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Developing an Enterprise Risk Management Maturity Model Applicable for Construction Companies

By

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Abstract

Risk, a common phenomenon in the construction industry, remains a major challenge for construction companies in developing countries. Enterprise Risk Management (ERM) has been commended as an essential tool for managing a company's risks in a holistic and an integrated approach. Companies' ERM competence is measured using an ERM maturity model (ERM³); however, there exists no generic model that can be successfully applied in all companies. The aim of this study was, therefore, to develop an ERM maturity model that will be used to evaluate the risk management (RM) competence of construction companies.

Both qualitative and quantitative research approaches were employed in this research. A detailed review of the literature has showed major shortcomings in the existing ERM maturity models, mainly in the consistency in the content of the models and in following proper procedures while the models were developed. Accordingly, a new ERM maturity model (ERM³-CON) has been developed through a well-established procedural framework. This model contains six different attributes: (i) policy and strategy; (ii) structure and governance; (iii) culture; (iv) process; (v) competence; and (vi) implementation. The first two of these are new attributes introduced in this model, which were rarely considered in the existing models. Four levels of maturity, namely, *naive*, *novice*, *managed* and *optimised* were found suitable for gauging companies' ERM maturity.

The suitability of the proposed model was tested by a case study carried out with Ethiopian domestic contractors (EDCs) engaged in major federal road construction projects. Twenty-six (74.3%) out of the total of the thirty-five contractors that were operating in the road sector in 2020 were involved in the study; which also accounted for about 18% of the total of 145 Grade-1 contractors that were registered in Ethiopia in the same year. Thirty-six indicators were utilised for measuring the maturity. The interview survey data, analysed using a fuzzy analysis technique, revealed that contractors' ERM maturity scores ranged from 1.42 to 2.97 with a weighted average of 2.04 from 4.00 points, which can be generally categorised as a low level of ERM practice. In terms of the maturity levels, 21 (80.8%) of the 26 companies were found to be at a novice level with 4 (15.4%) at managed and 1 (3.8%) at naive levels. These results were found to be consistent with the practices of construction companies in other developing countries.

Several factors can be listed that make this study unique. Unlike many other models, this was developed using a well-defined procedural framework. It also attempts to define the contents of the attributes of the model through a combination of existing ERM maturity models, ERM standards and guidelines, organisational design models and business excellence models. Further, this thesis has managed to reach about three-quarters of the target companies by enabling experts in 26 companies to self-assess the ERM competence of their respective companies through well-established interview questionnaires. Although it was time consuming and demanded a great deal of effort and patience, the achievement of self-assessing 26 companies by a detailed interview was a great success. However, this study clearly has some limitations. The first limitation lies in the lack of validation of the contents of the model involving a large group of experts due to the COVID-19 pandemic's gathering restrictions. In fact, it was attempted to test the model through three small-scale group discussions. The other potential limitation is that the survey covers only contractors that were engaged in the MFRCPs. Hence, it might require future studies to further verify its application in the other sectors of the industry too. Lastly, appropriate debiasing strategies were also developed that to help overcome the potential limitations that would arise in association with subjectivity and cognitive biases.

This research contributes to foster the RM endeavors in the road construction companies. Most importantly, unlike the traditional RM approach, ERM enhances company performance and the value of a company by enabling companies' effectively handle their risks in a comprehensive and integrated manner. In addition, as ERM has been proven to improve project performance in the construction industry, practicing ERM is particularly pertinent for companies in the Ethiopian road sector, where successful project completion remains the issue of concern. This suggests that construction companies should start practicing ERM in order to effectively deal with their risks. Further, the proposed ERM³ will helps companies in implementing ERM through an established set of improvement targets.

Key Words:

Ethiopia, attributes, construction companies, developing countries, enterprise risk management (ERM), enterprise risk management maturity model (ERM³-CON), fuzzy logic, maturity model, maturity level, road sector.

Dedication

To my children

Beminet, Fikremariam and Yidiya

To my mom, Ayehu Abeje

And

To my children's grand mom, Guday Belay

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List of Principal Abbreviations

AHP	Analytical Hierarchy Process
BEMs	Business Excellence Models
CO	Competence
COM	Company (COM1 as Company 1)
COSO	Committee of Sponsoring Organizations of the Treadway Commission
CU	Culture
EDCs	Ethiopian Domestic Contractors
ERA	Ethiopian Roads Administration (the former Ethiopian Roads Authority)
ERM	Enterprise Risk Management
ERM ³	Enterprise Risk Management Maturity Model
ETB	Ethiopian Birr
FLS	Fuzzy Logic System
IACCM	International Association for Contract and Commercial Management
ISO	International Organization for Standardization
IRM	Institute of Risk Management
MCDM	Multi Criteria Decision Making
MECE	Mutually Exclusive and Conclusively Exhaustive
MFRCPs	Major Federal Road Construction Projects
MOFED	Ministry of Finance and Economic Development
ODMs	Organizational Design Models
PRM	Project Risk Management
PR	Process
PS	Policy and Strategy
RM	Risk Management
RM ³	Risk Management Maturity Model
RSDP	Road Sector Development Program
SG	Structure and Governance
TFN	Triangular Fuzzy Number
TMF	Triangular Membership Functions

1 INTRODUCTION

1.1 Background of the Study

Construction industry is regarded as a major driver of the global economy (Halpin & Senior, 2010) and a significant element in the growth and development of nations, providing the basis on which all economic activities are organised (Lopes, et al., 2002; Ofori, 2011). Typically, the industry generates around 10% of a country's gross domestic product (GDP) (Winch, 2010; Ofori, 2011) and creates job opportunities accounting for more than 5% of the global workforce (Ofori, 2011). However, the industry in developing nations is generally characterised by its poor performance (Ofori, 2012; Ssegawa-Kaggwa, et al., 2013; Mudi, et al., 2015; Yirenkyi-Fianko & Chileshe, 2015), where completing projects to the intended project objectives remain a major challenge.

Project delay, which also involves other unfavourable consequences such as cost overrun, contractual disputes, arbitration, and quality non-conformities in particular, is still a prevalent problem in the industry (Mejía, et al., 2020). For instance, a survey of 323 public construction projects in the Botswanan construction industry revealed that only 26 projects (8%) were completed within time, while 69 projects (21%) were abandoned (Ssegaw-Kaggwa, et al., 2013). An assessment of 48 road projects in Ghana also showed that 70% of the projects had experienced delays, with an average time overrun of 17 months (Amoatey & Ankrah, 2017). A delays of 48% was also reported in the surveys of 101 road projects in Palestine (Mahamid, 2017). Taddese, et al. (2016) also revealed an excessive delay in projects in Ethiopia with an average delay ranging between 61% and 80% beyond their schedules. A detailed analysis of 49 federal road construction projects in Ethiopia, that were completed between 2006 and 2015, also showed that the projects took on average 55% longer than expected (ERA, 2017). A more recent study by Solomon et al. (2021) also iterated that road construction projects in Ethiopia involved an average of 110% delays beyond their schedules, with a minimum and maximum delay of 3% and 312%, respectively.

A lack of institutional capacity is recognised as one of the critical factors attributed to such unsatisfactory performance of the industry in developing countries (Laryea, 2010; Ofori, 2012; Nhabinde, et al., 2012; Ssegawa-Kaggwa, et al., 2013; Osabutey, et al., 2014). As part of a company's management capability, inadequacy in organisational level risk management (RM) practice in the industry has also been identified among the most significant contributing factors

(Desalegn & Mahesh, 2019). Consequently, the literature and other industry bodies strongly suggest that companies in the construction industry should implement effective RM that can enable successful handling of risks via an integrated and holistic approach (Low, et al., 2013; Zhao, et al., 2013a; COSO, 2017; Ibrahim & Esa, 2017). The practice of organisational level RM is known as enterprise risk management (ERM), which according to Deloitte (2021) has evolved rapidly and has become more institutionalised in many countries.

1.2 ERM in Construction Companies

Various empirical studies have shown that practising ERM has many benefits, including enhancing the company's performance and value, as well as improving project performance. For example, from a review of three different studies that were conducted to explore the association between ERM implementation and companies' performance, Gatzert and Martin (2015) found that practising ERM was contingent with a company's performance. They argued that the empirical findings are generally in agreement with relevant theories regarding the positive impact of ERM implementation on shareholders' value and a company's performance. A study by Ibrahim and Esa (2017) about the impact of ERM on the performance of the companies in the Malaysian housing sector, also revealed that ERM was a key factor in the success of construction companies.

A positive association was also revealed between an ERM implementation and project delivery in the construction industry (Siang & Ali, 2012; Liu, et al., 2013; Low, et al., 2013). A survey of three Malaysian construction companies, two of which were practising risk management (RM) more comprehensively and inclusively than the third, found that project performance in the third company was comparatively unsatisfactory, involving a higher cost and time overrun (Siang & Ali, 2012). This implies that implementing ERM has the potential to enhance the cost and time performance of projects. Low, et al. (2013) also explored the association of ERM and project performance of local contractors in Singapore, and their research found that effective ERM is positively correlated with the success of the projects. Similar findings were also identified by Liu, et al. (2013) in their comparison of two Chinese international construction companies with different ERM practices.

However, there are two critical issues related to ERM in the construction industry, especially in developing countries, namely a low level of ERM practice and a shortage of research on the

discipline. Concerning the practice, research in: Ghana (Yirenkyi-Fianko & Chileshe, 2015); Nigeria (Salawua & Abdullah, 2014; Salawu, 2016); Egypt (Hassanein & Afify, 2007); Lithuania (Banaitienė, et al., 2011); and India (Jayasudha & Vidivelli, 2016) all revealed consistently low ERM implementation.

Although ERM-related studies appear to have increased (Renault, et al., 2016; Ibrahim & Esa, 2017), studies related to construction companies are still limited compared to the other industries (Low, et al., 2013; Yirenkyi-Fianko & Chileshe, 2015; Renault, et al., 2016; Ching, et al., 2020). Yirenkyi-Fianko and Chileshe (2015), among others, contended that there is a paucity of ERM research, especially related to the African context. Low, et al. (2013) also highlighted the shortage; and thereby there is a need for more studies related to the ERM implementation, with a focus on construction companies.

Serpell, et al. (2015) also emphasised that much research remains to be done in the discipline, as it is critical for the future performance and success of construction projects. Yirenkyi-Fianko and Chileshe (2015) further highlighted that it is essential to examine the readiness of domestic construction companies in developing countries to practise RM. Ching, et al. (2020) have reiterated that the situation of practising ERM has not changed much until recently. Further, noting that most ERM scholarships have roots in the financial sector, Lopez (2021) has claimed that there are a limited number of ERM-related studies in industries outside the financial sector.

1.3 Ethiopian Domestic Contractors in the Road Sector

It is widely recognised that the provision of a safe, affordable, efficient, and well-maintained road infrastructure is critical to the socio-economic development of most developing countries (Chongvilaivan, et al., 2016). This is particularly pertinent for Ethiopia, in which road transport is the dominant mode of transport, accounting for 90% to 95% of the motorised inter-urban freight and passenger movements of the nation (Ibrahim, 2011). In recognition of this, the government of Ethiopia has strived to improve the country's road infrastructure by launching a special road sector development programme (RSDP) in 1997 (ERA, 2016). The programme has brought notable improvements to the country's road infrastructure, which nevertheless is still amongst the least developed in the world. For instance, the World Economic Forum (WEF, 2019) rated the road connectivity of Ethiopia in 2019 to be 53 out of 100 points, rating the country 124th from a total of

141 countries. Its road quality was also measured to be 3 out of 7 points (putting the country 115th out of 141) (WEF, 2019). This implies that much remains to be done to bring the country's road network to an acceptable level.

Although the RSDP was designed primarily for developing the country's road infrastructure, it was also aimed to enhance the institutional capacity of the domestic road sector (MOFED, 2002; ERA, 2005). Accordingly, several initiatives have been put in place to build the domestic capacity, including the arrangement of a special capacity building project for domestic companies (MOFED, 2002). The implementation of the programme for 23 consecutive years (1998-2020) has brought considerable achievements both in increasing the number of contractors that could participate in the road sector and the volume of projects in which these contractors have been involved. For instance, the number of Ethiopian Domestic Contractors (EDCs) that operate in major federal road construction projects (MFRCPs) has risen from a few small-scale companies in the mid-1990s (Wondwossen, 1998; ERA, 2005; EEA, 2008) to approximately 35 by 2020 (ERA, 2021a). Further, there were only two Grade-1¹ and one Grade-2 contractors registered in the country in 1993 (ERA, 2005) that were also operating in the road sector. In 2020, the number of Grade-1 contractors alone has grown to 145, of which 35 were operating in the MFRCPs. The number of projects awarded to EDCs has also increased to 47 (76%) with a total value of ETB 49.04 bl (64% market share) in 2020 from the total of 62 projects at a total cost of ETB 77.13 billion (equivalent to \$2.2²) awarded in the year (ERA, 2021a). This is much higher than the six projects (33.3%) with a value of ETB 0.18 billion (\$0.016 billion; 5.1%), which were awarded to EDCs in 1999 (ERA, 2021a).

However, the market share and performance of EDCs is still a major concern for the sector. Building the capacity of domestic construction companies is one of the key objectives in Ethiopia's

¹ In Ethiopia, contractors are categorised as General Contractors, Building Contractors, and Road Contractors. Each of these categories is further classified into ten different grades (Grade-1 to Grade-10), with Grade 1 representing the highest (i.e. most capable) grade (MODC, 2013).

² Calculated using the rates in (Exchange Rates UK, 2021)

national construction industry policy (MUDC, 2012) and the construction industry capacity building framework (MOC, 2016). The goal of this policy is to fulfil the national demand and then to enable the domestic construction industry to compete in the global market (MUDC, 2012; MOC, 2016). However, the 23-year RSDP performance report (ERA, 2021a) indicated that EDCs were able to manage projects that account for only 51% (ETB 212 billion) out of the total 909 MFDCPs, worth ETB 412 billion (\$25 billion), implemented in the country from 1998 to 2020. A survey by Clifton, et al. (2016) on 100 projects completed in 2015 worth ETB 83.3 billion found an even lower share of EDCs accounting for approximately 37% of the total cost of these projects. Based on a random selection of 97 MFRCPs awarded to contractors through an international competitive bidding process from 2017 to 2019, Zemenu (2020) indicated that the market share attributable to the EDCs was limited to 46%. These findings are consistent with a report by the United Nations Economic Commission for Africa (UNECA, 2015), which highlighted that in most African countries, domestic construction companies have difficulty in competing with the large international companies even in their own markets.

Further, road construction projects implemented with the financial support from development partners, such as the World Bank, African Development Bank, European Union and Exim Bank, were found to be entirely dominated by foreign firms (ERA, 2005; Solomon, 2015; Worku, et al., 2021). The major reason for this was that EDCs have not been able to meet technical requirements set by the respective international organisations (MUDC, 2012; Solomon, 2015).

In terms of performance, EDCs are also generally characterised by unsatisfactory performance especially in completing their projects within the contract period (Koshe & Jha, 2016; Rahel, 2016; Siraw, 2016; Tsegay, 2016; Zewdu, 2016; Solomon, et al., 2021). The industry-wide survey by Rahel (2016), for instance, showed that 54.2% of the professionals involved in federal road construction projects perceive that the performance of EDCs in the road sector was poor and 46% thought it was fair. None of the respondents, however, perceived it to be good. Tsegay (2016) also found that 81% of the practitioners in the sector (clients, contractors, and consultants) had a view that the time performance of EDCs was unsatisfactory. The Ethiopian Roads Authority (ERA, 2005; 2011; 2014; 2019) has been consistently pointing out in its annual RSDP reports that the poor performance of domestic contractors in completing their projects is a persistent challenge to the road infrastructure development of the nation.

The above clearly shows that the market share of domestic contractors anticipated in the national capacity building policy, and the road infrastructure development demands are in strict conflict, since only a few EDCs are performing to the level the road sector demands. This low performance, in turn, was identified to be associated with contractors' low level of institutional capacity (MUDC, 2012; Solomon, 2015; Tsegay, 2016; Desalegn & Mahesh, 2020).

The government's efforts to build the capacity of contractors in the road sector was focused majorly on how domestic contractors can access more projects, and little attention has been paid to requiring them to enhance their institutional capacity. As a result, institutional transformations seem to be neglected in many companies since their main focus is on the day-to-day operations of projects. Hence, there is an urgent need for the contractors to work on fostering their institutional competence.

A recent study by Desalegn and Mahesh (2019) has identified RM to be one of the major areas which requires advancement to improve the performance of the Ethiopian construction industry. As discussed in section 1.1, ERM is potentially a powerful tool for construction companies as it has demonstrable benefits in enhancing project and company performance. Hence, it seems important that EDCs adopt ERM by assessing and benchmarking their current RM practices to help them improve their ERM implementation efforts through pre-defined targets. This would suggest that a model, which can help to assess the capabilities (or maturity) of a company in relation to good ERM practice, is required. However, the literature indicates that there is no such generic ERM maturity model that could be successfully used for all companies. Further, most of the available models according to Proenca (2018) and Hoseini, et al. (2019) were developed without clearly explaining the adopted procedure. Zhao, et al. (2013a) and Hoseini, et al (2019) have also highlighted that the applicability of most of the existing models was not empirically verified. Most importantly, the iterative nature of RM itself demands updating of the ERM standards, models and actions using the new knowledge that could be acquired through practice and experience (IRM, 2018; ISO, 2018).

This clearly suggests the need for developing a suitable ERM maturity model that could be used to evaluate the ERM capabilities of construction companies in general and of EDCs in particular. It is also important to note that no definitive piece of research has been conducted to evaluate the RM capability of Ethiopian domestic construction companies.

1.4 The Aim and Objectives of the Research

To address the issues highlighted above, this study aims to develop an enterprise risk management maturity model (ERM³) for the road construction sector. To achieve this aim, the study has defined the following objectives.

1. Conduct an extensive critical literature review, focusing on existing RM practices, with particular attention on the practices which might be pertinent to construction companies in developing countries.
2. Identify and prioritise risks of EDCs operating in federal road construction projects.
3. Review existing ERM maturity models and evaluate their applicability to construction companies.
4. Create a maturity model development procedural framework, utilising the findings from objectives (3) above, that can help to design an ERM maturity model.
5. Using the procedural framework developed in (4), build an ERM maturity model that could be used by construction companies.
6. Recognising that RM is relatively new for EDCs, identify and incorporate within the ERM maturity model appropriate data analysis techniques that can deal with ambiguity and imprecision in human judgments, and quantify the linguistic facet of any data.
7. Consult companies using a detailed questionnaire to objectively provide feedback on the developed model and assess a company's ERM maturity level.
8. Explore the implications of the above for policy and practice.

1.5 Structure of the Thesis

The thesis is structured in six chapters. After this introductory chapter, Chapter 2 presents a review of the relevant literature with a focus on RM practices of construction companies in developing countries. The theoretical concepts of risk and RM are presented. The chapter also discusses the existing ERM models comprising risk maturity models and identifies the gaps in the available research.

Chapter 3 deals with the methodology of the research, in which the approaches and methods used are discussed. The proposed ERM maturity model is also presented in this chapter. The data analysis and discussions are provided in Chapters 4 and 5, respectively; and finally, conclusions and recommendations of the study are provided in Chapter 6.

The findings of this research have been published in Worku (2020) and Worku et al. (2021). These publications are attached in Appendix A.

1.6 Innovation and Contribution

Although many RM maturity models have been developed over the past twenty-five years, there exists a wide inconsistency between them, mainly in defining ERM maturity attributes. Consequently, there was no generic model that adequately accommodated all the essential key ERM attributes. Beyond this, several models have been found to inter-mix the key attributes with diagnostic indicators, while their purpose is very different. This inconsistency occurred since most of the models were not developed based on pre-defined frameworks. This study has addressed this gap by designing a maturity model development framework that can be used to develop a maturity model.

A fuzzy logic system that enables the transformation of linguistic variables, that involve ambiguity and vagueness, into classical (crisp) numbers was used to model the data obtained from the interview in the form of descriptive statements. Following a five-stage fuzzy analysis technique, the ERM capabilities of the companies surveyed were determined. These five steps are: (i) define linguistic variables; (ii) define fuzzy rating scores; (iii) define fuzzy numbers; (iv) aggregation of fuzzy numbers; and (v) defuzzification.

The novelty of this study involves the development of an ERM maturity model that can adequately measure the RM capabilities of construction companies. The model contains six ERM attributes (policy and strategy, structure and governance, culture, process, competence, and implementation). To the knowledge of the researcher, it is the first to attempt to incorporate the two key attributes: (i) policy and strategy, and (ii) structure and governance with the four conventional attributes. Further, previous models were developed dominantly based on existing maturity models. However, in addition to the existing ERM maturity models, this study has evaluated ERM

frameworks as well as other relevant models, mainly organisational development models and business excellence models, to identify the appropriate attributes.

In the previous studies Likert scales were used to measure maturity levels. With the aim of minimising subjectivity, this study, however, has provided a detailed interview questionnaire with descriptive statements under each indicator. Further, the fuzzy logic system formulated in this study to test the suitability of the proposed model yielded results that reflect the current practices of Ethiopian domestic contractors. This is also an indication that a fuzzy logic system is an effective tool to measure companies' ERM maturity, which can be considered as a significant contribution of this study.

It is believed that this study will have several implications. First, the proposed model will allow professionals in the construction industry to self-assess the ERM competence of their company, based on which they could devise strategies for further improvements. Second, the low level of ERM practice found in the Ethiopian road sector may also provide a useful insight into the overall maturity of construction companies in other similar countries. Third, policy makers in the Ethiopian construction industry and other similar countries may use the result of this study to initiate policies and strategies. Last, but not the least, this study will also contribute to filling the gap in the shortage of research in the domain of ERM in the construction industry, especially in developing nations.

2 LITERATURE REVIEW

2.1 Introduction

This chapter provides a detailed review of the literature related to the RM practised in construction companies. The chapter begins with an overview of the state of the construction industry with a focus on its business environment in developing countries. It also presents a critical review of the literature related to the concept of risk and risk management. An overview of the RM practices of construction companies is provided in this chapter to assess whether their RM is adequate. The concept and significance of ERM is also explained. The existing ERM maturity models are also explored to check whether there is a suitable model that can be applied to all companies, or otherwise to determine whether a new model needs to be developed. Finally, in order to adopt the most suitable method(s), the potential risk maturity assessment techniques are also overviewed.

2.2 Construction Companies in Developing Countries

2.2.1 The state of the construction industry in developing countries

Construction is the main engine that drives the overall economy of the globe (Halpin & Senior, 2011) and the important building block of a country's economy providing foundations upon which all economic activity is organised (Ofori, 2011). Generally, the industry generates around 10% of the gross domestic product (GDP) of a country (Winch, 2010; Ofori, 2011). The World Economic Forum (WEF, 2016) indicated that, with a total annual revenue of almost \$10 trillion and added value of \$3.6 trillion, the construction industry accounted for about 6% of the global GDP in 2015. The WEF (2016) also indicated that the industry contributed about 5% and 8% to the total GDP of the developed and developing countries, respectively. The other major role of the industry is in creating job opportunities, by accounting for more than five per cent of the workforce of the world (Ofori, 2011). The great flexibility of the industry in adapting to various frameworks enables it to significantly contribute to the process of economic growth and development (Lopes, et al., 2002).

Consequently, construction has become one of the core industries usually considered in formulating countries' development strategies (Lopes, et al., 2002). Awareness has also been established within developing countries of its significance for the effective implementation of

poverty reduction initiatives (Zawdie & Langford, 2002). As a result, a promising growth has been reported in the construction industry of developing nations, including the African countries (KPMG, 2014; Alagaidede & Menash, 2016; AfDB; OECD; UNDP, 2017). The Global Construction Survey (KPMG, 2014), for instance, showed that construction works were expanded in many African nations, including, Angola, Ethiopia, Ghana, Kenya, Lesotho, Mozambique, Nigeria, Tanzania, Uganda, and Zambia. The African Economic Outlook (AfDB; OECD; UNDP, 2017) also reported a 300% average growth by the industry on the continent. Furthermore, Alagaidede and Menash (2016) demonstrated a positive effect of the industry on the growth of Sub-Saharan African (SSA) nations.

The benefits of the construction industry, however, come with some adverse environmental impacts and several kinds of occupational fatalities. For instance, being the largest global consumer of raw materials and constructed objects, construction contributes to 25% to 40% of the world's total carbon emissions (WEF, 2016). In addition, at least 60,000 fatal accidents occur yearly on construction sites worldwide, representing one fatal accident every 10 minutes (Asah-Kissiedu, et al., 2021).

To this end, the industry in developing nations is generally characterised by its poor performance (Ofori, 2012; Ssegawa-Kaggwa, et al., 2013; Mudi, et al., 2015; Yirenkyi-Fianko & Chileshe, 2015). Mudi et al. (2015) and Yirenkyi - Fianko and Chileshe (2015), conceded that time and cost overruns are pertinent issues in the Ghanaian construction industry. Similarly, a survey of 323 public construction projects in Botswana revealed the industry to be inefficient and ineffective in completing projects within the anticipated time, with only 8% of these projects completed within their contract time (Ssegaw-Kaggwa et al., 2013). Thus, 21% of the projects were abandoned, and the remaining 71% struggled to complete them even outside their contract period. A similar result has also been reported in the Ethiopian construction industry, with an excessive slippage ranging from 61% to 80% beyond the projects' schedule (Tadesse, et al., 2016).

Consequently, Ofori (2001, 2012, 2018b), who has been conducting a series of studies specific to the construction industry in developing countries over four decades, contended that the performance of the industry in these countries is unsatisfactory. He also argued that the efforts to foster the industry in these countries over the past decades have failed to succeed (Ofori, 2012).

This suggests the need to identify the major gaps that contribute to such an unsatisfactory performance and to adopt better practices that can improve the performance of the industry.

2.2.2 The major challenges of the construction industry in developing countries

The factors attributing to the poor performance of the industry in the developing nations were discussed in Section 2.2.1. Some of these are industry-wide, while others are unique to domestic construction companies. The major challenges related to the industry are highlighted in Table 2-1, which shows inadequacy of regulation and policies are the most frequently cited factors in the considered articles. In other words, as claimed by Ofori (2011), the dominance of informality is a prominent feature in the industry in developing countries. Consequently, Nhabine et al. (2012) and Mesino (2016) suggested developing countries should develop regulatory and policy tools that could frame the industry. A lack of collaboration among the stakeholders was also reported to be a significant contributor to underperforming of the construction industry in developing countries (Faris, et al., 2022).

Table 2-1 Summary of major challenges of the construction industry in developing nations

Description	Author
Inadequate regulatory and policy conditions	(Masino, 2016; Ofori, 2012; Nhabinde, et al., 2012; Corkin, 2012; Ofori, 2011).
Lack of collaboration among stakeholders	(Faris, et al., 2022)
Macroeconomic factors (inflation, lack of access to credit, high interest rate)	(Windapo & Cattell, 2013; Masino, 2016; Osei, 2013)
Lack of management skills	(Baloi & Price, 2003; Chileshe, et al., 2016)
Shortage of resource (skilled labour, equipment, material)	(Baloi & Price, 2003)
Low productivity	(Baloi & Price, 2003)
Inappropriate supplies	(Baloi & Price, 2003)
Inability to discuss weaknesses	(Ofori, 2012)
High rate of failure of construction enterprises	(Windapo & Cattell, 2013)

It can be seen in Table 2-1 that inadequacy of resources and macroeconomic factors are also the key challenges. Another critical but least emphasised challenge of the industry in such countries is the high rate of failure of construction companies (Windapo & Cattell, 2013). This is a common phenomenon in Ethiopia in which the overall lifespan of most domestic companies is associated with the existence of their respective founders. As a result, EDCs (except a few public enterprises)

have less than 30 years experience. The data from the ERA (ERA, 2021a) indicates that more than 55 domestic Grade-1 contractors have been engaged in major federal road construction projects (MFRCs) since the mid-1990s. However, about 20 of the contractors ceased trading due to various reasons, mostly bankruptcy and insolvency. Subsequently, there were only about 35 contractors that were engaged in MFRCs by 2020. This raises a concern about the business sustainability of Ethiopian contractors.

Further to the industrial level challenges, there are also specific problems pertinent to the construction companies of these countries; as summarised in Table 2-2, which shows that finance, lack of management experience, and limited organisational capacity to be the most frequently cited constraints. The business environment (including the construction market), bureaucratic procedures and a shortage of skilled labour are also the other critical challenges impacting companies' performance and thereby, their sustainability.

These clearly indicate that construction companies in such countries are operating under many uncertainties and risks. In contrast, as illustrated in Table 2-2, companies in most countries do not have an appropriate organisational capacity to deal with these challenges. This further suggests reviewing the RM practice of construction companies to check whether effective systems are in place that can respond successfully to the aforementioned risks.

Table 2-2 Summary of challenges and problems of the domestic contractors in developing countries

No	Challenge	Mudi et al. (2015)	Odediran et al. (2012)	Ssegawa-Kaggwa (2013)	Masino (2016)	Osei (2013)	Osabutey & Dabrah (2014)	Laryea (2010)	Ofori (2012)	Debrah & Ofori (2006)	Corki (2012)	Nhabine et.al (2012)	Alagidede & Menash (2016)	Lopese, et al. (2017)	Luu, et al. (2008)	Enshansi et al. (2006)
		NGA ¹		BWA ²		GHA ³				TZA ⁴	ANG ⁵	MOZ ⁶	General, SSA			PSE ⁷
1.	Inadequacy of finance	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓
2.	Lack of adequate experience at senior management level, poor technical manpower	✓	✓	✓		✓	✓	✓		✓		✓	✓		✓	
3.	Lack of organisational capacity			✓	✓		✓	✓				✓				
4.	Business environment (including market)			✓				✓			✓	✓				✓
5.	Bureaucratic procedures										✓	✓			✓	
6.	Inadequacy of skilled labour				✓							✓	✓			
7.	Absence of specialisation in the industries	✓					✓			✓						
8.	The “get rich quick” contractors prefer hush money to prosper business development	✓														
9.	Fraudulent														✓	
10.	Weak credibility of local contractors in association with their experience											✓				
11.	Low level of productivity	✓														

¹ NGA – Nigeria, ²BWA – Botswana, ³GHA – Ghana; ⁴TZA – Tanzania, ⁵ANG – Angola, ⁶MOZ – Mozambique, ⁷PSE – Palestine

2.3 The Concept of Risk and Risk Management

As discussed in the preceding sections, construction companies in developing countries operate under diverse risks and uncertainties that demand an effective RM approach. Hence, it is important to review the concepts of risk and RM, described as follows.

2.3.1 Risk

Although risk is a widely studied concept, no consistent definition has been provided for this term (Aven & Renn, 2009; Siang & Ali, 2012; Saunders, 2016); subsequently, the definition for risk is still unclear (Siang & Ali, 2012). To demonstrate this, Aven and Renn (2009) have highlighted ten different definitions offered for the term while Saunders (2016) and Hopkin (2010) presented Eight and five descriptions, respectively. However, the following definition provided by ISO (2009) is the most commonly used (Hopkin, 2010): “*risk is the combination of the probability of occurrence of an event and its consequences.*”

However, it is important to note that despite the divergence of the definitions, most of them contain two important dimensions in common (Aven & Renn, 2009; Hopkin, 2010): *uncertainty* (the probability of occurrence) and *effect impact* (the consequences on desired objectives). Hence, the ISO’s definition has been found to be suitable for this study as it is a generic definition containing the two essential parameters (probability of occurrence of an event and consequence) associated with risk.

The other issue worth mentioning is that although risk is perceived in its adverse side in most cases, it has two aspects: negative (threat) and positive (opportunity) (BSI, 2010; IRM, 2012; PMI, 2017). That is, in all types of undertakings, there is a potential for events and consequences that constitute *opportunities for benefit* or *threats to success*. Hence, it is suggested these two aspects to be considered as equally important in any attempt of managing risks (BSI, 2010; IRM, 2012).

2.3.2 Risk management

A risk, specifically in the construction industry, can hardly ever be eliminated (Andi, 2006); hence, success is measured in terms of the approaches adopted to manage it (Smith, et al., 2006). However, like risks, there is no universally accepted definition for risk management (RM). To illustrate this, some of the many definitions cited in the literature are set out in Table 2-3.

Table 2-3 Summary of RM Definitions

Author/ Organisation	Definition
IRM (2002)	RM is the process whereby organisations methodically address the risks attaching to their activities with the goal of achieving sustained benefit within each activity and across the portfolio of all activities.
Haseeb et al. (2014)	RM is defined as a systemic process used to identify, analyse, and manage the risks during a construction project.
Wang et al. (2004)	RM is a formal and orderly process of systematically identifying, analysing, and responding to risks.
AS/NZS (2004)	RM is the culture, processes and structures that are directed towards realising potential opportunities whilst managing adverse effects.
Smith et al. (2006)	RM is all about analysing the implications, response to minimise risk and the allocation of appropriate responses for risks with the ultimate goal of meeting the missions of the enterprise through performing well in projects.
Crouhy et al. (2006)	RM is about how organisations actively select the type and level of risk that it is appropriate for them to assume.
NYSDOT (2008)	RM is the intentional, systematic process of planning, identifying, analysing, responding to, monitoring of, and controlling of risks
Coleman (2011)	RM is about managing risk—about managing people, processes, data, and projects.
Siang and Ali (2012)	RM is the process of identifying, evaluating, and managing risks.
PMI (2017)	RM includes the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk.
ISO (2018)	RM is coordinated activities to direct and control an organisation with regard to risk.

As it can be seen in Table 2-3 and conceded in Perera et al. (2009), most definitions of RM seem to be provided based on a narrow context mainly related to the risk management process (NYSDOT, 2008; Siang & Ali, 2012; PMI, 2017). RM is generally described in terms of its process stages, namely, identifying, analysing, and responding to risks as explicitly stated in Haseeb, et al. (2014) and Wang et al. (2004).

In contrast, definitions provided for RM at organisational levels, such as, ISO (2018), AS/NZS (2004) and IRM (2002) appear to encompass relatively broader concepts and dimensions, such as, culture, process, competence, and integration. Among these, the definition in AS/NZS (2004), was found to contain the key dimensions, such as culture, processes and structures that are involved in the RM discipline. Further, this definition has attempted to consider the two essential sides of the risk (i.e., opportunities and threats). Such detailed contents of RM will be discussed in Section 2.4, in the context of enterprise risk management (ERM).

2.3.3 RM process

The RM process is the systematic application of management policies, procedures, and practices to the tasks of communicating, establishing the context, identifying, analysing, evaluating, treating, monitoring, and reviewing risk (AS/NZS, 2004). The literature provides different stages for the RM process (Perera, et al., 2009; Hopkin, 2010; Spikin, 2013a), which, according to Perera et al. (2009), vary from three upwards. These steps, however, are consistent in terms of incorporating risk identification, risk analysis, and risk response as the key stages (Perera, et al., 2009; Hopkin, 2010), with a slight difference in descriptions (Hopkin, 2010). Hence, this study has adopted a four-step RM process from the BSI (2010), namely, risk identification, risk analysis, risk response, and risk monitoring and review, which are described in the following subsections.

2.3.3.1 Risk identification

According to the BSI (2010), *risk identification* is a process that is involved in the finding, recognising, and describing of risks that could affect the achievement of an organisation's objectives. This also contains the identification of the causes and sources of the risk events, situations or circumstances which could have a measurable impact upon the objectives. Generally, risk identification, according to FHWA (2006), has two specific objectives: (i) to identify and categorise risks, and (ii) to document them.

It is also generally perceived that the success and failure of modern RM in many instances is associated with the understanding and managing of extreme risk events. However, Perera and Higge, (2017) contended that the existing RM literature focuses extremely on the known risks. As a result, events such as the COVID 19 pandemic that appear less frequently were found to be sudden and result in unexpected shocks. Hence, it is strongly suggested comprehensive

identification and recording of risk events is ensured. Risk breakdown structure and risk profile are useful tools to ensure that no essential risk remains unidentified (Larson & Gray, 2018).

2.3.3.2 Risk analysis

Risk analysis involves consideration of the causes and sources of risk, their consequences, and the associated probability (BSI, 2010) with the goal of prioritising risks (APM, 2008; Ehsanifar & Hemesy, 2019). The probability–impact matrix is the most common risk analysis technique (APM, 2008) used to determine the relative risk scores (values) by multiplying the measures of probability and impact of an event (APM, 2008; BSI, 2010; Elmontsri, 2014).

2.3.3.3 Risk response

Once the identified risks are prioritised in the analysis stage, the next step is to establish appropriate risk response strategies to optimise opportunities and minimise threats. Risk response (treatment) involves selecting and agreeing on one or more relevant options to reduce the probability of occurrence, the effect of risks or both, and implementing these options (BSI, 2010). There are five common risk response strategies (FHWA, 2006; PMI, 2017) that can be selectively applied depending on the severity and nature of the risks which are briefly explained below.

- a) Mitigating Risk:** this is usually the first and most essential alternative employed through the two important strategies: (i) reducing the likelihood that an event will occur; and/or (ii) reducing the impact of the adverse event on the objectives.
- b) Avoiding Risk:** because of the inherent nature of risk, it is not always possible to avoid all risk events. However, it might be possible to avoid a risk by changing or partially modifying methodologies.
- c) Transferring Risk:** this is just shifting a risk to another party for total absolution from such risk. Insurance is the most palpable approach of transferring risk in construction.
- d) Sharing Risk:** this is the approach of apportioning of the burdens of losses, or benefits of gains associated with a particular risk with another party (AS/NZS, 2004).
- e) Accepting Risk (also called retention, absorption):** there are some risks with a lesser probability of occurrence but with an extremely severe impact, such as an earthquake. Subsequently, the widely used FIDIC conditions of contract documents categorise such

risks as Acts of God, where project owners commonly take full responsibility for such risks if they occur (FIDIC, 2000).

2.3.3.4 Risks monitoring and review

Risks could dynamically evolve (FHWA, 2006); hence RM is a continuous process that demands close monitoring and frequent review. Risk monitoring and review, in terms of ISO (2009), involves various activities, including:

- The implementation of risk response plans,
- Tracking the identified risks,
- Monitoring residual risks,
- Identifying new risks,
- Evaluation of the risk process effectiveness, and
- Capturing of lessons learnt for future risk assessment and allocation efforts.

2.4 ERM in Construction Companies

The purpose of this section is to present the basic concepts and development of the ERM. It also covers the significance of implementing ERM and its practice in the construction companies.

2.4.1 Risks in construction companies

The construction industry is subjected to more risk and uncertainty than many other industries (Al-Sayegh, 2008; Abd Karim, et al., 2012; Iqbal, et al., 2015). Further, it is perceived that the construction environment in developing countries is becoming riskier (Luu, et al., 2008). Consequently, business failure, collapse and bankruptcy are common in the industry due to many inherited risks (Enshassi, et al., 2006; Raz, et al., 2002). The common factors attributing to the risk vulnerability of the industry comprise the following:

- The business in the industry is sensitive to the economic and political factors (Al-Sayegh, 2008).
- Difficulty to coordinate the diverse and complex activities (Abd Karim, et al., 2012)

- Each construction project is unique and often involves new techniques and procedures (Abd Karim, et al., 2012).
- Projects evolve in rapidly changing environments because of the pace of technological development, increasing complexity, new methods and tools, new markets, increased competition, novel business opportunities and demanding customers (Smith, et al., 2006).
- Construction projects are inherently complex and dynamic and involve various stakeholders (Banaitienė, et al., 2011). The lack of proper collaboration among these stakeholders is one of the major factors contributing to the low performance of the industry (Faris, et al., 2022).

To identify the common risks of the industry, the literature was reviewed (Appendix B) indicating that the number of risk factors identified in these studies vary from four in the Sri Lankan construction industry (Fernando, et al., 2017) to 145 in the Nigerian road sector (Ekung, et al., 2015). In a detailed exploration of the most critical risk factors listed in the literature, 33 factors were identified as summarised in Table 2-4. The summary illustrates the diverse list of risks containing macro-economic factors (inflation, delay in payment, access to financial facility, shortage of materials, etc.), technical factors (defective design, change in design by the owner), political issues and unforeseen physical conditions. Among these, inflation, delay in payment, defects in design, and political issues appear to be the most mentioned risks experienced in many countries. Table 2-4 also demonstrates that there are other risk events critical in some specific countries but less significant in the others.

The existence of such diverse and complex risk events suggests the need for an effective RM approach. The ERM has become a popular tool for managing risks in a holistic and integrated manner. The basic concepts of the ERM are presented as follows, including its potential benefits and the overall experience of the industry in adopting it.

Table 2-4 Key risk factors in construction companies

S/ No.	Risk Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.	Inflation		✓	✓	✓	✓	✓	✓				✓		✓	✓			✓	✓	✓	✓
2	Delay in payments (project budget problem)			✓				✓	✓	✓				✓	✓			✓			
3.	Defective design			✓	✓			✓						✓	✓	✓		✓	✓		
4.	Delays in decisions (approvals, ...)		✓			✓			✓			✓	✓			✓	✓		✓		
5.	Shortage and/or delay of material supply					✓						✓		✓	✓			✓	✓		✓
6.	Political instability, change in government, ...		✓				✓	✓		✓	✓		✓								
7.	Poor financial market (interest rate, credit access,)		✓				✓	✓						✓				✓			✓
8.	Contractors' incompetence (project team, etc.)					✓		✓		✓		✓						✓	✓		
9.	Design change by owner, scope change			✓	✓	✓											✓	✓		✓	
10	Unforeseen site condition (weather, etc.)			✓	✓											✓			✓		
11.	Security (threats from gangs, damage of properties, ...)	✓											✓		✓						
12.	Change in law, policies		✓				✓	✓													
13.	Corruption		✓								✓		✓								
14.	Lack or departure of labour					✓		✓										✓			
15.	Quality and performance control							✓				✓		✓							
16.	High competition in bids									✓								✓			
17.	Poor communication between construction parties								✓	✓									✓		
18.	Poor performance and management					✓			✓										✓		
19.	Owners' unreasonably tight schedule					✓								✓			✓				
20.	Financial failure of contractors, poor cost control							✓		✓										✓	
21.	Requests for contributions to local community	✓	✓																		
22.	Productivity							✓												✓	
23.	Shortage of equipment									✓									✓		
24.	Accidents/safety during construction													✓					✓		
25.	Unexpected expenses to dispose material	✓																			

26.	Disputes		✓																		
27.	Termination		✓																		
28.	Cost overrun		✓																		
29.	Unofficial holidays												✓								
30.	Local partner's creditworthiness		✓																		
31.	Performance of subcontractors													✓							
32.	Frequent breakdown of equipment and plans														✓						
33.	Natural forces						✓														

1 = Wang and Chou (2003); 2 Wang (2004); 3 = Wiguna and Scott (2005); 4 = Andi (2006); 5 = El-Sayegh (2008); 6 = Banaitiene et al. (2011); 7= Chileshe and Yirenkyi - Fianko (2011); 8 = Alhomidan (2013); 9 = Mahamid (2013); 10 = Ekung et al. (2015); 11= Helen, et al. (2015); 12= Jaber (2015); 13= Iqbal et al. (2015); 14= Yoon et al. (2015); 15= El – Sayegh and Mansour (2015); 16 = Befrouie et al. (2015); 17 = Emuze (2016); 18 = Mishra & Mishra (2016); 19= Mohammed (2016); 20 = Fernando et al. (2017)

2.4.2 The concept of ERM and its differences from traditional risk management

Traditionally, RM is segmented and conducted in discrete business units or departments (i.e. as a silo management) within a company (Zhao, et al., 2013a; Gatzert & Martin, 2015). However, the ever-changing internal and external factors in the corporate environment, which involve diverse and complex risks, call for adopting a holistic and company-wide risk management approach (Hoyt & Liebenberg, 2011; Gatzert & Martin, 2015; COSO, 2017; ISO, 2018), referred to as ERM. While several definitions have been provided for ERM in the literature (Renault, et al., 2016; Razali & Tahir, 2011), the definition offered by the Committee of Sponsoring Organisations of the Treadway Commission (COSO, 2017) stated below is found to be suitable for this study. According to COSO (2017):

“ERM is the culture, capabilities, and practices, integrated with strategy setting and performance that organisations rely on to manage risk in creating, preserving and realising value.”

This definition attempts to incorporate the basic RM dimension (culture, capability, and practice) that are conceded as essential in many of the available RM maturity models. This also highlights the importance of integrating these dimensions into the new concepts, namely, strategy and performance, which were rarely addressed in other definitions and even its earlier version. It is also important to note that the ERM can be used by all kinds of organisations, from small businesses to community-based social enterprises to government agencies (COSO, 2017). Further, the term ‘organisation’ is dominantly used in the ISO (2018) and COSO (2017) frameworks. Hence, this term is used in this document and the term company is also used alternatively to refer to construction entities.

There are also some fundamental concepts related to the ERM. For instance, upon reviewing various definitions of ERM provided in the literature, Abrams et al. (2007) conceded that *integration, comprehensiveness, and strategy* are the common basic features reflected in many ERM definitions. Introducing some more essential concepts over these three features, the ISO (2018) has set out the following eight ERM principles that provide guidance on the characteristics of effective and efficient RM, communicating its value and explaining its intention and purpose.

- i. **Integrated:** RM is an integral part of all organisational activities.
- ii. **Structured and comprehensive:** to ensure consistent and comparable results.
- iii. **Customised:** the RM framework and process needs to be customised and proportionated to the organisation's external and internal context related to its objectives.
- iv. **Inclusive:** appropriate and timely involvement of stakeholders enables their knowledge, views, and perceptions to be considered.
- v. **Dynamic:** since risks can emerge, change, or disappear as an organisation's external and internal context changes, RM anticipates, detects, acknowledges, and responds to changes.
- vi. **Best available information:** to ensure information to be timely, clear, and available to relevant stakeholders.
- vii. **Human and cultural factors:** human behaviour and culture influence all aspects of RM.
- viii. **Continual improvement:** RM is continually improved through learning and experience.

To appreciate the significance of ERM, it is also important to clearly distinguish the basic features of the ERM from the traditional risk management (TRM) approach. Most importantly, unlike the TRM, ERM enables a systematic understanding of the interdependencies and correlations among risks (McShane, et al., 2011; Zhao, et al., 2013a; Renault, et al., 2016). An ERM also treats each risk as part of the entire risk portfolio of an organisation, rather than as a discrete risk dealt in TRM. The details of the basic distinctions between TRM and ERM are compiled from Spikin (2013a) and Zhao et al. (2013a) as described in Table 2-5.

Table 2-5 Distinction between TRM and ERM

Key dimensions	TRM	Comprehensive or ERM approach
Integration within an organisation	Segmented and conducted in separate business units (i.e. silos) within a company	Treats each risk as part of the entire risk portfolio of an organisation rather than as a discrete risk
Interaction between risks	Fails to consider the interactions between risks	Concerns risk interactions and how risk response measures can deal with multiple risks across multiple business areas
Relationship between RM and strategy	Limited influences of RM to strategic planning	Effective support of RM to strategic planning
Focus of the RM	Focuses only on the threats	Focuses on both threats and opportunities
Assessment of risk	Irregularly and reactively	Frequently and proactively
Risk management	“Specialist” approach	Centralise the management of the risk
Reporting of risk	Risk mapping unstructured and incomplete	Consolidation of the risks with clear and complete reports
Risk communication and organisation	Related to the affected function on a particular exposure	Vertical coordination towards the top management and horizontal given the nature of RM process
Liability of risk	Definition of responsibility is often lacking certain types of risks	Clear responsibility for all the risks and subsequently introduced a reward system.

Compiled from Spikin (2013) and Zhao et al. (2013a)

2.4.3 The significance of ERM

Much research has been devoted in recent years to investigate the benefits of practising ERM in various sectors, including the construction industry (Gordon, et al., 2009; McShane, et al., 2011; Liu, et al., 2013; Low, et al., 2013; Gatzert & Martin, 2015; Abdullah, et al., 2017). The main significances of the ERM identified in the literature include enhancing organisational value and organisation performance. The ERM also helps to enhance project performance as explained in the following subsections. It is also important to note that many of these benefits were validated by means of empirical techniques (Gatzert & Martin, 2015; Grace, et al., 2015; Hoyt & Liebenberg, 2011).

a) ERM enhances organisation value

Enterprise risk management is recognised as a value-contributing management tool in professional organisations (Whiteman, 2015) and this has been demonstrated by empirical evidence (Gatzert &

Martin, 2015; Grace, et al., 2015; Hoyt & Liebenberg, 2011). In a review of five empirical studies that exclusively dealt with the association of ERM implementation and organisation/shareholder value, Gatzert and Martin (2015) indicated a (significant) positive association between them. In four of these studies, the Tobin's Q (the ratio of the total market value and total asset value of an organisation) was applied to approximate the organisation's value from the shareholder perspective, to enable reflection on the future expectations of shareholders. Further, among these five, a survey by Hoyt and Liebenberg (2011) demonstrated a positive and highly significant impact of ERM on the surveyed insurance companies, with an increment of a higher shareholder value of approximately 17% to 20%. This is partly consistent with the results from McShane et al. (2011), who found a similar significant positive relationship with shareholder value.

Moreover, a survey by Kommunuri et al. (2016) on a range of Vietnamese industries also revealed that implementing effective ERM enhances the values of organisations across industries, including construction. In an attempt to explore how ERM adds organisational value, Grace, et al. (2015) also found that implementing ERM is significantly (positively) associated with companies' revenue and cost efficiency.

Several arguments have been compiled in the literature on the association of ERM on organisational value. Such a positive association, according to McShane, et al. (2011), is because the risk of an aggregate portfolio should be less than the sum of the individual risks in the case where risks are not 100% correlated. Further, managing each risk even in a separate silo approach creates inefficiencies due to the lack of coordination between the various RM departments. This shortcoming is addressed by integrating decision making across all risk classes; ERM enables organisations to avoid duplication of RM expenditure (Hoyt & Liebenberg, 2011).

The other potential source of value in adopting ERM according to Hoyt and Liebenberg (2011) arises due to improved information about the organisation's risk profile. Outsiders are more likely to have difficulty in assessing the financial strength and risk profile of organisations that are highly financially and operationally complex. Thus, ERM might enable these opaque organisations to better inform outsiders of their risk profile and should serve as a signal of their commitment to RM. This seems to be of particular importance to construction companies because project owners and financiers might be encouraged to offer projects to an organisation that has ERM in place. This is because construction demands an effective RM that would effectively address the potential risk.

b) ERM enhances organisation performance

Organisational performance is an organisation's ability to achieve its goal by using resources in an efficient and effective way (Ibrahim & Esa, 2017). Based on this, studies have been done to evaluate the association of ERM with organisational performance and it was found that an appropriate ERM fosters organisational performance. By reviewing three different studies that were conducted to explore this association, Gatzert and Martin (2015) showed consistent results that practising ERM is contingent with organisational performance. These studies were focused particularly on financial variables as well as cost and revenue efficiency. One of these three surveys is the empirical study carried out on 112 US companies by Gordon et al. (2009); which illustrated that ERM and organisational performance are contingent. Gatzert and Martin (2015) have also contended that the empirical findings are generally consistent with theoretical arguments regarding the positive impact of an ERM implementation on shareholder value and company performance.

Involving the top 100 Malaysian public companies, Ali, et al. (2019) examined the relationship between ERM and a firm's performance, and achieved a positive significant coefficient between profitability and the firm's performance towards ERM implementation. Ibrahim and Esa (2017) have also explored the impact of ERM on the performance of companies in the Malaysian housing sector and concluded that ERM is an essential factor with a significant impact on the success of an organisation. A survey of Italian companies also revealed that firms with advanced levels of ERM implementation present higher performance, both as financial performance and market evaluation (Florio & Leoni, 2017). This indicated the positive impact of the ERM on both the financial and non-financial components of an organisation. In association with this, the updated COSO (2017) ERM framework suggests risk should be viewed in the context of an organisation's performance rather than as the subject of an isolated exercise.

c) ERM improves project performance

Studies also indicated that ERM can contribute to improving the performance of construction projects (Siang & Ali, 2012; Liu, et al., 2013; Low, et al., 2013). Siang and Ali (2012) have investigated the significance of ERM on the success of projects by surveying three Malaysian construction companies. Two of the companies surveyed were practising RM in a more comprehensive and inclusive approach than the third one. The results of study indicated that the

performance of projects in the third company were relatively unsatisfactory, with a higher cost and time overruns. As a result, Siang and Ali (2012) conceived this is an indication that project performance could be improved by implementing appropriate ERM.

Further, in a study to explore the nexus between ERM and the performance of local contractors in Singapore, Low, et al. (2013) examined the impact of ERM on the ten selected project performance indicators. The considered indicators included profitability, satisfaction, and productivity. The findings of the study revealed that ERM has an impact on the identified performance indicators, demonstrating a positive correlation between ERM and project performance.

Another study was carried out by Liu et al. (2013) on two Chinese international construction organisations with different RM practices. One of the companies had an independent RM department at the company level with a responsibility for developing RM policy and procedure; coordinating RM of various departments at the enterprise level; monitoring the enforcement of the policy and procedure; and providing intellectual support for the project risk management (PRM). On the contrary, in the other company there was neither an RM department nor any other department or individual coordinating and presiding over the organisation's RM work at the company level. The comparison of the two companies was based on four key components: RM department, RM procedure, external service, and corporate culture; and indicated that the company with RM at the company level had performed better, demonstrating that ERM can positively influence the implementation of project risk management and thereby project performance.

d) Other benefits

In addition to the above, practising ERM according to COSO (2018) can increase opportunities; increase positive outcomes and advantages while reducing negative surprises; reduce performance variability; improve resource deployment and enhance company resilience. The list of benefits outlined above clearly shows the importance of ERM for a company. It also has potential benefits for construction organisations that are prone to various risks. This suggests that companies should implement ERM by evaluating their ERM practice and identifying gaps. Consequently, it is perceived that the ERM discipline has evolved rapidly, becoming more institutionalised and establishing strategic credentials in many countries, such as in the UK (Deloitte, 2021).

2.4.4 ERM practice in construction companies

Numerous studies have been conducted to explore the level of ERM implementation in companies of several industries, although a vast majority of them were based in the financial sector (Althonayan, et al., 2012; Ibrahim & Esa, 2017). The transitioning of risk culture into ERM and embedding it across the financial institutions has become an area of increased focus, especially since the deficiency in risk culture was identified as a primary contributor to the 2008/09 global financial crisis (Althonayan, et al., 2012; IRM, 2018). This crisis has prompted not only financial institutions but also companies in other sectors to put ERM in place. Further, recognising the diverse benefits of ERM, it has been observed that some countries are trying to promote ERM through legal provisions as well (Coetzee & Lubbe, 2013; Whiteman, 2015). The COVID 19 pandemic, which is having a major impact on global socio-economic performance, should also be another salient factor for companies to foster their effort towards implementing effective ERM (Worku, 2020; Deloitte, 2021).

However, there are two key issues that require a great deal of effort related to the implementation of ERM in the construction industry: (i) the adequacy of studies conducted so far, and (ii) the current level of ERM implementation in construction companies. In regards to the adequacy of studies, although it appears to have improved recently (Renault, et al., 2016; Ibrahim & Esa, 2017), the literature shows that ERM studies related to construction companies are still limited compared to other industries (Low, et al., 2013; Yirenkyi-Fianko & Chileshe, 2015; Renault, et al., 2016; Ibrahim & Esa, 2017). Low, et al. (2013) have also pointed out that there is a lack of studies on ERM implementation in construction organisations, in particular. Further, Yirenkyi-Fianko & Chileshe (2015) contended that most of the available studies have concentrated on the developed nation, and that there is still a shortage of research in the African context. Ching, et al. (2020) have reiterated that the companies' ERM practice has not changed much until recently. Further, noting that most ERM scholarships have roots in the financial sector, Lopez (2021) has claimed that there are still limited ERM-related studies in industries outside the financial sector.

Concerning the level of ERM implementation, the limited available studies also demonstrated that ERM has not been well practised in the industry in general and in developing countries in particular. Notably, consistent low-level ERM practice has been reported in the construction

companies of several countries, namely, Ghana (Yirenkyi-Fianko & Chileshe, 2015); Nigeria (Salawua & Abdullah, 2014; Salawu, 2016); Egypt (Hassanein & Afify, 2007); Lithuania (Banaitienė, et al., 2011); and India (Jayasudha and Vidivelli, 2016). Studies in the Ethiopian construction industry as well showed that generally RM is one of the most overlooked areas in construction companies (Tadesse, et al., 2016; Zinabu, 2016; Desalegn & Mahesh, 2019).

Surveys specific to domestic contractors also revealed low-level ERM practice. For instance, according to Goh and Abdul Rahman (2013) only eight (18%) of the 45 domestic contractors surveyed in Malaysia were adopting formal RM. Studies in the Nigerian road sector also indicated that the domestic contractors involved in highway projects were categorised only at a beginner level (Salawua & Abdullah, 2014; Fabi & Awolesi, 2015). Yet it is of paramount importance to note that, unlike many other findings, a promising practice has been reported in South African private construction organisations where they are found to be at a relatively better mature level (Coetzee & Lubbe, 2013). Several factors have been identified in the literature attributing to such low-level ERM implementation in construction companies, including:

- A low level of RM knowledge and experience from professionals (Hassanein & Afify, 2007; Coetzee & Lubbe, 2013; Goh & Abdul-Rahman, 2013; Hansen-Addy & Fekpe, 2015)
- An undesirable attitude from contractors towards RM (Goh & Abdul-Rahman, 2013)
- The absence of an RM supportive culture (Coetzee & Lubbe, 2013);
- A low level of awareness of the benefits of ERM (Jayasudha & Vidivelli, 2016; Renault, et al., 2016)
- The size of the company and the level of institutional ownership (Gatzert & Martin, 2015). Gatzert and Martin (2015) showed that the size of the company and the level of institutional ownership are positively related to the implementation ERM, but there is still a debate on the issue of whether firm size impacts ERM (Ali, et al., 2019).

These suggest the need for a significant effort to improve the level of ERM practice in the industry, comprising further studies. The other general barriers to adopting ERM are also described in the following subsection.

2.4.5 Barriers for implementing ERM

As explained in the preceding sections, although ERM has numerous benefits, it has not yet been well practised. As a result, a number of studies have been conducted to identify the critical factors that impede companies in implementing ERM (Low, et al., 2013; Zhao, et al., 2014a; Fabi & Awolesi, 2015; Kommunuri, et al., 2016; Renault, et al., 2016; Beasley, et al., 2018). Among these studies, some by Zhao, et al. (2014a) and Low, et al. (2013) are related to the factors pertinent to construction companies.

Table 2-6 Summary of factors that affect companies in implementing ERM

No	Risk Factor	Renault et al. (2016)	Beasley et al. (2018)	Zhao et al. (2014a)	Low et al. (2013)	Fabi & Awolesi (2015)	Rostami et al. (2015)
1.	Insufficient resources	✓	✓	✓	✓	✓	
2	Lack of awareness of the perceived value of ERM	✓	✓	✓			✓
3.	Lack of internal knowledge, skills, and expertise	✓			✓		✓
4.	Lack of support from top management/board	✓	✓	✓			
5.	Difficulties in quantifying the risks, lack of model	✓				✓	
6.	Management competing priorities	✓	✓				
7.	Inadequate training on ERM	✓		✓			
8.	Perception that ERM adds cost and administration/bureaucracy		✓	✓			
9.	Lack of common risk language	✓					
10	Lack of quality data and limited access to data	✓					
11.	Sensitive information	✓					
12.	Legal or regulatory barriers		✓				
13.	Human/organisational resistance					✓	
14.	Lack of ERM consultant						✓

Through a review of the relevant literature, 14 factors that hamper companies in implementing ERM were identified. This is summarised in Table 2-6 above, illustrating inadequate resources to be the most common impeding factor, followed by lack of awareness of the perceived value of ERM. Specific to construction, Zhao, et al. (2014a) identified the critical factors in Singapore-based construction organisations, including inadequate resources, lack of awareness of the perceived value of ERM and lack of internal knowledge, skills, and expertise as the most critical factors. Low, et al. (2013) also identified inadequate time for implementation, lack of experienced staff, and inadequate resources as the most critical factors for Singapore construction organisations. This suggests organisations need to work on the critical factors towards ensuring effective ERM and thereby to attain the expected benefits.

2.4.6 Does ERM replace project risk management in construction companies?

Construction companies being project-based entities, their major strategies and operations are intertwined with the management of projects. However, construction projects are more prone to risk and uncertainty than those in the other sectors (Wang & Chou, 2003; Banaitienė, et al., 2011; Gohar, et al., 2012) and such risks have been found to impose a significant impact on project and company objectives (Gohar, et al., 2012; Zhao, et al., 2015). Hence, RM appears to be a critical success factor for construction project management (Banaitienė, et al., 2011). In view of this, project risk management (PRM) has been introduced as a major project management knowledge area (PMI, 2017). On the other hand, as described in the preceding sections, ERM is also widely regarded as an essential RM tool with a wide range of benefits (section 2.4.3).

Now the question, especially in the construction industry, is whether ERM would/should replace PRM? To respond to this, it is important to have an overview of the distinctions and interrelations between these two risk management areas. The literature shows that ERM and PRM are very different but interrelated, which could be applied at different levels of a company with distinct goals (Liu, et al., 2011; Renault, et al., 2016). Liu, et al. (2013) have described the discrete features of these two RM disciplines in respect of some essential parameters described in Table 2-7.

This clearly demonstrates that ERM cannot substitute for the role of PRM (Renault, et al., 2016). Hence, PRM should be regarded as indispensable in construction organisations and considered as an integral part of ERM (Zou, et al., 2010; Zhao, et al., 2013a; Zhao, et al., 2015; Renault, et al.,

2016) . As project risks are within the whole risk profile of a construction organisation, ERM should be executed at all levels of an organisation, including the project level (Zhao, et al., 2013a; Renault, et al., 2016).

Table 2-7 Comparison between ERM and PRM

Key Features	ERM	PRM
Objectives	Align to the four enterprise objectives: strategic, operations, reporting, and compliance	To complete the project successfully
Scope	Internal and external events affecting achievement of an entity's objectives must be identified	Cost, time, quality, safety, and environment-related risks (that influence the implementation of project)
Risk Categories	Strategic risks, market risks, operation risks, financial risks, and compliance risks	Site conditions, owner-contractor agreement, subcontractor, project preparation, planning and execution, contracting, and administration procedures, and external risks, etc.
Framework and Methods	Relatively stable in a period	Change from project to project
Person in Charge	Top managers (e.g. Chief Risk Officer) of the entity	Project Managers

Source (Liu, et al., 2013)

Yet, it is worth mentioning that although PRM is an essential tool at the project level, PRM alone could not provide a better solution for organisations if it is not integrated with the ERM (Zhao, et al., 2014a). Conversely, Zhao, et al. (2013a) and Renault, et al. (2016) have claimed that overemphasis on PRM has several limitations that may, according to Zhao, et al. (2013a), lead to numerous problems; namely, the lack of a holistic view of project risks, lack of transparency across multiple projects, and inappropriate resource allocation among projects. Further, managing risks in a silo-based approach and applying only PRM, according to Laslo and Goldberg (2008, as cited in Zhao et al., 2014b), may be misleading. Hence, RM in construction companies must cover not only project risks but also the overall organisational risks, by integrating PRM within the ERM.

2.5 ERM Competence Measurement

The implementation of ERM is a change management project, in which an organisation moves to risk-informed decision making with the goal of improving the confidence of decision makers

through a more explicit understanding of the risks facing the organisation (IMA, 2007). Further, as described in section 2.4.2, continual improvement is one of the core principles in ERM. To get a clear view of a company's current ERM practice and to improve the weak areas, Zhao et al. (2013a) and Wieczorek-Kosmala (2014) have suggested the need for measuring companies' ERM competence.

The ERM Maturity Model (ERM³) is a popular tool used to measure companies' RM competence (Wieczorek-Kosmala, 2014). According to Imam (2011), ERM maturity can be defined as a *'comparative level of advancement an organisation has achieved with regard to managing risks at the organisational level'*. Measuring ERM maturity helps an organisation to: evaluate the adequacy of its approaches towards RM; identify its current level of maturity; compare its approach with best practices or against its competitors; create an accepted benchmark; set realistic targets for improvement and measure progress towards achieving them. (IACCM, 2003; Becker, et al., 2009; Jia, et al., 2013)

Generally, an RM maturity model is structured as a matrix of *attributes* (also called dimensions or characteristics) and *maturity levels*. The attributes according to Mokgoantle (2012) are the basic characteristics used for evaluating the competence of a company's ERM. To enable a detailed investigation of a company, each attribute needs to be further broken down into diagnosis criteria (indicators) (IACCM, 2003).

Maturity levels, on the other hand, measure company's RM positions in terms of certain specified scales; where these scales, according to Proenca, et al. (2017), are organised from an initial level of lower competence to an advanced level corresponding to the maximum capacity of the reality in question. To reach the highest maturity level, a continuous progression of the capability of the organisation under each indicator set for the purpose of valuating the status of the company needs to be ensured.

Several maturity models have been developed in the past two decades. Such an ever-growing number of maturity models, according to Becker et al. (2009), indicates a certain degree of arbitrariness concerning their development processes. To explore whether these models are suitable for construction companies, the existing models are evaluated in the following subsections.

2.5.1 Review of the available maturity models

Through a comprehensive review of the literature, 22 different maturity models were identified as highlighted in Table 2-8 (see also Appendix C for the details of attributes and maturity levels of each model). These models are evaluated in terms of some essential parameters, mainly, their contents and areas of applications. Hopkinson and Lovelock (2004) conceded that some of the existing models have originated from Hillson's (1997) generic model. Many of the remaining models, on the other hand, have defined attributes and maturity levels in a very different form.

Further, as illustrated in Table 2-8, some of these models have been designed for use by companies across various industries. Whereas some other models have been developed specifically for the construction industry, including those designed by RMRDPC (2002); Loosemore, et al. (2006); Zou, et al. (2010); Zhao, et al. (2013a); Salawua & Abdullah (2014); Caiado et al. (2016); and Hoseini, et al. (2019). Most importantly, the last five of these models, i.e. No. 18 to 22 in Table 2-8, were designed specifically for evaluating the RM competence at a company level, i.e. ERM. Among these, the model by Salawu, et al. (2014) was developed particularly for construction companies that were engaged in highway projects. Models by Caiado, et al. (2016) and Hoseini, et al. (2019), were developed to assess the RM competence of construction projects as well.

A closer look at the existing models reveals a number of gaps and shortcomings. The first major gap is the inconsistency in the contents of the models, reflected in the two key components of an ERM maturity model (ERM³), namely: maturity attributes and maturity levels (sections 2.5.1.1 and 2.5.1.2, respectively). The second shortfall is that most authors have not described the procedures adopted in developing their models (Jia, et al., 2013; Proenca, et al., 2017; Hoseini, et al., 2019). Jia, et al. (2013) highlighted that although evaluation-oriented RM³s were built up, there was a lack of an in-depth description about the process. This suggests that a clear procedural framework should be established to develop an effective model, as applied in Becker et al. (2009) and Proenca (2017).

Table 2-8 Summary of the available models

No	Author(s)	Model	Suitable sector
1.	Hillson (1997)	RM Maturity (RMM)	To all organisations
2.	Project Management Solutions (2002)	Project Management Maturity Model (PMMM)	Project-based organisations
3.	PMI-EUA (RISK SIG, 2002)	RMM	All types of projects, organisations in any industry, business or government sectors.
4.	RMRDPC (2002)	RM Maturity Model (RM ³)	Construction organisations
5.	IACCM (2003)	Business RM Maturity Model (BRM ³)	All organisations
6.	Hopkinson and Lovelock (2004)	Project RMM	To all projects
7.	Ren and Yeo (2004)	RM Capability Maturity Model	Software organisations
8.	RIMS (2006)	RMM for Enterprises	All business organisations
9.	Loosemore et al. (2006)	RM ³	Construction industry
10.	Ferrando (2007)	Operational RM ³	Insurance companies
11.	Ongel (2009)	RM3 used for construction industry	All kinds of organisations of any sector, government or commercial
12.	Mayer and Fagundes (2009)	Maturity Model to RM Process in Information Security	Information security
13.	Zou, et al. (2010)	RM ³	Construction companies
14.	Pangeran et al. (2012)	RM Capacity Model	To all organisations
15.	IRM (2012)	General	General
16.	Zhao et al. (2013a)	ERM ³	Construction companies
17.	Salawu and Abdullah (2014)	RM3	Contractors involved in highway projects
18.	Caiado et al. (2016)	RMM	Construction Project
19.	ORR and HSL (2017)	RM ³	Railway and road specific to health and safety
20.	Proenca et al. (2017)	RM: A maturity model based on ISO 31000	Construction companies
21.	Hoseini et al. (2019)	Construction Projects Generic RM ³	Construction projects
22.	OECD (2021)	ERM ³	Tax administration

The other major gap, as part of a maturity model development procedural requirement, is that many of the existing models are not empirically validated. The detailed review of about 237 articles on maturity models covering more than 20 domains by Wendler (2012) revealed scarce attempts to empirically validate the models. Hoseini, et al. (2019) reiterated that there is no validated RMM

for the construction industry, either using theory or experts' opinions. The literature also indicates that some models were designed based on the ERM frameworks which have already been updated and replaced by new versions. For instance, Zhao et al. (2013a) and Proenca et al. (2017) have adopted their model based on the first version of ISO (2009) 31000 RM guidelines; whereas this guideline has been already replaced by the 2018 version. This suggests that such models need to be updated.

Overall, it is conceded that although many RM maturity models were proposed over the last two decades, their suitability remains a subject of discussion (Wondler, 2012; Jia, et al., 2013; Hoseini, et al., 2019). The major gaps noted from existing models related to the contents of ERM attributes and maturity levels are described in detail as follows.

2.5.1.1 Categories and contents of attributes

Diverse categories of attributes have been adopted in the existing models (see Appendix C), envisaged both in the number and designation. The number of attributes spans from three in Ren and Yeo (2004) to about 16 in Zhao, et al. (2013a), with most models containing four to six attributes. However, it is important to note that despite not having a defined number in the literature, it is generally preferred to have limited key attributes, e.g. four to six, as considered in most of the considered models. In this regard, Zou et al. (2010) pointed out that though it is possible to have more attributes, for simplicity, the five categories may be sufficient for construction enterprises, because, if necessary, the detailed characteristics could be measured by diagnostic indicators that could be defined under each of the key attributes.

The other critical gap related to attributes is the inclusion of detailed factors as key attributes, which can instead be used as diagnosis indicators. This is observed in many models, including those of Zou, et al. (2010), ORR and HSL (2017), Hoseini, et al. (2019), and OECD (2021), where the RM process stages (risk identification, risk analysis and risks treatment) were included as main attributes. The Project Management Solutions (2002) and Mayer and Fagundes' (2009) models contained exclusively the RM process components. Hence, it can be argued that these models are inadequate and do not contain the most essential dimensions. For instance, the culture, competence, and implementation are the most essential attributes, but are overlooked in such models.

Hence, as it is not always easy to list all the attributes on one hand, and the dimensions included in all the existing models are not key attributes, on the other hand, it has been found important to identify the most common and relevant attributes. These are highlighted in Table 2-9, which shows that the conventional Hillson's (1997) four RM maturity attributes (culture, process, competence and applications) are the most frequently used. Table 2-9 also indicates the tendency to introduce new attributes, such as policy, strategy, structure, governance, and leadership in the recent models. These attributes were rarely used in the earlier models. For instance, Hoseini, et al. (2019) have included policy and strategy as one of the seven attributes of their model. Despite this the ORR and HSL (2017) have adopted a completely different approach from many of the other models to classify attributes; they have incorporated policy, governance, and leadership as a key attribute. A more recent model by OECD (2021) has also introduced strategy and governance among the key attributes. This clearly suggests that policy and strategy, as well as structure and governance should be considered as the key attributes in ERM³.

Table 2-9 Summary of RM maturity attributes

S/ No.	Author(s)	Attributes							Remark
		Culture	Process	Experience	Application	Management and Leadership	Policy and/or Strategy	Structure and/or Governance	
1.	Hillson (1997)	✓	✓	✓	✓				
2.	Project Management Solutions (2002)								Detail RM process stages
3.	PMI – EUA (RISK SIG, 2002)	✓	✓	✓	✓				
4.	RMRDPC (2002)	✓	✓			✓			Other detailed dimensions
5.	IACCM (2003)	✓	✓	✓	✓				
6.	Hopkinson and Lovelock (2004)	✓							Other detailed dimensions
7.	Ren and Yeo (2004)	✓	✓	✓					Other detailed dimensions
8.	RIMS (2006)		✓						Other detailed dimensions
9.	Loosemore et al. (2006)	✓	✓	✓	✓				
10.	Ferrando (2007)	✓	✓	✓	✓				
11.	Ongel (2009)	✓	✓		✓				Other (Resource)
12.	Mayer and Fagundes (2009)								Detail RM processes stages
13.	Zou et al. (2010)	✓				✓			Other detailed dimensions
14.	Pangeran et al. (2012)	✓	✓	✓	✓				Other (Partnership)
15.	IRM (2012)					✓		✓	Other detailed dimensions
16.	Zhao et al. (2013a)								Used ISO (2009) components
17.	Salawu and Abdullah (2014)	✓	✓		✓				Other (Resource)
18.	Caiado et al. (2016)								Other detailed dimensions
19.	ORR and HSL (2017)								Followed a different classification
20.	Proenca et al (2017)								Used ISO (2009) components
21.	Hoseini et al. (2019)	✓					✓		Other details
22.	OECD (2021)	✓					✓ (Strategy)	✓ (Governance)	Other detailed dimensions

Adapted by the Authors (Salawu and Abdullah, 2014; Caiado et al., 2016; Zou et al., 2010; ORR and HSL, 2017; Hoseini et al., 2019)

2.5.1.2 ERM maturity levels

Like the attributes discussed in section 2.5.1.1 there is a dissimilarity among the maturity levels of the existing models highlighted in Table 2-10. These differences are exhibited not only in the number of levels of maturity but also in their designations.

Table 2-10 Common risk management maturity levels

Model Authors	Maturity Levels						No. of Maturity Levels
	0	1	2	3	4	5	
Hillson, (1997); Hopkinson (2011)		Naive	Novice	Normalised	Natural		4
RMRDPC (2002)		Ad hoc	Initial	Repeatable	Managed		4
IACCM (2003)		Novice	Competent	Proficient	Expert		4
ACCM-B RM3-(2003); Mu, et al. (2013)		Naive	Novice	Normalised	Optimised		4
Ren and Yeo (2004)		Initial	Repeatable	Defined	Managed	Optimised	5
Loosemore et al (2006)		Ad hoc	Established	Managed	Integrated		4
RIMS (2006)	Non - existent	Ad hoc	Initial	Repeatable	Managed	Leadership	6
Zou, et al., (2010)		Initial and ad hoc	Repeatable	Managed	Optimised		4
Wibowo and Taufik (2016)		Naive	Novice	Normalised	Managed		4
Ponca et al (2017)	Non - existent	Initial	Managed	Defined	Quantitatively managed	Optimised	6
ORR and HSL (2017)		Ad hoc	Managed	Standardised	Predictable	Excellent	5
Hoseini, et al. (2019)		Not applied	Limited applied	Large extent applied	Totally applied		
OECD (2021)		Emerging	Progressing	Established	Leading	Aspirational	5

Adapted by the Authors (Salawu and Abdullah, 2014; Caiado et al., 2016; Zou et al., 2010; ORR and HSL, 2017; Hoseini et al., 2019)

As illustrated in Table 2-10, the number of maturity levels vary from four to six, while a four-scale maturity appears to be the most dominant. However, there are some useful views in regard to the possible number of levels of maturity. For instance, Zou et al. (2010) contended that providing an odd number of scales might guide respondents to select the middle. Beyond that, the meaning of

the middle category in an odd number of levels is ambiguous, which can be interpreted as: ‘has no opinion’, ‘is indifferent/does not care’ and/or ‘does not understand the question’ (Willits et al., 2016). Caiadoa (2016) also argued that evaluating maturity in a scale of more than four stages would increase ambiguity in the maturity levels. Above all, Zou, et al. (2010) conceived that it is not easy to establish a clear demarcation between the first two levels (i.e. ad hoc, and initial) in a five-level maturity and recommended merging them to one level.

Further, Zou et al. (2010) noted that in models that use five levels, Level 1 and Level 2 offer similar meaning in that it is either *non-existent, ad hoc or initial*. As shown in Table 2-10, RIMS (2006) and Proenca, et al. (2017) included a non-existence Level 0, which according to Proenca, et al. (2017) means the organisation at this stage is not executing any RM process or task at all. However, as pointed out by Proenca, et al. (2017) and shown in Table 2-10, Level 0 is not explicitly mentioned within the majority of the existing maturity RM³.

Considering these, Zhao, et al. (2013a) and Zou, et al. (2010) suggested that four levels of maturity are sufficient to best represent RM maturity scales. These levels however, need to define all levels of maturity ranging from the benchmarks of initial or lacking RM practices to the mature. For instance, according to Ciorciari and Blattner (2008), the lowest maturity level implies that no documentation and communication are available, and a very low formalisation exists. Conversely, at the highest level, the process is optimised, i.e. the RM principles and processes are integrated in the management process.

Second, with regards to the designations, different terms have been used for the same maturity levels (See Table 2-9). For instance, terms like ‘naïve’, ‘initial’, ‘ad hoc’, ‘novice’, ‘very weak’, and ‘red’ have been utilised to designate Level 1, with ‘ad hoc’ being the most often used term. It can also be seen that in the models that have adopted ‘ad hoc’ and ‘initial’ as separate stages, such as RMRDPC (2002) and RIMS (2006), ‘initial’ was considered as the second level of maturity. Recognising that it is not easy to distinguish these two stages, Zhou, et al. (2010) merged them as a single level, namely, Level 1 - ‘initial and ad hoc’. Similarly, a wide range of terms have been used to designate the other levels as well.

Hence, the use of different maturity levels and the diverse designations in the existing models dictate the need to define a generic maturity level that could be widely used to evaluate companies' maturity.

2.5.2 RM maturity models related to construction

As illustrated in Table 2-8, some of the models were designed specifically for the construction industry (Loosemore, et al., 2006; Zou, et al., 2010; Zhao, et al., 2013a; Salawua & Abdullah, 2014; Caiado, et al., 2016; Hoseini, et al., 2019) and some others were considered to be used for companies of different sectors containing construction. Hence, these are described in detail in sections 2.5.2.2 to 2.5.2.8. As a fundamental model, Hillson's model is also overviewed in section 2.5.2.1 to better comprehend the basic contents of an ER3.

2.5.2.1 Hillson's RM³

Hillson's (1997) model was the first developed generic risk maturity model, with a primary aim of providing a framework against which RM practice can be benchmarked. This model was designed to be used in companies across various industries. In this model, the RM maturity is evaluated against the four levels (*naive, novice, managed* and *natural*) linked with four different attributes (*culture, process, experience, and application*). Hillson's model has been serving as a foundation for many of the subsequent maturity models, such as, the IACCM (2003), Hopkinson (2011), and Caiado et al. (2016) RMM models. The four attributes have been utilised in many other models in combination with additional new dimensions. However, this appears to be limited to incorporating some other essential dimensions, mainly policy and strategy, and structure and governance.

2.5.2.2 Business risk management maturity model (BRM³)

The BRM³ was designed by the International Association for Contract and Commercial Management (IACCM, 2003), aiming to evaluate an organisation's maturity in the area of business RM. This model has tried to maintain the basic structure of Hillson's model, and measure maturity in terms of the four key attributes (culture, process, experience, application) defined against four maturity levels (novice, competent, proficient, expert). Each attribute was further defined by means of diagnostic indicators corresponding to the four increasing levels. Like Hillson's model,

this model has not included policy and strategy, and structure and governance as key attributes. Most importantly and very differently from many other models, this model contains a detailed level questionnaire comprising 31 different questions which can be adopted by organisations.

2.5.2.3 *PMI's RM³*

The Project Management Institute developed the RM³ in 2002, simplifying the Hillson's model (Ongel, 2009; Elmaalam & Kriouile, 2011). This model categorises an organisation's RM systems and practices into four levels of maturity (*ad hoc, established, managed, and integrated*). The model was considered applicable to all types of projects and organisations across all industries, government, or commercial sectors. Loosemore, et al. (2006) further adapted this model, making it suitable for various industries, mainly the construction industry. However, some of the dimensions included in this model, namely, awareness, image, confidence, and resource are narrow in scope; hence, they should not be considered as key attributes. For instance, as presented in the IACCM (2003), awareness is simply a component of the culture dimension and not an attribute. Similarly, resource as an indicator is related to structure and governance.

2.5.2.4 *RM³ for construction*

Zou et al. (2010) formulated a model to be used for assessing the RM maturity of construction companies. This model is composed of five attributes: management, risk culture, ability to identify risk, ability to analyse risk, and application of standardised RM process/system. The last three are the components of the RM process that should rather be described as a diagnosis indicator. Further, this model fails to incorporate the basic and common attributes, mainly, competence and application. The usefulness of the model was validated using a survey of experts in the Australian construction industry (Zou et al., 2010). Results were reported to reflect the industry; while it was stated that the number of respondents were insufficient to represent the industry.

2.5.2.5 *ERM³ for construction organisations*

This model was developed by Zhao et al. (2013a) for measuring the ERM maturity of construction organisations. The model was established based on the ISO (2009) 31000 RM guidelines and contained 16 attributes and four maturity levels. The applicability of the model was tested on

Chinese contractors that were based in Singapore and provided results that reflected the actual practice of the contractors. A questionnaire survey was conducted to collect data.

However, the model has several limitations. Unlike the many other models, this model contains a long list of attributes (i.e. 16 attributes) which should have been organised as a manageable number as suggested in Zou, et al. (2010). Further, the model does not include policy and strategy, and structure and governance as key attributes. Above all, the model was developed based on the first edition of the ISO ERM framework, which has now been replaced by ISO (2018), so it might need to be revised.

2.5.2.6 RMM

The RMM model was primarily designed by Caiado et al. (2016) as a guideline based on a comprehensive review of 14 different RM models to help construction companies evaluate the RM capability of their entire projects or activities separately. The model contains four RM maturity attributes (i.e. *RM knowledge*, *support from senior management*, *communications with stakeholders* and *contingency plan*) and four maturity levels (*ad hoc*, *initial*, *repeatable* and *managed*). However, most of the attributes included in this model seem to be more specific and detailed. Most importantly, this model is different from many of the other models, because it has not included the conventional key attributes.

2.5.2.7 Generic risk management model

This is a recent model developed by Hoseini et al. (2019) based on the European Foundation for Quality Management (EFQM) model. It was built as a matrix of seven attributes and four maturity levels (Appendix C). This was aimed to be used for planning and improving RM, as well as for cross-project analysis for learning purposes.

The strength of this model is that it has introduced a new attribute, namely, policy and strategy, which is rarely accommodated in the previous models. However, it contains a list of the process attribute steps (i.e. risk assessment, risk treatment, risk monitoring and review) as key attributes that could instead be used as diagnosis indicators under the RM process. Further, the terms used to describe the maturity levels of this model (i.e. not applied, limited applied, large extent applied, and totally applied) appear to be unfamiliar and very different from those used in other models.

2.5.2.8 RMM for construction projects

Salawu and Abdullah (2014) have established this model for assessing the RM capability of the Nigerian contractors involved in the Federal Highway projects. This model contains four attributes: *culture, practice and application, resources* and *process* and the relative diagnostic dimensions (indicators) under each attribute. The model was applied to assess the maturity of contractors under four-scale maturity levels (naive, novice, managed and optimised). However, like the many other models, this model has failed to incorporate policy, strategy, structure and governance as basic dimensions. The strength of this model is that it was validated involving Nigerian contractors that were operating in eighteen rehabilitation projects across the southwest of Nigeria and provided consistent results with the actual practices of the sector.

2.5.3 Other related standards and models

Organisational Design Models (ODMs) and Business Excellence Models (BEMs) are closely related to the RM3s. In association with this, Hoseini et al. (2019) have pointed out that the EFQM model, which is one of the BEMs, has the same intention as RMMs despite having different focus areas. As a result, Hoseini et al. (2019) have customised the EFQM model to develop a new model (section 2.5.2.7). Assessing the interconnections between the 7S model (one of the ODMs) and the BSC (one of the BEMs), Kaplan (2005) also argued that these two models share many features in common.

Further, as discussed in the preceding sections, Zhao, et al. (2013a) and Proenca, et al. (2017) have customised the ISO (2009) 31000 ERM Guideline to design their respective ERM maturity models, which reveals the association between ERM frameworks and ERM³. These suggest that the ERM frameworks, ODMs and BEMs should be reviewed in connection with the RM maturity models. Accordingly, these models are briefly reviewed as follows.

2.5.3.1 ERM frameworks/standards

A risk management framework is a set of components that provide the foundations and organisational arrangements for designing, implementing, monitoring, reviewing and continually improving RM throughout the organisation (ISO, 2009). The ISO 31000 RM guidelines and COSO ERM framework are the popular and widely accepted RM standards (Zhao, et al., 2013a; IRM,

2017; IRM, 2018). Upon reviewing the ISO 31000: 2018 and COSO (2017) frameworks, the IRM (2018) suggested that organisations should consider the basic principles and components from these standards that are best suited to their particular circumstances.

The IRM (2002) RM standard, developed by the UK's three main RM organisations including the Institute of Risk Management (IRM), is the other important framework. However, this deals merely with the RM processes missing to incorporate the other essential dimensions. Therefore, the ISO 31000 and COSO ERM standards were reviewed in the context of the ERM maturity attributes.

2.5.3.1.1 ISO 31000 risk management guideline

The ISO 31000 was originally published in 2009 and further updated in 2018, with the overall purpose of integrating the management of risk into a strategic and operational management system. The 2018 version is quite similar to the original version, with a few changes (IRM, 2018; ISO, 2018). The main components of the guideline associated with the ERMMM include the following:

- The RM principles have been reviewed incorporating the key criteria for successful RM
- The importance of leadership by top management and the integration of RM is highlighted, starting with the governance of the organisation
- Greater emphasis is placed on the iterative nature of RM, because new knowledge and analysis leads to revision of processes, actions and controls
- The content is streamlined with greater focus on sustaining an open systems' model to fit multiple needs and contexts

Considering their significance for effective RM, the guideline also defines in clear terms that the leadership should demonstrate its commitment by:

- i. Issuing a statement or policy that establishes an RM approach, plan, or course of action
- ii. Ensuring that the necessary resources are allocated to managing risk
- iii. Assigning authority, responsibility, and accountability at appropriate levels within the organisation.

These show the close association between the ERM maturity models and the ERM guidelines. It is also particularly important to note that the updated ISO guideline emphasises that policy,

strategy, suitable structure and governance are essential for effective RM. As part of the organisational risk culture, one of the key issues emphasised in the guideline is leadership commitment.

2.5.3.1.2 COSO ERM – Integrating with strategy and performance

The COSO ERM cube was originally published in 2004 and further revised in 2017. The basis of the COSO (2017) standards is that ERM should be embedded into the activities of an organisation, including the mission, vision and core values. This edition also focuses on the need for organisations to become more adaptive to changes. Like the ISO (2018), this framework emphasises that the management should take a better look at how to manage the growing volatility, complexity, and uncertainty in the marketplace.

This framework contains a set of 20 different principles organised under five interrelated components. Many of these principles and components are closely related to the conventional ERM maturity attributes, mainly, the culture and process. Further, the newly emerging concepts in the ERM maturity models, such as governance and strategy appear to gain a special focus in this edition. Two of the five main components of this framework are briefly described as follows.

1. Governance

The governance and culture factor is one of the five basic components of this framework, in that governance sets the tone for the organisation and establishes oversight responsibilities for ERM. Whereas, as usual, culture relates to ethical values, desired behaviours, and understanding of risk. The governance and culture component itself contains the following five of the 20 basic principles:

- (i) exercises board risk oversight,
- (ii) establishes operating structures,
- (iii) defines desired culture,
- (iv) demonstrates commitment to core values, and
- (v) attracts, develops, and retains capable individuals.

While these all are essential to an effective ERM, the second principle demonstrates how suitable structure is essential to ensure successful ERM, and supports the recent initiatives to incorporate structure in ERM³.

2. Strategy and Objective-Setting

The updated COSO framework according to IRM (2017) elevates the discussion of strategy and the integration of ERM with strategy by asserting that all its aspects and implications need to be considered when setting strategy. There are four principles for this component:

- (i) Analyses business context,
- (ii) Defines risk appetite,
- (iii) Evaluates alternative strategies, and
- (iv) Formulates business objectives

These also illustrate how important it is for companies to set a suitable strategy to ensure a successful ERM. Hence, as also outlined in the updated ISO 31000 RM guideline, governance and strategy are found to be the essential RM dimensions to be introduced when establishing ERM³.

2.5.3.2 Organisational design models

Generally, an ODM is the complete specification of strategy, structure, processes, people, coordination and control, and incentive components of the organisation (Burton, et al., 2006). The available ODMs, namely, the Jay Galbraith's Star Model, Tom Peters' 7S, Higgins 8S Successful Strategy (Higgins, 2005; Kaplan, 2005; Burton, et al., 2006) Execution Model, and the Transformational Model are reviewed related to ERM maturity attributes as follows.

The Star Model

Galbraith's Star Model has been used as an important standard for conceptualising organisations' design since the early 1970s (Kasler & Kates, 2010). As shown in Figure 2-1, the model consists of five dimensions: *strategy*, *structure*, *process*, *reward* and *people* (Galbraith, 2002). The list of these five components indicates a close association with the ERM maturity attributes described in section 2.5.1.1. The two components (process and people), are directly related to the attributes in the traditional RM maturity models, such as Hillson's model.

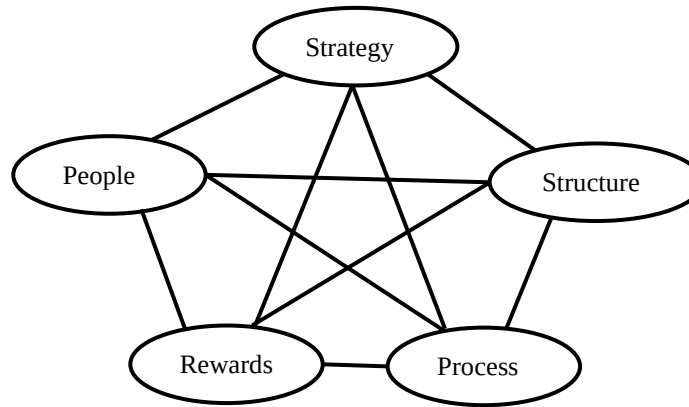


Figure 2-1 The Star Model

Despite being less common in the earlier models, the ‘strategy’ and ‘structure’ components of this model are becoming more common in the recent ERM³ (ORR & HSL, 2017; Hoseini, et al., 2019; OECD, 2021), further strengthening the link between the ERM³ and ODMs. Despite not being indicated as a main attribute, ‘reward’ is one of incentive approaches to establish RM culture in an organisation. Hence, the dimensions of this model appear to be closely associated with ERM maturity attributes.

McKinsey’s 7S Model

The McKinsey 7S Model was originally designed by Peters & Waterman (1980) and later modified by McKinsey & Co (Kaplan, 2005). It is composed of seven dimensions: strategy, structure, system, shared values, skills, style, and staff referred to as 7S’s (Waterman, et al., 1980). Despite being expressed in different terms, this model shares several dimensions with the conventional ERM³ attributes. Style and shared value dimensions are more related with ‘culture’; system with ‘process’; and skill and staff with ‘competence’. Like the Star model, the 7S model also contains ‘strategy’ and ‘structure’ dimensions.

This model is widely used to assess the internal alignments of organisations (Hayes, 2002; Kaplan, 2005; Demir & Kocaoglu, 2009). This has also been employed in various disciplines (Demir & Kocaoglu, 2009), including in RM operations (Jing-xin & Wei, 2010). As depicted in Figure 2-2, the central idea of the model is that an organisation’s effectiveness emanates from the interaction of the seven factors (Waterman, et al., 1980). This suggests diverse ideas that are also important for ERM³, containing the following:

- i. The seven variables are interconnected with the idea that it is difficult, perhaps impossible, to make significant progress in one area without making progress in the others as well.
- ii. The shape of the Figure is significant. That is, it has no starting point or implied hierarchy. There is no clear indication which of the seven factors will be the driving force in changing a particular organisation at a particular point in time.

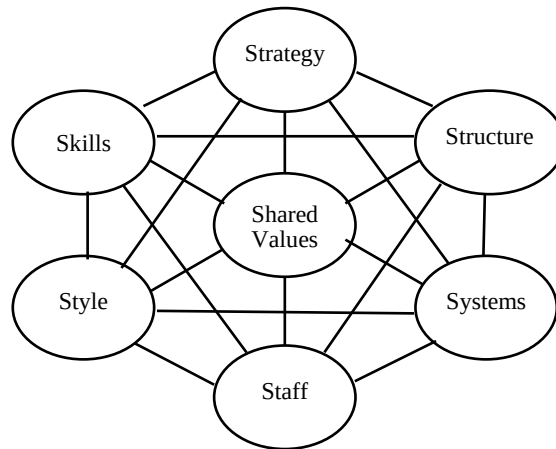


Figure 2-2 McKinsey 7S Model (extracted from Waterman et al., 1980)

The meaning of these points in the context of ERM³ is that it is crucial to create balanced maturity levels across all attributes to ensure effective ERM. However, the absence of hierarchy in the components of this model appears to dictate a further study to explore whether there is a priority within the ERM maturity attributes.

Higgins 8S Successful Strategy Execution

The Higgins 8S model (Higgins, 2005) is the modification of the McKinsey 7S model with two main changes. That is, unlike the 7S model, the 8S model:

- i) suggests an additional 8th S, namely, ‘Strategic Performance’ to the original McKinsey 7S Model,
- ii) proposes to delete ‘Staff’ in the 7S model and replace it with ‘reSource’.

The first proposal to incorporate the ‘performance’ as an additional dimension appears to coincide with the ‘implementation’ dimension that appears in most RM maturity models. Nevertheless,

since resource could be considered as part of the ‘structure’ component, it is not found relevant for ERM³.

Transformational Model

This model is a framework created and used by the Centre for Organisational Design (COD, 2015). As can be seen in Figure 2-3, this model appears to be a modification of the Star Model by incorporating three additional components (external environment, result, performance, and leadership). However, unlike the Star Model (Galbraith, 2002), this model takes 'system' and 'main process' as separate dimensions. It can also be seen that the 'result' component of this model is related to the implementation/application dimension of the RM maturity models.

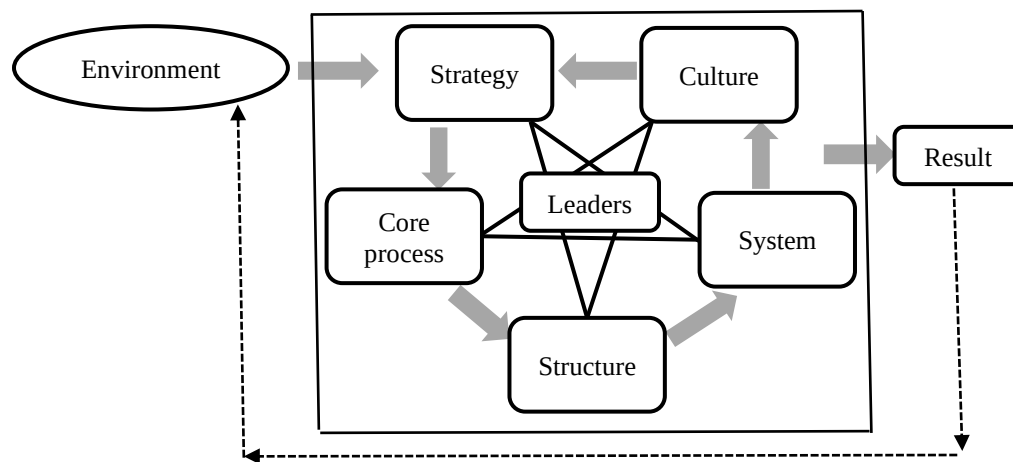


Figure 2-3 Transformation Model

Overall, a brief review of the ODMs shows a broad interrelation between the dimensions of ODMs and RM maturity models. As summarised in Table 2-11, three of the four attributes (i.e. culture, process, and competence) of the conventional ERM³ appear to be directly introduced in the ODMs or in different forms. The ‘Style’ in the McKinsey’s 7S (Waterman, et al., 1980) and Higgin’s 8S (Higgins, 2005) models is related to ‘culture’ which is explicitly defined as ‘culture’ in the Transformational Models as well. The ‘process’ attribute, has also been defined with similar terms in the Star Model; while the term ‘system’ is used in the 7S and 8S models (Waterman, et al., 1980; Higgins, 2005). Unlike the other models, however, ‘system’ and ‘process’ are designated as separate dimensions in the transformational model. Whereas people, staff and skill are used in

these models that are also associated with the ‘staff/ competence’ attribute in the ERM³s. Further, unlike the ERM³s, the strategy and structure are consistently defined as core dimensions in all the four ODMs. This suggests the need to borrow the two parameters (strategy and structure) from the ODMs and introduce them as basic attributes in ERM³s.

Table 2-11 Comparison of ODM and RM maturity attributes across different models

Dimension	McKinsey 7S Model	Star Model	Higgins 8S Model	Transformational models	Relationships with conventional RM models	Remarks
Strategy	√	√	√	√		Incorporated in the recent COSO and ISO ERM frameworks
Structure	√	√	√	√		
System	√	√ (Process)	√	√ (System/ process)	Process	
Staff	√	√	√ (resource)		Competence	
Skill	√		√			
Style	√		√	√ (Culture)	Culture	
Shared Value	√		√			
Reward		√				
Performance			√	√ (Result)	Implementation	
Environment				√		
Leadership				√		

2.5.3.3 Business excellence models

Business excellence models (BEMs) are designed as assessment frameworks for organisational management quality. BEMs are generally developed based on the principles of the Total Quality Management model (Leonard & McAdam, 2002; Jankalová & Jankal, 2020). The ISO Quality Management System (ISO 9001), European Foundation for Quality Management (EFQM), the United States’ Malcolm Baldrige National Quality Award Model (MBNQA) and the Balanced Scorecard (BSC) are the most widely used BEMs (Fonseca, 2015; Jankalová & Jankal, 2020). As noted in Jankalová & Jankal (2020), the national quality award models were developed based on the MBNQA and EFQM models for 53 and 26 countries respectively. The ISO survey in 2013 also indicated that over one million companies were certified with the ISO 9001 Management System

(Fonseca, 2015). The South Africa Construction Excellence Model (SACEM) has also been employed to assess the competence of the country's construction industry.

In view of this, these models were reviewed in comparison with the ERM³s and summarised in Table 2-12. The summary indicates that, although they are described in different terms, there is a major interrelation between the dimensions of the BEMs and ERM³, mainly the staff/competence and process dimensions. The 'policy and strategy' dimension is also the other essential component closely associated with the recent ERM³s.

Table 2-12 Summary of attributes in BEMs

Criteria/Attributes					Relationships with ERM
ISO 9001: 2015	EFQM 2020	MBNQA	SACEM	BSC	
Leadership	Organisational culture & leadership	Leadership	Leadership	Finance	
Engagement of people.	Engaging stakeholder	Work force	People management	Growth	Staff/ Competence
Customer focus	Stakeholder performance	Customer and market focus	Customer and market focus	Customer	
Process approach		Process management	Processes	Internal process	Process
	Purpose, vision & strategy	Strategy planning	Policy and strategy		
	Creating sustainable value	Business results			
		Impact on society			
		Customer satisfaction			
		People satisfaction			
Relationship management		Measurement, analysis, and knowledge management	Resources and information management		
Improvement	Driving performance & transformation				
Evidence-based decision making					
	Strategic & operational performance		Supplier and partnership performance		

2.6 Maturity Model Development Procedures

As highlighted in section 2.5.1, absence of an in-depth description about the process beyond the development of existing RM³s (Jia, et al., 2013; Proenca, et al., 2017; Hoseini, et al., 2019), is one of the major issues associated with the existing maturity models. Hence, it is of paramount importance to set a clear framework that could show the process through which the model was established. The development procedures of De Bruin et al. (2005) and Becker et al. (2009) are the most popular (Proenca, et al., 2017). Proenca, et al. (2017) have also established a four-stage procedure based on Becker, et al.'s (2009) framework. Hence, these basic stages of the procedural framework are briefly discussed based on Becker et al. (2009) and Proenca et al. (2017) as follows.

Step 1 Problems' identification

At this stage, the application domain, the application conditions, and the expected benefits of the new model must be properly defined before starting to develop a model.

Step 2 Evaluating the existing models

To support the importance of developing a new maturity model or simply to improve an existing maturity model, the existing maturity models should be evaluated and compared at this stage. The selected models were evaluated based on a specific criterion, such as, the procedure followed to develop the models, the contents of the models and the scope of the applications. The goal of this step is to determine whether it is required to develop a new model.

Step 3 ERM³ Development Design

According to the maturity model development approach of Becker et al. (2009), a new maturity model must be established if no existing or the advancement of an existing one is capable of addressing the identified problem. This approach seeks to design a suitable framework for developing a model that will adequately address the problem identified in Step 1. An iterative process shall be adopted to properly conceptualise the maturity levels and refine the anticipated maturity models.

Step 4 Maturity Model Evaluation

The final step of the maturity model development procedure is evaluation of the developed ERM³. At this stage, all the principles and premises employed for the development of the maturity model, as well as the usefulness, quality, and effectiveness of the proposed model, must be evaluated iteratively in light of the problem identified in Step 1.

2.7 ERM Maturity Assessment Techniques

There are several techniques in the literature that can be utilised to analyse RM maturity. The multi criteria decision making (MCDM) techniques, such as, the analytical hierarchy process (AHP) (Sansakorn, 2017; Ardeshir & Mohajeri, 2018; Jefmanski & Sagan, 2021); the technique for order of preference by similarity to ideal solution (TOPSIS) (Sansakorn, 2017; Ardeshir & Mohajeri, 2018), and the fuzzy logic system (FLS) (Zhao, et al., 2013a; Park, 2013; Salawua & Abdullah, 2014; Zhao, et al., 2014b; Ardeshir & Mohajeri, 2018) are the widely applied techniques among many others. The fuzzy hybrid methods, namely, fuzzy TOPSIS (Salawu, 2016; Sansakorn, 2017; Ardeshir & Mohajeri, 2018; Jefmanski & Sagan, 2021) and fuzzy AHP (FAHP) (Ardeshir & Mohajeri, 2018) have also been employed to analyse risk and risk maturity. Further to the MCDM techniques, a number of studies have also applied the Likert scale to measure maturity using the statistical mean (Ciorciari & Blattner, 2008; Zou, et al., 2010; Pangeran, et al., 2012a; Low, et al., 2013; Beasley, et al., 2018; Hoseini, et al., 2019).

To overview the merits and demerits of the existing models, the most widely used methods are summarised in Table 2-13. Eventually, the suitable technique for measuring companies' RM capability was identified and described in section 2.7.1.

Table 2-13 Review of ERM maturity assessment techniques

Model (author)	Description of the model and its application	Main feature	Limitations	Applications in RM maturity analysis
AHP (Satty, 2018)	- Commonly applied in the group decision-making process - Commonly applied in many fields, especially in making comparisons (Sansakorn, 2017).	- Is used for selection and evaluation (Vaidya & Kumar, 2006) - Relatively easy to handle multiple criteria (Ishizaka & Labib, 2009)	- Rank reversal is the most debated problem of the method - The assumption of criteria independence (no correlation) (Ishizaka and Labib, 2009)	- Rarely applied - Mostly applied as a fuzzy hybrid, called FAHP (Tarroun, 2014; Salawa, 2016)
TOPSIS (Yoon & Hwang, 1981)	It compares a set of alternatives by identifying weights and normalising scores for each criterion; calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion.	Has attained a reputation in the MCDM arena because of its practicality and straightforward nature (Ardeshir & Mohajeri, 2018; Jefmanski & Sagan, 2021)	- Since it is applied based on human judgements and is represented with crisp numbers, it is non-obtainable and cannot provide precise numerical values and crisp data (Sansakorn, 2017).	Has practically applied for the RM competence measurement (Chen, 2000; Nadaban, et al., 2016; Sansakorn, 2017; Ardeshir & Mohajeri, 2018; Jefmanski & Sagan, 2021)
Fuzzy Logic (Zadeh, 1965)	Transforms linguistic variables into fuzzy sets replacing the crisp set (Hassall, 1999)	FLS has been applied to model the concept of human judgment due to the existence of uncertainty and ambiguity in expert opinions	- Since, the system is evolving several options in diverse features, there are different options to be considered for the same issues. For instance, there are different TFNs that can be considered which the users are supposed to check the appropriate one. - It is relatively a new concept. Subsequently collecting fuzzy data ease not easy as in Likert scales	Successfully applied for evaluating the RM maturity survey data (Zhao, et al., 2013a; Salawua & Abdullah, 2014; Salawu, 2016; Zhao, et al., 2014b).
Statistical Mean using Likert Scale	Converts qualitative values into quantitative values to make a best statistical analysis	Statistical mean, standard deviation and standard errors are used to compare results	- Data content from the Likert scale is an ordinal level; hence, all the levels defined in Likert scale cannot be categorically separated; meaning, one level overlaps with others where there is an ambiguous opinion (Vonglao, 2017) - Likert scale adopts a similar variance between two successive scale points, which is the most critical issue in the Likert scale (Pervez, et al., 2020). Hence, assessing risk with the existing simple Likert scale is not entirely appropriate (Pervez, et al., 2020; Vonglao, 2017). - Since it is applied based on human judgements and is represented with crisp numbers, it is non-obtainable and cannot provide precise numerical value	This method has been frequently applied to determine RM maturity (Ciorciari & Blattner, 2008; Zou, et al., 2010; Pangeran, et al., 2012a; Beasley, et al., 2018; Hoseini, et al., 2019)

2.7.1 The suitable technique for measuring companies' RM capability

Results that can be obtained in AHP, TOPSIS and other methods including the Likert's scale statistical mean values are in the form of crisp numbers. However, many things in the globe are vague and uncertain; hence, it is not always possible to accurately express opinions. In other words, human judgments are often indefinite and cannot provide precise numerical values and crisp³ data that could adequately simulate real-life decision-making problems (Andersen & Jessen, 2002). To address such issues and to precisely model these situations, Zadeh (1965) developed a modified set theory called fuzzy set theory, which transforms linguistic variables into fuzzy sets replacing the crisp set (Hassall, 1999).

The FLS is a set of mathematical principles, applied on the premise of this set theory, for knowledge representations based on degrees of membership (Chen & Pham, 2001; Lee, 2005). It has been applied to model the concept of human judgment due to the existence of uncertainty and ambiguity in expert opinions (Hassall, 1999; Park, 2013; Zhao, et al., 2013a; Ardeshir & Mohajeri, 2018;). This is because a fuzzy set theory can present vague knowledge by allowing mathematical operators to be applied to the fuzzy domain (Xia, et al., 2011; Zhao, et al., 2013a) through partial membership values ranging from 0 to 1 (Chen & Pham, 2001; Lee, 2005).

The review of the applicability of various techniques and methodologies for assessing risk, revealed FLS to be a highly relevant tool for the construction industry (Baloi & Price, 2003). As a result, it has been successfully applied for measuring the maturity of companies and projects in the industry. For example, Sansakorn (2017) employed it to measure the risk assessment and safety management in high-rise buildings. It was also employed to evaluate contractors' competitiveness (Tan, et al., 2011) and safety culture in construction projects (Ardeshir & Mohajeri, 2018).

³ Crisp set is a set with a membership function of either 1 (full membership) or 0 (non-membership). That is for a function X_A , of a set A , the membership function can be defined as

$$X_A = \begin{cases} 1, & \text{if } x \in A, \\ 0, & \text{if } x \notin A \end{cases}$$

Further, FLS has been satisfactorily applied to measure the ERM competence of construction companies as well (Zhao, et al., 2013a; Salawua & Abdullah, 2014; Salawu, 2016; Zhao, et al., 2014b). That is, Zhao et al. (2013a, 2014b) applied this method to measure the ERM maturity of Singapore-based Chinese construction organisations; results in both studies were revealed to be closer to the actual ERM practices of the surveyed companies. Salawu and Abdullah (2014) and Salawu (2016) also applied the FLS to assess the ERM competence of Nigerian domestic companies that were operating on highway construction projects.

As highlighted in Zhao, et al. (2014b), the maturity criteria ranking using the mean values of the Likert scale, as in Ciorciari & Blattner (2008), Pangaran, et al. (2012), Beasley, et al. (2018), Hoseini, et al. (2019) and Zou, et al. (2010), is not noticeably different from the ranking of the fuzzy model. However, mathematically, the statistical mean of ordinal values in the Likert scale has no meaning because ordinal values do not allow partial membership.

Hence, the FLS method appears to be a more useful method because it can handle the problems relating to the ambiguity and imprecision in human judgments and quantify the linguistic facet of the data. Of course, the fuzzy systems have some limitations as highlighted by Ross (2010). As the fuzzy systems are now, they can be described as shallow models in the sense that they are primarily used in deductive (shallow) reasoning. In contrast to this, in inductive reasoning, a general is inferred from the particular; whereas this method of inference is called deep because human knowledge is of a deep and substantial kind.

The basic concepts of the fuzzy theory related to the measurement of management maturity are briefly described as follows.

2.7.1.1 Fuzzy membership functions

Generally, a fuzzy set over a given set X of elements is defined by its membership function as denoted in Equation 2-1 (Chen & Pham, 2001):

$$\mu_A: X \rightarrow [0, 1] \quad \text{Equation (2-1)}$$

In many application areas, expert knowledge is expressed in terms of imprecise ('fuzzy') words or linguistic variables (Hassall, 1999). To quantify these linguistic variables, fuzzy numbers are used in the form of membership function (MF) (Lee, 2005; Rattanalertnusorn, et al., 2013). There are

various types of MFs, some of which are presented in the MATLAB Fuzzy Logic Toolbox interface (Mathworks, 2021), including trapezoidal (trapmf), Gaussian bell (gbellmf), triangular (trimf), and singleton. Of these, the triangular membership function (TMF) is the most widely used MF (Sansakorn, 2017; Zhao, et al., 2013a; Salawua & Abdullah, 2014) because it is easy to apply and transform into crisp numbers (Zhao, et al., 2013a; Ardeshir & Mohajeri, 2018).

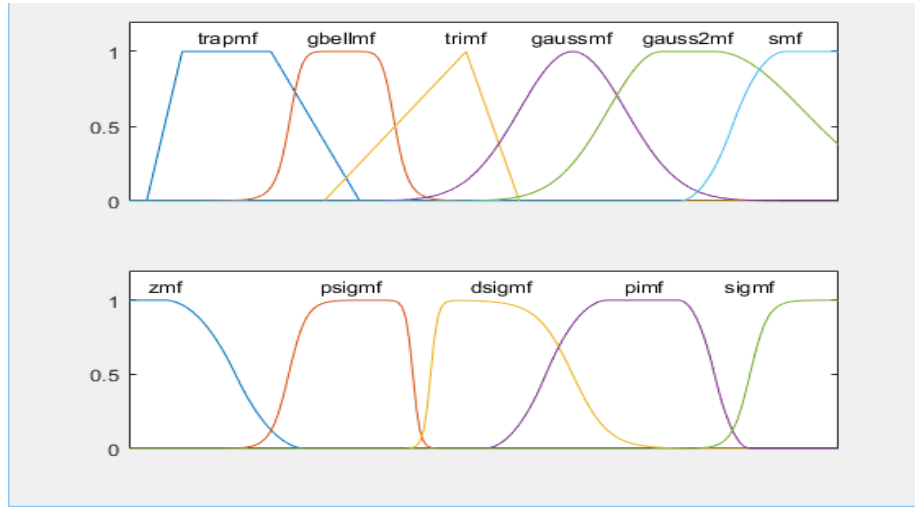


Figure 2-4 Types of membership functions

Zhao et al. (2013a) and Salawua & Abdullah (2014) have applied TMF to evaluate the ERM maturity of construction companies. This was also applied by Ardeshir and Mohaje (2018) to assess the safety culture among the job positions in a high-rise building.

2.7.1.2 Fuzzy operations

Let l , m , and u be the x coordinates of the three vertices of a triangle in a fuzzy set A presented in Figure 2-5. Then the TMF $\mu_A(x)$ of a fuzzy set A is defined by Equation 2-2.

$$\mu_A(x) = \begin{cases} \frac{x-l}{m-l}, & x \in (l, m) \\ \frac{u-x}{u-m}, & x \in (m, u) \\ 0, & \text{Othewise} \end{cases} \quad \text{Equation (2-2)}$$

Where, l is the lower bound, u is the upper bound, and m is the middle (strongest) membership function.

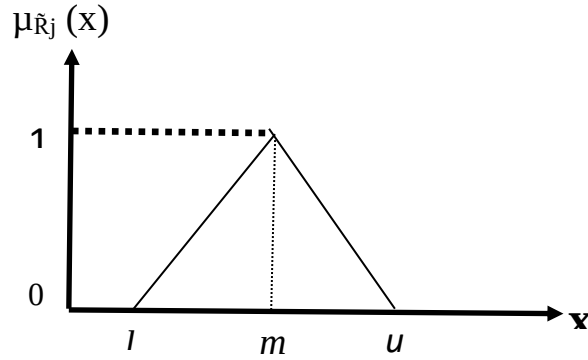


Figure 2-5 Membership function of a triangular fuzzy number

In the fuzzy environment, the fuzzy operations should be completed to return the entire process to the original real-world setting through the ‘fuzzification - fuzzy operation - defuzzification’ routine in the fuzzy logic system’s theory (Chen & Pham, 2001), as described in section 2.7.1.3. To overview the few of the available operations, by taking two TFNs, $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$, and a scalar factor λ , some of the basic fuzzy arithmetic operations could be described as follows (Chen & Pham, 2001; Lee, 2005; Chou, et al., 2011).

1. $M_1 \oplus M_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$
2. $M_1 \otimes M_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 l_2, m_1 m_2, u_1 u_2)$
3. $M_1 / M_2 = (l_1, m_1, u_1) / (l_2, m_2, u_2) = (l_1 / u_2, m_1 / m_2, u_1 / l_2)$
4. $\lambda M_1 = (\lambda, \lambda, \lambda) \otimes (l_1, m_1, u_1) = (\lambda l_1, \lambda m_1, \lambda u_1)$
5. $(M_1)^{-1} = (l_1, m_1, u_1)^{-1} = (1/u_1, 1/m_1, 1/l_1)$

2.7.1.3 Basic stages of a fuzzy logic system

Generally, FLS is the nonlinear mapping of an input data set to a scalar output data and commonly involves four stages (Figure 2-6): fuzzification, fuzzy rule base, fuzzy inference system, and defuzzification (Chen & Pham, 2001).

i) Fuzzification

Fuzzification is the process of transforming a crisp value into a fuzzy value (Lee, 2005; Ross, 2010). In the fuzzification stage, a crisp set of gathered input data is converted into a fuzzy set using fuzzy linguistic variables, and fuzzy membership functions.

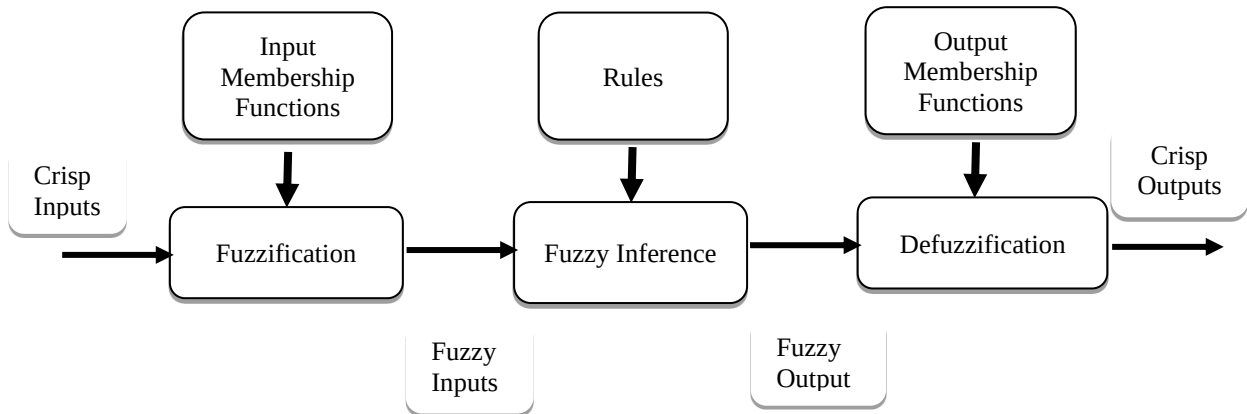


Figure 2-6 Fuzzy Logic System

ii) Composition/Aggregation

In the composition sub-process, all of the fuzzy subsets assigned to each output variable are combined to form a single fuzzy subset for each output variable. A set of relevant fuzzy operations are applied in composing output variables.

iii) Defuzzification

The output fuzzy number should be converted into a crisp number through a process called defuzzification (Lee, 2005) because fuzzy numbers cannot be ranked as they are not crisp values. There are several forms of defuzzification (Lee, 2005; Rattanalertnusorn, et al., 2013; Chen, et al., 2006) including the following:

- Centre of Sums Method
- Centroid Method
- Bisector of Area Method
- Weighted Average Method
- Mean of Maximum Method
- Graded Mean Integration Method

Lee (2001) pointed out that there is no systematic procedure for choosing an appropriate defuzzification strategy. Yet, centroid is perceived to be the most widely used technique (Cox,

1994; Ross, 2010; Zhao, et al., 2013a; Ku-Khalif, 2016; Pandey, et al., 2020). Comparing the effect of using different defuzzification methods, Naaz, et al. (2011) iterated that centroid is one of the most appropriate methods. Subsequently, Cox (1994) suggested that either the composite moments (centroid) or the composite maximum defuzzification technique would be adequate for model validation and verification, unless there is a reason to use a more advanced or a specialised method of defuzzification.

Therefore, centroid appears to be the most suitable technique for this study, which was also effectively applied by Zhao et al. (2013a, 2014b). Mathematically, the centroid technique takes the weighted sum of the domain and divides this by the sum of the truth vector to produce the expected value; and for a fuzzy set ‘A’ it is defined by Equation 2-3 (Voskoglou, 2016).

$$R \leftarrow \frac{\sum_{i=0}^n d_i \mu_A(d_i)}{\sum_{i=0}^n \mu_A(d_i)} \quad \text{Equation (2-3)}$$

Where R is the defuzzified value; d_i indicates the sample element; μ_A is the membership function; and n represents the number of elements in the sample. In a simplified form, for a triangular fuzzy number (a, b, c) of a TMF, Wang and Luoh (2000) demonstrated that the centroid position could be computed using Equation 2-4.

$$d = \frac{a+b+c}{3} \quad \text{Equation (2-4)}$$

Further, Ismail et al. (2019) have also pointed out that the following three equations are equivalent for the centroid method and a researcher can choose any of them.

- 1) $A = 1/3 * (a_1 + b_2 + c_3)$; or
- 2) $A = 1/4 * (a_1 + 2b_2 + c_3)$; or
- 3) $A = 1/6 * (a_1 + 4b_2 + c_3)$.

Zhao, et al. (2013a; 2014b) employed the first of the above options. The third alternative, defined as the graded mean integration method formulated by Chen, et al. (2006) for a TFN ($a_1 + b_2 + c_3$), was applied in the work of Chou, et al. (2011), Chen, et al. (2014), Pandey (2016) and Dhingra and Chattopadhyay (2021). Chen, et al. (2006) also verified that for symmetric fuzzy numbers, options (2) and (3) provide closer results.

2.8 Summary

This chapter has reviewed the literature, including the overall business environment and RM practices of the construction companies in developing countries, as well as the potential tools that can be used to measure companies' ERM capabilities. The review revealed that although construction is inherently more prone to risks and uncertainty, such risks are more pronounced in developing countries than in developed countries. This suggests the need for an appropriate RM that can adequately respond to such risks and uncertainties.

The results of the review also indicate that while ERM is becoming an effective tool to handle company risks in a holistic and integrated approach, there are still some gaps in the domain of ERM. First, although the dynamic and complex nature of risks in the construction industry demand continuous research, there is limited research related to the ERM in the industry in general and in developing countries in particular. It was also found that these limited studies were concentrated on the financial institutions in developed countries. Second, ERM has not yet been widely implemented in the construction industry, while the industry is conceded to be a prime candidate to adopt it.

Third, despite several ERM maturity models being established over the past two decades, there is significant inconsistency between most of these models. Further, most of the existing models do not provide their development procedures. The other issue worth mentioning is that there was only a limited attempt to validate the usefulness of these models.

The lack of suitable maturity models on one hand and the inadequacy of empirically validated ERM³ on the other, calls for further study on the ERM discipline. These all suggest the need to develop a maturity model for a wider scope of applications through a defined model development procedural framework.

The critical review of the maturity measurement techniques has indicated that the fuzzy logic system is a suitable method for analysing fuzzy data associated with ERM³ evaluation.

3 METHODOLOGY

3.1 Introduction

The literature review demonstrated that there is no suitable ERM³ that can be consistently applied by all companies in the construction industry. To address this gap, this chapter provides the research methodology designed to develop a new framework that can be used for evaluating the ERM capability of construction companies. The chapter contains the following five sections:

- **Research design** (section 3.2): this describes the overall conceptual structure within which the research is conducted.
- **ERM maturity model development framework** (section 3.3): discusses theories and procedures which need to be considered in developing the most appropriate ERM³s.
- **Proposed ERM³** (section 3.4): this section presents the proposed model for measuring the ERM competence of construction companies. Two essential components of the maturity model, namely ERM maturity attributes and maturity levels are described.
- **Measuring the ERM maturity of a company** (section 3.5): provides the research methods employed in the case study conducted to verify the usefulness of the proposed model.
- **Summary** (section 3.6): summarises the overall content of the chapter.

3.2 Research Design

A mixed research design that involves both qualitative and quantitative data was utilised in this study as it helps to better understand research problems (Faryadi, 2019). A framework shown in Figure 3-1 was developed for the study containing five stages described below:

1. **Formulating the research aim and objectives:** the aim and objectives of the research were defined in Chapter One.
2. **Review of relevant literature:** the construction industry in developing countries is reviewed to better understand the state of the industry, with a special focus on the business environment under which the construction companies operate. The literature was also reviewed to grasp the concepts of risk and RM. The potential benefits of ERM and the

critical barriers to ERM implementation were also reviewed and discussed. Existing ERM³s and other relevant models, such as organisational design models (ODMs) and business excellence models (BEMs) were also critically reviewed. Further, the data analysis techniques suitable for analysing the ERM maturity data were appraised.

3. **Developing a new ERM³:** based on the existing ERM³s, ERM standards and guidelines, ODMs and BEMs, a new ERM³ was developed, which is presented in this chapter.
4. **Case study:** the usefulness of the ERM³ developed in this chapter was tested by evaluating the RM competence level of EDCs operating in major federal road construction projects (MFRCPs) in Ethiopia. The case study is presented in Chapter 4. The key findings of the study are discussed in Chapter 5.
5. **Conclusions and recommendations:** based on the key findings of the study, conclusions and recommendations are established in Chapter 6.

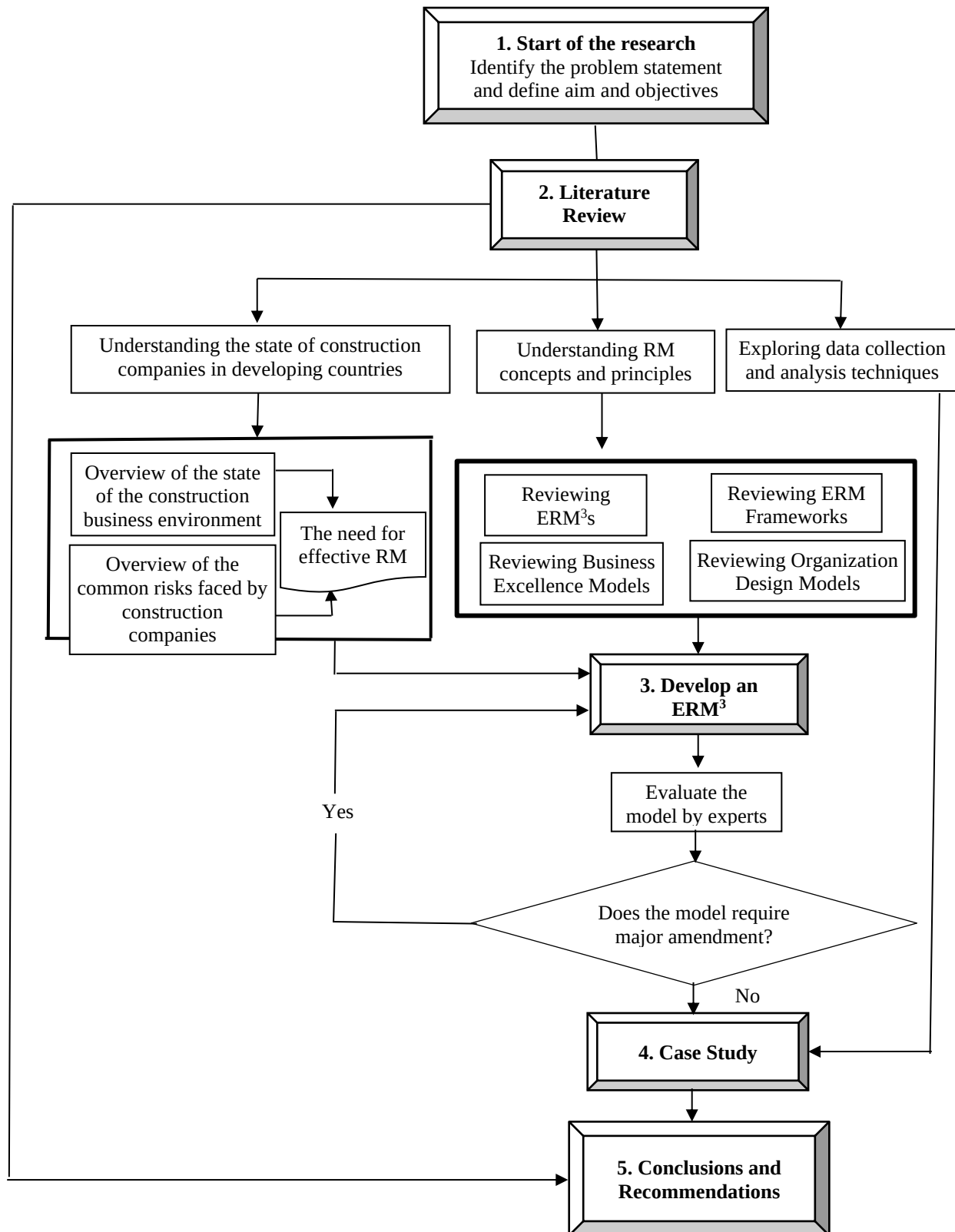


Figure 3-1 The research framework

3.3 ERM Maturity Model Development Framework

It is clear from section 2.6 that it is always important to have a suitable procedural framework to develop a successful mature model. To this end, the procedural framework illustrated in Figure 3-1 was designed based on the four steps adapted from Becker, et al. (2009) and Proenca, et al. (2017) as discussed in section 2.6.

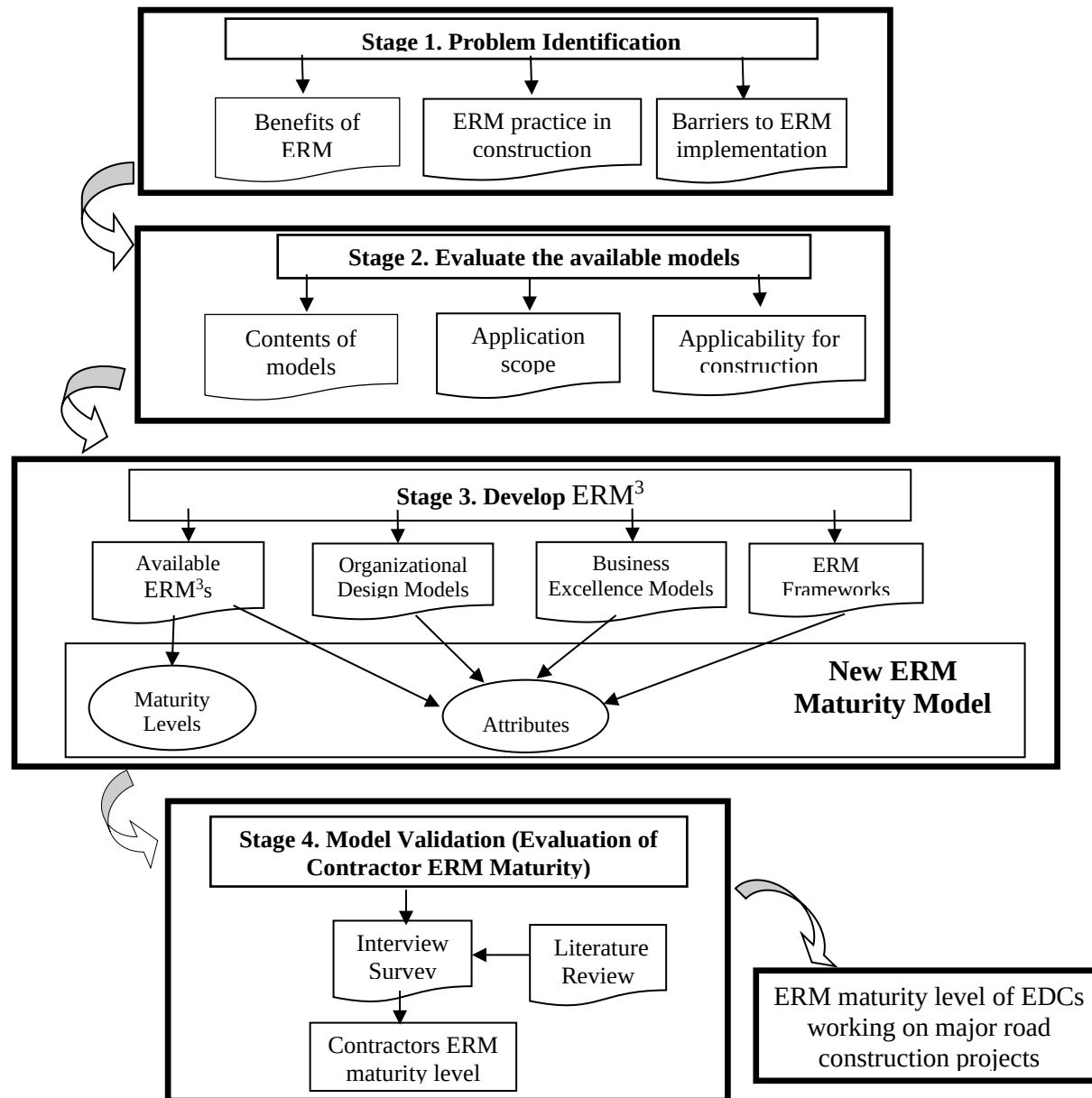


Figure 3-2 ERM Maturity model development framework

3.3.1 Step 1 Problems' identification

At this stage, the application domain, the application conditions and the expected benefits of the maturity model must be defined before starting the development of an ERM³ model. This facilitates the design of a maturity model that can be consistently used to evaluate the ERM capability of construction companies.

3.3.2 Step 2 Evaluating existing models

In order to support the need to develop a new maturity model or simply to improve an existing maturity model, some existing maturity models were evaluated and compared in sections 2.5.1 and 2.5.2. The evaluation was based on some specific criteria, including, the procedure followed to develop the models, the contents of the models and their scope of applications.

In order to provide a consistent and precise problem definition, the first RM maturity model developed by Hillson (1997) was overviewed. As discussed in section 2.5.2.1, Hillson's model was established as a matrix of four attributes (culture, process, experience and application) and four maturity levels (naive, novice, normalised and natural). Hence, the consistency and suitability of the existing 22 RM maturity models identified during the literature review, were assessed by comparison with this baseline model. The procedures adapted by these models were also evaluated in terms of the frameworks established.

The result of the review indicated that many of the models are generally fairly inconsistent in terms of content, the types and designations of maturity attributes, and the maturity levels used. In addition, procedures are not clearly defined in many of the models concerning how they were developed. The main inconsistencies exhibited in the models are:

The contents of maturity attributes

- As discussed in section 2.5.1 and shown in Appendix C, there exists a wide inconsistency both in the number and designations of attributes included in most existing models. That is to say, there are several models containing a different number of attributes starting from three in Ren and Yeo (2004) to about 16 in Zhao et al. (2013a). Further, the designations given to the attributes presented in these models vary.

- While a number of models (RISK – SIG, 2002; IACCM, 2003; Ferrando, 2007) were adapted from the four attributes (culture, process, experience and application) of the baseline model (Hillson's model), some other models were also developed by combining all or part of these four attributes with other new attributes.
- Some models, in addition to their limitations in terms of containing the key attributes, include some detailed and specific RM factors as key attributes that could instead be used as diagnostic indicators.
- Importantly, unlike the baseline model, a few recent models have attempted to introduce some new attributes, such as policy and strategy and, structure and governance.

Contents of maturity levels

- Major differences were found among the existing models both in the number and designation of the maturity levels adopted. That is, while a four-stage maturity is the most dominant, generally, four to six stages of maturity have been adopted in the existing models. A variety of terms were also used to designate the same maturity levels.

Model development procedures

- In the majority of the models, there was only a little effort needed to set adequate procedures when developing the maturity components. Further, many of the models have not been empirically validated.

Applicability scope

- While many models were developed for a wide range of applications, some models were designed for companies in specific industries, including construction.

According to the maturity model development approach of Becker et al. (2009), a new maturity model should be established if no existing model is capable or the improvement of an existing one is insufficient in addressing the identified problem. Therefore, taking into account the major shortcomings identified in the existing models above, it was found necessary to develop a new model applicable to companies in the construction industry, especially in developing countries.

3.3.3 Step 3 ERM maturity model development design

The comparison of the existing maturity models with the problem definition suggests a design strategy that combines several models into a new one. Further, as discussed in section 2.5.3, the recent advancements in the ERM standards highlight the need to introduce ERM maturity dimensions such as policy and strategy, and structure and governance as the key attributes of an ERM³. The literature review also indicated that there are some other models that are closely related to the ERM³s, namely ODMs and BEMs; this further enforces the importance of considering strategy and structure in the ERM³s. In view of this, a new model was developed as described in section 3.4.

As suggested in De Bruin, et al. (2005) and Becker, et al. (2009), it would be more helpful if an iterative approach was employed to develop the model by further consulting experts using questionnaires or in workshops to ensure that the identified ERM maturity attributes and diagnostic indicators are relevant and exhaustive to adequately measure a company's RM competence. However, due to the limited awareness of the ERM discipline in the road construction sector in Ethiopia, it was considered that such an approach would be problematic to achieve for the prototype model. How a revised model could be developed using such an approach and what some of its attributes are described in the discussion chapter (see section 5.2.5). Hence, for the developed prototype model the attributes and diagnostic indicators were identified based on a comprehensive literature review.

3.3.4 Step 4 Maturity model evaluation

The final step of the maturity model development procedure was the evaluation of the usefulness of the proposed model. This is done in Chapter 4, by the use of a case study involving 26 companies to self-assess their ERM practices.

3.4 Proposed ERM³

To address the major shortcomings exhibited in the existing models, appropriate attributes were defined from the existing ERM³s, RM standards, ODMs, and BEMs identified in the literature, using the framework illustrated in Figure 3-3. Maturity levels were also determined from existing maturity levels. This comprehensive approach is unique because existing models described in the

literature were established by considering only a few existing maturity models or some RM standards, separately.

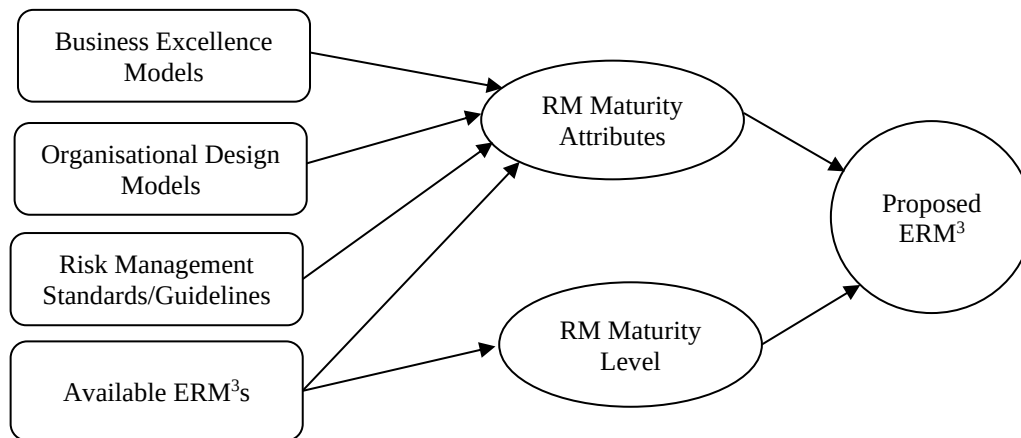


Figure 3-3 Proposed framework for developing the ERM³

3.4.1 Defining ERM attributes

As highlighted in section 2.5.1.1, the four conventional attributes (culture, process, competence and implementation) are the most widely used. Further, attempts have been made in more recent ERM³s to introduce policy and strategy as well as structure and governance as key RM maturity dimensions, but in different forms. For example, policy, governance and leadership were considered as one attribute in ORR and HSL (2017); strategy and policy were included in Hoseini, et al. (2019) and strategy and governance were defined as two separate attributes in OECD (2021). The latest survey by Deloitte (2021) to assess the ERM competence of companies in the UK also incorporated attributes related to the above two attributes, such as ‘risk strategy and reporting’ and ‘the structure of the risk function’. The recent versions of ISO 31000 RM standard (ISO, 2018) and COSO ERM framework also indicated the importance of incorporating these new attributes (COSO, 2017). Apart from this, policy and strategy, and structure and governance were found to be the essential components in the ODM and BEM models.

Based on the literature review, six key ERM maturity attributes are proposed for the ERM³ developed herein, incorporating two new attributes (policy and strategy, and structure and

governance) with the four conventional attributes (see Table 3.1). Each of these attributes are briefly discussed below with a special focus on the two newly proposed ones.

Table 3-1 Proposed attributes

No.	Proposed Attributes	Main Sources				Remarks
		Conventional ERM's	ERM frameworks	ODMs	BEMs	
1.	Policy and Strategy		√	√	√	Newly proposed attributes
2	Structure and Governance		√	√		
3	Culture	√	√	√		Most frequently used in existing models
4	Process	√	√	√	√	
5	Experience/Competence	√	√	√	√	
6	Implementation	√	√	√	√	

1. Policy and strategy

Risk management policy is a statement of the overall intentions and directions of an organisation in relation to its RM activities (ISO, 2009). According to Hopkin (2010), policy will set out the overall strategy of the company towards RM, define RM roles and responsibilities and set out the protocols that should be followed. According to AS/NZS (2004), an organisation's board or executive should define and document its policy for managing risk. Strategy, on the other hand, is the set of actions a company plans in response to, or in anticipation of, changes in its external environment (Waterman, et al., 1980).

The literature review highlighted that an organisation's policy and strategy are important for effective RM (Terzi & Posta, 2010; Gibson & Young, 2012; Kikwasi, 2018; Yazid, et al., 2018), and indeed Gibson and Young (2012) suggested that strategy is the most essential factor for operational RM. A formal ERM policy and framework according to Terzi and Posta (2010) enables challenges to be overcome that are related to creating common understanding and harmonising individual RM practices. In view of this, Gibson and Young (2012) contended that an organisation should have well-defined and documented operational RM policies, as these are critical to the success of the implementation of RM. The most recent RM survey to provide an up-to-date view of current UK RM practices, including the level of RM maturity, technology enablement and the

impact of COVID-19 on the risk function strongly suggested that clear vision and strategy are essential for effective RM.

Accordingly, the availability of an organisation's RM policy and strategy, and its RM objectives and risk appetite were used to assess the status of the organisation in the policy and strategy dimension of ERM.

2. Structure and governance

The structure of an organisation, according to Waterman et al. (1980), is about the distribution of power and authority across the organisation's hierarchy. Whereas governance is the process of decision-making (OECD, 2021). Although structure and governance have been rarely considered as core ERM attributes, several studies highlight them as critical success factors for effective RM (Yaraghi and Langhe, 2011; Gibon and Youang, 2012; Agoi, 2013; Banasadeh et al., 2014; Yazid et al., 2018). The lack of an appropriate governance and structure to support implementation was reported to be a critical factor in contributing to the poor ERM practices as reported in some UN agencies (Terzi & Posta, 2010). Hence, Terzi and Posta (2010), COSO (2017) and ISO (2018) have suggested that organisations establish appropriate governance and structures and determine roles and responsibilities to facilitate their RM endeavours. In the sectors where RM has reached a relatively better level of maturity, such as the financial institutes, companies' risk management is handled at an executive level, namely by the Chief Risk Officers.

3. Culture

The IRM (2012) has offered a working definition of risk culture which is: *'the values, beliefs, knowledge and understanding about risk, shared by a group of people with a common purpose'*. The International Finance Corporation (IFC, 2015) and Deloitte (2012) also referred to *culture* as *'the general awareness, attitudes and behaviors of the management and employees towards risk'*. According to the COSO ERM framework, culture pertains to ethical values, desired behaviors, and understanding of risk in the entity (COSO, 2017).

Hence, the RM culture of an organisation could be evaluated in terms of the awareness and belief of the staff on the value of implementing ERM within the organisation, as well as the attitude and commitment of the leadership to practise ERM and effectively communicate this to colleagues.

4. Process

The RM process is a set of procedures followed in RM endeavours. This attribute is discussed in detail in 2.3.3 containing the different stages, namely, risk identification, risk analysis, risk response, and risk monitoring and evaluation. Hence, process definitions should precisely describe the sequence of activities and tasks that must be performed to execute the desired risk response.

5. Competence

Competence measures the collective proficiency of an organisation (Deloitte, 2012). According to Akkemans et al. (2013), an organisation's competence contains knowledge, skills and abilities. Further, Protiviti (2006) conceived that competence concerns employees within an organisation having requisite knowledge, expertise and experience that is used to execute the entities' process. This suggests that RM competence of an organisation could be measured in terms of the RM knowledge, skill, and experience of employees engaged in RM activities and training provided to enhance the competence of these employees.

6. Application/Implementation

The application of ERM is the practical implementation of RM at the company level. The measurement of companies' RM maturity focuses on evaluating the status of RM applications in the company. This includes the formalisation of RM practices, the scope of RM applications and dedication of resources for RM purposes.

3.4.1.1 ERM maturity indicators

In order to assess a company's ERM competence with detail and transparency, each of the attributes was further broken down into sub-attributes (i.e. diagnosis indicators). To this end, taking into account the above and following a detailed review of ERM3 and RM standards available in the literature, 36 ERM maturity diagnostic indicators were identified under these six proposed attributes. Figure 3-4, briefly illustrates the relationships of the indicators identified with the six attributes, and the details are presented in Table 3-4. As shown in Table 3-2, four (diagnosis) indicators were used for each of the three attributes (policy and strategy, structure and governance, and competence). Six, eight and ten indicators were identified for the culture, process, and implementation dimensions, respectively.

This model is also believed to minimise the mixing up of indicators that are observed in some models due to the absence of certain essential attributes. A look at the case presented in Ching, et al. (2020) clearly shows how indicators that can be grouped as part of the policy and strategy, and structure and governance attributes were presented as components of a culture attribute. Ching, et al. (2020) have considered six indicators under the risk culture attribute: risk policy and risk appetite; key risk indicators; accountability; incentives; risk language; and internal relationships. However, the IRM has devoted an independent guideline that entirely deals with risk culture. This guideline clearly states that risk culture contains subsidiary components, including: values, beliefs, knowledge and understanding. However, Ching, et al. (2020) have included, for example the risk policy and risk appetite as indicators of culture that can instead be categorised under the policy and strategy attribute proposed in this model. Accountability is also an indicator that could be included in the structure and governance attribute.

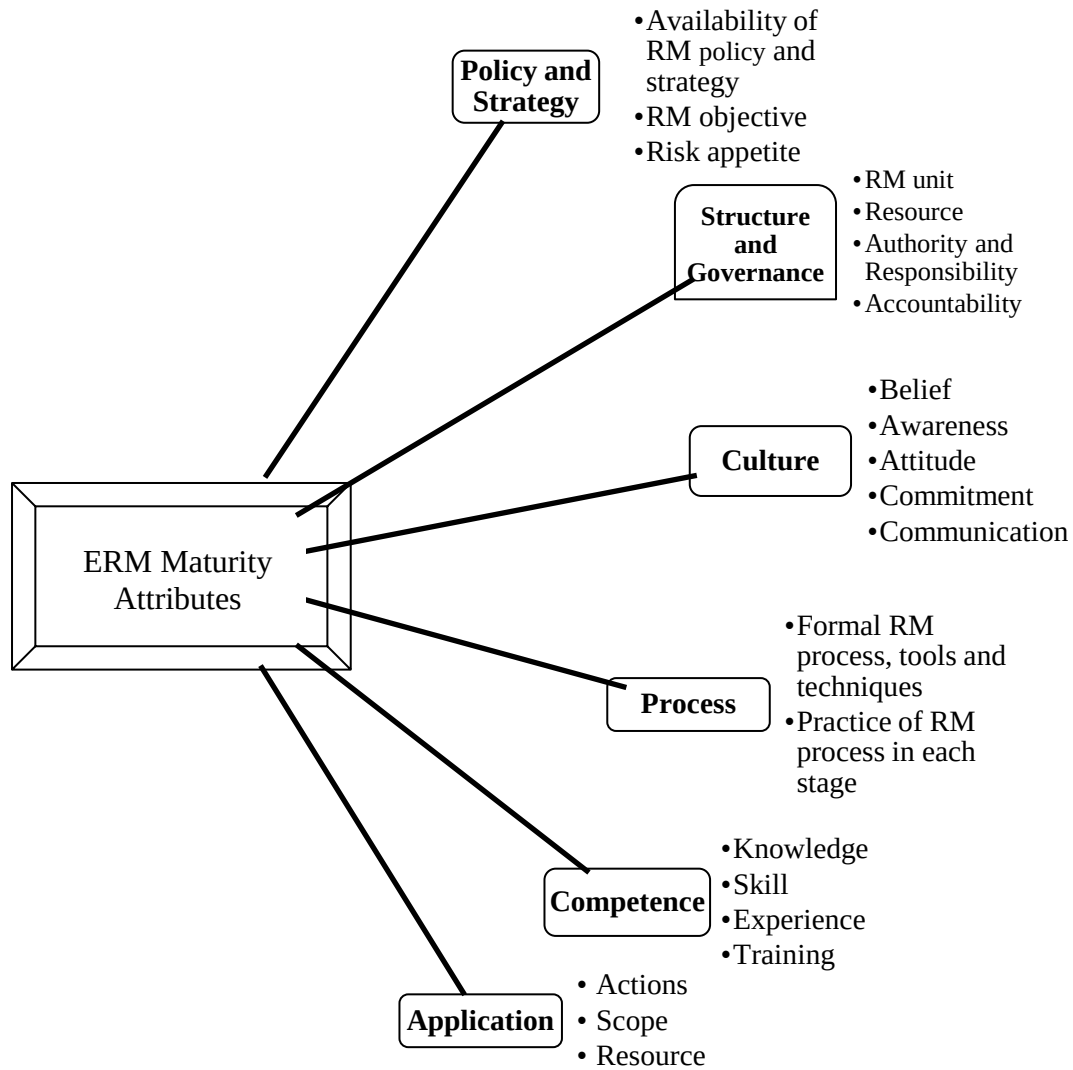


Figure 3-4 Proposed ERM maturity attributes and diagnostic indicators

Table 3-2: Identified ERM maturity diagnostic indicators

Attribute	Indicator	References
Strategy and Policy	Existence written of policy and strategy	(Beasley, et al., 2018; Gates, et al., 2012; Pangeran, et al., 2012a; Hopkin, 2010; AS/NZS, 2004; Hoseini, et al., 2019)
	Availability of defined RM objectives	(COSO, 2004 ; COSO, 2017; Hopkin, 2010; AS/NZS, 2004; Hoseini, et al., 2019)
	Availability of risk appetite	(COSO, 2017; Gates, et al., 2012; Gibson & Young, 2012; Hopkin, 2010)
	Alignment of risk policy and strategy	(COSO, 2017; ISO, 2018; Hopkin, 2010)
Structure and Governance	Integration of RM in organisation's structure	(IRM, 2012; Altuntas, et al., 2011; ISO, 2018)
	RM role and responsibility	(IRM, 2012; Wibowo & Taufik, 2016; ISO, 2018; Terzi & Posta, 2010; AS/NZS, 2004)
	RM accountability	(IRM, 2012; ISO, 2018; AS/NZS, 2004)
	RM reporting/communication scheme	(Beasley, et al., 2018; Gates, et al., 2012; Hopkin, 2010)
Culture	Belief in value of RM	(IACCM, 2003)
	Awareness of RM	(Gates, et al., 2012; Pangeran, et al., 2012a; IACCM, 2003; IRM, 2012)
	Attitude of the leadership to RM	(Pangeran, et al., 2012a; IACCM, 2003; IRM, 2012)
	Commitment of the leadership	(IRM, 2012; Wibowo & Taufik, 2016)
	Availability of core values/principles	(COSO, 2017)
	Risk information sharing culture/communication	(IACCM, 2003; Wibowo & Taufik, 2016)
Process	Availability of formal RM process	(IACCM, 2003)
	Availability of RM guidelines and standards	(Pangeran, et al., 2012a)
	Availability of risk identification techniques	(Altuntas, et al., 2011; Wibowo & Taufik, 2016)
	Availability of risk analysis techniques	(Altuntas, et al., 2011; Altuntas, et al., 2011)
	Availability of risk response strategy	(ISO, 2018)
	Availability of risk monitoring and evaluation techniques	(Pangeran, et al., 2012a; IACCM, 2003)
	Availability of risk recording techniques	(ISO, 2018; IRM, 2018)
	Overall effectiveness RM process	(Pangeran, et al., 2012a)
Competence	RM knowledge of staff	(IRM, 2012; Pangeran, et al., 2012a; IACCM, 2003)
	RM skill of staff	(IRM, 2012; Pangeran, et al., 2012a; IACCM, 2003)
	RM experience of staff	(IRM, 2012; Pangeran, et al., 2012a)
	Training on RM	(Pangeran, et al., 2012a; IACCM, 2003)
Implementation	Overall RM practice	(IRM, 2012)
	Level of information used in decision making	(IRM, 2012)
	Scope of RM practised (comprehensiveness)	(COSO, 2017; ISO, 2018; IRM, 2018)
	Level of integration of RM in different units	(ISO, 2018; COSO, 2017; IACCM, 2003)
	Adequacy of RM resource	(Pangeran, et al., 2012a; IACCM, 2003; Terzi & Posta, 2010)
	Level of risk identification practice	(Pangeran, et al., 2012a)
	Level of risk analysis practice	(Pangeran, et al., 2012a)
	Effectiveness of risk responses	(IACCM, 2003)
	Level of risk monitoring and evaluation operations	(Pangeran, et al., 2012a; IACCM, 2003)
	Risk recording practices	(ISO, 2018; IRM, 2018)

3.4.1.1.1 Mutual exclusiveness and collective exhaustiveness (MECE) of the indicators

Efforts were made to ensure that ERM maturity indicators (Table 3-2) are MECE (mutually exclusive and collectively exhaustive). The three important stages of the MECE feature selection scheme, that is, independence, importance, and completeness, adopted in Lee and Chen (2018) were considered through a detailed literature review to ensure that the overall identification and categorising of these indicators satisfies the MECE principle.

Concerning the need for the indicators to be collectively exhaustive, it was attempted to ensure a comprehensive collection of the indicators without leaving alternatives gathering them from the existing models and associated literatures. To achieve this, a systematic approach was adopted to obtain the relevant literature. To mention, the Google Scholar and ResearchGate search engines were utilised to search literatures related to the RM diagnostic indicators. The list of references in column 3 of Table 3-2 shows that a range of relevant literatures were consulted to identify the indicators. In term of the mutually exclusiveness, it was attempted to reduce complexity by avoiding overlaps among the indicators by categorising them based on the basic concepts and definitions of the six ERM maturity attributes. For instance, indicators such as risk identification, risk analysis and risk response were included under the ‘process’ attribute based on the basic definition of risk management process itself. Similar principles were also employed to define the indicators of the remaining attributes.

3.4.2 Maturity levels

As described in section 2.5.1.2 and shown in Table 2-9, there is a major inconsistency in the maturity levels of existing models, mainly in the numbers and designations. That is, while a four-stage maturity is the most dominant, generally, four to six stages of maturity have been utilised in the models identified from the literature.

There is some discussion in the literature regarding the number of maturity levels. The details of the arguments are presented in section 2.5.1.2. For instance, providing an odd number of levels might guide respondents to select the middle one (Zou, et al., 2010). According to Willits et al. (2016), the meaning of the middle category in an odd number of levels might be regarded as ambiguous which could be interpreted as: ‘has no opinion’, ‘is indifferent/does not care’ and/or ‘does not understand the question’. Further, evaluating maturity using a scale with more than four

levels would increase ambiguity according to Caiadoa (2016) and OECD (2021). It might not also be easy to establish a clear demarcation between the first two levels, in an approach which has five levels like in Zou, et al. (2010).

In view of the above, this research has considered a four-level maturity to be adequate to measure a company's RM maturity. In consideration of the vocabulary definitions of the terms and their application in the other models, '*naive*', '*novice*', '*managed*' and '*optimised*' were used to define these four maturity levels, in the order of precedence from least mature to most mature. The definitions of these terms are further expanded below. Since ERM is a continuing endeavour, the upward arrow shown in Figure 3-5 is used to illustrate that achieving a maturity level may be considered to be a progression towards improving the RM activities of a company.

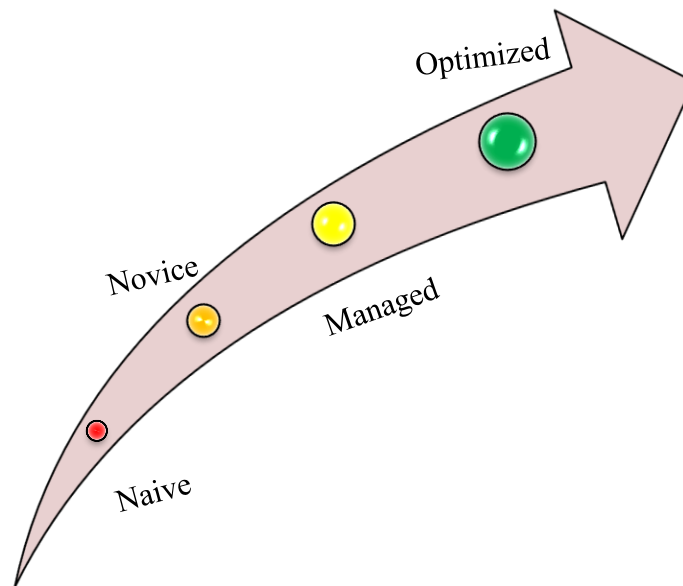


Figure 3-5 Proposed risk management maturity levels

1. **Level 1 (Naive):** this is the lowest level characterised by an unstructured, informal, inconsistent, ad hoc and reactive RM approach (Hillson, 1997; IACCM, 2003; Loosemore, et al., 2006; Ongel, 2009; Caiado, et al., 2016).

2. **Level 2 (Novice):** organisations at this level of maturity have characteristics of structured implementation, basic architecture, some reporting and repeatable management processes (Hillson, 1997; IACCM, 2003; Loosemore, et al., 2006; Ongel, 2009; Caiado, et al., 2016).
3. **Level 3 (Managed):** the term ‘managed’ in this model implies ‘*succeed in surviving or in achieving something despite difficult circumstances*’. Generally, this is the stage most organisations aspire to achieve. The main features of companies at this level comprise: ERM capabilities and practices are generally well established in the culture and formal processes of the administration; ERM and business unit risk management are standardised, coordinated and promoted consistently; risk information is increasingly taken into account in decision making and resource allocation (Hillson, 1997; IACCM, 2003; Loosemore, et al., 2006; Ongel, 2009; Caiado, et al., 2016; ORR & HSL, 2017; Hoseini, et al., 2019; OECD, 2021).
4. **Level 4 (Optimised):** this is the highest level of maturity where ERM culture is perceived to be fully embedded across the organisation. This is also characterised by fully proactive ERM handling and resourcing, a fully integrated ERM practice with strategy and performance management and reinforced through the organisation’s culture at all levels. Innovations that exploit the best RM practices are continuously developed, identified and transferred throughout the organisation. In companies that attain this level, there is active use of information to improve organisational processes, learn and disseminate lessons and gain competitive advantage (Hillson, 1997; IACCM, 2003; Loosemore, et al., 2006; Ongel, 2009; Caiado, et al., 2016; ORR & HSL, 2017; Hoseini, et al., 2019; OECD, 2021).

Generally, as highlighted in Farrell and Gallagher (2015), a clear distinction could be drawn between the first two maturity levels (naive and novice) and the last two levels (managed and optimised). That is, naive and novice maturity levels feature an RM process that lacks discipline and company-wide coordination. Ren et al. (2014) have characterised the bottom three levels of their five-stage maturity level as the foundational tier to achieve increasing security with systems’ capability in terms of process and technology applications.

In contrast, companies at the managed and optimised maturity levels have established, integrated, and repeatable RM practices in place throughout the enterprise, with engagement coming from senior management. In addition, a risk framework is generally in place and risk-based discussions

are embedded at a strategic level with effective communication throughout the enterprise. Enterprises at levels 3 and 4 are engaged in a more holistic and integrated approach to risk, which aligns with the general ERM aims (IACCM, 2003; Farrell & Gallagher, 2015; OECD, 2021). The higher level involves increasing robustness and innovation, as well the most advanced RM techniques (Ren, et al., 2014).

3.4.3 ERM maturity attribute – Maturity level matrix

To make it easier to develop questionnaires for evaluating the RM maturity of a company according to the six attributes identified above, the matrix shown in Table 3-3 was developed. The descriptions in Table 3-3 are defined based on the literature and are adapted mainly from (Hillson, 1997; IACCM, 2003; Ongel, 2009; Loosemore, et al., 2006; Caiado, et al., 2016; Coetzee & Lubbe, 2013; Liu, et al., 2018; Hoseini, et al., 2019).

Table 3-3: Risk maturity matrix

ATTRIBUTE	LEVEL OF MATURITY			
	Naive	Novice	Managed	Optimised
Policy and strategy	No RM policy and strategy No RM vision objective	An attempt to incorporate RM policy and strategy into other disciplines	There is clear policy and strategy on RM but demands updating There are clear objectives on RM	RM policies and strategies proactively revised These policies and strategies are aligned at all levels Every RM activity is done based on the policy and strategy of the organisation
Structure and governance	No clear structure and governance regarding RM	An ad hoc assignment while the need arises No clear responsibility and accountability are set	RM is considered as a core function in the company The required resources are indicated in the structure (but not adequately assigned) Authority, responsibility and accountability is clearly defined	Overseen by the board of directors and executive management Lead by Chief Risk Officer or Equivalent Required resource dedicated
Culture	No risk awareness on the need for RM Risk averse No top management support or involvement Risk fear culture Lacking commitment Resistance/reluctant to change	Some understanding/ awareness Partial acceptance of RM Upper management encourages but doesn't require RM Cautious approach, reactive	Benefits of RM recognised, accepted and proven Prepared to take appropriate risks Informal Communication to the top management Limited need for external support	Intuitive understanding RM widely seen as a core business function Full top – down commitment to RM Proactive RM encouraged and rewarded Top management use risk information for decision making
Process	No formal RM process	No generic risk processes No structured and documented approach to deal with risk Inconsistent RM processes across different management systems.	Generic process applied to most projects Consistent approach but scalable Tailored to specific needs	Risk – based business process Fit for purpose Best of breed Total RM permeating entire business Continuously improved RM processes
Competence	No understanding of RM languages or principles No understanding or experience in accomplishing risk procedures	Partial knowledge on RM languages and principles No analysis capacity RM tools are used in some projects	Widespread understanding of RM languages or principles Mastering basic RM tools and techniques	Intimate and developing understanding of RM languages and principles All staff risk aware and capable of using basic risk skills

ATTRIBUTE	LEVEL OF MATURITY			
	Naive	Novice	Managed	Optimised
	No RM tools in use No experience in implementing RM procedures	Limited to individuals who may have had little or no formal training	Qualitative analysis is widely practised and some basic quantitative analysis	Complex quantitative analysis using sophisticated probabilistic and simulation techniques Extensive experience Excellence in RM knowledge management
Application	No risk identification and risk analysis performed No dedicated resource No risk tools in use No or very few managers practice RM	Inconsistent application Inadequately resourced Cautious approach, reactive Process driven Discrete RM in in different management tasks, PM tasks and corporate tasks RM only in some units	Routinely and consistently applied RM Adequately resourced RM focused on operational risks Integrated tools and methods	Applied across entire business Proactively resourced Measured for improvement Risk based reporting and decision

Extracted from:

Hillson (1997); IACCM (2003); Loosemore, et al. (2006); Ongel (2009); Caiado, et al. (2016); Coetzee & Lubbe (2013); Liu, et al. (2018); Hoseini, et al. (2019)

3.5 Measuring Companies' ERM Capability (Case Study)

3.5.1 Research instruments

Using a case study, the applicability of the proposed framework was assessed using specific research instruments (i.e. data collection, analysis and interpretation techniques). These are discussed in the following subsections.

3.5.1.1 Data collection

In addition to the information obtained from the literature, experts were consulted to verify the usefulness of the proposed model. Group discussions and interviews were used to gather opinion from experts on the overall experience of the EDCs in terms of implementing ERM.

3.5.1.1.1 Group discussions

Initially, it was planned to hold a workshop with the participation of sufficient experts and have a discussion on the proposed model. The discussion was also intended to obtain an overview of the perception of the Ethiopian road sector about the benefits of the ERM and evaluate the actual ERM implementation level. However, it was not possible to realise this due to the COVID-19 gathering restrictions imposed in the country. Instead, three separate discussions were held involving two senior experts from three different companies. To ensure that participants had the appropriate knowledge and experience, experts that had at least 10 years of experience in the road sector were selected as highlighted in Table 3-4. It was also attempted to involve employees at the executive levels. To maintain confidentiality, arbitrary names were used to designate the companies involved in the discussion.

Table 3-4 Details of group discussions and profile of experts

Company	Expert	Profile of experts	
		Position	Experience in the road sector
Company A	Expert A1	CEO	More than 20 years
	Expert A2	Technical Manager	15-20 years
Company B	Expert B1	D/CEO	15-20 years
	Expert B2	Contract Manager	10-15 years
Company C	Expert C1	Department Head	15-20 years
	Expert C2	Project Coordinator	10-15 years

The discussions were focused on the experts' general awareness of the benefits of ERM, the ERM practice in their companies, and potential barriers to implementing ERM. Experts were also requested to comment on the contents of the proposed model.

3.5.1.1.2 Interview

An interview is one of the most common primary data collection instruments in survey-based research (Creswell, 2009; Kothari & Garg, 2014; Adhabi & Anoze, 2017; Faryadi, 2019). An interview enables a frank and an open discussion, which is essential for an accurate self-assessment to be made (OECD, 2021). Individual interviews conducted throughout different levels of an organisation according to Farrell and Gallagher (2015) is also an important technique for providing a thorough, valid, and clear picture of a company's ERM status.

Among the various forms of interviews, the structured interview is recommended by the Institute of Risk Management (IRM, 2012) as a means to assess a company's RM practices and culture. This method has also been successfully applied by several researchers, including, Ferrell and Gallagher (2015) who utilised the method to evaluate the ERM practice in the leading insurance companies in the USA. This was also applied by Pangerna et al. (2012) to investigate the RM capability of Indonesian local public sector organisations that were potentially involved in public private procurement schemes for water supply. Therefore, a structured interview (see Appendix D) was used in this research.

As suggested in Faryadi (2019), the questionnaire was designed to ensure the collection of uniform and comparable data. The questionnaire was developed to enable an interviewee to assess the current RM status of their companies and was formulated from the diagnosis indicators described in Table 3-2 and the characteristics of each of these indicators defined under the four maturity levels provided in Table 3-3. The questionnaire contains three sections: (1) general information; (2) questions related to a company's ERM maturity level; and (3) questions related to barriers to implementing ERM. The draft questionnaire was checked and reviewed through a pilot study by three experts in the road sector to check its structure, content, format, and suitability. The main comments received from this process are summarised as follows:

- As recommended in the group discussions, the lack familiarity of interview participants on the concept of ERM was of concern. Consequently, it was suggested an adequate explanation be provided to the interviewee during the interview.
- Some issues that need further clarifications were highlighted, including the ‘ERM maturity itself’. It was also suggested that the terms used to describe the four stages of maturity, in particular, might not be clear to the interviewees to easily differentiate each other and it was suggested they be modified.

Accordingly, the final questionnaire was prepared in consideration of the comments gathered from the pilot study. The contents of the final questionnaires are briefly discussed as follows.

1. Questions on general information

This part was included to obtain information concerning the background of the companies and the interviewees.

2. Questions on companies’ ERM maturity

In this part of the questionnaire, the 36 ERM diagnosis indicators listed in Table 3-2 were incorporated for the purpose of evaluating the maturity of a company under each of these indicators. Each question was designed to cover one key issue (indicator) that contains four alternative answers presented in descriptive statements representing the four maturity levels. These descriptive statements were adapted from the ERM maturity matrix in Table 3-3, representing the four maturity levels, in their order of precedence, from naive (least mature,) to optimised (most mature). Following the procedure suggested by Ren and Yeo (2004) and Hoseini, et al. (2019), all questions were assumed to have equal weight as well.

Sample questions related to the ‘policy and strategy’ attribute are shown in Table 3-5. It should be noted that, to minimise any potential bias, the maturity levels indicated in the parentheses at the end of each alternative statement shown in Table 3-5 were not visible in the questionnaires used in the interview. These are provided here for illustration purposes only.

Table 3-5 Sample ERM³ interview questions

Attributes/ Characteristics	Possible options (<i>Tick only one</i>)
1. Policy and Strategy	
The following questions are related to the company's risk management policies and strategies. Please select and tick the option that best describes your organisation for the following issues.	
2.1 Existence of RM policy and strategy in the company:	☐ None. No separate risk management (RM) policy and strategy (Naive) . ☐ No separate RM policy and strategy. But there is an effort to incorporate it within other business policies and strategies (Novice) . ☐ There is a separate written RM policy and strategy. But needs further revision and update (Managed) . ☐ There is a separate written RM policy and strategy and it is regularly evaluated and refined to suit the various changes that occur (Optimised) .

3. Questions related to the barriers to implement ERM in companies

From a review of the literature, ten factors that would hinder companies in implementing ERM were identified. The interviewees were requested to judge the level of significance of each of the ten impeding factors in attempting to implement RM in their company using a scale of 1 to 4 (1 = least significant to 4 = the most significant impact).

3.5.1.1.3 Significance of self – assessment in ERM maturity measurement

Self-assessment is a key tool in the drive for continuous improvement (McGiffen, 1998) which helps to identify the strengths and areas for improvement of a company (Ritchie & Dale, 2000; Hongzhen, 2013). From the definition provided in IAEA (1997), self-assessment in the perspective of ERM can be termed as a structured, objective and visible procedure or set of procedures whereby individuals, groups and management within an operating organisation evaluate the effectiveness of their own RM against predetermined targets and goals.

The literature outlined several advantages of using this survey technique against the feedbacks that could be gathered involving external bodies. Most importantly, self-assessment uses and values

the knowledge of those who work in an organisation which can help ensuring the participation and ownership the employees' in the performance improvement programme of their organisations (McGiffen, 1998; Smutylo & Lusthaus, 1998). Further, a self – assessment offers a direct source of information as the individuals have access to information about themselves that outside observers may not be aware of (Allen & Velden, 2005). Because organizational self-assessment is conducted based on the knowledge that already exists within the organisation (McGiffen, 1998) with a little or no outside assistance (Ford & Evans, 2002).

Consequently, this method was employed for gauging the ERM competence of companies by involving experts from their own companies. As discussed in section 3.5.1.1.2 above, this technique was also successfully applied by Pangerna et al. (2012); Farrell and Gallagher (2015); and OECD (2021) for measuring the ERM competence of several companies.

Yet it worth noting that, if not handled properly, a self-assessment process could have some shortcomings (McGiffen, 1998; Smutylo & Lusthaus, 1998; Ritchie & Dale, 2000). Evaluation in any form, including organizational assessment, is often viewed with suspicion (Smutylo & Lusthaus, 1998). Hence, to have an effective input into the assessment, it is suggested that participants are reassured that the information gathered will be used with due regard to issues such as confidentiality, fairness, misrepresentation and misuse (Smutylo & Lusthaus, 1998). Further, assessments completed by one person are more likely to be subjective and incomplete than demand attempting to have group assessment to achieve the most comprehensive assessments (McGiffen, 1998). The ambiguity or lack of clarity of the measurement scale, referred as an anchor problem, would also lead to unintentional measurement errors (Allen & Velden, 2005). This can lead to a systematic overestimation or underestimation. Accordingly, it was attempted to devise appropriate measures to address such and other possible pitfalls of the self-assessment. Most importantly, fuzzy logic system was applied to model the imprecise and ambiguous judgements expected in the interview.

3.5.1.1.4 Interview administration

Although risk should be considered at all levels of a company, it is highly valued by senior executives and oversight bodies (ISO, 2018; IRM, 2018). It is also suggested to involve the staff with ERM responsibilities in the self-assessment (OECD, 2021). The ERM maturity surveys in

Beasley et al. (2018) and Deloitte (2021) deliberately involve senior executives to ensure reliable responses. For instance, in the ERM UK Survey 2021, about 63.6% (28) of the 44 respondents had the designation of Chief Risk Officer (Deloitte, 2021). Therefore, the target group of the interviewees was planned to comprise of professionals from senior experts to company executives who are believed to have relatively better RM knowledge.

In doing so, all the 35 contractors that were actively working in the MFRCs were approached through their executives to participate in the survey. Of these, 26 companies participated, while it was not possible to reach the remaining nine companies even after repeated requests. One expert (two in four companies) participated in the interview from each company to assess the current ERM position of their organisations. Farrell and Gallagher (2015), Hillson (2003) and Wibowo and Taufik (2016) have engaged only one expert from each of the companies surveyed to assess the companies' ERM maturity.

Further, despite the technology providing different facilities that enable interviews to be carried out virtually, the face-to-face approach has continued to be the most preferred mode of interview (Adhabi & Anoze, 2017). Hence, with the exception of the two telephone interviews and one interview in Telegram, the interview was conducted predominantly in a face-to-face approach. Since company names and responses were anonymised, it was assumed that there would be no incentive for an individual to overstate a company's actual capabilities. Considering that the interview in the context of ERM³s was potentially a new concept to the participants, a brief explanation had been provided to the participants before the interviews started (presentation slides are provided in Appendix E).

3.5.2 Data analyses - construction of fuzzy rating

Results that would be obtained in AHP, TOPSIS and other methods including the Likert's scale average values are in the form of crisp values as discussed in section 2.7. However, many things in the globe are vague and uncertain; hence, it is not always possible to accurately express opinions. Thus, the FLS method is applied in this study because it enables the modelling of the concept of human judgment due to the existence of uncertainty and ambiguity in expert opinions (Hassall, 1999; Park, 2013; Zhao, et al., 2013a; Ardeshir & Mohajeri, 2018). The basic difference from the statistical results is that FLS can present vague knowledge and allows mathematical operators to

be applied to the fuzzy domain (Xia, et al., 2011; Zhao, et al., 2013a) that allow partial membership with membership values spanning from 0 to 1 (Chen & Pham, 2001; Lee, 2005). The basic difference of using fuzzy values from the statistical mean of the ordinal variables (such as the four maturity scales naive, novice, managed and optimised) is that ordinal data can use the mean as a measure of central tendency. Because it is mathematically incorrect to calculate average for variables. The most appropriate measure for such is the mode to show the most frequent responses, or the median to find the middle value. Hence, average values of Likert scales considered for measuring ERM have no mathematical or statistical ground.

This method was used successfully to measure the ERM competence of construction companies among many others (Zhao, et al., 2013a; Salawua & Abdullah, 2014; Salawu, 2016; Zhao, et al., 2014b). As highlighted in Zhao, et al. (2014b), the maturity criteria ranking using the mean values of the Likert scale as in Ciorciari & Blattner (2008); Pangeran, et al. (2012); Beasley, et al. (2018); Hoseini, et al. (2019); and Zou, et al. (2010) is not noticeably different from the ranking of the fuzzy model.

The fuzzy logic approach consists of five steps illustrated in Figure 3-6. Each step, as applied in this research, is briefly described as follows.

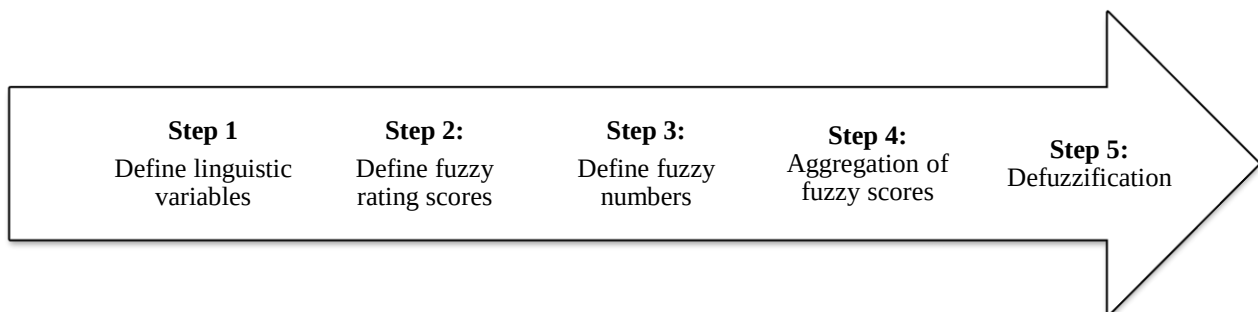


Figure 3-6 Steps of construction fuzzy rating

Step 1 Define the linguistic variables

Based on the maturity levels defined in the proposed maturity model described in section 3.4.2, the fuzzy linguistic variables were defined as naive, novice, managed and optimised.

Step 2 Define numerical fuzzy rating scores

The input data collected from the interviewees were in linguistic forms (i.e. statements). The concept and definition of a fuzzy set leads to that of a fuzzy number which is a fuzzy, or vaguely defined version of an ordinary number (Hassall, 1999). Hence, the linguistic forms of the data were defined with the fuzzy scores, namely, 1 = Naive (Level 1); 2 = Novice (Level 2); 3 = Managed (Level 3); and 4 = Optimised (Level 4).

Step 3 Formulate triangular fuzzy numbers (Fuzzification)

From the various types of membership functions discussed in section 2.7.1.1 and illustrated in Figure 2-4, the triangular membership function (TMF) was used in this study to quantify linguistic variables (the four maturity levels explained above) into fuzzy numbers for the following basic reasons.

1. As described, in section 2.7.1.1, TMF is the most widely used membership function (Zhao, et al., 2013a; Salawua & Abdullah, 2014; Sansakorn, 2017) because it is easy to apply and transform into crisp numbers, whilst producing reasonable results (Zhao, et al., 2013a; Ardeshir & Mohajeri, 2018).
2. TMFs were also successfully applied by Zhao et al. (2013a) and Salawua and Abdullah (2014) to evaluate the ERM maturity of construction companies. Ardeshir and Mohaje (2018) had also applied TMF to assess employees' safety culture in high-rise construction projects.

In applications of TMFs, the overlap of the triangle-to-triangle fuzzy regions are typically between 25% and 50% of the fuzzy set base (Cox, 1994; Zhao, et al., 2013a). As in Zhao, et al. (2013a) and Roghabad, et al. (2020), this study adapted a 50% overlap between the two neighbouring triangular fuzzy regions.

Further, the right and left extreme TFNs according to Borovicka (2014) can be formally defined as (a, a, b) and (b, c, c) , respectively. For example, for a three-level maturity of R1, R2 and R3 of fuzzy values 1, 2 and 3 respectively, the TMF can be defined for the three levels as illustrated in Figure 3-7. That is, the TMF of these three values is defined as R1 as (a, a, b) , R2 as (a, b, c) and

R3 (b, c, c). Chen (2014), Nadaban et al. (2016) and Pervez, et al. (2020) successfully determined the scaling values for fuzzy numbers based on this principle.

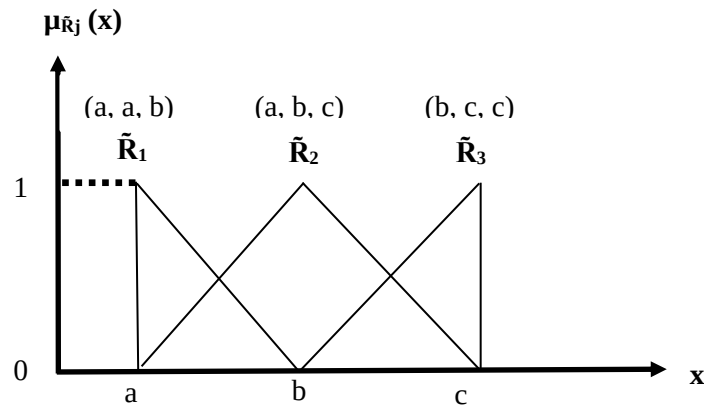


Figure 3-7 The spectrum of fuzzy rating scores

Accordingly, the spectrum of the fuzzy rating scores of this study was defined as illustrated in Figure 3-8 and Table 3-6. That is, the TFN of the fuzzy values of an ‘n’ maturity levels can be presented as: 1 = TFN (1,1,2); 2 = TFN (1,2,3); 3 = TFN (2,3,4), ..., n = TFN (n-1, n, n). In the case of this study, n = 4. Therefore, TFNs of the study were defined as 1 = TFN (1,1,2); 2 = TFN (1,2,3); 3 = TFN (2,3,4), and 4 = TFN (3,4,4).

Table 3-6 – Fuzzy scales for the linguistic terms

Linguistic levels	Notation	Triangular fuzzy values	Triangular fuzzy reciprocal values
Level 1	R_1	(1,1,2)	(1/2,1,1)
Level 2	R_2	(1,2,3)	(1/3,1/2,1)
Level 3	R_3	(2,3,4)	(1/4,1/3,1/2)
Level n	R_n	(n-1, n, n)	(1/n,1/n,1/(n-1))

In this interpretation, an interviewee who judges 3 to be the appropriate score makes a constrained choice in the range where 2 is the minimum value and n the maximum. Further, as stated in Hassal (1999), the two extreme scores (1 and n) reflect the fact that the respondent is constrained within the range and cannot for example rate a score of 0.5 or (n+1).

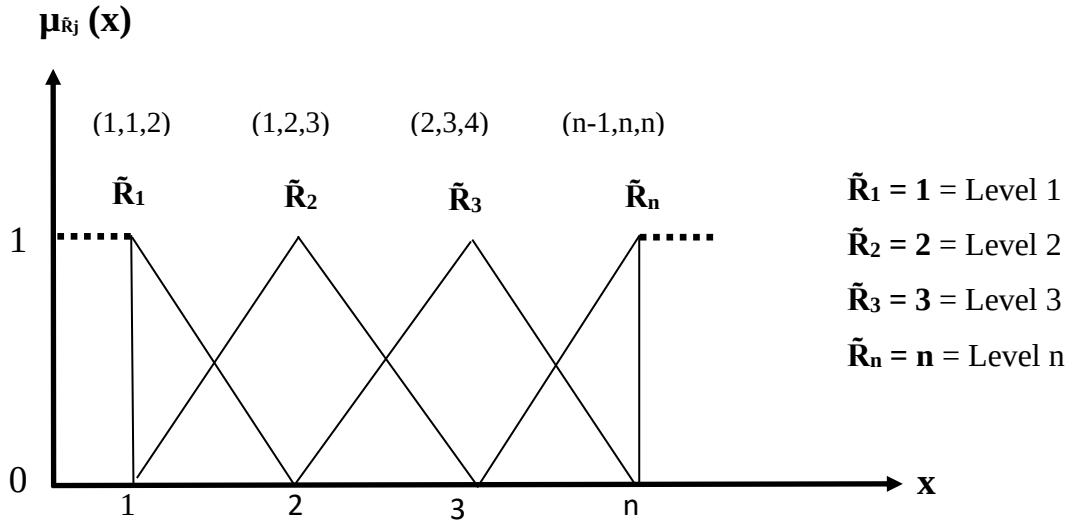


Figure 3-8 The spectrum of fuzzy rating scores of 'n' levels

Further, from Figure 3-7, the membership functions of the n maturity levels could be defined as shown in Equation 3-1.

$$\mu_{R1}(x) = \frac{2-x}{2-1}, 1 \leq x \leq 2$$

$$\mu_{R2}(x) = \begin{cases} \frac{x-1}{2-1}, & 1 \leq x \leq 2 \\ \frac{3-x}{3-2}, & 2 \leq x \leq 3 \end{cases}$$

$$\mu_{R3}(x) = \begin{cases} \frac{x-2}{3-2}, & 2 \leq x \leq 3 \\ \frac{4-x}{4-3}, & 3 \leq x \leq 4 \end{cases}$$

$$\mu_{Rn}(x) = \frac{x-(n-1)}{n-(n-1)}, n-1 \leq x \leq n \quad \text{Equation (3-1)}$$

Based on these relationships, the ranges of the maturity scores were determined for the four maturity levels described in Table 3-7

Table 3-7 Fuzzy scales for the linguistic terms

Linguistic scales	Notation	Maturity level
$1 \leq x < 1.5$	R_1	Naïve
$1.5 \leq x < 2.5$	R_2	Novice
$2.5 \leq x < 3.5$	R_3	Managed
$x \geq 3.5$	R_n	Optimised

Step 4 Aggregation (Composition) of fuzzy scores

Aggregation is the process by which the fuzzy sets (outputs of each rule) are combined into a single fuzzy set (Dhingra & Chattopadhyay, 2021). Fuzzy aggregation operators are applied to combine and summarise a finite set of fuzzy values into a single fuzzy value. The interviewees involved in the study were considered to have an equal level of knowledge (and therefore their opinions were considered to be equally important). Hence, a weighted average fuzzy aggregation operator was applied following the method used by Chou et al. (2011), Zhao et al. (2013a), and Dhingra and Chattopadhyay (2021). Accordingly, the aggregated fuzzy values were determined using Equations 3-2 to 3-5 described below.

The aggregation of the fuzzy values of sub – attributes (indicators)

As discussed above, one questionnaire was completed for each company. Hence, since the opinions of all participants were conceived to have equal validity, the TFN associated with (c^{th}) criteria (or question) of attribute (i), was defined by Equation 3-2.

$$L_{ic} = (f_{c1}, f_{c2}, f_{c3}) = \frac{1}{p} * \sum_{j=1}^p L_{icj} \quad \text{Equation (3-2)}$$

Where:

L_{ic} = implementation level of the (c^{th}) criteria (indicator) in company j

f_{c1}, f_{c2}, f_{c3} , = lower bound, strongest membership degree, and upper bound of L_{ic} , respectively

p = number of individuals (interviewees) who assess the implementation level of each sub – attribute in the respective company

L_{icj} = TFN of (c^{th}) criteria of attribute (i) rated by (j^{th}) participant in (j^{th}) company

The aggregated TFN of an attribute

The six attributes of the proposed ERM³ contain a different number of criteria (defined in questions). Therefore, the maturity level of each of the six attributes was determined using Equation 3-3.

$$L_i = (f_{i1}, f_{i2}, f_{i3}) = \frac{1}{n} * \sum_{c=1}^n L_{ic} \quad \text{Equation (3-3)}$$

Where:

L_i = maturity level of attribute i

f_{i1}, f_{i2}, f_{i3} , = lower bound, strongest membership degree, and upper bound of L_i , respectively

n = number of criteria (questions) associated with attribute (i)

L_{ic} = (as determined in equation 3-5)

Overall (aggregated) TFN of a company

The overall TFN of the RM maturity level of the respective company was determined based on Equation 3-4.

$$M = (m_1, m_2, m_3) = \sum_{i=1}^n (L_i) \quad \text{Equation (3-4)}$$

Where:

m_1, m_2, m_3 = lower bound, strongest membership degree, and upper bound of M , respectively

n = number of ERM diagnosis indicators

Step 5 Determine the maturity levels (Defuzzification)

Based the premises discussed in section 2.7.1.3, a centroid method is applied in this study to defuzzify fuzzy numbers. Further, as described in section 2.7.1.3, the three alternative formulae described to be used to convert TFNs into fuzzy scores (Equation 2-4) using the centroid method were reported to be equivalent (Ismail, et al., 2019). Further, these methods were successfully applied by different researchers, of which Zhao et al. (2013a, 2014b) employed the first of the three options. The third alternative, defined as the graded mean integration method formulated by Chen, et al. (2006) for a TFN, was applied in Chou, et al. (2011), Chen et al. (2014), Pandey (2016) and Dhingra and Chattopadhyay (2021). Chen et al. (2006) also demonstrated that for symmetric fuzzy numbers, the second and the third options provide similar results. Therefore, as these three formulae provide similar results, option 2 is applied in this research. Accordingly, the fuzzy RM maturity values were converted into a crisp score (S) through the centre of area defuzzification method (Equation 3-5).

$$S = \frac{m_1 + 2m_2 + m_3}{4} \quad \text{Equation (3-5)}$$

3.5.3 Statistical Analysis

Cronbach's alpha coefficients were computed to check the consistency and reliability of the data. The two-basic data sets collected to evaluate companies' ERM maturity, and to assess the significance of the factors impeding companies to implement ERM were evaluated. The category suggested by George and Mallery (2003) was applied to evaluate the calculated alpha coefficients, which contains the following: ≥ 0.9 – Excellent; ≥ 0.8 – Good; ≥ 0.7 – Acceptable; ≥ 0.6 – Questionable; ≥ 0.5 – Poor; and ≤ 0.5 - Unacceptable.

Inferential statistical analyses, which help to generalise the findings from a sample to the entire population of interest (Allua, 2009; Marshal & Jonker, 2011), were also applied to compare the ERM maturity within different groups and to check the relationships of ERM with certain characteristics of the companies. Among the many different inferential statistics tests, the t-test, Analysis of Variance (ANOVA), correlation and regression tests were used in this study. Unpair t – test was calculated to check the statistical significance of the differences in means between the public and private companies on companies' ERM maturity. A one-way ANOVA was also calculated to test the statistical significance of the differences in means between groups and within groups of companies that have different years of experience in companies' ERM maturity (See Appendix G2). Pearson's correlation coefficient and a simple regression were also calculated to evaluate the association of companies' ERM maturity with the volumes of projects executed within companies.

3.6 Summary

This chapter presented the methodology employed to develop an ERM³ to measure the RM competence of construction companies. The chapter described the research framework for developing the ERM³ and the applicable methods to check the suitability of the established model. The data collection and analysis methods were outlined to test the applicability of the proposed model, in which a face-to-face interview was found to be an effective method to enable professionals to assess the RM maturity level of their respective companies. Of the 35 contractors

that were actively working in the MFRCs, experts from 26 companies participated in the interview.

While several approaches are available to analyse the data provided by the experts in order to obtain an RM maturity level, fuzzy logic analysis was found to be an appropriate technique as it allows handling of the problems relating to the ambiguity and imprecision in human judgments and quantifies the linguistic facet of the data. Hence, based on the fuzzy logic system, suitable procedures were formulated to analyse the data collected. Different statistical methods were also adopted that will help to test the reliability of the data, as well the potential associations of certain characteristics of the companies with the ERM practice. The data was analysed using these procedures; this will be described in Chapter 4.

4 CASE STUDY: MEASURING THE ERM MATURITY OF ETHIOPIAN DOMESTIC ROAD CONSTRUCTION COMPANIES

4.1 Introduction

This chapter assesses the use and applicability of the proposed model developed in Chapter 3 using data collected from Ethiopian domestic construction companies that have been involved in Ethiopia's MFRCs. The ERM maturity of the companies was determined based on the 36 diagnosis indicators and the six attributes identified in Chapter 3, to evaluate their current ERM compatibilities against the four maturity levels. The relative maturity of the six attributes listed in Table 3-1 and the 36 diagnostic indicators listed in Table 3-2 in Chapter 3 were also determined to identify the strong and weak areas of the Ethiopian road sector in terms of ERM. Further, the potential factors that might impede the implementation of the ERM are discussed.

4.2 Background to the Case Study

According to the data available through the Ethiopian Construction Authority (ECA), there were about 145 Grade-1 registered domestic contractors (100 building contractors, 41 general contractors and 4 road contractors) by 2020. Of which 35 companies (24%) were involved in the MFRCs of Ethiopia. Accordingly, all the 35 companies were approached to participate in the survey by email and telephone, and 26 companies (18% and 74% of the total Grade-1 contractors and the total contractors involved in the MFRCs, respectively) showed interest to take part in the survey.

Experts that had experience of more than five years' involvement in RM-related duties were targeted for interview, including the company leadership. These experts were expected to self-assess their respective companies through the interview questionnaires designed for this purpose (see Appendix D). The interview questionnaire contained three main parts: (i) Profile (profile of companies and of interviewee) - to provide an overview of the overall background of companies and experts and to explore the possible association of companies' profiles with companies' ERM maturity; (ii) ERM maturity indicators; and (iii) barriers for practising ERM. The profiles of the participating companies and experts are described below.

4.2.1 Profile of companies

For the sake of confidentiality, the companies surveyed were designated by anonymous names using the acronym ‘COM’ and sequential numbers 1 to 26. These numbers were allocated by arranging the companies surveyed in their alphabetical order. For instance, ‘COM1’ implies the first company among the companies participated in this survey. Accordingly, the data were analysed based on the essential characteristics of the companies incorporated in the questionnaire, namely the ownership type, their experience in the road sector, and the major area(s) where they were engaged most in the construction industry.

Table 4-1 and Figure 4-1 show that the vast majority (88%) of the companies surveyed were private companies. Further, 23 of the 26 companies were established in the last 30 years, of which 15 (58%) have emerged within the last 20 years. Table 4-1 also highlights the various sectors of the construction industry in which these contractors were engaged most, with transport being the main sector that nearly all of the companies were operating in. This indicates that the road sector could be investigated separately from the Ethiopian construction industry as a specialised area. It also appears to be fair to consider that the surveyed population represents the country’s major construction companies, as nearly a quarter of the total Grade-1 contractors (24%) that were registered in the country in 2020 and 74% (26) of the total of 35 contractors that were operating in the road sector were involved in the survey.

Table 4-1 Profile of companies

Characteristics		Number	Proportion
Category in ownership	Public	3	12%
	Private	23	88%
	Total	26	100%
Experience in the industry	Less than 10 years	1	4%
	10 to 20 years	14	54%
	20 to 30 years	8	31%
	Above 30 years	3	12%
	Total	26	100%
Major areas of construction	Building	15	58%
	Real state	8	31%
	Transport	25	96%
	Water works	7	27%
	Others	-	-

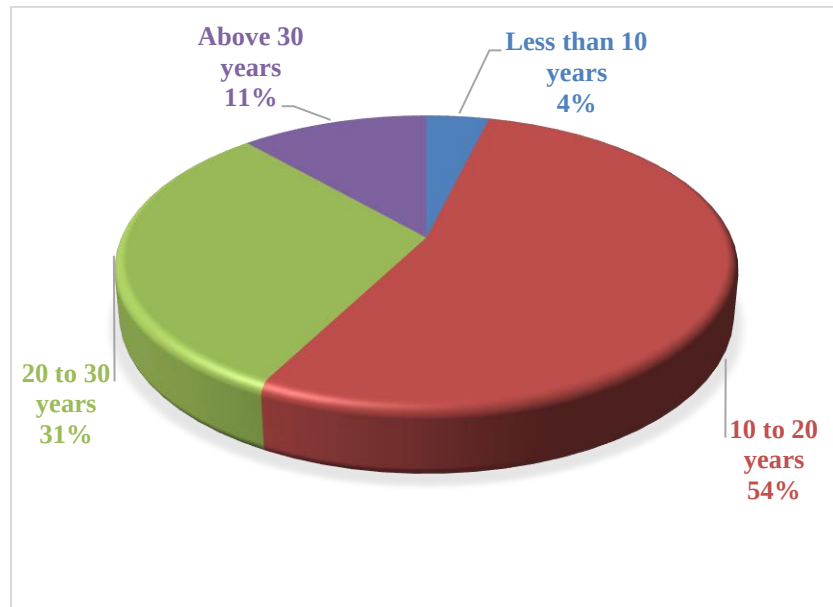


Figure 4-1 Years of experience of construction companies

In addition to the data obtained from the interview, the details of projects handled by the contractors were collected from the available data in ERA (the client of federal road projects) to test the possible relationship of a company's ERM maturity with their characteristics.

4.2.2 Profile of interviewee

Since the purpose of the interview was to self-assess companies' ERM maturity, only one questionnaire was completed for each company. Consequently, experts who signed on the final interview questionnaires and the consent forms were considered in the analysis for the companies in which more than one person participated. As shown in Table 4-2 and Figure 4-2, nearly 90% (23) of the 26 interviewees were senior officials holding positions ranging from department heads to company CEOs, and the remaining three were team leaders/project coordinators. Two (8%) of the 23 senior officials were CEOs (general managers) and seven (26.9%) were D/CEOs (deputy general managers). As might have been expected, none of the companies had a chief risk officer or any other person assigned specifically for the RM tasks.

The analysis also indicates that most of the participants had an extensive experience in the industry, with more than three-quarters (77%) with more than 10 years and 10 (38%) with more than 20 years of experience.

Table 4-2 Profile of interviewees

Characteristics	Number	Proportion
Position in their companies		
CEO, General Manager	2	8%
D/CEO, D/General Manager	7	27%
Manager, Director, Department Head	14	54%
Chief Risk Officer	0	0%
Others (Team leader, coordinator)	3	12%
Total	26	100%
Experience in the construction industry		
5 to 10 years	6	23%
10 to 15 years	9	35%
15 to 20 years	1	4%
Above 20 years	10	38%
Total	26	100%

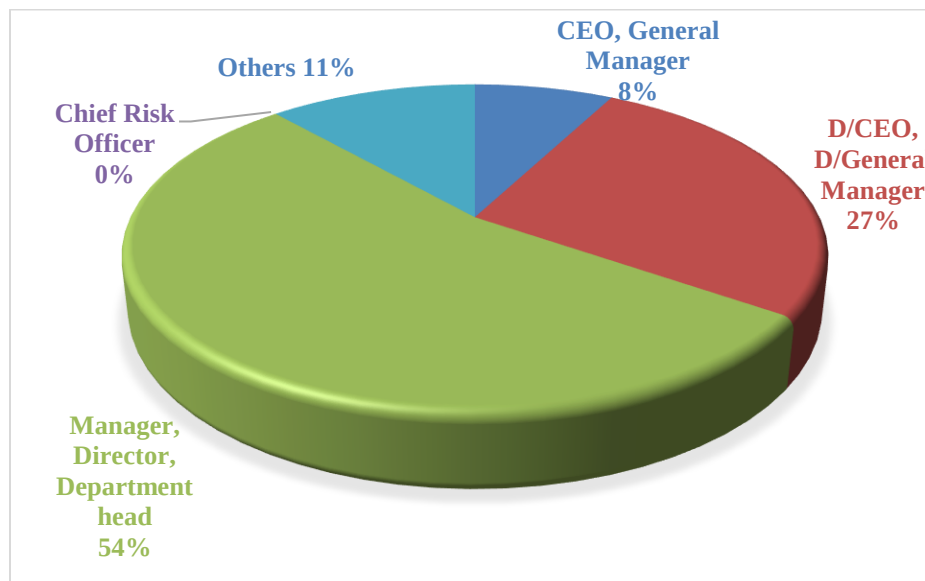


Figure 4-2 Positions of interviewees in their companies

4.3 Consistency of Responses

Prior to undertaking any computation, it is important to evaluate the consistency of the survey data. Cronbach's alpha, which ranges from 0 to 1.00 (Cronbach, 1951), is one of the most widely used measures of reliability and internal consistency of responses (Zhao, et al., 2013a; Altoryman, 2014). This was also applied in several similar studies such as, Zhao, et al. (2013a) and Ardeshir and Mohaje (2018) to test the reliability of the data collected to measure companies' ERM capability. A minimum alpha coefficient value of 0.6 is expected for the reliability of the questionnaire to avoid correction or elimination of some variables (Cronbach, 1951) and it should be at least 0.7 to be reliable (Nunnally, 1978). George and Mallery (2003) suggested a tiered approach consisting of the following: ≥ 0.9 - Excellent; ≥ 0.8 - Good; ≥ 0.7 - Acceptable; ≥ 0.6 - Questionable; ≥ 0.5 - Poor; and ≤ 0.5 - Unacceptable.

Accordingly, the Cronbach's alpha coefficients were computed for the data (see Appendix G1) in Excel, as summarised in Table 4-3, with the values ranging from 0.70 to 0.89 for the six maturity attributes and with the overall value of 0.95. This indicates an acceptable internal consistency within the responses provided by the 26 companies. As can also be seen in this table, all responses corresponding to the six maturity attributes were also found to be favourably above the acceptable tier. The overall alpha coefficient calculation table of the 36 diagnostic indicators is also presented in Table 4-4 (see Appendix G1 for alpha coefficients of the six attributes).

Table 4-3 Cronbach's alpha coefficients of the survey data

Attribute	Number of indicators	α – Coefficient	Remarks
Policy & Strategy	4	0.77	Acceptable
Structure & Governance	4	0.86	Good
Culture	6	0.70	Marginally Acceptable
Process	8	0.87	Good
Competence	4	0.80	Good
Implementation	10	0.89	Good
Overall	36	0.95	Excellent

Table 4-4 Overall Cronbach's alpha coefficient table

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	129.1207	25	5.164829	20.2103	5.04E-70	1.518705
Columns	82.13996	35	2.346856	9.183393	9.29E-40	1.436541
Error	223.61	875	0.255554			
Total	434.8707	935				
Alpha coefficient			0.95			

As a result, the data collected was found to be reliable and consistent. Thereafter, the data from the questionnaires were assessed as follows.

- The ERM competence of the road sector in respect of the companies (section 4.4);
- The ERM maturity of the road sector in respect of the selected key attributes and diagnostic indicators (section 4.5).

4.4 Analysis of the ERM Maturity of Companies

In this section, the RM competence of the companies surveyed was analysed using the data collected from the interview (see detailed data in Appendix F). In addition to determining the overall ERM maturity level of the companies, the maturity of each company was analysed to evaluate their respective RM capabilities. The analysis utilised the fuzzy logic system defined in section 3.5.2, i.e. fuzzification, aggregation of fuzzy numbers and defuzzification as follows.

4.4.1 Determining the TFNs of indicators (Fuzzification)

To make it easier for interviewees to choose their organisation's ERM practice level, the four alternative maturity levels were presented in the questionnaires using descriptive statements without any visible values that would prescribe maturity levels. This is believed to minimise potential biases. Accordingly, the contractors surveyed were evaluated based on the scores provided by the interviewees for the 36 indicators categorised under six attributes.

Generally, for a self-assessment within a company using only one questionnaire, the TFN is the direct score provided from this questionnaire, i.e. no fuzzy operation is required. Hence, the alternatives selected for each question by the interviewee(s) who assessed the company were changed into TFNs based on the fuzzy scales provided in Table 3-6. For example, if the expert(s) of a company chooses the third statement for a particular question, it means that the company is at level 3 (managed) with respect to this indicator. Hence, the corresponding TFN of the indicator was taken from Table 3-6 to be (2, 3, 4). Following a similar procedure, TFNs were defined for all indicators of the companies surveyed. By doing so, the collected data was fuzzified for subsequent fuzzy operations.

4.4.2 Aggregation of fuzzy numbers

At this stage, the TFNs defined in section 4.4.1 were aggregated using Equations (3-2) to (3-4) to determine the aggregated TFN an indicator, an attribute and a company, respectively as described below.

4.4.2.1 Aggregation of the fuzzy value of indicators of a company

As described earlier, the TFN associated with the (c^{th}) criteria (indicator) was computed using Equation (3.2). However, since only one questionnaire was completed for each company, the fuzzy value of an indicator of a company is the value obtained in the interview itself. Example (1) below provides an illustration of the procedure.

Example (1)

Let's consider the indicators of the culture attribute (CU^4) of company 1 (COM1). Six indicators were included in the questionnaire to evaluate a company's ERM culture: Belief in the value of

⁴ To make the analysis easier, acronyms were used to represent the six characteristics, i.e. policy and strategy (PS), structure and governance (SG), culture (CU), process (PR), competence (CO), and implementation (IM). These acronyms, followed by consecutive numbers, were used to designate the 36 indicators identified to measure a company's ERM capabilities. For example, the six indicators included in the culture attribute are defined in the order they were presented on the questionnaire as CU1, CU2, CU3, CU4, CU5, and CU6.

risk management (CU1); Awareness of the company of risk (CU2); Attitude of the leadership towards risk (CU3); Commitment of the leadership to practise risk management (CU4); Core values/principles on risk management (CU5); and risk information sharing/communication (CU6).

From the alternatives selected by the interviewee for each of the 36 indicators (questions) presented in Appendix F1 and the equivalent TFNs provided in Table 3-6, fuzzy scores and the corresponding TFNs were determined for the six indicators of the CU attribute of COM1 to be CU1 - (3, 4, 4); CU2 - (1, 2, 3); CU3 - (2, 3, 4); CU4 - (2, 3, 4); CU5 - (1, 2, 3); and CU6 - (1, 2, 3) as shown in Table 4-5. For instance, the expert who evaluated COM1 rated the company at level 3 in terms of the fourth indicator of the culture attribute (CU4). Hence, based on the alternative chosen by the interviewee, the corresponding TFN of this indicator can be defined as (2, 3, 4) as illustrated in Table 3-6.

Table 4-5 Interviewee's response on the RM culture of COM1

Indicator	CU1	CU2	CU3	CU4	CU5	CU6	Remarks
Alternatives selected by the interviewee (Fuzzy Score)	4	2	3	3	2	2	Appendix F1
Equivalent TFN	(3, 4, 4)	(1, 2, 3)	(2, 3, 4)	(2, 3, 4)	(1, 2, 3)	(1, 2, 3)	Table 3-6

4.4.2.2 Aggregation of fuzzy values of indicators within attributes

As illustrated in Table 4-6, all of the six attributes of the model contain more than one indicator. Hence, the TFNs of the indicators under each of the attributes were aggregated to determine aggregated TFNs for the six attributes. Hence, since all the indicators have the same level of importance, the fuzzy aggregation operator was applied using Equation (3.3) to calculate the aggregated TFNs for these attributes. Example (2) illustrates the overall procedure for aggregating the fuzzy numbers of COM1.

Table 4-6 Number of indicators (criteria) under each attribute

Attribute	Policy & Strategy (PS)	Structure & Governance (PG)	Culture (CU)	Process (PR)	Competence (CO)	Implementation (IM)
Number of indicators (n)	4	4	6	8	4	10

Example (2)

Using Equation (3-3), the TFN of the culture attribute of COM1 was calculated by aggregating the TFNs of the six indicators contained in CU as shown in the Example (1): for the culture (CU) attribute, $n = 6$ (number of indicators under CU shown in Table 4-6). Using the fuzzy addition and scalar multiplication operation properties described in section 2.7.1.2, the TFN of the culture attribute was computed based on Equation (3-3) as follows.

$$(l_1, l_2, l_3) = 1/6 (CU1 \oplus CU2 \oplus CU3 \oplus CU4 \oplus CU5 \oplus CU6)$$

Taking the TFNs in Table 4-5,

$$\begin{aligned} (l_1, l_2, l_3) &= 1/6 * [(3, 4, 4) \oplus (1, 2, 3) \oplus (2, 3, 4) \oplus (2, 3, 4) \oplus (1, 2, 3) \oplus (1, 2, 3)] \\ &= 1/6 * [(3+1+2+2+1+1), (4+2+3+3+2+2), (4+3+4+4+3+3)] \\ &= 1/6 * (10, 16, 21) = (1.67, 2.67, 3.50) \end{aligned}$$

That is, the TFN of the ERM culture of COM1 is (1.67, 2.67, 3.50). Following similar procedures, the TFNs were computed for the remaining five attributes of the company, namely, PS, SG, PR, CO and IM, yielding (1.00, 1.75, 2.75), (1.00, 1.25, 2.25), (1.00, 1.88, 2.88), (1.00, 2.00, 2.00) and (1.20, 2.10, 3.10), respectively (See Table 4-7).

Following the same procedure, the aggregated TFNs of the attributes were calculated for the remaining companies surveyed as summarised in Table 4-8.

Table 4-7 Summary of the TFNs of company 1 (COM1)

Attribute	Indicators	Interviewee's perception for c^{th} indicator		Aggregated TFNs for j^{th} attribute (L_i)
		Linguistic variable	TFN (L_{ci})	
Policy & Strategy (SG)	PS1	Novice	(1, 2, 3)	(1.00, 1.75, 2.75)
	PS2	Novice	(1, 2, 3)	
	PS3	Naive	(1, 1, 2)	
	PS4	Novice	(1, 2, 3)	
Structure & Governance (SG)	SG1	Naive	(1, 1, 2)	(1.00, 1.25, 2.25)
	SG2	Naive	(1, 1, 2)	
	SG3	Naive	(1, 1, 2)	
	SG4	Novice	(1, 2, 3)	
Culture (CU)	CU1	Optimised	(3, 4, 4)	(1.67, 2.67, 3.50)
	CU2	Novice	(1, 2, 3)	
	CU3	Managed	(2, 3, 4)	
	CU4	Managed	(2, 3, 4)	
	CU5	Novice	(1, 2, 3)	
	CU6	Novice	(1, 2, 3)	
Process (PR)	PR1	Novice	(1, 2, 3)	(1.00, 1.88, 2.88)
	PR2	Novice	(1, 2, 3)	
	PR3	Novice	(1, 2, 3)	
	PR4	Naive	(1, 1, 2)	
	PR5	Novice	(1, 2, 3)	
	PR6	Novice	(1, 2, 3)	
	PR7	Novice	(1, 2, 3)	
	PR8	Novice	(1, 2, 3)	
Competence (CO)	CO1	Novice	(1, 2, 3)	(1.00, 2.00, 3.00)
	CO2	Novice	(1, 2, 3)	
	CO3	Novice	(1, 2, 3)	
	CO4	Novice	(1, 2, 3)	
Implementation (IM)	IM1	Novice	(1, 2, 3)	(1.20, 2.10, 3.10)
	IM2	Managed	(2, 3, 4)	
	IM3	Novice	(1, 2, 3)	
	IM4	Novice	(1, 2, 3)	
	IM5	Naive	(1, 1, 2)	
	IM6	Managed	(2, 3, 4)	
	IM7	Novice	(1, 2, 3)	
	IM8	Novice	(1, 2, 3)	
	IM9	Novice	(1, 2, 3)	
	IM10	Novice	(1, 2, 3)	

Table 4-8 Summary of the aggregated TFNs of attributes

Company	TFNs of Attributes					
	Policy & Strategy (PS)	Structure & Governance (SG)	Culture (CU)	Process (PR)	Competence (CO)	Implementation (IM)
COM1	(1.00, 1.75, 2.75)	(1.00, 1.25, 2.25)	(1.67, 2.67, 3.50)	(1.00, 1.88, 2.88)	(1.00, 2.00, 3.00)	(1.20, 2.10, 3.10)
COM2	(1.00, 2.00, 3.00)	(1.25, 1.50, 2.50)	(1.33, 2.33, 3.33)	(1.13, 2.13, 3.13)	(1.00, 1.75, 2.75)	(1.10, 2.10, 3.10)
COM3	(1.00, 1.50, 2.50)	(1.00, 1.25, 2.25)	(1.17, 1.67, 2.67)	(1.00, 1.88, 2.88)	(1.00, 2.00, 3.00)	(1.00, 1.90, 2.90)
COM4	(1.00, 2.00, 3.00)	(1.00, 1.75, 2.75)	(1.00, 1.83, 2.83)	(1.00, 1.75, 2.75)	(1.00, 1.50, 2.50)	(1.00, 1.60, 2.60)
COM5	(2.00, 3.00, 4.00)	(1.00, 1.25, 2.25)	(1.67, 2.67, 3.67)	(1.13, 1.88, 2.88)	(1.00, 1.50, 2.50)	(1.00, 1.50, 2.50)
COM6	(1.00, 1.75, 2.75)	(1.25, 2.00, 3.00)	(1.50, 2.33, 3.17)	(1.00, 1.50, 2.50)	(1.25, 2.00, 3.00)	(1.00, 2.00, 3.00)
COM7	(1.25, 2.25, 3.25)	(1.00, 1.25, 2.25)	(1.50, 2.50, 3.33)	(1.00, 1.75, 2.75)	(1.00, 2.00, 3.00)	(1.00, 1.70, 2.70)
COM8	(1.00, 2.00, 3.00)	(1.25, 1.75, 2.75)	(1.83, 2.83, 3.67)	(1.13, 2.13, 3.13)	(1.25, 2.25, 3.25)	(1.40, 2.40, 3.40)
COM9	(1.00, 1.75, 2.75)	(1.00, 1.50, 2.50)	(1.33, 2.33, 3.33)	(1.13, 2.13, 3.13)	(1.25, 2.00, 3.00)	(1.60, 2.60, 3.60)
COM10	(2.00, 3.00, 4.00)	(2.25, 3.25, 4.00)	(1.83, 2.83, 3.83)	(2.13, 3.13, 4.00)	(2.25, 3.25, 4.00)	(1.80, 2.80, 3.70)
COM11	(1.00, 1.50, 2.50)	(1.00, 1.25, 2.25)	(1.17, 2.17, 3.17)	(1.00, 1.50, 2.50)	(1.00, 1.50, 2.50)	(1.00, 1.50, 2.50)
COM12	(1.00, 1.25, 2.25)	(1.00, 1.25, 2.25)	(1.17, 2.00, 3.00)	(1.00, 1.38, 2.38)	(1.00, 1.50, 2.50)	(1.10, 1.30, 2.30)
COM13	(1.00, 2.00, 3.00)	(1.00, 1.50, 2.50)	(1.17, 2.00, 3.00)	(1.00, 1.75, 2.75)	(1.00, 1.75, 2.75)	(1.20, 2.00, 3.00)
COM14	(1.50, 2.50, 3.50)	(1.50, 2.50, 3.50)	(2.33, 3.33, 4.00)	(1.63, 2.63, 3.63)	(1.75, 2.75, 3.75)	(1.60, 2.60, 3.60)
COM15	(1.50, 2.25, 3.25)	(1.50, 2.50, 3.50)	(1.83, 2.83, 3.67)	(1.25, 2.13, 3.13)	(1.50, 2.50, 3.50)	(1.70, 2.70, 3.60)
COM16	(1.00, 2.50, 3.50)	(1.00, 1.50, 2.50)	(1.50, 2.50, 3.50)	(1.00, 2.00, 3.00)	(1.00, 1.75, 2.75)	(1.10, 2.00, 3.00)
COM17	(1.25, 1.75, 2.75)	(1.50, 2.50, 3.50)	(1.17, 2.00, 3.00)	(1.00, 1.88, 2.88)	(1.00, 1.75, 2.75)	(1.00, 1.60, 2.60)
COM18	(1.00, 2.25, 3.25)	(1.00, 1.50, 2.50)	(1.50, 2.50, 3.50)	(1.00, 1.75, 2.75)	(1.00, 1.00, 2.00)	(1.00, 1.50, 2.50)
COM19	(1.25, 2.00, 3.00)	(1.00, 2.00, 3.00)	(1.17, 2.17, 3.17)	(1.00, 2.00, 3.00)	(1.00, 1.75, 2.75)	(1.00, 1.90, 2.90)
COM20	(1.50, 2.00, 3.00)	(1.00, 1.75, 2.75)	(1.67, 2.33, 3.33)	(1.00, 1.75, 2.75)	(1.50, 2.25, 3.25)	(1.10, 1.90, 2.90)
COM21	(1.00, 2.50, 3.50)	(2.00, 3.00, 4.00)	(1.50, 2.33, 3.33)	(1.50, 2.50, 3.50)	(1.25, 2.25, 3.25)	(1.40, 2.30, 3.30)
COM22	(1.00, 1.50, 2.50)	(1.00, 1.25, 2.25)	(1.00, 1.67, 2.67)	(1.00, 1.00, 2.00)	(1.00, 1.00, 2.00)	(1.00, 1.10, 2.10)
COM23	(1.75, 2.75, 3.75)	(1.00, 1.75, 2.75)	(1.17, 2.00, 3.00)	(1.00, 1.75, 2.75)	(1.00, 1.50, 2.50)	(1.10, 1.90, 2.90)
COM24	(1.00, 1.25, 2.25)	(1.00, 2.00, 3.00)	(1.00, 1.67, 2.67)	(1.00, 1.50, 2.50)	(1.00, 2.00, 3.00)	(1.10, 2.00, 3.00)
COM25	(1.25, 2.25, 3.25)	(1.25, 2.00, 3.00)	(1.67, 2.67, 3.67)	(1.25, 2.25, 3.25)	(1.00, 1.75, 2.75)	(1.30, 2.10, 3.10)
COM26	(1.00, 1.75, 2.75)	(1.00, 1.25, 2.25)	(1.17, 2.00, 3.00)	(1.00, 1.88, 2.88)	(1.00, 1.00, 2.00)	(1.20, 2.10, 3.10)

4.4.2.3 Aggregation of TFNs of a company

The overall TFN of the RM maturity of an individual company (M) was determined based on Equation (3-4). The following provides an example of the use of the equation to this end.

Example (3)

Let's again consider COM1. Using the TFNs computed for the 36 ERM diagnosis indicators (see Table 4-7) following the procedures in section 4.4.2.1, the aggregated TFN of COM1 was computed using Equation (3-4) as follows.

$$M_{COM1} = (m_{1,COM1}; m_{2,COM1}; m_{3,COM1}) = \frac{1}{36} * \sum_{i=1}^{36} L_{ci}$$

$$M_{COM1} = 1/36 * (L_{c1} + L_{c2} + L_{c3} + \dots + L_{c36})$$

Where, L_{ci} is the TFN of indicator i ($i = 1, 2, 3, \dots, 36$) computed in section 4.4.2.1 and described in Table 4-7 for COM1, and $(m_{1,COM1}; m_{2,COM1}; m_{3,COM1})$ is the aggregated TFN of COM1.

To simplify the computations, the frequencies of the maturity scores obtained via interview for the 36 indicators are summarised in Table 4-9.

Table 4-9 Frequencies of scores of indicators for COM1

Maturity Score (n)	TFN ($\tilde{R}_i$)	Frequency (f_i)
1	(1, 1, 2)	6
2	(1, 2, 3)	25
3	(2, 3, 4)	4
4	(3, 4, 4)	1
Total		36

Let, f_n be the frequency of maturity score (n) obtained from the interview, and $\tilde{R}_n$ be the equivalent TFN of maturity score (n). Then, using the fuzzy addition and scalar multiplication operations, the aggregate fuzzy number of the company was calculated based on Equation (3-4) as:

$$M_{COM1} = (m_1, m_2, m_3) = \frac{1}{36} * \sum_{i=1}^4 f_n \tilde{R}_n$$

$$= 1/36 * [6*(1, 1, 2) + 25*(1, 2, 3) + 4*(2, 3, 4) + 1*(3, 4, 4)]$$

$$= 1/36*(42, 72, 107)$$

$$M_{COM1} = (m_1, m_2, m_3) = (1.17, 2.00, 2.97)$$

That is, the aggregated TFN of COM1 was found to be (1.17, 2.00, 2.97).

Therefore, following the same procedures as above, the aggregated TFNs were computed for the other companies surveyed, resulting in the TFNs summarised in Table 4-10.

Table 4-10 Summary of the aggregated TFNs of companies

Company	Aggregated TFNs of Companies
COM1	(1.17, 2.00, 2.97)
COM2	(1.14, 2.03, 3.03)
COM3	(1.03, 1.75, 2.75)
COM4	(1.00, 1.72, 2.72)
COM5	(1.25, 1.92, 2.92)
COM6	(1.14, 1.92, 2.89)
COM7	(1.11, 1.89, 2.86)
COM8	(1.33, 2.28, 3.25)
COM9	(1.28, 2.17, 3.17)
COM10	(2.00, 3.00, 3.89)
COM11	(1.03, 1.58, 2.58)
COM12	(1.06, 1.44, 2.44)
COM13	(1.08, 1.86, 2.86)
COM14	(1.72, 2.72, 3.67)
COM15	(1.56, 2.50, 3.44)
COM16	(1.17, 2.06, 3.06)
COM17	(1.08, 1.86, 2.86)
COM18	(1.11, 1.75, 2.75)
COM19	(1.03, 1.97, 2.97)
COM20	(1.22, 1.97, 2.97)
COM21	(1.50, 2.44, 3.44)
COM22	(1.00, 1.22, 2.22)
COM23	(1.14, 1.92, 2.92)
COM24	(1.03, 1.75, 2.75)
COM25	(1.31, 2.19, 3.19)
COM26	(1.08, 1.78, 2.78)

4.4.3 Determine maturity scores (Defuzzification)

The third step of the fuzzy logic system defined in the study is defuzzification. Hence, the fuzzy maturity output values computed in section 4.4.2 were converted into classical (crisp) values, referred to as maturity scores (S), using Equation (3-5).

4.4.3.1 Determining the maturity scores of attributes

Example (4)

To illustrate the procedure, let the aggregated TFN of the CU attribute in COM1 be defuzzified. From Table 4-7, the aggregated TFN of the CU attribute of COM1 is (1.67, 2.67, 3.50). Then, the maturity score of the ERM CU attribute of COM1 was estimated using Equation (3-5) to be 2.63.

$$S = \frac{m_{1,CU} + 2m_{2,CU} + m_{3,CU}}{4}$$
$$S = \frac{1.67+2*2.67+3.5}{4} = 2.63$$

That is, the COM1 is at a maturity level of 2.63 in respect of the culture attribute. However, this value could not define a single maturity level. In classical sets, it is practically difficult to categorise the maturity of the company using such values, because it does not allow partial membership. Hence, the significance of applying a fuzzy logic system appears to be more evident while such results are attained, because in a fuzzy logic system, partial membership is allowed between the two neighbouring triangular fuzzy regions. Hence, the output values can be easily interpreted based on the degree of the membership of the output value with respect to the associated two-neighbouring triangular fuzzy regions.

To better visualise the actual maturity level of the company in this particular attribute, the degree of memberships of the output value are determined by computing the TMFs using Equation (3-1). That is, for the input value, $x = 2.63$, Equation (3-1) provides the degrees of the membership functions as $R2 = 0.37$ and $R3 = 0.63$. Meaning, the company was computed to have 63% degree of membership function at a managed and 37% at a novice level, in terms of the CU attribute. Consequently, with reference to Table 3-7 and Figure 4-3, the company can be regarded as having a managed maturity level ($2.5 \leq x < 3.5$). This indicates that although the company could generally

be categorised as a managed level in terms of the culture dimension, about 37% of the company's maturity belonged to the novice level. This suggests that if the company desires to attain a 100% managed level, it should improve the areas that attributed to the calculated novice portion.

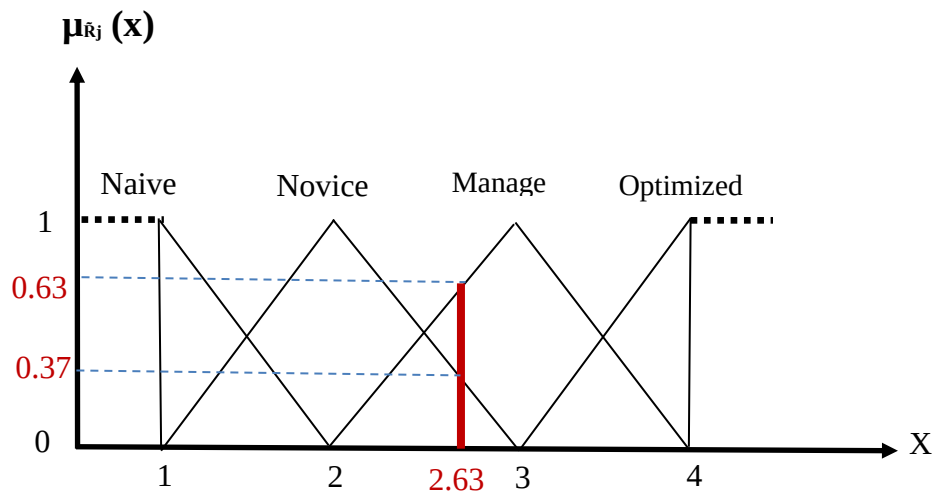


Figure 4-3 Degree of membership of the ERM culture of COM1

Using similar procedures as above, the defuzzified maturity scores, degrees of membership functions and the overall maturity levels were computed for the remaining five attributes of the company as set out in Table 4-11. As can be seen from Table 4-11, COM1 has computed maturity scores ranging between 1.44 and 2.63, in which four of the attributes could be considered to be at a novice level (i.e. $S = 1.5 \leq x < 2.5$) while the structure and governance attribute was computed to be naive and the culture was at a managed level.

Table 4-11 Summary of the maturity of attributes for COM1 (illustrative)

Attributes	Aggregated fuzzy numbers (L_i)	Defuzzified/aggregated scores (S_i)	Degrees of MF of maturity level	Overall maturity level
Structure & Governance	(1.00, 1.25, 2.25)	1.44	56% Naive, 44% Novice	Naïve
Competence	(1.00, 2.00, 2.00)	1.75	75% Novice, 25 Naive	Novice
Policy & Strategy	(1.00, 1.75, 2.75)	1.81	81% Novice, 19% Naive	Novice
Process	(1.00, 1.88, 2.88)	1.91	91% Novice, 9% Naive	Novice
Implementation	(1.20, 2.10, 3.10)	2.13	87% Novice, 13% Managed	Novice
Culture	(1.67, 2.67, 3.50)	2.63	63% Managed, 37% Novice	Managed

The radar diagram (Figure 4-4) also helps us to see the relative maturity levels of each attribute against the maximum possible level expected to be achieved. It also enables a comparison of the maturity of the attributes with each other.

Overall, from the results achieved, COM1 appears to be the most mature in practising ERM in the CU (culture) attribute with a maturity score of 2.63 out of 4.00. Conversely, the company was found to be the least mature in the structure and governance attribute with a maturity score of 1.44. Further, the results indicate that the company's ERM practice is inconsistent when evaluated in terms of the six attributes, suggesting that the company should attempt to improve its approach by addressing the major gap, mainly on attributes that are found relatively at the lower level of maturity.

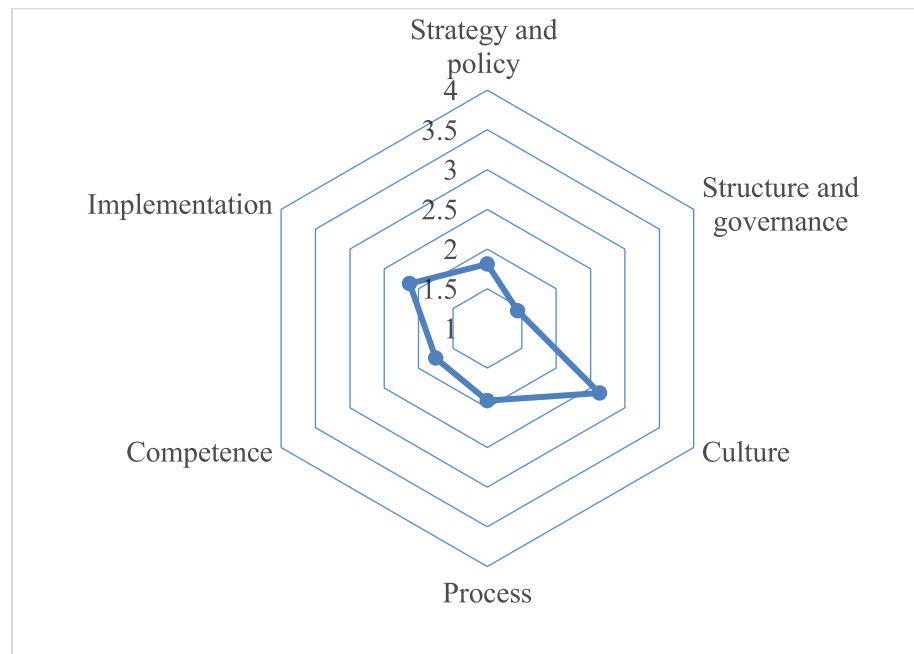


Figure 4-4 ERM maturity of COM1 respective of its six attributes (illustrative example)

4.4.3.2 Determining maturity scores

The maturity score (S) was determined for each of the companies surveyed using Equation (3-5) and following the same procedure as in section 4.4.3.1. Example (5) below provides an illustration of the procedure.

Example (5)

For the purpose of illustration, the ERM maturity was computed for COM1 using Equation (3-5). From Table 4-7, the aggregated TFN of COM1 is TFN_{COM1} (1.17, 2.00, 2.97). Therefore, the maturity score of the company (S_{COM1}) was determined to be 2.04. This, in terms of the membership functions, means that the company's aggregated ERM maturity was primarily at a novice level (96%), with a few areas (4%) at a managed level.

By applying similar procedures to the TFNs highlighted in Table 4-10, maturity scales were also computed for the other companies, as summarised in Table 4-12. Similarly, using the aggregated TFNs of the attributes determined for each company highlighted in Table 4-10, maturity scales of attributes were also computed for all the companies and these are presented Table 4-12. These results are discussed in section 4.4.4.

Table 4-12 Summary of companies' aggregated maturity scales (S)

Company	Attributes						Aggregated Score
	PS	SG	CU	PR	CO	IM	
COM1	1.81	1.44	2.63	1.91	1.44	2.13	2.04
COM2	2.00	1.69	2.33	2.13	1.69	2.10	2.06
COM3	1.63	1.44	1.79	1.91	1.44	1.93	1.82
COM4	2.00	1.81	1.88	1.81	1.81	1.70	1.79
COM5	3.00	1.44	2.67	1.94	1.44	1.63	2.00
COM6	1.81	2.06	2.33	1.63	2.06	2.00	1.97
COM7	2.25	1.44	2.46	1.81	1.44	1.78	1.94
COM8	2.00	1.88	2.79	2.13	1.88	2.40	2.29
COM9	1.81	1.63	2.33	2.13	1.63	2.60	2.20
COM10	3.00	3.19	2.83	3.09	3.19	2.78	2.97
COM11	1.63	1.44	2.17	1.63	1.44	1.63	1.69
COM12	1.44	1.44	2.04	1.53	1.44	1.50	1.60
COM13	2.00	1.63	2.04	1.81	1.63	2.05	1.92
COM14	2.50	2.50	3.25	2.63	2.50	2.60	2.71
COM15	2.31	2.50	2.79	2.16	2.50	2.68	2.50
COM16	2.50	1.63	2.50	2.00	1.63	2.03	2.09
COM17	1.81	2.50	2.04	1.91	2.50	1.70	1.92
COM18	2.25	1.63	2.50	1.81	1.63	1.63	1.84
COM19	2.00	2.00	2.17	2.00	2.00	1.93	1.99
COM20	2.06	1.81	2.42	1.81	1.81	1.95	2.03
COM21	2.50	3.00	2.38	2.50	3.00	2.33	2.46
COM22	1.63	1.44	1.75	1.25	1.44	1.33	1.42
COM23	2.75	1.81	2.04	1.81	1.81	1.95	1.98
COM24	1.44	2.00	1.75	1.63	2.00	2.03	1.82
COM25	2.25	2.06	2.67	2.25	2.06	2.15	2.22
COM26	1.81	1.44	2.04	1.91	1.44	2.13	1.86

4.4.4 Evaluation of companies' maturity based on the calculated maturity scores

In section 4.4.3, the ERM maturity values were computed for the surveyed companies. Based on these values, the overall maturities of the surveyed companies were evaluated as described below.

4.4.4.1 Maturity of companies in terms of attributes

To further analyse the attributes highlighted in Table 4-12, the companies surveyed were ranked in the order of the maturity scores of each attribute as shown in Table 4-13. Table 4-13 illustrates that the aggregated maturity scores span from 1.88 (for SG) to 2.33 (for CU), with all aggregated scores being categorised as at the novice maturity level.

Table 4-13 Ranks of companies in terms of the aggregated maturity scores of the six attributes

Company	CU	Company	PS	Company	IM	Company	PR	Company	CO	Company	SG
COM14	3.25	COM5	3.00	COM10	2.78	COM10	3.09	COM8	3.19	COM10	3.19
COM10	2.83	COM10	3.00	COM15	2.68	COM14	2.63	COM2	2.75	COM21	3.00
COM8	2.79	COM23	2.75	COM9	2.60	COM21	2.50	COM9	2.50	COM14	2.50
COM15	2.79	COM14	2.50	COM14	2.60	COM25	2.25	COM3	2.31	COM15	2.50
COM5	2.67	COM16	2.50	COM8	2.40	COM15	2.16	COM19	2.25	COM17	2.50
COM25	2.67	COM21	2.50	COM21	2.33	COM2	2.13	COM5	2.25	COM6	2.06
COM1	2.63	COM15	2.31	COM25	2.15	COM8	2.13	COM6	2.06	COM25	2.06
COM16	2.50	COM7	2.25	COM1	2.13	COM9	2.13	COM24	2.06	COM19	2.00
COM18	2.50	COM18	2.25	COM26	2.13	COM16	2.00	COM10	2.00	COM24	2.00
COM7	2.46	COM25	2.25	COM2	2.10	COM19	2.00	COM14	2.00	COM8	1.88
COM20	2.42	COM20	2.06	COM13	2.05	COM5	1.94	COM25	2.00	COM4	1.81
COM21	2.38	COM2	2.00	COM16	2.03	COM1	1.91	COM12	2.00	COM20	1.81
COM2	2.33	COM4	2.00	COM24	2.03	COM3	1.91	COM21	1.81	COM23	1.81
COM6	2.33	COM8	2.00	COM6	2.00	COM17	1.91	COM23	1.81	COM2	1.69
COM9	2.33	COM13	2.00	COM20	1.95	COM26	1.91	COM13	1.81	COM9	1.63
COM11	2.17	COM19	2.00	COM23	1.95	COM4	1.81	COM16	1.81	COM13	1.63
COM19	2.17	COM1	1.81	COM3	1.93	COM7	1.81	COM1	1.81	COM16	1.63
COM12	2.04	COM6	1.81	COM19	1.93	COM13	1.81	COM22	1.81	COM18	1.63
COM13	2.04	COM9	1.81	COM7	1.78	COM18	1.81	COM15	1.63	COM1	1.44
COM17	2.04	COM17	1.81	COM4	1.70	COM20	1.81	COM17	1.63	COM3	1.44
COM23	2.04	COM26	1.81	COM17	1.70	COM23	1.81	COM4	1.63	COM5	1.44
COM26	2.04	COM3	1.63	COM5	1.63	COM6	1.63	COM20	1.63	COM7	1.44
COM4	1.88	COM11	1.63	COM11	1.63	COM11	1.63	COM11	1.63	COM11	1.44
COM3	1.79	COM22	1.63	COM18	1.63	COM24	1.63	COM18	1.25	COM12	1.44
COM22	1.75	COM12	1.44	COM12	1.50	COM12	1.53	COM7	1.25	COM22	1.44
COM24	1.75	COM24	1.44	COM22	1.33	COM22	1.25	COM26	1.25	COM26	1.44
Overall	2.33		2.08		2.03		1.97		1.93		1.88

Accordingly, companies surveyed were evaluated by categorising them into their respective maturity levels based on maturity score ranges provided in Table 3-7, i.e. naive ($S = 1 \leq x < 1.5$), novice ($S = 1.5 \leq x < 2.5$), managed ($S = 2.5 \leq x < 3.5$), and ($S = x \geq 3.5$).

Based on this categorisation, the number of contractors was summarised in terms of the four maturity levels and the six attributes as shown in Table 4-14 and Figure 4-5. These indicate that the majority of the contractors were categorised as being novice in all the six attributes, and none of the companies reached the optimised level with respect to any attributes. It can also be seen that there were a considerable number of companies ($n = 9$) at the managed level in the culture attribute, compared to the others. The analysis also illustrates that a significant number of contractors were rated as being at the naive level according to the structure and governance attribute. The results are described below and further discussed in section 5.2.3.4.

Table 4-14 Propositions of maturity of companies in terms of attributes

Attribute	Number of contractors				Total
	Naive	Novice	Managed	Optimised	
Policy and Strategy	2	18	6	-	26
Structure and Governance	8	13	5	-	26
Process	1	22	3	-	26
Culture	0	17	9	-	26
Competence	3	20	3	-	26
Implementation	1	21	4	-	26

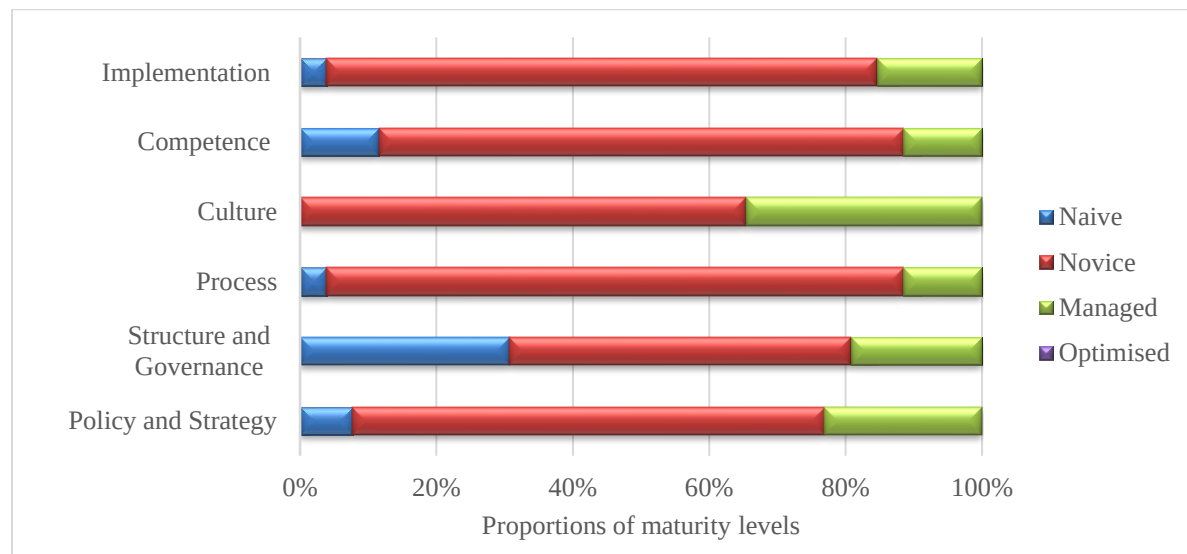


Figure 4-5 Propositions of the maturity of companies in terms of attributes

i) Companies' maturity in terms of the culture attribute

As shown in Table 4-13, the aggregated maturity score of the culture attribute is 2.33 with individual company scores ranging between 1.75 and 3.25 out of a maximum score of 4.00. The highest score ($S = 3.25$) was attained by COM14 and the lowest score ($S = 1.75$) was achieved by COM22 and COM24. By comparison with the other five attributes (Table 4-13), it may therefore be seen that based on the aggregated score achieved, the sector could be considered to be the most mature in the ERM culture attribute. As illustrated in the maturity spectrum in Figure 4-6, the aggregated score of 2.33 indicates that the overall ERM maturity of the companies surveyed was with the degree of membership functions of 67% novice and 33% managed, which can be categorised based on Table 3-7 as novice (i.e. $S = 1.5 \leq x < 2.5$), in terms of this attribute.

As illustrated in Table 4-13, over half of the contractors surveyed achieved maturity scores equal to or above the aggregated score of 2.33. Table 4-14 also indicates that nearly two-thirds of the companies (65%) were computed to be at the novice level and the remaining 9 (35%) were considered to be at the managed level. Further, none of the companies were computed to be in the naive or the optimised maturity levels, according to this particular attribute.

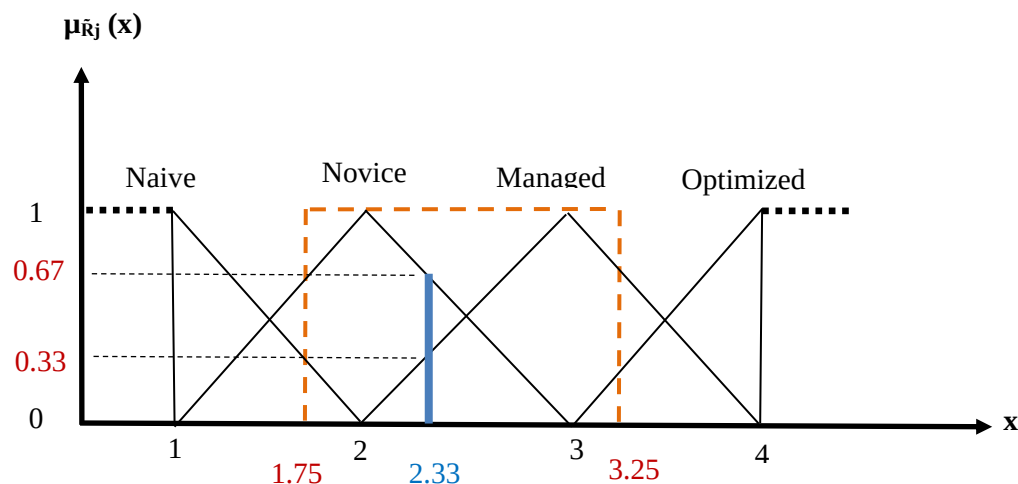


Figure 4-6 The range of the TMF of companies' ERM maturity in CU attribute

ii) Maturity of companies in terms of the policy and strategy attribute

As illustrated in Table 4-13 and Figure 4-7, the maturity scores of the companies in the PS attribute ranged from 1.44 to 3.00, with an aggregated maturity score of 2.08. Accordingly, from Table 4-

14, it can be seen that, by comparison with other attributes, this attribute was ranked the second most mature. Moreover, as illustrated in Figure 4-7, the calculated aggregated maturity score of 2.08 reveals that the overall maturity of the contractors surveyed was 92% novice and 8% managed degrees of membership functions, in terms of this attribute, with the overall maturity of the novice level.

Overall, above two-thirds (69%) of the companies were categorised as at the novice level in terms of this attribute and the remaining six (23%) and two (8%) companies were ranked as being at the managed and naive levels, respectively. Further, it can also be seen that only 10 (38%) of the 26 companies had scores above the aggregated score (2.08).

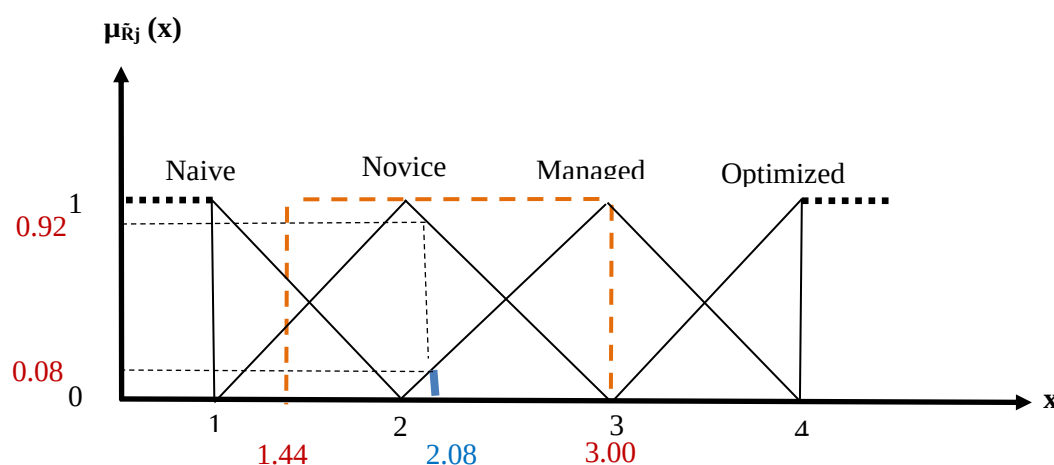


Figure 4-7 The range of the TMFs of contractors' ERM maturity - PS attribute

iii) Maturity of companies in terms of the implementation attribute

Again, from Table 4-13 and Figure 4-8, it can be seen that the aggregated maturity of the companies surveyed were computed to be at the novice level according to this attribute, with scores spanning from 1.33 to 2.78, and an aggregated score of 2.03. The 2.03 aggregated maturity score of this attribute shows that the overall ERM maturity level of the companies surveyed could be categorised as novice, with the degree of membership function of 97% novice and 3% managed in the case of implementing ERM. Further, as illustrated in Table 4-14, more than three-quarters (81%) of the companies surveyed were computed to be in the novice stage with four (15%) companies at the managed level. Yet it is worth noting that one company (COM22) was found to be at the naive level with a score of 1.33 (67% naive and 33% novice).

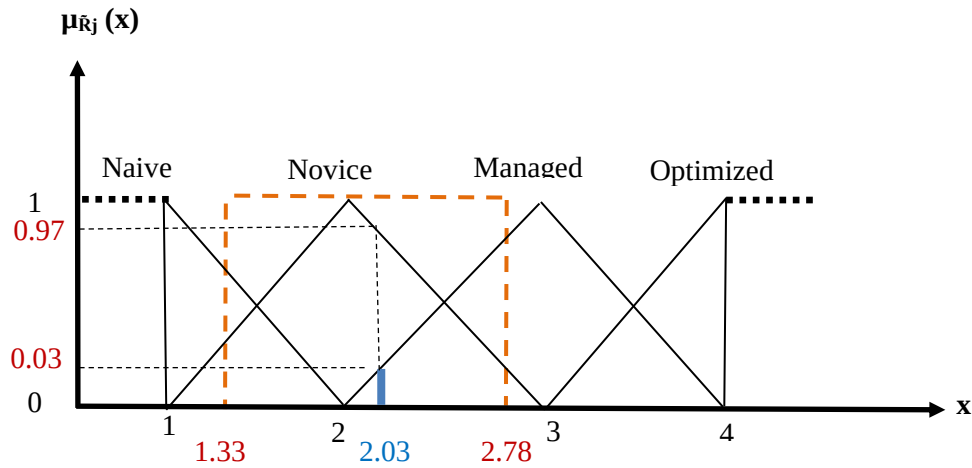


Figure 4-8 The range of the TMFs of contractors' ERM maturity - IM attribute

iv) Maturity of companies in terms of the process attribute

As illustrated in Table 4-13 and Figure 4-9, the aggregated maturity score of companies surveyed in terms of the PR attribute was found to be 1.97 (i.e. 97% novice and 3% naive according to the membership function shown in Figure 4-9) with maximum and minimum scores of 3.09 and 1.25, respectively. From Table 4-14, it can also be seen that that the predominant number of the companies surveyed (22 out of 26) were computed to be at a novice level (i.e. $S = 1.5 \leq x < 2.5$, in terms of Table 3-7) according to the PR attribute. From the remaining four companies, three were found to be at a managed level and the other one at a naive level.

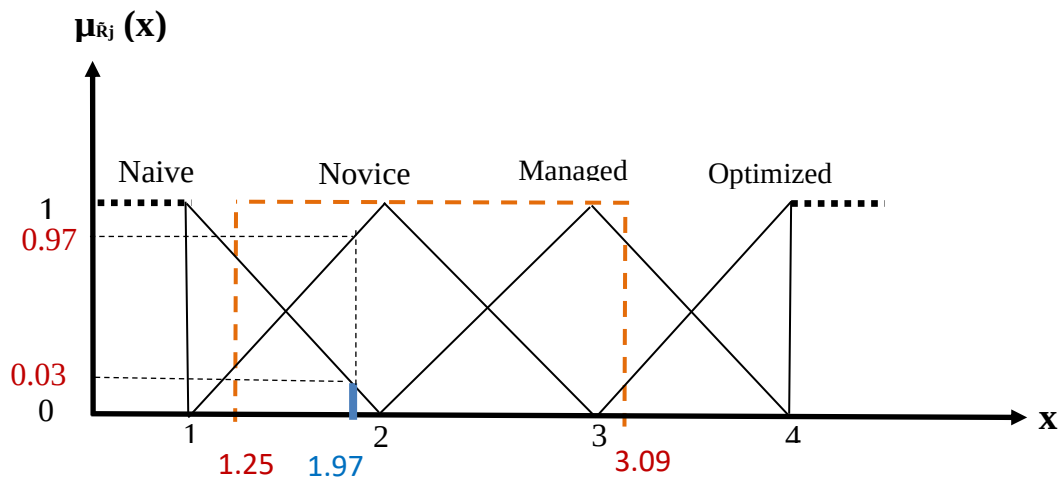


Figure 4-9 The range of the TMFs of contractors' ERM maturity - PR attribute

v) Maturity of companies in terms of the competence attribute

Table 4-14 also shows that, CO is the second least mature attribute with an aggregated maturity score of 1.93 (i.e. with the degree membership functions of 93% novice and 7% naive levels, as illustrated in Figure 4-10) and with the minimum and maximum scores of 1.25 and 3.19, respectively. The maturity scores in Table 4-13 show that only three (12%) companies were able to attain the managed level (i.e. $S = 2.5 \leq x < 3.5$). Of the remaining 23 (88%), 20 companies were computed to be at the novice level (i.e. $S = 1.5 \leq x < 2.5$) and three companies at a naive level ($S = x < 1.5$). That is, there were some companies at the lower maturity level that contributed the CO attribute to be 7% at a naive level. Evidently, this suggests that all of the surveyed companies need to develop an appropriate strategy in order to improve their ERM under the CO attribute. Approaches which may be adapted to improve the current scenario are discussed in section 5.2.3.4.

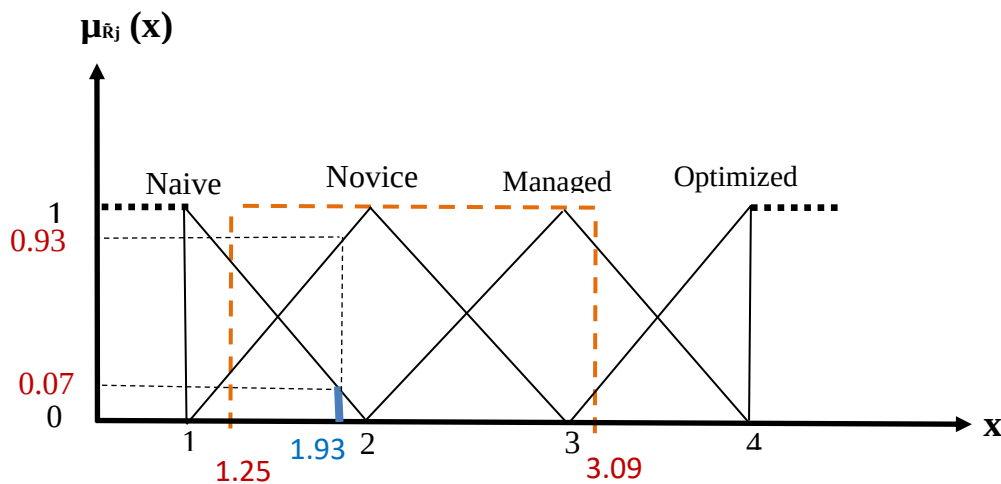


Figure 4-10 The range of the TMFs of contractors' ERM maturity - CO attribute

vi) Maturity of companies in terms of the structure and governance attribute

From the computed maturity scores presented in Table 4-13, the companies surveyed were found to be the least mature according to this attribute, with an aggregated score of 1.88, i.e. with the degree of membership functions of 88% novice and 12% naive levels, respectively, as illustrated in Figure 4-11. The maturity scores of the companies varied between 1.44 and 3.19. The table also indicates that only ten (38%) of the companies surveyed were above or equal to the aggregated score (1.88) of the attribute and 16 (62%) had less than the aggregated score.

Half (13) of the companies were at a novice level and five (19%) were at the managed level in this attribute (Table 4-14). As an exception to the other attributes, however, nearly one-third of the contractors (30.8%) were found to be at a naive level. This generally suggests that a considerable effort is required to improve the ERM approach of the sector in terms of this attribute, with a special focus on the areas of the weaknesses. Approaches which may be adopted to improve the practices are discussed in section 5.2.3.4.

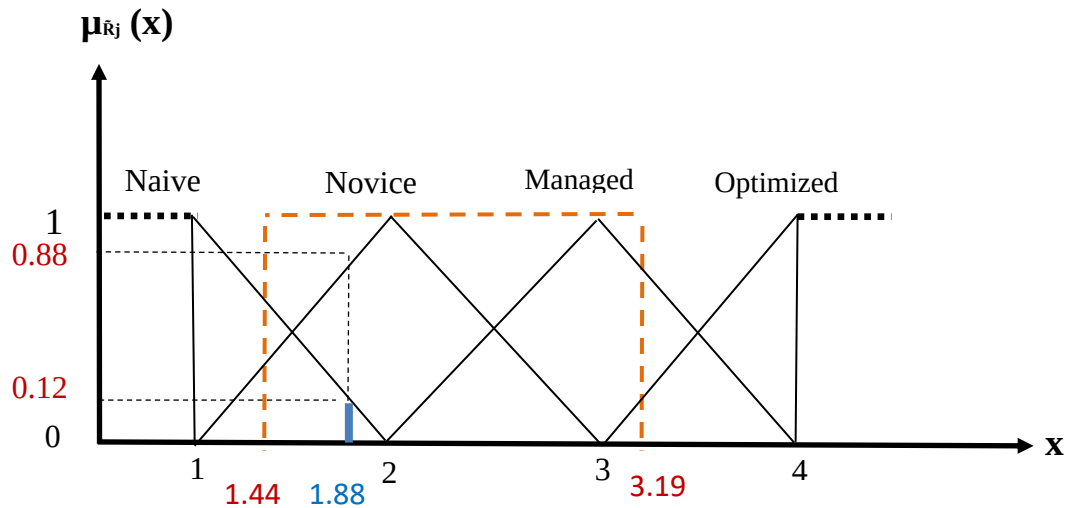


Figure 4-11 The range of the TMFs of contractors' ERM maturity - SG attribute

4.4.4.2 Companies' aggregated ERM maturity

The aggregated maturity scores of the 26 companies determined in section 4.4.3.2 (see Table 4-12) are shown in Table 4-15 in the order of their maturity scores, together with their associated TMFs. As shown in Table 4-15 and Figure 4-12, the aggregated ERM maturity scores of the companies varied between 1.42 and 2.97 with an overall aggregated score of 2.04. The highest aggregated score ($S = 2.97$) and the lowest score ($S = 1.42$) were achieved by COM10 and COM21, respectively. Surprisingly, this also indicates that none of the companies computed aggregated ERM maturity scales reached to the fully fledged managed level, attaining a minimum score of 3.00. Generally, although it is not always easy to achieve a fully mature company (Andersen & Jessen, 2002), companies should ensure an efficient RM system (Chapman & Ward, 2002) to treat their risks reasonably. At least at a complete managed level ($S = 3.00$) company was expected to

effectively treat their risks. Hence, this suggests that the sector demands transformation in many aspects to improve the practice.

Table 4-15 Summary of companies' maturity

Company	Aggregated interviewee's perception on ith company	Aggregated maturity score	Degree of TMFs	Maturity level
COM10	(2.00, 3.00, 3.89)	2.97	97% Managed, 3% Novice	Managed
COM14	(1.72, 2.72, 3.67)	2.71	71% Managed, 29% Novice	Managed
COM15	(1.56, 2.50, 3.44)	2.50	50% Novice, 50% Managed	Managed
COM21	(1.50, 2.44, 3.44)	2.46	54% Novice, 46% Managed	Novice
COM8	(1.33, 2.28, 3.25)	2.29	71% Novice, 29% Managed	Novice
COM25	(1.31, 2.19, 3.19)	2.22	78% Novice, 22% Managed	Novice
COM9	(1.28, 2.17, 3.17)	2.20	80% Novice, 20% Managed	Novice
COM16	(1.17, 2.06, 3.06)	2.09	91% Novice, 9% Managed	Novice
COM2	(1.14, 2.03, 3.03)	2.06	94% Novice, 6% Managed	Novice
COM1	(1.17, 2.00, 2.97)	2.04	96% Novice, 4% Managed	Novice
COM20	(1.22, 1.97, 2.97)	2.03	97% Novice, 3% Managed	Novice
COM5	(1.25, 1.92, 2.92)	2.00	100% Novice	Novice
COM19	(1.03, 1.97, 2.97)	1.99	99% Novice, 1% Naive	Novice
COM23	(1.14, 1.92, 2.92)	1.98	98% Novice, 2% Naive	Novice
COM6	(1.14, 1.92, 2.89)	1.97	97% Novice, 3% Naive	Novice
COM7	(1.11, 1.89, 2.86)	1.94	94% Novice, 6% Naive	Novice
COM13	(1.08, 1.86, 2.86)	1.92	92% Novice, 8% Naive	Novice
COM17	(1.08, 1.86, 2.86)	1.92	92% Novice, 8% Naive	Novice
COM26	(1.08, 1.78, 2.78)	1.86	86% Novice, 14% Naive	Novice
COM18	(1.11, 1.75, 2.75)	1.84	84% Novice, 16% Naive	Novice
COM3	(1.03, 1.75, 2.75)	1.82	82% Novice, 18% Naive	Novice
COM24	(1.03, 1.75, 2.75)	1.82	82% Novice, 18% Naive	Novice
COM4	(1.00, 1.72, 2.72)	1.79	79% Novice, 21% Naive	Novice
COM11	(1.03, 1.58, 2.58)	1.69	69% Novice, 31% Naive	Novice
COM12	(1.06, 1.44, 2.44)	1.60	60% Novice, 40% Naive	Novice
COM22	(1.00, 1.22, 2.22)	1.42	58% Naive, 42% Novice	Naïve
Overall	(1.21, 1.99, 2.98)	2.04	96% Novice, 4% Managed	Novice

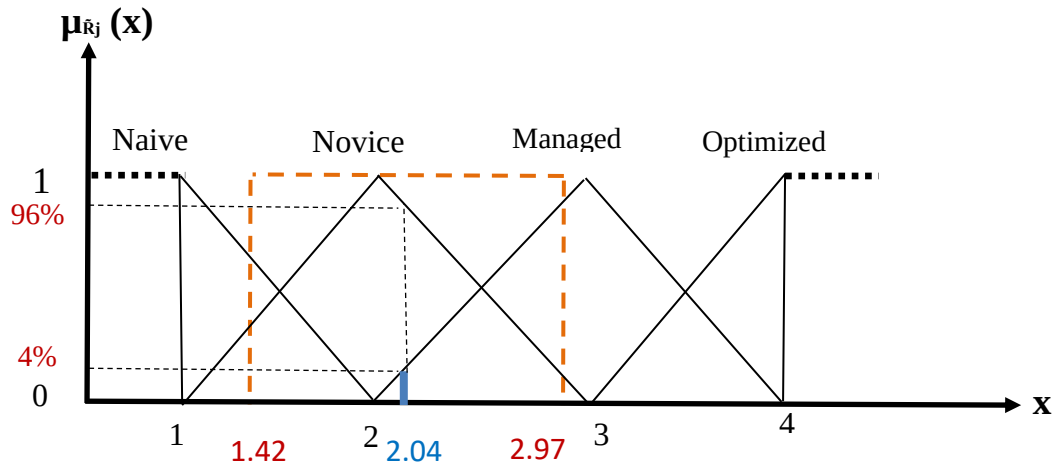


Figure 4-12 The range of the TMFs of contractors' - ERM maturity

The vein diagram in Figure 4-13 also shows the relative positions of companies surveyed against the maximum expected scores of 4.00 points, which shows that there is no outlier company for the highest level of maturity. Instead, the maturity of most of the companies was concentrated below the 2.5 maturity region, with one outlier company that had less than a 1.5 maturity score.

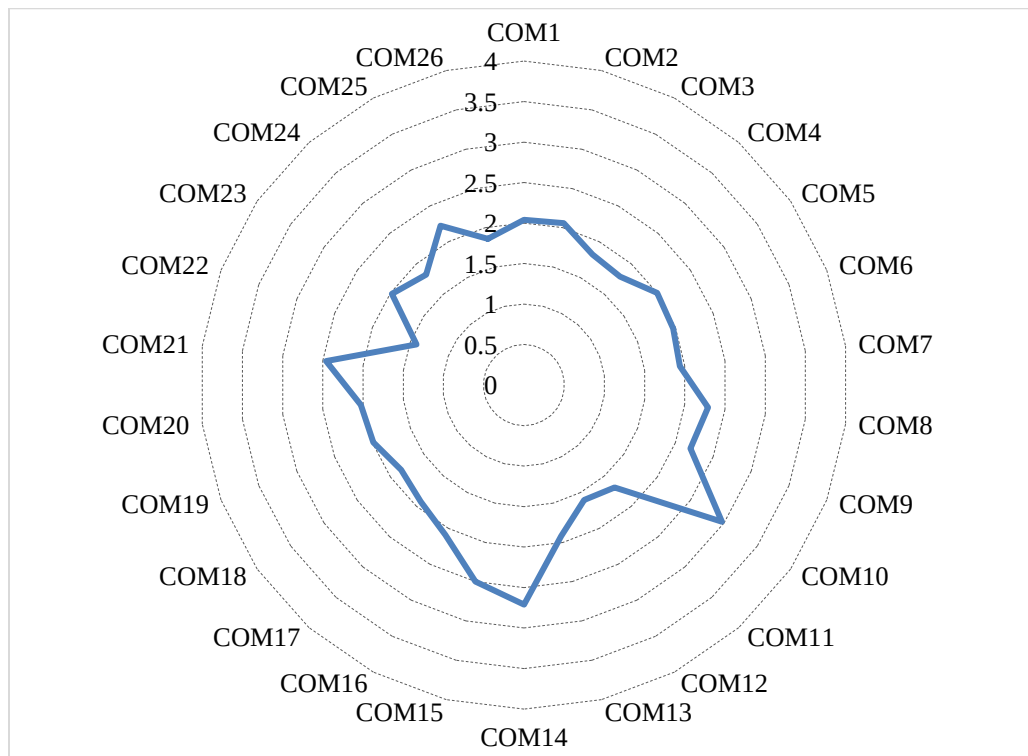


Figure 4-13 The radar distribution of companies' maturity

In order to assess the proportions of companies in the four levels of maturity, the computed maturity levels were analysed further and the results are summarised in Table 4-16, Figures 4-14 and 4-15. As shown in Table 4-16 and Figure 4-14, 21 (80%) out of the 26 contractors were found to have maturity at a novice level and four (15%) were at a managed level. The ERM maturity of the remaining one contractor was computed to be at the lowest (naive) level with a maturity score of 1.42 (with the degree of membership of 58% naive and 42% novice). This demonstrates that the road sector was at a relatively low level of maturity. Given the diverse and complex risks involved in the sector, the existence of such ineffective ERM practice poses a great concern to the country's road infrastructure development. Further, if the practice is not transformed, it is expected that Ethiopian companies will continue to face stiff competition from their foreign counterparts, making it difficult for them to win projects.

The maturity of the contractors was further categorised based on the triangular membership functions as illustrated in Table 4-16 and Figure 4-14. According to Table 4-16 and Figure 4-15, out of the 21 companies that were computed to have a novice level ERM, only eight (38%) had advanced from novice to managed level and one company was 100% at a novice level. The remaining 12 (57%) contractors were computed to have ERM maturity scores belonging to both the naive and novice levels. It can also be seen in Table 4-16 that the four contractors categorised predominantly as being at a managed level were also partly categorised as being at a novice maturity level. Meaning, none of the companies had reached the fully fledged managed level, let alone had advanced to the optimised level.

Table 4-16 Proportions of companies under the four maturity levels

S/ No.	Maturity Level	No. of contractors	Proportion	Degree of TMF under each maturity level
1.	Naive	1	4%	
2.	Novice	21	81%	Naive to Novice (12) Novice to Managed (8) 100% Novice (1)
3.	Managed	4	15%	Novice to Managed
4.	Optimised	-	-	
Total		26	100%	

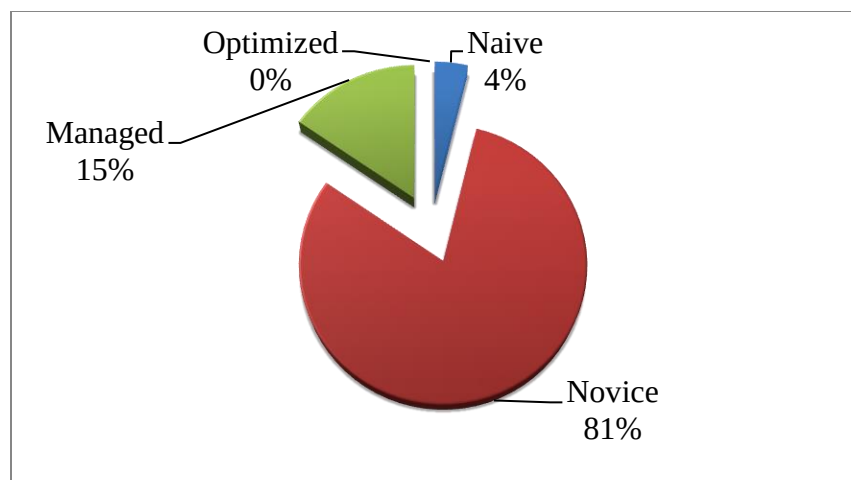


Figure 4-14 Proportion of companies' ERM maturity

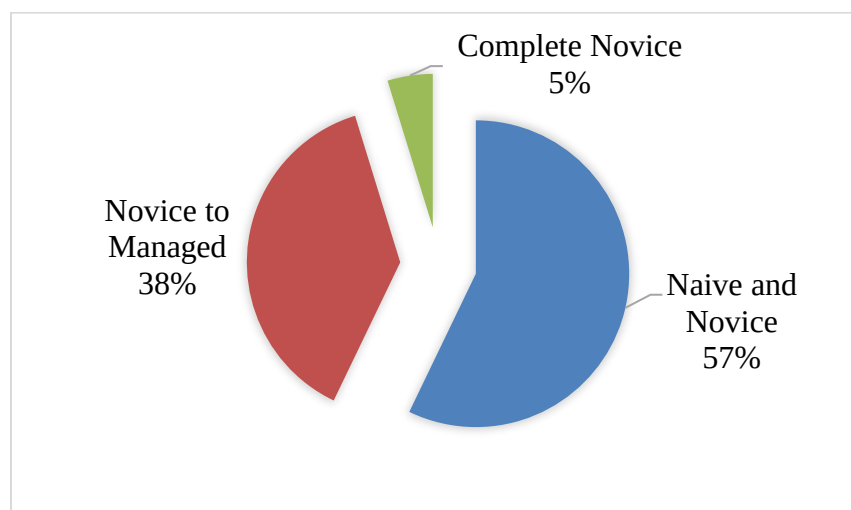


Figure 4-15 Categories of companies within the novice level of maturity

Overall, the analysis in the preceding sections shows that the ERM capability of the companies surveyed is relatively low according to the aggregated ERM capability scores computed for all companies. Similarly, the number of companies achieving the higher levels of maturity were few when the six measures of ERM capability (policy and strategy, structure and governance, process, culture, competence and, implementation) were considered individually or aggregated.

As also described in section 4.4.1, the results achieved reflect the current experience of the Ethiopian road sector, which suggests that the method used to measure the maturity of companies

is appropriate. Practically, it also demonstrates that the sector needs to develop an appropriate strategy that can fundamentally improve existing practices. The approach needs to focus on all the six maturity attributes. However, since strategy and governance, which is a key attribute to implement the ERM is at a relatively low level of maturity, the change should begin with formulating a workable organisational structure that accommodates ERM as a key function of companies. The appropriate staff should also be assigned with the right duties and responsibilities that can help to establish strategy for ERM implementation, and ensure that this is realised as set out in the strategy. In companies of the EM mature sectors, such as the financial sector, RM is led by a chief risk officer or equivalent, which indicates that the construction industry in Ethiopia must strive to gradually reach this level. Another key attribute to practising ERM efficiently but at the second least mature level is competence. This suggests that companies should hire employees with adequate experience, skills and knowledge in risk management, and that appropriate training should be provided to further enhance their RM performance.

The important finding achieved in section 4.4.4.1 is that the sector is relatively more mature in the ERM culture, which is essential for bringing changes in the other attributes too. Hence, companies should attempt to foster their culture and embed it at all levels.

4.4.5 Companies' ERM maturity versus their characteristics

Inferential statistics were used to measure whether there are differences in the ERM maturity scores of different groups of companies, categorised on some selected characteristics. These categories include the type of ownership of the company (i.e. private or public); the number of years of experience a company had in the sector (i.e. less than 10 years, 10 to 20 years, 20 to 30 years and above 30 years); and the scope of projects handled by the respective companies. The analysis is described below.

4.4.5.1 Companies' ERM maturity versus ownership

Of the 26 companies involved in this study, three (COM4, COM7 and COM10) are state owned and the remaining 23 were private companies. A t-test inferential statistic was used to explore if there is a statistical difference between the mean maturity scores of these two groups of companies, i.e. considering all six measures together (for more information about the t-test see Marshal & Jonker, 2011). Since the samples are independent, a two-sample t-test was computed assuming

equal variances for alpha ($\alpha = 0.05$) with a null hypothesis, i.e. there is no difference between the mean maturity scores of the public and private companies. The results are given in Table 4-17.

Table 4-17 t-Test: two-sample, assuming equal variances

	Public	Private
Mean	2.203704	1.960145
Variance	0.090653	0.101364
Observations	36	36
Pooled Variance	0.096008	
Hypothesised Mean Difference	0	
df	70	
t Stat	3.334924	
P(T<=t) one-tail	0.000684	
t Critical one-tail	1.666914	
P(T<=t) two-tail	0.001367	
t Critical two-tail	1.994437	

As can be seen in Table 4-17, the probability (two-tailed) ($p = 0.001367$) is less than the alpha level of 0.05. Further, the t Critical two-tail is found to be 1.994437, which is less than the t Stat of value of 3.334924 at 95% confidence interval. Hence, the null hypothesis can be rejected. That is, there is a significant difference in the maturity scores of the public ($M = 2.2$, $SD = 0.30$) and private enterprises ($M = 2.0$, $SD = 0.31$), $t = 3.33$, $p = 0.001$. This suggests that a company's type of ownership has a significance on its ERM maturity level. As the means of the two groups show, the maturity of public companies was found to be relatively higher compared to the private ones (i.e. 2.2 vs. 1.96). This finding concurs with Ali, et al. (2019), Beasley et al. (2018) and Zhao, et al. (2013a), who compared the ERM capabilities of the public and private companies in Malaysia, the USA, and China, respectively. All the three studies found that public companies had more advanced RM practices relative to private companies. As far as the Chinese study is concerned, it is stated that implementing ERM is a pre-requisite for Chinese state-owned companies to have demonstrated RM capabilities (Zhao, et al., 2013a). A contrasting result was reported in a South African study, in which public companies were reported much less mature than private companies (Coetzee & Lubbe, 2013).

4.4.5.2 The ERM maturity versus companies' experience

A one-way between-groups analysis of variance (ANOVA) test was conducted to determine whether there is a significant difference in the companies' ERM competence with respect to their years of experience in the sector.

The significance level of the analysis was set at a p-value of 0.05 as suggested by Cohen (1992; cited in Chileshe & Yirenyi-Fianko, 2011). According to Dulaimi et al. (2002), the inference to be drawn from a significance level > 0.05 is that the null hypothesis (H_0) in this case is: 'RM maturity has no association with companies' experience in the road sector.' According to the data in Table 4-1, 15 (58%) of the 26 companies had less than 20 years, 8 had between 20 and 30 years and the remaining 3 companies had more than 30 years' experience. Hence, the ANOVA analysis has provided the results presented in Table 4-18 below.

Table 4-18 Years of experience versus RM companies' maturity level

SUMMARY				
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Less than 20 years	36	70.8	1.966667	0.115429
20 to 30 years	36	69.875	1.940972	0.109363
Above 30 years	36	80	2.222222	0.101587

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	1.740845	2	0.870422	8.000734	0.000583	3.082852
Within Groups	11.42325	105	0.108793			
Total	13.16409	107				

From Table 4-18, it can be seen that the F-value (8.00) is greater than the F-critical value (3.08) for the alpha level selected (0.05). In addition, the *p-value* ($p=0.0006$) is less than the alpha level selected (0.05). Therefore, the null hypothesis is rejected, meaning there is a statistically significant difference between the computed ERM maturity levels of the three groups of companies in their years of experience. That is, firm experience has an impact on their ERM maturity levels (as might be expected).

However, the results provided in Table 4-18 appear to be a little unusual, with companies with less than 20 years of experience having relatively higher ERM scores than those with above 20 years. Unfortunately, this is the actual scenario in Ethiopia, in which most companies decline in every aspect while their years of experience increase. As a result, most of the companies that had been operating in the Ethiopian road sector in the 1990s are no longer in the industry. Although it requires further studies, institutional maturity is a major concern for the sustainability of companies in developing countries, including Ethiopia.

4.4.5.3 *The ERM maturity versus the scope of projects*

The RSDP report on Ethiopia (ERA, 2021a) summarised in Table 4-19 indicates that about 909 MFRCs worth ETB 411,817.5 billion were awarded to construction companies between 1998 and 2020. Of this, 722 (79.4%) projects to the value of ETB 211,859.82 (51.4%) were contracted to EDCs.

Table 4-19 Summary of major road projects implemented in Ethiopia (1998-2020)

Contractor	No. of projects	Total cost of projects (ETB billion)
Domestic contractors	722	211.86
Foreign contractors	187	199.66
Total	909	411.82

(Adapted from ERA, 2021a)

The details of projects awarded to the 26 surveyed contractors during this period are highlighted in Table 4-20 (ERA, 2021a). The following is a summary of the information in this table:

- The 26 contractors considered in this study were engaged in 206 (28.5%) of the total 722 projects contracted to EDCs. The total length of these projects was estimated to be 11,870.27 km and worth approximately ETB 139.79 billion (65.6%) out of the total ETB 211.86 billion awarded to EDCs.
- The number of projects constructed by companies surveyed ranged from two projects constructed by COM1 to 54 projects constructed by COM10 with an average of eight projects per company.

- The total length of projects handled by the contractors surveyed varied from 28 km (0.2%) of COM26 to 2,278.9 km (19.2%) of COM10.
- An average of ETB 5.38 billion was awarded to each contractor with a maximum amount of ETB 19.56 billion awarded to COM1 and a lowest value of ETB 0.56 billion contracted with COM26.

Table 4-20 Scope of the projects in which the contractors surveyed were involved (1998-2020)

Company	No of projects		Length		Cost	
	No	%	km	%	(ETB billion)	%
COM1	3	1.5%	192.5	1.6%	2.97	2.1%
COM2	7	3.4%	452.7	3.8%	3.03	2.2%
COM3	5	2.4%	278.0	2.3%	2.68	1.9%
COM4	5	2.4%	305.7	2.6%	4.14	3.0%
COM5	3	1.5%	114.0	1.0%	2.87	2.1%
COM6	6	2.9%	351.0	3.0%	1.29	0.9%
COM7	14	6.8%	1056.0	8.9%	19.37	14.0%
COM8	3	1.5%	75.0	0.6%	1.40	1.0%
COM9	6	2.9%	329.0	2.8%	5.49	4.0%
COM10	54	26.2%	2278.9	19.2%	19.56	14.1%
COM11	3	1.5%	166.0	1.4%	1.81	1.3%
COM12	5	2.4%	272.0	2.3%	2.86	2.1%
COM13	8	3.9%	489.4	4.1%	6.48	4.7%
COM14	6	2.9%	483.0	4.1%	4.58	3.3%
COM15	4	1.9%	177.2	1.5%	3.67	2.6%
COM16	1	0.5%	74.0	0.6%	0.97	0.7%
COM17	3	1.5%	161.6	1.4%	1.97	1.4%
COM18	3	1.5%	167.4	1.4%	4.23	3.0%
COM19	3	1.5%	90.7	0.8%	2.30	1.7%
COM20	3	1.5%	61.0	0.5%	0.99	0.7%
COM21	17	8.3%	1,761.0	14.8%	7.50	5.4%
COM22	15	7.3%	986.0	8.3%	11.75	8.5%
COM23	5	2.4%	264.0	2.2%	4.08	2.9%
COM24	14	6.8%	827.0	7.0%	11.91	8.6%
COM25	8	3.9%	429.1	3.6%	10.32	7.4%
COM26	2	1.0%	28.0	0.2%	0.56	0.4%
Total	206	100%	11,870.2	100%	139.79	100%
Average	8		456.5		5.38	

Adapted from the detailed data in (ERA, 2021a)

In order to investigate whether the scope of projects awarded to a company is related to its ERM maturity level, a Pearson's correlation and a linear regression were performed using the total cost of projects awarded to the companies in the 23-year period and their ERM maturity level. It is assumed that the number of projects, their total length and the costs are intimately related.

Pearson's product-moment correlation or Pearson's coefficient (r_p) is a common statistical method used to describe the relationship (the correlation) between two variables (Marshall & Jonker, 2011). For the Pearson correlation, an absolute value of 1 indicates a perfect linear relationship and close to 0 indicates no linear relationship between the variables. Accordingly, the Pearson's correlation coefficient (r_p) was calculated to test the correlation between the ERM maturity and volume of projects (in cost) yielding 0.25. The details of the calculation are shown in Appendix G3. This suggests that there is no perfect relationship between the two parameters.

A linear regression was computed to further supplement the correlation between the above two variables (see Fig. 4-16). For a linear regression analysis, the computed R^2 value (also called as the coefficient of determination) is used to measure how close the data are to a fitted regression line. This value ranges from 0 (essentially a random cloud of points) to 1 (the points fall perfectly on a straight line). Accordingly, the value of R^2 was computed using companies' ERM Maturity Level (ML) as a dependent variable and the cost of the project (PC) the companies engaged in as an independent variable resulting an R^2 value of 0.06. This value is closer to 0, indicating a weak correlation between the companies' ERM maturity and the value of projects in which the companies were engaged. Hence, reject the null hypothesis. That is, the scope of projects handled by the companies has no significant implications on the companies' ERM maturity levels in the EDCs.

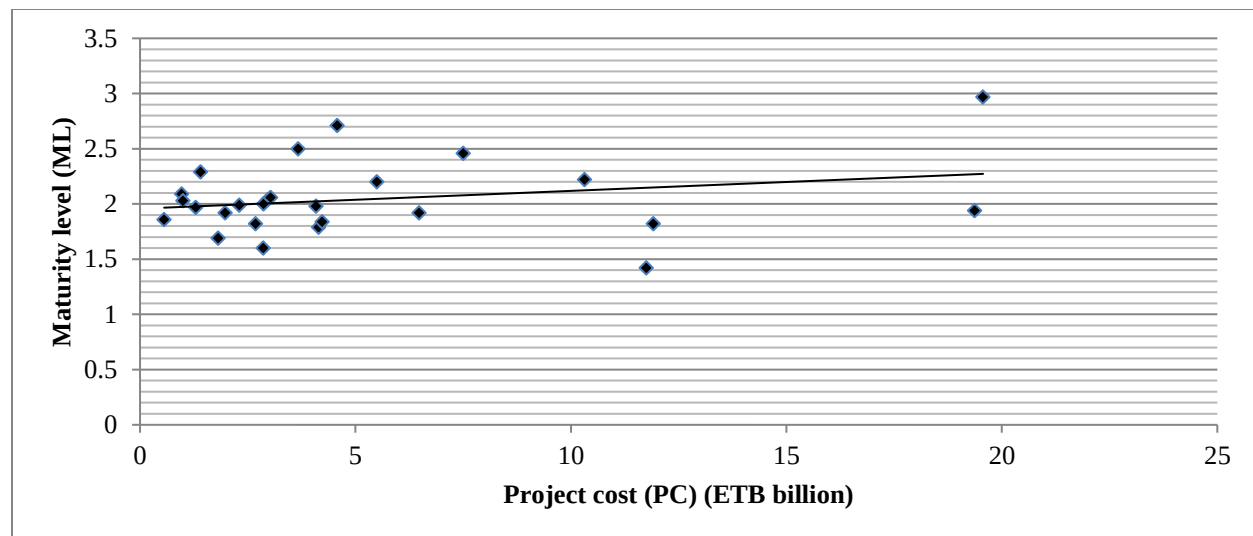


Figure 4-16 Construction companies' ERM maturity versus project scope

The low Pearson's correlation coefficient (0.25) and R^2 (0.06) values achieved would suggest that there is little correlation between the value of the projects awarded to the 26 companies and their computed ERM maturity levels. This appears to be consistent with the results obtained in 4.4.5.2, as no significant advancement has been seen in the ERM practice by contractors who have carried out relatively many projects.

This might have been expected as the contract awarding body did not consider a company's ERM practices when awarding contracts, because risk management is often not considered as a qualification criterion for evaluating the technical capability of bidders. Further, risk management is not regarded as a key criterion for registering a contractor in the country; as a result, the issue of risk management might not be seen as an immediate priority for contractors.

4.5 Analysis of the Relative Maturity of Indicators and Attributes

In section 4.4, the ERM maturity was measured at a company level, in which the maturity of each individual company was explored to enable an overview of the risk management practices of EDCs that operate in the federal road construction projects. Further to this, the RM maturity of the road sector was also examined in terms of the identified indicators and attributes for examining their relative maturity levels. The fuzzy logic systems followed in section 4.4 were also applied to compute maturity scores. This helps to identify the strong and weak areas of the sector.

4.5.1 Determining the relative maturity of indicators

4.5.1.1 Determining of the aggregated TFNs (aggregation)

The aggregated TFN of the indicator (L_i) of the road sector was determined by aggregating the scores provided for indicator (i) by interviewee (j) using Equation (3-2). Similar data used in section 4.4 was utilised for this purpose (see Appendix F1). To illustrate the computations carried out, an example is provided below (Example 6) by computing the aggregated TFN for the first indicator of the policy and strategy attribute, i.e. PS1 (existence of policy and strategy). For ease of calculating the 26 items of data, the frequency of the scores provided by interviewees under each of the four maturity levels is summarised in Table 4-21.

Table 4-21 Frequencies of score provided for indicators in the PS attribute

Category	PS1	PS2	PS3	PS4
Naive	8	2	7	2
Novice	16	17	12	17
Managed	2	7	7	7
Optimised	-	-	-	-
Total	26	26	26	26

Using these frequency values, the aggregated TFNs were determined for the four indicators in the PS attribute as follows.

Example (6): Indicator 1 (PS1): existence of policy and strategy

From Table 4-21, the numbers of the maturity levels provided by the interviewee for indicator L_{PS1} are as follows: naive = 8, novice = 16 and managed = 2. Therefore, using the TFNs defined for each maturity level in Table 3-6, the aggregated TFN of PS1, L_{PS1} , is calculated as:

$$\begin{aligned}
 L_{PS1} &= 1/26*[8*(1, 1, 2) + 16*(1, 2, 3) + 2*(2, 3, 4)] \\
 &= 1/26*[(8, 8, 16) + (16, 32, 48) + (4, 6, 8)] \\
 &= 1/26*(28, 46, 72) = (1.08, 1.77, 2.77)
 \end{aligned}$$

Hence, the aggregated TFN of the first indicator (L_{PS1}) was found to be (1.08, 1.77, 2.77). Using the same procedures, TFNs were also determined for the other three indicators of the attribute, yielding the aggregated TFNs of L_{PS2} , L_{PS3} , and L_{PS4} to be (1.27, 2.1, 3.19), (1.27, 2.00, 3.00) and

(1.27, 2.19, 3.19) respectively. Following a similar process, the aggregated TFNs were determined for the indicators incorporated under the other five remaining attributes (SG, CU, PR, CO, and IM) (See Table 4-22, column 3).

4.5.1.2 Determining the maturity scores of indicators (Defuzzification)

The TFNs computed for indicators in section 4.5.1.1 were converted (defuzzified) to crisp numbers using Equation (3-5). The policy and strategy attribute was used to illustrate the defuzzification procedures as outlined below.

Example (7)

Defuzzified score of indicator 1 (PS1)

The TFN of PS1 was calculated in section 4.5.1.1 as $L_{PS1} = (1.08, 1.77, 2.77)$.

Therefore, the crisp score (S_{PS1}) of the indicator based on Equation (3-5) provides:

$$\begin{aligned} S_{PS1} &= \frac{1.08 + (2 * 1.77) + 2.77}{4} \\ &= 7.39/4 = 1.85 \end{aligned}$$

That is, the maturity score of PS1 is 1.85, which can be categorised as novice ($S = 1.5 \leq x < 2.5$), with an 85% degree of membership function of novice and a 15% degree of membership function of naive levels. In other words, most of the organisations were at a novice level in the ‘availability of policy and strategy’ indicator. Applying the same procedure above, maturity scores were also computed for the other indicators of the PS attribute, resulting in maturity scores of 2.21, 2.03, and 2.08 for PS2, PS3, and PS4, respectively.

4.5.1.3 Summary of maturity scores

The results obtained in sections 4.5.1.1 and 4.5.1.2 are summarised in Table 4-22, which shows the corresponding TFNs and the aggregated maturity scores of the selected indicators, and attributes. These results will be used for further analysis in the subsequent sections.

Table 4-22 Summary of the defuzzified indicators, attributes and the sector

No	Indicators	Aggregated TFNs for k th indicator	Defuzzified score for k th indicator	Aggregated TFNs for the j th attribute	Defuzzified score for j th attribute
1. Policy and Strategy					
PS1	Existence of policy and strategy	(1.08, 1.77, 2.77)	1.85	(1.22, 2.04, 3.04)	2.08
PS2	Availability of defined RM objectives	(1.27, 2.19, 3.19)	2.21		
PS3	Availability of risk appetite	(1.27, 2.00, 3.00)	2.07		
PS4	Alignment of risk policy and strategy	(1.27, 2.19, 3.19)	2.21		
Cronbach's alpha coefficient (Policy and Strategy)			0.77		
2. Structure and Governance					
SG1	Integration of RM in organisation's structure	(1.12, 1.46, 2.42)	1.62	(1.19, 1.78, 2.77)	1.88
SG2	RM role and responsibility	(1.15, 1.58, 2.58)	1.72		
SG3	RM accountability	(1.12, 1.73, 2.73)	1.83		
SG4	RM reporting/communication scheme	(1.35, 2.35, 3.35)	2.35		
Cronbach's alpha coefficient (Structure and Governance)			0.86		
3. Culture					
CU1	Belief in the value of RM	(1.92, 2.88, 3.77)	2.87	(1.42, 2.31, 3.27)	2.33
CU2	Awareness of RM	(1.35, 2.27, 3.19)	2.27		
CU3	Attitude of the leadership to RM	(1.42, 2.38, 3.38)	2.39		
CU4	Commitment of the leadership	(1.46, 2.38, 3.38)	2.40		
CU5	Availability of core values/principles	(1.15, 1.81, 2.81)	1.89		
CU6	Risk information sharing culture/communication	(1.23, 2.15, 3.08)	2.15		
Cronbach's alpha coefficient (Culture)			0.77		
4. Process					
PR1	Availability of formal RM process	(1.15, 2.04, 3.04)	2.07	(1.13, 1.91, 2.91)	1.97
PR2	Availability of RM guidelines & standards	(1.15, 1.69, 2.65)	1.80		
PR3	Availability of risk identification techniques	(1.12, 1.96, 2.96)	2.00		
PR4	Availability of risk analysis techniques	(1.12, 1.92, 2.92)	1.97		
PR5	Availability of risk response strategy	(1.15, 2.04, 3.04)	2.07		

No	Indicators	Aggregated TFNs for k th indicator	Defuzzified score for k th indicator	Aggregated TFNs for the j th attribute	Defuzzified score for j th attribute
PR6	Availability of risk monitoring and evaluation techniques	(1.12, 1.96, 2.96)	2.00		
PR7	Availability of risk recording techniques	(1.15, 1.85, 2.85)	1.92		
PR8	Overall effectiveness RM process	(1.04, 1.85, 2.85)	1.89		
Cronbach's alpha coefficient (Process)			0.87		
5. Competence					
CO1	RM Knowledge of staff	(1.27, 1.96, 2.96)	2.04		
CO2	RM skill of staff	(1.19, 2.00, 2.96)	2.04	(1.16, 1.86, 2.85)	1.93
CO3	RM experience of staff	(1.12, 1.96, 2.96)	2.00		
CO4	Training on RM	(1.04, 1.50, 2.50)	1.63		
Cronbach's alpha coefficient (Competence)			0.80		
6. Implementation					
IM1	Overall RM practice	(1.12, 1.88, 2.88)	1.94		
IM2	Level of risk information used in decision making	(1.46, 2.46, 3.42)	2.45		
IM3	Scope of RM practice (comprehensiveness)	(1.27, 2.15, 3.15)	2.18		
IM4	Level of integration of RM in different units	(1.12, 1.77, 2.77)	1.86		
IM5	Adequacy of RM resource	(1.08, 1.54, 2.50)	1.66	(1.19, 1.97, 2.96)	2.02
IM6	Level of risk identification practice	(1.50, 2.35, 3.35)	2.38		
IM7	Level of risk analysis practice	(1.12, 1.81, 2.81)	1.88		
IM8	Effectiveness of risk responses	(1.04, 1.92, 2.92)	1.95		
IM9	Level of risk monitoring and evaluation operations	(1.23, 2.08, 3.08)	2.12		
IM10	Risk recording practices	(1.00, 1.73, 2.73)	1.80		
Cronbach's alpha coefficient (Implementation)			0.80		
Overall Maturity				(1.21, 1.99, 2.98)	2.04
Cronbach's alpha coefficient (Overall)			0.95		

4.5.1.4 Overview of the relative ERM maturity of indicators

The maturity scores calculated for the 36 indicators in the preceding sections are ranked in Table 4-23 in the order of significance of the values obtained. Cronbach's alpha was calculated to measure the internal consistency of scores and yielded an overall alpha coefficient of 0.95 (Table 4-22) which suggests an internal consistency within the calculated maturity scores (George & Mallery, 2003). According to Table 4-23, the maturity score of indicators ranged from 1.62 to 2.87 with the highest and the lowest scores representing the 'belief in the value of ERM' and 'integration of RM in organisation's structure' indicators, respectively. The aggregated maturity score of the companies surveyed, which is the same as that determined in section 4.4.4.2, was found to be 2.04.

From Table 4-23, it can be seen that 21 (58%) of the 36 indicators were below the aggregated maturity scores of 2.04. From the maturity spectrum in Figure 4-17, it can also be seen that none of the indicators has attained a managed level with a 100% degree of membership (i.e. $S = 3$).

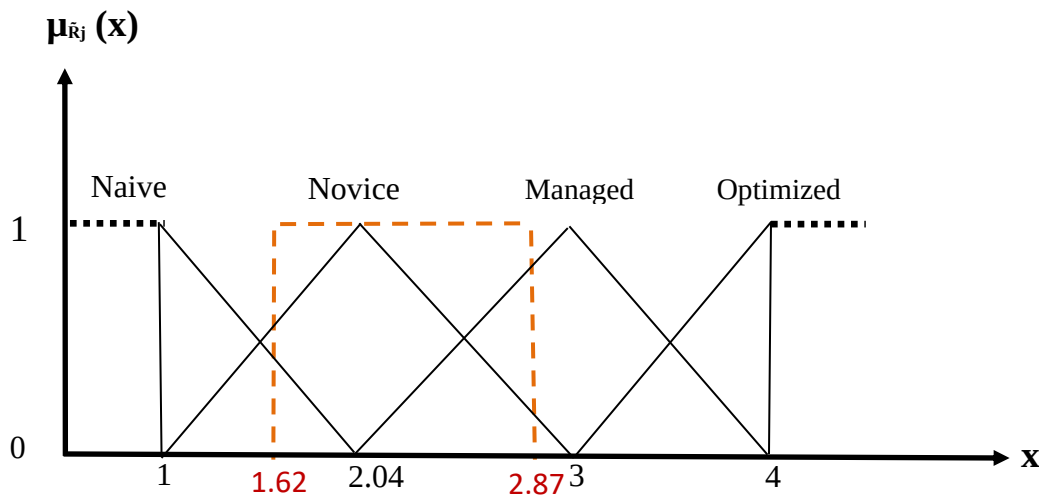


Figure 4-17 Ranges of the membership functions of indicators

Table 4-23 Relative aggregated maturity scores of the identified ERM indicators

ID/No.	Description	Maturity Score	Rank
CU1	Belief in the value of ERM	2.87	1
IM2	Level of risk information used in decision making	2.45	2
CU4	Commitment of the leadership	2.40	3
CU3	Attitude of the leadership to RM	2.39	4
IM6	Level of risk identification practice	2.38	5
SG4	RM reporting/communication scheme	2.35	6
CU2	Awareness of the benefits of RM	2.27	7
PS2	Availability of defined RM objectives	2.21	8
PS4	Alignment of risk policy and strategy	2.21	9
IM3	Scope of RM practice (comprehensiveness)	2.18	10
CU6	Risk information sharing culture/communication	2.15	11
IM9	Level of risk monitoring and evaluation operations	2.12	12
PS3	Availability of risk appetite policy	2.07	13
PR1	Availability of formal RM process	2.07	13
PR5	Availability of risk response strategy	2.07	13
CO1	RM knowledge of staff	2.04	16
CO2	RM skill of staff	2.04	16
PR3	Availability of risk identification techniques	2.00	18
PR6	Availability of risk monitoring and evaluation techniques	2.00	19
CO3	RM experience of staff	2.00	20
PR4	Availability of risk analysis techniques	1.97	21
IM8	Effectiveness of risk responses	1.95	22
IM1	Overall RM practice	1.94	23
PR7	Availability of risk recording techniques	1.92	24
CU5	Availability of core values/principles	1.89	25
PR8	Overall effectiveness RM process	1.89	26
IM7	Level of risk analysis practice	1.88	27
IM4	Level of integration of RM in different units	1.86	28
PS1	Existence of policy and strategy	1.85	29
SG3	RM accountability	1.83	30
PR2	Availability of RM guidelines & standards	1.80	31
IM10	Risk recording practices	1.80	31
SG2	RM role and responsibility	1.72	33
IM5	Adequacy of RM resource	1.66	34
CO4	Training on RM	1.63	35
SG1	Integration of RM in organisation's structure	1.62	36

The radar diagram in Figure 4-18 was also used to provide an overview of the maturity levels of each of the indicators. This shows that all the maturity scales were above 1.5, but none of the indicators has approached the maximum level (4.0). Further, from both Table 4-23 and Figure 4-

18, it can be seen that the maturity scores of all indicators (except CU1 of value 2.87) were concentrated in the region below 2.5. The shape of the radar diagram demonstrates that the maturity scores of most of the companies are concentrated at approximately equal distances from the centre with only a few outliers that fall between the maturity scores of 2.5 and 3.0. This suggests that the RM practices of the companies surveyed were relatively close to each other.

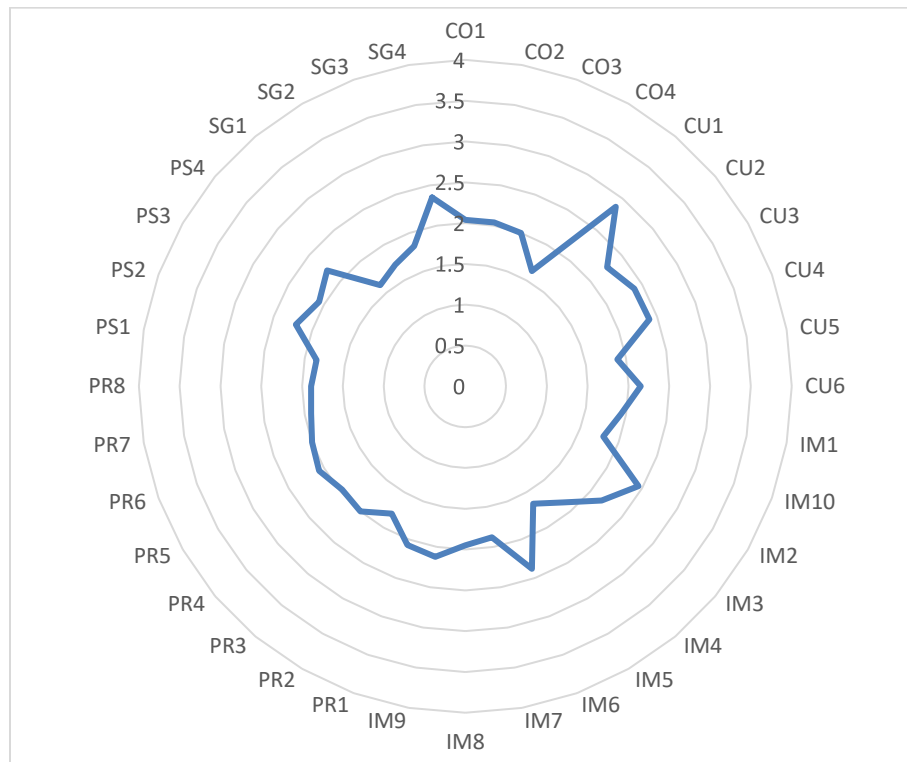


Figure 4-18 Maturity scores of indicators

There are also a few issues worth mentioning in conjunction with the interrelations of the maturity scores and therefore the corresponding ranks of the indicators presented in Table 4-23. Most importantly, although the maturity results for most indicators are relatively similar, there are a few results that are possibly unexpected. For instance, one could ask why the ‘level of risk analysis practice’ and ‘integration of RM in organisation's structure’ were at the lower end of the rankings i.e. 27th and 36th, respectively, when ‘leadership commitment in the sector’ ranked 3rd. As discussed in Section 4.5.1.6.1, the commitment by senior management is one of the contingent factors for a successful RM. Hence, the existence of permissible commitment could be viewed as an interesting finding. Yet, the low level of practice mentioned above indicates that leadership

commitment has not yet been reflected in promoting RM to be practiced in their respective companies. The latter should be the next course of action in the progressive improvement of the ERM in the Ethiopian road sector.

4.5.1.5 Categories of indicators in terms of their maturity levels

The aggregated maturity scores determined in section 4.5.1.4 were further analysed based on their TMFs, which illustrate maturity levels in terms of the triangular fuzzy regions. As discussed in 4.4.3.1, Equation (3-1) was employed to define the degree of membership functions of the calculated scores. For instance, the first indicator PS1 of ERM maturity score ($S = 1.85$) could be interpreted as having an 85% degree of membership to the novice level and a 15% degree of membership to the naive level, with an overall novice maturity. Following the same procedures, the degrees of membership were determined for all the 36 indicators as summarised in Table 4-24.

Table 4-24 Maturity levels of indicators

I/ No	Indicators	Aggregated Score	Maturity Membership Function	Maturity Level
CU1	Belief in the value of RM	2.87	13% NOV, 87% MAN	Managed
IM2	Level of risk information used in decision making	2.45	55% NOV, 45%, MAN	Novice
CU4	Commitment of the leadership	2.40	60% NOV, 40%, MAN	Novice
CU3	Attitude of the leadership to RM	2.39	61% NOV, 39%, MAN	Novice
IM6	Level of risk identification practice	2.38	62% NOV, 38%, MAN	Novice
SG4	RM reporting/communication scheme	2.35	65% NOV, 35%, MAN	Novice
CU2	Awareness of RM	2.27	73% NOV, 27%, MAN	Novice
PS2	Availability of defined RM objectives	2.21	79% NOV, 21%, MAN	Novice
PS4	Alignment of risk policy and strategy	2.21	79% NOV, 21%, MAN	Novice
IM3	Scope of RM practice (comprehensiveness)	2.18	82% NOV, 18%, MAN	Novice
CU6	Risk information sharing culture/communication	2.15	85% NOV, 15%, MAN	Novice
IM9	Level of risk monitoring and evaluation operations	2.12	88% NOV, 12%, MAN	Novice
PS3	Availability of risk appetite	2.07	93% NOV, 7%, MAN	Novice
PR1	Availability of formal RM process	2.07	93% NOV, 7%, MAN	Novice
PR5	Availability of risk response strategy	2.07	93% NOV, 7%, MAN	Novice
CO1	RM knowledge of staff	2.04	94% NOV, 4%, MAN	Novice
CO2	RM skill of staff	2.04	94% NOV, 4%, MAN	Novice
PR3	Availability of risk identification techniques	2.00	100% NOV	Novice
PR6	Availability of risk monitoring and evaluation techniques	2.00	100% NOV	Novice
CO3	RM experience of staff	2.00	100% NOV	Novice
PR4	Availability of risk analysis techniques	1.97	3% NAV, 97% NOV	Novice
IM8	Effectiveness of risk responses	1.95	5% NAV, 95% NOV	Novice
IM1	Overall RM practice	1.94	6% NAV, 94% NOV	Novice
PR7	Availability of risk recording techniques	1.92	8% NAV, 92% NOV	Novice
CU5	Availability of core values/principles	1.89	11% NAV, 89% NOV	Novice
PR8	Overall effectiveness RM process	1.89	15% NAV, 85% NOV	Novice
IM7	Level of risk analysis practice	1.88	12% NAV, 88% NOV	Novice
IM4	Level of integration of RM in different units	1.86	14% NAV, 86% NOV	Novice
PS1	Existence of policy and strategy	1.85	15% NAV, 85% NOV	Novice
SG3	RM accountability	1.83	17% NAV, 83% NOV	Novice
PR2	Availability of RM guidelines & standards	1.80	20% NAV, 80% NOV	Novice
IM10	Risk recording practices	1.80	20% NAV, 80% NOV	Novice
SG2	RM role and responsibility	1.72	28% NAV, 72% NOV	Novice
IM5	Adequacy of RM resource	1.66	34% NAV, 66% NOV	Novice
CO4	Training on RM	1.63	37% NAV, 63% NOV	Novice
SG1	Integration of RM in organisation's structure	1.62	38% NAV, 62% NOV	Novice

Remarkably, the maturity of the contractors surveyed appeared to be entirely at a novice level in all the indicators, except for CU1 (belief in the value of RM) which was computed to be at a managed maturity (Table 4-24). The value of the maturity scored even indicates that CU1 was not able to attain the managed level with a 100% degree of membership function, rather it was computed as having an 87% degree of membership in the managed category and a 13% in the novice category. The table also shows that none of the identified indicators were at a naive level.

Another important point to note is that the 35 indicators that were categorised as novice could be further classified in terms of their TMFs as illustrated in Table 4-25. This will provide a further insight into their overall status with respect to the respective TMFs. Accordingly, companies in the novice level were categorised into three groups based on their membership functions on the respective two triangular fuzzy regions as shown in Table 4-25 and Figure 4-19. From these, it can be seen that three (9%) of the 35 novice level indicators were at a novice level with a 100% degree of membership function ($S = 2.5$), 16 (45%) were with the degree membership functions belonging to both the naive and novice levels ($S = 1.5 \leq x < 2.5$), and the remaining 16 (45%) indicators were with the membership function belonging to both the novice and managed levels ($S = 2.5 \leq x < 3.5$).

Table 4-25 Membership functions of indicators in terms of their TMFs

No.	Maturity Level	No. of contractors	Proportion	Membership Category
1.	Naïve	-	-	
2.	Novice	35	96%	Naïve and Novice (16) 100% Novice (3) Novice and Managed (16)
3.	Managed	1	4%	Novice and Managed (1)
4.	Optimised	-	-	
	Total	36	100%	

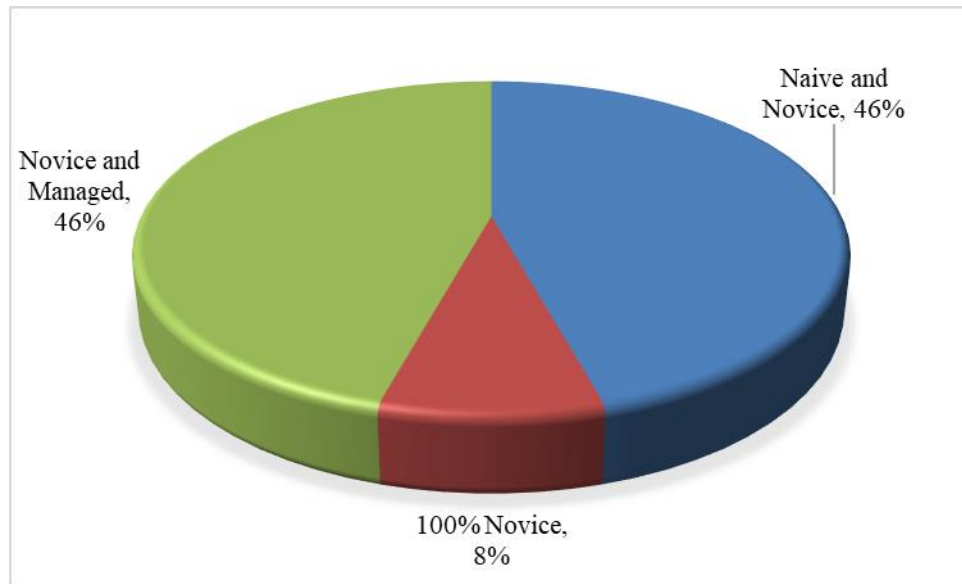


Figure 4-19 Proportion of maturity levels of indicators in the novice category w.r.t. their TMFs

4.5.1.6 Most significant indicators

In order to more easily understand the relative maturity of the indicators, the top five most mature and least mature indicators are extracted from Table 4-24 as presented in Table 4-26. These are discussed in sections 4.5.1.6.1 and 4.5.1.6.2 below.

Table 4-26 The top five most mature and least mature indicators

ID/No.	Description	Aggregated Maturity Score	Rank
1. Top five most mature indicators			
CU1	Belief in value of ERM	2.87	1
IM2	Level of risk information used in decision making	2.45	2
CU4	Commitment of the leadership	2.40	3
CU3	Attitude of the leadership to RM	2.39	4
IM6	Level of risk identification practice	2.38	5
2. Top five least mature indicators			
PR2	Availability of RM guidelines & standards	1.80	31
IM10	Risk recording practices	1.80	31
SG2	RM role and responsibility	1.72	33
IM5	Adequacy of RM resource	1.66	34
CO4	Training on RM	1.63	35
SG1	Integration of RM in organisation's structure	1.62	36

4.5.1.6.1 The top mature indicators

As illustrated in Table 4-26, Of these five indicators identified in this category, three are indicators of the CU attribute and the other two are that of the IM attribute.

(i) Belief in the values of ERM (S = 2.87)

According to the results, ‘belief in the values of ERM’ (S = 2.87) was ranked the most mature indicator. This agrees with the study by Pangeran et al. (12) who found that the Indonesian public water supply organisations had a strong belief that implementing RM added to an organisation’s value. As a core component of the risk culture, ‘belief in the value of RM’ will reinforce the correct behaviour towards risk-related actions, including risk-based decision-making, risk processes, etc. (IRM, 2012). This suggests that there appears to be a basic potential in Ethiopian domestic contractors to practise ERM and this could be realised through devising incentives or motivating schemes by the regulatory bodies and project owners.

(ii) Informed risk decisions (S = 2.45)

The second most mature indicator is ‘level of risk information used in decision making’. The ERM implementation in terms of IMA (2007) is a change management project, with an ultimate goal of enabling an organisation to move towards risk-informed decision making. An effective risk culture, in effect, ensures that risk information is integrated with business information and it is delivered in a timely and appropriate manner to ensure that business decisions have a balanced view of risk implications (IRM, 2012). The existence of initiatives for making informed decisions in the Ethiopian road sector seems to have emanated from the relatively better understanding embedded in the leadership on the benefits of implementing ERM described in (i) above. In fact, whether or not proper RM is implemented, the volatile business environment in the construction sector always demands adequate information about the potential risks and uncertainties prior to making any decision.

(iii) Commitment of the leadership (S = 2.40)

The score for the commitment of the leadership is the third highest amongst all of the indicators. The literature suggests that the commitment by senior management is one of the contingent factors for a successful RM (Zhao, et al., 2013b; Mikes & Kaplan, 2014; Hoseini, et al., 2016; Yazid, et al., 2018). In a study conducted on Chinese contractors that resided in Singapore, Zhao et al.

(2013a) also found that commitment of the board and management had the highest mature indicator.

While it is important to have such a relatively promising commitment in the leadership of Ethiopian domestic contractors, it should be demonstrated by improving areas where the sector is less mature. This includes formulating policy and strategy that can convey the objectives of companies' and their commitments to RM. The leadership is also expected to ensure that their companies have a suitable structure with people who are clearly responsible and accountable for implementing ERM.

(iv) Attitude of the leadership (S = 2.39)

The attitude of a company's leadership towards RM was rated as the fourth most mature of the indicators assessed. Risk attitude in terms of the ISO (2009) represents the organisation's approach to assess and eventually pursue, take or refuse risk. Wang and Yuan (2011) and Harvette (2013) have pointed out that the attitude of individuals and an organisation has a significant influence on the success of the RM endeavours. Further, Wang and Yuan, 2011) highlighted that the negative risk attitude of decision makers has had an adverse effect on the RM practice of domestic contractors in the Malaysian construction industry. Hence, the relatively high maturity score attributed to the attitude of the leadership towards RM, in addition to the relatively high maturity score of the two indicators described in (i) and (ii), reinforces the existence of potential for ERM implementation in the Ethiopian road sector.

(v) Level of risk identification practice (S = 2.38)

The fifth most mature indicator was found to be 'level of risk identification practice'. This concurs with the finding of Zhao et al. (2013a) who indicated that risk identification, analysis and response was among the five most mature ERM indicators in Chinese construction companies engaged in the Singapore construction business. Of course, this result should not come as a surprise, because companies, whether it is in a formal or in an informal way, are generally concerned about the risks involved in their day-to-day operations.

4.5.1.6.2 Least mature indicators

As shown in Table 4-26, the five least mature areas of the ERM maturity, from least to highest, are (i) integration of RM in organisation's structure ($S = 1.62$); (ii) availability of training on RM ($S = 1.63$); (iii) adequacy of RM resources ($S = 1.66$); (iv) risk recording practices (1.72); (v) RM role and responsibility definition ($S = 1.80$) and (vi) availability of RM guidelines and standards ($S = 1.80$). Out of these six indicators, the PR and CO attributes contribute one indicator each and the SG and IM contribute two indicators each. The relatively small maturity scores exhibited from these indicators suggest special efforts are needed to improve the situation in the Ethiopian construction industry. For instance, the maximum scores of indicators under this category ($S = 1.80$) shows that the indicator was novice with an 80% degree of membership and naive with a 20% degree of membership. These indicators are briefly discussed below.

(i) Integration of RM in an organisation's structure ($S = 1.62$)

This indicator was found to be at the lowest maturity level of the 36 indicators considered in the study attaining only 1.62 from the maximum of 4.00 points. This score ($S = 1.5 \leq x < 2.5$) implies that the indicator can generally be categorised as a novice level with a 62% degree of membership in novice and a 38% degree of membership in a naive maturity level. This is in contrast to the accepted ERM principle, which requires companies to integrate RM at all levels of their companies to realise an effective RM. Further, such a low level of RM integration suggests that the companies surveyed were attempting to handle risks in an isolated (silo) approach, which may lead to many problems. These include: duplication of risk response efforts; gaps in comprehensively identifying and effectively analysing of risks; lack of suitable process to aggregate critical risks; and an absence of sharing risk information across a company

(ii) Availability of training on RM ($S = 1.63$)

The second least mature indicator was found to be inadequate training on RM. Several researchers have revealed training to be one of the critical factors for effective RM (Zhao, et al., 2013b; Hoseini, et al., 2016; Kikwasi, 2018; Ranong & Phuennngam, 2009; Yazid, et al., 2018). In their study on the organisational factors that affect ERM effectiveness, Yazid et al. (2018) have identified training to be one of the critical factors that have significant and direct effects on ERM effectiveness. Conversely, inadequate training was reported as a critical factor impeding the

adaption of ERM implementation (Zhao et al., 2014a; Renault et al., 2016). Subsequently, training is highlighted as one of the essential components of several ERM standards and guidelines, such as ISO 31000 (ISO, 2018).

To mitigate a similar gap experienced in the Ghanaian construction sector, Hansen-Addy and Fekpe (2015) recommended proper RM training to be provided for construction professionals. Fabi and Awolesi (2015) also suggested suitable training to be provided to professionals as part of improving the management of risks in the Nigerian highway construction sector. Hence, companies in the Ethiopian road sector should consider that the key to successful RM is having the people with the right knowledge and skills. Further, the low-level RM maturity found in most companies surveyed suggests that tailored RM training is the most critical for the sector. Hence, appropriate training should be designed for the staff that could improve their overall RM culture. Well-tailored technical training should also be provided to staff that could enable them to apply effective RM techniques.

(iii) Adequacy of RM resource (S = 1.66)

The third least mature indicator was found to be inadequate resources allotted for RM. Generally, ERM requires time, commitment and resources. Indeed, Terzi and Posta (2010) pointed out that adequate resources are essential to promote ERM and sustain the implementation process; which was also highlighted as a critical success factor in Kikwasi (2018) and Zhao, et al. (2013b). Further, recognising the impact of resource shortage on a smooth operating environment in Botswana's construction industry, Kaggwa, et al. (2013) recommended substantial transformation to be made in the industry towards allotting optimum resources for RM. Masino (2016) has also suggested the need for policy priority that facilitates adequate resources for RM in the Ghanaian domestic construction sector.

Recognising the ultimate benefits of ERM, construction companies in the Ethiopian road sector should allot adequate resources specific to RM. Generally, the cost of risk management is not perceived to be as such too considerable for construction companies that are involved in mega projects. Therefore, it is recommended the leadership of the road sector ensures that the necessary resources that could support the RM efforts of the sector are dedicated to RM by their companies. It should be noted that these resources also include the time dedicated to RM by the leadership, the assignment of the right people, allocation of an adequate budget, providing facilities, etc.

(iv) RM role and responsibility definition (S = 1.72)

The fourth least mature indicator was found to be the limitation in properly defining roles and responsibilities for RM. This is again in contrast to the notion of risk being managed in every part of an organisation's structure and everyone in an organisation having responsibility for managing risk (ISO, 2018). This concurs with the findings reported in section 4.2.2 which showed that none of the companies surveyed was assigned experts specifically for RM activities. Hence, the leadership should play a major role in ensuring that the RM-related duties and responsibilities are clearly defined in their companies, along with the equivalent accountabilities.

(v) Risk recording practices (S = 1.80)

Risk recording and reporting is one of the key components of an RM process and involves appropriately documenting and reporting RM processes and their outcomes. This is because, according to BSI (2010), in the RM process, records provide the foundation for improvement in methods and tools, as well as in the overall process. Further, RM activities should also be traceable (FHWA, 2006; BSI, 2010). However, the practice of the sector, as represented by the companies surveyed, indicated that this indicator was the fifth least mature. Ciorciari and Blattner (2008) claimed that absence of documentation is one of the characteristics of the lowest maturity level. Hence, the Ethiopian road sector should attempt to establish a successful risk monitoring and updating process that will systematically track risks, invite the identification of new risks, and capture lessons learned for future RM efforts. This should also be enhanced with the support of technology products.

4.6 Relative Impact Levels of Barriers in ERM Implementation

Ten factors that would hinder a company to implement ERM were included in the questionnaire. In order to assess the impact of these factors on the attempts to practise ERM, interviewees were asked to rate the factors by selecting the appropriate level of significance using a scale of 1 to 4 (1 = for least significant to 4 = most significant). The collected data is provided in Appendix F2.

Hence, using Equation (3-2) of the fuzzy logic system, significance scores were calculated for all the ten factors, and the results are provided in Table 4-27. The values of the factors range from 2.23 to 2.95. According to this same table, the unavailability of an RM consultant, inadequate training, and lack of awareness of the values of the ERM were found to be the three most significant factors

that hinder companies from practising ERM. These three factors are briefly discussed below. In contrast, lack of risk language, followed by human/organisational resistance was found to have had relatively little impact on the practice of ERM in the sector and are not discussed further.

Table 4-27 Contribution factors of interviewees

Id/ No	Barriers	Score
BR10	Unavailability of risk management consultants	2.95
BR4	Inadequate training on ERM	2.88
BR1	Lack of awareness of RM	2.84
BR9	Difficulties in quantifying the risks	2.82
BR5	Lack of quality data and limited access to data	2.67
BR7	Lack of support from top management	2.62
BR2	Lack of internal knowledge, skills, and expertise	2.61
BR6	Insufficient resources	2.52
BR8	Human/organisational resistance	2.33
BR3	Lack of common risk language	2.23

The Cronbach's alpha coefficient, which was calculated to test the consistency of the responses, and was found to be 0.54. This, according to George and Mallery (2003), implies that the consistency of the responses was questionable, which suggests a more detailed study should be undertaken (see section 6.2).

Lack of risk management consultants

With their expertise, RM consultants can help companies to develop RM practices, and lay the foundation for a robust risk culture. However, a lack of RM consultants was found to be the most significant barrier to practising ERM in EDCs with an overall score of 2.95. This concurs with the findings of Chileshe, et al. (2016) who revealed this factor as the second most critical factor impeding ERM implementation in the Iranian construction industry. This suggests that there is a need for promoting RM professional consultancy services in the construction industry in Ethiopia.

Inadequacy of training

Lack of training on RM was identified as the second most critical factor impeding ERM practice in the Ethiopian road sector. This is consistent with the findings in section 4.5.1.6.2, in which this factor was found as the second least mature indicator out of the 36 indicators. This also concurs with Zhao et al. (2014a), who showed that inadequate training was one of the critical hindrances

to the implementation of ERM in Singapore-based Chinese construction companies. In support of this, lack of experience and information (Rostami, et al., 2015) and inadequate knowledge and necessary skills (Chileshe, et al., 2016) were reported as significant challenges in practising ERM.

Hence, as suggested in Zhao, et al. (2014a), regular training programmes should be provided to Ethiopian domestic contractors to help employees clearly understand the ERM philosophy and policy (including the vision and the need for ERM implementation), the ERM process, as well as the benefits and value of ERM, which would minimise misunderstandings and concerns about ERM.

Lack of awareness of ERM

Awareness is one of the key components of an RM culture (Deloitte, 2012; IRM, 2012; IFC, 2015). However, lack of awareness of ERM was rated the third most influential barrier to ERM implementation in the Ethiopian road sector. As discussed in section 2.4.5 and Table 2-6, this is one the top critical factors impeding ERM implementation in several industries, including construction (Zhao, et al., 2014b; Rostami, et al., 2015; Jayasudha & Vidivelli, 2016; Renault, et al., 2016). As shown in Table 2-6, the lack of awareness about ERM was found to be the second most cited factors from the 14 factors identified from the literature to affect its implementation.

This is also associated with the lack of training, which is found to be the second most critical factor that hinders the implementation of ERM discussed above, and the second least mature of the 36 diagnostic indicators described section 4.5.1.6.2. Hence, it is strongly suggested that the industry work on establishing essential awareness of the significance of ERM.

4.7 Overcoming the Potential Subjectivity and Bias on the Data

Evaluation in any form, including organisational assessment, is often viewed with suspicion (Smutylo & Lusthaus, 1998). Specifically, the issue of cognitive bias based on human mental shortcuts is a common phenomenon in subjective assessment and decision making (Siefert, 2007; Emmons, et al., 2018). Cognitive bias, often referred as a decision bias or judgement bias (Arnott, 2006), is a systematic pattern of deviation from rationality in judgment or decision-making (Blanco, 2017). Such biases result in an adverse impact on the quality of judgement (Arnott, 2006; Blanco, 2017; Emmons, et al., 2018). To mention, Seifert (2007) pointed out that cognitive bias is

one of the typical drivers that attributed for the failure of most RM programs in the construction industry. Further, Emmons, et al. (2018) showed that the four decision-making biases; i.e., optimism, planning fallacy, anchoring, and ambiguity effect; would have a strong influence on the risk management process. Anchoring bias, in particular, is the common predisposition to rely on initial information, results, or experience (i.e., the *anchor*) in making judgments (Tversky & Kahneman, 1974).

Hence, establishing an understanding of such psychological impacts will make successful implementation and provide more consistent research results (Siefert, 2007). To this end, researchers have tried to find out ways to effectively overcome potential subjectivity and cognitive biases, a practice commonly known as *debiasing* (Blanco, 2017; Emmons, et al., 2018). Accordingly, this research has as well adopted several strategies pertinent to overcome the potential biases. First, following the approach of Emmons et al (2018) designed to debias anchoring cognitive biases, an attempt was made to identify ERM diagnostic indicators that represent indicators from across the full attributes of the ERM using a comprehensive literature review (See Table 3.2). Second, owing that the use of a user-friendly research instrument ensures better responses, a structured interview was utilised to collect the data required for measuring the companies' ERM competence. In addition, to minimise potential biases, an attempt was made to make the questions objective by presenting the alternative responses of each question in descriptive statements as described in Section 3.5.1.1.4.

Third, the pre-mortem technique proposed by Klein (2007) was utilised for reducing biases that may arise in the interviewees. This tool is used at the beginning of a discussion asking the interviewee why companies in the construction industry may fail in connection with the risk management gaps (Klein, 2007), assuming that the proposed company will fail and the interviewee needs to presume the potential factors of failure. In view of this, a brief explanation was provided to the participants using a Power Point presentation before starting the actual interviews with the aim of creating understanding on the benefits of measuring the RM maturity of a company (presentation slides are provided in Appendix E). As suggested by Stockhammer, et al. (2021), this presentation was also found to be useful in raising awareness and building knowledge, which is one of the instrument to correct the judgement heuristics of the interviewee.

Fourth, opportunities of bias in a self-assessment can be minimised by emphasising the need for participants to provide evidence for their views (McGiffen, 1998). Accordingly, the interviewer attempted to describe what the descriptions under each questionnaire mean to help the interviewee reasonably gauge the ERM competence of their respective company. Fifth, the use of mathematical methods is also the other basic instruments to minimise cognitive biases on the subjective human inputs. Accordingly, the fuzzy logic system was applied to address the potential imprecision in the collected data (see section 3.5.2).

4.8 Comparison with Other Related Studies

The key findings of the study were compared with the results achieved in other similar studies, using a narrative synthesis, as a means to check whether the proposed model and method provide reliable results. Generally, the results of this survey were found to be consistent with many other studies, conducted using different RM maturity models that showed a relatively low-level RM practice. These include the studies in Ghana (Hansen-Addy & Fekpe, 2015; Yirenkyi-Fianko & Chileshe, 2015); Egypt (Hassanein & Afify, 2007); Nigeria (Salawua & Abdullah, 2014), South Africa (Coetzee & Lubbe, 2013); and Lithuania (Banaitienė, et al., 2011). Similar results were also found in studies of developed countries such as the UK (Deloitte, 2021), and the USA, (Beasley, et al., 2018).

For comparison, nine studies published since 2010 covering ERM practice in several industries, including companies in the construction industry, were selected from the literature. The countries surveyed in these studies cover different regions of the world, including Australia, China, UK, USA, and many countries from Africa. Some of these are generic and some others are construction specific. The findings of these papers in relation to those found in this research are discussed below based on their chronological order.

Zhou, et al. (2010) developed an RM maturity assessment model for construction companies. This model was demonstrated through a questionnaire survey of 60 respondents in the Australian construction industry and revealed an overall low level of maturity with 32% rated as Level 2 (repeatable) and 52% as Level 3 (managed) from the four maturity scales defined in the study (initial and ad hoc, repeatable, managed, optimised). Zhao, et al. (2013a) also explored the ERM best practices in Chinese construction firms based in Singapore and developed an ERM³, which

revealed a medium overall maturity with a maturity score of 0.43 out of 1.00. A similar survey in the Malaysian construction industry also found that RM was not well practised, and only eight (18%) out of 45 companies surveyed employed a formal RM process (Goh & Abdul-Rahman, 2013). Further, the Goh and Abdul- Rahman (2013) study revealed that RM was not widely implemented in the Malaysian domestic construction companies compared with their foreign counterparts. This concurs with the findings of this study for Ethiopian domestic construction companies.

The RM practice of companies in South Africa was examined by Coetzee (2013) who assessed 76 companies (40 private and 36 public) across all industries. The questionnaire survey carried out based on the selected attributes with criteria of ‘mature’ and ‘non-mature’ provided an overall low level of maturity, with 46 (61%) of the 76 companies rated as non-mature. The study found that private companies were relatively more mature than the public companies, and is in contrast with the case in the EDCs, as well as the studies by Beasley et al. (2018) and Zhao, et al (2013a), which reported that public companies were more mature than their private counterparts.

Salawu and Abdullah (2014) assessed the RM competence of 18 Nigerian contractors that were involved in federal highway projects (a similar sector to this particular research). The study used four levels of maturity similar to this study. That study provided results that categorised the overall maturity of the companies surveyed as novice, with 80% of the contractors at a novice level and the remaining 20% at a naive level. Yirenkyi-Fianko and Chileshe (2015) also revealed a relatively low ERM practice in their survey that examined the level of awareness and usage and the perceived benefits of RM practices within the Ghanaian construction industry.

Serpell et al. (2015) assessed the RM capability of contractors in developing countries by means of an established maturity model of five attributes and four maturity levels. Their study assessed three construction companies involving 30 experts and demonstrated a low level of maturity, with an aggregated score of 2.0 out of 4.0. Their result is approximately equal to the finding achieved in this particular study for the EDCs that was estimated to be 2.04 out of 4.0

Liu et al. (2018) also explored the ERM practices of the top international contractors as ranked by the Engineering News Record magazine. Examining 61 of the 250 contractors ranked in 2013 based on the ERM-related data collected in the magazine, the study concluded that ERM practice

is a proactive and continuing process for international contractors. According to the study, this result was driven by the internal enterprise culture and RM desires established with this contractor as well as other external requirements and constraints. These results differ from most of the other studies discussed above because the different business environment they have involved urged them to implement an effective ERM to remain competitive in such diverse market conditions.

A relatively recent study conducted by Beasley et al. (2018) overviewed the ERM practice of companies in the USA. About 474 survey responses were received in 2017 from practitioners that represented a variety of industries, including construction, and company size. The study showed that RM practices in most organisations remained relatively immature. More specifically, two-thirds of companies surveyed reflected that they were not able to claim they had complete ERM practices in place. Although the study found that there was a low level of ERM practice in 2017 in the majority of the companies surveyed, there was an overall improvement in ERM practice compared to a similar survey undertaken in 2009. For example, only 9% of the companies surveyed had a complete ERM system in 2009 and this grew to 31% in 2017. Nevertheless, two-thirds of the surveyed companies in 2017 did not have a complete ERM.

A very recent study by Deloitte (2021) to evaluate the UK's ERM practice in connection with the emergence of the COVID 19 pandemic and its impact on the ERM practice involved 44 UK-listed⁵ companies. The key findings of this survey were that 86% of companies believed to varying degrees that their organisation needed to be more resilient, with only 5% of companies indicating their ERM systems were fully integrated with other corporate functions. Further, 57% of companies were yet to fully articulate their risk appetite and 64% perceived that they were in the early stage of their journey towards assessing, establishing and embedding risk culture. The most striking finding of this study is that in 64% of the companies surveyed, disaster management is directly managed by the CEO. This is a valuable experience for the construction industry in general

⁵ A listed company is a company whose shares are brought and sold on a particular stock market <https://dictionary.cambridge.org/dictionary/english/listed-company>

and the Ethiopian road sector in particular, who do not have the experience to hire the right expert to manage a company's risks.

Overall, the findings of the above study indicate that ERM is generally not well practised, with the exception of companies in a few countries with better experience, such as the UK and the USA. The only study that indicates a divergence from the majority of the studies is that undertaken by Liu, et al. (2018). Hence it can be argued that ERM is not still widely practised globally and the finding of this study would appear to be in general agreement with the situation of the majority of the countries considered in the above.

Further, other studies conducted in the context of the Ethiopian construction industry also indicated that RM is the most overlooked (Tadesse, et al., 2016) and less practised (Addis, 2014; Desalegn & Mahesh, 2019) area of management that requires improvement. This implies that the proposed model (ERM³-CON) has yielded results that reflect the current state of the Ethiopian construction industry. Hence, it is believed that the proposed model is suitable for measuring the ERM capabilities of construction companies in Ethiopia.

4.9 Summary

This chapter presented the case study on the ERM competence of EDCs that were engaged in the MFRCs, to evaluate the applicability of the ERM³ developed in Chapter 3. The fuzzy logic system was applied to assess the data gathered in a self-assessment of 26 contractors. Inferential statistics, namely, Cronbach's alpha, t-test, ANOVA, the Pearson's correlation coefficient, and linear regression analyses, were used to test the reliability of the data.

The results of the study indicated that the ERM practice in the Ethiopian road sector is generally at a low level of maturity, referred to as novice. A detailed analysis on the sector in terms of the 36 indicators categorised under the six attributes also revealed that sector is consistently at a novice level in the majority of the indicators. Although all the six attributes were at a low level of maturity, the RM management culture was found to be relatively mature in the sector. The findings of this study were also found to be consistent with other similar studies conducted in various countries with different economic statuses. These results will be discussed in depth in Chapter 5.

5 DISCUSSION

5.1 Introduction

This chapter discusses the key findings of the study realised in the course of developing the ERM³ for construction companies. These findings are those related to the literature review, methodology and the case study. The major achievements and limitations of the study are also discussed.

5.2 The Key Findings of the Research

5.2.1 ERM in the construction industry (Research objective 1)

The detailed review of the literature indicated that while the construction industry is an important economic sector contributing to the growth and development of nations, it is suffering from poor performance. Project delays, that also have unfavourable consequences such as cost overruns, contractual disputes, arbitration, and quality non-conformities (Mejía, et al., 2020) are still a prevalent problem in the industry, and are more pronounced in developing countries (Elawi, et al., 2015; Tadesse, et al., 2016; Amoatey & Ankrah, 2017; Mahamid, 2017; Mejía, et al., 2020; Solomon, et al., 2021).

Unfortunately, the evidence from published studies is that there has been a lack of any notable improvements in the industry recently, and specifically in developing countries, in terms of meeting the demands of such nations. For instance, Ofori⁶ (2001, 2012, 2018b), who conducted a series of studies specific to the construction industry in several developing countries over four decades, contended that its performance in these countries in particular remains unsatisfactory. He also argued that efforts to foster the industry in these countries have largely failed. This

⁶ As highlighted in Ofori (2015), Prof. George Ofori was involved as a lead researcher in more than 35 studies related to the construction industry in developing countries, published from 1981 to 2015.

undoubtedly suggests a need to identify and address the key factors that contribute to such an unsatisfactory performance.

While many factors attribute to the poor performance of the industry (see section 2.2.2), inadequate RM has been found to be a major issue; due to the fact that the industry requires effective RM to address the diverse and multiple risks associated with construction. A detailed review of the literature revealed that ERM is emerging as a useful tool for managing company risks through an integrated and holistic approach. Indeed, companies who adopt ERM are respected and its significance has been demonstrated by several empirical studies that show amongst other benefits, practising ERM enhances a company's performance and value (section 2.4.3). The literature review also found that ERM enhances project performance (Siang & Ali, 2012; Liu, et al., 2013; Low, et al., 2013), which is essential for construction companies as mentioned above.

Apart from the potential benefits of implementing ERM, the literature such as Althonayan, et al. (2012) and IRM (2018) also highlighted that inadequate ERM would result in severe consequences, citing the 2008/2009 global financial crisis as evidence. This means that for a company that envisions remaining competitive, practicing effective ERM is essential. Recurring global incidences, such as the COVID 19 pandemic, further highlighted the need for implementing ERM (Worku, 2020; Deloitte, 2021).

However, the literature has identified several factors that would impede companies from practising ERM, such as a lack of awareness, inadequate resources, and a lack of training (section 2.4.5). This suggests the need for devising strategies that could encourage companies to practise ERM and achieve the potential benefits. It is important for the construction industry to share the experience from companies in the financial sector, which have benefited from properly practicing ERM, and where often it is considered as a strategic tool. It is also advisable for countries to look at the countries, such as the USA (Beasley, et al., 2018) and South Africa (Coetzee & Lubbe, 2013) which have been attempting to promote ERM practice to companies through legal provisions. Such initiatives recognise the significance of ERM in improving a company's performance and value.

Another key finding of the literature review is that there are relatively few studies in the domain of ERM related to construction companies, especially in developing countries. The recent literature also highlighted that the problem is still a pertinent gap in many of the industries (Lopez, 2021)

including construction (Ching, et al., 2020). In this regard, it would be reasonable to mention the effort in Malaysia where a series of studies have been conducted recently on ERM in the construction industry from which other countries could also learn. This research has drawn much from these studies, including those by Ali, et al. (2019), Ibrahim and Esa (2017), Siang and Ali (2012), and Ching, et al. (2020). Hence, a series of further studies are recommended associated with determining why ERM is less practised in the construction industry, along with the potential solutions that could transform the current practice.

Another key finding pertinent to construction companies is the association between project risk management (PRM) and ERM. The literature indicates that while PRM is an essential tool at the project level, PRM alone could not provide a better solution for organisations if it is not integrated with ERM (section 2.4.6). Overemphasis on PRM, otherwise, may lead to various problems; namely, the lack of a holistic view of project risks; lack of transparency across multiple projects; and inappropriate resource allocation among projects. Therefore, construction companies should always regard PRM as an integral part of ERM.

5.2.2 Findings from the analyses of risk factors pertinent to EDCs (Research objective 2)

As explained in section 2.2, construction companies in developing nations share many common features, including risks and uncertainties. The assessment made in the Ethiopian road sector demonstrated that EDCs that engage in the MFRCs are susceptible to various risk factors (Worku, et al., 2021). Through an in-depth review of risks involved in the industry, 47 risk factors were identified to be pertinent to the EDCs engaged in the road sector. A questionnaire survey involving professionals from the three main contracting parties (contractors, consultants, and the client), identified the ten most critical risk factors from these 47 factors. These were: shortage of cash; inadequate planning; lack of access to foreign currency; delay in possession of site; frequent breakdown of equipment; delay in delivery of material and equipment; financial failure; inflation; delay in payments; and poor commitment and coordination within the contractors' team. Further, the research revealed, by comparison with studies published in the literature, that many of these risk factors are also common to companies in other similar countries.

It is not surprising that a lack of cash constraint was the most critical risk factor identified because it is well documented that EDCs routinely suffer from poor cash flow. This might arise in

association with the other four factors of the list, namely, shortage of foreign currency, financial failure, inflation, and delay in payments, in particular. A possible mitigation for this risk is for contractors to have a suitable financial management system in place. The second is to utilise the unused opportunities in the financial sector of the nation, mainly banks, that enable contractors access to cash while they face cash-flow problems. Inadequate planning is associated with contractors' institutional capacity, and ranking as the second most critical risk factor. This was also found as critical for domestic contractors in other developing countries.

The third most critical factor is shortage of foreign currency, which arises due to the fact that most of the plant and equipment used by EDCs is foreign owned or purchased from international markets and EDCs therefore require foreign currency to make these transactions. Consequently, it is unsurprising for EDCs where contractors project payments have been fully paid only in the local currency, while some portion of their foreign counterparts have been in foreign currency. Constraint of foreign currency and inflation in particular are associated with the macro-economic policy of the nation, and the client (the government) should take the major share in treating contractors' risks in association with these factors; because these factors, coupled with the cash-flow constraint, which is majorly related to the contractors' cash-flow management, would impose other challenges such as shortage of materials and spare parts for equipment described under the list mentioned above.

Overall, the existence of such risks clearly suggests that EDCs should put in place suitable ERM procedures that could enable them to respond adequately to these and other risks. In light of this, it was found appropriate to use EDCs as a case study for evaluating the usefulness of the model (ERM³- CON) proposed in this study. The findings from this case study were primarily intended to test whether the proposed model provides reliable results that reflect the current practices of the road sector. The key finding of the case study are discussed below.

5.2.3 Adequacy of existing maturity models (Research objective 3)

An ERM maturity model (ERM³) was found to be an important instrument for measuring companies' RM capability. This is especially important for companies that intend to better implement ERM and benefit from it; because an effective ERM³ model allows a company to evaluate the adequacy of its approaches towards RM; identify its current level of maturity; compare

its approach with best practices; create an accepted benchmark; set realistic targets for improvement and measure progress towards achieving them (section 2.5).

Accordingly, several such models have been developed since the late 1990s. However, a critical review of the literature indicated that none of these models were effective in adequately measuring a company's ERM capability. A review of those related to the construction industry also showed these to be inadequate in measuring the RM competence of the construction companies. As discussed in sections 2.5.1 and 3.4.1, a wide range of inconsistencies was observed in the existing models in terms of defining the key ERM attributes and maturity levels. Essential attributes, namely policy and strategy as well as structure and governance were missing in many of them. Another limitation that appears in many of these models is intermixing of detailed and specific diagnostic indicators with the key attributes. In addition, although testing the suitability of the maturity models is an essential requirement in a maturity model development procedure, it was found that only a few of the proposed models have been empirically tested (Hoseini, et al., 2016).

Accordingly, the review demonstrated the need for developing a new ERM³ that will enable the comprehensive measurement of the ERM capabilities of a construction company. Above all, due to the iterative nature of RM itself, it demands continual improvement through learning and experience (ISO, 2018) for ensuring effective ERM. Therefore, developing a new model based on the practical experience gained from existing models is also of paramount importance in terms of contributing to the ERM discipline.

5.2.4 ERM³ development framework (Research objective 4)

The literature indicated that most of the existing models have shortcomings in demonstrating how they were developed (Becker, et al., 2009; Proenca, et al., 2017), which according to Becker et al. (2009) appear to result in a wide range of arbitrariness within these models. Hence, through a critical review of the literature, a suitable framework was established that will help to develop an effective ERM³ (see section 3.3). This procedural framework contains five basic steps: problem identification; evaluation of the existing models; developing the ERM³; and model testing.

5.2.5 The proposed ERM³ (Research objective 5)

As suggested in De Bruin, et al. (2005) and Becker, et al. (2009), an iterative approach containing a comprehensive literature review and expert consultation using questionnaires or in workshops could be utilised to ensure that the identified ERM maturity attributes and diagnostic indicators are relevant and exhaustive to adequately measure a company's RM competence. However, due to the limited awareness of the ERM discipline in the road construction sector in Ethiopia, it was considered that such an approach would be problematic to achieve for the prototype model. Further, the COVID-19 outbreak occurred during the study did not make it possible to conduct questionnaire surveys or organise such workshops. Consequently, a comprehensive literature review was utilised to select the appropriate ERM maturity attributes and diagnostic indicators as also applied in (Zhao, et al., 2013a; Hoseini, et al., 2019).

A comprehensive review of the literature on the contents of the existing models, mainly the attributes and maturity levels, indicated that culture, process, competence and implementation are the common and most frequently used attributes (see sections 2.5.1.1). A review of recent ERM³s (ORR & HSL, 2017; Hoseini, et al., 2019; OECD, 2021), and ERM standards such as ISO (2017) and COSO (2017) indicated the importance of introducing some more attributes, namely 'policy' 'strategy', 'structure', 'governance' and 'leadership' in different forms. The review of other related models, mainly the organisational development models and business excellence models also showed these are essential ERM attributes.

Hence, it was found that introducing the 'policy and strategy' and 'structure and governance' as additional key attributes to the four conventional attributes mentioned above will make the measurement criteria more complete. Further, it will help to avoid the intermixing of attributes and indicators, which is not suitable for carrying out an effective ERM measurement.

In addition, from a review of existing models, it was found that an assessment system based on four levels of maturity, which the literature review found to be the most frequently used, would be adequate to measure the ERM capability of a company (see Table 2-10); while five and six levels of maturity were also used in a few models. An even number of possible levels would help to avoid the ambiguity of interpretation of the middle level if an odd number of maturity levels (three or five) is used, as the middle one might be interpreted as 'has no opinion', 'is indifferent/does not

care’ and/or ‘does not understand the question’, as described in Willits et al. (2016). Further, Caiadoa’s (2016) argument that ‘evaluating maturity using a scale with more than four levels would increase ambiguity’ was also taken into account when deciding the number of levels.

Accordingly, a new ERM maturity model (ERM³-CON) was developed containing six maturity attributes and four maturity levels. The six attributes are policy and strategy (PS), structure and governance (SG), culture (CU), process (PR), competence (CO) and implementation (IM). These attributes are presented in detail in section 3.4.1. The four maturity levels, from least mature to most mature, are defined as naive, novice, managed and optimised.

The comprehensive approach to developing a ERM maturity model (ERM³-CON) is considered to be unique because existing models described in the literature were established by considering only a few existing maturity models or by utilising some RM standards, separately. This model, however, has considered the relevant existing RM maturity models, ERM standards, and some other related models, including organisational development models and business excellence models (see section 3.4), which enables the incorporation of the essential maturity attributes.

1. Policy and Strategy

An RM policy is a statement of the overall RM-related intentions and directions of a company (ISO, 2009). Strategy, on the other hand, is the set of actions and firm plans in response or anticipation of changes in an organisation’s external environment (Waterman, et al., 1980). Hence, this attribute enables the overall strategy of the organisation towards RM to be set out, the RM roles and responsibilities to be defined, and the protocols that should be followed in managing risks to be established. A formal ERM policy according to Terzzi and Posta (2010) also enables the challenges related to creating common understanding and harmonising individual RM practices to be overcome. Several literature studies highlighted that policy and strategy is an essential factor for successful RM (AS/NZS, 2004; Terzi & Posta, 2010; Gibson & Young, 2012; Kikwasi, 2018; Yazid, et al., 2018) .

It has also been found that other related models, mainly ODMs, incorporate strategy as a core attribute against which a company’s competence is measured. The emerging ERM³s developed by ORR & HSL (2017), Hoseini et al. (2019), and OECD (2021) have also attempted to introduce policy and strategy in different forms. Further, many standards (AS/NZS, 2004; COSO, 2017; ISO,

2018) and studies (Gibson & Young, 2012; Deloitte, 2021) suggest companies should have well-defined and documented operational RM policies and strategies as the critical success factor in their RM implementation. Deloitte (2021), who surveyed the UK's ERM practice, highlighted that RM demands a clear vision and strategy. All these sources suggest policy and strategy to be an indispensable attribute in the ERM³. Hence, the ERM capability measurement should check whether there exists a suitable policy and strategy that could support the ERM implementation of the company.

2. Structure and governance

Several researchers have pointed out that structure and governance is a critical success factor for effective RM (Gibson & Young, 2012; Yazid, et al., 2018). In contrast, the lack of an appropriate governance structure to support RM implementation was highlighted as a factor that hinders ERM practice (Terzi & Posta, 2010). Consequently, several of the reviewed literature studies state that organisations should set up appropriate structures and governance, and should determine roles and responsibilities in the RM endeavours.

This evidence supports why it was considered essential to introduce this dimension as a key ERM maturity attribute. Hence, the RM capability of a company should also be measured in terms of this essential attribute, which enables the evaluation of whether a company accommodates the right personnel with the appropriate authorities, responsibilities and accountability.

Another issue worth mentioning in connection with the identified attributes is the need to have a comprehensive list of diagnostic indicators. In order to enable a company to have clear evaluation criteria against which they can assess their capabilities and thereafter design an appropriate improvement strategy, it was necessary to identify a set of diagnostic indicators, that would help to assess a company's ERM maturity in a more detailed and measurable level. Accordingly, by means of the literature review, 36 diagnostic indicators were selected under the six attributes (Table 3.2). These indicators were chosen from the basic definitions and concepts of the attributes contained in the ERM guidelines, and the indicators considered in existing models. It was attempted to ensure the list would be exhaustive enough through the literature, because it was not possible to review it via conference discussions due to the COVID pandemic restrictions. Consequently, it is acknowledged that there might be some limitations in terms of including all the relevant indicators, while they are found adequate for the purpose of this study. Hence, it is

recommended users further verify the proposed indicators prior to using them for similar studies or applications.

The other four attributes are thought to be better understood by professionals as they are common in the other models. Hence, they are brief discussed as follows.

RM culture

This is the third important attribute that pertains to ethical values, desired behaviors, and understanding of risk in the company (COSO, 2017). It involves on the belief, awareness, attitude and commitment of the company towards RM, and shapes the company's overall practice in handling risk. Hence, to attain a successful ERM, risk culture needs to be properly embedded within the organisation. The commitment of the management in this regard is crucial in promoting an open communication about risk at all levels.

Risk management process

This is also the other essential attributes of an ERM³ that helps to systematically apply management policies, procedures and practices in the process of handling risk. This commonly involves the risk identifying, analysing, responding, monitoring and reviewing of risk (Section 2.3.3). For a successful implementation of ERM, adopting suitable risk management system is always important. This should also be supplemented by advanced risk identification, analysis and monitoring techniques, which also demand competent experts.

Competence

Enterprise risk management requires qualified professionals who can effectively handle company risks using state-of-the-art techniques. As discussed in the structure and governance attribute, the structure should be adequate to accommodate experts required, include the chief risk expert. Risk management competency is measured by the availability of knowledgeable, skilled and experienced staff, which is by a continuous training. Hence, the leadership needs to demonstrated its commitment towards ensuring these happens in the company.

Implementation

As discussed in section 2.3.3.4 RM is a continuous process that demand close monitoring and frequent review. Hence, implementation is a common ERM attribute, which intends to measure whether the ERM is applied in line with the policies and strategies of the company. The major tasks contain ensuring the assignment of resource, including RM experts. It also evaluates whether permissible RM culture is embedded within the organisation. Hence, a company's ERM maturity measurement should include this attribute to evaluate the overall status of the ERM implementation against the targets.

5.2.6 Defining a suitable ERM maturity measurement technique (Research objective 6)

5.2.6.1 Data collection techniques

As part of the maturity model development, the application of the proposed model was tested by applying it into practical case studies. To help with this, data collection and analysis techniques were defined in section 3.5. Upon a review of several data collection techniques, a structured interview was found to be the most appropriate technique for consulting experts because it enables a frank and an open discussion. It also provides uniform and comparable data (Faryadi, 2019) compared to an unstructured interview. In the course of this study's interviews, it is also well recognised that the interview provides an opportunity to clarify ambiguities and unclear issues for the interviewee. Hence, a structured interview is found appropriate for less familiar disciplines, such as ERM.

Despite its several merits, an (structured) interview has also some weaknesses (Kothari & Garg, 2014), a few of which were experienced in this study. Firstly, there was some difficulty in easily approaching certain types of respondents, in particular important officials and executives. Because of this, 9 of the 35 targeted companies were not included in this study. Secondly, interviewing is a relatively time-consuming task, especially when the sample is large and more than one visit to a company is required, for example to seek clarification to answers, as experienced in this particular study. It was also a challenge to conduct many of the interviews at their scheduled times due to frequent postponements by the participants. In addition, each of the interviews were time consuming, with interviews ranging from two to three hours in duration. Thirdly, compared to the

questionnaire, it is also noted to be more costly as it demands a face-to-face discussion, going to their office.

The literature indicates that responses in the questionnaires are typically recorded using Likert scales in the form of numerical values or variables. However, from the pilot review of the questionnaire, it was found that the use of numerical values or variables would make it difficult for respondents to determine the appropriate level of maturity. This is because the terms proposed in the model to define the four ERM maturity levels (naive, novice, managed, and optimised) are less familiar for experts in the Ethiopian construction industry. Hence, equivalent descriptive statements were used in the ERM maturity related questions. While it was initially time consuming to define descriptive statements for the 36 questions, it was recognised as essential during the interview period as it provided more objective responses compared with numerical values or variables.

5.2.6.2 The use of fuzzy logic analysis

It was recognised that because of the unfamiliarity of the respondents to the terms in the model, the potential immaturity of RM within the companies interviewed and other uncertainties associated with the expertise of the respondents themselves, that a data analysis system should be developed which can handle problems involving ambiguity and imprecision in human judgment, and can quantify the linguistic facet of the data. A review of the literature (section 3.5.2) found that fuzzy logic analysis could be a particular useful technique to address such issues. The method has been used successfully in many studies to measure ERM maturity (Zhao, et al., 2013a; Salawua & Abdullah, 2014; Zhao, et al., 2014a). Accordingly, a fuzzy rating system was developed in section 3.5.2 containing five distinct steps: defining linguistic variables; defining fuzzy rating scores; defining fuzzy numbers (fuzzification); aggregation of fuzzy numbers (aggregation); and determining fuzzy scores (defuzzification).

As described above, the data collected in linguistic terms (descriptive statements) was quantified (transformed into fuzzy numbers) using the fuzzy logic system. The output fuzzy numbers enabled an adequate definition to be made of the ERM maturity of companies surveyed, and attributes and indicators discussed below in section 5.2.6. The results obtained in this system were found to reflect the results obtained from the group discussions presented in section 5.2.6.1; where it was

perceived by the participants that the ERM practice in the Ethiopian roads sector is relatively low. Indeed, the actual practice of the construction industry as a whole is not as such different from this.

Hence, it can be concluded that a fuzzy logic system is adequate as a tool for capturing and assessing the different levels of ERM maturity in construction companies. Apart from its significance, the fuzzy logic system also has some limitations. First, since it is less familiar in the RM discipline, it demands due care is taken in ensuring reliable data, especially in the case where the maturity levels are provided in the assessment tool in linguistic terms. This study has tried to tackle this problem by converting the maturity levels provided in linguistic variables (naïve, novice, managed and optimised) into equivalent descriptive statements that are found relatively understandable to the interviewee.

Second, in some cases there are varied options, for the same issue, to be applied in the fuzzy logic system. For instance, as described in section 2.7.1.1, there are different forms of membership functions, which demand due care in determining the appropriate one. The same applies in the defuzzification techniques (section 2.7.1.1). This study has overcome this shortcoming by a thorough literature review and judgment.

5.2.6.3 Findings from the group discussions (pilot model test)

The questionnaire developed based on the findings in section 5.2.6.1 and 5.2.6.2 and the suitability of the model developed in Section 5.2.5 were reviewed using group discussions. The following key findings were obtained from the three group discussions made with experts from three different companies, to evaluate the proposed ERM³ (section 3.5.1.1.1). The discussions were primarily aimed at evaluating the contents of the proposed model. Along with this, the road sector's overall understanding of ERM, as well as its level of implementation, was discussed; yielding the following.

1. Awareness of the sector of the significance of ERM

- The benefits of RM are well recognised at the senior management level.
- It was noted that the effects of inadequate RM are often recognised when adverse events happen such as the COVID 19 pandemic. It was emphasised that the risk of ensuring

the adequate supply of industrial materials during the first wave of the pandemic in particular, was a serious threat for most companies. Despite the lack of commitment for the full implementation, such events appeared to cause the leadership of the sector to start thinking about RM.

2. Status of ERM implementation in the sector

- There were no, or only a few, ERM practices at the company level.
- There was some effort at the project level mainly towards identifying the critical risks, especially during the bidding stages. This has been used to decide whether to participate in the bids, and if there is a need to participate in set strategies for how these risks could be treated. One of the major strategies used by many of the contractors is to try to embed it in their costs to be offered for tender.
- Risk issues commonly appear during the initial annual planning and periodic performance review sessions. Meaning, there is no intermediate review, monitoring and evaluation, except when something extraordinary happens. This is contrary to the actual risk management process requirements which demand frequent updates (2.3.3). The overseeing body, in particular, needs to be well informed all the time to help them make informed decisions.
- As a result, in most cases, risk responses were more or less reactive.

3. Barriers to the attempt to practise ERM

- Apart from a little attention being paid to ERM, no defined barrier was stated by participants. Only a few tended to mention that the lack of skills and knowledge would contribute to the inadequacy of ERM implementation in the industry. However, most stressed the issue was associated with the commitment of the company to start implementing it.

4. Comments on the proposed model

- Mentioning their limited experience in using ERM³, experts refrained from providing detailed comments on the proposed model.
- Initially, interview questions were prepared so that participants could choose one from the four alternatives defined using numerical scales ranging from 1 to 4 (1 for naive,

i.e. least mature and 4 for optimised, i.e. most mature). However, citing the limited experience of the industry with respect to ERM, participants suggested that the four alternatives provided in numerical scales under each of the ERM maturity questions should be modified into descriptive statements, so that respondents could easily understand them.

- They also commented that a brief introduction should be presented to respondents prior to starting the interviews, aiming to establish an understanding of the ERM concept and principles.

Accordingly, the interview questions were modified by changing the four alternatives provided in numerical values into descriptive statements. Brief presentations were also made to participants using PowerPoint prior to the interviewee. The presentation contained the overall concept of ERM focusing mainly on the ERM³s (See Appendix E).

5.2.7 Findings from the case study (Research objective 7)

5.2.7.1 The survey data

The model was used to measure the RM competence of 26 (74.3%) of the 35 EDCs that were operating in MFRCs by 2020. The analysis of the available data indicated that these companies have been involved in a considerable volume of the federal road construction projects implemented in the RSDP of the nation, to a value of about 33.8% of the total expenditure of all projects implemented from 1998 to 2020. This is equivalent to 65.6% of the total cost of projects awarded to domestic companies alone. This suggests that companies considered in the case study represent EDCs operating in the MFRCs. Further, the data in the Ethiopian Construction Authority shows that the contractors surveyed accounted for 18% of the total number of Grade-1 registered domestic contractors in 2020. Further, roads are perceived to be the major sector in the Ethiopian construction industry, accounting for about 50% of the government's expenditure on the industry (EEA, 2008). Hence, it could be considered that the surveyed contractors also represent the country's major construction companies as well.

The interview was generally with a senior professional for the company leadership, with 88% of them holding positions ranging from department head to the company's CEOs or general manager. This is in line with Deloitte (2021) and Beasley, et al (2018) who involved executive equivalent

experts to explore ERM practices in the UK and USA, respectively. These participants had also extensive exposure and practical knowledge in the construction industry, of which 77% had more than 10 years of experience.

However, none of the participants were directly responsible for risk management due to the fact that it was not indicated as a function in the organisational structures of the companies. This raises a concern about the overall RM approach of the sector. As highlighted in sections 5.2.6.4 and 5.2.6.5 below, this is associated with the absence of a suitable ERM function in the companies' organisational structures. Hence, it is suggested companies incorporate ERM functions in their companies and assign competent experts that could handle risk associated issues. It is important to note that ERM is no longer inevitable, as the risk is mainly due to external sources. Hence, what is essential is to establish an appropriate system that could successfully respond to risks.

The Cronbach's alpha was calculated to test the reliability of the ERM maturity data and provided an alpha coefficient of 0.95, which suggests a general internal consistency and reliability in the responses. Different inferential statistics' analyses were applied to test the potential association of companies' characteristics with the ERM implementation. These include ANOVA, the t-test, Pearson's correlation coefficient, and regression. The findings of the analyses are discussed in sections 5.2.6.3 to 5.2.3.5.

5.2.7.2 ERM maturity of the companies surveyed

Although it is not always possible to achieve a fully mature level (Andersen & Jessen, 2002), the leadership should ensure that an effective RM system is in place (Chapman & Ward, 2002). However, the results of the study revealed that the overall maturity of the companies surveyed was about 2.04 out of 4.00 points, with the maximum and minimum scores of 2.97 and 1.42, respectively. The aggregated 2.04 maturity implies companies were belonging to the naive and novice maturity levels with a 54% and 46% degree of membership functions, respectively. The detailed fuzzy TMF of the maturity scores also indicated that 21 (81%) of the 26 companies were at a novice, four (15%) were at a managed and the remaining one was at a naive level. Further, out of the 21 companies that were found as novice, the vast majority (57%) were with the degree of TMFs belonging to the naive and novice levels (i.e. $S = 1.5 < x < 2.5$). Eight (38%) companies

were with the degree of TMFs belonging to the novice and managed ($S = 2.5 < x < 3.5$) and the remaining one company was at 100% novice stage ($S = 2.5$).

According to Farrell and Gallagher (2015), the naive and novice levels are low levels of maturity characterised by an RM process that lacks discipline and company-wide coordination. Hence, the ERM capabilities of companies involved in the study could generally be categorised as low. In line with the characteristics of the ERM maturity levels described in section 3.4.2, the RM practice of companies of this level can also be described as follows:

- No clear ERM policy and strategy existed but there was an attempt to incorporate it into other disciplines
- No structured and documented generic risk management processes existed
- Inadequate knowledge of RM concepts and principles and limited skills and experience to handle RM were evident
- Informal and inconsistent RM application with an attempt in limited units of companies where utilised
- RM approaches were dominantly reactive
- Inadequately resourced and process driven RM approaches were present

Indeed, these characteristics are reflected in the analysis of the 36 indicators (section 5.2.65) upon which companies' maturity was measured. These findings are consistent with the practice in many other developing countries, discussed in section 4.7, in which a general low level of ERM implementation was reported. Further, the findings of the study reflected the current practice of the Ethiopian road sector found in the group discussion (section 5.2.6.1).

In association with the Ethiopian road infrastructure development, the low level of ERM practice of EDCs achieved in this study draws concerns as it is in contrast with the actual diverse risks involved in the sector. This suggests strategic intervention from both the regulatory bodies and stakeholders in the industry, mainly the contractors. From the side of the ERA, it is advisable to consider the ERM training to the contractors in the policy directions of the National Roads Policy (ERA, 2021c) is specified to enhance domestic contractors' capacity building.

5.2.7.2.1 Statistical test results

The potential association between the important characteristics of companies with ERM maturity was evaluated using statistical tests (section 4.4.5). The t-test carried out to explore the association between ERM implementation with companies' ownership (section 4.4.5.1) showed that ERM is contingent the ownership category of companies, where public companies were found to be relatively more mature compared with the private ones. However, it should be noted that the mean values of the two groups have no major differences.

This finding concurs with Beasley et al. (2018) and Zhao, et al. (2013a) that the indicated public companies had more advanced RM practices relative to private companies; while a contrary result was reported in South Africa, in which public companies were reported as much less mature than private companies (Coetzee & Lubbe, 2013). While the difference between the two groups is not significant, the finding indicates that private companies in particular need to be encouraged to improve their current risk management practices. This could be achieved by promoting the practice of ERM through legal means or bidding requirements; and thereby establishing some sort of motivation mechanism, such as in giving project in a direct award to those companies that showed notable improvement in terms of practicing ERM.

The ANOVA analysis provided in section 4.4.5.2 suggests that there is a significant difference between the three groups of companies (less than 20 years; 20 to 30 years; and above 30 years) in terms of their years of experience. However, the results appear to be unusual, with companies with less than 20 years' experience having relatively higher ERM scores than those with above 20 years. Unfortunately, this appears to reflect the actual situation in Ethiopia, in which most companies decline in every aspect while their years of experience increase. Indeed, most of the companies that were operating in the Ethiopian road sector at the beginning of the road sector in 1997 are no longer in the industry. The important finding, however, is that companies with above 30 years' standing have better ERM experience as expected. This might indicate why they survived in the sector (three companies that took part in the survey had more than 30 years of experience).

The Pearson's correlation coefficient, and low linear regression correlation values show there is no strong association between a company's maturity level and the volumes of projects executed by the respective company. Hence, the scope of projects handled by the companies has no

significant implication on the companies' ERM maturity levels. This is somewhat consistent with the result in relation to ownership where companies with less than 20 years of experience were found to have a better ERM competence than those with between 20 and 30 years.

Such results are a little shocking for stakeholders in the sector, especially for those that are involved in order to enhance the domestic sector, anticipating institutional improvements. This suggests the overall domestic construction sector capacity building approach needs to be reviewed, and devise a suitable means that would reverse the practice. It is also important to examine whether this low level of ERM contributes to the attrition and departure of the nearly 20 contractors (section 2.2.2) from the road sector over the past 25 years or so.

5.2.7.3 *Relative maturity of attributes*

The detailed diagnosis of the road sector in terms of the attributes also indicated that the sector was at a novice maturity in all the six attributes, with the overall maximum and minimum maturity scores of 2.33 (for culture) and 1.88 (for structure and governance), respectively. Yet it appears to be promising that the sector is relatively mature in terms of culture with a score of 2.33, because a mature ERM culture is a prerequisite for a sustainable and value-adding ERM (Althonayan, et al., 2012). In a specific study conducted to test the relationship between risk culture and ERM implementation among Malaysian construction public companies, Ching, et al. (2020) indicated that risk culture will have a significant influence on ERM. The impact of the weak organisational culture, for instance, was reported to have impacted the ERM implementation in South Africa (Coetzee & Lubbe, 2013). Further, as stated in IRM (2012), the RM culture at a company's board and senior levels determines its governance and structures and risk appetite.

Apart from their slight relative differences, the maturity scores of the remaining five attributes were close to one another. Among these, the policy and strategy (S=2.08), and implementation (S=2.03), for example were almost entirely at a complete novice level with only 8% and 3% degrees of membership in the managed region, respectively. The process (S=1.97), competence (S=1.93), and structure and governance (S=1.88) were all at a novice level with 3%, 7% and 12% naive degrees of membership, respectively. This implies that considerable improvement is demanded across the attributes, including the culture attribute. The structure and governance as well as the competence attributes were found to be the least mature attributes, while they are the

basis to implement ERM. Hence, the leadership in the Ethiopian road sector should attempt to improve on these areas. That is, companies should incorporate the ERM as a key function in their organisational structure and assign competent experts with defined duties, responsibilities and accountabilities. Tailor-made training should be provided to the employees at all levels, to enhance the awareness in the benefits of practising ERM. Technical training should also be facilitated by RM experts to help them effectively handle the RM process.

The relatively low ERM maturity found in the remaining attributes confirms that a considerable effort is required in the section to improve these RM attributes. The first responsibility to transform this experience lies upon the contractors themselves, as it is a main part of institutional transformations. Further, practitioners and the regulatory body should also play their role in facilitating training and sharing best experiences; which would help to overcome the gap in the competence attribute. The regulatory bodies and/or the procuring entities might also demand contractors to implement effective RM, which is essential for the project owners and the public as well. This could be defined as a mandatory requirement for registering contractors in high grades of category that are involved in high volume projects. Furthermore, the relatively different maturity among the maturity levels also dictates an important concept: the balanced maturity within the attributes. As recognised in the 7S organisational development model (section 2.53.1.2), it would be difficult, perhaps impossible, to make significant progress in one particular attribute, say in culture, without making progress in the other five attributes. Hence, as suggested in ISO (2018) the executive should demonstrate their leadership and commitment by formulating a suitable RM policy and strategy that enables effective and efficient ERM with balanced competence levels in all the RM six attributes, and ultimately all diagnostic indicators.

5.2.7.4 *Relative maturity of indicators*

Examining the maturity of companies in terms of diagnosis indicators helps to provide an overview of the key areas of strength and weakness of the companies in managing risks (Salawua & Abdullah, 2014). Accordingly, the sector was examined in-depth in terms of the identified 36 indicators, which revealed that the majority of the indicators were at a low level of maturity with the aggregated scores varying between 1.62 and 2.87. The fuzzy TMFs of the calculated maturity scores also demonstrated that only one indicator was at a managed level out of the 36 indicators, with a maturity score of 2.87 out of 4.00 points. However, this indicator itself did not reach a

completely managed level as it also belongs to the novice level with a 13% degree of membership. The remaining 35 indicators were at a novice level. This further emphasises that the Ethiopian road sector is consistently at a low level of maturity in almost all the indicators.

Albeit there was an overall low level of maturity, it was also found that the sector was relatively more mature in some areas according to a few of the indicators. The top five relatively mature indicators, in their order of maturity from most to least mature, are: (i) belief in the value of ERM ($S = 2.87$); (ii) level of risk information used in decision making ($S = 2.45$); (iii) commitment of the leadership ($S = 2.40$); (iv) attitude of the leadership to RM ($S = 2.39$); and (v) risk identification practice ($S = 2.38$). Three of these indicators, i.e. (i), (iii) and (iv) are components of the ERM culture (See Table 4-24). This finding seems to be in contrast to those of many other studies where unsuitable culture was identified as the most critical factor impeding the implementation of ERM in many countries, such as Malaysia (Goh & Abdul-Rahman, 2013) and South Africa (Coetzee & Lubbe, 2013). Hence, this demonstrates the potential of the sector for further enhancement to the existing ERM practice.

It is also worth noting that there are some important indicators, but at a relatively low maturity, requiring special attention. For instance, while integrating the RM at all levels of an organisation is one of the core principles in ERM practice, this was found to be the most immature with a maturity score of 1.62, i.e. 62% novice and 38% naive degrees of membership. Similarly, the sector was relatively least mature in some indicators, such as, assigning appropriate authorities, responsibilities and accountability; in allocating the necessary resources; and in facilitating the essential training on ERM. This demonstrates that these companies should use the permissible culture established in the leadership, which was also consistently reflected in the group discussion in section 5.2.6.1, to improve the least mature indicators as well.

Further, the finding of the study suggests that there is a need to enhance the awareness of the professionals in the road sector to improve the recent low-level ERM practice. Providing tailor-made training would also be helpful to achieve the required competence.

5.2.1 Major barriers to practising ERM

Ten barriers that would impact companies in the road sector to put in place ERM were identified from the literature. Accordingly, participants were requested to evaluate the impact of the

identified ten barriers on the implementation of ERM in their respective companies. The results indicated: (i) the unavailability of RM consultants; (ii) inadequate training on ERM; and (iii) a lack of awareness of ERM were found to be the three most significant factors (from high to low) that impede the implementation of ERM in EDCs. The first two factors are related to the knowledge and expertise to apply risk management. Similar results, mainly the lack of knowledge and skill to practise RM were found to be the most significant factors in Iraqi contractors (Abdulhussein & Shibaani, 2016). A lack of the necessary expertise to properly identify risk and to take appropriate responses was also reported with Egyptian contractors engaged particularly in power station projects (Hassanein & Afify, 2007).

This demands specialised training focusing on RM. In this regard, it would be advisable for the ERA to consider ERM as one of the core areas of training that needs to be carried out as a strategy in domestic contractors' capacity. Promoting consultants to the area of risk management is also the other possible option, as was experienced in the financial sectors. Higher education institutions should also look at developing a curriculum for specialised fields in areas of the construction management stream.

Consistently, with the maturity of the indicators discussed above, the lack of support from the senior management was ranked sixth, affirming that the support of the management is vital at an acceptable level. Overall, this suggests that suitable training can help to improve the competence of the sector.

5.2.2 Policy and Practical Implications (Research objective 8)

As stated in section 1.3, the Ethiopian government is making great efforts to strengthen the country's construction industry, which includes enhancing the institutional capacity of domestic contractors. In order to put some of the findings of this research into this context, the policy and practical implications of the results of the study are discussed in relation to three policy documents published by the Ethiopian government.

Ethiopian National Construction Industry Policy

This policy was formulated from a draft produced by the Ministry of Construction and Urban Development of the Federal Democratic Republic of Ethiopia in 2013 (MOCUD, 2013), and has

three primary objectives. One of these is ensuring the viability and competitiveness of domestic construction companies. This policy recognised that the inadequate capacity of local contractors emanated from various factors including a lack of institutional management skills. This may include the risk management which Desalegn (2019), in his study related to the Ethiopian domestic industry development, found to be one of the necessary improvement areas of management in the industry, towards establishing competent construction companies.

To overcome inadequate local capacity in the sector, a number of policies are provided; one of which is associated with promoting the application of best practice standards on productivity, quality management, and delivery arrangements. The ERM tool developed as part of this research could be considered as important to help improve the performance of EDCs by successfully handling risks that would impact projects and thereby company performances (section 2.4.3).

Ethiopian National Construction Industry Capacity Building Framework (ENCICBF)

The ENCICBF has been developed as a guideline for the implementation of the National Construction Industry Policy as described above (MOC, 2016). Apart from the low performance of domestic contractors, the framework recognised their limited market share in the industry. Accordingly, the ENCICBF aims to enhance the institutional capacity of domestic contractors would enable them to deliver at least 70 per cent of the country's construction work, as well as participating in the global market. As found in this study and by others (Taddese, et al. (2016) and Desalegn, et al. (2019)), RM is less practiced in the EDCs, but is considered to be important for the success and sustainability of road construction companies.

Through the interview that involved almost three-quarters of companies that operate in the road sector and one-fifth of Grade-1 domestic contractors, it was attempted to introduce the ERM and its significance. Now using the findings of this study as a benchmark, contractors could be further provoked to start implementing the ERM. Further, the study could also be used as a resource along with the other documents to prepare training modules for the construction companies. Hence, it is recommended contractors be further encouraged to practice ERM.

Ethiopia's 10-year National Road Sector Development Plan

The national road sector development plan was prepared by the ERA with the intention of being implemented in the period between 2021 to 2030 (ERA, 2021b). While there have been some improvements, the inadequate performance of EDCs was identified to be a prevalent threat in implementing the plan. Consequently, enhancing the capacity of EDCs working in the road sector was considered to be one of the core areas of focus towards realising the plan. A study by Worku, et al. (2021) also indicated that EDCs operating in the MFRCs are susceptible to many risks and uncertainties that require adequate mitigation.

In light of its positive implications in increasing project and company performance, implementing ERM will help improve the institutional capacity of EDCs. Further, the levels of ERM maturity identified in this study could be used as a benchmark by which future improvements of the ERM practice of domestic contractors engaged in the road sector development can be judged. Most importantly, contractors need to be urged to introduce the ERM function within their organisational structure and assign the right personnel directly responsible for risk management. The ERA could facilitate incentives to contractors that attempt to adopt risk management in the bids.

In respect to the road sector development of the nation, it would not be feasible to attempt to implement a project with the design and build delivery system, in which the majority of the project risks are in principle transferred to contractors, under the situation that contractors have limited ERM practice. Hence, an effective ERM system should be a core criterion for selecting contractors for design and build projects. This would indirectly motivate companies to establish the system.

5.3 The Major Achievements and Significances of the Study

This study has provided a new ERM³ that can be used to evaluate the ERM capability of construction firms. The inadequacy in the contents of the ERM maturity evaluation attributes/indicators and the absence of clear procedures on how they were developed were found to be the major constraints of the existing models. To bridge this, two key attributes (policy and strategy; and structure and governance) were introduced in this model in addition to the four conventional attributes, resulting in six attributes. Further, a detailed questionnaire was prepared

based on the identified 36 indicators to enable companies to self-assess their RM capability. Hence, the model is believed to be adequate in terms of content.

A major issue of such evaluation models concerns the accuracy of the data provided by respondents. In this case, RM is a relatively new concept to the Ethiopian road industry and therefore it might be expected the respondents may not have sufficient experience and/ or expertise to adequately answer the questions. To address such uncertainty, it was recognised that the developed approach should be capable of dealing with ambiguity and imprecision in human judgments, and quantify the linguistic facet of the data. To this end a fuzzy logic approach was utilised.

Another major weakness of the existing models reported in the literature was that, except for a few, the theoretical basis on which they were developed was not clear. Accordingly, a procedural framework was established to help develop a model. Further, most models were not empirically tested to check their usefulness. To address this, the proposed model was tested by a means of a practical case study involving 26 EDCs that revealed consistent results with the current practices of the Ethiopian road sector in many aspects. The findings of the survey were also found to be in close agreement with the results achieved in other related studies conducted in various developing nations. Therefore, it is believed the model is adequate in terms of content and is developed through a well-established procedural framework. Hence, it could successfully be used for evaluating the ERM maturity of construction companies in particular and companies in the other industries at large.

5.4 Summary

This chapter discussed the key findings of the study in line with the objectives of the research, and the major contributions of the study. The detailed literature review has provided results for the first five objectives, which showed that ERM is less practiced in the construction industry, especially in developing countries. Further, the review of the existing ERM³ revealed that there is an effective model that could adequately measure the RM competence of construction companies, which suggests the development of a new ERM³. Accordingly, a new model that could be applicable for the companies in the domain was developed containing six maturity attributes (policy and strategy; structure and governance; culture; process, competence and implementation) and four maturity

levels (naive, novice, managed and optimised). The review of the literature also showed that a fuzzy logic system can be an effective analysis technique for the ERM data, which involved vagueness, uncertainty and subjectivity.

A case study was carried out to test the suitability of the proposed model using the EDCs that are involved in the MFRCPs. The analysis of the study using the fuzzy logic system has yielded ERM maturity levels for contractors, identified attributes, as well as indicators. The low level of ERM maturity achieved in the study, which was also found to reflect the current practice of the industry in other similar countries, showed that the proposed model is applicable for measuring companies' ERM maturity. Furthermore, it indicates that the fuzzy logic system is a powerful tool to measure linguistic data in ERM maturity measurement. Finally, the proposed ERM³ was discussed to contribute to the body of knowledge in the emerging ERM discipline.

6 CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

6.1 Introduction

This study aimed to develop an ERM maturity model (ERM³) that could be applied for evaluating the RM capability of construction companies. To achieve this aim, some specific objectives were also defined. This chapter concludes the study by summarising the key finding of the research in relation to the aim and objectives, as well as the contributions and significances of the research. It also presents the limitations of the study and proposes opportunities for future research.

6.2 Accomplished work

This research project has achieved the objectives which were planned to develop a generic ERM³ to be used to measure the RM competence of construction companies. The main achievements of this research are:

1. A critical literature review of RM practices in construction companies in developing countries.
2. Review of risk factors pertinent to construction companies in developing countries. The ten most critical risk factors to the EDCs that involve in the MFRCs were identified (Worku, et al., 2021).
3. A review of existing maturity models and an evaluation of their applicability to construction companies.
4. The development of an ERM³ procedural framework that contains four distinct steps, namely (i) identify the problem, (ii) evaluate the existing models, (iii) design a new maturity model, and (iv) evaluate the proposed model.
5. The establishment of a fully working ERM³ tool that can be used by companies to self-assess their ERM maturity level. The tool was developed by harmonising existing ERM maturity models, ERM guidelines, organisational design models and business excellence models. The model contains six ERM attributes (policy and strategy, structure and governance, culture, process, competence, and implementation), each

- assessed and based on the four maturity levels (i.e., naive, novice, managed and optimised).
6. The adoption of a fuzzy logic system to analyse ERM maturity data obtained through expert consultation, involving ambiguous and imprecise human judgments, and quantify the linguistic facet of that data. The system contains five distinct steps: (i) define linguistic variables; (ii) define fuzzy rating scores; (iii) define fuzzy numbers; (iv) aggregation of fuzzy numbers; and (v) defuzzification.
 7. The use of the ERM³ tool to evaluate EDCs operating in MFRCs.
 8. An exploration of the implications of the evaluation for policy and practice.

6.3 Conclusions

Based on the principal findings of the research, the following key conclusions can be drawn.

- In addition to being inherently a risk-prone industry, the recent volatile global economic environment makes construction more susceptible to complex and dynamic risks. Unmitigated risks have had a significant impact on the poor performance of the industry, especially in the successful completion of projects in developing countries.
- ERM, that helps to treat risks via a holistic and an integrated approach, was identified as an effective management tool to overcome risks of a company. The literature indicated empirically proven benefits that could be achieved by implementing ERM, namely, it enhances a company's performance and thereby value. ERM has also been found to enhance project performance; hence, practicing ERM is essential for companies in the construction industry towards improving the industry's perceived problems in terms of successfully completing projects.
- Given that construction industry is inherently risk-prone, construction companies are perceived prime candidates for implementing ERM. However, the findings in the literature indicated that ERM is not yet widely practised in the industry, especially in developing countries.
- In relation to implementing ERM, an ERM³ was found to be a useful tool that can help a company evaluate its current level of RM practice and dictate how it can progressively

improve it in the future. However, a critical review of the existing RM maturity models revealed that there is no generic model that can adequately measure a company's ERM capability, which could be adopted in all companies.

- The ERM³ proposed in this research, which is composed of six ERM attributes (policy and strategy, structure and governance, culture, process, competence and implementation), and four maturity levels (naive, novice, managed and optimised), is believed to be comprehensive to measure companies' RM maturities across the diverse dimensions.
 - The applicability of the model was tested in a practical case study involving domestic contractors operating in the Ethiopian road sector and the results showed a low level of ERM practice in the Ethiopian road contractors. This result was also found to be broadly consistent with the actual practice of the sector and was found to reflect the actual practice of the Ethiopian construction industry at large.
 - Hence, it can be concluded that the proposed ERM³ can be used to be effectively assess the RM competence of construction companies.
- A fuzzy logic system was utilised to quantify the survey data collected in the case study to test the suitability of the proposed model. The result of the analysis using this system, which reflects the actual practice of the industry, indicated that fuzzy logic system is a powerful instrument for analysing vague and uncertain human judgments in RM assessment.
- The case study involved about 74% of the total of 35 Ethiopian domestic contractors that were operating in the Ethiopian road sector in 2020 and 18% of Grade-1 contractors that were registered. Hence, it can be said that the findings of the study represent the Ethiopian construction industry in general and the road sector in particular. On this basis, it is therefore possible to draw the following conclusion from the results of the case study:
 - To remain competitive, Ethiopian construction companies, especially those engaged in the road sector, need to implement ERM which enables to effectively manage the dynamic and complex risks of the industry.
 - With respect to the barriers to implementing ERM, the lack of RM consultants; inadequate training on ERM; and a lack of awareness in the values or benefits of ERM were found to be the three most critical factors that impede companies in implementing

ERM. Hence, this suggests the need for an integrated effort to promote the implementation ERM in construction companies.

6.4 Theoretical and Practical Benefits of the Research

The findings of this research have several theoretical and practical implications. Firstly, enterprise risk management is a relatively new discipline that needs further continual improvements. Hence, it is believed that the proposed model will contribute to the growing body of knowledge in the field of ERM as it can address the gap in the availability of a suitable ERM³. This study also provides an ERM³ development procedural framework that can be used in developing other similar models.

Secondly, since the current volatile business environment is making ERM inevitable in the construction industry, companies can use the proposed model to self-assess their current ERM capabilities and set targets for progressive improvements.

Thirdly, in many circumstances, the low level of ERM practice found in the Ethiopian construction sector can also provide a useful insight into the overall ERM capabilities of construction companies in other developing countries. More specifically, such a low level of ERM practice might provoke policy makers to devise suitable policies and strategies that could promote the application of ERM in the construction industry. This would be especially important for the Ethiopian construction industry in general and the road sector in particular where many construction projects perform poorly. In this regard, it is important to note that, in recognition of its significance, some countries have already levied legal provisions to enforce companies to implement ERM. The framework developed in this research could be a useful tool to facilitate this.

Fourthly, the findings of this research could attract the attention of practitioners to the ERM concept which is a basis for implementing ERM in the construction industry. Last, but not least, the study is believed to address research gaps in the ERM discipline in the construction industry in general and in developing countries in particular.

6.5 Recommendations for Future Study

Although the objectives of the research were achieved, it is recognised that there are some limitations associated with the dynamics of the ERM discipline, the diversity of the used indicators

and the ERM research experience in the sector. These areas are recommended for future study and include:

- Efforts were made to adequately identify the relevant ERM maturity indicators from the literature. It was also intended to check the relevance and comprehensiveness of the identified indicators via discussions with researchers and practitioners at international conferences. However, this was not realised due to the COVID 19 pandemic gathering restrictions. Hence, it is suggested that the users of the model carry out their own verification activities on the diagnostic indicators prior to using it.
- Although most interviewees were able to easily describe the RM maturities according to each of the specified indicators, some participants were nervous about specifying the maturity levels of their own companies (particularly if this reflected poorly on the company concerned). Hence, the absence of additional verification of the self-assessed maturity levels, e.g. by using actual records, could be considered a limitation of the accuracy of the obtained data. It is recommended therefore that further studies are conducted to determine how supplementary data, such as actual records, could be used to augment and verify the data collected by interview.
- Similarly, the maturity data obtained was based upon self-assessments done by a single individual in each company. However, it would be incorrect to assume that the responses of all participants were completely free of any bias. Hence, a more comprehensive study involving a larger number of experts from each firm might enable more accurate results to be obtained on the maturity of the respective companies. This should also be an area of further research.

For the findings from this study to be more widely extended the following are recommended:

- The research was conducted on EDCs engaged in the MFRCs. However, there are also several other companies that are not currently operating in the road sector. To reach general conclusions about the RM practice of EDCs, further research is recommended using the proposed model to assess contractors that are operating in the other sectors of the construction industry. It would also make the conclusion more comprehensive if contractors of different categories (e.g. Grade-2 and Grade-3) were incorporated in the study.

- In the 7S organisational design model (Waterman, et al., 1980) , it is perceived that there is no clear indication which of the seven factors will be the driving force(s) in changing a particular organisation at a particular point in time. In view of this concept, further research is recommended to explore whether there exists a clear indication of which of the six attributes of the proposed ERM maturity model would be the driving force(s) in changing a companies' ERM practice.
- The findings of the case study in the Ethiopian road sector support the findings of other studies which also show a low level of ERM practice in the construction industry of many other countries. Hence, this would suggest the need to conduct research to better understand the reason(s) behind this and whether there is a prevalence amongst developing countries. Research questions, such as 'Why is ERM less practised by contractors in developing countries?' and 'What would be the possible factors that affect companies in practising ERM?' might help to frame such research. Benchmarking and empirical research on the factors impeding ERM implementation in construction companies with a particular focus in the developing countries could also provide further insights.
- In Ethiopia, the performance of domestic contractors is recognisably poor, and this study has found that there is a low level of ERM practice in domestic contractors that are engaged in the road sector. Although it is assumed that there is a causal link between performance and ERM practice, it is recommended that a detailed study should be carried out to explore the potential association between these two factors.

In recognition of the benefits of practising ERM, some countries have compulsory legal requirements for the implementation of ERM. This might suggest a further study to explore whether levying mandatory ERM legal requirements would encourage companies working on large construction projects to practise ERM. This might be particularly important for contractors that would engage the design-build, and design-build-managed delivery methods, where in most cases clients attempt to transfer their considerable risks to contractors.

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Appendix A: Publications and Conferences

- Worku , A. W., Burrow, M. & Ghataora, G., 2021. Risks affecting the performance of Ethiopian domestic road construction contractors. *International Journal of Construction Management*, pp. 1-9.
- Worku, A Wubet (2020). COVID - 19 Further Calls for Practising Enterprise Risk Management in Construction Companies: Paper presented at the 10th BEAR Birmingham Environment for Academic Research Conference, September 14-16, 2020 (online). Paper available at:

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Appendix B: Summary of studies related to risks in construction companies

S/ No	Author	Case Study	No of identified RFs
1.	Goh and Abdul- Rahman, 2013	Malaysian Construction Industry	42
2.	Wiguna and Scott (2005)	Indonesian Building Contracts	16
3.	Ekung et al (2015)	Nigerian highway sector	145
4.	Helen, et al (2015)	Nigeria building industry	46
5.	Jaber (2015)	Iraq	65
6.	Jayasudha Vidivelli (2016)	India	90
7.	Mishra, S. and Mishra, B. (2016)	India, all sub sector	10
8.	Kishan et al, 2014	India Building sector	47
9.	Shaikh (2014)	India	39
10.	Wang (2004)	International contractors in developing countries	28
11.	Gohar et al (2012)	Iranian Construction projects	26
12.	Mohammed (2016)	Building project, India	50
13.	Mahamid (2013)	Road projects in Palestine	45
14.	Fernando et al (2017)	Siri Lanka	4
15.	Banaitiene et al (2011)	Lithuanian local contractors	
16.	Wang and Chou (2003)	Taiwan Highway	32
17.	Iqbal et al (2015)	Pakistan	37
18.	El – Sayegh and Mansour (2015).	Highway projects, UAE	33
19.	Yoon et al (2015)	Construction	
20.	Zou et al (2007)	China	55
21.	Hastak and Shaked, 2000	Risk of international contractors	73
22.	Alhomidan (2013)	Risk of cost overrun in road projects, Saudi Arabia	41
23.	El-Sayegh (2008)	UAE construction industry	42
24.	ANDI (2006)	Indonesian Construction Industry	27
25.	Chileshe & Yirenkyi Fianko (2011).	Ghanaian construction sector	25
26.	Befrouie et al, (2015)	Iran	
27.	Emuze (2016)	Malawi road sector	

Appendix C: Summary of the Available Maturity Models

S/ N o.	Author	Model	More suitable sector	Maturity levels	Dimensions
1.	Hillson (1997)	Risk Management Maturity (RMM)	To all organisations	Level 1: naive Level 2: novice Level 3: normalised Level 4: natural	(1) culture, (2) process (3) experience and (4) application
2.	Project Management Solutions (2002)	Project Management Maturity Model (PMMM)	Project – based organisations	Level 1: initial Level 2: structured and standards Level 3: organisational standards and institutionalised Level 4: managed Level 5: optimizing	(1) risk identification, (2) risk quantification, (3) risk response development, (4) risk control, and (5) risk documentation
3.	PMI – EUA (RISK SIG, 2002)	RMM	All types of projects, organisations in any industry, business or government sectors.	Level 1: ad hoc Level 2: initial Level 3: repeatable Level 4: managed	(1) culture, (2) process, (3) experience and (4) application
4.	RMRDPC (2002)	RMMM	Construction organisations.	Level 1: initial and/or ad hoc Level 2: repeatable Level 3: managed Level 4: optimised	(1) management and leadership capabilities in relation to risks, (2) organisational RM culture, (3) ability to identify risks, ability to analyse risks and (4) development and application of standardised RM process
5.	IACCM (2003)	Business Risk Management Maturity Model (BRM3)	All organisations	Level 1: novice Level 2: competent Level 3: proficient Level 4: expert	(1) Culture, (2) process, (3) experience and (4) application.
6.	Hopkinson <i>et</i> Lovelock (2004)	Project Risk Maturity Model (RMM)	To all projects	Level 1: naive Level 2: novice Level 3: normalised Level 4: natural	(1) project stakeholders, (2) risk identification, (3) risk analysis, (4) risk responses, (5) project management, and (6) risk management culture
7.	Ren and Yeo (2004)	Risk Management Capability Maturity Model (RM-CMM) for CoPS projects.	Software organisations	Level 1: initial Level 2: repeatable Level 3: defined Level 4: managed Level 5: optimizing	(1) knowledge and technology: (2) Risk management process: (3) Organisational culture

S/ N o.	Author	Model	More suitable sector	Maturity levels	Dimensions
8.	RIMS (2006)	Risk Maturity Model (RMM) for Enterprises	All business organisations	Level 1: ad hoc Level 2: initial Level 3: repeatable Level 4: managed Level 5: leadership	(1) adoption of ERM-based approach, (2) ERM process management, (3) the risk appetite of management, (4) root cause discipline, (5) uncovering risks, (6) performance management (7) business resiliency and sustainability
9.	Loosemore, et al. (2006)	RMMM	Construction Industry	Level 1: Ad hoc Level 2: Established Level 3: Managed Level 4: Integrated	(1) Awareness, (2) Culture, (3) Processes, (4) Skills/Experience, (5) Image, (6) Application, (7) Confidence and (8) Resources
10.	Ferrando (2007)	Operational Risk Management Maturity Model (ORMMM)	Insurance companies	Level 1: traditional Level 2: awareness Level 3: monitoring Level 4: quantifications Level 5: integration	(1) practical application, (2) processes, (3) culture, and (4) experience
11.	Ongel (2009)	RMMM used for construction industry	All kinds of organisations of any sector, government or commercial.	Level 1: ad hoc Level 2: established Level 3: managed Level 4: integrated	(1) Awareness/ culture, (2) Practices, (3) Resources, (4) Processes
12.	Mayer <i>et</i> Fagundes (2009)	Maturity Model to RM Process in Information Security (MMGRseg)	Information Security	Level 1: initial Level 2: known Level 3: standardised Level 4: managed Level 5: optimised	(1) Context definition, (2) risk analysis / assessment, (3) risk treatment, (4) risk acceptance, (5) risk communication, and (6) monitoring and critical risk analysis.
13.	Zou, et al. (2010)	RMMM	Construction companies	Level 1: initial and ad hoc Level 2: repeatable Level 3: managed Level 4: optimised	(1) culture, (2) management, (3) identifying risk, (4) analysing risk and (5) standardizing risk
14.	Pangeran et al.. (2012)	Risk Management Capacity Model (RMCM)	To all organisations	Level 1: ad hoc Level 2: initial Level 3: competent Level 4: excellent	(1) culture, (2) process, (3) experience, (4) application and (5) partnership
15.	IRM (2012)	General	General	Level 1: Red Level 2: Yellow Level 3: Green Level 4: Blue	(1) Leadership, (2) Dealing with bad news (3) Accountability and Governance, (4) Risk transparency, (5) Risk resource, (6) Risk skill, (7) Informed risk decisions, (8) Rewarding appropriate risk taking, ...

S/ N o.	Author	Model	More suitable sector	Maturity levels	Dimensions
16.	Zhao et al. (2013a)	ERM ³ for construction companies	Construction companies	Level 1: Very Low Level 2: Low Level 3: Medium Level 4: High Level 5: Very High	16 attributes, such as Commitment of the board and senior management, ERM ownership, etc.
17.	Salawu and Abdullah (2014)	Risk Management Maturity Model	Contractors involved in Highway projects	As Hillson (1997)	(1) Culture (2) Practice and Application (3) Resource (4) Process
18.	Caiado et al. (2016)	Risk Maturity Model (RMM)	Construction Project	Level 1: ad hoc Level 2: established Level 3: managed Level 4: integrated	(1) support from management (2) RM knowledge (3) Contingency plan (4) communication with stakeholders
19.	Proenca et al. (2017)	Risk Management A Maturity Model based on ISO 31000	Generic for a all organisations	Level 0: Non-existence Level 1: Initial Level 2: Managed Level 3: Defined Level 4: Quantitatively managed Level 5: Optimised	ISO RM process
20.	ORR and HSL (2017)	Risk Management Maturity Model (RM ³)	Railway and Road Specific to Health and Safety	Level 1: Ad hoc Level 2: Managed Level 3: Standardised Level 4: Predictable Level 5: Excellence	(1) Policy, governance and leadership; (2) Organising for control and communication; (3) Securing co-operation, competence and development of employees at all levels, (4) Planning & implementing risk controls through coordinated management arrangements, (5) Monitoring, audit and review
21.	Hoseini et al. (2019)	Construction Projects Generic RMMM	Construction Projects	Level 1: Not applied Level 2: Limited applied Level 3: Large extent applied Level 4: Totally applied	(1) Strategy and Policy (2) Top management commitment (3) Personnel knowledge (4) Culture, (5) Risk Assessment, (6) Risk Treatment, (7) Risk Monitor and Review
22.	OECD (2021)	ERM ³	Tax Administration	Level 1: Emerging Level 2: Progressing Level 3: Established Level 4: Leading Level 5: Apparitional	1) Strategy, (2) Governance, (3) Culture, (4) Risk Identification (4) Risk Analysis and Evaluation, (5) Risk Treatment, (6) Review and Revision, (7) Information, Communication, and Reporting

Source (Adapted from Ongel, 2009; IRM, 2012; Salawu and Abdullah, 2014; Caiado et al., 2016; ORR and HSL, 2017; Hoseini et al., 2019)

Appendix D: Interview Questionnaires (Uncompleted)

University of Birmingham Department of Civil Engineering

Research Title: - ‘Developing an Enterprise Risk Management Maturity Model Applicable for Construction Companies: A Case Study: Ethiopian Domestic Contractors Operating in Federal Road Construction Projects’

Researcher: - Worku Asratie Wubet

Advisors: - Dr. Michael Burrow
Dr. Gurmel Ghataora

Abstract:

The construction industry is subject to more risk and uncertainty than many other industries for several reasons. The complexity of the industry, fragmentation of the business in the industry, its sensitivity to economic and political factors, uniqueness of individual projects which require new techniques and procedures, and the involvement of a large scale of stakeholders are a few of the many other factors. Domestic construction industries in developing nations, in particular, are reported to be more prone to such risks and uncertainties than their peers in developed nations. Several studies indicate that measuring the effectiveness of enterprises’ risk management helps to enhance companies’ risk management operations.

The risk management capability of an organization is measured using a risk maturity model that aids to determine the strengths and weaknesses, eventually to target areas of improvement. Several risk management maturity models have been developed in various sectors, including, the construction industry. Therefore, this research aims to assess the critical risk factors of Ethiopian domestic road contractors working in federal road construction projects and then to investigate their risk management capability. Questionnaires and interviews are used to gather experts’ views and opinions engaged in the road sector. In Phase I, the risks of domestic contractors were prioritised through the detailed questionnaire survey. In Phase II, the overall risk management practice of construction firms will be evaluated through an interview survey. To ensure reliable information, companies’ top management is considered in this interview.

Keywords: *Key Risk Factor, Enterprise Risk Management, Risk Management Maturity,*

Company Code: _____

Part A: General Information

The following questions are related to the general information of respondents and the companies. Please provide the appropriate information for each question.

1. Respondents Profile:

- 1.1. Name (Optional): _____ e-mail: _____
- 1.2. Years of experience in the road sector:
 5 to 10 years ☐ 10 to 15 year ☐ 15 to 20 years ☐ more than 20 years ☐
- 1.3. The current position in the company: *Please tick one.*
 CEO, General Manager ☐ Manager, Director, Department Head ☐
 D/ CEO, Deputy GM ☐ Chief Risk Officer ☐
 Others. Please specify. _____

2. Company Profile:

- 2.1. Full name of the Company: _____
- 2.2. Ownership:
 Private ☐ Public ☐
- 2.3. Years of experience of the company in the construction industry:
 Less than 10 years ☐ 10 to 20 year ☐ 20 to 30 years ☐
 more than 30 years ☐
- 2.4. Major sector(s) the company is predominantly involving:
☐ Building construction
☐ Real estate development
☐ Transport infrastructure (road, bridge, airports, ...) development
☐ Waterworks (dams, irrigation, water supply, etc.)
 Others. Please specify, _____
- 2.5. Road projects the company has been involving: No of projects: _____
 Total length of these projects (Km): _____

Part B: Enterprise Risk Management Maturity

The following questions are designed to evaluate the risk management maturity level of construction companies engaged in the Ethiopian federal road construction projects. Enterprise Risk Management Maturity (ERM) measures the degree of capability of a firm in managing its risks in an integrated and holistic approach. Six attributes are considered to evaluate the ERM maturity of firms; namely, (i) *policy and strategy*, (ii) *structure*, (iii) *culture*, (iv) *process*, (v) *competence*, and (vi) *practice/ implementation*. Different characteristics are included under each attribute. Accordingly, each characteristic is evaluated in terms of four different maturity levels (Level I = Naive, II = Novice, III = Managed and IV = Optimized).

S/ No.	Attributes/ Characteristics	Possible options (Tick only one)
1. Policy and Strategy		
The following questions are related to the company's risk management policies and strategies? <i>Please select and tick the option that best describes your firm for the following issues.</i>		
1.1.	Existence of risk management policy and strategy in the company: <i>(Please tick the appropriate option)</i>	☐ None. No separate risk management (RM) policy and strategy ☐ No separate RM policy and strategy. But there is an effort to incorporate it within other business policies and strategies. ☐ There is a separate written RM policy and strategy. But needs further revision and update ☐ There is a separate written RM policy and strategy and it is regularly evaluated and refined to suit the various changes that occur.
1.2.	Availability of defined RM objectives	☐ None ☐ No specific objective on RM but an attempt to incorporate it within the other business objectives ☐ There are some RM related objectives but are inconsistent with the business objectives of the company. ☐ Clear and measurable RM objectives are set consistent with the business objectives of the company.
1.3.	Availability of defined risk appetite policy	☐ No defined risk appetite policy. ☐ No defined risk appetite policy but determined by the management when the need arises. ☐ There is a tailored appetite policy specific to some critical risk events. ☐ There is a defined risk appetite policy applicable to the enterprise-wide risks.
1.4.	Alignment/ Communication of risk strategies and policies within the company	☐ None ☐ Little or ad hoc communication ☐ Well communicated and aligned to the management level. ☐ The risk management strategies and policies are communicated consistently from top to down and well-aligned at all levels.

S/ No.	Attributes/ Characteristics	Possible options (Tick only one)
2. Structure and Governance		
The following questions are related to the ERM structure and governance of the company. <i>Please pick the statement that best describes the experience in your company for each issue.</i>		
2.1.	Integration of the risk management activities into the organizational structure of the company.	☐ Risk management is not a defined activity; subsequently, no separate unit or function exists specific to RM. ☐ There is a per – time RM unit/ committee functional when the need arises ☐ There is a function/ unit dedicated to risk management. But RM is an additional duty over its core duties. ☐ There is an independent unit in the organizational structure explicitly dedicated to enterprise-wide risk management activities.
2.2.	Role and responsibility definition for risk management activities	☐ No defined roles and responsibilities on risk management. ☐ Roles and responsibilities are defined but lack clarity. ☐ Roles and responsibilities are clearly defined. However, a similar understanding has not been created within the respective units and/ or individuals. ☐ Roles and responsibilities are clearly defined and clear understanding has been established at all levels. It is also considered that RM is a core responsibility of each unit and it is enforced at every level.
2.3.	Accountability scheme for failures to meet RM duties and responsibilities on risk management:	☐ No defined accountability ☐ There is little RM accountability limited on RM process owners. ☐ RM accountability is well defined. However, there is a limitation properly practising it. ☐ RM accountability is embedded into all processes and functions as a way to achieve goals.
2.4.	Risk and risk management reporting/ communication scheme:	☐ None ☐ Risk is communicated in ad hoc discussions at management meetings ☐ Risk is communicated through written reports prepared on a regular basis, i.e, monthly, quarterly, or annually ☐ There is a corporate-wide common language for communicating risk exposures, controlling activities, and monitoring efforts.

S/ No.	Attributes/ Characteristics	Possible options (Tick only one)
3. Risk Management Culture		
The following questions are related to the risk management culture of the company. <i>Please tick the appropriate statement from the four options stated under each question.</i>		
3.1.	Belief in the value of risk management	
	Which statement best describes your company's perception regarding the values of practising enterprise risk management?	☐ It is perceived that risk management is a distraction ☐ It is perceived as having limited value for the company ☐ It is believed that risk management can help and add value ☐ Risk management is believed as a value driver for the company. An in-built understanding and belief has been developed on the benefits of risk management.
Awareness of the company on risk		
3.2.	How do you describe the overall awareness/ understanding of your company on the concept of risk?	☐ Lacking or poorly understood ☐ Some understanding. ☐ Basic understanding - All employees are aware of risk pertaining to their roles. ☐ Intuitive understanding. All employees are aware of the impact of risk in the context of the company.
3.3.	The attitude of the leadership towards risk	
	Which one best describes the attitude of your organization towards risk?	☐ The entire leadership is risk-averse. ☐ The top management is ready to take and avoid some critical/ significant risks. ☐ The leadership is ready to take appropriate risks. But there is a gap in maintaining consistency ☐ The management is proactive to take risks. A distinct and consistent tone has been established from the top and senior management in respect of risk-taking and avoidance. A risk-based approach is practiced at all levels to achieve goals.
3.4.	The commitment of the leadership to practise risk management	
	How do you describe the commitment of the management to practise risk management at the organization level?	☐ Lacking commitment. No upper management involvement. ☐ Partial encouragement and passive support from upper management ☐ High commitment at the top management, but it has not been properly aligned to the bottom leadership ☐ Full and whole-hearted top-down commitment. The leadership for risk management is embedded at all levels of the organization.

S/ No.	Attributes/ Characteristics	Possible options (Tick only one)
3.5.	Core Values/ Principles on risk management	
	Availability of defined core values and guiding principles relevant to the ERM. Common core risk management values/ principles include – integration, holistic, comprehensiveness, ... (Please tick the appropriate option)	☐ None. No defined core value in respect of risk management ☐ There are some risk management values incorporated in the general organizational value statements ☐ There are some values specific to risk management. But not adequately shared at all levels. ☐ The company has well defined ERM values and principles. These values are communicated, shared, and well-aligned at all levels.
3.6.	Risk information Sharing/ Communication	
	Which best describes your organization's risk information-sharing/ communication (if it is not confidential) practice?	☐ No risk communication at all. Risk information is usually kept confidential to the top management ☐ There is informal risk information only ☐ Risks are well communicated through the established formal risk communication channels ☐ There is a transparent and timely risk information flow up and down the organization with bad news rapidly communicated without fear of blame
4. Risk Management Process		
The risk management process is an organized framework that helps to control and manage risks effectively and efficiently. <i>Please select the appropriate statement that best describes the experience in your firm.</i>		
4.1.	Availability of formal risk management process in the firm (Formality).	☐ No defined risk management process. ☐ There is an informal, ad hoc and inconsistent RM process. ☐ There is a formal generic process tailored to specific needs. ☐ There is an advanced formal RM process, adaptive and fit for purpose for a wide range of risk events.
4.2.	Availability of risk management guidelines and standards:	☐ None. ☐ There is an attempt to establish in house guidelines. ☐ Few guidelines and standards have been customized from global standards. ☐ There are well-established risk management guidelines and standards fit for enterprise-wide risk management.

S/ No.	Attributes/ Characteristics	Possible options (<i>Tick only one</i>)
4.3.	Availability of standardised risk identification techniques.	☐ No defined risk identification technique ☐ There are informal ad hoc risk identification techniques. ☐ There are formal risk identification techniques such as checklists and brainstorming suitable to identify the majority of risks in the firm. ☐ There is an advanced risk identification technique that can provide a comprehensive list of risks. Risk identification is a documented and repeatable process.
4.4.	Availability of systematic risk analysis techniques	☐ No defined risk analysis technique. ☐ There is an informal ad hoc risk analysis technique. ☐ There are formal qualitative risk analysis techniques. ☐ There are qualitative and quantitative risk analysis methods. Advanced risk analysis techniques (sensitivity testing, simulation, etc.) that can effectively evaluate the likelihood and impact of each risk event is also developed.
4.5.	Risk response strategy	☐ No defined risk response strategy. ☐ There are some informal strategies used while the need arises. ☐ There is a formal risk response strategy. However, it is not proactively updated. ☐ The standard risk response options (avoid, mitigate, transfer, accept) are used consistently balancing their respective benefits and disadvantages. The strategy is proactively modified to reflect changes in the environment
4.6.	Risk process monitoring and review techniques	☐ No formal monitoring and evaluation technique ☐ There is an informal risk monitoring and review method applicable when the need arises. ☐ A formal monitoring and reviewing system is in place but not effective for all risk types. ☐ Effective monitoring and review system is in place to improve the quality and effectiveness of the process. The system enables to track and evaluate the entire risk management process.

S/ No.	Attributes/ Characteristics	Possible options (Tick only one)
4.7.	Risk record/ information/ documentation system	☐ None ☐ There is an informal and inconsistent risk recording form. ☐ There is a formal risk recording system in Microsoft, mainly, an Excel sheet. ☐ There is an advanced risk recording system that would enable to track risk events.
4.8.	How do you evaluate the overall effectiveness of the risk management process/ framework being used in your firm, if any?	☐ None. Not effective ☐ Works in specific areas (partially effective) ☐ Works consistently at all levels in the organization ☐ Effective. Adapts pro-actively to internal and external changes
5. Competence		
The risk management competence of a firm is commonly evaluated in terms of the knowledge, skill, and experience of the personnel responsible for risk management and the adequacy of training provided to employees. <i>Please evaluate the competency of your firm in terms of these four factors and tick the appropriate box.</i>		
5.1.	The level of knowledge of the staff assigned for risk management:	☐ None. No staff is assigned for risk management. No relevant knowledge in RM ☐ Little knowledge gained informally ☐ Basic knowledge gained from short term training. ☐ A high degree of knowledge on risk management discipline gained from university or colleges.
5.2.	Skills and capabilities of the staff on risk management:	☐ No relevant skill. ☐ Basic skills that enable to participate in RM issues ☐ An adequate skill that enables to lead and take risk management initiatives ☐ In addition to the above, some staffs are capable to act as trainer/ mentor for others and could formulate solutions to more complex RM issues
5.3.	The level of familiarity and expertise of the staff in using the practical RM skills and techniques:	☐ None. No relevant experience ☐ Limited to individuals who have had little experience in managing risk ☐ Adequate experience in the use of RM techniques with support from external experts ☐ Extensive experience and expertise that help to independently handle risk management activities.

S/ No.	Attributes/ Characteristics	Possible options (<i>Tick only one</i>)
5.4.	Training and development on risk management	☐ No formal and planned training specific on risk management ☐ There are pieces of training organized incorporating within other training. ☐ Training is formally organized specifically to risk management. But it is not adequate. ☐ There is adequate regular training for personnel to maintain a high level of knowledge and skills. Risk management training is an integral part of the organization.
6. Enterprise Risk Management Implementation		
How do you evaluate the implementation level of ERM in your company? <i>Please tick the appropriate level that best reflects the experience in your firm.</i>		
6.1.	How do you describe the overall risk management practice of your company?	☐ No formal RM activity in the company. ☐ Inconsistent – risk management is applied occasionally. ☐ RM is routinely applied in projects, and business units. ☐ RM is highly embedded in the organization and decision making.
6.2.	To what level RM information is used in the decision-making endeavors of the company?	☐ Risk information is not formally considered in business decisions ☐ Leaders occasionally seek risk information on an ad hoc basis to support decisions ☐ Leaders actively seek risk information to use in their judgment on key business decisions. ☐ In addition to the above, leaders refuse to take major decisions without an explicit risk study. Key business decisions are not made without consideration of risk management information.
6.3.	How do you describe the scope of the RM application within your company (Comprehensiveness)?	☐ None ☐ RM is focused only on a few selected projects or business operations. ☐ Project basis (Total project risks are covered, but risks in the other business operation are not included). ☐ Organizational basis – the RM approach is highly comprehensive and covers risks in the entire business operations and projects.

S/ No.	Attributes/ Characteristics	Possible options (<i>Tick only one</i>)
6.4.	Which best describes the level of integration of risk management activities at functions, business units, and projects?	☐ None. No proper integration ☐ Isolated and insular (Functionally oriented). ☐ Part of the business process (cross-functional) ☐ Apart from the central risk management unit, the risk management efforts are highly integrated within the organization, namely, in business units, projects, and company-wide functions.
6.5.	How do you describe the adequacy of the resource allocation for the ERM?	☐ No dedicated resources for ERM ☐ Limited resource (limited staff and infrastructure) has been assigned. ☐ RM is supported by adequate resources. All the required personnel and infrastructure have been allocated. ☐ Adequate resource has been dedicated to supporting the ERM function. The organization is committed to proactively resource the ERM operations.
6.6.	To what level risk identification is conducted in the company?	☐ None. No formal risk identification ☐ Risk identification is made occasionally on selected projects. ☐ There is an effort to identify risks but it is not sufficient to exhaustively identify the essential risks. ☐ A comprehensive list of risks is produced using a combination of risk identification techniques.
6.7.	How do you evaluate the level of risk analysis activities conducted in your firm?	☐ None. No risk analysis is practised ☐ There is an attempt to analyze risks using qualitative techniques. ☐ Risks are analyzed and prioritized using both qualitative and quantitative risk analysis techniques ☐ In addition to the above, advanced risk analysis testing methods such as sensitivity testing, simulation, etc are utilized to evaluate the significance of risks
6.8.	How do you evaluate the effectiveness of the risk response operations of your firm?	☐ Little or no proper risk response is in place. ☐ Selected responses are in place for a few particular risks ☐ Risk responses are well planned and effectively employed for all identified risks. ☐ In addition to the above, the efficiency of the existing response is consistently evaluated and updated.

S/ No.	Attributes/ Characteristics	Possible options (<i>Tick only one</i>)
6.9.	How do you evaluate the monitoring and review operations of the risk management process?	☐ None. No formal monitoring and review ☐ Rarely applied when some risk surprises have happened ☐ The RM process is evaluated regularly by the internal/ external audit. But there is a limited effort to proactively improve the identified gaps. ☐ The RM process is evaluated regularly by the internal/ external audit. The necessary improvements are in place based on the feedback.
6.10.	Which best describes the RM recording and documentation practices of your firm?	☐ No record of risk information ☐ Basic information is recorded. ☐ Risk management activities are recorded, monitored and reviewed ☐ In addition to the above, risk information is recorded consistently and securely. Each stage of risk management is recorded appropriately.

Part C: Barriers for practicing Enterprise Risk Management in Construction Companies

Ten factors are identified from **the** literatures impeding firms to practice Enterprise Risk Management. Please rate the level of significance of the following factors which you believe is impacting the application of ERM in your company (1 = Least Significant, 4= the most significant). *Please tick the appropriate box*

S/ No	List of ERM Barriers	1	2	3	4
1.	Lack of awareness of the ERM				
2.	Lack of internal knowledge, skills, and expertise				
3.	Lack of common risk language				
4.	Inadequate training on ERM				
5.	Lack of quality data and limited access to data				
6.	Insufficient resources				
7.	Lack of support from top management				
8.	Human/ organizational resistance				
9.	Difficulties in quantifying the risks				
10.	Unavailability of risk management consultants				

Thank You for Your Valuable Contribution!!!

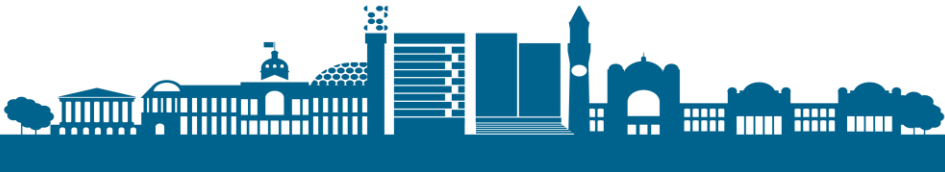
Appendix E: A Brief Introduction on ERM (ppt presentation)



UNIVERSITY OF
BIRMINGHAM

**Developing an Enterprise Risk Management Maturity Model
Applicable for Construction Companies: A Case Study:
Ethiopian Domestic Contractors Involving in Federal Road
Construction Projects**

Researcher: Worku Asrate Wubet
Supervisors: Dr. Michael Burrow
Dr. Gurmel Ghataora



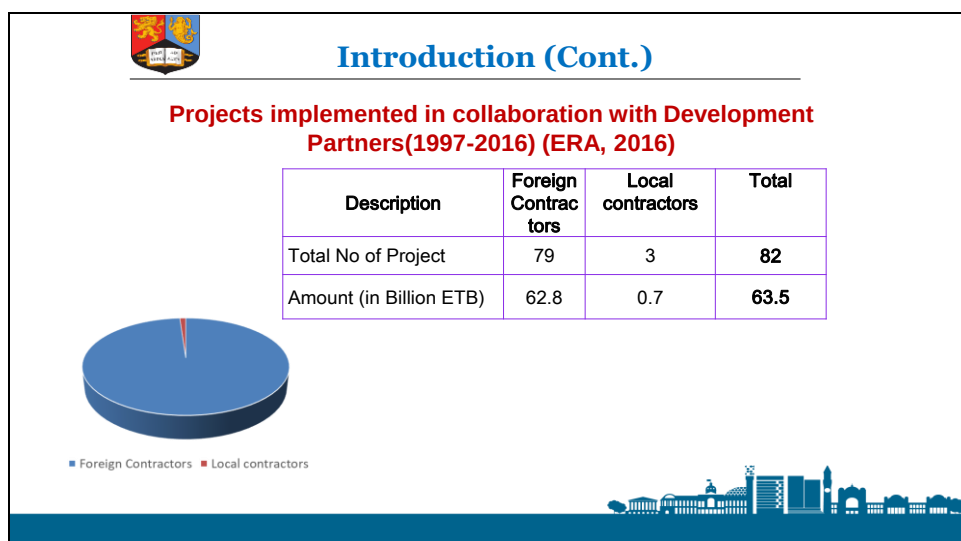
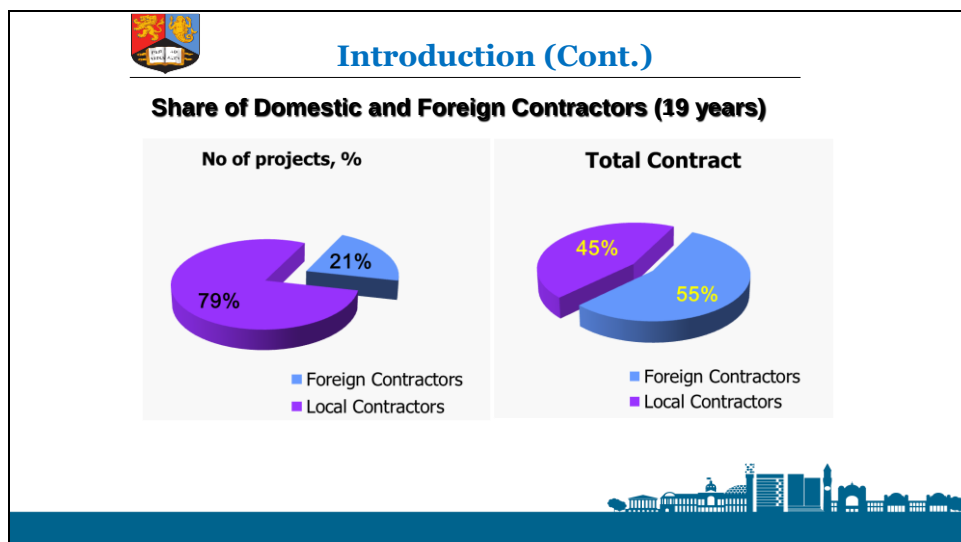
1. Introduction (Cont.)

- ❑ The Government of Ethiopia has been accomplishing extensive work in the Road Sector Development Program (RSDP) since 1997
- ❑ **Institutional capacity of the road sub-sector** - one of the three major objectives of the programme

**Projects awarded and costs of projects (1997-2016)
(ERA, 2016)**

Description	Foreign Contractors	Local contractors	Total
Total No of Project	123	466	599
Amount (in Billion ETB)	102.76	82.74	185.50





- 1. Introduction (Cont.)**
- Situation of Domestic Contractors**
1. There is a challenge to complete projects within the contract time.
 2. The participation of domestic contractors is limited only in government financed projects which they are not able to partake in donor financed road construction



Obejective of the survey

Aim: To develop an enterprise risk management maturity model that can be used for construction companies

Specific objective: To assess the ERM capability of Ethiopian domestic contractors operating in the federal road construction projects



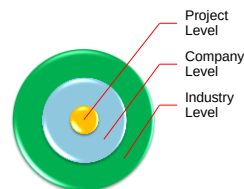
Ten Most Critical Risks

Rank, Average										
RISK Factor	CNT		CNS		EMP		AVE		Remark	
	RV	Rank	RV	Rank	RV	Rank	RV	Rank		
RF09	21.33	3	20.37	1	20.30	1	20.56	1	Financial constraint	
RF03	21.50	2	18.97	4	19.28	3	19.63	2	Hard currency	
RF14	22.20	1	17.42	7	19.35	2	19.14	3	Delay in ROW Mgt.	
RF28	20.53	4	18.69	5	18.76	5	19.12	4	Equipment breakdown	
RF24	18.77	5	19.17	2	18.67	6	18.87	5	Inadequate Planning	
RF25	18.77	5	18.10	6	19.26	4	18.65	6	Delay in delivery of material and equip	
RF31	17.00	10	19.10	3	18.26	7	18.35	7	Poor financial control	
RF01	18.47	7	16.51	8	16.00	8	16.76	8	Inflation	
RF23	16.37	14	15.83	10	15.39	11	15.80	9	Delay in payments	
RF29	14.37	23	15.76	12	15.59	10	15.39	10	Poor coordination of teams	



Risk Management Maturity

Risk management in the construction Industry



Enterprise Risk Management (ERM) – “the culture, capabilities, and practices, integrated with strategy setting and performance that organizations rely on to manage risk in creating, preserving and realizing value.” (COSO 2017 ERM Framework)

COSO (Committee of Sponsoring Organizations of the Treadway Commission)





Risk Management Maturity

Risk management in the construction Industry

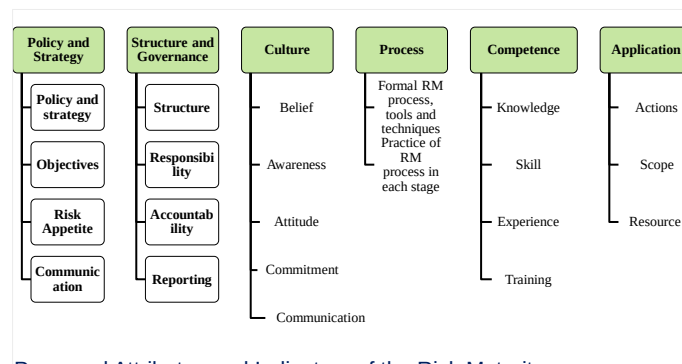
- I. Construction Industry Level
- II. Company Level (Enterprise Risk Management) – Integrated, and holistic approach at the company level
- III. Project Level

Enterprise Risk management Maturity

- Risk Maturity Model - Used to measure the competence of organization's risk management practice
- Risk Maturity Model - is commonly structured as a matrix
 1. Risk Maturity Attributes - characteristics or qualities that can be associated with the risk management of the firm.
 2. Maturity Levels - provides a layer in the foundation for continuous process improvement



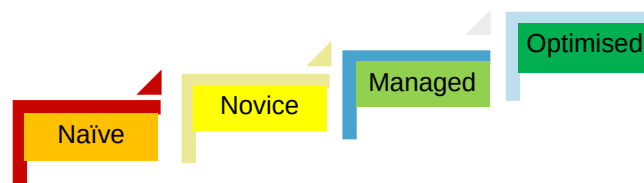
ERM Maturity Attributes



Proposed Attributes and Indicators of the Risk Maturity



ERM Maturity Levels



Proposed Dimension of the key Risk Maturity Levels





Thank you very much for your patience!!!



Appendix F: Row Data from the Interview

Appendix F1: ERM Maturity Data

No	Description	Company Surveyed						
		COM1	COM2	COM3	COM4	COM5	COM6	COM7
1	Policy and Strategy (PS)							
1.1	Existence of policy and strategy	2	2	1	2	3	2	2
1.2	Availability of RM objectives	2	2	2	2	3	2	3
1.3	Availability of risk appetite	1	2	1	2	3	1	2
1.4	Alignment of risk policy and strategy	2	2	2	2	3	2	2
2	Structure and Governance (SG)							
2.1	Integration of RM in organization's	1	1	1	1	1	1	1
2.2	RM role and responsibility	1	1	1	2	1	2	1
2.3	RM accountability	1	1	1	2	1	2	1
2.4	RM reporting/ communication scheme	2	3	2	2	2	3	2
3	Culture (CU)							
3.1	Belief in value of RM	4	3	1	2	3	4	4
3.2	Awareness of RM	2	2	1	2	3	2	3
3.3	Attitude of the leadership to RM	3	2	3	2	3	3	2
3.4	Commitment of the leadership	3	3	2	2	3	2	2
3.5	availability of core values/ principles	2	2	1	2	2	1	2
3.6	Risk information sharing culture	2	2	2	1	2	2	2
4	Process (PR)							
4.1	Availability of defined RM process	2	2	2	2	2	2	2
4.2	Availability of RM guidelines &	2	2	1	1	3	1	1
4.3	Availability of risk identification	2	2	2	1	2	2	2
4.4	Availability of risk analysis techniques	1	2	2	2	1	2	2
4.5	Availability of risk response strategy	2	2	2	2	2	1	2
4.6	Availability of risk monitoring and	2	2	2	2	2	1	2
4.7	Availability of risk recording techniques	2	3	2	2	1	1	1
4.8	Overall effectiveness RM process	2	2	2	2	2	2	2
5	Competence (CO)							
5.1	RM Knowledge of staff	2	2	2	1	1	3	2
5.2	RM skill of staff	2	2	2	1	2	2	2
5.3	RM experience of staff	2	2	2	2	2	2	2
5.4	Training on RM	2	1	2	2	1	1	2
6	Implementation (IM)							
6.1	Overall RM practice	2	2	2	1	2	2	1
6.2	Level of information used in decision	3	2	2	2	2	2	2
6.3	Scope of RM practised	2	2	2	2	2	2	2
6.4	Level of integration of RM in different	2	2	1	2	1	2	1
6.5	Adequacy of RM resource	1	2	2	1	1	2	2
6.6	Level of risk identification practice	3	3	2	2	1	2	2
6.7	Level of risk analysis practice	2	2	2	1	1	2	1
6.8	Effectiveness of risk responses	2	2	2	2	2	2	2
6.9	Level of risk monitoring and evaluation	2	2	2	2	2	2	2
6.10	Risk recording practices	2	2	2	1	1	2	2

Appendix F1: ERM Maturity Data (Cont.)

No.	Description	Company Surveyed						
		COM 8	COM 9	COM 10	COM 11	COM 12	COM 13	COM 14
1	Policy and Strategy (PS)							
1.1	Existence of policy and strategy	2	1	3	2	1	2	2
1.2	Availability of RM objectives	2	2	3	2	1	2	3
1.3	Availability of risk appetite	2	2	3	1	1	2	3
1.4	Alignment of risk policy and strategy	2	2	3	1	2	2	2
2	Structure and Governance (SG)							
2.1	Integration of RM in organization's	2	1	4	1	1	1	2
2.2	RM role and responsibility	1	1	3	1	1	1	2
2.3	RM accountability	1	2	3	1	1	2	3
2.4	RM reporting/ communication scheme	3	2	3	2	2	2	3
3	Culture (CU)							
3.1	Belief in value of RM	3	3	3	3	3	3	3
3.2	Awareness of RM	4	2	3	2	2	2	4
3.3	Attitude of the leadership to RM	2	2	3	2	2	2	3
3.4	Commitment of the leadership	3	3	3	2	2	2	3
3.5	availability of core values/ principles	2	2	2	2	1	1	3
3.6	Risk information sharing culture	3	2	3	2	2	2	4
4	Process (PR)							
4.1	Availability of defined RM process	2	2	3	2	2	1	3
4.2	Availability of RM guidelines &	2	2	4	1	1	1	2
4.3	Availability of risk identification	3	2	3	1	1	2	3
4.4	Availability of risk analysis techniques	2	2	3	1	1	2	3
4.5	Availability of risk response strategy	2	3	3	2	2	2	3
4.6	Availability of risk monitoring and	2	2	3	1	2	2	3
4.7	Availability of risk recording techniques	2	2	3	2	1	2	2
4.8	Overall effectiveness RM process	2	2	3	2	1	2	2
5	Competence (CO)							
5.1	RM Knowledge of staff	3	3	3	1	1	2	3
5.2	RM skill of staff	2	2	4	2	1	2	3
5.3	RM experience of staff	2	2	3	2	2	1	3
5.4	Training on RM	2	1	3	1	2	2	2
6	Implementation (IM)							
6.1	Overall RM practice	2	3	3	1	1	2	3
6.2	Level of information used in decision	3	3	3	2	3	2	3
6.3	Scope of RM practised	3	2	3	1	1	3	3
6.4	Level of integration of RM in different	2	3	3	2	2	2	3
6.5	Adequacy of RM resource	2	2	4	1	1	1	2
6.6	Level of risk identification practice	3	3	3	2	1	3	3
6.7	Level of risk analysis practice	2	3	2	1	1	1	2
6.8	Effectiveness of risk responses	2	2	2	2	1	2	2
6.9	Level of risk monitoring and evaluation	3	3	3	1	1	2	3
6.10	Risk recording practices	2	2	2	2	1	2	2

Appendix F1: ERM Maturity Data (Cont.)

No.	Description	Company Surveyed					
		COM 15	COM 16	COM 17	COM 18	COM 19	COM 20
1	Policy and Strategy (PS)						
1.1	Existence of policy and strategy	1	2	2	2	2	1
1.2	Availability of RM objectives	2	2	2	2	2	3
1.3	Availability of risk appetite	3	3	1	2	2	2
1.4	Alignment of risk policy and strategy	3	3	2	3	2	2
2	Structure and Governance (SG)						
2.1	Integration of RM in organization's structure	2	1	2	1	2	2
2.2	RM role and responsibility	3	1	3	1	2	1
2.3	RM accountability	2	2	2	2	2	2
2.4	RM reporting/ communication scheme	3	2	3	2	2	2
3	Culture (CU)						
3.1	Belief in value of RM	3	3	3	3	3	3
3.2	Awareness of RM	2	2	2	2	2	3
3.3	Attitude of the leadership to RM	3	3	2	3	2	1
3.4	Commitment of the leadership	3	3	2	3	2	3
3.5	availability of core values/ principles	2	2	1	2	2	3
3.6	Risk information sharing culture	4	2	2	2	2	1
4	Process (PR)						
4.1	Availability of defined RM process	3	2	2	2	2	2
4.2	Availability of RM guidelines & standards	1	2	1	2	2	2
4.3	Availability of risk identification techniques	2	2	2	2	2	2
4.4	Availability of risk analysis techniques	2	2	2	2	2	2
4.5	Availability of risk response strategy	3	2	2	1	2	2
4.6	Availability of risk monitoring and evaluation	2	2	2	2	2	1
4.7	Availability of risk recording techniques	2	2	2	1	2	2
4.8	Overall effectiveness RM process	2	2	2	2	2	1
5	Competence (CO)						
5.1	RM Knowledge of staff	2	2	2	1	2	3
5.2	RM skill of staff	3	2	2	1	2	3
5.3	RM experience of staff	3	2	2	1	2	2
5.4	Training on RM	2	1	1	1	1	1
6	Implementation (IM)						
6.1	Overall RM practice	2	2	2	2	2	1
6.2	Level of information used in decision making	4	2	2	2	2	3
6.3	Scope of RM practised (Comprehensiveness)	3	2	2	2	2	2
6.4	Level of integration of RM in different units	2	1	1	1	2	2
6.5	Adequacy of RM resource	2	2	1	1	1	1
6.6	Level of risk identification practice	3	3	2	1	2	2
6.7	Level of risk analysis practice	3	2	2	1	2	2
6.8	Effectiveness of risk responses	3	2	2	1	2	2
6.9	Level of risk monitoring and evaluation operations	3	2	1	2	2	2
6.1	Risk recording practices	2	2	1	2	2	2

Appendix F1: ERM Maturity Data (Cont.)

No.	Description	Company Surveyed					
		COM 21	COM 22	COM 23	COM 24	COM 25	COM 26
1	Policy and Strategy (PS)						
1.1	Existence of policy and strategy	2	1	2	1	2	1
1.2	Availability of RM objectives	3	1	3	2	2	2
1.3	Availability of risk appetite	2	2	3	1	3	2
1.4	Alignment of risk policy and strategy	3	2	3	1	2	2
2	Structure and Governance (SG)						
2.1	Integration of RM in organization's structure	3	1	1	2	1	1
2.2	RM role and responsibility	3	1	2	2	2	1
2.3	RM accountability	3	1	2	2	2	1
2.4	RM reporting/ communication scheme	3	2	2	2	3	2
3	Culture (CU)						
3.1	Belief in value of RM	3	2	2	2	3	3
3.2	Awareness of RM	1	2	2	2	3	2
3.3	Attitude of the leadership to RM	3	2	2	2	3	2
3.4	Commitment of the leadership	2	1	3	1	2	2
3.5	availability of core values/ principles	3	1	1	1	3	1
3.6	Risk information sharing culture	2	2	2	2	2	2
4	Process (PR)						
4.1	Availability of defined RM process	2	1	2	1	3	2
4.2	Availability of RM guidelines & standards	3	1	2	1	2	1
4.3	Availability of risk identification techniques	2	1	2	2	2	2
4.4	Availability of risk analysis techniques	3	1	2	2	2	2
4.5	Availability of risk response strategy	2	1	2	2	2	2
4.6	Availability of risk monitoring and evaluation	3	1	2	2	2	2
4.7	Availability of risk recording techniques	3	1	1	1	3	2
4.8	Overall effectiveness RM process	2	1	1	1	2	2
5	Competence (CO)						
5.1	RM Knowledge of staff	3	1	1	2	2	1
5.2	RM skill of staff	2	1	2	2	2	1
5.3	RM experience of staff	2	1	2	2	2	1
5.4	Training on RM	2	1	1	2	1	1
6	Implementation (IM)						
6.1	Overall RM practice	2	1	2	2	2	2
6.2	Level of information used in decision making	3	2	2	2	3	3
6.3	Scope of RM practised (Comprehensiveness)	2	1	3	2	3	2
6.4	Level of integration of RM in different units	2	1	1	2	1	2
6.5	Adequacy of RM resource	2	1	1	2	1	1
6.6	Level of risk identification practice	3	1	2	3	3	3
6.7	Level of risk analysis practice	3	1	2	2	2	2
6.8	Effectiveness of risk responses	2	1	2	2	2	2
6.9	Level of risk monitoring and evaluation	3	1	2	2	2	2
6.1	Risk recording practices	1	1	2	1	2	2

Appendix F2: Data on Barriers on ERM Implementation

No	Factor	Company Surveyed								
		COM 1	COM 2	COM 3	COM 4	COM 5	COM 6	COM 7	COM 8	COM 9
1.	Lack of awareness of the values or benefits of ERM	2	4	4	4	2	2	2	2	3
2.	Lack of internal knowledge, skills, and expertise	3	3	3	3	2	2	2	2	3
3.	Lack of common risk language	2	2	2	1	1	1	4	2	4
4.	Inadequate training on ERM	4	4	3	3	2	3	3	2	4
5.	Lack of quality data and limited	4	2	3	1	2	3	4	2	4
6.	Insufficient resources	2	3	3	2	2	3	1	3	3
7.	Lack of support from top management	2	4	4	3	3	2	3	2	3
8.	Human/ organizational resistance	3	2	2	2	3	1	1	1	3
9.	Difficulties in quantifying the risks	4	3	3	2	3	3	3	2	2
10.	Unavailability of risk management consultants	3	3	2	3	3	2	4	3	2

No	Factor	Company Surveyed								
		COM 10	COM 11	COM 12	COM 13	COM 14	COM 15	COM 16	COM 17	COM 18
1.	Lack of awareness of the values or benefits of ERM	2	4	4	4	2	3	2	4	4
2.	Lack of internal knowledge, skills, and expertise	1	3	3	3	2	3	2	3	2
3.	Lack of common risk language	1	4	3	2	2	2	3	3	2
4.	Inadequate training on ERM	2	4	3	3	3	4	3	2	2
5.	Lack of quality data and limited	2	1	2	3	3	2	3	3	3
6.	Insufficient resources	1	3	3	3	4	3	3	2	3
7.	Lack of support from top management	1	3	3	2	1	4	3	3	3
8.	Human/ organizational resistance	2	2	3	1	2	2	2	3	3
9.	Difficulties in quantifying the risks	3	4	4	2	2	2	3	2	4
10.	Unavailability of risk management consultants	2	4	4	4	3	4	3	3	4

Part 2: Data on Barriers on ERM Implementation (Cont.)

No	Factor	Company Surveyed							
		COM 19	COM 20	COM 21	COM 21	COM 23	COM 24	COM 25	COM 26
1.	Lack of awareness of the values or benefits of ERM	3	2	2	3	2	3	3	4
2.	Lack of internal knowledge, skills, and expertise	3	2	4	3	2	3	3	3
3.	Lack of common risk language	3	1	3	3	1	2	4	1
4.	Inadequate training on ERM	4	4	3	2	2	3	4	1
5.	Lack of quality data and limited access to data	4	4	1	3	4	2	3	3
6.	Insufficient resources	2	2	2	1	4	2	3	3
7.	Lack of support from top management	3	4	1	3	2	3	2	2
8.	Human/ organizational resistance	2	4	4	3	3	3	3	1
9.	Difficulties in quantifying the risks	3	4	4	3	4	3	2	1
10.	Unavailability of risk management consultants	2	4	2	4	4	3	3	1

Appendix G: Statistical Analysis**Appendix G1: Cronbanch's Alpha Tables for Maturity Attributes****i) Policy and Strategy**

ANOVA: Two-Factor Without Replication

<i>SUMMARY</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Row 1	4	7	1.75	0.25
Row 2	4	8	2	0
Row 3	4	6	1.5	0.333333
Row 4	4	8	2	0
Row 5	4	12	3	0
Row 6	4	7	1.75	0.25
Row 7	4	9	2.25	0.25
Row 8	4	8	2	0
Row 9	4	7	1.75	0.25
Row 10	4	12	3	0
Row 11	4	6	1.5	0.333333
Row 12	4	5	1.25	0.25
Row 13	4	8	2	0
Row 14	4	10	2.5	0.333333
Row 15	4	9	2.25	0.916667
Row 16	4	10	2.5	0.333333
Row 17	4	7	1.75	0.25
Row 18	4	9	2.25	0.25
Row 19	4	8	2	0
Row 20	4	8	2	0.666667
Row 21	4	10	2.5	0.333333
Row 22	4	6	1.5	0.333333
Row 23	4	11	2.75	0.25
Row 24	4	5	1.25	0.25
Row 25	4	9	2.25	0.25
Row 26	4	7	1.75	0.25
Column 1	26	46	1.769231	0.344615
Column 2	26	57	2.192308	0.321538
Column 3	26	52	2	0.56
Column 4	26	57	2.192308	0.321538

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	22.84615	25	0.913846	4.325243	4.45E-07	1.653205722
Columns	3.153846	3	1.051282	4.975728	0.00334	2.726589156
Error	15.84615	75	0.211282			
Total	41.84615	103				

Crobanh's alpha 0.77

ii) Structure and Governance

ANOVA: Two-Factor Without Replication

<i>SUMMARY</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Row 1	4	5	1.25	0.25
Row 2	4	6	1.5	1
Row 3	4	5	1.25	0.25
Row 4	4	7	1.75	0.25
Row 5	4	5	1.25	0.25
Row 6	4	8	2	0.666667
Row 7	4	5	1.25	0.25
Row 8	4	7	1.75	0.916667
Row 9	4	6	1.5	0.333333
Row 10	4	13	3.25	0.25
Row 11	4	5	1.25	0.25
Row 12	4	5	1.25	0.25
Row 13	4	6	1.5	0.333333
Row 14	4	10	2.5	0.333333
Row 15	4	10	2.5	0.333333
Row 16	4	6	1.5	0.333333
Row 17	4	10	2.5	0.333333
Row 18	4	6	1.5	0.333333
Row 19	4	8	2	0
Row 20	4	7	1.75	0.25
Row 21	4	12	3	0
Row 22	4	5	1.25	0.25
Row 23	4	7	1.75	0.25
Row 24	4	8	2	0
Row 25	4	8	2	0.666667
Row 26	4	5	1.25	0.25
Column 1	26	38	1.461538	0.578462
Column 2	26	41	1.576923	0.573846
Column 3	26	45	1.730769	0.444615
Column 4	26	61	2.346154	0.235385

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	32.16346	25	1.286538	7.071882	1.94E-11	1.653206
Columns	12.10577	3	4.035256	22.18111	2.2E-10	2.726589
Error	13.64423	75	0.181923			
Total	57.91346	103				

Crobanh's alpha 0.86

iii) ERM Culture

ANOVA: Two-Factor Without Replication

<i>SUMMARY</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Row 1	6	16	2.666667	0.666667
Row 2	6	14	2.333333	0.266667
Row 3	6	10	1.666667	0.666667
Row 4	6	11	1.833333	0.166667
Row 5	6	16	2.666667	0.266667
Row 6	6	14	2.333333	1.066667
Row 7	6	15	2.5	0.7
Row 8	6	17	2.833333	0.566667
Row 9	6	14	2.333333	0.266667
Row 10	6	17	2.833333	0.166667
Row 11	6	13	2.166667	0.166667
Row 12	6	12	2	0.4
Row 13	6	12	2	0.4
Row 14	6	20	3.333333	0.266667
Row 15	6	17	2.833333	0.566667
Row 16	6	15	2.5	0.3
Row 17	6	12	2	0.4
Row 18	6	15	2.5	0.3
Row 19	6	13	2.166667	0.166667
Row 20	6	14	2.333333	1.066667
Row 21	6	14	2.333333	0.666667
Row 22	6	10	1.666667	0.266667
Row 23	6	12	2	0.4
Row 24	6	10	1.666667	0.266667
Row 25	6	16	2.666667	0.266667
Row 26	6	12	2	0.4
Column 1	26	75	2.884615	0.426154
Column 2	26	59	2.269231	0.524615
Column 3	26	62	2.384615	0.326154
Column 4	26	62	2.384615	0.406154
Column 5	26	47	1.807692	0.481538
Column 6	26	56	2.153846	0.455385

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	26.10897	25	1.044359	3.314076	5.29E-06	1.594281
Columns	16.10897	5	3.221795	10.22376	3.13E-08	2.286771
Error	39.39103	125	0.315128			
Total	81.60897	155				

Crobanch's alpha 0.70

iv) ERM Process

ANOVA: Two-Factor Without Replication

<i>SUMMARY</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Row 1	8	15	1.875	0.125
Row 2	8	17	2.125	0.125
Row 3	8	15	1.875	0.125
Row 4	8	14	1.75	0.214286
Row 5	8	15	1.875	0.410714
Row 6	8	12	1.5	0.285714
Row 7	8	14	1.75	0.214286
Row 8	8	17	2.125	0.125
Row 9	8	17	2.125	0.125
Row 10	8	25	3.125	0.125
Row 11	8	12	1.5	0.285714
Row 12	8	11	1.375	0.267857
Row 13	8	14	1.75	0.214286
Row 14	8	21	2.625	0.267857
Row 15	8	17	2.125	0.410714
Row 16	8	16	2	0
Row 17	8	15	1.875	0.125
Row 18	8	14	1.75	0.214286
Row 19	8	16	2	0
Row 20	8	14	1.75	0.214286
Row 21	8	20	2.5	0.285714
Row 22	8	8	1	0
Row 23	8	14	1.75	0.214286
Row 24	8	12	1.5	0.285714
Row 25	8	18	2.25	0.214286
Row 26	8	15	1.875	0.125
Column 1	26	53	2.038462	0.278462
Column 2	26	44	1.692308	0.621538
Column 3	26	51	1.961538	0.278462
Column 4	26	50	1.923077	0.313846
Column 5	26	53	2.038462	0.278462
Column 6	26	51	1.961538	0.278462
Column 7	26	48	1.846154	0.455385
Column 8	26	48	1.846154	0.215385

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	35.44231	25	1.417692	7.620201	2.24E-17	1.569084
Columns	2.442308	7	0.348901	1.875369	0.076168	2.06224
Error	32.55769	175	0.186044			
Total	70.44231	207				
Crobanh's alpha		0.87				

v) ERM Competence

ANOVA: Two-Factor Without Replication

<i>SUMMARY</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Row 1	4	8	2	0
Row 2	4	7	1.75	0.25
Row 3	4	8	2	0
Row 4	4	6	1.5	0.333333
Row 5	4	6	1.5	0.333333
Row 6	4	8	2	0.666667
Row 7	4	8	2	0
Row 8	4	9	2.25	0.25
Row 9	4	8	2	0.666667
Row 10	4	13	3.25	0.25
Row 11	4	6	1.5	0.333333
Row 12	4	6	1.5	0.333333
Row 13	4	7	1.75	0.25
Row 14	4	11	2.75	0.25
Row 15	4	10	2.5	0.333333
Row 16	4	7	1.75	0.25
Row 17	4	7	1.75	0.25
Row 18	4	4	1	0
Row 19	4	7	1.75	0.25
Row 20	4	9	2.25	0.916667
Row 21	4	9	2.25	0.25
Row 22	4	4	1	0
Row 23	4	6	1.5	0.333333
Row 24	4	8	2	0
Row 25	4	7	1.75	0.25
Row 26	4	4	1	0
Column 1	26	51	1.96153846	0.598462
Column 2	26	52	2	0.48
Column 3	26	51	1.96153846	0.278462
Column 4	26	39	1.5	0.34

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	26.58654	25	1.06346154	5.03643	2.64E-08	1.653206
Columns	4.413462	3	1.47115385	6.967213	0.000337	2.726589
Error	15.83654	75	0.21115385			
Total	46.83654	103				

Crobanh's alpha 0.80144665

vi) ERM Implementation

ANOVA: Two-Factor Without Replication

<i>SUMMARY</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Row 1	10	21	2.1	0.32222222
Row 2	10	21	2.1	0.1
Row 3	10	19	1.9	0.1
Row 4	10	16	1.6	0.26666667
Row 5	10	15	1.5	0.27777778
Row 6	10	20	2	0
Row 7	10	17	1.7	0.23333333
Row 8	10	24	2.4	0.26666667
Row 9	10	26	2.6	0.26666667
Row 10	10	28	2.8	0.4
Row 11	10	15	1.5	0.27777778
Row 12	10	13	1.3	0.45555556
Row 13	10	20	2	0.44444444
Row 14	10	26	2.6	0.26666667
Row 15	10	27	2.7	0.45555556
Row 16	10	20	2	0.22222222
Row 17	10	16	1.6	0.26666667
Row 18	10	15	1.5	0.27777778
Row 19	10	19	1.9	0.1
Row 20	10	19	1.9	0.32222222
Row 21	10	23	2.3	0.45555556
Row 22	10	11	1.1	0.1
Row 23	10	19	1.9	0.32222222
Row 24	10	20	2	0.22222222
Row 25	10	21	2.1	0.54444444
Row 26	10	21	2.1	0.32222222
Column 1	26	49	1.8846154	0.34615385
Column 2	26	64	2.4615385	0.33846154
Column 3	26	56	2.1538462	0.37538462
Column 4	26	46	1.7692308	0.42461538
Column 5	26	40	1.5384615	0.49846154
Column 6	26	61	2.3461538	0.55538462
Column 7	26	47	1.8076923	0.40153846
Column 8	26	50	1.9230769	0.15384615
Column 9	26	54	2.0769231	0.39384615
Column 10	26	45	1.7307692	0.20461538

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	46.15385	25	1.8461538	9	2.74E-22	1.555092
Columns	19.44615	9	2.1606838	10.5333333	1.41E-13	1.921657
Error	46.15385	225	0.2051282			
Total	111.7538	259				
Cronbach's Alpha			0.89			

vii) Overall Consistency

ANOVA: Two-Factor Without Replication

<i>SUMMARY</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Row 1	36	72	2	0.4
Row 2	36	73	2.027778	0.256349
Row 3	36	63	1.75	0.25
Row 4	36	62	1.722222	0.206349
Row 5	36	69	1.916667	0.592857
Row 6	36	69	1.916667	0.421429
Row 7	36	68	1.888889	0.387302
Row 8	36	82	2.277778	0.377778
Row 9	36	78	2.166667	0.371429
Row 10	36	108	3	0.228571
Row 11	36	57	1.583333	0.307143
Row 12	36	52	1.444444	0.368254
Row 13	36	67	1.861111	0.294444
Row 14	36	98	2.722222	0.320635
Row 15	36	90	2.5	0.485714
Row 16	36	74	2.055556	0.28254
Row 17	36	67	1.861111	0.294444
Row 18	36	63	1.75	0.421429
Row 19	36	71	1.972222	0.084921
Row 20	36	71	1.972222	0.484921
Row 21	36	88	2.444444	0.368254
Row 22	36	44	1.222222	0.177778
Row 23	36	69	1.916667	0.364286
Row 24	36	63	1.75	0.25
Row 25	36	79	2.194444	0.389683
Row 26	36	64	1.777778	0.349206
Column 1	26	46	1.769231	0.344615
Column 2	26	57	2.192308	0.321538
Column 3	26	52	2	0.56
Column 4	26	57	2.192308	0.321538
Column 5	26	38	1.461538	0.578462
Column 6	26	41	1.576923	0.573846
Column 7	26	45	1.730769	0.444615
Column 8	26	61	2.346154	0.235385
Column 9	26	75	2.884615	0.426154
Column 10	26	59	2.269231	0.524615
Column 11	26	62	2.384615	0.326154
Column 12	26	62	2.384615	0.406154

Column 13	26	47	1.807692	0.481538
Column 14	26	56	2.153846	0.455385
Column 15	26	53	2.038462	0.278462
Column 16	26	44	1.692308	0.621538
Column 17	26	51	1.961538	0.278462
Column 18	26	50	1.923077	0.313846
Column 19	26	53	2.038462	0.278462
Column 20	26	51	1.961538	0.278462
Column 21	26	48	1.846154	0.455385
Column 22	26	48	1.846154	0.215385
Column 23	26	51	1.961538	0.598462
Column 24	26	52	2	0.48
Column 25	26	51	1.961538	0.278462
Column 26	26	39	1.5	0.34
Column 27	26	49	1.884615	0.346154
Column 28	26	64	2.461538	0.338462
Column 29	26	56	2.153846	0.375385
Column 30	26	46	1.769231	0.424615
Column 31	26	40	1.538462	0.498462
Column 32	26	61	2.346154	0.555385
Column 33	26	47	1.807692	0.401538
Column 34	26	50	1.923077	0.153846
Column 35	26	54	2.076923	0.393846
Column 36	26	45	1.730769	0.204615

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	129.1207	25	5.164829	20.2103	5.04E-70	1.518705
Columns	82.13996	35	2.346856	9.183393	9.29E-40	1.436541
Error	223.61	875	0.255554			
Total	434.8707	935				

Cronbach's Alpha 0.95052

Appendix G2: ANOVA Table (Correlation between ERM Maturity and Company Experience)

ANOVA: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Less than 20 years	36	70.8	1.966667	0.115429
20 to 30 years	36	69.875	1.940972	0.109363
Above 30 years	36	80	2.222222	0.101587

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	1.740845	2	0.870422	8.000734	0.000583	3.082852
Within Groups	11.42325	105	0.108793			
Total	13.16409	107				

Appendix G3: Pearson's correlation coefficient between the value of projects and companies maturity levels

Pearson Correlation coefficient

	Project value (ETB Billion)	Maturity level		
COM1	2.97	2.04	Project value	Maturity level
COM2	3.03	2.06	Project value	1
COM3	2.68	1.82	Maturity level	0.250226125
COM4	4.14	1.79		1
COM5	2.87	2		
COM6	1.29	1.97		
COM7	19.37	1.94		
COM8	1.4	2.29		
COM9	5.49	2.2		
COM10	19.56	2.97		
COM11	1.81	1.69		
COM12	2.86	1.6		
COM13	6.48	1.92		
COM14	4.58	2.71		
COM15	3.67	2.5		
COM16	0.97	2.09		
COM17	1.97	1.92		
COM18	4.23	1.84		
COM19	2.3	1.99		
COM20	0.99	2.03		
COM21	7.5	2.46		
COM22	11.75	1.42		
COM23	4.08	1.98		
COM24	11.91	1.82		
COM25	10.32	2.22		
COM26	0.56	1.86		