM maturity in Brazilian public organisations, and as a result developed a reference model identifying what key attributes and contingent factors influence the levels of maturity of a PSRMMM, contributing to the development of future MMs.

In this sense, the systematic application of a PSRMMM would enable public organisations to better understand RM practices and self-assess their performance with the aim to identify what they need to do to enhance their RM implementation. Moreover, a PSRMMM can be used as a government tool to facilitate the GPMs' role in assessing the organisations and finding out if they need more consulting services, or if they are mature enough to receive RM audits (IIA, 2009). It is also expected that a PSRMMM can motivate public top managers in championing and supporting the RM practices of the organisations they are accountable for, especially when their performance is compared to other organisations of the government, thus demonstrating that a PSRMMM can be used strategically by GPMs.

5 PRISK-MM: A PUBLIC SECTOR RM MATURITY MODEL FOR BRAZILIAN PUBLIC ORGANISATIONS

This chapter is based on De Lorena and Costa (2023c), and presents how the PRisk-MM was developed and validated considering the study developed in De Lorena and Costa (2023a), whose content is represented in the fourth chapter of this thesis. It answers the second research question: “How to assist the Brazilian public organisations to improve the maturity of their RM systems?”, and attends to the following secondary objectives: “to identify in the literature which steps are considered state-of-the-art to develop an MM”, “to identify which measures can satisfactorily treat subjective judgements for the attributes”, “to identify which practices are important to be prescribed and improve the RM attributes”, “to validate the PSRMMM”.

5.1 CONTEXTUALISATION

ERM has been recognised as fundamental to organisational success and, as a discipline, it has been developed briskly over the last decade (WOODS, 2022). In order to be effective and impact the value creation in organisations, ERM needs to reach mature patterns of implementation, thus leaving a silo-based approach to become integrated and embedded in both strategic planning and operational routine (FARRELL; GALLAGHER, 2015). For such, mature organisations in ERM are expected to present risk governance, a greater engagement of top managers, more formal and frequent reports, to articulate better risk appetites in strategic planning, etc. (BEASLEY; BRANSON; PAGACH, 2015; LUNDQVIST, 2015). Nonetheless, achieving mature levels of ERM is not so easy because not always is the connection between the ERM system and the strategic planning as strong as desired, indicating that it is limited to a supportive organisational culture with staff sharing information about key risks, along with the requirement of sufficient leadership and top management commitment (VISCELLI; HERMANSON; BEASLEY, 2017). These findings indicate that achieving ERM maturity is a process that needs progressive efforts, considering attention to processes and structures, as well as to people and culture.

Regarding specifically the public context, public organisations are surrounded by factors that particularly influence their efforts to reach higher levels of maturity in the public sector RM (RAINEY; CHUN, 2005; WOODS, 2022; DE LORENA; COSTA, 2023a). Some examples are related to the fact that they have more formal authority, are more exposed to external control, have more limited managerial procedures, deal with more debatable goals,

have top managers that are influenced by political pressures and have a more expository role, etc. (RAINEY; CHUN, 2005). Consequently, the practical challenges that public organisations face in implementing RM are more compelling (WOODS, 2022), and achieving more mature RM levels in this context is a very slow process (BRAZIL/ME 2022).

A tool that may help to accelerate the achievement of public sector RM maturity is the MM. MMs are used to evaluate the current maturity level of a certain domain and to assist the organisation in increasing such domain's capability, thus implying an evolutionary progress to reach a predefined target (DE BRUIN *et al.*, 2005; METTLER, 2011). Therefore, MMs display a path of improvement that guides the organisations (SANTOS-NETO; COSTA, 2019). The recognition of the benefits and relevancy of MMs is observed through the increased number of publications since 2002 (SANTOS-NETO; COSTA, 2019). Although emerged in computing and software engineering, MMs have been applied to several other domains such as the medical sector, supply chain management, education, IT outsourcing, e-governance, project management, and business process management (WENDLER, 2012; SANTOS-NETO; COSTA, 2019). Nonetheless, in this study, we discuss the lack of publications about PSRMMM.

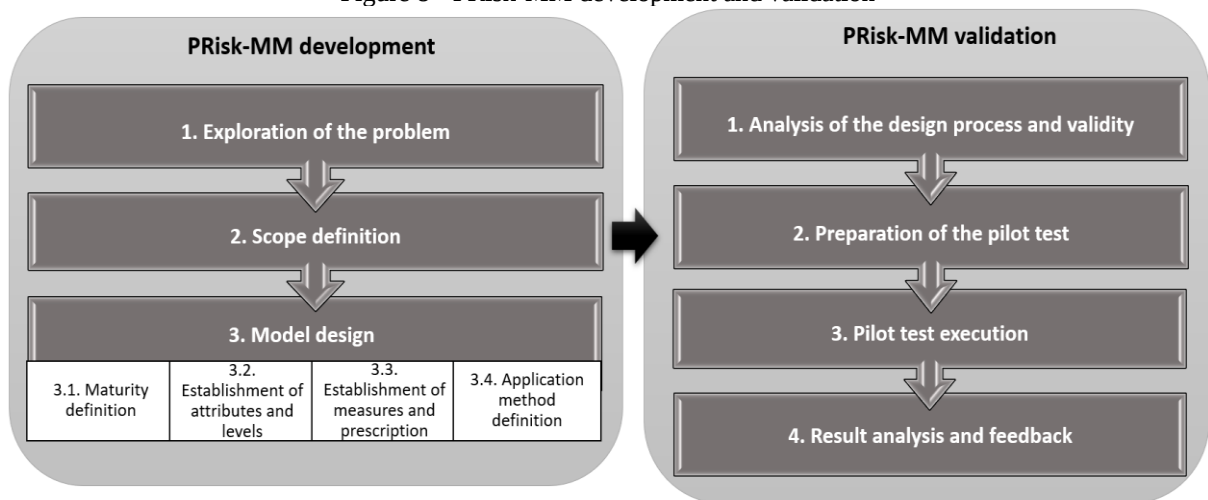
To address this gap, this study introduces the PRisk-MM, a PSRMMM for the Brazilian public organisations. Hence, the PRisk-MM assesses the public organisations' maturity in RM considering 5 levels of maturity and 23 attributes distributed into 15 dimensions. The model is based on a previous study conducted by De Lorena and Costa (2023a) once they presented attributes and key contingent factors that are significant to build PSRMMMs, thus demonstrating a sound theoretical foundation that most MMs do not disclose (METTLER, 2011; WENDLER, 2012). Moreover, the assessment procedure of the PRisk-MM uses triangular fuzzy numbers to better treat the subjectivity and ambiguity of human judgement, being validated in 3 public organisations of 1 state government in Brazil.

5.2 METHODOLOGY OF THE STUDY

Observing the criticism as to the MM conception that academics bring in systematic literature reviews (e.g.: WENDLER, 2012; SANTOS-NETO; COSTA, 2019), the PRisk-MM was thought with the aim to become a useful PSRMMM for the Brazilian public organisations by reflecting their context and considering the scientific rigour an MM must have. Hence, the PRisk-MM was inspired by the typical phases proposed by Mettler (2011) and De Bruin *et al.* (2005) to design an MM, thus reflecting the Design Science Research as it is related to a

problem-solving paradigm in the organisational context (HEVNER *et al.*, 2004; DRESCH; LACERDA; ANTUNES JR, 2015). The phases proposed by De Bruin *et al.* (2005) include defining the scope and the design of the MM, followed by its population in terms of deciding the content of the model (what needs to be measured and how). The testing phase comes next, followed by deploying and maintaining the MM. Mettler (2011), in turn, states that an MM must contain a development cycle (defining scope, designing the model, evaluating the design, and reflecting on its evolution) as well as an application cycle (preparing deployment, selecting the model, taking corrective actions, and applying the model). Figure 8 below depicts the steps used to develop and validate the PRisk-MM, considering the phases mentioned above.

Figure 8 - PRisk-MM development and validation



Source: De Lorena and Costa (2023c).

The development of the PRisk-MM comprises three steps: the identification of the problem or need, the scope definition, and the design *per se*, which was divided into four substeps. Substeps 3.2 (Establishment of attributes and levels) and 3.3 (Establishment of measures and prescription), in particular, were based on the study developed by De Lorena and Costa (2023a). This study presents 5 levels of maturity with a set of variables identified throughout a consistent statistical path analysis applied to data collected from Brazilian public organisations. These variables reflect contingent factors and public sector RM attributes, thus incorporating the features and needs of the audience the PRisk-MM is devoted to.

The next phase, the PRisk-MM validation, consists of four main steps that were carried out as a pilot test in 3 public organisations of 1 Brazilian state government. The details on how the pilot tests occurred and their results are exposed later.

5.3 PRISK-MM DEVELOPMENT

The first step of the development phase was the exploration of the problem which comprised the identification of the real need for a new PSRMMM that could be directed to public organisations. Empirically, the PRisk-MM is valuable as a government tool because auditors are generally in charge of assessing RM implementation in public organisations, and consequently of identifying their maturity status (WOODS, 2009; DE LORENA *et al.*, 2022). In Brazil, these auditors are considered GPMs because they not only evaluate public sector RM maturity, but also provide guidelines for implementation, training sessions and even consultancy services (DE LORENA *et al.*, 2022). The public sector RM maturity evaluation is considered part of the controlling role GPMs generally exert over public organisations (RAINEY; CHUN, 2005). Moreover, within a single government, the PRisk-MM can be used to compare the organisations' performances in implementing public sector RM. The PRisk-MM may also be useful to public organisations when the interest is to conduct self-assessments and to identify what needs to be improved.

In the theory, there was a scientific gap in the literature involving the lack of a specific MM for public sector RM. For this purpose, ERM MMs were sought in the literature using the academic research “Web of Sciences” and “Scopus” databases with keywords “maturity model”, “multilevel model” and “maturity level” combined with “risk management”. The results were then filtered to only include articles classified into fields related to “business” or “management”. During the analysis, articles that did not provide new MMs or publications not classified as articles were excluded. As a result, from an initial list of 53 papers, the final list comprised 12 articles, 10 of which represented new ERM MMs directed to different application scopes, and 2 which discussed theories regarding ERM maturity.

The next step was the model scope definition. This step is considered the most important as decisions here influence all the following steps (DE BRUIN *et al.*, 2005; METTLER, 2011). Regarding the domain focus, the PRisk-MM is specific to public sector RM implementation with an organisational level of analysis because it evaluates public sector RM as part of the corporate governance, considering its integration to both organisational strategy and operations. Besides, the PRisk-MM is tailored to a management-oriented audience as the idea is to address managerial needs when self-assessments are performed within the public organisations, and to GPMs because they evaluate the performance of public organisations on behalf of the governments (DE LORENA; COSTA, 2023a).

The third step was the model design, comprising: (1) the definition of maturity, (2) the establishment of attributes and levels, (3) the establishment of measures and prescription, and (4) the application method. Regarding the first aspect, maturity definition, the PRisk-MM combines the focus on processes and structures, as well as on people and culture (METTLER, 2011). The focus on processes and structures implies the importance of centring maturity on public sector RM activities and work practices to deliver more effective procedures. Attributes related to RM process and to strategy integration, for instance, reflect this maturity focus. Alternatively, the focus on people and culture considers the maturity of staff skills and proficiency in public sector RM execution. Attributes related to RM awareness and top management commitment are good examples as these attributes emphasise people's behaviour.

Thereafter, based on De Lorena and Costa (2023a), the maturity levels were established for the PRisk-MM considering the same labels and definitions the authors proposed in their maturity reference model. Therefore, the PRisk-MM is meant to be theory-driven because this reference model is rooted in a literature review that comprised contingent factors and PSRMMM attributes. This feature brings a consistent theoretical foundation for the PRisk-MM's development (METTLER, 2011), from which the contingent factors are considered an important aspect that makes the PRisk-MM special for public organisations. Moreover, the PRisk-MM's design process follows a bottom-up approach because the reference model's significant variables (or maturity attributes) were identified first, with the definitions of the levels (Table 12) being a reflection of those (DE BRUIN *et al.*, 2005).

Table 12 - Description of the PRisk-MM's maturity levels

Maturity levels	Description
Ad hoc	At this level, RM is silo-based and presents little formality. The organisations do not have the support from top management and the staff do not understand the importance of RM. Therefore, employees perform RM process when it is necessary in specific situations, demonstrating no standardisation of procedures.
Initial	RM structure and risk governance features start to be planned, standardised, and formalised through a framework elaborated or adapted by a specific team, department, or committee (the focal point). Nonetheless, RM proper implementation is not yet observed. Accordingly, top management needs to actively communicate the importance of RM, and risk awareness starts to be established, fostering an initial risk culture and the notion of accountability. Level 2 shows a primitive engagement.
Constant	Level 3 requires an established public sector RM framework, with a formalised, standardised, ongoing, cyclical RM process in the organisation. It is expected, for instance, that a systematic analysis of the environment and a culture of risk thinking be in place, and that employees already demonstrate responsibility for their actions and decisions related to risks. Furthermore, risk information starts to feed the strategic planning process, and employees demonstrate an innovation-oriented culture by searching out new working methods or instruments, thus becoming more receptive to RM.
Managed and participative	At this level, top management must actively encourage the staff to participate in RM, and the communication of treatment and monitoring activities must be standardised and working appropriately. Also, staff skills, their receptivity to RM and their risk awareness are more developed, with consistent risk analysis becoming part of the organisations' strategic planning.
Strategic and Integrated	This level has well-established strategic processes, such as the establishment of objectives, indicators, and more structured strategic planning to better receive and integrate the information that RM can provide, making it a more strategic tool in the organisation. For this reason, well-structured and regular risk reporting is fundamental. In addition, the accumulation of skills regarding other aspects is also paramount.

Source: based on De Lorena and Costa (2023a).

The maturity attributes represent what needs to be measured within an MM, considering that they must be mutually exclusive and collectively exhaustive (DE BRUIN *et al.*, 2005). Hence, the PRisk-MM was populated with the attributes used in the multinomial logistic regression De Lorena and Costa (2023a) performed, being complemented with two more attributes: A3 and A4 (see Appendix A). These attributes represent the organisational governing body (that may or may not be presented in the form of a committee) and the focal point (a person, a team, or a department with the responsibility to lead public sector RM implementation and behave as the second line of defence) (IIA 2022). In De Lorena and Costa (2023a), these attributes were referred to as variables “RMcomm” and “RMspe”, being withdrawn from their final analysis because in their first statistical analysis, using CATPCA, the variables did not show a good fit to public sector RM maturity. Nonetheless, in their study they were dummies representing the existence or not of a risk-related committee and an RM specialist duly formalised. In the PRisk-MM, attributes A3 and A4 give emphasis not on their formalised existence, but on their role, composing the leaderships IIA (2022) advocates as necessary to

support an RM structure. Hence, the PRisk-MM is comprised of 23 attributes distributed among 15 dimensions as described in Table 13.

Table 13 - Attributes and dimensions of the PRisk-MM

Dimensions		Attributes	Variables in De Lorena and Costa (2023a)
Top management commitment	A1	The top management clearly and formally communicates not only the importance of considering risks in the activities of all employees and suppliers, but also the need to investigate and manage them appropriately.	ToneTop1*
	A2	The top management encourages employees to register and communicate the potential risks directly to the focal point team or to the top managers themselves, as soon as they are perceived, as well as to indicate and give opinions on any other risks.	ToneTop2*
Governing body	A3	The governing body of the organisation, whether or not in committee form, delegates responsibilities, oversees RM and discusses the most critical risks with other government authorities, ensures organisational transparency, and plans the allocation of resources to aid management in achieving strategic objectives and enabling RM implementation.	-
Focal point	A4	The team leading RM implementation, the "focal point", is the main access to central government demands regarding RM issues, also being responsible for operationalising RM internally and assisting the top management and/or the governing body in overseeing and monitoring risk treatment actions.	-
Context analysis	A5	RM includes a systematic context analysis of the object under investigation (e.g.: processes, projects, strategic decisions, etc.), comprising the analysis of the internal and external environments, the organisational objectives related to the object, as well as the involvement of stakeholders.	RContext*
Risk assessment	A6	The organisation's RM seeks to identify risks of various types, such as compliance, integrity, strategic, external (e.g.: political, economic, social and partnerships), and operational risks (in processes or projects), using techniques and tools that ensure consistent identification of risks and relying on key employees who have knowledge about the object under analysis.	RIdentif
	A7	Risk assessment relies on an analysis of the probability of occurrence and the consequences of risk events, using previously defined criteria to prioritise risks in the most appropriate possible way, as well as analysing existing controls if applicable.	RAnalysis1
	A8	The organisation has a portfolio of risks in which the main ones are integrated and analysed regarding their interdependence, aggregating the quantifiable risks whenever possible.	RAnalysis2
Risk treatment	A9	RM includes risk treatment decisions that are formalised in an action plan with a clear definition of deadlines and employees in charge, considering a prior analysis of various treatment options, cost-benefit analyses, and the evaluation of management controls.	RTreat

Continues...

Dimensions		Attributes	Variables in De Lorena and Costa (2023a)
RM Monitoring	A10	Periodically, the focal point team oversees the risk treatment actions to be carried out by the units of the organisation and reviews its own RM methodology.	RMonit
	A11	The tactical and operational managers continuously monitor the achievement of objectives and actions to treat risks in their respective departments in order to effectively report on the evolution and dynamics of the identified risks.	
Risk report	A12	The assessed risks are reported to the top management and/or to the governing body on a regular basis, or even immediately, depending on the level of urgency and criticality of risks.	RReport*
RM standardisation	A13	The organisation defines and follows a standard process to identify and assess risks, as well as to classify risks and maintain a common risk language internally.	StandRM1*
	A14	Risk treatment actions and monitoring indicators are communicated in a standardised form throughout the organisation.	StandRM2*
Risk awareness	A15	Our employees at all levels are aware of the importance of maintaining risk aspects in their decisions, as well as of trusting the RM methodology used in the organisation.	RAwareness1
	A16	Our employees have incorporated risk thinking into their work routine naturally, with RM and the execution of organisational processes or projects being integrated.	RAwareness2*
Receptive culture	A17	Our employees maintain the habit of seeking new working methods, techniques, or instruments, demonstrating openness and easy adaptation to changes, as well as commitment to improving the management of their routine.	Innov2*
Accountability	A18	All the staff is clear about their roles in RM so that they understand their responsibilities for actions and decisions as risk managers.	RAccount*
RM strategic integration	A19	The organisation manages risks in its strategic objectives and uses the information resulting from RM to inform strategic decisions and to allocate resources.	RMStratInteg*
Risk appetite	A20	The top management and/or the governing body clearly define and communicate their expectations regarding risk appetites and risk tolerances, as well as following up RM with the focal team.	RApette1
	A21	The top management and/or the governing body apply risk appetite concepts in developing organisational strategy.	RApette2
Organisational strategy	A22	The top management specifies and details the organisational strategic goals, which are based on the government's strategic planning.	Goal2*
	A23	The organisation demonstrates commitment to the strategic planning, so that operational managers observe the actions and objectives that are their responsibility, and the top management demonstrates concern through periodic monitoring.	StratPlan2*

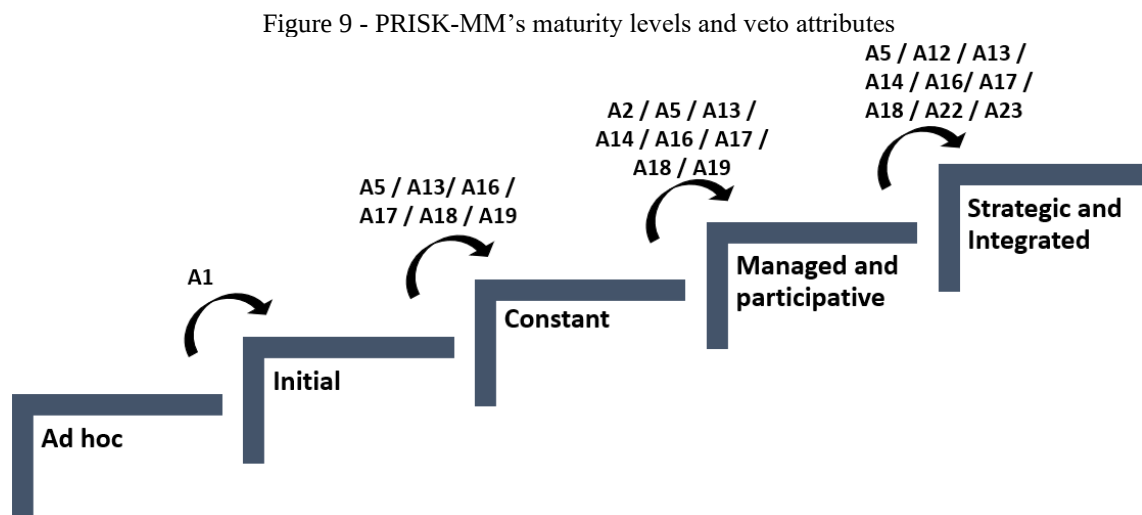
Source: De Lorena and Costa (2023c).

*Variables that De Lorena and Costa (2023) found to be statistically significant in the progression of levels of a PSRMMM.

Observing the descriptions of the attributes in Table 13, it is possible to recognise the specific application of the PRisk-MM in the public sector context. For instance, attribute A3

expects the “Governing body” of RM to maintain a good relationship with other government authorities by discussing the most critical risks for the government, in addition to ensuring organisational transparency and allocation of resources. In attribute A4, the “focal point” team is expected to be the bridge between the central government policymakers and the organisations’ top managers and/or governing body regarding RM issues. Moreover, through attribute A22, the PRisk-MM expects top managers to specify and detail organisational strategic goals based on the government’s strategic planning. Further peculiarities are found in the prescriptions of the PRisk-MM (see Appendix C).

Through the multinomial logistic regression De Lorena and Costa (2023a) performed, the variables that were statistically significant to establish a maturity progression path were identified (see the variables in Table 13). Hence, Figure 9 depicts the attributes that are paramount to determine the level of maturity into which a public organisation may be classified. Nonetheless, it does not mean that other attributes must be avoided during maturity assessment, which is the case of the steps that comprise the RM process (e.g.: risk identification, risk analysis, and risk treatment) (DE LORENA; COSTA, 2023a). Therefore, in the PRisk-MM, the attributes displayed in Figure 9 are treated as vetoes, meaning that the organisation needs to have them applied before being classified into a determined level of maturity. For instance, supposing that organisation “Alpha” has not yet applied attribute A18, “Alpha” will remain at level 2 of maturity (initial), even if presenting a sufficient final score for level 3 (constant).



Source: based on De Lorena and Costa (2023a).

The assessment procedure designated for the PRisk-MM was developed based on the fuzzy set theory as detailed followingly. The result is supposed to provide a prescription containing a list of actions the public organisation may plan to execute to improve its RM

system. This is deemed as very important since an MM without an improvement action plan may end up not providing substantial outcomes for the organisation under evaluation (SANTOS-NETO; COSTA, 2019). An example of the PRisk-MM's prescription list is demonstrated in Appendix C.

Finally, the application method of the PRisk-MM was defined as consisting of two phases. The first one comprises its preparation by the government, when GPMs define weights for the dimensions. Such weight definition can be decided either by a single GPM or by a team, with the possibility to also assign weights to the GPMs' judgements. This feature is an advantage of the model as it provides the GPMs with the chance to adapt the PRisk-MM to the government context by giving more importance to the dimensions they deem to be more important to achieve the government objectives, thus being in accordance with the contingent theory appointed by De Lorena and Costa (2023a). The second phase comprises the organisational self-assessment performed by an employee who must occupy a management position and lead the RM implementation locally. Both phases are applied through a spreadsheet, whose patent is pending by the number BR1020230044859. More details on how the weights are assigned and how the public organisations are self-assessed are described below.

5.3.1 Model assessment procedure and prescription

For both phases of the PRisk-MM application method, the calculations are based on the fuzzy set theory. This theory was developed by Zadeh (1965) with the promise to deal with nonnumerical information, presenting varying values that are associated to semantic labels. The partitions of these labels overlap to represent the transition from one state to another (COX, 1994), characterising the ambiguity in human judgement. Unlike the classic binary-valued logic, the fuzzy logic does not restrict a set of numbers to absolutes, but considers the concept of partial truth with varying degrees of membership function in the closed interval $[0, 1]$ (PECKOL, 2021). Therefore, in subjective and imprecise judgements, fuzzy numbers usually provide a better set than the corresponding crisp values and play an important role when defining weakly bounded concepts such as “few” or “some” (COX, 1994). The fuzzy logic is particularly suitable to assess the maturity levels because it can be used in classification patterns (ZADEH, 1965), and the evaluation of the attributes is generally subjective, containing linguistic concepts that represent a sense of imprecision or vagueness (PECKOL, 2021).

Among the existent types of fuzzy membership functions, the PRisk-MM uses the triangular type with 50% of overlap in the fuzzy membership degrees. Known as triangular

fuzzy numbers (TFN), this membership function is considered simpler to specify and easier to visualise, being represented with absolute truth at the midpoint of the fuzzy set (COX, 1994). In the PRisk-MM, the input data used for the weight assignment of the dimensions have different linguistic terms from those used by the public organisations during self-assessment. The TFNs for the assignment of weights (Table 14) represent the level of importance a specific dimension has for the public sector RM implementation in the government, whereas the TFNs for the organisations' self-assessment (Table 15) represent how intense the application of a determined attribute is in the organisation. In both cases, the scores vary from 1 to 5.

Table 14 - Linguistic terms and TFNs for the dimension scores

Score	Linguistic terms	Correspondent TFN
1	Not important	(0.2, 0.2, 0.4)
2	Of little importance	(0.2, 0.4, 0.6)
3	Important	(0.4, 0.6, 0.8)
4	Very important	(0.6, 0.8, 1.0)
5	Essential	(0.8, 1.0, 1.0)

Source: De Lorena and Costa (2023c).

Table 15 - Linguistic terms and TFNs for the attribute scores

Score	Linguistic terms	Correspondent TFN
1	It is not applied yet	(0.0, 0.0, 0.25)
2	It is partially applied (a little bit)	(0.0, 0.25, 0.5)
3	It is partially applied (moderately)	(0.25, 0.5, 0.75)
4	It is partially applied (a lot)	(0.5, 0.75, 1.0)
5	It is fully applied	(0.75, 1.0, 1.0)

Source: De Lorena and Costa (2023c).

During the assignment of scores for the weight definition of the dimensions, the GPMs may opt to establish different weights for their own judgements, possibly considering criteria such as the amount of knowledge one has regarding both the government context and the public sector RM domain. Therefore, the PRisk-MM regards the GPMs' tenure as government employees and specifically as RM experts. Their weights must sum 1, that is, $w_{p1} + w_{p2} + \dots + w_{pj} = 1$. Consider the following equation for the dimension weights:

$$W_i = (W_{li}, W_{mi}, W_{ui}) = \sum_{j=1}^p w_j \times \text{TFN}_{ij}(s_{ij}) \quad (13)$$

where W_i is the TFN of the weight for dimension i ; W_{li} , W_{mi} and W_{ui} are the lower bound, the strongest membership degree and the upper bound of W_i , respectively; p is the

number of GPMs; w_j is the weight assigned to each GPM; and TFN_{ij} is the fuzzy number of score s_{ij} given by the GPM j for dimension i .

Regarding the organisation's self-assessment, the agent accountable for judging the attributes is the RM implementation leader of the public organisation. In this process, some attributes are supposed to receive a single score because they represent a general aspect of the organisation, while others have a more operational nature and therefore must be assessed with separate scores for each department of the organisation. The reason for separate judgements is that some departments may have a more advanced RM implementation whilst others are more immature. For this reason, the final score of such attributes is calculated considering the round mean of the individual departments' scores. The attributes under this condition are: A5, A6, A7, A9, A11, A12, A16, A17 and A18.

Hence, considering the final scores of all attributes, the PRisk-MM first fuzzifies them according to Table 15, and then aggregates the multiplications of each attribute fuzzified number by the fuzzified weight of its respective dimension. The equation is below:

$$M = (M_l, M_m, M_u) = \sum_{i=1}^{15} \sum_{k=1}^{a_i} W_i \times TFN_{ki}(s_{ki}) \quad (14)$$

where M is the organisation's fuzzified index represented by M_l , M_m and M_u (the lower bound, the strongest membership degree and the upper bound, respectively); a_i is the number of attributes for dimension i ; and TFN_{ki} is the fuzzified number of score s_{ki} for attribute k for dimension i , that in turn is multiplied by the respective W_i according to equation 13.

The next step consists of the defuzzification of index M . In a fuzzy system, defuzzification is the step in which a crisp number is produced to represent a fuzzy number. Three common methods are mentioned in the literature: the centroid method, mean of maximum, and maximum criterion (COX, 1994; NEGNEVITSKY, 2005; PECKOL, 2021). The centroid method was chosen among them to defuzzify M because it is the most widely used technique, as well as easy to calculate (COX, 1994). The centroid method is also known as centre of gravity (COG) because it seeks to find the point where a vertical line divides the fuzzy set into two equal areas (NEGNEVITSKY, 2005). In the PRisk-MM, the defuzzification of M , that is, M_{def} , is calculated using COG as follows:

$$M_{def} = \frac{M_l + M_m + M_u}{3} \quad (15)$$

Besides these calculations, it is necessary to find the boundaries between levels. These boundaries strictly depend on W_{di} (equation 13); therefore, it is not possible to assume constant values to limit the levels as the weights may vary from government to government. To solve this issue, the PRisk-MM measures the interval between maximum M_{def} (assigning 5 to all attributes) and minimum M_{def} (assigning 1 to all attributes); then, the remaining result is divided by five, which is the number of levels the PRisk-MM supports. The equations are below:

$$Interval = M_{defmax} - M_{defmin} \quad (16)$$

$$limit_{level2} = M_{defmin} + \frac{Interval}{5} \quad (17)$$

$$limit_{level3} = limit_{level2} + \frac{Interval}{5} \quad (18)$$

$$limit_{level4} = limit_{level3} + \frac{Interval}{5} \quad (19)$$

$$limit_{level5} = limit_{level4} + \frac{Interval}{5} \quad (20)$$

Another feature in the PRisk-MM is the existence of vetoes. As observed in Figure 9, there are attributes that are statistically significant for the levels (DE LORENA; COSTA, 2023a); therefore, for these attributes, the organisation must score at least 3 to assume that the attribute is reasonably applied. Otherwise, even displaying a sufficient M_{def} for a certain level, if a required attribute is not scored at least 3, the level is vetoed, and the organisation returns to the immediately lower level. Moreover, the PRisk-MM also demands that no attribute receives score 1 in level 5, also working as a new veto.

Once the level of maturity is defined, the PRisk-MM brings prescriptions to assist the organisation to improve its RM implementation. In this case, the PRisk-MM calculates which attributes were vetoed first, and then which attributes received lower scores. Hence, the Prisk-MM sorts the prescriptions for a maximum of thirteen most critical attributes at a time and supports the elaboration of an improvement action plan for the organisation.

5.4 PRISK-MM VALIDATION

The validation of the PRisk-MM followed the steps depicted in Figure 8. The first step, “analysis of the design process and validity”, involved the analysis of the model’s content and assessment procedure. For this purpose, the state government of Pernambuco, represented by the “Secretariat of Comptroller General of Pernambuco” (SCGE-PE), the state government of Minas Gerais, represented by the “Comptroller General of Minas Gerais” (CGE-MG), and the

Federal District government, represented by the “Comptroller General of the Federal District” (CGDF), were chosen because they were acknowledged by the Brazilian Federal Ministry of Economy as having notorious expertise in RM discipline, as well as performing good practices (BRAZIL/ME 2022).

The first action was to contact the GPMs of those governments and arrange meetings. As observed in Table 16, separate meetings occurred with the GPMs from the governments of Pernambuco and the Federal District, and a single meeting occurred with the GPMs from Minas Gerais. At the end of the meetings, they all gave positive feedback regarding the explanation of the assessment procedure, and then were asked to read the content of the PRisk-MM and analyse if the model could represent the real world of their RM practices with sufficient accuracy (METTLER, 2011). Correspondingly, they provided comments on the readability and comprehensiveness of the model, but no new attributes or dimensions were added. Nonetheless, new RM practices could be added to the prescriptions of the model. Therefore, the PRisk-MM was considered valid as it presented face and content validity. In this case, face validity implied that the dimensions and the attributes could translate RM practices in the public organisations, and content validity regarded how completely public sector RM was represented (DE BRUIN *et al.*, 2005).

Table 16 - GPMs who validated the content of the PRisk-MM

Government leading organisations	GPMs' positions	GPMs' Tenure in the organisation*	GPMs' Tenure working with RM *	Meetings	
				Month/ Year	Duration
SCGE-PE	Director of Governance and Risks	12	2	February/2023	1h
	Executive Secretary of Audits and Governance	13	2	February/2023	2h
CGE-MG	Comptroller-general of the government	4	15	February/2023	50 minutes
	Head of cabinet	3	3		
CGDF	Coordinator of Risk Audits and Integrity	7	5	February/2023	1h30
	Coordenator of Governance	12	6	January/2023	2h

* Data provided in years.

Source: De Lorena and Costa (2023c).

The second step followed with the preparations for the pilot tests in the government of Pernambuco. The referred GPMs were asked to choose two public organisations besides self-testing the PRisk-MM in the SCGE-PE. Then, after an informal explanation provided by the

SCGE-PE, formal invitations were sent to the two public organisations requesting authorisation and an agenda.

Next, during the pilot test execution (step three), the first phase was to assign weights to the PRisk-MM's dimensions, so the SCGE-PE team decided to provide the scores in a group of 5 with equal weights to the respondents, that is, 20% to each. The participants were the Executive Secretary of Audits and Governance, the Director of Governance and Risks, the Coordinator of Risk Management, the Head of the Risk Management Consultancy Unit, and all the remaining members of the team of auditors who answered in consensus. The dimensions' scores were then transformed into TFN by using Table 14, and their respective aggregation formed the weights below (Table 17) according to equation 13.

Table 17 - Dimensions' weights in TFN defined during the PRisk-MM application in the government of Pernambuco

Dimensions	W_{di}		
	W_{li}	W_{mi}	W_{ui}
Top management commitment	0.76	0.96	1.00
Governing body	0.68	0.88	1.00
Focal point	0.72	0.92	1.00
Context analysis	0.68	0.88	1.00
Risk assessment	0.72	0.92	1.00
Risk treatment	0.68	0.88	0.96
RM Monitoring	0.72	0.92	1.00
Risk report	0.72	0.92	1.00
RM standardisation	0.64	0.84	0.96
Risk awareness	0.68	0.88	0.96
Receptive culture	0.52	0.72	0.92
Accountability	0.72	0.92	1.00
RM strategic integration	0.68	0.88	1.00
Risk appetite	0.44	0.64	0.84
Organisational strategy	0.72	0.92	1.00

Source: adapted from De Lorena and Costa (2023c).

Table 17 indicates that, for the government of Pernambuco, the GPMs in SCGE-PE recognise the “receptive culture” and “risk appetite” dimensions as being the least important for RM implementation. On the other hand, “top management commitment” is the most important, followed by “focal point”, “risk assessment”, “RM monitoring”, “risk report”, “accountability” and “organisational strategy”. Then, considering those weights, the limits of

the PRisk-MM's levels were calculated by using equations 16, 17, 18, 19 and 20. Therefore, the limit to reach the second level of maturity was 5.09, the third level was 8.32, the fourth level was 11.54, and the fifth level was 14.77, 17.99 being the maximum possible M_{def} applied by this government.

The second phase comprised the evaluation of the PRisk-MM's attributes. In this case, separate meetings were held with the public organisations, lasting on average one and a half hours. One of them preferred to remain anonymous, providing services in the technology industry; the other two were Compesa and the SCGE-PE itself, providing services in the water utility industry and in the internal control of the government, respectively. Table 18 below provides an overview of the profiles of the organisations and of their respective RM leaders who evaluated the PRisk-MM's attributes. Table 19 provides the results obtained with the PRisk-MM's application, considering the TFN of Table 15 and equations 14 and 15.

Table 18 - Public organisations' and RM leaders' profiles

Public organisations' profile			RM leaders' profile		
Organisation	Type of industry	Year when RM started	Position in the organisation	Tenure working with RM*	Tenure working within the organisation*
SCGE-PE	Internal Control	2021	Director of Governance and Risks	2	12
Compesa	Water utility	2018	Manager of Compliance, RM and Internal Control	3	26
Anonymous	Technology	2022	Advisor of Internal Control	2	3

Source: adapted from De Lorena and Costa (2023c).

Table 19 - Results of the PRisk-MM application

Public organisations	PRisk-MM's defuzzified index (M_{def})	Current Maturity level	Attributes with veto power	Prioritised attributes for prescription
SCGE-PE	5.57	2 - Initial	None	A3, A5, A6, A7, A8, A9, A10, A11, A12, A16, A17, A18, A19
Compesa	12.39	3 - Constant	A2, A16, A18	A2, A8, A11, A15, A16, A18
Anonymous	8.68	2 - Initial	A5, A16, A18, A19	A5, A6, A7, A8, A9, A11, A12, A16, A18, A19, A22, A23

Source: adapted from De Lorena and Costa (2023c).

The fourth step comprised the results analysis and the collection of feedback. Concerning the dynamics of the attributes with veto power, only the SCGE-PE was not affected; that is, their M_{def} was compatible with level 2 of maturity, having also achieved a sufficient

score in attribute A1, which is the veto for level 2. Consequently, to reach level 3, the SCGE-PE needed to improve their RM implementation internally and reach better punctuations, especially in the attributes that are vetoes for level 3 and in other attributes that had scores 1 and 2. As a result, the prescription for the SCGE-PE consisted of 13 prioritised attributes.

On the other hand, Compesa and the anonymous organisation had enough M_{def} to reach levels 4 and 3, respectively; nonetheless, they had vetoes which assigned them to lower levels. Compesa, for example, did not reach enough scores in attributes A2, A16 and A18, remaining at level 3. The anonymous organisation, in turn, had vetoes in attributes A5, A16, A18 and A19, remaining at level 2. Consequently, their prescriptions prioritised these vetoed attributes, also adding the ones which had scores 1 and 2. In general, all three organisations had poor performance in attributes A8, A11, A16 and A18, indicating that they need to improve the assessment of interdependencies of risks within a portfolio, assure that tactical and operational managers continuously monitor the achievement of objectives and actions to treat risks in their respective departments, assure that employees have incorporated risk thinking into their work routine naturally, and assure employees are clear about their roles in RM.

Concerning the feedback, the PRisk-MM received positive comments in all public organisations. The RM leaders believed that the model reflected their real level of maturity in RM implementation, and that all attributes could comprehensively reflect their RM practices. Further compliments comprised the objectivity and clarity of the model by analysing the key points of RM, as well as the provision of prescriptions to help building future action plans. Nonetheless, based on their comments, one new edition was still necessary on the readability of the attributes. As a result, the PRisk-MM had its reliability analysed and approved; testing the model was important to ensure that it could measure what was intended to, and that the results were accurate (DE BRUIN *et al.*, 2005).

5.5 FINAL CONSIDERATIONS

This study proposed the PRisk-MM, a PSRMMM developed for Brazilian public organisations. The model consists of 5 maturity levels and 23 attributes distributed into 15 dimensions. The maturity levels and attributes derived from the study by De Lorena and Costa (2023a), and the step-by-step used to develop the PRisk-MM was inspired in the phases proposed by Mettler (2011) and De Bruin *et al.* (2005). The assessment procedure uses triangular fuzzy numbers during the weight assignment of the dimensions (judged by the GPMs) and the assignment of scores of the attribute (judged by the RM leader in the organisation).

The model presents theoretical implications. To begin with, this is the first study to deliver a PSRMMM. Secondly, the PRisk-MM addresses the contingent factors that are considered significant to public sector RM maturity according to De Lorena and Costa (2023a). Finally, the PRisk-MM fulfills issues that are commonly criticised by academics (WENDLER, 2012; SANTOS-NETO; COSTA, 2019), such as the lack of prescription, the lack of a sound theoretical basis and the lack of validation.

The PRisk-MM also has practical implications as a government tool, since GPMs are supposed to assess the organisations' status of maturity as part of the controlling role they exert over the public organisations (WOODS, 2009; DE LORENA *et al.*, 2022). Hence, the PRisk-MM provides a clear and objective assessment procedure besides being easily understood, and GPMs may use the Prisk-MM to compare the RM implementation performances of various organisations. As changes in public organisations generally take some time, it is advisable that the PRisk-MM be applied annually in each public organisation. Moreover, the PRisk-MM is an adaptative model due to the possibility of assigning weights to the dimensions or withdrawing dimensions from the model, thus incorporating the GPMs' perceptions on how important the dimensions are, considering the current government context. Finally, the prescriptive feature of the model provides the organisations with the chance to develop action plans and improve their RM.

This study is limited to the Brazilian context because its development procedure is based on data collected in Brazil, and its validation took place in Brazilian public organisations. Therefore, for a broader analysis, future studies could analyse the effectiveness of the PRisk-MM in public organisations from other countries. Moreover, scholars could find inspiration in the PRisk-MM development mode and create MMs for further domains, presenting prescriptions, validation and a sound theoretical background (WENDLER, 2012; SANTOS-NETO; COSTA, 2019).

6 CONCLUSIONS

This thesis is composed of three main studies. The first study constitutes a qualitative and exploratory research in which challenges are found concerning RM implementation in 6 Brazilian state governments. As a result, the GPMs of these states perform strategies with the aim to attenuate such challenges and better approach the public organisations. The main variable responsible for the elaboration of these strategies is the “general weak tone from the top” performed by public top managers. Further variables that were found as influencing the strategies were “risk types” and “innovation-oriented culture”. A consequence of these results is the general low level of maturity in implementing RM in the settings.

The second and third studies focus on developing a tool that could help mitigating this problem and enhancing the maturity of RM implementation in public organisations. The second study, specifically, investigates which attributes and contingent factors are relevant to develop a PSRMMM. For such, three multivariate statistical techniques were used systematically to analyse the data collected from 330 survey responses in Brazil. The outcome of the first technique, CATPCA, resulted in the selection of 29 variables (out of 33) that presented a good fit for public sector RM maturity. Next, these variables were used within the *K*-modes clustering algorithm to group the observations into five different levels of maturity. Finally, the multinomial logistic regression analysis provided the verification of 12 statistically significant variables that were distributed among those levels, facilitating the development of maturity levels and improvement prescriptions. Given this methodological path, this study contributed to the literature by providing a reference model for future studies related to PSRMMM.

In turn, the third study develops and validates the PRisk-MM, which arises as a pragmatic and scientifically sound tool to assess the RM maturity of public organisations and provide prescriptions for improvement. The model consists of 5 maturity levels and 23 attributes distributed into 15 dimensions. The maturity levels and attributes derive from the study by De Lorena and Costa (2023a), and the step-by-step used to develop the PRisk-MM was inspired in the phases proposed by Mettler (2011) and De Bruin *et al.* (2005). The assessment procedure uses TFN during the weight assignment of the dimensions (judged by the GPMs) and the assignment of scores of the attribute (judged by the RM leader in the organisation). The PRisk-MM can be used by GPMs to stimulate public top managers and further employees to implement RM and seek greater maturity. Besides, the prescriptions generated by the PRisk-MM help developing action plans to improve RM practices.

6.1 MAIN CONTRIBUTIONS OF THE THESIS

This thesis has practical and theoretical contributions. In terms of theory, the first study, Chapter 3, addresses problems in implementing RM in the public sector that are not commonly discussed in the literature. For example, the study describes that RM implementation is not always an easy endeavour and strategies may be developed by GPMs to approach public organisations because of the generally weak tone from public top managers. Consequently, it is difficult to reach mature levels of RM implementation.

Concerning the elaboration of the PRisk-MM (Chapters 4 and 5), no previous PSRMMM has been found in the literature focusing on the public sector RM like the PRisk-MM does. Firstly, the model addresses the contingent factors that are considered significant to public sector RM maturity according to De Lorena and Costa (2023a). Secondly, the PRisk-MM arose as a PSRMMM that fulfills issues criticised by academics, such as the fact that most MMs are not effective because they do not bring prescriptions on how to progress, neither are validated nor based on a sound theoretical foundation (WENDLER, 2012; SANTOS NETO; COSTA, 2019). Thirdly, the identification of statistically significant variables *per* maturity level stands out the originality of the PRisk-MM as no previous research was found with such analysis. Finally, this distribution of variables *per* maturity level is paramount to build the so-called prescriptions.

Regarding the practical contributions of this thesis, the PRisk-MM is observed to have a solid economic, environmental and social impact in governments. The PRisk-MM is a tool that contributes to the enhancement of RM maturity in public organisations; in this sense, such mature public organisations are expected to reduce a wide variety of risks (e.g.: integrity, corruption, compliance, etc.), as well as to better manage the public resources, thus contributing to an economic impact. Moreover, in terms of environmental impact, mature public organisations in RM implementation can better manage external risks and avoid or mitigate public disasters, according to the industry such organisations are responsible for. For instance, a government must be worried about risks related to flooding in specific parts of its jurisdiction, thus delegating the management of this risk to a specific agency. Furthermore, mature public organisations in RM may deliver a social impact when contributing with better services to citizens, through the management of operational risks. Finally, in terms of technicalities, some practical contributions may be listed below in relation to the PRisk-MM:

1. The first study of this thesis provides ideas at government level of how to mitigate the difficulties in implementing public sector RM, bringing the PSRMMM as one of the

tools that could encourage public top managers to become RM champions and foster more practical knowledge to all employees on how to improve public sector RM.

2. The second study of this thesis alone (Chapter 4) brings the basis of what a PSRMMM consists of and may guide GPMs onto developing future independent MMs.
3. The PRisk-MM was developed as a government tool that GPMs can use to assess the RM implementation of the public organisations under their jurisdiction (WOODS, 2009; DE LORENA; COSTA, 2023a), and thus exert their controlling role in the governments (DE LORENA, *et al.*, 2022).
4. GPMs may use the PRisk-MM to compare the RM implementation performance of various organisations, as well as to identify which ones deserve more consultancy services or RM audits (IIA, 2009; DE LORENA, *et al.*, 2022).
5. The PRisk-MM provides a clear and objective assessment procedure.
6. The PRisk-MM is an adaptative model due to the possibility of assigning weights to the dimensions, thus incorporating the GPMs' perceptions on how important such dimensions are, considering the current government context.
7. The PRisk-MM provides prescriptions on how to develop RM in public organisations and facilitates the development of action plans.
8. The systematic application of the PRisk-MM may enable the public organisations to better understand their RM practices and self-assess their performance with the aim to identify what they need to do in order to enhance their RM implementation.

6.2 LIMITATIONS AND FUTURE WORKS

The studies of this thesis are limited to the Brazilian public context. All of them considered data collected solely in Brazil, with the exploratory study (Chapter 3) being based on semi-structured interviews, while the development procedure of the PRisk-MM (Chapters 4 and 5) was influenced by general countrywide practices, such as the presence of RM specialists and not of CROs. Therefore, the PRisk-MM's validation needed to take place in Brazilian public organisations as well, reflecting their contexts.

Moreover, as observed in Chapter 5, the PRisk-MM's validation only took place in state public organisations, clarifying how the dynamics of the model is supposed to be performed between the state GPMs and the public organisations' RM leaders. Nonetheless, it is also possible to apply the PRisk-MM in federal public organisations, the dimensions being weighted

by the GPMs from the CGU. Considering that the Brazilian federal public organisations are spread throughout the country, it is an option to have the weights assigned by decentralised federal GPMs as well, following the hierarchical structure of the CGU in each state of Brazil.

For future research, based on the first study of this thesis, academics may investigate what further alternatives can be employed to better deal with the challenges found during the implementation of public sector RM. Besides, more in-depth investigation on why public employees and managers generally avoid considering integrity risks in processes may also be carried out with more focus on politicised contexts, and/or on psychological and cultural aspects.

On the other hand, concerning the elaboration of the PRisk-MM, it can be replicated in further national contexts, thus extending the findings of this thesis and adding more value to RM research in the public sector. Therefore, for a broader analysis, future studies may deepen the analysis on the effectiveness of the PRisk-MM in public organisations. Moreover, scholars could find inspiration in the PRisk-MM development mode and create MMs for further domains, presenting prescriptions, validation, and a sound theoretical background (WENDLER, 2012; SANTOS-NETO; COSTA, 2019).

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APPENDIX A – INTERVIEW GUIDE

General questions	
What is the nature of the organisation you represent?	
What is your position/function at the organisation?	
When did RM start to be implemented in the government?	
How many employees do you have in your team?	
How many public organisations have started to implement RM in the government?	
Specific questions	Main theoretical background
What contextual factors do you perceive to facilitate RM implementation in public organisations? Please describe and give examples.	Hinings, Greenwood and Ranson (1975); Greenwood and Hinings (1976); Leung and Isaacs (2008); Woods (2009); Paape and Speklé (2012); Mikes and Kaplan (2013); Palermo (2014); Kim (2014); Lundqvist (2015); Beasley, Branson and Pagach (2015); Oulasvirta and Anttiroiko (2017); COSO (2017); ISO 31000:2018; Scarozza, Rotundi and Hinna (2018); George, Van de Walle and Hammerschmid, (2019); Chen, Jiao and Harrison (2019); Woods (2022).
What contextual factors do you perceive to hinder RM implementation in public organisations? Please describe and give examples.	
How do you approach the public organisations to implement RM?	
Could you describe the activities you (your team) perform for RM implementation?	
Could you describe in detail how RM implementation is conducted in the government?	
Could you describe the connection between RM implementation and the Integrity/Compliance Programme of the government?*	

*This question was made when appropriate because not all SGOVs had an institutionalized Integrity/Compliance Programme.

APPENDIX B – LIST OF VARIABLES

Variables		Definitions	References
ERM Maturity Attributes			
Risk Context	Rcontext	RM includes a systematic evaluation of the environment.	[10]; [17]
Risk Identification	Ridentif	The RM process includes risk identification.	[9]; [16]; [17]; [33]; [34]
Risk Analysis	Ranalysis1	RM includes the assessment of risk probabilities and consequences.	[5]; [9]; [15]; [16]; [17]; [23]; [33]; [34]
	Ranalysis2	All major risks are aggregated as regards the total business risk.	
Risk Treatment	Rtreat	RM includes the decision on risk mitigation.	[9]; [16]; [17]; [22]; [33]
RM Monitoring	Rmonit	RM includes a follow-up of its implementation.	[16]; [23]; [24]; [33]
Risk Reporting	Rreport	The evaluated risks are reported to the top management regularly.	[3]; [5]; [9]; [22]; [23]; [26]; [33]
RM Specialist	RMspec	It remarks whether the RM expert exists or not in the public organisation.	[2]; [16]; [19]; [22]; [24]; [26]; [27]
RM Committee	RMcomm	It remarks whether the public organisation officially has a committee that oversees RM implementation.	[3]; [22]
Standard RM Process	StandRM1	Our organisation has a standard process to identify and evaluate risks.	[3]; [10]; [16]; [18]; [19]; [20]; [30]; [34]
	StandRM2	The control activities and monitoring measures are communicated in a standardised form throughout the organisation.	
Risk Awareness	RAwareness1	Our employees at all hierarchical levels are aware of the importance to take risk aspects into account in their decisions.	[5]; [6]; [15]; [16]; [17]; [21]; [24]; [33]; [34]
	RAwareness2	Our employees have embedded risk thinking in their work modes.	
Risk Accountability	RAccount	Employees are held accountable for their actions and decisions regarding RM.	[16]; [33]; [34]
RM Strategic Integration	RMStratInteg	Information generated from the RM process actively informs the strategic planning processes.	[5]; [9]; [16]; [17]; [23]
Risk Appetite	Rapetite1	Top management clearly communicates the expectations regarding risk appetite.	[3]; [5]; [9]; [10]; [16]; [22]; [23]
	Rapetite2	Top management applies concepts of risk appetite to strategy development.	

Continues...

Contingent factors			
Tone from the Top	Tonetop1	Top managers clearly communicate the importance of considering risks in business activities to all employees.	[6]; [12]; [15]; [16]; [18]; [21]; [24]; [25]; [33]; [34]
	Tonetop2	Top managers put special emphasis on ensuring that our corporate culture encourages employees to signal potential risks.	
Innovation-oriented Culture	Innov1	Employees regularly create new ideas for improvements.	[7]; [8]; [28]; [31]; [33]
	Innov2	Employees often search out new work methods, techniques, or instruments.	
	Innov3	Employees transform innovative ideas into useful applications.	
RM Training	RMTrain	Many opportunities for RM training and education are offered to all employees.	[3]; [15]; [16]; [23]; [30]; [33]
Job Autonomy	JobAut1	Employees have freedom and independence to decide themselves how to go about doing their work.	[1]; [7]; [13]
	JobAut2	Employees have authority and responsibility to act alone if they think it is for the best interest of the organisation.	
Formalisation	Form1	Duties, authority, and accountability are documented in policies, procedures, or job descriptions.	[20]; [30]; [32]
	Form2	There is a logical and clear way to perform tasks.	
	Form3	Employees rely on standard procedures and rules to perform their tasks.	
Strategic Planning	StratPlan1	My organisation develops major long-term objectives.	[9]; [11]
	StratPlan2	My organisation is committed to the strategic plan.	
Goal Clarity	Goal1	The set of goals of my organisation is internally consistent.	[4]; [14]; [29]
	Goal2	Our organisation's goals are specific and detailed.	
Output Measures	Output	The output metrics of the organisation provides a complete picture of the results to be achieved.	[29]

Legend: [1] Andersen (2010); [2] Beasley, Clune and Hermanson (2005); [3] Beasley, Branson and Pagach (2015); [4] Bozeman and Kingsley (1998); [5] Braumann (2018); [6] Braumann, Grabner and Posch (2020); [7] Bysted and Hansen (2015); [8] Chen, Jiao and Harrison (2019); [9] COSO (2017); [10] Domanska-Szaruga (2020); [11] Elbanna, Andrews and Pollanen (2016); [12] Farrell and Gallagher (2015); [13] Fernandez and Pitts (2011); [14] George, Van de Walle and Hammerschmid (2019); [15] Hartono, Wijaya and Arini (2014); [16] Hoseini, Hertogh and Bosch-Rekvelde (2019); [17] ISO 31000:2018; [18] Jean-Jules and Vicente (2020); [19] Kim (2014); [20] Kirkhaug (2010); [21] Kleffner, Lee and McGannon (2003); [22] Lundqvist (2015); [23] Macgillivray *et al.* (2007); [24] Oliveira *et al.* (2019); [25] Osman and Lew (2021); [26] Paape and Speklé (2012); [27] Palermo (2014); [28] Rainey and Chun (2005); [29] Spékle and Verbeeten (2014); [30] Woods (2009); [31] Wynen *et al.* (2014); [32] Yaraghi and Langhe (2011); [33] Yeo and Ren (2009); [34] Zou, Chen and Chan (2010).

APPENDIX C – EXAMPLES OF PRISK-MM’S PRESCRIPTIONS

Dimensions	Attributes	Prescriptions for the organisations	Supporting References*
Top management commitment	A1	Top managers could reinforce the importance of RM to the organisation, as well as their commitment to supporting its implementation through the following means of communication: - rules, RM policy pointing out roles, guidelines, and objectives, as well as other formal types of guidance. - availability of videos and direct quotes in mass communication channels such as the organisation's website, social networks and endomarketing. - participation in podcasts, webinars, courses, and lectures on the subject. - reminding participants of and/or deliberating on the subject in meetings.	[2]; [5]
Context analysis	A5	The organisation will be able to improve the context analysis of the object through: - the description and analysis of critical factors and trends that may affect the achievement of organisational objectives involving the object. Some examples include cultural, political, legal, regulatory, financial and budgetary, economic, technological and competitive factors, if any, among others. - internal and external environment analysis, using, for example, tools such as the "SWOT Analysis". - analysis of stakeholders, including the understanding of their needs, interests, expectations, and responsibilities in the execution of the object. - encouraging the study and constant search for consistent information to assist in the context analysis of the object, counting on information from both the external and internal environments through the habit of recording historical decisions of changes and analysis of previous documents. - the use of information acquired from past audits and ombudsman channels.	[4]; [6]; [7]; [9]
Risk assessment	A7	The organisation may: - establish prior risk ranking criteria to guide judgements of likelihood and consequence of risk events, thus enabling the prioritisation of risks according to their level. - stimulate the use of methods such as “failure mode and effect analysis”, “root cause analysis”, “structured What if? analysis”, “bow tie”, “decision tree”, “cause-and-effect analysis”, “Monte Carlo simulation”, “Ishikawa analysis”, among others. - encourage the analysis of risks based on quantitative data whenever possible, using calculations of probabilities of occurrence of the risk in a certain period, for example. - encourage the recording of failures or occurrences of risks as a way of generating a history of them. - establish criteria to define whether a given risk should be accepted or not according to its type of consequence, considering previous definitions of risk appetite and tolerance. For example, criteria for accepting financial and/or budgetary risks should be different from criteria for accepting risks to human life.	[6]; [7]; [9]

Continues...

Dimensions	Attributes	Prescriptions for the organisations	Supporting References*
Receptive culture	A17	To improve the organisational culture and make it more receptive to RM, the organisation can: - promote a technological and interactive environment wherever possible. - encourage managers and the staff to monitor market trends and further trends from other government agencies, especially possible competitors, record the observations and provide suggestions for improvement. - encourage an environment of creation and collective learning internally. - constantly offer training opportunities, not only in RM, but also in various topics that may contribute to the management of the organisation and stimulate a learning environment. - guide managers to avoid a culture of pointing blame or causing fear of error and, instead, support a culture of accepting that people make mistakes and can improve without fear of error. - guide managers to always listen to the staff and give feedback on actions related to RM. Whenever possible, it is important to record the actions or attitudes that support a receptive culture in the organisation.	[3]; [4]; [9]
RM strategic integration	A19	To further integrate RM into strategic planning, the organisation can: - invest in prioritising the risks identified by operational managers with greater criticality and/or impact trends regarding strategic objectives to be considered when analysing and planning the organisational strategy. - allocate resources in strategic planning considering the analyses carried out in RM. - perform RM processes in the strategic objectives and consider the treatment of these risks when preparing/reviewing strategic planning and its actions. - seek to identify external risks that could affect the organisation's strategy. - determine and monitor key critical risk indicators aligned with organisational performance indicators. - consider all stakeholders in the organisation's strategic planning (internally and externally) and how organisational risks may affect them.	[1]; [3]; [7]; [8]; [10]

* [1] Braumann (2018); [2] Braumann, Grabner and Posch (2020); [3] Brazil/ME (2022); [4] Hoseini, Hertogh and Bosch-Rekveltdt (2019); [5] ISO 31000:2018; [6] ISO 31010:2019; [7] TCU (2018); [8] Viscelli, Hermanson and Beasley (2017); [9] Woods (2022); [10] Zhao, Hwang and Low (2013).