# ASSESSING THE EFFECTIVENESS OF RISK MANAGEMENT PRACTICES USED BY CONTRACTORS IN SOUTH AFRICAN CONSTRUCTION


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## Abstract

This research examines the risk management practices prevalent in the South African construction industry. This was necessitated by the dearth in effective risk management in the construction industry particularly in developing countries such as South Africa. A comprehensive literature review was conducted to establish the risk management practices in use. Based on the literature, a questionnaire was developed and administered electronically to contractors operating in South Africa.

The study established that contractors face a significant number of risks, chief among them, high competition in bids, political instability, payment delays, corruption and bribery and an overbearing influence of bureaucratic processes from government aligned agencies. Furthermore, it was also established that risk management amongst South African contractors is largely informal due to a mediocre appreciation of risk management. It also emerged that risk management implementation is perceived to be an expensive venture that erodes the marginal profits contractors aim to make. Resultantly, risk management practices implementation is low amongst the contractors.

Based on the findings, the study concludes that the South African construction industry suffers from ineffective risk management implementation. To improve the implementation of risk management practices amongst contractors, it is recommended that contractors increase their risk management awareness through risk management training and risk knowledge management. Overall, this will be beneficial for their operations as risk management has been found to yield a positive effect on the meeting of project objectives. Furthermore, private and public sector clients are also encouraged to demand evidence of risk management competency from contractors upon engaging them for work.



**KEY WORDS**

Construction, Contractor, Risk Management, South Africa.

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# CHAPTER 1: INTRODUCTION

This chapter provides a brief outline of the concept of risk management and its significance to the construction industry. Furthermore, it outlines the knowledge gap, the problem statement, background to the study, hypothesis, research aim, objectives and research methodology.

## 1.1 Background to the Study

The construction industry is an essential pillar of the South African economy (Bowen et al., 2007). The industry employed 11% of the national workforce (CIDB, 2019) and made an average contribution of 4% to national GDP during the period between 2010 and 2018 (AfDB, 2019). In any economy, the construction industry serves as an engine for national economic development (Enshassi et al., 2008).

As the South African construction industry continues to experience growth in terms of complexity and output, there is need for improved operational efficiency, and project risk management is one way of achieving better project yields in terms of time, cost and quality (Chihuri and Pretorius, 2010). While risk management today is an essential tool in the management of projects (Wood and Ellis, 2003), it evolved from the insurance industry where its early focus was on mitigation against catastrophic incidents (Windapo and Martins, 2010).

Project risk management is identified as one of the nine project management knowledge areas in the Project Management Body of Knowledge (PMBOK). According to PMI (2013) risk management is a formal process involving risk management planning, risk identification, analysis, response planning and risk control. Its overall objective is to minimise the negative impacts and maximise the positive effects of project risks (PMI, 2013).

Risk management is an important project management practice that aids in successful project delivery (Goh and Abdul-Rahman, 2013; Hwang et al., 2014; Kassem et al., 2019). A successful project can be described as one that is completed within time, cost, quality and safety expectations of all stakeholders (El-Sayegh, 2014). Through following risk management steps, possible disparities between projected and real cost, time and quality of a project can be prevented or minimised thus facilitating the prediction of final costs and completion dates with a higher degree of confidence (Mohebbi and Bislimi, 2012).

Risk management practices are the summation of the various techniques and methods applied within the risk management process. The ultimate goal of implementing risk management practices in construction is to enable value addition to project delivery and simultaneously enhance the efficiency of construction industry practitioners (Tang et al., 2007). Furthermore, paying attention to risk aspects in a construction project aids in the achievement of profitable project outcomes subsequently ensuring business success for construction companies (Sharma and Swain, 2011).

Risk is influenced mainly by the unique characteristics of the construction industry in each country (Andi, 2006). In cognisance of this, the research seeks to investigate the risk management practices prevalent in construction companies operating in South Africa. In the research, companies that execute construction work in exchange for financial reward are referred to as contractors (Iyagba and Mafimidiwo, 2016).

Risk in construction is defined as the likelihood of an event or incident that hinders the viability of a project (Ali et al., 2007; Anton et al., 2011). Compared to other industries, the construction industry is generally regarded as highly risky due to the nature of its activities, environment and organisation (Akintoye and Macleod, 1997; Kartam and Kartam, 2001; Enshassi et al., 2008; Banaitiene et al., 2011; El-Sayegh, 2014). The high risk prevalence in construction is as a result of its unique characteristics such as the involvement of different project participants with incoherent objectives and their linkage to the socio-cultural, political and economic dynamics of the areas in which projects are executed (Anton et al., 2011). Resultantly, no construction project is regarded as risk free (Ali et al., 2007; Mhetre et al., 2016) thus emphasizing the need for risk management.

Despite its risky nature, the construction industry is equally notorious for its inadequate risk management mechanisms resulting in many projects failing to meet cost and completion targets (Ahmed and Azhar, 2004). Unfortunately, the high risk prevalence in construction has equally resulted in its personnel becoming fearful of innovative procedures and methods (Abderisak and Lindahl, 2015). Various stakeholders such as clients, contractors and the general public usually fall victim to the negative consequences of failed projects (Akintoye and Macleod, 1997; Banaitiene et al., 2011).

In the South African context, several prominent failed projects become apparent. For instance, the Gautrain project costs shot up to R25Billion from an initially projected cost of R7Billion (Chihuri and Pretorius, 2010). The Medupi power station is still ongoing with little signs of success and a largely discontent public (Sovacool and Rafey, 2011). Interestingly, failed projects are not limited to the public sector as several notable private sector initiatives have also been unsuccessful. For instance, the failure of the innovative smart city project, Modderfontein New City - a megacity project in northeast Johannesburg that failed to take off and hence suffered a stillbirth (Brill and Reboredo, 2019). This prevalence of failed projects might point towards cross cutting inefficient risk management practices prevalent in the South African construction sector.

Risks that contractors face include exposure to business failure, escalating project costs, major construction incidents, defaulting business associates and contractual disputes and organisation risks (Wang et al., 2004). Contractors are also at risk of payment delays, tight project timelines, inaccurate construction cost estimates, client attributed variations and design changes (Rostami and Oduoza, 2017). In a South African study, Chihuri and Pretorius (2010) found escalating costs, power shortages and skills shortages as the most critical risks prevalent locally. In the presence of these and other risks and without adequate management mechanisms, risks in local construction projects will continue to negatively affect the achievement of primary project objectives in respect of time, cost and quality (Visser and Joubert, 2008).

Despite an awareness of the prevalent and well documented risks, contemporary literature points towards the absence of risk management in construction projects resulting in an endless chain of negative project performance (Serpella, Ferrada, Howard, et al., 2014). According to Chihuri and Pretorius (2010) the implementation of risk management tools and techniques is virtually non-existent in South African construction and engineering industries resulting in poor project performance. Additionally, most construction projects’ risk management processes depend on money contingencies and time floats that are adopted in the absence of comprehensive analysis of their adequacy (Serpella, Ferrada, Howard, et al., 2014). These inadequacies and their negative impacts are more pronounced in developing countries’ construction industries such as South Africa (Ali et al., 2007; Kululanga and Kuotcha, 2010; Serpella, Ferrada, Rubio, et al., 2014).

The prevalence of risk in the South African construction industry is further compounded by the fact that procurement mostly involves the dissemination of large amounts of information to contractors at bidding stage. Contractors are then required to furnish the client with a realistic, profitable bid in a limited amount of time and by default, they assume more risk (Othman and Harinarain, 2009). Consequently, this lukewarm approach to risk management at the bidding stage compromises project success from its formative stages and most likely results in project failure (Tadayon et al., 2012). As such, there is perpetual failure to meet set time and cost targets resulting in the South African construction industry earning a negative reputation due to the continued demonstration of inadequate risk management competency (Othman and Harinarain, 2009).

Contemporary South African construction enterprises operate in a unique market and are ever confronted by unique problems arising from ever changing client expectations coupled with a demand for quality, timeous and low cost builds; new construction methods, materials and complicated designs (Othman and Harinarain, 2009). These market features underscore the need for appropriate risk management to be implemented. In the absence of adequate risk management, South Africa will continue to provide a risky business climate for construction companies.

Despite the risky climate in which South African contractors operate, there is limited research that investigates whether the risk management tools and practices in use within these organisations are appropriate. An understanding of the risk management techniques in use assists in ensuring that construction companies deliver successful projects, thrive and contribute to much needed national economic growth.

The South African economy is regarded as the economic powerhouse of Sub-Saharan Africa, it is thus imperative that research be undertaken in its various forms to enable the stimulation of the growth of the economy (Brand, 2009) and the greater African economy (Arora and Vamvakidis, 2005) .

## 1.2 Statement of the problem

South African contractors are operating in an inherently risky environment and have continuously failed to meet project objectives in terms of time, cost, quality, safety and other contemporary success factors. This has sometimes resulted in reputational damage and business failure on the part of the contractors while negatively affecting both their public and private sector clients. However, there has been limited research to investigate the tools and practices used by contractors to counteract these inherent risks. This study therefore investigated the risks encountered and the risk management techniques used by contractors.

## 1.3 Research Question

The issues highlighted in the background forms the basis for the research question of this academic endeavour:

*What are the risk management techniques implemented by contractors to counteract the risks encountered in South African construction?*

## 1.4 Research Aim

The research aim is to:

*Investigate whether the risk management techniques implemented by South African contractors are related to the risks inherent in construction.*

## 1.5 Research Hypothesis

The research hypothesis tested in this study states that:

*The risk management techniques used by South African contractors are significantly related to the severity of risks encountered in construction*.

## 1.6 Research Objectives

1. Establish the level of knowledge of risk management as an operational contractor practice.
2. Identify and evaluate the severity of the significant risks encountered by contractors.
3. Establish the risk management techniques implemented by contractors.
4. Identify barriers that hinder effective implementation of risk management practices amongst contractors.
5. Determine whether there is a relationship between risk severity and risk management practices used by South African construction contractors.

## 1.7 Research Methodology

The research adopted a quantitative research approach which employed a cross-sectional survey of contractors operating in South Africa using an electronic questionnaire administered via the Survey Monkey platform.

Analysis of the data collected from the questionnaire survey was conducted using the Mean Item Score (MIS), Severity Ranking Index and Spearman Rho statistical analysis techniques and subsequently presented.

## 1.8 Limitations

The most significant limitation to the research was the fact that the data gathered were purely quantitative; hence limited qualitative conclusions were drawn from the research. As such, results obtained may not be exhaustive and not fully reflective of other aspects that would have required other qualitative data gathering techniques such as interviews.

The random sampling technique used in the research might have enabled the introduction of bias in the results as a large number of respondents fell within the cidb Grades 1 – 4. Due to their small size in terms of project scope, companies within these grades largely do not practice formal risk management.

Additionally, the research sought to establish risks as perceived by contractors and excluded other construction industry stakeholders such as consultants, suppliers and project financiers. As a result, the data gathered was limited to contracting organisations who only constitute a part of the construction industry.

The research effort was also negatively affected by the Coronavirus pandemic and the initially projected timelines were not met.

## 1.9 Scope of Study

The study sought to establish the inherent risks and overall risk management practices prevalent amongst South African contractors. The sample frame of these contractors was obtained from the national construction industry development board (cidb)

Register of Contractors. The cidb is established through an Act of Parliament, cidb Act (Act 38 of 2000). The cidb Act makes it mandatory for all organisations wishing to conduct business with government or public sector entities to register according to their financial and works execution capability (CIDB, 2019).

Within the targeted organisations, data was sought from mid to senior level personnel with influence over project implementation within their organisations. Preference of mid to senior personnel was influenced by the fact that they are usually well positioned to influence the risk management processes within their organisations hence it was assumed they would provide informed data relevant to the study. Input from personnel who hold no influence in overall project implementation was not sought as it was feared they would not possess adequate knowledge on the risk management decisions being made within their organisations.

## 1.10 Significance of the study

Risk management continues to be influential on the success of companies in construction and beyond. This study seeks to establish the effectiveness of current risk management practices implemented by contractors.

Through the establishment of the inherent risk management techniques, companies with limited risk management competency are informed of the risk management techniques prevalent in the market and may adopt the same as part of their operational strategy and hence become more competitive. Equally, those with demonstrated risk management competency may also improve their competency using improved methods and techniques. Ultimately, this results in better project performance and positive gains for all construction industry stakeholders.

Additionally, the establishment of barriers that hinder effective risk management implementation will assist companies in coming up with the relevant mechanisms to enhance their risk management competency through elimination and addressing these challenges. The research findings will also be of use to the South African government, the cidb and statutory bodies in addressing the risks encountered by construction companies.

## 1.11 Structure of the research report

The report comprises five chapters.

Chapter 1 provides a brief outline of risk management and its significance to the construction industry. Furthermore, the problem statement, background to the study, proposition, research aim, objectives and research methodology are outlined in this chapter.

Chapter 2 comprises of a review of literature on risk management, risks encountered by construction companies, risk management techniques used as well as challenges faced in the quest to implement risk management practices in the construction sector.

Chapter 3 is a brief outline and justification of the research methodology used. In this chapter, research subjects are identified, the sample size is determined, and the necessary statistical tools are chosen and justified. This chapter serves as a guide for the research data collection.

In Chapter 4, results and analysis of data from the fieldwork are presented concisely with key findings being discussed and presented using text and various graphical tools.

The summary of findings, conclusion, recommendations for stakeholders and future research areas are outlined in Chapter 5. Subsequently, a full list of references used in the research together with an Appendix containing a copy of the questionnaire and the Ethics approval is also attached.

## 1.12 Chapter Summary

In this chapter, risk management and its relationship with construction has been introduced. Furthermore, the problem statement, study aims, objectives, hypothesis and limitations have also been outlined. In conclusion, the chapter also provided an outline of the report. In the next chapter, a comprehensive literature review is conducted.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

This chapter seeks to provide an in-depth analysis of risk, the management thereof as well as its relationship with construction. Literature on the definition of risk, existing risks in construction, risk management techniques and barriers encountered in the implementation of risk management are reviewed.

## 2.2 Overview of the Construction Industry and its problems

Construction projects are generally associated with negative connotations such as being over budget, failure to meet deadlines, lack of coordination and delays in resolving intermittent disputes (Isa et al., 2020). In comparison with other economic sectors, the construction industry is also lagging behind in keeping up with contemporary business trends, operational processes development and most importantly, technology advancement (Iyagba and Mafimidiwo, 2016). Zeng et al*.* (2007) attribute the challenges faced in construction to the nature and features of the industry such as constant changes in the construction environment, demanding schedules and increasing complexity in construction techniques.

In South Africa, the construction industry is increasingly becoming more complex due to significant financial investments from the public and private sectors (Thwala and Mofokeng, 2012). While there have been concerted efforts by the public sector to promote organic construction businesses growth, the state of the South African economy has failed to sustain the growth of small, upcoming construction companies who make up the bulk of companies in the sector (Martin and Root, 2010). Oyewobi et al*.* (2014) assert that the construction industry is still reeling from the negative effects of the 2008 global economic recession.

The negativity that is generally attached to the construction industry is particularly concerning to project financiers as construction ventures are normally a huge capital investment (Aigbavboa et al., 2016). Regardless of the negative connotations attached to the local construction industry, careful, calculated consideration of the risks attached to each construction venture enhances the chances of successful project execution thereby driving construction company growth (Abd Karim et al., 2012).

## 2.3 The Concept of Risk

There are numerous definitions of risk in literature (Garrido et al., 2011; Siang and Ali, 2012). Generally, risk can be described as a potential deviation from a predetermined target (Mohebbi and Bislimi, 2012). In construction, risk refers to interference in a planned project activity or expected outcome (Wanyona, 2005). Accordingly, risk is any action or occurrence yielding a negative effect on the achievement of project objectives (Mahendra et al., 2013; El-Sayegh, 2014). The aforementioned definitions are in sync with the general notion where risk is identified as a source of negative consequences without regard for its positive consequences (Schieg, 2006).

However, several authors also proffer balanced definitions of risk which capture both its negative and positive effects. For instance, according to PMI (2013), project risk is an uncertain event or condition that in the event of its occurrence, has a positive or negative effect on one or more project objectives. Iqbal et al. (2015) also describe risk as an event yielding a negative or positive impact on project objectives in the micro, meso and macro environments in which it occurs. This indicates that a risk event may result in either positive or negative outcomes thus resulting in opportunity or loss respectively (Ahmed et al., 2007).

Normally, risk is presented in terms of probability of occurrence and the size of the loss or gain attributed to it (Goh and Abdul-Rahman, 2013). In mathematical terms this can be appropriately presented as follows:

1. *Risk = Hazard x Exposure* (Abu Mousa, 2005).
2. *Risk = Probability of event x Magnitude of loss / gain* (Jannadi and Almishari, 2003; Goh and Abdul-Rahman, 2013; Purohit *et al.*, 2018).

Risk can also be presented in graphical form indicating both its likelihood and anticipated impact thus enabling the deduction of the region of highest risk (Jayasudha and Vidivelli, 2016). This is depicted in Figure 2.1.

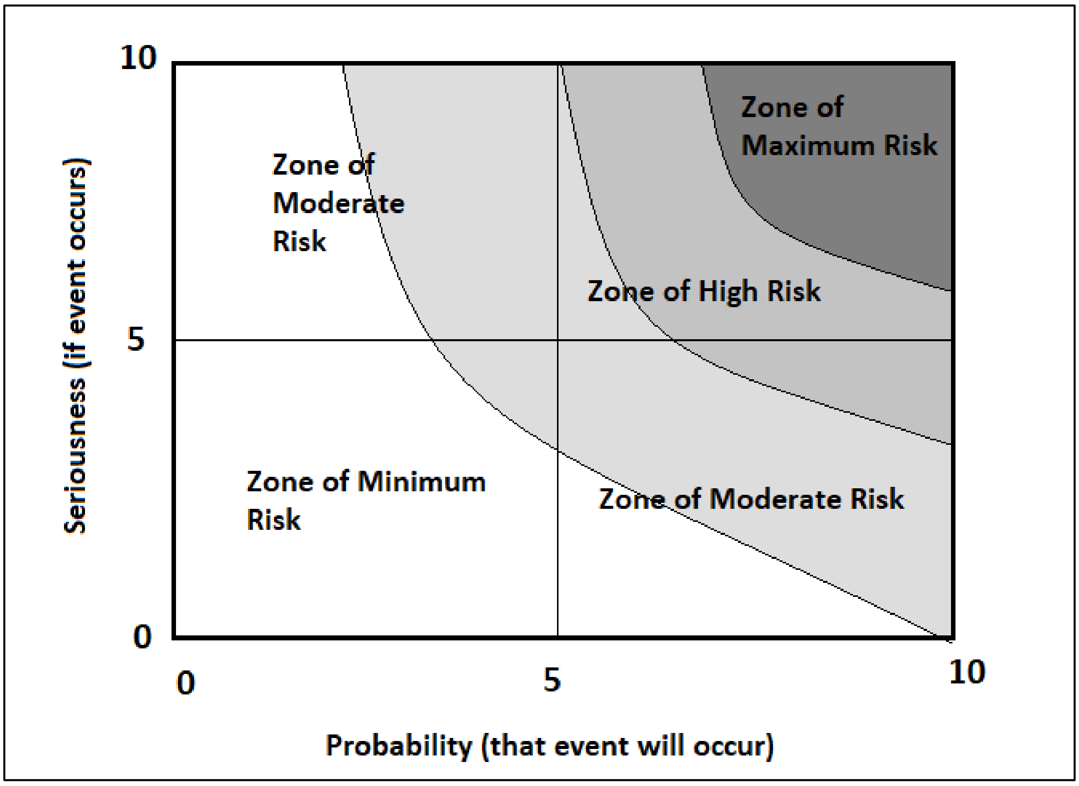


*Figure 2.1: Graphical presentation of risk (Jayasudha and Vidivelli, 2016)*

While the term risk is generally interchanged with uncertainty, it is important to note that there are differences between these two aspects (Nguyen Phuong and Yuansheng, 2012). KarimiAzari et al. (2011) present a vital distinction between the two aspects as follows: risk is measurable uncertainty and uncertainty is immeasurable risk. Thus, it can be deduced that an uncertain event whose chance of occurrence can be measured is a risk.

Without nullifying other risk definitions that focus on either its positive or negative outcomes, the definition of risk adopted in this research is an event that yields negative consequences on the achievement of project objectives thereby negatively affecting the viability of construction company operations.

## 2.4 Risks in construction industry

Risk is inevitable in an industry as dynamic and multifaceted as construction (Ghahramanzadeh, 2013). As previously mentioned, risk is a versatile concept whose outcomes may be worse off or better than expected (Wang et al., 2004). Furthermore, not only can risks affect project outcomes, but they have also been found to influence the occurrence of one another (Goh and Abdul-Rahman, 2013).

The classification of project risks into identifiable categories is an essential foundation for successful management of risks (Sharma and Swain, 2011; Hwang et al., 2017). For instance, Edwards and Bowen (1998) broadly categorised risks into human and natural risks. Herein, natural risks result from natural phenomenon such as weather and geological systems. Similarly, human risks result from human activity such as social, political and economic systems.

Zou et al. (2007) categorised risks in terms of their effect on project objectives of quality, cost, time, safety and the environment. Arguably, this approach assists in matching project objectives to imminent risks thus enhancing chances of successful achievement of project objectives. Furthermore, according to Ghahramanzadeh (2013), risks can also be categorised as subjective or objective. Subjective risks are qualitative and determined by the experience and knowledge of the risk analyst while objective risks are exact, quantitative and based on the calculation of their impact of their likelihood and impact.

Risks can also be categorised based on their source, that is they can be identified as internal, external and project risks (Zavadskas et al., 2010; Rehacek, 2017). In this regard, external risks are beyond the control of the project organisation such as political and economic risks. Internal risks are unique to the organisation and well known such that they can be allocated to the party best suited to address them. Examples of internal risks are resource, personnel availability and construction site risks. Project risks are unique to the project and they are in respect of the project objectives of time, cost and quality.

Mhetre et al. (2016) categorised construction related risks in terms of technical, construction, physical, organisational, financial, socio-political and environmental risks. They opine that this categorisation best suits the unique characteristics of the construction industry. Similarly, Odediran (2016) appropriately categorised risks encountered by construction companies seeking to penetrate the greater African market as follows: political, social, economic/financial, procurement-related, design-related and construction-related risks. The study has chosen to adopt categorisation based on a combination of research by Odediran (2016) and Mhetre et al. (2016). The risk categories are briefly discussed below.

### 2.4.1 Political risks

According to Xiaopeng and Pheng (2013), political risks result from political events, inadequate or discriminatory action from government or influential groups in a country. They add that these actions or lack thereof normally result in unexpected changes in the operating environment coupled with negative effects on the operations of a construction enterprise. From the aforementioned, it can be deduced that political risk not only arises from state aligned sources but from societal sources as well (Al Khattab et al., 2007). Common sources of political risks include political events (internal conflict, political violence, terrorism) and discriminatory actions (investment restrictions, nationalisation, corruption) taken by influential parties (Chang et al., 2018).

### 2.4.2 Economic / Financial risks

Financial risks result from inconsistencies in the macro-economy (Zavadskas et al., 2010) and yield a negative effect on the financial performance of a project (El-Sayegh, 2008). They can manifest in the form of price increments of construction elements such as material and personnel costs, rampant inflation, exchange rate fluctuations, escalation of local and national levies and resource shortages (Olamiwale, 2014; Mhetre et al., 2016). Mubin and Mubin (2008) combined social and economic factors to pen the term socio-economic factors to elucidate the social effects that also result from negative economic indicators.

### 2.4.3 Procurement risks

The procurement stage of a project provides an outline of risk governance, distribution and responsibility assignment at an early stage (Osipova, 2008). Since procurement planning falls in the project inception stage, the assumptive nature of project initiation activities such as bidding process, estimating and negotiating make procurement an inherently risky undertaking (Odediran, 2016). Procurement risks are not only related to contractor and client/financer relations but they also yield influence over main contractor and sub-contractor interaction hence they are deserving of attention in order to address potential risk issues (Yin et al., 2014).

### 2.4.4 Social risks

Social risks refer to risks that could bring rise to events of social tension resulting in confrontation, protest or violent conflict ultimately leading to negative consequences for the contracting organisation (Liu et al., 2016). Social risks are heightened by differences that shape modern society relationships and the dynamic environment in which projects are executed (Zhang, 2011). Consequently, addressing social risks before project commencement assists in ensuring that projects proceed without future disturbances from the community (Shi et al., 2015).

### 2.4.5 Design-related risks

They occur due to design or specification mishaps resulting in construction problems (Rehacek, 2017). According to Sharma and Swain (2011), these can be in the form of inadequate design scope subsequently resulting in poor articulation of design detail by the contractor. Despite this, Enshassi et al. (2008) noted that contractors suffer from a plethora of incorrect design information and in the absence of due diligence, repercussions from such are usually borne by them as well. Resultantly, early assessment of design risks assists in reducing risk impact or project failure (Sharma and Swain, 2011) thereby enhancing chances of project success.

### 2.4.6 Construction-related risks

These are risks that become apparent during the construction stage of the project as a result of onsite / offsite actions or lack thereof by contractors; subcontractors and clients (Odediran, 2016). They become apparent when there a misalignment between specifications and implementation due to misunderstanding or disregard of contract documents by any of the parties to the contract (Kishan et al., 2014). Sharma and Swain (2011) opine that these risks are the most important as they yield a significant impact on project objectives of time, cost and quality.

### 2.4.7 Environmental risks

While virtually all things outside a project constitute its environment (technology; clients; competition; geographic setting) (Akanni et al., 2015), this research focusses on the features of the natural environment as the source of environmental risks in construction projects. Ansah et al. (2016) identified these risks as being inclined to weather, ground conditions, dust, noise among a host of others. More explicitly, Mhetre et al. (2016) allude to weather conditions and natural disasters as apt environmental risks. Environmental risks can also result from the operations of construction companies thereby causing damage to the natural environment in which projects are executed (Ab Rahman and Esa, 2014).

## 2.5 Risk Management in Construction

Risk management is now a recognised field with its own philosophy, language, techniques and tools (Ongel et al., 2009). Risk management is the systematic process of identifying, analysing and responding to project risks in a manner that maximises the probability and consequences of positive attributes and conversely minimizing the same for negative attributes (Kululanga and Kuotcha, 2010; Abd El-Karim et al., 2017). Simply put, risk management is risk identification and its subsequent apportionment to the party most qualified to deal with it (Gruneberg et al., 2007). While Tummala and Schoenherr (2011) opine in favour of total risk avoidance if at all possible, El-Sayegh (2008) advised against this approach since risks may be related to rewards thus some risks should be accepted as long as the financial returns are worthwhile.

In the engineering and construction sectors, efficient risk management has been identified as a driver of company growth given how investments have paid off following its implementation (KPMG, 2013). Resultantly, risk management is relevant to all construction stakeholders (clients, design team, contractors and suppliers) who are concerned with the time, cost and quality of the finished project (Akintoye and Macleod, 1997). This is because it is essential in ensuring the attainment of project objectives regardless of project size (Hwang et al., 2014; Kassem et al., 2019). However, as pointed out by Kishk and Ukaga (2008), efficient risk management can only be achieved if it is integrated with the project decision making processes.

Various characteristics of the construction industry make it more prone to risk as compared to other sectors (Banaitiene et al., 2011). In addition to the political, social, economic and cultural environments in which projects are executed, the size and complexity of construction projects is increasing (El-Sayegh, 2008). In addition, Abd El-Karim et al. (2017) indicate that uncertainty present in construction projects leads to a large number of unknowns such as contractual parties' performance, environmental conditions and resource availability.

Risk management in construction assists project participants to meet their project commitments while minimizing negative impacts of project performance hindrances (Banaitiene et al., 2011; Rather, 2018). In order for this to be achieved effectively, Rehacek (2017) states the project risk management strategy should be based on the specifics of the project in question and integrated into the overall project management plan. This is because each project is unique, for example, projects are measured by varying time, cost and quality metrics (Siang and Ali, 2012); certain types of construction projects are found to possess more risk than others (Perera et al., 2014). Olamiwale (2014) also argues in favour of risk management and asserts that beyond risk containment, it also assists in efficient resource allocation and management.

In light of these factors, effective risk management should be project specific and the adopted risk management process should be indicative of this (Perera et al., 2014). The following section outlines the typical risk management process.

## 2.6 Project risk management process

The risk management process consists of a series sequential steps that enable constant, enhanced decision making (Kululanga and Kuotcha, 2010). Ahmed et al. (2007) outline a risk management process comprising of seven iterative sub-processes of context establishment, identifying risks, analysing risks, evaluating risks, communication and consultation across stakeholders and monitoring and controlling risk events. According to Zavadskas et al. (2010) the risk management process can be divided into three stages of identification, analysis and control. In addition to the same, Zou et al. (2010) went on to add risk communication, review and learning to the risk management stages. APM (2010) outline a risk management process comprising initiate, identify, assess, plan responses and implement responses stages. Similarly, PMI (2013) offer a more refined outline of the project risk management process as encompassing risk management planning, risk identification, qualitative and quantitative risk analysis, risk response and control.

Overall, the risk management process seeks to achieve the basic integration of risk policy, establishment of risk consciousness coupled with organisational integration (Schieg, 2006). The study has chosen to adopt the risk management processes according to PMI (2013) depicted in Figure 2.2.

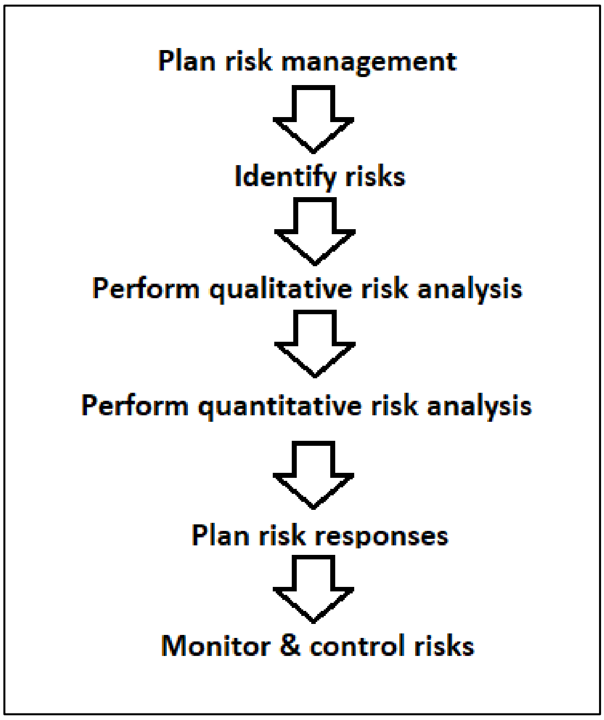


*Figure 2.2: Risk management process (PMI, 2013)*

## 2.7 Risk management techniques

Actual risk management implementation involves the use of various techniques unique to each stage of the risk management process (Cagliano et al., 2015). Essentially, this means that various techniques are implemented during the different risk management processes to obtain the effects of the overall risk management effort. PMI (2013) outlines the objectives of each risk management process as follows: risk management planning allows for outlining of project objectives, establishment of resources availability and overall determination of the risk management approach; risk identification allows for the definition of risk causes; risk analysis determines the probability of occurrence and anticipated impacts; finally, risk response enables the development of actions to reduce risks or enhance opportunities. The various techniques applicable to each respective risk management process are discussed below.

### 2.7.1 Risk management planning

Risk management planning is the process of outlining the procedure to be used in project risk management and it is essential in obtaining support of the risk management effort from all relevant stakeholders early on in the project (PMI, 2013). Simply put, risk management planning is the formulation of the risk management strategy (Karim et al., 2012).

Beyond obtaining consensus amongst stakeholders, risk management planning ensures that the risk management measures chosen are commensurate with the project type, size and importance (Goh and Abdul-Rahman, 2013). Elaborate, contemporary risk management planning literature is relatively limited since a number of authors such as Zwikael and Sadeh (2007); Zwikael and Ahn (2011) have identified risk management planning as part of the overall project management planning exercise.

However, del Caño and de la Cruz (2002) isolated risk management planning as an independent process and outline a four stage risk management planning exercise comprising: requirements; project; process and team stages. Additionally Keshk et al. (2018) also outline components of a risk management plan as including: establishing methodology; roles and responsibilities; budgeting; scheduling and timing; scoring; risk categories; formats and templates and tracking.

In order to achieve effective risk management planning, PMI (2013) suggest the use of expert judgment where opinions are sought from senior management and experts in the field as well as meetings amongst concerned stakeholders.

### 2.7.2 Risk identification

This stage of the risk management process seeks to identify the risks, assess relative importance and assign the risks to the parties best positioned to deal with them (Ali et al., 2007; Tadayon et al., 2012). Earlier, Abu Mousa (2005) presented a similar definition of the risk identification process, however they added the aspect of documentation of the identified risks, an essential feature should the exercise yield positive value.

Despite the existence of the risk management planning stage, a number of authors such as Zavadskas et al. (2010); Makombo (2011) and Rehacek (2017) allude to risk identification as being the first and most crucial stage of the risk management process. The importance of risk identification is reinforced by the fact that unidentified risks cannot be effectively dealt with or prepared for beforehand (Schieg, 2006; Chihuri and Pretorius, 2010; El-Sayegh, 2014). However, it is important to note that risk identification is as important as any other stage of the risk management process as synergy amongst the different risk management processes is essential for project success (Rostami, 2016).

The output of the risk identification process is the risk register outlining the risks and the parties they have been assigned to (Chihuri and Pretorius, 2010). Although every project endeavour seeks to achieve exhaustive, non-biased risk identification, Perera et al. (2014) assert that outcomes of the risk identification stage are entirely dependent on the experience and backgrounds of participants of the exercise.

In order to present identified risks in a manner that is easy to understand Mehdizadeh (2012), propose the use of a Risk Breakdown Structure (RBS) which groups identified risks into different using a bottom-up approach. The RBS shows risk groups, risk categories and risk events (El-Sayegh, 2008). A typical RBS in shown in Figure 2.3.

Needless to say, in order to identify risks inherent in a project, a number of specialised techniques are used (Renault, Agumba and Ansary, 2016). Amongst construction companies in Brazil, Garrido et al. (2011) found checklists, root cause identification and flowcharts as the main risk identification techniques used while the least used were electronic brainstorming, Synectic and the SWIFT (Structured What If Technique) structure.

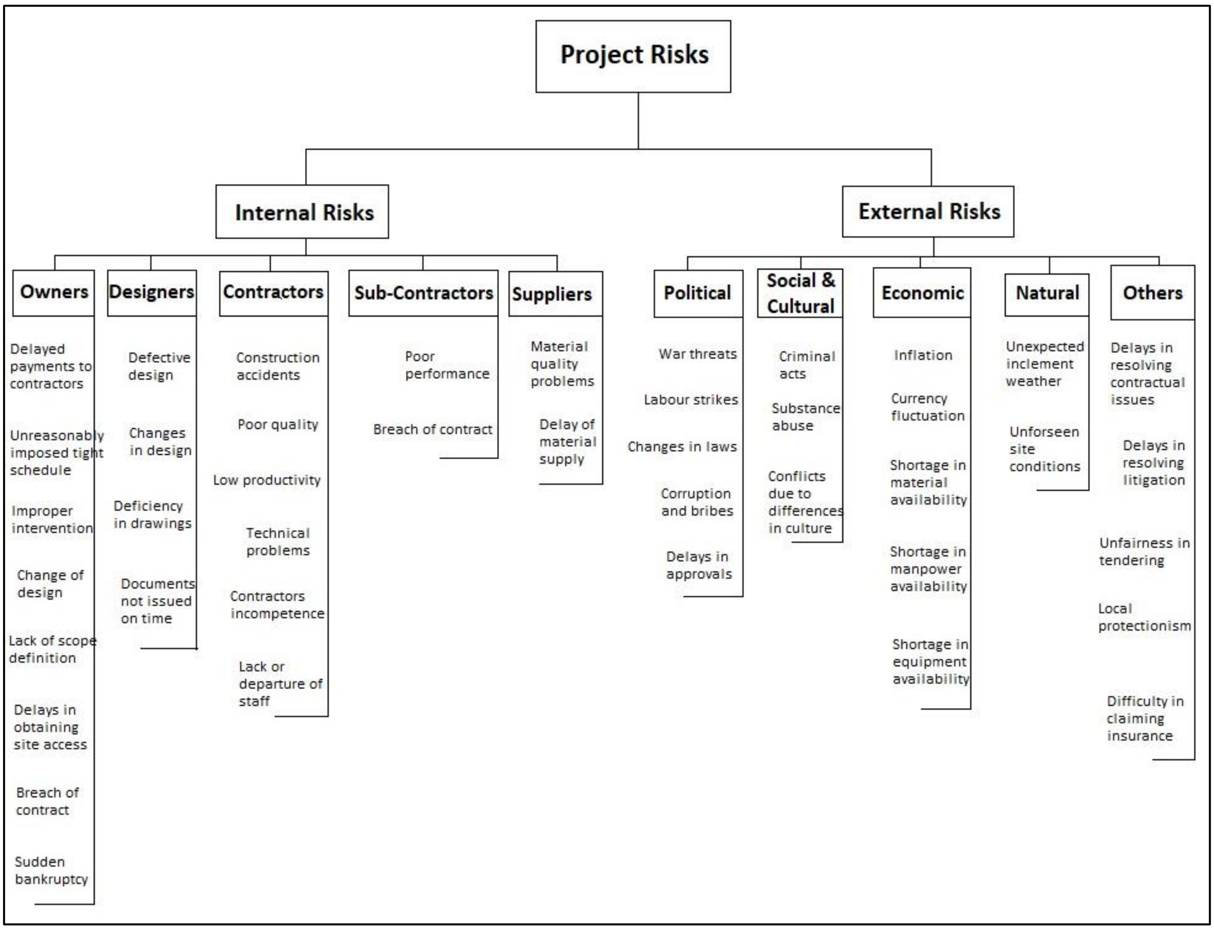


*Figure 2.3: Typical risk breakdown structure (El-Sayegh, 2014)*

A similar study on Swaziland contractors, distinguished as either indigenous or multinational by Olamiwale (2014) established that brainstorming and document reviews are the most frequently used risk identification techniques amidst limited usage of questionnaires, interviewing and Delphi techniques.

A specialised study on construction small to medium enterprises (SMEs) in the United Kingdom established a high usage of document reviews, expert judgement, checklist analysis and information gathering mainly on account of their simplicity (Rostami, 2016). They state that complex techniques such as the Delphi techniques are less used due to the lack of expertise in SMEs and this is similar to findings by Garrido et al. (2011); Olamiwale (2014); El-Sayegh (2014) despite the lack of SME bias in their respective studies.

Beyond construction, a multi-sectoral research on small, medium and micro enterprises (SMMEs) operating in South Africa, Boubala (2010) found customer complaints, incident registers and audit reports as the most prominent risk identification techniques. Furthermore, Boubala (2010) found that risk identification exercises are conducted more frequently as most respondents conduct these monthly. Despite the multisectoral approach of the research, the frequency of risk identification is in tandem with Chihuri and Pretorius (2010) who suggest iterative risk identification in light of the variability of the construction project life cycle.

A brief description of the various risk identification techniques outlined by the above-mentioned researchers is presented below.

#### 2.7.2.1 Risk checklist

The risk checklist is developed based on information accumulated from similar, past projects or any other reputable sources (PMI, 2013). According to Chihuri and Pretorius (2010), it is virtually impossible to produce an exhaustive risk checklist and for the sake of learning for future projects, project closure should involve a review of apparent risks that were not initially identified. These will be included in future risk checklists.

#### 2.7.2.2 Flowchart

A graphical tool used to indicate the steps of a process to be executed (Garrido et al., 2011). Arguably, this technique is well suited for better understanding of project risks and their interrelatedness in the overall project context (Jayasudha and Vidivelli, 2014).

#### 2.7.2.3 Brainstorming

Involves the gathering of a multidisciplinary set of experts and the subsequent structured or informal sharing of anticipated risks and experiences (Mahendra et al., 2013). These gatherings are an essential feature of risk management workshops (Tadayon et al., 2012). Since brainstorming promotes idea generation, it ultimately assists in exhaustive risk identification hence it is very popular and useful (Mahendra et al., 2013).

#### 2.7.2.4 Delphi techniques

This technique is similar to brainstorming, but herein, the experts are anonymous and operate from different locations (Renault, Agumba and Ansary, 2016). The facilitator of the exercise distributes a risk questionnaire to the experts, obtains responses, summarises them and subsequently recirculates them for further comments from the same experts (PMI, 2013). This process is repeated and its success is dependent upon the final consensus of the participating experts (Jayasudha and Vidivelli, 2014).

#### 2.7.2.5 Interview / expert opinion

Involves the interviewing of project participants, stakeholders and experts in order to identify the inherent risks (PMI, 2013). Interviews can be conducted individually or collectively in an unstructured, semi-structured or structured way (Garrido et al., 2011).

#### 2.7.2.6 Questionnaire

Structured risk questionnaire is distributed amongst project participants in order to obtain and document their opinions (Olamiwale, 2014). Questionnaires allow for consistency in the risk identification process as well as openness in disclosing potential risks (Renault, Agumba and Ansary, 2016).

#### 2.7.2.7 Influence diagrams

They are a graphical illustration containing the decision variables of potential problems in a project (Garrido et al., 2011). Through this graphical presentation, ordering of events, interrelatedness between variables and outcomes are shown thus allowing for easier decision making for the project team (PMI, 2013).

#### 2.7.2.8 Expert systems

This technique involves the use of past experience of experts to identify potential risks derived from similar, past projects (Renault, Agumba and Ansary, 2016).

#### 2.7.2.9 Past experience

This technique allows for making reference to risks experienced on previous similar projects, thus trends can be deduced thereby allowing project team members to identify risks that could be repeated in the new project (Makombo, 2011).

#### 2.7.2.10 Document review

Encompasses the systematic review of project documentation such as drawings, assumptions, contracts amongst others to check their general quality and consistency (PMI, 2013). As such, high inconsistency in project documentation is indicative of a high risk project (PMI, 2013).

#### 2.7.2.11 SWOT (Strengths, Weaknesses, Opportunities and Threats) Analysis

Involves the evaluation of a project on the basis of its strengths, weaknesses, opportunities and threats (Chihuri and Pretorius, 2010). According to Garrido et al. (2011), it can also be used as a strategic decision making tool beyond one particular project.

#### 2.7.2.12 Cause and effect diagrams

They are also known as Ishikawa or fishbone diagrams and useful in showing how project characteristics may be linked to potential problems or effects (Jayasudha and Vidivelli, 2014). Ahmed et al. (2007) opine that despite their ease of use, cause and effect diagrams do not provide an adequate foundation for further risk analysis.

### 2.7.3 Risk Analysis

Risk analysis provides a crucial link between systematic risk identification and the management of identified, substantial risks (Mehdizadeh, 2012). It is the step that follows on from risk identification and can also be termed risk assessment or risk evaluation in various literature (Olamiwale, 2014). Risk analysis is the systematic consideration of risk sources, their consequences and the likelihood that those consequences may occur (Ali et al., 2007). While it is arguably the most difficult stage of the risk management process, it is possibly the most important (Taroun et al., 2011).

Through the establishment of likelihood and severity of a risk event, its relative importance is determined, for example, a high probability and high severity event would require a significant amount of attention (Othman and Harinarain, 2009). This aligned approach to risk management is supported by Kishan et al. (2014) who indicate that effective risk analysis is focussed on the events with significant impact on projects and is achieved through accurate and unbiased determination of risk.

Risk analysis is carried out by decision makers to indicate the projected implications of risk events and the responsive measures that can be taken (Öztaş and Ökmen, 2004; Ali et al., 2007) and it can be conducted using qualitative or quantitative methods (Azhar et al., 2008; Banaitiene et al., 2011). In essence, qualitative analysis involves identifying and preliminary assessment of risks and quantitative analysis encompasses the evaluation of risks in order to measure the consequences (Abu Mousa, 2005).

Quantitative methods rely on probability distribution of risks while qualitative methods are subjective and dependent on the experience of the analysts and thus prone to inconsistent results (Azhar et al., 2008). Results are influenced by the use of descriptive analysis, ranking options, direct judgement and comparing options in qualitative risk analysis and conversely the use of statistical analysis in quantitative risk analysis (Ali et al., 2007; Ubani et al., 2015).

Risk analysis is essential because it provides early indication of the consequences of the project not going according to plan (Abu Mousa, 2005). In reinforcement, Ahmed et al. (2007) state that risk analysis is essential as it offers a global picture of the risk situation and allows for high level risk analysis that considers the cumulative effects of risk events on successful project delivery. This enables a collective, all-encompassing approach to risk management.

#### 2.7.3.1 Qualitative Risk Analysis

Qualitative risk analysis entails prioritization of risks for further analysis or action through assessing their likelihood and impact (PMI, 2013). The process makes use of a descriptive or nominal scale to define risk events and their consequences

(Mehdizadeh, 2012). This means that risks can be placed on a descriptive scale from least significant to most significant (Gajewska and Ropel, 2011).

Qualitative methods of risk analysis are more widely used than quantitative methods (Lyons and Skitmore, 2004; Banaitiene et al., 2011; El-Sayegh, 2014). Mhetre et al. (2016) attribute their popularity to their relative ease of use. Asadi (2015) reiterate that qualitative risk analysis sometimes suffices since relative awareness of probability and impact is usually enough to assist project decision makers.

However, in scenarios where two stage risk analysis is required, qualitative risk analysis is the foundation for subsequent quantitative analysis and risk response planning (PMI, 2013). According to Adedokun et al. (2013), qualitative risk analysis is useful in the following ways: it is an initial screening activity to identify risks requiring more attention; provides sufficient information for decision making even when data is insufficient to conduct quantitative risk analysis.

The main qualitative analysis techniques in use are discussed below:

1. Risk probability and impact assessment – This technique allows for the evaluation of the probability of a risk event occurring (Olamiwale, 2014). Not only does the risk impact assessment allow for a detailed assessment of the negative effects risk events might yield on the meeting of project objectives but it also allows for the magnification of opportunities that might arise from the same (PMI, 2013).
2. Probability-impact risk ranking matrix – Following the assessment of risks, it is vital to rank them according to their probability of occurrence and severity on project objectives (PMI, 2013). Risk ranking is done according to a predetermined scale and presented in grid format through use of a risk and impact matrix shown in Figure 2.4 (Mehdizadeh, 2012).
3. Risk categorization – This technique involves the structuring of risks into defined categories (Mhetre et al., 2016). Risks can be categorized based on source, project phase or common root causes thus allowing for informed formulation of risk response techniques (PMI, 2013).
4. Risk Urgency Assessment – Encompasses the assessment of risks based on the urgency of the risk response action required (Mhetre et al., 2016).

| Probability and Impact Matrix | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Probability** | **Threats** | | | | | **Opportunities** | | | | |
| **0.90** | 0.05 | 0.09 | 0.18 | 0.36 | 0.72 | 0.72 | 0.36 | 0.18 | 0.09 | 0.05 |
| **0.70** | 0.04 | 0.07 | 0.14 | 0.28 | 0.56 | 0.56 | 0.28 | 0.14 | 0.07 | 0.04 |
| **0.50** | 0.03 | 0.05 | 0.10 | 0.20 | 0.40 | 0.40 | 0.20 | 0.10 | 0.05 | 0.03 |
| **0.30** | 0.02 | 0.03 | 0.06 | 0.12 | 0.24 | 0.24 | 0.12 | 0.06 | 0.03 | 0.02 |
| **0.10** | 0.01 | 0.01 | 0.02 | 0.04 | 0.08 | 0.08 | 0.04 | 0.02 | 0.01 | 0.01 |
| | 0.05/ Very Low | 0.10/ Low | 0.20/ Moderate | 0.40/ High | 0.80/ Very High | 0.80/ Very High | 0.40/ High | 0.20/ Moderate | 0.10/ Low | 0.05/ Very Low |
| **Impact (numerical scale) on an objective (eg. cost, time scope or quality)** | | | | | | | | | | |
| **Each risk is rated on its probability of occuring and impact on an objective if it does occur. The organisation's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.** | | | | | | | | | | |

*Figure 2.4: Risk and impact matrix (PMI, 2013)*

#### 2.7.3.2 Quantitative Risk Analysis

Quantitative analysis is the process of quantifying risks and their impact on the achievement of overall project objectives (El-Sayegh, 2014). In other words, quantitative analysis expresses the possible effects of occurrence of risk events in terms of time, cost and quality (Olamiwale, 2014). This is achieved through the use of advanced statistics and mathematical methods and according to Purnus and Bodea (2013), this makes quantitative risk analysis the most difficult part of risk management.

In the presence of reliable data and the necessary skills set, quantitative risk analysis methods may give more accurate results than qualitative methods (Azhar et al., 2008). However, it is important to note that due to its reliance on historical data and estimates, quantitative analysis is prone to subjectivity (Blackburne, 2012). Quantitative risk analysis is conducted on risks that have been prioritised in qualitative risk analysis as possessing a significant impact on the achievement of project objectives (PMI, 2013; Gupta and Thakkar, 2018).

The commonly used quantitative risks analysis techniques according to PMI (2013); Mubin and Mubin (2008); Mahendra et al. (2013) and Thaheem et al. (2012) are listed and discussed below.

1. Sensitivity analysis – Useful in determining the most severe risks on a project. This is done through the examination of uncertainty of each project element and establishing its overall effect on a specific project objective while all other project elements are held constant. As a result, an understanding of how variations in project objectives relate to variations in various uncertainties.
2. Decision trees – A graphical presentation of a decision under consideration as well as the implications of making the decision. It involves the consideration of varying situations and their respective implications while allowing for the selection of the best option. By providing the risk probabilities and cost implications, decision trees are highly effective at best informing project teams of the available options and the possible outcomes.
3. Modelling and simulation – A model used to translate the detailed uncertainties into their potential impact on project objectives. The model undergoes various simulations such as the Monte Carlo simulation where various iterations with different input values are conducted to deduce the probability distributions of these outputs and hence come up with the various, expected outcomes.
4. Expert judgement – Ideally, this makes use of experts with relevant experience to identify potential impacts on projects objectives in terms of time, cost and quality. Experts should be able to input probabilities of various happenings as well as interpretation of outputs of the exercise.

### 2.7.4 Risk Response

Risk response involves taking action to address the identified and analysed risks (Simu, 2006). Risk response are measures taken to eradicate, reduce or transfer risks and their consequences (Olamiwale, 2014). According to Ghahramanzadeh (2013), this is achieved through the evaluation of potential impacts of risks and taking the necessary action to minimize their negative impacts while maximising their positive impacts. Ali et al. (2007) state that action taken in response to risks should be achievable, affordable and appropriate.

Formulation of an appropriate risk response plan is preceded by establishment of the acceptable risk threshold for the project (Asadi, 2015; Mhetre et al., 2016). Selection of the right technique allows for addressing risks according to project priorities while allowing efficient resource allocation into the project (PMI, 2013).

While various risk response strategies are available, Ghahramanzadeh (2013) noted that a majority of authors proffer risk response strategies for negative risks. For instance, the most popular risk response strategies are risk avoidance, transfer, reduction and retention or acceptance as the most used risk response strategies (Abu Mousa, 2005; Mehdizadeh, 2012; Olamiwale, 2014). In addition to the same, Nguyen Phuong and Yuansheng (2012) also discussed risk sharing as an additional technique. In light of the predominant negative view on risks, Mhetre et al. (2016) identified all the aforementioned risk response strategies in addition to the use of contingency. However, they went on to add risk exploitation and enhancement, strategies that seek to obtain benefit from risks.

Key risk response strategies can be one or a combination of the following options (Abu Mousa, 2005; Mehdizadeh, 2012; Nguyen Phuong and Yuansheng, 2012; Olamiwale, 2014; Otali and Odesola, 2014; Mhetre et al., 2016).

1. Risk avoidance – This technique is sometimes referred to as risk elimination. It involves altering project plan to eliminate risk events or ensure achievement of project objectives. Risk is avoided when a party is not willing to accept a risk and its subsequent consequences. In construction an example of risk avoidance may be placing an exceedingly high bid to avoid a project that is perceived to be risky.
2. Risk transfer – Involves transfer of risks to another party that is better positioned to deal with threats. As a result, risks are not eliminated however, their management and liability are transferred to another party. Examples of risk transfer tools are insurance, bonds and guarantees. Importantly, risk transfer almost always involves payment of a premium to the party adopting the risk.
3. Risk reduction – Arguably the most used risk response technique. Herein, risk and its consequences are stabilized without transferring the risks to other parties. In other words, risk reduction involves reducing the probability and consequences of risk. However, risk reduction entails an investment that should be less than the cost of mitigating the risks. Examples of risk reduction are

redesign of project, employment of knowledgeable personnel and use of familiar project execution methodologies.

4. Risk sharing – Involves partial or full transfer of risks consequences or opportunities to a third party better equipped to deal with the risk. In construction, risk sharing can be achieved through joint ventures, risk sharing partnerships and special purpose vehicles (SPV).
5. Risk exploitation – Seeks to eliminate the uncertainty attached to a positive risk to ensure that the risk occurs. Occurrence of such a risk would have positive impacts on project objectives. For example, a scheduling error that leads to budget saving.
6. Risk enhancement – This response technique aims to positively manipulate the magnitude of positive risks to magnify anticipated positive outcomes. This is achieved by increasing probability and/or impact of risk events through targeting and reinforcing their trigger conditions.
7. Contingency plan – Involves the use of a backup plan in case risk events occur. In construction, this can be in the form of a set amount of money that is set aside to deal with project uncertainties. It can also be in the form of time where time provision is made to grant the contractor extension of time in the event of risk events occurring.
8. Risk acceptance / retention – Used as a last resort when other techniques are not feasible or when risk probability is small coupled with acceptable effects. In other words, the accepted risks cannot be dealt with, however, their acknowledgement and documentation are essential. Consequently, this technique involves inaction unless the risk and its consequences occur.

### 2.7.5 Risk Control

Risk control is the iterative process of employing risk response strategies, active and residual risk tracking, re-identification of risks and overall evaluation of the risk management process (PMI, 2013). Essentially, this stage encompasses monitoring and evaluation of the overall risk management process (Gajewska and Ropel, 2011). Risk control is important because as the project progresses, new information becomes available and changes occur in terms of project risks (Mehdizadeh, 2012).

According to Choudhry and Iqbal (2013) risk control can be achieved through incident inspection and regular audits. El-Sayegh (2014) also identified updating risk registers and holding regular risk meetings as common risk control tools in construction companies. Despite these techniques alluded to, Renault, Agumba and Ansary (2016) stress that risk control is basically an ongoing process of revisiting the entire risk management process and ensuring that it is still relevant to the prevailing project characteristics.  It is against this backdrop that the study has opted to place less emphasis on risk control and not explore the techniques associated with it.

## 2.8 Barriers to risk management implementation

Barriers to risk management implementation can be attributed to individual biases and cultural norms since risk management actions are ultimately made by individuals who are inevitably influenced by the environment they operate in (Harner, 2010). Similarly, Rostami et al. (2015) attribute barriers to the personnel involved, organisational characteristics and comprehension of the risk management process itself. In terms of their classification, barriers to risk management implementation may be identified by their source, that is, from an organisational or environmental context (Abed, 2018). Needless to say, it is important to note that failure to identify and eradicate barriers to risk management practices implementation will result in project failure (Dandage et al., 2018).

Chileshe and Kikwasi (2014) trace the dearth of risk management in Sub-Saharan Africa to a lack of appreciation of the barriers that hinder effective risk management implementation. They contend that an understanding of barriers to risk management implementation precedes effective implementation of risk management. Therefore, identifying and understanding barriers to risk management implementation assists management in coming up with the necessary, enabling strategic and operational responses (Renault, Agumba and Balogun, 2016).

While Kim and Bejaj (2000) conducted research on risk management practices implementation barriers peculiar to contractors, more crosscutting research has been conducted based on the perceptions of the various key project participants (contractors; consultants; clients) for example,  Tang et al. (2007), Hwang et al. (2014)

and El-Sayegh (2014) amongst others. Table 2.1 indicates the various barriers to risk management implementation identified by various authors in different environments.

*Table 2.1: Summary of barriers to risk management implementation*

| | Tang et al. (2007) | Azhar et al. (2008) | Hlaing et al. (2008) | Choudhry and Iqbal (2013) | Hwang et al. (2014) | El-Sayegh (2014) | Rostami et al. (2015) |
|---|---|---|---|---|---|---|---|
| Low profit margins | | X | | | X | X | |
| Lack of qualified personnel to implement risk management | X | X | X | X | X | | X |
| Inadequate training on risk management | | X | X | | X | | |
| Lack of clear risk management implementation plan | X | | | X | | X | X |
| Insufficient resources | | X | X | | X | | X |
| Unsupportive organisational culture to risk management | X | X | X | | | | X |
| Difficulties in quantifying risks | | X | X | | | X | |
| Lack of commitment of senior management and the board | | X | | | | X | X |
| Lack of time | | X | | | X | | X |

A brief description of the barriers outlined in Table 2.1 are as follows:

1. Low profit margins – The costs related to risk management implementation do not justify its use especially in smaller projects where profit margins are relatively small (Hwang et al., 2014).
2. Lack of qualified personnel to implement risk management – There is a significant dearth of risk management knowledge and experience amongst construction industry practitioners (Azhar et al., 2008; El-Sayegh, 2014).

3. Inadequate training on risk management – There is no motivation to conduct formal risk management training among construction company personnel (Azhar et al., 2008).
4. Unsupportive organisational culture to risk management – Organisations are largely unable to support investment in risk management due to a lack of capacity (Rostami et al., 2015).
5. Lack of clear risk management plan – Construction practitioners are not only unaware of the risk management plans within their organisations, but also do not see the relevance for such (Choudhry and Iqbal, 2013).
6. Insufficient resources – Hwang et al. (2014) found that investments in risk management compete with a range of other operational expenses that are deemed to be more important in construction organisations.
7. Difficulties in quantifying risks – This is attributed to the level of risk management skill possessed by construction personnel thus they perceive quantifying risk to be a difficult exercise (Azhar et al., 2008; El-Sayegh, 2014).
8. Lack of commitment from senior management and the board – Azhar et al. (2008) view that the lack of formal training for risk management amongst top management results in their lack of appreciation of its benefits thus resulting in a negative organisational culture to risk management practice.
9. Lack of time – Many project managers feel that risk management requires a lot of time and effort and thus they will seek to bypass while pushing to meet project objectives (El-Sayegh, 2014).

## 2.9 Risk management knowledge

Marshall et al. (1996) attributed risk management failure to dysfunctional organisational culture, ineffective internal controls, and the lack of management of organizational knowledge. Therefore, in the context of risk management at organisational level, knowledge is applicable in the quest to control deviations from objectives, enhancing shareholder value and alignment of stakeholder relationships (Rodriguez and Edwards, 2008). Even at project level, effective risk management requires a well-defined methodology and most importantly, experience and knowledge (Serpella, Ferrada, Howard, et al., 2014).

Knowledge is information held in the mind and relates to facts, ideas, judgement, concepts and interpretations (Alavi and Leidner, 2001) and is information in use (Jafari et al., 2011). On the other hand, knowledge management is the interaction of two types of knowledge, tacit and explicit knowledge (Rodriguez and Edwards, 2008). Tacit knowledge is represented by beliefs, experience and skills accumulated while explicit knowledge refers to the knowledge expressed in codified formats such as documents and data. Effectively, knowledge management involves the creation, storage and utilisation of knowledge to achieve success at organisational and project levels (Serpella, Ferrada, Howard, et al., 2014).

Massingham (2010) put forward a proposition that introduces concepts of knowledge management to risk management. Herein, they opine that the introduction of knowledge management principles such as consideration of the individual decision makers results in better risk management decision making competency. For instance, risk related knowledge gained from past projects is useful in future risk management and such data can only be useful in the presence of adequate knowledge management systems (Cárdenas et al., 2013).

However, despite the importance of knowledge management in risk management, there is still limited usage of risk management tools and techniques due to a lack of data thus resulting in low risk management maturity in construction companies (Jepson et al., 2020). Risk maturity of an organisation reflects the level of organisational understanding of risks, the risk management competency and the level interaction between the risk management systems and the entire business operation (Zou et al., 2010).

Serpella, Ferrada, Howard, et al. (2014) concluded that risk management in construction companies is not only ineffective due to a lack of risk management knowledge but also due to the absence of knowledge management of the limited risk management capacity held within the organisations.

## 2.10 Risk management approaches

There is a need to develop formal approaches to cater for different contexts where risk is an issue (Verbano and Venturini, 2011). A systematic risk management approach provides a framework of finding, assessing and responding to risks (Mills, 2001; Rashed, 2005). To address the informality that is prevalent in construction risk management practice, there has been development of various instruments such as Project Risk Analysis and Management (PRAM) and Risk Analysis and Management for Projects (RAMP) (Tah and Carr, 2001).

Mills (2001) asserts that formal risk management approaches are largely practiced instinctively without written procedures. This becomes a challenge considering that construction professionals are expected to possess an ability to balance risk contingencies with specific contractual, financial and operational requirements (Sharma and Swain, 2011) thus resulting in inconsistent results.

Various risk management approaches have been proposed to tackle the problem of informal risk management. For instance, Kartam and Kartam (2001) proposed two approaches to guide risk management implementation, preventive, aimed at early project stages , and mitigative, aimed at risk minimization during project execution. Zou et al. (2008) also proposed a risk management approach based on the lifecycle of the project. Dey (2009) proposed a risk management approach to guide successful implementation of large-scale projects.

In coming up with the various risk management approach proposals, the above-mentioned authors report a lack of a formal approach in their respective focus areas resulting in construction practitioners applying informal, harp-hazard risk management practices in their respective projects.

### 2.11 Risk severity and risk management techniques

Various risk management techniques are used in present-day projects, however, the selection and application of techniques depends on project features such as the severity of anticipated risks (Dey and Ogunlana, 2004). Risk severity represents the outcome generated from a risk event (Koh et al., 2007) thus it reflects the seriousness of the risk (Abdelgawad and Fayek, 2010). Steps towards the effective determination of risk severity should commence early on at project planning phase to enable selection of relevant risk management techniques (Nieto-Morote and Ruz-Vila, 2011).

While there are many risk management techniques available, construction practitioners are notorious for relying and focusing on a small number of techniques they are familiar with and not necessarily because they are appropriate for the situation at hand (Forbes et al., 2008). Furthermore, as a result of a lack of knowledge in adequate selection of risk management tools practitioners fail to identify, analyse and respond to risks in a coherent and effective manner (Goh et al., 2013).

According to Amoatey and Danquah (2018) poor risk management competency results from a lack of risk severity knowledge thus organisations are unable to adequately counter risks ultimately leading to project failure. Equally, the lack of competency introduces decision making challenges to the construction practitioners (Thaheem et al., 2012). The organisational risk management maturity can thus be established through the evaluation of the level of usage of risk management techniques by its personnel (Oliva, 2016).

In a bid to bring uniformity to organisational risk management, Carbonara et al. (2015) introduced a systematic approach to risk management that enables the determination risk severity and establishment of a risk allocation scheme based on the type of project in question. This also means chances of adequate risk management techniques implementation are enhanced when the skills to determine risk severity are available (Ehsan et al., 2010). However, it has been found that contractors normally apply risk management aligned processes during construction hence a dearth in systematic risk management techniques implementation (Reddy, 2015).

## 2.12 Chapter Summary

In this chapter, various literature on risk management and its application in the construction industry has been extensively reviewed. In the next chapter, the research methodology will be presented.

# CHAPTER 3: RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter presents, discusses, and justifies the research strategy used in the study. Critical areas of research approach, population, data collection and analysis methods are presented.

## 3.2 Research approach

In the quest to investigate the risk management practices prevalent in South African construction, the research adopted the quantitative methodology as being the most appropriate for the endeavour. Quantitative research methodology was deemed appropriate as it enables the examining of relationships among variables (Creswell, 2014).

Quantitative research involves the collection of numerical data and the application of statistical procedures to observe certain phenomenon and thus leading to informed conclusions (Sukamolson, 2007). The quantitative research approach is related to the positivist approach (Creswell, 2014) which is premised on the assumption that full understanding of phenomenon can be obtained from experiment and observation (Ryan, 2006).

Sukamolson (2007) outlines the four types of quantitative research approach as survey, correlational, experimental, and causal-comparative research. This research takes the form of a survey type of quantitative research and employs the use of a cross-sectional survey that uses a questionnaire to obtain data from respondents. Survey type research is appropriate for the study because it enables the establishment of results for the entire population based on a sample (Creswell, 2014). Subsequently, various quantitative statistical analysis methods are employed to enable the making of informed conclusions about the research topic.

## 3.3 Study population, Sampling Technique and Sample size

This section outlines the population, sampling technique and sample size used in the study.

### 3.3.1 Study population

The research targeted all cidb registered construction companies operating in the entirety of South Africa. According to CIDB (2019), there are 51,513 cidb registered contractors. Within these companies, personnel with direct involvement in project execution was sought.

*Table 3.1: cidb summary of contractors grading*

| Grading designation | Number of contractors |
|---|---|
| 1 | 43 580 |
| 2 | 2 768 |
| 3 | 1 178 |
| 4 | 1 429 |
| 5 | 740 |
| 6 | 904 |
| 7 | 578 |
| 8 | 251 |
| 9 | 85 |
| **Total** | **51 513** |

Source: CIDB (2019)

### 3.3.2 Sampling technique and sample size

The research targeted all companies registered on the cidb register of contractors operating in South Africa. Companies were to be selected using random sampling technique based on the register. However, collecting information from the entire population is virtually impossible and Czaja and Blair (1996) cited by Ankrah (2007) proposed the determination of minimum sample size using a non-response bias method shown in Equation 1.

$$ss = \frac{z^2 \times p(1-p)}{c^2} \qquad \text{Equation 1}$$

Where:

$ss$ = sample size

$z$ = standard variable

$p$ = percentage picking a choice, expressed as a decimal

$c$ = confidence interval, expressed as a decimal

Equation 1 assists in the determination of sample size and its effectiveness is dependent on the required degree of accuracy and confidence level. According to Ankrah (2007) a 95% confidence level is appropriate for construction related research with significant level, a = 0.05; z = 1.96 and a confidence interval, c of ±10%. According to Czaja and Blair (1996) cited by Ankrah (2007), to determine the sample size for a defined level of accuracy, the worst case percentage picking a choice (p) should be assumed. In the research, it was assumed to be at 50%.

$$ss = \frac{1.96^2 \times 0.5(1-0.5)}{0.1^2}$$

$$ss = 96.04$$

The results obtained show that the required sample size is 96 contractors. However, the figure requires correction for defined populations, in this research, it is the total number of contractors on the cidb register.  The formula for the new sample size is given by Czaja and Blair (1996) cited by Ankrah (2007) as shown in Equation 2.

$$new\ ss = \frac{ss}{1+\frac{ss-1}{pop}} \qquad \text{Equation 2}$$

Where:

$pop$ = population

$$new\ ss = \frac{96.04}{1+\frac{96.04-1}{51513}}$$

$$new\ ss = 95.86$$

The sample size remains 96 contractors. However, the construction industry is known for poor response to questionnaire surveys which normally ranges from 10 – 70% (Odediran, 2016). Considering this, the study sought to adjust the sample size to account for the high incidence of non-response. Thus, a modest response rate of 15% was assumed and thus the new sample size was determined in Equation 3.

$$survey\ ss = \frac{new\ ss}{response\ rate} \qquad \text{Equation 3}$$

$$survey\ ss = \frac{96}{0.15} = 640\ contractors$$

Upon establishment of the sample size, a random list of 640 contractors was selected from the cidb contractors register.

## 3.4 Methods of data collection

The research was of a quantitative nature and quantitative research takes two forms, it is either survey or experimental research (Creswell, 2014). This research was a survey type of quantitative research since it involved a cross-sectional survey that adopts the use of an online questionnaire to obtain primary, raw data. Survey type research allows for data collection from a sample with the intention of generalizing the sample data to a population (Creswell, 2014).

### 3.4.1 Questionnaire design

The questionnaire was designed in a way that enabled the meeting of project objectives. Questions in the questionnaire where direct and to the point. Proper design of the questionnaire is fundamental for meeting project objectives and thus enabling overall research success (Hong, 2002). The questionnaire contained five sections as shown in Appendix B.

The first section of the questionnaire contained personal general questions such as job title, academic qualifications held and years of experience in construction. Respondents also had to indicate certain information about their organisations such as the cidb rating, the company’s area of specialisation and the turnover generated in the preceding year. This data enabled the obtaining of a general idea of the characteristics of individuals and companies participating in the survey.

The second section sought to not only to establish the level of risk management knowledge held by the respondents but the level of knowledge they perceive of their work colleagues. It also sought to establish the risk management culture in organisations by asking whether the organisations had formal risk management procedures in place or not.

As the research sough to identify risks and their severity, the third section was aimed at achieving this objective. First, it presented the respondents with a list of risks and requested them to highlight their likelihood of occurrence. Consequently, the respondents had to highlight the impact of such risk events occurring. Obtaining the likelihood of occurrence and impact of a risk would thus lead to the establishment the severity of the said risks.

To establish the risk management techniques in use amongst companies, techniques where categorised per risk management process, that is, lists of risk identification techniques, risk assessment techniques and risk response techniques were presented to the respondents. From these lists, the respondents would indicate their level of usage of each of the techniques.

Finally, the last section sought to show the barriers to risk management practices in companies. Herein, a list of perceived barriers was put forward to the respondents and they were required to indicate their level of agreement to these barriers.

### 3.4.2 Questionnaire administration and collection

Initially, the questionnaire was sent to the supervisor for approval. Upon receipt of the approval, ethics clearance was subsequently sought. Upon receipt of ethics clearance, the questionnaire was sent out to the respondents via an email containing a link to the online questionnaire. The link to the questionnaire would direct the respondent to the Survey Monkey platform used in the research. The questionnaire was accompanied by a cover letter (Appendix B). The cover letter is a crucial part of the questionnaire that provides the respondent with an introduction while serving as a tool to encourage participation in the survey (King et al., 2001).

Despite online questionnaire surveys being normally characterised by low response rates, they offer more benefits in respect of their low cost, direct analysis and a wider reach to respondents irrespective of geographic location (Odediran, 2016).

Additionally, they also offer an easy-to-use platform to remind potential respondents to participate in the research. Accordingly, the researcher took advantage of this tool and had to constantly send reminders to the selected contractors to encourage participation. Data were collected over a period of 8 weeks, that is from June 2020 to August 2020.

### 3.4.3 Response rate

Questionnaires were sent to an estimated 640 potential respondents. However, at the end of the survey, the researcher received, 173 questionnaires with 78 questionnaires answered fully. The incomplete questionnaires where not set aside because certain respondents would answer certain important questions. For instance, a respondent might have answered the question on the risks they face but opted not to respond to the risk management techniques usage question. As such, in such a scenario, the data on the risks they encountered was deemed important and therefore considered. In terms of the total questionnaires received, the response rate was 27% which is considered acceptable considering previous research in construction risk by Xiaopeng and Pheng (2013) that achieved a response rate of 28.2%.

## 3.5 Types of data collected

Primary data was collected for the study. The same data subsequently underwent various statistical processes for results elucidation.

### 3.5.1 Nominal scales

Data obtained from the first section of the questionnaire was based on nominal scales. It fits in this category since it involved stating the answer amongst a set of predetermined responses or defined categories (Bhattacherjee, 2012). The major characteristic sought herein was the frequency as the study sought to determine characteristics of the respondents.

### 3.5.2 Likert scales

Data obtained from the rest of the questionnaire was based on Likert scales since it involved the rating of various aspects as posed to the respondents. Subsequent operations where conducted, for instance, to rank the outcomes for the results. Likert scales allow for greater distribution of results since they offer a broad spectrum of response choices (Bhattacherjee, 2012).

## 3.6 Methods of Data Analysis

Since the research was quantitative, data was analysed using both descriptive and inferential statistics such as the Mean Item Score (MIS) and scatter plots to study the relationships between variables.

### 3.6.1 Mean Item Score

The MIS was used to obtain ranking for the various aspects that were being researched. It was determined using the formula below adopted from Windapo and Martins (2010).

$$MIS = \frac{5M_5 + 4M_4 + 3M_3 + 2M_2 + 1M_1}{5\,(M_5 + M_4 + M_3 + M_2 + M_1)}$$

Where $M_5$, $M_4$, $M_3$, $M_2$, and $M_1$ are the frequencies of the rating responses allocated to each risk factor.

### 3.6.2 Determination of Risk Severity

*Table 3.2: Categorisation of risk severity*

| Risk severity scale | Rank |
|---|---|
| >0.20 | Extremely low severity |
| 0.20 – 0.40 | Low severity |
| 0.40 – 0.60 | Moderate severity |
| 0.60 – 0.80 | High severity |
| 0.80 – 1.00 | Extremely high severity |

Source: PMI (2013)

Upon establishing the likelihood and impact of risk events, the risk severity was subsequently determined using the formula severity = likelihood x impact (El-Sayegh, 2008). The determination of the risk severity allows for risk ranking thus enabling the importance of each risk to be established (El-Sayegh, 2008). Further categorisation of risk severity was conducted based on PMI (2013) and is shown in Table 3.2.

### 3.6.3 Spearman Rho Method of Data Analysis

The study also made use of data to produce scatter plots to establish the relationships between severity of the risks encountered by the contractors and the risk management techniques used. The Spearman Rho statistical analysis technique was used in testing the hypothesis stated to guide the direction of the study and confirm the significance of the results of the Scatterplots. The formula to determine Spearman Rho coefficient, $r_s$ was adopted from Ramsey (1989).

$$r_s = 1 - \frac{6\sum d^2}{N^3 - N}$$

Where:

$r_s$ = the Spearman Rho coefficient.

$d^2$ = difference between the rankings of the X-Y variables

$N$ = Number of items

To test for significance, the significant level of p = 0.05 was chosen.

## 3.7 Validity and reliability

To enhance the validity of the research, the data collection instrument was thoroughly checked by the researcher and supervisor to confirm its suitability to answer the research questions. The wide range of response characteristics indicates the suitability of the sample size determination thus further enhancing validity of the research. Furthermore, the research obtained data from experienced personnel whose extensive experience assists in validating the research findings.

The Cronbach's alpha was used to measure reliability of data. This is because it is a suitable tool to demonstrate that tests and scales used in research are fit for purpose (Taber, 2018). In this research, Cronbach's alpha was used to determine the internal consistency of the Likert scale scores used. Reliability results are summarised in Table 3.3.

*Table 3.3: Summary of Reliability Results for Various Scales*

| Scale | Cronbach's alpha | Mean | Standard deviation |
|---|---|---|---|
| Risk severity | 0.713 | 0.65 | 0.197 |
| Risk identification | 0.876 | 0.83 | 0.144 |
| Risk assessment | 0.747 | 0.72 | 0.193 |
| Risk response | 0.832 | 0.81 | 0.227 |

According to Taber (2018), Cronbach alpha value is considered sufficient if it has a minimum value of 0.50. Table 4 shows that each of the examined questionnaire elements of risk severity, risk identification, risk assessment and risk assessment possess a Cronbach's alpha value greater than 0.70. Taber (2018) regards such values as high, thus signifying high reliability of the collected data.

## 3.8 Ethical considerations

Ethics clearance was sought before embarking on the research. The approved Ethics clearance form is in Appendix A. In full consideration of the competitive nature of the construction industry and the sensitivity of company information received, high confidentiality was maintained throughout the research. To enhance confidence in the respondents, a detailed cover letter was attached to the questionnaire. In the cover letter, the respondents were introduced to the researcher and provided with a brief outline of the research objectives. This was done to further entrench confidence in the respondents.

Various ethical considerations were stated in the cover letter (See Appendix A). For instance, potential respondents were notified that participation in the survey was voluntary and they could withdraw at any point during the survey. In addition, the anonymity of respondents was guaranteed.

In the analysis, there is no reference to the identity of any of the participants thus upholding the ethical considerations. Furthermore, the appendix documents submitted herein also do not refer to the identities of the participants. In conclusion, data obtained in the research has been kept securely and no access has been granted to third parties.

## 3.9 Chapter Summary

This chapter presented the research methodology used in the study. It outlines and justifies the approach that was used in determining the various tools used to collect and analyse data.

The research approach employed was of a quantitative nature that employed the use of a cross-sectional research design using a questionnaire that was distributed electronically amongst a list of randomly selected respondents from the cidb Register of Contractors. Furthermore, the overall data collection was done in line with approved ethical considerations.

# CHAPTER 4: DATA ANALYSIS

## 4.1 Introduction

The research findings presented herein are based on the outcomes of the questionnaire survey conducted amongst participating construction companies, represented by individuals in their employ. The chapter is presented as follows: a summary of individual and organisation demographics; outcomes of the survey; and finally, a detailed discussion of the research findings.

## 4.2 Presentation of findings

This section comprises the research findings in respect of individual and organisational profiles, the risks encountered in construction and the risk management techniques used to address them.

### 4.2.1 Background profile of the respondents

The research sought to establish personal characteristics of respondents, such as job title, number of years of construction experience and highest academic qualification obtained. As shown in Table 4.1, the majority of respondents held positions with influence over risk management decisions made within their respective organisations. Notably, 53% of respondents held the title of Managing Director within their respective organisations. Other influential positions held by respondents include Project and Contract Managers, encompassing 15% and 11% of respondents respectively. Respondents who selected "Other" indicated varying job titles, such as Health and Safety Officer, Business Development Manager, and Finance and Human Resources Manager.

Of the respondents, 56% had more than ten years' direct experience in construction. Additionally, in terms of academic qualifications, 69% of them held a diploma as their minimum qualification. This level of experience and academic exposure enhances confidence in the research findings, as respondents are clearly knowledgeable in construction, given their extensive experience and academic backgrounds.

*Table 4.1: Background profile of the respondents*

| Category | Respondents | |
|---|---|---|
| | Number | Percentage |
| **Job title** | | |
| Project Manager | 26 | 15.03% |
| Contract Manager | 20 | 11.56% |
| Managing Director | 90 | 52.02% |
| Technical/Operations Manager | 2 | 1.15% |
| Commercial Manager / Quantity Surveyor/Estimator | 6 | 3.47% |
| Site Engineer / Agent | 4 | 2.31% |
| Other | 25 | 14.50% |
| | | |
| **Years of experience** | | |
| 1 – 5 years | 18 | 10.40% |
| 6 – 10 years | 58 | 33.53% |
| 11 – 20 years | 74 | 42.77% |
| 21 – 30 years | 13 | 7.51% |
| Over 30 years | 10 | 5.78% |
| | | |
| **Highest academic qualification** | | |
| Higher certificate | 54 | 31.21% |
| National diploma | 61 | 35.26% |
| Bachelor's degree | 28 | 16.18% |
| Honours degree | 21 | 12.14% |
| Master's degree | 8 | 4.62% |
| Doctoral degree | 1 | 0.58% |

### 4.2.2 Organisational profiles

The study sought to obtain data on the respective organisations of the respondents. This was essential to identify the risk management practices prevalent in construction companies. Thus, the characteristics of participating organisations had to be established. As depicted in Table 4.2, 88% of respondents' organisations are in the building and civil engineering sub-sectors.

*Table 4.2: Organisational profiles*

| **Category** | **Respondents** | |
|---|---|---|
| | **Number** | **Percentage** |
| **Area of specialisation** | | |
| Specialist works | 8 | 4.62% |
| Mechanical engineering | 2 | 1.16% |
| Electrical engineering | 10 | 5.78% |
| Building and civil construction | 49 | 28.32% |
| Civil engineering | 51 | 29.47% |
| Building construction | 53 | 30.64% |
| | | |
| **Head office location** | | |
| North West | 4 | 2.31% |
| Limpopo | 8 | 4.62% |
| Northern Cape | 12 | 6.94% |
| Free State | 14 | 8.09% |
| Kwazulu Natal | 24 | 13.88% |
| Eastern Cape | 25 | 14.45% |
| Mpumalanga | 26 | 15.03% |
| Gauteng | 29 | 16.76% |
| Western Cape | 31 | 17.92% |
| | | |
| **cidb Rating** | | |
| Grade 9 | 6 | 3.46% |
| Grade 8 | 11 | 6.36% |
| Grade 7 | 27 | 15.60% |
| Grade 1 - 6 | 129 | 74.58% |
| | | |
| **Annual turnover** | | |
| Over R1 billion | 1 | 0.57% |
| R500 million – R1 billion | 0 | 0.00% |
| R170 million – R500 million | 2 | 1.16% |
| R75 million – R170 million | 15 | 8.67% |
| R10 million – R75 million | 43 | 24.86% |
| Less than R10 million | 112 | 64.74% |

Furthermore, Table 4.2 shows that the geographical spread of head office locations covers the entire country. Economic centres such as the Western Cape (17.92%), Gauteng (16.76%) and Kwazulu Natal (13.88%) are well represented as there is a larger number of companies located in these provinces. Table 4.2 also shows that 75% of the organisations of the respondents are in the cidb grades 1 to 6 categories. In terms of turnover generated in the preceding year, 64.74% of participating organisations generated an annual turnover of less than R10Million, signifying slow activity in the construction industry.

### 4.2.3 Risk management knowledge and implementation

The research sought to establish the level of knowledge on the concept of risk management at personal and organisational level. Regarding this enquiry, Table 4.3 shows that 42% of respondents indicated that their organisations have a formal written risk management procedure. The rest practice risk management in a haphazard, unregulated manner. Table 4.4 shows that on a personal level, 88% of the respondents indicated an average to very good appreciation of the general concept of risk management. Furthermore, at organisational level, 83% of respondents also indicated that their work peers held an above average understanding of the concept of risk management.

*Table 4.3: Organisational risk management practices implementation*

| | **Frequency** | **Percentage** |
|---|---|---|
| Implement risk management with formal written procedure | 72 | 41.60% |
| Implement risk management without formal written procedure | 101 | 58.40% |

*Table 4.4: Respondents' appreciation of risk management*

| | **1 Very Poor** | **2 Poor** | **3 Average** | **4 Good** | **5 Very Good** |
|---|---|---|---|---|---|
| How do you rate your appreciation of the concept of risk management? | 5 | 9 | 35 | 33 | 38 |

As shown in Table 4.5, even at organisation level, risk management is perceived by the respondents as a concept that the majority of construction company personnel are familiar with.

*Table 4.5: Respondents' co-workers' appreciation of risk management*

| | 1<br>Very Poor | 2<br>Poor | 3<br>Average | 4<br>Good | 5<br>Very Good |
|---|---|---|---|---|---|
| How do you rate your work colleagues' appreciation of the concept of risk management? | 8 | 12 | 37 | 35 | 28 |

### 4.2.4 Risks encountered in construction

Respondents were asked to indicate the likelihood of occurrence of risk events prevalent in a particular construction project they recently executed. Broadly, risks were listed under various categories namely economic, political, social, environmental, procurement, design and construction related risks. Results of the risks encountered by respondents are shown in Table 4.6.

*Table 4.6: Risk Likelihood of Occurrence*

| Risk event | 1 – Unlikely | 2 – Seldom | 3 – Occasionally | 4 - Likely | 5 – Highly likely | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| High competition in bids | 7 | 9 | 19 | 28 | 47 | 0.7800 | 1 |
| Payment delays | 10 | 15 | 14 | 36 | 44 | 0.7496 | 2 |
| Political instability | 14 | 12 | 19 | 27 | 42 | 0.7246 | 3 |
| Bureaucracy of local / national government agencies | 11 | 14 | 26 | 30 | 38 | 0.7176 | 4 |
| Price inflation | 10 | 8 | 30 | 46 | 25 | 0.7143 | 5 |
| Project funding problems | 16 | 14 | 21 | 30 | 40 | 0.7058 | 6 |
| Corruption / Bribery | 24 | 13 | 11 | 17 | 53 | 0.7051 | 7 |
| Biased procurement policies | 11 | 17 | 23 | 25 | 36 | 0.7036 | 8 |
| Criminal acts (theft/vandalism) | 8 | 19 | 27 | 29 | 32 | 0.7009 | 9 |
| Payment risk | 13 | 14 | 22 | 43 | 28 | 0.6983 | 10 |

| Risk event | 1 – Unlikely | 2 – Seldom | 3 – Occasion ally | 4 - Likely | 5 – Highly likely | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Working in politically sensitive / dangerous areas | 14 | 17 | 27 | 23 | 38 | 0.6908 | 11 |
| Excessive procedures of government approvals / permits | 11 | 11 | 37 | 37 | 24 | 0.6867 | 12 |
| Societal unrest / disorder (strikes/riots) | 16 | 19 | 23 | 23 | 35 | 0.6724 | 13 |
| Biases in bidding process | 14 | 22 | 23 | 15 | 34 | 0.6611 | 14 |
| Cost and time overruns | 13 | 16 | 25 | 45 | 15 | 0.6579 | 15 |
| Inadequate social infrastructure / facilities (power, communication, roads) | 10 | 19 | 33 | 33 | 19 | 0.6561 | 16 |
| Tight project schedule | 13 | 20 | 25 | 41 | 17 | 0.6500 | 17 |
| Lack of judicial reinforcement | 23 | 20 | 13 | 30 | 30 | 0.6414 | 18 |
| Low management competency of subcontractors | 17 | 18 | 26 | 33 | 21 | 0.6400 | 19 |
| Inadequate forecast about market demand | 13 | 18 | 17 | 20 | 19 | 0.6360 | 20 |
| Poor communication between parties | 15 | 22 | 38 | 23 | 17 | 0.6087 | 21 |
| Unstable interest rates | 15 | 29 | 26 | 33 | 14 | 0.6034 | 22 |
| Adverse weather conditions | 19 | 17 | 41 | 29 | 12 | 0.5966 | 23 |
| Stringent environmental protection by government bodies | 14 | 27 | 40 | 30 | 10 | 0.5917 | 24 |
| Poor wellbeing of employees | 15 | 25 | 37 | 30 | 10 | 0.5915 | 25 |
| Exchange rate fluctuation | 23 | 21 | 32 | 27 | 17 | 0.5900 | 26 |
| Unavailability of sufficiently skilled professionals and managers | 22 | 19 | 35 | 27 | 14 | 0.5863 | 27 |
| Suppliers incompetence to | 18 | 22 | 32 | 29 | 10 | 0.5838 | 28 |

| Risk event | 1 – Unlikely | 2 – Seldom | 3 – Occasionally | 4 - Likely | 5 – Highly likely | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| deliver materials on time | | | | | | | |
| Inadequate site information | 21 | 22 | 34 | 28 | 12 | 0.5795 | 29 |
| Incomplete or inaccurate cost estimates | 26 | 26 | 28 | 23 | 18 | 0.5686 | 30 |
| Lack of design co-ordination among design professionals and clients | 22 | 31 | 23 | 24 | 16 | 0.5672 | 31 |
| Low construction productivity | 22 | 26 | 26 | 27 | 12 | 0.5664 | 32 |
| Unavailability of materials | 15 | 33 | 32 | 22 | 10 | 0.5625 | 33 |
| Frequent design variations | 18 | 33 | 27 | 27 | 9 | 0.5579 | 34 |
| Difficulty to access site | 19 | 34 | 31 | 24 | 11 | 0.5563 | 35 |
| Legal disputes | 24 | 30 | 26 | 18 | 16 | 0.5509 | 36 |
| Undocumented design variations | 25 | 26 | 28 | 23 | 12 | 0.5491 | 37 |
| Inaccurate project program | 25 | 37 | 19 | 28 | 10 | 0.5491 | 37 |
| Equipment / property / materials damage | 20 | 30 | 32 | 22 | 9 | 0.5469 | 39 |
| Unavailability of quality materials | 21 | 30 | 31 | 24 | 8 | 0.5439 | 40 |
| Incomplete design information | 23 | 30 | 29 | 23 | 9 | 0.5386 | 41 |
| Complex construction projects / methods | 21 | 30 | 34 | 20 | 8 | 0.5363 | 42 |
| Defective design | 20 | 34 | 32 | 17 | 10 | 0.5345 | 43 |
| Expropriation (threat of business takeover by other agencies) | 40 | 22 | 20 | 13 | 22 | 0.5231 | 44 |
| Absence of fire systems on site | 35 | 27 | 21 | 23 | 10 | 0.5069 | 45 |
| On site accidents | 27 | 34 | 29 | 17 | 6 | 0.4956 | 46 |
| Environmental factors (floods, earthquakes) | 45 | 26 | 22 | 14 | 10 | 0.4598 | 47 |
| Prosecution due to unlawful disposal of construction waste | 47 | 28 | 21 | 14 | 8 | 0.441 | 48 |

It can be seen from a ranking perspective that the top five prevalent risks are: high competition in bids (MIS = 0.7800), payment delays (MIS = 0.7496), political instability (MIS = 0.7246), bureaucracy of local/national government agencies (MIS = 0.7176) and price inflation (MIS = 0.7146). By contrast, the risks with the least likelihood of occurrence include prosecution due to unlawful disposal of construction waste (MIS = 0.441), environmental factors such as floods and earthquakes (MIS = 0.4598), on-site accidents (MIS = 0.4956), the absence of fire systems on site (MIS = 0.5069) and expropriation, resulting in the forceful takeover of a business by other agencies (MIS = 0.5231).

Additionally, the study sought to establish the impact of occurrence of risk events. Table 4.7 shows that from a ranking perspective, the respondents perceived that the top five risk events that have a high impact on occurrence are; high competition in bids (MIS = 0.8192), corruption and bribery (MIS = 0.7919), political instability (MIS = 0.7811), bureaucracy of local/national government agencies (MIS = 0.7627) and payment delays (MIS = 0.7494). Risk events posing the least impact upon occurrence include the absence of fire systems on site (MIS = 0.4693), environmental factors such as floods and earthquakes (MIS = 0.4730), on-site accidents (MIS = 0.4795), prosecution due to the unlawful disposal of construction waste (MIS = 0.5093) and damage to equipment/ property, or materials damage (MIS = 0.5378).

*Table 4.7: Risk Impact of Occurrence*

| Risk event | 1 – Very Low | 2 – Low | 3 – Moderate | 4 - High | 5 – Very High | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| High competition in bids | 2 | 2 | 16 | 20 | 33 | 0.8192 | 1 |
| Corruption / Bribery | 6 | 8 | 8 | 13 | 39 | 0.7919 | 2 |
| Political instability | 2 | 8 | 15 | 19 | 30 | 0.7811 | 3 |
| Bureaucracy of local / national government agencies | 3 | 9 | 14 | 22 | 27 | 0.7627 | 4 |
| Payment delays | 4 | 9 | 17 | 22 | 27 | 0.7494 | 5 |
| Biased procurement policies | 3 | 9 | 19 | 16 | 26 | 0.7452 | 6 |
| Working in politically sensitive / dangerous areas | 4 | 14 | 11 | 16 | 29 | 0.7405 | 7 |
| Criminal acts (theft/ vandalism) | 8 | 9 | 9 | 22 | 27 | 0.7360 | 8 |

| Risk event | 1 – Very Low | 2 – Low | 3 – Moderate | 4 - High | 5 – Very High | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Project funding problems | 8 | 6 | 14 | 24 | 25 | 0.7351 | 9 |
| Payment risk | 5 | 12 | 10 | 30 | 23 | 0.7350 | 10 |
| Excessive procedures of government approvals / permits | 4 | 10 | 19 | 24 | 18 | 0.7120 | 11 |
| Biases in bidding process | 7 | 11 | 17 | 13 | 24 | 0.7000 | 12 |
| Societal unrest / disorder (strikes/riots) | 11 | 7 | 16 | 17 | 24 | 0.6960 | 13 |
| Price inflation | 6 | 6 | 24 | 31 | 12 | 0.6937 | 14 |
| Inadequate forecast about market demand | 7 | 7 | 23 | 22 | 14 | 0.6795 | 15 |
| Lack of judicial reinforcement | 7 | 12 | 19 | 20 | 16 | 0.6703 | 16 |
| Low management competency of subcontractors | 8 | 14 | 16 | 18 | 17 | 0.6603 | 17 |
| Tight project schedule | 5 | 13 | 18 | 30 | 7 | 0.6575 | 18 |
| Cost and time overruns | 6 | 15 | 19 | 19 | 14 | 0.6548 | 19 |
| Incomplete or inaccurate cost estimates | 6 | 10 | 27 | 26 | 8 | 0.6519 | 20 |
| Inadequate social infrastructure / facilities (power, communication, roads) | 8 | 9 | 24 | 23 | 10 | 0.6486 | 21 |
| Legal disputes | 8 | 12 | 22 | 19 | 13 | 0.6459 | 22 |
| Stringent environmental protection by government bodies | 5 | 17 | 19 | 25 | 8 | 0.6378 | 23 |
| Poor communication between parties | 10 | 10 | 23 | 22 | 9 | 0.6270 | 24 |
| Unstable interest rates | 5 | 21 | 22 | 18 | 11 | 0.6234 | 25 |
| Inadequate site information | 5 | 18 | 26 | 17 | 9 | 0.6187 | 26 |
| Low construction productivity | 9 | 15 | 20 | 21 | 8 | 0.6110 | 27 |
| Exchange rate fluctuations | 8 | 18 | 22 | 23 | 7 | 0.6077 | 28 |

| Risk event | 1 – Very Low | 2 – Low | 3 – Moderate | 4 - High | 5 – Very High | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Poor wellbeing of employees | 8 | 18 | 21 | 20 | 8 | 0.6053 | 29 |
| Adverse weather conditions | 9 | 18 | 21 | 17 | 10 | 0.6027 | 30 |
| Expropriation (threat of business takeover by other agencies) | 13 | 15 | 19 | 15 | 13 | 0.6000 | 31 |
| Unavailability of sufficiently skilled professionals and managers | 11 | 15 | 22 | 16 | 9 | 0.5918 | 32 |
| Complex construction projects / methods | 6 | 18 | 27 | 18 | 4 | 0.5890 | 33 |
| Suppliers incompetence to deliver materials on time | 8 | 23 | 19 | 13 | 10 | 0.5836 | 34 |
| Lack of design co-ordination among design professionals and clients | 9 | 19 | 25 | 10 | 10 | 0.5808 | 35 |
| Incomplete design information | 11 | 19 | 20 | 15 | 9 | 0.5784 | 36 |
| Inaccurate project program | 8 | 20 | 24 | 12 | 8 | 0.5778 | 37 |
| Frequent design variations | 9 | 24 | 17 | 15 | 9 | 0.5757 | 38 |
| Defective design | 11 | 19 | 23 | 12 | 9 | 0.5703 | 39 |
| Undocumented design variations | 12 | 15 | 23 | 16 | 6 | 0.5694 | 40 |
| Unavailability of materials | 9 | 24 | 23 | 11 | 7 | 0.5541 | 41 |
| Unavailability of quality materials | 11 | 23 | 20 | 14 | 6 | 0.5486 | 42 |
| Difficulty to access site | 10 | 23 | 27 | 6 | 7 | 0.5440 | 43 |
| Equipment / property / materials damage | 11 | 26 | 18 | 13 | 6 | 0.5378 | 44 |
| Prosecution due to unlawful disposal of construction waste | 17 | 25 | 15 | 11 | 7 | 0.5093 | 45 |
| On site accidents | 14 | 30 | 19 | 6 | 4 | 0.4795 | 46 |
| Environmental factors (floods, earthquakes) | 20 | 28 | 13 | 5 | 8 | 0.4730 | 47 |
| Absence of fire systems on site | 21 | 25 | 16 | 8 | 5 | 0.4693 | 48 |

### 4.2.5 Risk identification techniques

The study sought to establish the level of use of risk identification techniques by the respondents on a scale of 1 to 5, where 1 is "never used" and 5 is "always used". It can be seen from Table 4.8 that the most used risk identification technique is past experience (MIS = 0.7549) followed by Risk checklist (MIS = 0.7277), Document reviews (MIS = 0.7101) and Brainstorming (MIS = 0.7014). The least used risk identification techniques are Delphi techniques (MIS = 0.5154), influence diagrams (MIS = 0.5634), expert systems (MIS = 0.5971) and questionnaires (MIS = 0.6028). Results of the usage of the risk identification techniques are presented in Table 4.8.

### 4.2.6 Risk assessment techniques

The study sought to establish the level of use of risk assessment techniques by the respondents on a scale of 1 to 5, where 1 is "never used" and 5 is "always used".

*Table 4.8: Ranking of frequency of use of risk identification techniques*

| **Risk identification technique** | **1 Never** | **2 Rarely** | **3 Some-times** | **4 Often** | **5 Always** | **Mean Item Score** | **Ranking** |
|---|---|---|---|---|---|---|---|
| Past experience | 3 | 11 | 13 | 16 | 28 | 0.7549 | 1 |
| Risk checklist | 5 | 6 | 20 | 20 | 21 | 0.7277 | 2 |
| Document reviews | 6 | 7 | 18 | 19 | 19 | 0.7101 | 3 |
| Brainstorming | 8 | 6 | 19 | 18 | 20 | 0.7014 | 4 |
| SWOT Analysis | 6 | 12 | 22 | 12 | 16 | 0.6588 | 5 |
| Interviews / Expert Opinion | 7 | 13 | 19 | 20 | 12 | 0.6479 | 6 |
| Flow charts | 5 | 16 | 18 | 20 | 11 | 0.6457 | 7 |
| Cause and effect diagrams | 8 | 14 | 24 | 10 | 13 | 0.6173 | 8 |
| Questionnaires | 8 | 19 | 18 | 16 | 10 | 0.6028 | 9 |
| Expert systems | 10 | 14 | 22 | 15 | 9 | 0.5971 | 10 |
| Influence diagrams | 14 | 17 | 18 | 12 | 10 | 0.5634 | 11 |
| Delphi technique | 19 | 14 | 22 | 10 | 6 | 0.5154 | 12 |

It can be seen from Table 4.9 that the most used risk assessment technique is "Probability and impact assessment" (MIS = 0.7117) followed by "Probability / impact rating matrix" (MIS = 0.6725) and "Risk categorization and risk urgency assessment" (MIS = 0.6725). The least used risk identification techniques are Probabilistic analysis

(Monte Carlo Simulation) (MIS = 0.5043), Decision trees (MIS = 0.5617) and Sensitivity analysis (MIS = 0.6347). Results of the usage of risk assessment techniques are presented in Table 4.9.

### 4.2.7 Risk response techniques

The study sought to establish the level of use of risk response techniques by the respondents on a scale of 1 to 5 where 1 is never used and 5 is always used. It can be seen from Table 4.10 that the most used risk response technique is Contingency plan (MIS = 0.7910) followed by Risk reduction/mitigation (MIS = 0.7536), Risk avoidance (MIS = 0.7749) and Risk acceptance (MIS = 0.7043).

*Table 4.9: Ranking of frequency of use of risk assessment techniques*

| Risk assessment technique | 1 Never | 2 Rarely | 3 Some-times | 4 Often | 5 Always | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Probability and impact assessment | 5 | 8 | 17 | 20 | 18 | 0.7117 | 1 |
| Probability / impact rating matrix | 8 | 9 | 20 | 14 | 18 | 0.6725 | 2 |
| Risk Categorization and Risk Urgency Assessment | 6 | 13 | 16 | 18 | 16 | 0.6725 | 2 |
| Expert Judgement | 10 | 11 | 16 | 17 | 13 | 0.6358 | 4 |
| Sensitivity analysis | 8 | 10 | 29 | 6 | 16 | 0.6347 | 5 |
| Decision trees | 13 | 17 | 17 | 12 | 9 | 0.5617 | 6 |
| Probabilistic analysis (Monte Carlo Simulation) | 19 | 17 | 18 | 8 | 7 | 0.5043 | 7 |

The least used risk response techniques are Risk enhancement (MIS = 0.6000), Risk exploitation (MIS = 0.6323), Risk sharing (MIS = 0.6695) and Risk transfer (MIS = 0.6753). Results of the usage of risk response techniques are presented in Table 4.10.

*Table 4.10: Ranking of frequency of use of risk response techniques*

| Risk response technique | 1 Never | 2 Rarely | 3 Sometimes | 4 Often | 5 Always | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Contingency plan | 2 | 6 | 13 | 18 | 28 | 0.7910 | 1 |
| Risk reduction / mitigation | 1 | 10 | 16 | 19 | 23 | 0.7536 | 2 |
| Risk avoidance | 4 | 7 | 18 | 15 | 25 | 0.7749 | 3 |
| Risk acceptance | 6 | 5 | 24 | 15 | 19 | 0.7043 | 4 |
| Risk transfer | 4 | 9 | 28 | 13 | 15 | 0.6753 | 5 |
| Risk sharing | 6 | 7 | 25 | 19 | 12 | 0.6695 | 6 |
| Risk exploitation | 6 | 14 | 25 | 9 | 14 | 0.6323 | 7 |
| Risk enhancement | 9 | 11 | 26 | 15 | 17 | 0.6000 | 8 |

### 4.2.8 Barriers to risk management implementation

The study sought to establish the barriers to risk management as perceived by respondents on a scale of 1 to 5, where 1 indicates “strongly disagree” and 5 indicates “strongly agree”. The most influential barrier to risk management is low profit margins (MIS = 0.8000), followed by lack of qualified personnel to implement risk management (MIS = 0.7462), inadequate training on risk management (MIS = 0.7441) and lack of a clear risk management implementation plan (MIS = 0.7043). The least influential barriers to risk management implementation are: lack of time (MIS = 0.6492), lack of commitment of the board and senior management (MIS = 0.6550), difficulties in quantifying risks (MIS = 0.6647) and an unsupportive organisational culture in terms of risk management (MIS = 0.6823). Results of the ranking of perceived barriers are summarised in Table 4.11.

### 4.2.9 Usage of risk management techniques

In conclusion, the study sought to establish the level of usage of risk management techniques across all the risk management processes of risk identification, risk assessment and risk response. Risk response is the most adopted risk management process with contingency plan (Average usage = 0.785), risk mitigation (Average usage = 0.762) and risk avoidance (Average usage = 0.749) being the most used risk management techniques.

*Table 4.11: Barriers to risk management implementation*

| Risk management implementation barrier | 1 Strongly disagree | 2 Disagree | 3 Undecid-ed | 4 Agree | 5 Strongly agree | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Low profit margins | 3 | 7 | 3 | 30 | 26 | 0.8000 | 1 |
| Lack of qualified personnel to implement risk management | 0 | 13 | 8 | 30 | 16 | 0.7462 | 2 |
| Inadequate training on risk management | 2 | 8 | 9 | 37 | 12 | 0.7441 | 3 |
| Lack of a clear risk management implementation plan | 5 | 11 | 7 | 35 | 11 | 0.7043 | 4 |
| Insufficient resources | 5 | 11 | 9 | 32 | 12 | 0.7015 | 5 |
| Unsupportive organisational culture in terms of risk management | 6 | 11 | 10 | 31 | 10 | 0.6823 | 6 |
| Difficulties in quantifying risks | 5 | 17 | 9 | 25 | 12 | 0.6647 | 7 |
| Lack of commitment of the board and senior management | 5 | 16 | 12 | 27 | 9 | 0.6550 | 8 |
| Lack of time | 1 | 22 | 14 | 23 | 9 | 0.6492 | 9 |

Additional risk management techniques with prevalent use fall under risk identification and are identified as past experience (Average usage = 0.738) and brainstorming (Average usage = 0.721). The least-used risk management techniques are Probabilistic analysis (Monte Carlo Simulation) (Average usage 0.508), Delphi techniques (Average usage = 0.523), Influence diagrams (Average usage = 0.567), Decision trees (Average usage = 0.569) and Risk enhancement (Average usage = 0.584). Results of the overall usage of risk management techniques are shown in Table 4.12.

*Table 4.12: Summary of risk management techniques usage*

| Risk management technique | Risk process | Average usage | Ranking |
|---|---|---|---|
| Contingency plan | Response | 0.785 | 1 |
| Risk mitigation / reduction | Response | 0.762 | 2 |
| Risk avoidance | Response | 0.749 | 3 |
| Past experience | Identification | 0.738 | 4 |
| Risk checklist | Identification | 0.7180 | 5 |
| Risk probability and impact assessment | Assessment | 0.721 | 5 |
| Brainstorming | Identification | 0.7102 | 7 |
| Document reviews | Identification | 0.705 | 8 |
| Risk acceptance | Response | 0.697 | 9 |
| Probability / impact risk rating matrix | Assessment | 0.682 | 10 |
| SWOT Analysis | Identification | 0.679 | 11 |
| Risk categorization and Risk urgency assessment | Assessment | 0.669 | 12 |
| Risk transfer | Assessment | 0.669 | 12 |
| Flow charts | Identification | 0.654 | 14 |
| Risk sharing | Response | 0.651 | 15 |
| Interviews | Identification | 0.649 | 16 |
| Sensitivity Analysis | Assessment | 0.628 | 17 |
| Risk exploitation | Response | 0.625 | 18 |
| Expert judgement | Assessment | 0.623 | 19 |
| Cause and effect diagrams | Identification | 0.621 | 20 |
| Questionnaires | Identification | 0.613 | 21 |
| Expert Systems | Identification | 0.592 | 22 |
| Risk enhancement | Identification | 0.584 | 23 |

| Risk management technique | Risk process | Average usage | Ranking |
|---|---|---|---|
| Decision trees | Assessment | 0.569 | 24 |
| Influence diagrams | Identification | 0.567 | 25 |
| Delphi technique | Identification | 0.523 | 26 |
| Probabilistic analysis (Monte Carlo simulation) | Assessment | 0.508 | 27 |

## 4.3 Data analysis

This section allows for the presentation of data that has been processed to enable the deduction of meaningful conclusions. The various statistical tools discussed in the preceding chapter were applied to produce the data.

### 4.3.1 Risk severity

The study sought to establish the severity of risks encountered by contractors, using the formula “severity = likelihood x impact” (El-Sayegh, 2008). The most severe risk encountered by contractors is high competition in bids (SI = 0.6389), followed by political instability (SI = 0.5659), payment delays (SI = 0.5617), corruption and bribery (SI = 0.5583) and bureaucracy of government institutions (SI = 0.5473). The least severe risks are environmental factors such as floods and earthquakes (SI = 0.2174), prosecution due to unlawful disposal of construction waste (SI = 0.2246), on-site accidents (SI = 0.4956), absence of fire systems on site (SI = 0.2378) and equipment/property or materials damage (SI = 0.2941). The severity ranking of risks is shown in Table 4.13.

Further categorisation of risks based on their severity was conducted and summarised in Table 4.14. In this regard, it was established that 58.33% of surveyed risks are in the low severity category, 39.58% of risks are in the moderate category and 2.09% of risks are in the high severity category. None of the risks encountered are in the extremely low or extremely high severity categories.

*Table 4.13: Risk severity ranking*

| Risk event | Frequency | | Importance | | Severity | |
|---|---|---|---|---|---|---|
| | **Index** | **Rank** | **Index** | **Rank** | **Index** | **Rank** |
| High competition in bids | 0.7800 | 1 | 0.8192 | 1 | 0.6389 | 1 |
| Political instability | 0.7246 | 3 | 0.7811 | 3 | 0.5659 | 2 |
| Payment delays | 0.7496 | 2 | 0.7494 | 5 | 0.5617 | 3 |
| Corruption / Bribery | 0.7051 | 7 | 0.7919 | 2 | 0.5583 | 4 |
| Bureaucracy of local / national government agencies | 0.7176 | 4 | 0.7627 | 4 | 0.5473 | 5 |
| Biased procurement policies | 0.7036 | 8 | 0.7452 | 6 | 0.5243 | 6 |
| Project funding problems | 0.7058 | 6 | 0.7351 | 9 | 0.5188 | 7 |
| Criminal acts (theft / vandalism) | 0.7009 | 9 | 0.7630 | 8 | 0.5158 | 8 |
| Payment risk | 0.6983 | 10 | 0.7350 | 10 | 0.5132 | 9 |
| Working in politically sensitive / dangerous areas | 0.6908 | 11 | 0.7405 | 7 | 0.5115 | 10 |
| Price inflation | 0.7143 | 5 | 0.6937 | 14 | 0.4955 | 11 |
| Excessive procedures of government approvals / permits | 0.6867 | 12 | 0.7120 | 11 | 0.4889 | 12 |
| Societal unrest / disorder (strikes / riots) | 0.6724 | 13 | 0.6960 | 13 | 0.4679 | 13 |
| Biases in bidding process | 0.6611 | 14 | 0.7000 | 12 | 0.4627 | 14 |
| Inadequate forecast about market demand | 0.6360 | 20 | 0.6795 | 15 | 0.4321 | 15 |
| Cost and time overruns | 0.6579 | 15 | 0.6548 | 19 | 0.4307 | 16 |
| Lack of judicial reinforcement | 0.6414 | 18 | | | 0.4299 | 17 |
| Tight project schedule | 0.6500 | 17 | 0.6575 | 18 | 0.4273 | 18 |
| Inadequate social infrastructure / facilities (power, communication, roads) | 0.6561 | 16 | 0.6486 | 21 | 0.4255 | 19 |
| Low management competency of subcontractors | 0.6400 | 19 | 0.6603 | 17 | 0.4225 | 20 |
| Poor communication between parties | 0.6087 | 21 | 0.6270 | 24 | 0.3816 | 21 |

| Risk event | Frequency | | Importance | | Severity | |
|---|---|---|---|---|---|---|
| | Index | Rank | Index | Rank | Index | Rank |
| Stringent environmental protection by government bodies | 0.5917 | 24 | 0.6378 | 23 | 0.3773 | 22 |
| Unstable interest rates | 0.6034 | 22 | 0.6234 | 25 | 0.3761 | 23 |
| Incomplete or inaccurate cost estimates | 0.5686 | 30 | 0.6519 | 20 | 0.3706 | 24 |
| Adverse weather conditions | 0.5966 | 23 | 0.6027 | 30 | 0.3595 | 25 |
| Exchange rate fluctuation | 0.5900 | 26 | 0.6077 | 28 | 0.35854 | 26 |
| Inadequate site information | 0.5795 | 29 | 0.6187 | 26 | 0.35853 | 27 |
| Poor wellbeing of employees | 0.5915 | 25 | 0.6053 | 29 | 0.3580 | 28 |
| Legal disputes | 0.5509 | 36 | 0.6459 | 22 | 0.3558 | 29 |
| Unavailability of sufficiently skilled professionals and managers | 0.5863 | 27 | 0.5918 | 32 | 0.3469 | 30 |
| Low construction productivity | 0.5664 | 32 | 0.6110 | 27 | 0.3460 | 31 |
| Suppliers incompetence to deliver materials on time | 0.5838 | 28 | 0.5836 | 34 | 0.3407 | 32 |
| Lack of design co-ordination among design professionals and clients | 0.5672 | 31 | 0.5808 | 35 | 0.3294 | 33 |
| Frequent design variations | 0.5579 | 34 | 0.5757 | 38 | 0.3211 | 34 |
| Inaccurate project program | 0.5491 | 37 | 0.5778 | 37 | 0.3172 | 35 |
| Complex construction projects/ methods | 0.5363 | 42 | 0.5890 | 33 | 0.3158 | 36 |
| Expropriation (threat of business takeover by other agencies) | 0.5231 | 44 | 0.6000 | 31 | 0.3138 | 37 |
| Undocumented design variations | 0.5491 | 37 | 0.5694 | 40 | 0.3126 | 38 |
| Incomplete design information | 0.5386 | 41 | 0.5784 | 36 | 0.3115 | 39 |
| Unavailability of materials | 0.5625 | 33 | 0.5541 | 41 | 0.3085 | 40 |
| Defective design | 0.5345 | 43 | 0.5694 | 40 | 0.3048 | 41 |

| Risk event | Frequency | | Importance | | Severity | |
|---|---|---|---|---|---|---|
| | Index | Rank | Index | Rank | Index | Rank |
| Difficulty to access site | 0.5563 | 35 | 0.5440 | 43 | 0.3026 | 42 |
| Unavailability of quality materials | 0.5439 | 40 | 0.5486 | 42 | 0.3013 | 43 |
| Equipment / property / materials damage | 0.5469 | 39 | 0.5378 | 44 | 0.2941 | 44 |
| Absence of fire systems on site | 0.5069 | 45 | 0.4693 | 48 | 0.2378 | 45 |
| On-site accidents | 0.4956 | 46 | 0.4795 | 46 | 0.2376 | 46 |
| Prosecution due to unlawful disposal of construction waste | 0.441 | 48 | 0.5093 | 45 | 0.2246 | 47 |
| Environmental factors (floods, earthquakes) | 0.4598 | 47 | 0.4730 | 47 | 0.2174 | 48 |

*Table 4.14: Summary of risk severity*

| Risk severity scale | Frequency | % Frequency | Rank |
|---|---|---|---|
| >0.20 | 0 | 0 | Extremely low severity |
| 0.20 – 0.40 | 28 | 58.33% | Low severity |
| 0.40 – 0.60 | 19 | 39.58% | Moderate severity |
| 0.60 – 0.80 | 1 | 2.09% | High severity |
| 0.80 – 1.00 | 0 | 0 | Extremely high severity |

Furthermore, since risks were categorised, it was essential to establish the average severity per risk category. The most severe risks encountered by contractors are distributed amongst the following categories: procurement risk (average severity = 0.526), political risk (average severity = 0.484) and economic risk (average severity = 0.481). The least severe risks encountered by contractors are distributed amongst the following categories: environmental risk (average severity = 0.279), design-related risk (average severity = 0.337) and construction related risk (average severity = 0.362). Results of the broad risk distribution per category are shown in Table 4.15.

*Table 4.15: Summary of risk severity by category*

| Risk category | Average severity | Rank |
|---|---|---|
| Procurement risks | 0.526 | 1 |
| Political risks | 0.484 | 2 |
| Economic risks | 0.481 | 3 |
| Social risks | 0.462 | 4 |
| Construction related risks | 0.362 | 5 |
| Design related risks | 0.337 | 6 |
| Environmental risks | 0.279 | 7 |

### 4.3.2 Relationship between the severity of the risks encountered and risk management techniques used

The study sought to establish the relationship between individual risk severity and the risk management techniques used. The data obtained from Tables 4.12 and 4.13 was used in generating the scatter plot graphs shown in Figures 4.1, 4.2 and 4.3.

The graphs show that there is a positive relationship between the perceived severity of the risks and the level of usage of risk identification and assessment techniques by respondents. The results support the alternate hypothesis stated in Section 1.6, namely that there is a relationship between the severity of risk, and the usage of risk identification techniques and risk assessment techniques.

However, when the severity of risks encountered by the respondents is related to the risk response techniques as shown in Figure 4.3, a weak positive relationship between the two variables becomes apparent, equally signifying a weak positive relationship.

It can be deduced from these findings that contractors sense the risks faced in their industry, and that the higher the severity of the risks perceived by the respondent, the higher their adoption of risk identification, risk assessment and risk response techniques will be, to adequately counter the perceived risks.

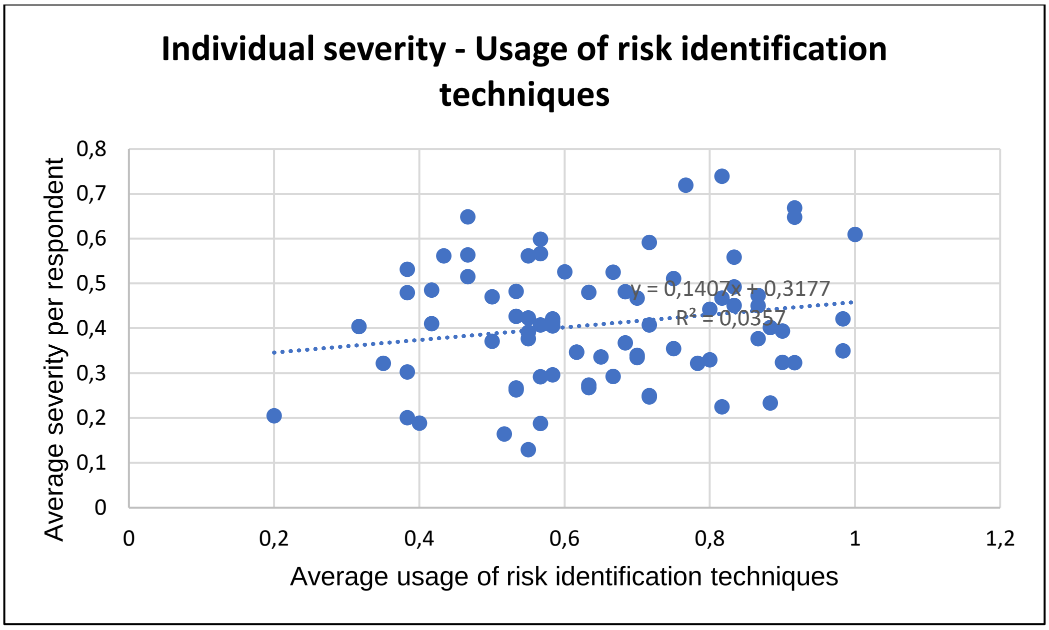


*Figure 4.1: Relationship between individual severity of the risk and average usage of risk identification techniques*

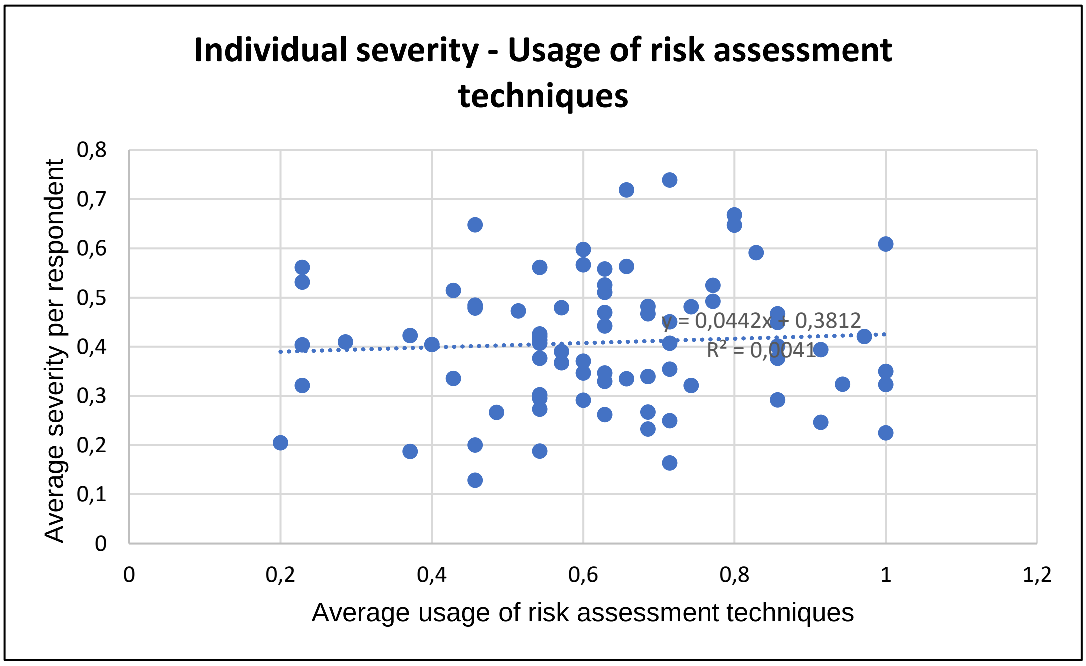


*Figure 4.2: Relationship between severity of the risk and average usage of risk assessment techniques*

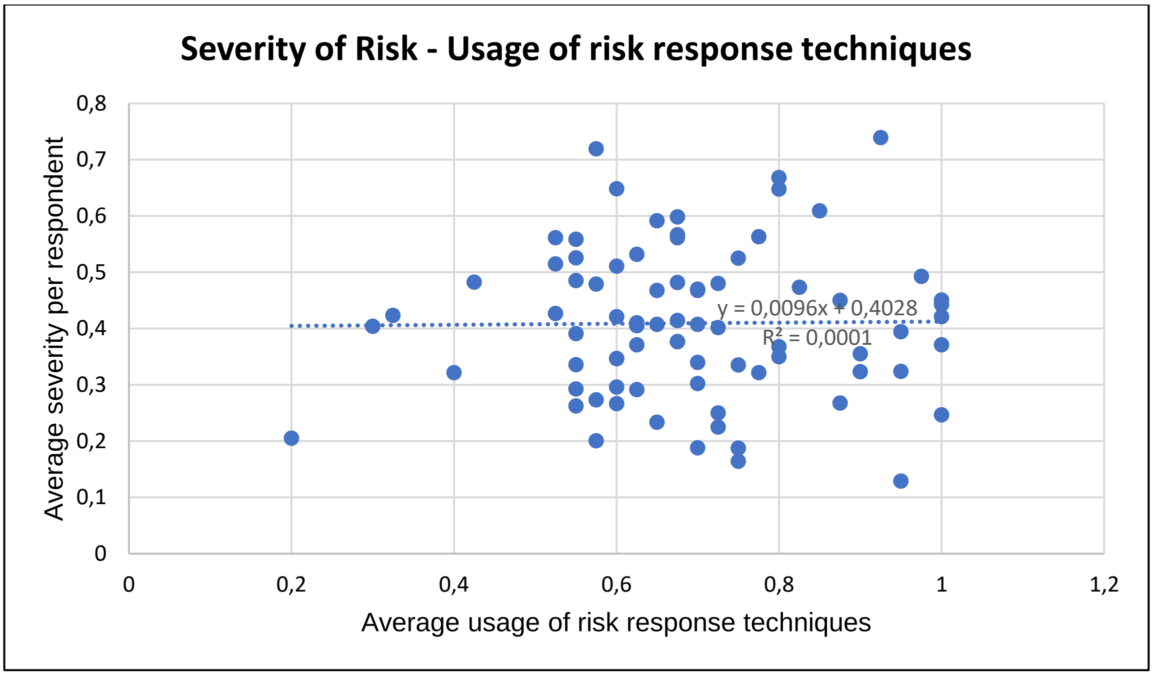


*Figure 4.3: Relationship between individual risk severity and average usage of risk response techniques*

### 4.3.3 Spearman Rho testing

The Spearman Rho correlation coefficient between the risk severity and the risk management techniques was established across the three risk management processes of identification, assessment, and response. Risk identification techniques (Spearman Rho coefficient = 0.198062), risk assessment techniques (Spearman Rho coefficient = 0.154488) and risk response techniques (Spearman Rho coefficient = 0.009896) all confirm the positive relationship between the usage of risk management techniques and the individual risk severity.

Further significance testing of the Spearman Rho coefficient values based on a significance level of 5% indicate that the established coefficients are statistically significant, thus confirming the assertion that risk severity and risk management techniques usage are positively interrelated.

## 4.4 Discussion of findings

This section provides a discussion on the research findings while referring to previous, similar research endeavours. While the past research has been conducted in different environments, this reference assists in providing a fair comparison, thus assisting the study in coming up with deductive, comparable conclusions.

### 4.4.1 Level of risk management knowledge

From the results presented above, it can be deduced that the respondents and their work colleagues appreciate the concept of risk management. However, it is important to point out that a concept is just an abstract and general idea, in the absence of exhaustive knowledge (Stevenson, 2010).

The study established that respondents are familiar with the term “risk management” due to its prevalent use in literature and media. However, most respondents only possess an elementary understanding of the concept and are not familiar with detailed risk management processes. For instance, at the beginning of the questionnaire survey, 173 respondents answered questions. However, further into the questionnaire, as the questions became more complex, the number of respondents fell to 78. It means 55% of respondents absconded from providing answers to detailed risk management questions in the questionnaire survey. Similarly, El-Sayegh (2014) reports of inadequate risk management education and experience amongst construction professionals.

This is evidence of a lack of structured risk management knowledge and a key function of adequate risk management performance is the ability to re-use the risk management knowledge base effectively (Tserng et al., 2009). In other words, upon their attainment of risk management knowledge, organisations should standardize processes and procedures to ensure that consistent knowledge is shared amongst team members, thus enhancing preparedness to respond to risks (Perminova *et al.*, 2008). Evidently, this is not the case with South African contractors.

As Khosravi et al. (2020) assert, risk management is simple and clear in theory, but in practice it is complex to understand and implement. This is particularly widespread in developing countries, due to lack of formal risk management training (Lu and Yan, 2013). The research found this phenomenon to be particularly true in the South African context which demonstrates a limited understanding and usage of risk management techniques amongst the surveyed respondents.

### 4.4.2 Severity of risks encountered by construction companies

The most severe risk is the high competition in bids (SI = 0.6389). This is unsurprising, given that 74% of respondent organisations in the survey are registered in cidb grades 1 to 6. In light of this, cidb (2012) reports that 80% of public infrastructure spending is on projects suited for contractors in Grade 7 and upwards. Effectively, this results in an oversupply of contractors competing in the less valued work categories, thus leading to steep competition amongst contractors when tendering for work. However, Maisonnave et al. (2019) report that the government has initiated various economic policies, such as the New Growth Path (NGP) and National Development Plan (NDP). These policies are aimed at increasing public sector infrastructure spending, so that should they achieve success, there may soon be less competition for work.

Political instability (SI = 0.5659) is the second most severe risk to construction companies. While it is ranked relatively low, working in politically sensitive areas (SI = 0.5115) is also a prominent risk. As can be deduced from findings by authors such as Hwang et al. (2017) and Kassem et al. (2019) political instability is a prevalent risk in construction projects undertaken in developing countries. This is largely attributed to the volatility of the environments in which the projects are undertaken, the fractured political institutions governing these areas, and intolerance amongst members of the surrounding communities.

Payment delays (SI = 0.5617), also identified by Rostami and Oduoza (2017) as a severe risk to Italian SMEs, are the second most severe risk to South African contractors. Corruption and bribery (SI = 0.5583) and bureaucracy of government agencies (SI = 0.5473), in descending order, complete the list of the five most severe risks to construction companies. Closely related to the bureaucracy risk are the excessive procedures which contractors must endure to obtain permits (SI = 0.4889). Interestingly, a multinational research project by Odediran (2016) also found corruption and bureaucracy as top risks encountered in the construction industries of numerous African countries. This indicates the inefficiencies rampant in the governance systems of developing countries.

Another top severe risk faced by contractors is the existence of biased procurement policies (SI = 0.5243). This is unsurprising, given the lack of robustness that characterises procurement systems used particularly in the public sector (cidb, 2012). Additionally, project funding problems (SI = 0.5188) are also prevalent. Zou et al. (2007) found that project funding problems not only emanate from a lack of access to capital, but that contractors have a propensity to abuse these funds upon obtaining them. Criminal acts of theft or vandalism (SI = 0.5158), and payment risks (SI = 0.5132) are also high severity risks plaguing the industry.

Calamities such as criminal acts and vandalism are inevitably prevalent due to the inequality that characterises South African society. According to Sulla and Zikhali (2018), by any measure, South Africa is one of the most unequal societies in the world with extremities being noted in income distribution, wealth distribution and even access to opportunities. Inevitably, the prevalence of inequality will also lead to societal unrest such as strikes (SI = 0.4679).

Medium severity risks that contractors are prone to include inadequate forecasts about market demand (SI = 0.4321), cost and time overruns (SI = 0.4307), lack of judicial reinforcement (SI = 0.4299), tight project schedules (SI = 0.4273) and inadequate social infrastructure (SI = 0.4255).

Despite their unpredictability, environmental factors such as floods and earthquakes (SI = 0.2174) where found to be the least severe risks to contractors. Other low severity risks that contractors encounter include prosecution due to unlawful disposal of construction waste (SI = 0.2246), on-site accidents (SI = 0.2376), absence of fire systems on site (SI = 0.2378) and equipment / property / material damage (SI = 0.2941).

Pollution levels in South Africa are relatively lower than those in China, hence the mismatch between the study findings and Zou et al. (2007) who found prosecution due to construction waste as a highly severe risk in that market. Other low severity risks such as on-site accidents (SI = 0.2376), absence of fire systems on site (SI = 0.2378) and damage to property and equipment (SI = 0.2941) may be attributed to the low complexity of the projects undertaken by most participants based on their indicated financial characteristics.

### 4.4.3 Risk management techniques used by contractors

The risk management process adopted was borrowed from Zavadskas et al. (2010) who outlined the major risk management processes as being risk identification, risk assessment and risk control or response. Following this conceptualisation, the study sought to investigate the various risk management techniques that are used in each of these crucial stages. The usage of each of the risk management techniques was measured using the mean item score.

#### 4.4.3.1 Risk identification techniques

The first stage and major step of risk management is risk identification. The most popular risk identification technique is past experience (MIS = 0.7549). This signifies an over-reliance on past projects executed by the surveyed respondents. It is important to note that the respondents possess a lot of construction experience and may be overconfident in their abilities. Reliance on past experience is dangerous as individuals who have worked on incident-free projects may adopt an optimistic approach and underestimate the level of risk in a new project and vice versa (Hlaing et al., 2008). In essence, this makes the risk identification exercise subjective and somewhat unreliable.

The risk checklist (MIS = 0.7277) and document reviews (MIS = 0.7101) were found to be the second and third most used risk identification techniques, respectively. This is not surprising as both approaches rely on previous, similar projects. Overall, these findings point towards an over-reliance on past projects in which the respondents have been involved. Furthermore, since these approaches are simple and straight forward, they do not require special skills to implement, apart from the construction knowledge already held by the respondents. The ranking of risk identification techniques found in this research is highly similar to findings by Gajewska and Ropel (2011).

Other risk identification techniques that are popular amongst contractors are brainstorming (MIS = 0.7014), SWOT analysis (MIS = 0.6588), interviews / expert opinion (MIS = 0.6479) and flow charts (MIS = 0.6457). The preceding techniques are fairly straight forward and Chihuri and Pretorius (2010) assert that brainstorming is the most appropriate risk identification technique. Similarly, Renault, Agumba and Ansary

(2016) found these three risk identification techniques to be amongst the most used in their own study.

More complex risk identification techniques such as influence diagrams (MIS = 0.5634), expert systems (MIS = 0.5971), questionnaires (MIS = 0.6028) and cause and effect diagrams (MIS = 0.6173) are the least used, due to the complexity associated with their application. Chihuri and Pretorius (2010) found that respondents generally tend to rely more on simple, straightforward approaches and less on the reported reliability of the methods. However, it is important to note that despite the Delphi technique (MIS = 0.5154) being a simple technique similar to brainstorming, except with anonymity of participants, it was found to be the least used risk identification technique; this is attributed to respondents being unfamiliar with the name of the technique.

The low usage of complex risk identification tools may also be attributed to the size of the organisations surveyed. A previously indicated, 64.74% of surveyed organisations generated turnover of less than R10Million. This means the bulk of surveyed organisations are small companies, and therefore mostly unable to employ or retain staff with the skills to implement complex risk identification techniques. As Garrido *et al.* (2011) found, companies with higher turnovers are able to afford to either train or hire well trained personnel who may then implement the complex risk identification techniques.

#### 4.4.3.2 Risk assessment techniques

In identifying the most used risk assessment techniques, a distinction was made between qualitative and quantitative risk assessment techniques on the distributed questionnaire. The most used risk assessment techniques are probability and impact assessment (MIS = 0.7117), the probability rating matrix (MIS = 0.6725) and risk categorisation and urgency assessment (MIS = 0.6725). All these are qualitative risk assessment techniques. Equally, the least used are quantitative risk assessment techniques: probabilistic analysis (MIS = 0.5043), decision trees (MIS = 0.5617), sensitivity analysis (MIS = 0.6347) and expert judgement (MIS = 0.6358).

Since qualitative risk assessment mainly involves establishing the risk and probability of occurrence, it precedes quantitative risk assessment. From the research findings, it can be deduced that respondents only go as far identifying and prioritizing risks. Further mathematical operations conducted under quantitative risk assessment techniques such as probabilistic and sensitivity analysis are largely ignored by the respondents. This is due to a limited skill capacity held by the respondents; authors such as Thaheem et al. (2012) have identified risk assessment as the most difficult stage in the risk management process.

Findings by authors such as Choudhry and Iqbal (2013) and El-Sayegh (2014) are supported by this research, as they also found limited use of quantitative risk assessment techniques versus above average usage of qualitative risk assessment techniques. Hence, respondents are unable to quantify the monetary value of risk consequences or the deviance from project objectives, resulting in further enhancement of risks in their respective construction projects (Keshk et al., 2018).

#### 4.4.3.3 Risk response techniques

The most used risk response technique was found to be the setting aside of a sum of money for risk contingency (MIS = 0.7910). The prevalence of contingency funding as a strategy is worrying, as Otali and Odesola (2014) note that despite widespread usage, any contingency plan determined in an abstract manner is usually inadequate to counter project risks. In a typical construction project, the contingency may be set at 10% of total project cost. Furthermore, the prevalent use of a contingency plan signifies a lack of competence in the other risk management processes of identification and assessment. This is because contingency planning is used as a blanket risk countering measure, meant to cater for all project shortcomings, which the team may be unaware of at project initiation stage.

The second most used risk response strategy is risk reduction (MIS = 0.7536), signifying that construction companies are unable to eliminate project risks completely, however, they seek to reduce the impact of those risks. Olamiwale (2014) showed similar findings in a study on the Eswatini construction industry and attributes the prevalent use of risk reduction to the resources of experience of the construction industry practitioners. The same findings apply to this research as the majority of respondents were found to be well experienced personnel.

The third most used risk response technique was risk avoidance (MIS = 0.7749). This is surprising, given the lack of risk management knowledge that was demonstrated by the respondents. This is because effective risk avoidance can only be possible when risks have been adequately identified (Perera et al., 2014). Subsequently, upon risk identification, construction companies implement measures to effectively counteract these risks. However, it is important to note that while the harshest form of risk avoidance is total abandonment of the project (Nguyen Phuong and Yuansheng, 2012), for South African construction companies operating in a tough economic environment, this may not be an option.

Other top rated risk response techniques that are implemented by contractors include risk acceptance (MIS = 0.7043) and risk transfer (MIS = 0.6753). Features of the risk response techniques and the environment in which risk occurs have a bearing on their usage. For instance, Mehdizadeh (2012) asserts that risk acceptance is only applicable as a last resort where other techniques have been deemed inapplicable. Furthermore, Lyons and Skitmore (2004) found risk transfer to be a prominent risk response feature in an Australian study, and they attribute this to the advanced nature of the insurance sector of that country.

Lastly, the research found risk enhancement (MIS = 0.6000), risk exploitation (MIS = 0.6323) and risk sharing (MIS = 0.6695) as the least used risk response techniques. Implementation of these methods requires a deep understanding of risk management processes since they involve manipulating risks into yielding positive returns. This action is risky, since attempts at risk manipulation may yield negative results, due to implementation errors.

### 4.4.4 Barriers to risk management implementation

Overall, the most influential barrier to risk management implementation was identified as low profit margins (MIS = 0.8000). As established earlier, the most severe risk to construction companies is high competition in bids. This means that for the companies to be awarded tenders, they must offer to execute projects at the lowest possible cost, and this leads to slim profit margins. Effectively, in a bid to contain costs, companies limit overhead costs, including the engagement employees who are conscious of risk management processes. Hwang et al. (2014) found that low profit margins were a significant barrier to risk management implementation, due to the low profit margins that are especially prevalent in difficult economic environments.

Furthermore, the second and third most prevalent barriers to risk management are: the lack of qualified personnel to implement risk management initiatives (MIS = 0.7462) and inadequate training in risk management (MIS = 0.7441). Similar to the cost containment aspect discussed above, and the tough economic environment in which local construction companies are operating, the cost of setting up qualified personnel and providing sufficient training, means that risk management is sacrificed.

Furthermore, another barrier equally related to cost containment is insufficient resources (MIS = 0.7015). Key resources necessary for the effective implementation of risk management include well trained personnel, reliable service providers and adequate plant and equipment.

Beyond the lack of resources to cater for risk management implementation (MIS = 0.7043), the lack of a clear risk management plan was found to be a significant barrier to risk management implementation. This is evidence of the lack of risk management knowledge within construction companies. This could be averted by engaging risk management consultants; however, given the low profit margins characterising contractor operations, this is almost impossible as it only increases operational costs.

Furthermore, the existence of an unsupportive organisational culture with regard to risk management (MIS = 0.6823) and the lack of commitment by the board and senior management (MIS = 0.6550) were found to be influential barriers. However, given that managing directors and top-level personnel make up the bulk of respondents, this barrier points towards the lack of initiative on the part of the respondents and their respective organisations. This aversion to risk management within the organisation will inevitably permeate all other aspects such as subcontractor and supplier engagements.

The organisational ignorance outlined above, results in the emergence of another barrier, namely the difficulty of quantifying risks (MIS = 0.6647). This results from a lack of capacity to evaluate the apparent risks, leading to, at best, mediocre risk management strategies and at worst, no risk management at all.

As identified by Choudhry and Iqbal (2013), it can be deduced that barriers to risk management implementation result from structural deficiencies within the surveyed organisations as well as personal attitudes of the organisation employees. On the part of organisations, there seems to be an overall unwillingness to implement risk management due to the high cost associated with it. This assertion is supported by the fact that the least influential barrier to risk management implementation is a lack of time (MIS = 0.6492). It means organisations do have the time to implement risk management, but they lack the will to do so.

On a personal level, the unwillingness to embrace risk management is attributed to overconfidence in technical capacity to effectively execute projects without a formal, structured risk management approach. Azhar et al. (2008) attribute this to the lack of formal risk management training within organisations.

#### 4.4.5 Overall risk management techniques used

Overall, across the entire risk management process, the most prevalent risk management techniques are the contingency plan (average usage = 0.785), risk mitigation / reduction (average usage = 0.762) and risk avoidance (average usage = 0.749). Since these three are risk response techniques, it essentially means construction practitioners are largely ignoring all other risk management processes and focussing on responding to the risk events as and when they become apparent. This is evidenced by haphazard risk management that is only responsive to risk events without adequate systems in place for prior risk management planning. However, these findings are not in tandem with Lyons and Skitmore (2004) who found risk assessment techniques to be the strategies most used by contractors.

Past experience (average usage = 0.738), risk checklist (average usage = 0.7180), brainstorming (average usage = 0.7102) and document reviews (average usage = 0.7050) also follow closely as the most widely used risk management techniques.

They are all risk identification techniques. However, as all are largely based on reliance on past projects, it shows the respondents are inclined to refer to experiences from the past and will continuously refer to past projects for future project execution. Similar findings were made by Taroun (2014), whose study showed these particular risk identification techniques to be dominant.

However, an over reliance on the past may be inappropriate for the less experienced practitioners as they might have limited project exposure, thus rendering them unfit to make correct risk management decisions. It thus becomes prudent for effective record keeping and knowledge management to enable less experienced personnel to refer to and make the right risk management decisions.

Risk probability and impact assessment (average usage = 0.721) and probability / impact risk rating matrix (average usage = 0.682) are also used quite extensively by contractors. Importantly, they are risk assessment techniques that fall under qualitative risk assessment techniques. As previously alluded to, contractors have been largely found to conduct qualitative risk assessment more than quantitative risk assessment, due to their limited understanding of the latter.

Mid-tier risk management techniques that are used by contractors include SWOT analysis (average usage = 0.679), risk transfer (average usage = 0.669), flow charts (average usage = 0.654), risk sharing (average usage = 0.651), interviews (average usage = 0.649) sensitivity analysis (average usage = 0.628) and risk exploitation (average usage = 0.625).

At the lower end of Table 14, summarising use of techniques, it is evident that the techniques become more complex and specialised, hence they are less used by the contractors. These neglected techniques include expert judgement (average usage = 0.623), cause and effect diagrams (average usage = 0.621), questionnaires (average usage = 0.613), expert systems (average usage = 0.592) and risk enhancement (average usage = 0.584).

### 4.4.6 Relationship between risk management techniques used and severity of the risks encountered

The study found a positive relationship between the perceived individual risk severity and the average usage of risk management techniques by respondents. As shown in the previous scatter plots, the average usage of risk management techniques across the three risk management processes of identification, assessment and response indicates a positive relationship with the individual severity experienced by respondents.

This means that respondents' usage of risk management techniques is determined by the risks they encounter. This assertion counters prior findings by Mahendra et al. (2013) that the usage of risk management techniques is dependent on the knowledge of the individual.

## 4.5 Chapter Summary

In summary, the objectives of the research were met. The overall appreciation of risk management was established. Risks encountered by construction companies were also identified. Furthermore, the study also established the risk management techniques implemented by construction companies in their quest to counteract the same risks. Most importantly, the research also established the barriers that hinder effective implementation of risk management techniques and the measures needed to enhance application of risk management. The data obtained also supported the hypothesis stated to guide the direction of the study that there is a relationship between the severity of the risks encountered by the contractors and their usage of risk management techniques in counteracting the risks.

# CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

This chapter brings finality to the research endeavour, summarising the objectives of the study and findings thereof, proffering a conclusion and recommendations to the research community and project managers in the field.

## 5.2 Restating the aim, objectives and hypothesis of the research

The research sought to establish whether the risk management techniques implemented by South African contractors are related to the risks inherent in construction. To achieve this aim, the following objectives were outlined:

1. Establish the level of knowledge of risk management as an operational contractor practice.
2. Identify and evaluate the severity of the significant risks encountered by contractors.
3. Establish the risk management techniques implemented by contractors.
4. Identify barriers that hinder effective implementation of risk management practices amongst contractors.
5. Determine whether there is a relationship between risk severity and risk management practices used by South African construction contractors.

The following hypothesis was also framed to guide the direction of the study:

The risk management practices used by South African construction companies are significantly related to the severity of risks encountered in construction.

## 5.3 Summary of findings

The study managed to successfully meet all the intended research objectives. A brief outline of the objectives and the respective findings is presented below.

### 5.3.1 Level of risk management knowledge

The study established that construction companies are operating in the absence of structured risk management systems. As a result, the level of risk management knowledge within the companies is elementary and in need of structured, coordinated development.

Even at individual level, the study established that the level of risk management knowledge held by construction practitioners is mediocre and informal. Resources will need to be expended to address this anomaly to enable the construction industry to operate at optimum levels.

### 5.3.2 Risks prevalent in the local construction industry and their respective severity

The study found that the local construction industry is prone to various risks with varying degrees of severity. Major risks plaguing the South African construction industry include high competition in bids, political instability, payment delays, corruption and an inherent bureaucracy in government institutions. The least significant risks are environmental factors, prosecution due to unlawful disposal of construction waste, on-site accidents and the absence of fire systems on site.

Across the various risk categories, the local construction industry was found to be most prone to procurement related risks, and less prone to political, economic and social risks. The least severe risks were found to be in the environmental, construction and design related risk categories.

Overall, the study found that most of the risks encountered by companies range from moderate to high severity meaning they can be dealt with without halting projects completely. This project continuity is crucial for a developing economy like South Africa where construction plays an important role in the overall economic performance of the country.

### 5.3.3 Risk management techniques implemented by contractors

The study identified the risk management techniques that are prevalent across the risk management processes of risk identification, risk assessment and risk response.

The common risk identification techniques are past experience, risk checklists, document reviews and brainstorming. These are simple techniques that are mainly dependent on experience held by participants in the risk identification exercise. The least used risk identification techniques are Delphi techniques, influence diagrams, expert systems and questionnaires. Similarly, these are complicated techniques that would require specialised knowledge to be fully implemented properly.

The common risk assessment techniques are probability and impact assessment, probability / impact rating matrix, and risk categorization and risk urgency assessment. The least used risk assessment techniques are sensitivity analysis and expert judgement.

The most common risk response techniques are contingency plan, risk reduction / mitigation, risk avoidance and risk acceptance. While the least used risk response techniques are risk enhancement, risk exploitation, risk sharing and risk transfer.

Overall, the study established that risk response techniques are used more than the other risk management processes techniques. This is evidence of a lack of understanding of the risk management processes within construction companies, as there is a greater focus on countering risks when they become apparent, rather than identifying, assessing and planning for an adequate response strategy.

### 5.3.4 Barriers that hinder effective implementation of risk management practices

Despite the well documented prevalence of risks in the local construction industry, the study identified several barriers that hinder effective risk management implementation. The most influential barriers identified are reflective of cost containment efforts by construction companies. These most influential barriers include low profit margins, lack of qualified personnel to implement risk management and inadequate risk management training.

The less influential barriers are a lack of time, lack of commitment of the board and senior management, difficulties in quantifying risks and an unsupportive organisational culture in relation to risk management. The less influential barriers to risk management are evidence that the construction companies themselves are not promoting the development of risk management skills. As a result, employees are not motivated to equip themselves with a deeper understanding of risk management, thus negatively affecting project execution and ultimately overall company growth.

### 5.3.5 Relationship between perceived risk severity and the risk management practices used

The study established that there exists a positive relationship between the perceived individual risk severity and the level of use of risk management techniques. This means that the more severe risks companies are exposed to, the more likely they will be to implement risk management techniques to counter these risks.

## 5.4 Conclusion

Based on the findings, the study concludes that South Africa offers a very risky environment for construction companies operating within it. The large number of failed small and large construction projects is testament to this. However, compounding the effects of the risky nature of the construction industry is the lack of risk management knowledge at organisational and personal level. The level of risk management knowledge held by practitioners within the industry is superficial and lacks depth.

Furthermore, several significant barriers hinder the effective implementation of risk management across construction projects. Broad consensus amongst construction stakeholders is required to improve the reputation of the construction industry. Importantly, synergy between contractors and project financiers will assist in improving the state and performance of the South African construction industry.

## 5.5 Recommendations

The following recommendations were made to help overcome the practical and theoretical problems of the study. The recommendations are differentiated by the party that is best suited to address them.

### 5.5.1 Construction companies

Construction companies should invest in risk management training for personnel across all organisational levels. Risk management has become a critical component for company survival in the twenty first century and beyond, thus the importance of risk management training at all levels of the organisation cannot be overstated. In the absence of training capacity, companies should at least engage risk consultants to establish and regularly check and evaluate their risk management systems.

Furthermore, a shift in the attitudes of those in the top management of the organisations is required, to ensure effective cultivation and subsequent implementation of risk management principles.

### 5.5.2 Government

The Government through its agencies should encourage risk management training for construction companies. For instance, through organisations such as cidb, the government should encourage companies to equip themselves with risk management skills. Enforcement of the same can be achieved through demanding proof of receipt of such training upon tender submission. This will ultimately result in better execution of projects, leading to better use of taxpayer funds.

### 5.5.3 Clients and consultants

Clients and professional consultants in the construction industry should demand evidence of risk management competence from construction companies before awarding them work. This will ensure that clients obtain value for money from the companies they appoint for work.

## 5.6 Areas for further research

To shed light on the dynamics of risk management in South Africa, it is essential to further investigate the phenomenon. Future research should focus on the investigation of the relationship between the implementation of risk management techniques and reported construction company performance.

Furthermore, research should also be undertaken to investigate the risks affecting the rest of the construction value chain, that is, consultants, suppliers and project financiers. This can ultimately develop into a comparative study between the perceived risks by each group and how this affects the meeting of project objectives.

Research should also be undertaken to establish the interaction between risk management and other pillars of the PMBOK, such as stakeholder management and the overall effect on the attainment of project objectives.

In conclusion, given the high severity of risks attributed to the government and its agencies, research should also be undertaken to establish the role government plays in enhancing risk management competence amongst construction companies.

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# APPENDIX A - Ethics Approval

Application for Approval of Ethics in Research (EiR) Projects
Faculty of Engineering and the Built Environment, University of Cape Town

## ETHICS APPLICATION FORM

**Please Note:**
Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form **before** collecting or analysing data. The objective of submitting this application *prior* to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. Please ensure that you have read, and understood the **EBE Ethics in Research Handbook** (available from the UCT EBE, Research Ethics website) prior to completing this application form: http://www.ebe.uct.ac.za/ebe/research/ethics1

| APPLICANT'S DETAILS | | |
|---|---|---|
| Name of principal researcher, student or external applicant | | Farai Chiswanda |
| Department | | Construction Economics and Management |
| Preferred email address of applicant | | faraichiswanda@outlook.com |
| If Student | Your Degree: e.g., MSc, PhD, etc. | MSc Project Management |
| | Credit Value of Research: e.g., 60/120/180/360 etc. | 60 |
| | Name of Supervisor (if supervised): | A/Prof Abimbola Windapo |
| If this is a researchcontract, indicate the source of funding/sponsorship | | |
| Project Title | | An investigation of the risk management practices prevalent in the South African construction industry : A case of Western Cape construction companies |

**I hereby undertake to carry out my research in such a way that:**

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

| APPLICATION BY | Full name | Signature | Date |
|---|---|---|---|
| **Principal Researcher/ Student/External applicant** | Farai Chiswanda | | 13 April 2020 |
| **SUPPORTED BY** | **Full name** | **Signature** | **Date** |
| **Supervisor (where applicable)** | Abimbola Windapo | | 14 April 2020 |

| APPROVED BY | Full name | Signature | Date |
|---|---|---|---|
| **HOD (or delegated nominee)** Final authority for all applicants who have answered NO to all questions in Section 1; and for all Undergraduate research (Including Honours). | Louie Van Schalkwyk | | 15 May 2020 |
| **Chair: Faculty EIR Committee** For applicants other than undergraduate students who have answered YES to any of the questions in Section 1. | Louie Van Schalkwyk | | 15 May 2020 |

Signatures Removed

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# APPENDIX B – Questionnaire

## Introduction

Dear prospective participant,

You are hereby invited to participate in a Master of Science (MSc) in Project Management research project that investigates the risk management practices prevalent in the South African construction industry. By identifying the risk management practices used by construction companies, this research has the potential to provide valuable insight to the construction sector regarding the practices being used by construction companies in counteracting the risks they face in the construction industry.

This is a research being undertaken by Farai Chiswanda, a student under the supervision of Associate Professor Abimbola Olukemi Windapo of the University of Cape Town. The outcome of the study will be presented to the Department of Construction Economics and Management in partial fulfilment of the requirements for the award of the MSc in Project Management.

This research does not pose any known risks and does not request any sensitive information. The questionnaire can be completed in approximately 15 minutes. All useful comments that will aid the researcher in carrying out the study are welcome. All subjects of this research and any information that you shall provide will be protected with unreserved confidentiality.

Should you have any queries or questions for clarification purposes about the study, do not hesitate to contact me via email on faraichiswanda@outlook.com.

Thank you for your assistance.

Mr. Farai Chiswanda A/Prof. Abimbola Olukemi Windapo

## Section A: General Profile of Respondent and Organisation

Please specify your **job title**

| | | |
|---|---|---|
| ☐ Project Manager | ☐ Managing Director | ☐ Engineer |
| ☐ Contracts Manager | ☐ Technical / Operations Manager | ☐ Site Agent |
| ☐ Estimator | ☐ Commercial Manager / Quantity Surveyor | ☐ Other |

Please state your number of years of **direct experience** in construction ……………….

Please specify your highest academic **qualification** obtained.

| | | |
|---|---|---|
| ☐ Higher Certificate | ☐ National Diploma | ☐ Bachelor's Degree |
| ☐ Honours Degree | ☐ Master's Degree | ☐ Doctoral Degree |
| ☐ Other | | |

Please specify your organisation's **CIDB Rating** ………………………………………………….

Please specify your organisation's area of **specialization**

☐ Building Construction ☐ Civil Construction ☐ Building & Civil Construction
☐ Electrical ☐ Mechanical ☐ Other

Please state where your **organisation head office** is located
……………………………………………………..………

Please indicate the number of **permanent** employees your organisation employs:
………………………….

Please indicate the **turnover** your organisation generated in the **2019 financial year.**

☐ Less than R10 Million ☐ R10 – R75 Million ☐ R75 – 170 Million
☐ 170 Million – R500 Million ☐ R500 Million – R1 Billion ☐ Over R1 Billion

## Section B: Risk Management knowledge

*Risk management is a formal process of risk management planning, risk identification, analysis, response planning and risk control.*

How do you rate **your appreciation** of the concept of Risk Management?

☐ Very poor ☐ Poor ☐ Good ☐ Very Good ☐ Excellent

How do you rate your **organisation's employees appreciation** of the concept of Risk Management?

☐ Very poor ☐ Poor ☐ Good ☐ Very Good ☐ Excellent

How do you describe your organisation's implementation of risk management practices?

☐ Implement risk management practices but do not have a formal written procedure for risk management.

☐ Implement risk management practices and have a formal written procedure for risk management.

☐ Other

If you answered 'other' above kindly explain further
……………………………………………………………………………
…………………………………………………………………………………………………………………………
……………………………………..………………………………………………………………………………
………………………………………………………………………………

**Section C: Risks faced by contractors**

Listed below are the risks which could affect project outcomes. Based on your experience, kindly indicate the **likelihood of occurrence** on a scale of 1 to 5 of each risk in your daily operations, where 1 = Unlikely and 5 = Highly Unlikely.

| | Likelihood of Occurrence | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| | **Unlikely** | **Seldom** | **Occasionally** | **Likely** | **Highly Likely** |
| **Economic / Financial Risks** | | | | | |
| Payment delays | | | | | |
| Price inflation | | | | | |
| Payment risk | | | | | |
| Incomplete or inaccurate cost estimates | | | | | |
| Project funding problems | | | | | |
| Exchange rate fluctuation | | | | | |
| Unstable interest rates | | | | | |
| | | | | | |
| **Political Risks** | | | | | |
| Bureaucracy of local / national government agencies | | | | | |
| Excessive procedures of government approvals/permits | | | | | |
| Corruption / Bribery | | | | | |
| Political instability | | | | | |
| Lack of judicial reinforcement | | | | | |
| Expropriation (threat of business takeover by other agencies) | | | | | |
| Legal disputes | | | | | |
| Working in politically sensitive / dangerous areas | | | | | |
| | | | | | |
| **Environmental Risks** | | | | | |
| Stringent environmental protection by government bodies | | | | | |
| Inadequate site information | | | | | |
| Prosecution due to unlawful disposal of construction waste | | | | | |
| Adverse weather conditions | | | | | |
| Difficulty to access site | | | | | |
| Environmental factors (floods; earthquakes) | | | | | |
| Absence of fire systems on site | | | | | |
| | | | | | |
| | | | | | |
| **Social risks** | | | | | |
| Poor communication between parties | | | | | |
| Societal unrest / disorder (strikes/riots) | | | | | |
| Criminal acts | | | | | |
| Inadequate social infrastructure / facilities | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Poor wellbeing of employees | | | | | |
| | | | | | |
| **Design-related Risks** | | | | | |
| Defective design | | | | | |
| Incomplete design information | | | | | |
| Frequent design variations | | | | | |
| Inaccurate project program | | | | | |
| Lack of design co-ordination amongst design professionals | | | | | |
| | | | | | |
| **Construction-related risks** | | | | | |
| Tight project schedule | | | | | |
| Cost and time overruns | | | | | |
| Unavailability of sufficient professionals and managers | | | | | |
| Low management competency of subcontractors | | | | | |
| Undocumented design variations | | | | | |
| Low construction productivity | | | | | |
| Complex construction projects / methods | | | | | |
| On site accidents | | | | | |
| Equipment / materials damage | | | | | |
| Unavailability of materials | | | | | |
| Suppliers incompetence to deliver materials on time | | | | | |
| Unavailability of quality materials | | | | | |
| | | | | | |
| **Procurement risks** | | | | | |
| Biases in bidding process | | | | | |
| Inadequate forecast about market demand | | | | | |
| High competition in bids | | | | | |
| Biased procurement policies | | | | | |
| | | | | | |

*Please add other additional risks and their likelihood of occurrence*
……………………………………………………

## Section D: Severity of risks faced by contractors

Listed below are the risks which could affect project outcomes. Based on your experience, kindly indicate the **impact** of each risk on the achievement of organisational profit objectives on a scale of 1 to 5, where 1 = Very Low and 5 = Very High.

| Risk category | Impact of Risk Incident | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| | Very Low | Low | Moderate | High | Very High |
| | | | | | |
| **Economic / Financial Risks** | | | | | |
| Payment delays | | | | | |
| Price inflation | | | | | |
| Payment risk | | | | | |
| Incomplete or inaccurate cost estimates | | | | | |
| Project funding problems | | | | | |
| Exchange rate fluctuation | | | | | |
| Unstable interest rates | | | | | |
| | | | | | |
| **Political Risks** | | | | | |
| Bureaucracy of local / national government agencies | | | | | |
| Excessive procedures of government approvals/permits | | | | | |
| Corruption / Bribery | | | | | |
| Political instability | | | | | |
| Lack of judicial reinforcement | | | | | |
| Expropriation (threat of business takeover by other agencies) | | | | | |
| Legal disputes | | | | | |
| Working in politically sensitive / dangerous areas | | | | | |
| | | | | | |
| **Environmental Risks** | | | | | |
| Stringent environmental protection by government bodies | | | | | |
| Inadequate site information | | | | | |
| Prosecution due to unlawful disposal of construction waste | | | | | |
| Adverse weather conditions | | | | | |
| Difficulty to access site | | | | | |
| Environmental factors (floods; earthquakes) | | | | | |
| Absence of fire systems on site | | | | | |
| | | | | | |
| **Social risks** | | | | | |
| Poor communication between parties | | | | | |
| Societal unrest / disorder (strikes/riots) | | | | | |
| Criminal acts | | | | | |
| Inadequate social infrastructure / facilities | | | | | |
| Poor wellbeing of employees | | | | | |
| | | | | | |
| **Design-related Risks** | | | | | |
| Defective design | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Incomplete design information | | | | | |
| Frequent design variations | | | | | |
| Inaccurate project program | | | | | |
| Lack of design co-ordination amongst design professionals | | | | | |
| | | | | | |
| **Construction-related risks** | | | | | |
| Tight project schedule | | | | | |
| Cost and time overruns | | | | | |
| Unavailability of sufficient professionals and managers | | | | | |
| Low management competency of subcontractors | | | | | |
| Undocumented design variations | | | | | |
| Low construction productivity | | | | | |
| Complex construction projects / methods | | | | | |
| On site accidents | | | | | |
| Equipment / materials damage | | | | | |
| Unavailability of materials | | | | | |
| Suppliers incompetence to deliver materials on time | | | | | |
| Unavailability of quality materials | | | | | |
| | | | | | |
| **Procurement risks** | | | | | |
| Biases in bidding process | | | | | |
| Inadequate forecast about market demand | | | | | |
| High competition in bids | | | | | |
| Biased procurement policies | | | | | |
| | | | | | |

*Please add additional risks and their impact*
*…………………………………………………………………………………….*

## Section E: Risk management techniques

The risk management process is made up of the following processes: Risk Identification; Risk assessment; Risk monitoring and response. Kindly indicate the **frequency** of use of each of the various tools and methods indicated below.

Kindly indicate the **frequency** of use of the risk identification tools shown below on a scale of 1 to 5, where 1 = Never and 5 = Always.

| Risk identification technique | Never | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|
| Risk checklist | | | | | |
| Flow charts | | | | | |
| Brainstorming | | | | | |
| Interviews / Expert Opinion | | | | | |
| Delphi technique | | | | | |
| Questionnaires | | | | | |
| Influence diagrams | | | | | |
| Expert systems | | | | | |
| Past experience | | | | | |
| SWOT analysis | | | | | |
| Document reviews | | | | | |
| Cause and effect diagrams | | | | | |

Kindly indicate the **frequency** of use of the risk assessment tools outlined below on a scale of 1 to 5, where 1 = Never and 5 = Always:

| Risk assessment technique | Never | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|
| **Quantitative methods** | | | | | |
| Sensitivity analysis | | | | | |
| Expert Judgement | | | | | |
| Probabilistic analysis (Monte Carlo Simulation) | | | | | |
| Decision trees | | | | | |
| | | | | | |
| **Qualitative methods** | | | | | |
| Risk probability and impact assessment | | | | | |
| Probability / impact risk rating matrix | | | | | |
| Risk categorization and Risk Urgency Assessment | | | | | |

Kindly indicate the **frequency** of the following risk response tools outlined below on a scale of 1 to 5, where 1 = Never and 5 = Always.

| Risk response technique | Never | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|
| Risk avoidance | | | | | |
| Risk transfer | | | | | |
| Risk reduction / mitigation | | | | | |
| Risk exploitation | | | | | |
| Risk sharing | | | | | |
| Risk enhancement | | | | | |
| Risk acceptance | | | | | |
| Contingency plan | | | | | |

## Section F: Barriers to the implementation of risk management practices

The following are barriers to risk management in construction companies. Kindly indicate your **level of agreement** with each of these barriers on a scale of 1 to 5, where 1 = Strongly disagree and 5 = Strongly agree.

| **Barrier to the implementation of Risk management** | **Strongly disagree** | **Disagree** | **Undecided** | **Agree** | **Strongly agree** |
|---|---|---|---|---|---|
| Insufficient resources | | | | | |
| Lack of qualified personnel to implement risk management | | | | | |
| Inadequate training on risk management | | | | | |
| Lack of commitment of the board and senior management | | | | | |
| Lack of clear risk management implementation plan | | | | | |
| Difficulties in quantifying the risks | | | | | |
| Lack of time | | | | | |
| Low profit margins | | | | | |
| Unsupportive organisational culture to risk management | | | | | |

# APPENDIX C – Questionnaire responses – Risk likelihood

| Risk event | 1 – Unlikely | 2 – Seldom | 3 – Occasionally | 4 - Likely | 5 – Highly likely | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| High competition in bids | 7 | 9 | 19 | 28 | 47 | 0.7800 | 1 |
| Payment delays | 10 | 15 | 14 | 36 | 44 | 0.7496 | 2 |
| Political instability | 14 | 12 | 19 | 27 | 42 | 0.7246 | 3 |
| Bureaucracy of local / national government agencies | 11 | 14 | 26 | 30 | 38 | 0.7176 | 4 |
| Price inflation | 10 | 8 | 30 | 46 | 25 | 0.7143 | 5 |
| Project funding problems | 16 | 14 | 21 | 30 | 40 | 0.7058 | 6 |
| Corruption / Bribery | 24 | 13 | 11 | 17 | 53 | 0.7051 | 7 |
| Biased procurement policies | 11 | 17 | 23 | 25 | 36 | 0.7036 | 8 |
| Criminal acts (theft/vandalism) | 8 | 19 | 27 | 29 | 32 | 0.7009 | 9 |
| Payment risk | 13 | 14 | 22 | 43 | 28 | 0.6983 | 10 |
| Working in politically sensitive / dangerous areas | 14 | 17 | 27 | 23 | 38 | 0.6908 | 11 |
| Excessive procedures of government approvals / permits | 11 | 11 | 37 | 37 | 24 | 0.6867 | 12 |
| Societal unrest / disorder (strikes/riots) | 16 | 19 | 23 | 23 | 35 | 0.6724 | 13 |
| Biases in bidding process | 14 | 22 | 23 | 15 | 34 | 0.6611 | 14 |
| Cost and time overruns | 13 | 16 | 25 | 45 | 15 | 0.6579 | 15 |
| Inadequate social infrastructure / facilities (power, communication, roads) | 10 | 19 | 33 | 33 | 19 | 0.6561 | 16 |
| Tight project schedule | 13 | 20 | 25 | 41 | 17 | 0.6500 | 17 |
| Lack of judicial reinforcement | 23 | 20 | 13 | 30 | 30 | 0.6414 | 18 |
| Low management competency of subcontractors | 17 | 18 | 26 | 33 | 21 | 0.6400 | 19 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inadequate forecast about market demand | 13 | 18 | 17 | 20 | 19 | 0.6360 | 20 |
| Poor communication between parties | 15 | 22 | 38 | 23 | 17 | 0.6087 | 21 |
| Unstable interest rates | 15 | 29 | 26 | 33 | 14 | 0.6034 | 22 |
| Adverse weather conditions | 19 | 17 | 41 | 29 | 12 | 0.5966 | 23 |
| Stringent environmental protection by government bodies | 14 | 27 | 40 | 30 | 10 | 0.5917 | 24 |
| Poor wellbeing of employees | 15 | 25 | 37 | 30 | 10 | 0.5915 | 25 |
| Exchange rate fluctuation | 23 | 21 | 32 | 27 | 17 | 0.5900 | 26 |
| Unavailability of sufficiently skilled professionals and managers | 22 | 19 | 35 | 27 | 14 | 0.5863 | 27 |
| Suppliers incompetence to deliver materials on time | 18 | 22 | 32 | 29 | 10 | 0.5838 | 28 |
| Inadequate site information | 21 | 22 | 34 | 28 | 12 | 0.5795 | 29 |
| Incomplete or inaccurate cost estimates | 26 | 26 | 28 | 23 | 18 | 0.5686 | 30 |
| Lack of design co-ordination among design professionals and clients | 22 | 31 | 23 | 24 | 16 | 0.5672 | 31 |
| Low construction productivity | 22 | 26 | 26 | 27 | 12 | 0.5664 | 32 |
| Unavailability of materials | 15 | 33 | 32 | 22 | 10 | 0.5625 | 33 |
| Frequent design variations | 18 | 33 | 27 | 27 | 9 | 0.5579 | 34 |
| Difficulty to access site | 19 | 34 | 31 | 24 | 11 | 0.5563 | 35 |
| Legal disputes | 24 | 30 | 26 | 18 | 16 | 0.5509 | 36 |
| Undocumented design variations | 25 | 26 | 28 | 23 | 12 | 0.5491 | 37 |
| Inaccurate project program | 25 | 37 | 19 | 28 | 10 | 0.5491 | 37 |
| Equipment / property / materials damage | 20 | 30 | 32 | 22 | 9 | 0.5469 | 39 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Unavailability of quality materials | 21 | 30 | 31 | 24 | 8 | 0.5439 | 40 |
| Incomplete design information | 23 | 30 | 29 | 23 | 9 | 0.5386 | 41 |
| Complex construction projects / methods | 21 | 30 | 34 | 20 | 8 | 0.5363 | 42 |
| Defective design | 20 | 34 | 32 | 17 | 10 | 0.5345 | 43 |
| Expropriation (threat of business takeover by other agencies) | 40 | 22 | 20 | 13 | 22 | 0.5231 | 44 |
| Absence of fire systems on site | 35 | 27 | 21 | 23 | 10 | 0.5069 | 45 |
| On site accidents | 27 | 34 | 29 | 17 | 6 | 0.4956 | 46 |
| Environmental factors (floods, earthquakes) | 45 | 26 | 22 | 14 | 10 | 0.4598 | 47 |
| Prosecution due to unlawful disposal of construction waste | 47 | 28 | 21 | 14 | 8 | 0.441 | 48 |

# APPENDIX D – Questionnaire responses – Risk impact

| Risk event | 1 – Very Low | 2 – Low | 3 – Moderate | 4 - High | 5 – Very High | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| High competition in bids | 2 | 2 | 16 | 20 | 33 | 0.8192 | 1 |
| Corruption / Bribery | 6 | 8 | 8 | 13 | 39 | 0.7919 | 2 |
| Political instability | 2 | 8 | 15 | 19 | 30 | 0.7811 | 3 |
| Bureaucracy of local / national government agencies | 3 | 9 | 14 | 22 | 27 | 0.7627 | 4 |
| Payment delays | 4 | 9 | 17 | 22 | 27 | 0.7494 | 5 |
| Biased procurement policies | 3 | 9 | 19 | 16 | 26 | 0.7452 | 6 |
| Working in politically sensitive / dangerous areas | 4 | 14 | 11 | 16 | 29 | 0.7405 | 7 |
| Criminal acts (theft/ vandalism) | 8 | 9 | 9 | 22 | 27 | 0.7360 | 8 |
| Project funding problems | 8 | 6 | 14 | 24 | 25 | 0.7351 | 9 |
| Payment risk | 5 | 12 | 10 | 30 | 23 | 0.7350 | 10 |
| Excessive procedures of government approvals / permits | 4 | 10 | 19 | 24 | 18 | 0.7120 | 11 |
| Biases in bidding process | 7 | 11 | 17 | 13 | 24 | 0.7000 | 12 |
| Societal unrest / disorder (strikes/riots) | 11 | 7 | 16 | 17 | 24 | 0.6960 | 13 |
| Price inflation | 6 | 6 | 24 | 31 | 12 | 0.6937 | 14 |
| Inadequate forecast about market demand | 7 | 7 | 23 | 22 | 14 | 0.6795 | 15 |
| Lack of judicial reinforcement | 7 | 12 | 19 | 20 | 16 | 0.6703 | 16 |
| Low management competency of subcontractors | 8 | 14 | 16 | 18 | 17 | 0.6603 | 17 |
| Tight project schedule | 5 | 13 | 18 | 30 | 7 | 0.6575 | 18 |
| Cost and time overruns | 6 | 15 | 19 | 19 | 14 | 0.6548 | 19 |
| Incomplete or inaccurate cost estimates | 6 | 10 | 27 | 26 | 8 | 0.6519 | 20 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inadequate social infrastructure / facilities (power, communication, roads) | 8 | 9 | 24 | 23 | 10 | 0.6486 | 21 |
| Legal disputes | 8 | 12 | 22 | 19 | 13 | 0.6459 | 22 |
| Stringent environmental protection by government bodies | 5 | 17 | 19 | 25 | 8 | 0.6378 | 23 |
| Poor communication between parties | 10 | 10 | 23 | 22 | 9 | 0.6270 | 24 |
| Unstable interest rates | 5 | 21 | 22 | 18 | 11 | 0.6234 | 25 |
| Inadequate site information | 5 | 18 | 26 | 17 | 9 | 0.6187 | 26 |
| Low construction productivity | 9 | 15 | 20 | 21 | 8 | 0.6110 | 27 |
| Exchange rate fluctuations | 8 | 18 | 22 | 23 | 7 | 0.6077 | 28 |
| Poor wellbeing of employees | 8 | 18 | 21 | 20 | 8 | 0.6053 | 29 |
| Adverse weather conditions | 9 | 18 | 21 | 17 | 10 | 0.6027 | 30 |
| Expropriation (threat of business takeover by other agencies) | 13 | 15 | 19 | 15 | 13 | 0.6000 | 31 |
| Unavailability of sufficiently skilled professionals and managers | 11 | 15 | 22 | 16 | 9 | 0.5918 | 32 |
| Complex construction projects / methods | 6 | 18 | 27 | 18 | 4 | 0.5890 | 33 |
| Suppliers incompetence to deliver materials on time | 8 | 23 | 19 | 13 | 10 | 0.5836 | 34 |
| Lack of design co-ordination among design professionals and clients | 9 | 19 | 25 | 10 | 10 | 0.5808 | 35 |
| Incomplete design information | 11 | 19 | 20 | 15 | 9 | 0.5784 | 36 |
| Inaccurate project program | 8 | 20 | 24 | 12 | 8 | 0.5778 | 37 |
| Frequent design variations | 9 | 24 | 17 | 15 | 9 | 0.5757 | 38 |
| Defective design | 11 | 19 | 23 | 12 | 9 | 0.5703 | 39 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Undocumented design variations | 12 | 15 | 23 | 16 | 6 | 0.5694 | 40 |
| Unavailability of materials | 9 | 24 | 23 | 11 | 7 | 0.5541 | 41 |
| Unavailability of quality materials | 11 | 23 | 20 | 14 | 6 | 0.5486 | 42 |
| Difficulty to access site | 10 | 23 | 27 | 6 | 7 | 0.5440 | 43 |
| Equipment / property / materials damage | 11 | 26 | 18 | 13 | 6 | 0.5378 | 44 |
| Prosecution due to unlawful disposal of construction waste | 17 | 25 | 15 | 11 | 7 | 0.5093 | 45 |
| On site accidents | 14 | 30 | 19 | 6 | 4 | 0.4795 | 46 |
| Environmental factors (floods, earthquakes) | 20 | 28 | 13 | 5 | 8 | 0.4730 | 47 |
| Absence of fire systems on site | 21 | 25 | 16 | 8 | 5 | 0.4693 | 48 |

# APPENDIX E – Questionnaire responses – Risk severity

| Risk event | Frequency | | Importance | | Severity | |
|---|---|---|---|---|---|---|
| | Index | Rank | Index | Rank | Index | Rank |
| High competition in bids | 0.7800 | 1 | 0.8192 | 1 | 0.6389 | 1 |
| Political instability | 0.7246 | 3 | 0.7811 | 3 | 0.5659 | 2 |
| Payment delays | 0.7496 | 2 | 0.7494 | 5 | 0.5617 | 3 |
| Corruption / Bribery | 0.7051 | 7 | 0.7919 | 2 | 0.5583 | 4 |
| Bureaucracy of local / national government agencies | 0.7176 | 4 | 0.7627 | 4 | 0.5473 | 5 |
| Biased procurement policies | 0.7036 | 8 | 0.7452 | 6 | 0.5243 | 6 |
| Project funding problems | 0.7058 | 6 | 0.7351 | 9 | 0.5188 | 7 |
| Criminal acts (theft/vandalism) | 0.7009 | 9 | 0.7630 | 8 | 0.5158 | 8 |
| Payment risk | 0.6983 | 10 | 0.7350 | 10 | 0.5132 | 9 |
| Working in politically sensitive / dangerous areas | 0.6908 | 11 | 0.7405 | 7 | 0.5115 | 10 |
| Price inflation | 0.7143 | 5 | 0.6937 | 14 | 0.4955 | 11 |
| Excessive procedures of government approvals / permits | 0.6867 | 12 | 0.7120 | 11 | 0.4889 | 12 |
| Societal unrest / disorder (strikes/riots) | 0.6724 | 13 | 0.6960 | 13 | 0.4679 | 13 |
| Biases in bidding process | 0.6611 | 14 | 0.7000 | 12 | 0.4627 | 14 |
| Inadequate forecast about market demand | 0.6360 | 20 | 0.6795 | 15 | 0.4321 | 15 |
| Cost and time overruns | 0.6579 | 15 | 0.6548 | 19 | 0.4307 | 16 |
| Lack of judicial reinforcement | 0.6414 | 18 | | | 0.4299 | 17 |
| Tight project schedule | 0.6500 | 17 | 0.6575 | 18 | 0.4273 | 18 |
| Inadequate social infrastructure / facilities (power, communication, roads) | 0.6561 | 16 | 0.6486 | 21 | 0.4255 | 19 |
| Low management competency of subcontractors | 0.6400 | 19 | 0.6603 | 17 | 0.4225 | 20 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Poor communication between parties | 0.6087 | 21 | 0.6270 | 24 | 0.3816 | 21 |
| Stringent environmental protection by government bodies | 0.5917 | 24 | 0.6378 | 23 | 0.3773 | 22 |
| Unstable interest rates | 0.6034 | 22 | 0.6234 | 25 | 0.3761 | 23 |
| Incomplete or inaccurate cost estimates | 0.5686 | 30 | 0.6519 | 20 | 0.3706 | 24 |
| Adverse weather conditions | 0.5966 | 23 | 0.6027 | 30 | 0.3595 | 25 |
| Exchange rate fluctuation | 0.5900 | 26 | 0.6077 | 28 | 0.35854 | 26 |
| Inadequate site information | 0.5795 | 29 | 0.6187 | 26 | 0.35853 | 27 |
| Poor wellbeing of employees | 0.5915 | 25 | 0.6053 | 29 | 0.3580 | 28 |
| Legal disputes | 0.5509 | 36 | 0.6459 | 22 | 0.3558 | 29 |
| Unavailability of sufficiently skilled professionals and managers | 0.5863 | 27 | 0.5918 | 32 | 0.3469 | 30 |
| Low construction productivity | 0.5664 | 32 | 0.6110 | 27 | 0.3460 | 31 |
| Suppliers incompetence to deliver materials on time | 0.5838 | 28 | 0.5836 | 34 | 0.3407 | 32 |
| Lack of design co-ordination among design professionals and clients | 0.5672 | 31 | 0.5808 | 35 | 0.3294 | 33 |
| Frequent design variations | 0.5579 | 34 | 0.5757 | 38 | 0.3211 | 34 |
| Inaccurate project program | 0.5491 | 37 | 0.5778 | 37 | 0.3172 | 35 |
| Complex construction projects / methods | 0.5363 | 42 | 0.5890 | 33 | 0.3158 | 36 |
| Expropriation (threat of business takeover by other agencies) | 0.5231 | 44 | 0.6000 | 31 | 0.3138 | 37 |
| Undocumented design variations | 0.5491 | 37 | 0.5694 | 40 | 0.3126 | 38 |
| Incomplete design information | 0.5386 | 41 | 0.5784 | 36 | 0.3115 | 39 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Unavailability of materials | 0.5625 | 33 | 0.5541 | 41 | 0.3085 | 40 |
| Defective design | 0.5345 | 43 | 0.5694 | 40 | 0.3048 | 41 |
| Difficulty to access site | 0.5563 | 35 | 0.5440 | 43 | 0.3026 | 42 |
| Unavailability of quality materials | 0.5439 | 40 | 0.5486 | 42 | 0.3013 | 43 |
| Equipment / property / materials damage | 0.5469 | 39 | 0.5378 | 44 | 0.2941 | 44 |
| Absence of fire systems on site | 0.5069 | 45 | 0.4693 | 48 | 0.2378 | 45 |
| On site accidents | 0.4956 | 46 | 0.4795 | 46 | 0.2376 | 46 |
| Prosecution due to unlawful disposal of construction waste | 0.441 | 48 | 0.5093 | 45 | 0.2246 | 47 |
| Environmental factors (floods, earthquakes) | 0.4598 | 47 | 0.4730 | 47 | 0.2174 | 48 |

# APPENDIX F – Questionnaire responses – Risk identification techniques ranking.

| Risk identification technique | 1 – Never | 2 – Rarely | 3 – Sometimes | 4 - Often | 5 – Always | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Past experience | 3 | 11 | 13 | 16 | 28 | 0.7549 | 1 |
| Risk checklist | 5 | 6 | 20 | 20 | 21 | 0.7277 | 2 |
| Document reviews | 6 | 7 | 18 | 19 | 19 | 0.7101 | 3 |
| Brainstorming | 8 | 6 | 19 | 18 | 20 | 0.7014 | 4 |
| SWOT Analysis | 6 | 12 | 22 | 12 | 16 | 0.6588 | 5 |
| Interviews / Expert Opinion | 7 | 13 | 19 | 20 | 12 | 0.6479 | 6 |
| Flow charts | 5 | 16 | 18 | 20 | 11 | 0.6457 | 7 |
| Cause and effect diagrams | 8 | 14 | 24 | 10 | 13 | 0.6173 | 8 |
| Questionnaires | 8 | 19 | 18 | 16 | 10 | 0.6028 | 9 |
| Expert Systems | 10 | 14 | 22 | 15 | 9 | 0.5971 | 10 |
| Influence diagrams | 14 | 17 | 18 | 12 | 10 | 0.5634 | 11 |
| Delphi Technique | 19 | 14 | 22 | 10 | 6 | 0.5154 | 12 |

# APPENDIX G – Questionnaire responses – Risk assessment techniques ranking.

| Risk assessment technique | 1 – Never | 2 – Rarely | 3 – Sometimes | 4 - Often | 5 – Always | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Probability and impact assessment | 5 | 8 | 17 | 20 | 18 | 0.7117 | 1 |
| Probability / impact rating matrix | 8 | 9 | 20 | 14 | 18 | 0.6725 | 2 |
| Risk Categorization and Risk Urgency Assessment | 6 | 13 | 16 | 18 | 16 | 0.6725 | 2 |
| Expert Judgement | 10 | 11 | 16 | 17 | 13 | 0.6358 | 4 |
| Sensitivity analysis | 8 | 10 | 29 | 6 | 16 | 0.6347 | 5 |
| Decision trees | 13 | 17 | 17 | 12 | 9 | 0.5617 | 6 |
| Probabilistic analysis (Monte Carlo Simulation) | 19 | 17 | 18 | 8 | 7 | 0.5043 | 7 |

# APPENDIX H – Questionnaire responses – Risk response techniques ranking.

| Risk response technique | 1 – Never | 2 – Rarely | 3 – Sometimes | 4 - Often | 5 – Always | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Contingency plan | 2 | 6 | 13 | 18 | 28 | 0.7910 | 1 |
| Risk reduction / mitigation | 1 | 10 | 16 | 19 | 23 | 0.7536 | 2 |
| Risk avoidance | 4 | 7 | 18 | 15 | 25 | 0.7749 | 3 |
| Risk acceptance | 6 | 5 | 24 | 15 | 19 | 0.7043 | 4 |
| Risk transfer | 4 | 9 | 28 | 13 | 15 | 0.6753 | 5 |
| Risk sharing | 6 | 7 | 25 | 19 | 12 | 0.6695 | 6 |
| Risk exploitation | 6 | 14 | 25 | 9 | 14 | 0.6323 | 7 |
| Risk enhancement | 9 | 11 | 26 | 15 | 17 | 0.6000 | 8 |

# APPENDIX J – Questionnaire responses – Overall risk management techniques ranking.

| Risk management technique | Risk process | Average usage | Ranking |
|---|---|---|---|
| Contingency plan | Response | 0.785 | 1 |
| Risk mitigation / reduction | Response | 0.762 | 2 |
| Risk avoidance | Response | 0.749 | 3 |
| Past experience | Identification | 0.738 | 4 |
| Risk checklist | Identification | 0.7180 | 5 |
| Risk probability and impact assessment | Assessment | 0.721 | 5 |
| Brainstorming | Identification | 0.7102 | 7 |
| Document reviews | Identification | 0.705 | 8 |
| Risk acceptance | Response | 0.697 | 9 |
| Probability / impact risk rating matrix | Assessment | 0.682 | 10 |
| SWOT Analysis | Identification | 0.679 | 11 |
| Risk categorization and Risk urgency assessment | Assessment | 0.669 | 12 |
| Risk transfer | Assessment | 0.669 | 12 |
| Flow charts | Identification | 0.654 | 14 |
| Risk sharing | Response | 0.651 | 15 |
| Interviews | Identification | 0.649 | 16 |
| Sensitivity Analysis | Assessment | 0.628 | 17 |
| Risk exploitation | Response | 0.625 | 18 |
| Expert judgement | Assessment | 0.623 | 19 |
| Cause and effect diagrams | Identification | 0.621 | 20 |
| Questionnaires | Identification | 0.613 | 21 |
| Expert Systems | Identification | 0.592 | 22 |
| Risk enhancement | Identification | 0.584 | 23 |
| Decision trees | Assessment | 0.569 | 24 |
| Influence diagrams | Identification | 0.567 | 25 |
| Delphi technique | Identification | 0.523 | 26 |
| Probabilistic analysis (Monte Carlo simulation) | Assessment | 0.508 | 27 |

# APPENDIX K – Questionnaire responses – Barriers to risk management

| Risk management implementation barrier | 1 – Strongly disagree | 2 – Disagree | 3 – Undecided | 4 - Agree | 5 – Strongly agree | Mean Item Score | Ranking |
|---|---|---|---|---|---|---|---|
| Low profit margins | 3 | 7 | 3 | 30 | 26 | 0.8000 | 1 |
| Lack of qualified personnel to implement risk management | 0 | 13 | 8 | 30 | 16 | 0.7462 | 2 |
| Inadequate training on risk management | 2 | 8 | 9 | 37 | 12 | 0.7441 | 3 |
| Lack of clear risk management implementation plan | 5 | 11 | 7 | 35 | 11 | 0.7043 | 4 |
| Insufficient resources | 5 | 11 | 9 | 32 | 12 | 0.7015 | 5 |
| Unsupportive organisational culture to risk management | 6 | 11 | 10 | 31 | 10 | 0.6823 | 6 |
| Difficulties in quantifying risks | 5 | 17 | 9 | 25 | 12 | 0.6647 | 7 |
| Lack of commitment of the board and senior management | 5 | 16 | 12 | 27 | 9 | 0.6550 | 8 |
| Lack of time | 1 | 22 | 14 | 23 | 9 | 0.6492 | 9 |