DEDICATION

To Maryam, Halima and Ahmed

Even though you will never read this, it wouldn’t have been possible without your encouragement and support.

RISK AND RATIONALITY: AN EXPLORATION OF PROSPECT THEORY IN THE CONTEXT OF PROJECT MANAGEMENT

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Declaration

I, Zakari Danlami Tsiga, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature:

Date:

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Abstract

Project management focuses on delivering outcomes using available resources with predetermined goals (Glemarec & Puppim de Oliveira, 2012). Economic theory presents the concept of utility in decision making, assuming that people are rational decision-makers, although behavioural economics and prospect theory have challenged this idea, making a number of specific claims about how decision-making behaviour in practice deviates from the predictions of rationality. This research explores whether the importance of risk management is understood by project participants, examines the applicability of prospect theory in projects and evaluates whether it adequately describes decision making in the context of project risk management. The research implements a mixed method sequential explanatory approach. Surveys provide quantitative data from a large population and focus group discussions are used to gain a causal understanding of decision makers' behaviour. This research finds that prospect theory provides a better prediction of project-based decision making than expected utility theory. In particular, prospect theory's concept of reference dependence applies, with the dual reference points of the current expected cost at completion and the original budget both significantly influencing decisions. When project performance is only slightly below expectations, project managers' decisions reflect a 'double-or-nothing' effect, as they take risks to try to get back within budget. As performance deteriorates further, however, decision makers become more risk averse, fitting a pattern of 'damage limitation', contradicting the predictions of prospect theory, which predicts increasingly risk-seeking behaviour when in an unfavourable position.

Impact Statement

This research contributes to two main bodies of knowledge. Firstly, the research contributes to the academic body of knowledge of prospect theory. Prospect theory has achieved wide acclaim, but its predictions have not yet been explored in a project management context. This research contributes some understanding of the applicability of prospect theory to risk-based decisions faced by professionals in engineering projects. Of particular importance is the finding that prospect theory does not apply in the same way in projects as standard prospect theory suggests.

Secondly, the research contributes to the practical body of knowledge of project management. The research focuses on risk-based decision making in projects and evaluates the extent to which managers behave rationally with respect to risk. The research helps us to understand the importance of risk in a project context through the study of critical success factors, and to understand the reasons why project participants make the choices they do. Knowing if and why decision makers deviate from rational choice can ultimately help project sponsors to understand the influences on managers' decisions. They can therefore ensure that appropriate guidance and incentives are in place to help managers make decisions in ways that optimise project performance and align with the objectives of the sponsors.

The research process implemented in this research could be used as a generic framework for comparison with other industries/sectors. The research contributes to the quantitative body of research, drawing from data obtained from the implementation of surveys, and qualitative data obtained from the focus group discussion. The researcher adopts the use of a quantitative study to find answers from a large population, with the hope that this might allow generalisation and the qualitative stream of research for drawing from the rich qualitative data.

Publications

All publications including conference and poster presentations are peer reviewed. Parts of these papers have been incorporated in different chapters of this thesis. The research published are:

Journal Papers

- **Tsiga, Z**., Emes, M. and Smith, A. (2016). **Attitudes to risk management in space projects**. *The Journal of Modern Project Management,* 4(1), pp.40-51.
- **Tsiga, Z**., Emes, M. and Smith, A. (2016). **Critical success factors for projects in the space sector**. *The Journal of Modern Project Management,* 3(3), pp.56-63.

Conference Papers

- **Tsiga, Z.**, Emes, M. and Smith, A. (2017). **Critical success factors for projects in the petroleum industry**. In: *ProjMan 2017 – International conference on Project Management*. Barcelona, Spain: Elsevier – Procedia Computer Science.
- **Tsiga, Z**., Emes, M. and Smith, A. (2016). **Attitudes to risk in petroleum projects**. In: *ProjMan 2016 – International conference on Project Management*. Porto, Portugal: Elsevier – Procedia Computer Science.

Poster Presentations

- **Tsiga, Z**., Emes, M. and Smith, A. (2016). **Risk management – perceptions and attitudes in space projects**. In: *INCOSE UK Annual Systems Engineering Conference*. Coventry, United Kingdom: INCOSE UK.

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

1. Introduction

1.1 Research background

Projects involve the systematic application of distinct technical skills, operational protocols, budgets and schedules to deliver desired outcomes with specific success criteria (Kerzner, 2013). Project management practice has traditionally been founded on the concept of expected utility as theorised in rational behavioural models (Barberis, 2013). The models suggest that, where individuals are not able to explicitly measure utility that comes from selecting between decision alternatives given the known certainties, it is usually still possible to rank decision alternatives based on preference to achieve the best outcome.

Evidence shows that in some cases, instead of selecting the best outcome based on expected utility, decision makers appear to be risk-averse in the face of uncertainty, even in situations when preferred outcomes are known; this can lead to decisions to select safe outcomes instead of optimum outcomes (Barberis, 2013; Anantatmula & Thomas, 2013; Dhami & Al-Nowaihi, 2013). Looking at decision making with a focus on risk when faced with uncertainty in projects is at the heart of the proposed research. Decision making in the face of uncertainty is the realm of prospect theory, and as such it provides a theoretical background to describe how people decide between alternatives that involve risk, where the probabilities of outcomes are known and the decision makers do not act rationally (Vis, 2011). This research looks at why people may not treat quantifiable risk rationally.

Prospect theory has provided a foundation for understanding behaviour in a variety of domains (Barberis, 2013; Anantatmula & Thomas, 2013; Dhami & Al-Nowaihi, 2013). It has not previously been applied in analysing decision making within the context of management of engineering projects, however, as will be discussed in this thesis.

1.2 Motivations behind the research

My experience as a programme manager in Nigeria has given me the opportunity to apply the knowledge, I have gained in project management on real-life government projects. Although I understand the significance of risk management and the theoretical background from my studies, my experience in projects has been that managers often do not understand its importance, and certainly do not seem to make risk-based decisions based on the 'rational' approach of utility maximisation. The project management body of knowledge does not give a clear answer as to why decision makers may not always act rationally (Association for Project Management, 2012; Project Management Institute, 2013). To investigate this problem is at the heart of this research.

1.3 Research problem

Projects are vital for the growth of any organisation, industry, or country. They play a significant role in being the vehicle for change, providing employment, and delivering value. When taking on new projects, it is essential to be able to employ techniques that will lead to a positive outcome on the selected project deliverables. Despite the vast experience, skill and project knowledge currently available, a significant number of projects still fail. According to the Gartner Group, as at 2012, 61% of technological projects were classified as 'unsuccessful.' A study by Mckinsey & Company in conjunction with the University of Oxford in 2011 also reveals that 17% of projects go so badly wrong that they can threaten the existence of a company, and on average 45% of projects run over budget and 7% are delivered late, while providing 56% less value than predicted (Mckinsey & Co.; Oxford University, 2011).

As new projects have higher complexity and risk, Pinto and Selvin (1988) argue that factors such as cost, time and technical performance are not the only key areas to focus on to improve success. Research is needed to help provide an

understanding as to how decision makers make choices in projects; understanding this may give some insight into why so many project projects go wrong.

In the context of engineering projects, this research investigates the question of whether project participants approach risk management rationally. The concept of expected utility and rationality have been a major foundation for standard economic decision making. But research has now established that expected utility does not always explain the decisions taken in many contexts (Tversky & Kahneman, 1981; Thaler & Johnson, 1990; Tversky & Kahneman, 1992; Camerer & Ho, 1994; Wu & Gonzalez, 1996; Roberts, Boyer, & Lusk, 2008; Harrison, Humphrey, & Verschoor, 2010). To explore the research problem, three real-life examples of ineffective risk-based decision making are described.

The first example is the British Petroleum (BP) Macondo well disaster. This project was about drilling and establishing a platform in the Gulf of Mexico, and involved drilling in September 2009 the world's deepest oil well at a vertical depth of 10,683 m. At the end of the drilling phase of the well project, a blowout occurred that led to the destruction of the Deepwater Horizon platform. A joint report from the United States Coast Guard and the Bureau of Ocean Energy Management (2011) found that the reason behind the blowout was a series of decisions that increased risk and a number of actions that failed to consider and mitigate those risks. The report suggests that BP did not perform any formal risk assessment of critical operational decisions made in the events leading to the blowout of the well. As such, because of the cost and time-saving decisions made by the employees of BP without considering the contingencies and mitigation options, they failed to ensure all risks associated with operations on the oil well were low. This led to the explosion of the well that killed 11 people, injured various others and led to over four million barrels of oil pouring into the Gulf of Mexico (Skogdalen & Vinnem, 2012). According to Jim Hackett, the CEO of Anadarko Petroleum Corporation, the risk management typically implemented in such projects involved understanding what the hazard drill crew faced as well as what should be done to prevent such

incidents (Connelly, 2010). But this was not the case, as the decision makers opted to make decisions to save cost and time, which ultimately ended in disaster.

The second example is the case of St Helena airport construction project with a budgeted cost of £285 million (Walmsley, 2017). Wind shear is one of the deadliest atmospheric conditions an aircraft can face especially when landing or taking off (Bray, 1988). As aeroplanes approach an airport wind shear can destabilise the approach and cause the plane to lose lift (Bray, 1988). Violent turbulence near the ground has resulted in many crashes and pilots have been trained to avoid flying into wind shear conditions (Walmsley, 2017). One of the triggers/hotspots for wind shear conditions is the topography. Mountainous terrain combined with strong winds has the potential to cause wind shear type events and as such flying near mountainous regions requires special care, attention and training (Jury, 1984). These issues are already known, and the proposal to build a new airport on the island of St Helena 2,000 km out in the Atlantic Ocean already had various warning signs. St Helena's prominent feature is a volcanic mountain that rises out of the sea to an elevation of 2,600 feet. As such the mountain has a significant effect on the atmospheric conditions in the area and is known to trigger substantial air turbulence in the St Helena area (Calder, 2016). Based on the weather conditions of the area, the mountain and the limited number of possible sites to build an airport has resulted in an airport that has turned out to be too dangerous to land an aircraft (Calder, 2016). A test flight was made using a Boeing 737 aircraft in June 2016. It was found that the wind shear conditions were significant, and view of the aeroplane landing shows the plane pitching and tilting near the ground as the turbulence hit the aircraft (Calder, 2016). This has led to an indefinite postponement of the opening of the airport. Currently, discussions are taking place on how to mitigate the problem, and it's a shame that more serious consideration was not given before the investment was made and the project took off even though adequate warning had been given about the wind shear issue prior to the project being approved (BBC, 2016). It seems the warnings were ignored/misjudged, and it appears that the project team failed to conduct appropriate studies before the construction began.

The third example is the Space Shuttle Challenger decision to launch for mission STS-51. The shuttle programme had originally been justified primarily on economic terms, with President Nixon announcing the shuttle programme on 5th January 1972, saying that it would "revolutionize transportation into near space, by routinizing it" (National Aeronautics and Space Administration, 1974). Mission STS-51 involved several projects, including the deployment of the second in a series of Tracking and Data Relay Satellites, the first flight of the Shuttle-Pointed Tool for Astronomy, and conducting several lessons from space as part of the Teacher in Space Project and Shuttle involvement Program (SSIP) (Vaughan, 1997). However, a structural failure during its ascent phase 73 seconds after launch led to an explosion that killed all crew members. The Rogers Commission determined that the cause of the destruction was due to the failure of an O-ring seal on the starboard Solid Rocket Booster (SRB) (Rogers, et al., 1986). The primary and secondary O-rings were designed to seal a tiny gap created by pressure at ignition in the joints of the Solid Rocket Booster (SRB). The O-rings resistance was impaired by the cold temperatures on the day of the launch. Once the ignition occurred, hot propellant gasses impinged on the O-rings, this created a flame that passed through the aft field joint of the right SRB, then the flames passed through the external tank that contains liquid hydrogen and oxygen. This caused the explosion and the disaster (Vaughan, 1997). In the investigations and report the Rogers Commission (Rogers, et al., 1986) revealed that the O-ring problem had a well-documented history at the space agency and also the engineers responsible for building the SBR (Morton Thiokol) protested the launch arguing that the O-rings were a threat to flight safety. The NASA managers decided to proceed, this decision ultimately led to the disaster. The decision to launch was a tragic decision that was a result framed as a choice between losses (Rogers, et al., 1986). Before the launch, there had been several launch delays which were not desirable from the perspective of NASA as they believed that the public and political support for the space programme would be affected (Esser & Lindoerfer, 1989). Delaying the launch further would have had a knock-on effect on upcoming scheduled launches such as the Astro mission and the planetary science mission already scheduled after the challenger. Programme constraints on launch schedules and the possibility of a

favourable mention by the President during the State of the Union message scheduled for the evening of the launch day of the Challenger conspired to make NASA to decide not to delay the launch as it would have led to certain losses. A successful launch would have avoided the negative consequences associated with another delay, even though the decision to launch exceeded the level of risk that was typically considered tolerable for NASA (Kramer, 1992). It became acceptable. The decision makers at NASA became accustomed to deviation so that they didn't consider it as being deviant even though the risk exceeded their own rules for elementary safety. Vaughan defines this as the normalization of deviance (Vaughan, 1997). Normalisation of Deviance can lead to groupthink as there is a natural human tendency to rationalise shortcuts under pressure, especially when nothing negative happens. The lack of bad outcomes reinforces the correctness of trusting past success instead of objectively assessing risk (Vaughan, 1997).

From the cases described above, there is a general behaviour that suggests that the importance of risk management is not treated seriously and approached in a rational manner in projects. According to expected utility theory, the decision maker chooses between risky or uncertain prospects by comparing their expected utility values (Mongin, 1997). In this sense, expected utility theory should be at the heart of risk-based decision making (Yang & Qiu, 2005). Looking at the cases above, however, we know that expected utility does not always apply in practical contexts (Tversky & Kahneman, 1981; Thaler & Johnson, 1990; Tversky & Kahneman, 1992; Camerer & Ho, 1994; Wu & Gonzalez, 1996; Roberts, Boyer, & Lusk, 2008; Harrison, Humphrey, & Verschoor, 2010). Even though the textbook approach to risk management tends to assume rationality, behaviour in the real world seems to be different (Rogers, et al., 1986; Zhou, 2016; Skogdalen & Vinnem, 2012; Walmsley, 2017; Krall & Peng, 2015). This research study aims to understand the extent of this rationality. Prospect theory has been presented as providing a better explanation of individuals' decision-making behaviour than expected utility theory. Prospect theory describes how individuals make choices between probabilistic alternatives where risk is involved, and the probability of different outcomes is either known or unknown (Kahneman & Tversky, 1979). It is not yet known

whether prospect theory generally works better than expected utility theory in a project context, where decisions may not reflect just a single individual's preferences, but also the preferences of other stakeholders.

1.4 Research approach

The previous section introduces examples of cases which provide a foundation for the research question and objectives developed in the literature review. In the literature review section core concepts are discussed. This includes the concept of risk, understanding risk management in the project management context, and approaches to managing risk in project management. Through the literature review, our understanding of the research area is put into perspective. The relationship between decision making and expected utility theory is discussed in a project context, highlighting the shortcomings of expected utility theory and proposing prospect theory as an explanation for such deviations. This has built on previous research in behavioural economics and project management.

The research problem is investigated in the context of engineering projects, with a particular focus on projects in the petroleum, construction and space sectors, by seeking respondents that focus on the delivery of such projects. The selection of the space sector was based on the interest of the UCL Department of Space and Climate Physics (which supervised this research) and its objective to deliver space technology in a cost effective and reliable way. The selection of the construction and petroleum industries is based on the interest of the Technology Management research group at UCL, and the Nigerian government agency that provided the funding for this investigation.

The first stage of the research consists of a literature review of the critical concept and works in the research area. The work was supplemented with two questionnaires, which were targeted to determine (i) the perceived importance of risk management in the delivery of projects, including whether hard aspects (such as quantification) or soft aspects (such as communication) were seen as more

important and (ii) how project participants behaved when faced with risk-based decisions. The final stage of the research was the implementation of focus group discussions to triangulate the results of the surveys and to help give a precise meaning and explanation as to how and why project participants behave the way they do when faced with risk-based decisions in projects. The data analysis takes an iterative look at the data gathered in the research and highlights patterns that can be derived from mining the data.

This study forms a foundation on which further research could be conducted, especially in the selected areas. The outcome of this research provides both qualitative and quantitative data to which other comparative studies could be carried out to address similar issues arising in other sectors.

1.5 Theoretical framework

Barberis (2013) states that historically, expected utility theory has provided an avenue to understanding decision making. In expected utility theory, when a decision maker has to decide between different options in a project, the best decision or answer will be one that gives the maximum return on the invested resources. Expected utility theory helps us understand decisions that are based on profit maximization; this profit maximisation can be easily measurable and tangible.

Prospect theory builds on expected utility theory but challenges the assumed rationality of decision makers, introducing four key concepts: reference dependence, loss aversion, diminishing sensitivity and probability weighting (Kahneman & Tversky, 1979). Prospect theory suggests that when decision makers are in a risky situation, they are inclined towards choosing safer outcomes that do not always provide the maximum expected utility rather than gambling on riskier outcomes with higher expected utility (Barberis, 2013). One of the main principles of prospect theory is that in weighting risk in situations of uncertainty, decision

makers consider avoiding the worst outcome as more important than obtaining the maximum utility (Kamleitner, Korunka, & Kirchler, 2012).

Prospect theory provides a possible explanation for the choices project managers make in projects; it is possible that the project managers are risk-averse to failure instead of being focused on achieving success. One of the significant findings of Kahneman and Tversky (1979) is to show that people are not always rational decision makers and as such project managers may not always approach the task of achieving the best outcome during a project in a rational manner. Prospect theory is the main theoretical framework examined in the current research, and the research question seeks to establish whether risk is treated rationally, and to test the predictions of prospect theory in a project management context. As a first step in understanding this, it is helpful to establish the extent to which managers recognise the importance of doing risk management well, and whether they see hard aspects like risk quantification as more critical, or soft aspects like risk communication. According to expected utility theory's rational approach, we would expect to see the hard, quantitative aspects of project risk management as critical to project success.

Research Question: Is the importance of risk management understood and is prospect theory a good model of understanding risk management behaviour in a project context?

One area of particular interest in projects is the relationship between project owner or sponsor and project manager. It is not clear to what extent the presence of a principal-agent problem may affect the predictions of prospect theory, where the project manager may not make decisions that are in the best interests of the project owner (Koppenjan, Leijten, ten Heuvelhof, Veeneman, & van der Voort, 2010). The reasons behind the decisions or choices made by the project manager may be influenced by information not available to the project owner, or by factors which the project owner would not see as important.

1.6 Significance of the study

This research provides both practical and theoretical contributions. In the aspect of practical contributions, the results of this research can help project managers improve the projects they supervise in achieving project success. This can be done by having a better understanding of the rationale behind the choices the project managers make which is the primary objective of this study. In the aspect of theoretical contributions, this research provides an understanding of prospect theory in the context of engineering projects, which is not well covered in the existing literature. The research seeks to establish whether risk is treated rationally, and to test the predictions of prospect theory in a project management context. As a first step in understanding this, it is helpful to establish the extent to which managers recognise the importance of doing risk management well, and whether they see hard aspects like risk quantification as more critical, or soft aspects like risk communication. From this research, it was determined that there is a positive relationship between project risk management and project success. Based on the results of the relative importance index, project risk management is very important and should be considered as a critical success factor in the future. Also, the findings show that the soft side of project risk management which constitutes "communication & culture" and "monitoring and review" is deemed of greater importance than the hard aspects. The results show that the participants' decisions are not consistent with expected utility theory and hence at least partially irrational, as they are influenced not only by the current project performance but also by how far they are from the original performance baseline. This research has also identified other possible reasons why decision makers may deviate from rational choice including 1) intuition drawn from experience, 2) fear of worsening project state, 3) interference from direct stakeholders, 4) government interference. 5) having the wrong information, 6) assume everything is under your control, 7) instability of project materials (market instability), 8) change of project scope/deliverable, and 9) Lack of understanding and knowledge.

Looking at risk management implementation in projects, this research finds that risk management is often implemented in a 'fire-fighting' style. Even though respondents agree that risk management is important in projects, its implementation is mostly an afterthought or for documentation purposes. However, the bigger the project, the more time is dedicated to risk management. This means that the approach to risk management in a project is dependent on factors such as size, complexity, focus and level of risk.

Prospect theory provides a possible explanation for the choices project managers make in projects. The four elements of prospect theory are 1) reference dependence, 2) loss aversion, 3) diminishing sensitivity, and 4) probability weighting. Reference dependence in prospect theory predicts that a decision maker's utility depends not just on the end-point, but also on the changes to his/her wealth. The results of this research show that respondents consider both the break-even point and the current performance (projected cost at completion) as reference points when making a decision. In relation to loss aversion, project managers tend to avoid making risky decisions that could lead to more losses; even when the expected value is positive, project managers generally tend to prefer to make risky decisions only when the conditions are already favourable. Diminishing sensitivity suggests that the further you get from the break-even point, the less you care about the possibility of further gain/loss – i.e. the utility vs cost position curve has a reducing gradient as you go away from the break-even point (positive or negative). Diminishing sensitivity means a flattening gradient as you move further from the origin – risk averse to gains and risk seeking for losses. The results show that project managers are more willing to take risk (risk seeking) if the project is going well (under budget) as even if the risky decision does not work out, the odds are favourable that the project will still be delivered on budget or slightly over budget. In the domain of losses, however, decision makers are more risk-averse. In the aspect of probability weighting function, the results of this research show that the focus group participants believe that in projects this is sometimes applicable, however there was no evidence to support this specific claim of prospect theory in the survey data in terms of the respondents overweighting low probability events. As such the author

can only claim partial support for this aspect of prospect theory in the project management context.

Finally, an overall significant contribution of this research is that the results could be used to help improve successful project delivery by giving an insight into how project decision-makers behave in the face of risk and uncertainty in projects.

1.7 Structure of the thesis

The thesis format follows the research approach taken during the research. The approach taken includes establishing the research question and objectives, developing the methodology, and gathering and analysing data to support the conclusions. The thesis is organised into five chapters explained below:

Chapter 1: This chapter discusses the background of the research by stating the research objectives, justification of research, introduction to sectors and finally the organisation of the study.

Chapter 2: This chapter presents the looks at our current understanding of projects and project management. The section also looks at project success and how to measure project success. Aspects such as definitions and problems that arise from understanding project success regarding perception and misinterpretation are discussed. This chapter also looks at risk and decision making in the project management context. Aspects such as the concept of risk, prospect theory, risk and uncertainty, project risk management and decision making are discussed in this section. The chapter also introduces the research objectives for this research.

Chapter 3: This chapter presents the research methodology section of this research. Details on the scope of the study, philosophical view, research design, research approach, data collection, instrumentation, data analysis and validation of research are given and discussed.

Chapter 4: This chapter presents the findings, analysis and discussions for both the explanatory (surveys) and exploratory (focus group) results conducted in this research. From the findings, discussion and reflections were carried out under the umbrella of the research objective.

Chapter 5: The final chapter presents conclusions of what has been found in the research, with a summary of the main results and an exploration of the theoretical and practical implications. Finally, this chapter also discusses the limitations of the research and contributions and reflects on possible areas for further investigation.

2 Literature review

Looking at how people behave in the face of risk and uncertainty in projects is an exciting area of research and as such the literature review was the first step to understand what is currently known and what can be done in the area. Authors in the field were identified from various books and journals. This was done via searches on databases such as EBSCO and Elsevier using keywords such as expected utility theory, prospect theory, risk decisions, project risk management, and project success. The search criteria allowed for recommendations in similar articles after the most relevant have been identified. The aim was to identify and highlight the methodologies that have been used in the study of decision making and to compare the methods and findings of other researchers with those found in this research. This allowed the author to have a concrete theoretical contribution in the subject area.

This chapter introduces the background literature for the research. Here, the author introduces projects, project management, project success and the concept of risk. The section also discusses the theories of Knight (1921) and Keynes (1921a) who explain the difference between risk and uncertainty. The chapter looks at the aspect of risk management in the management of projects, decision making in projects and explanations on expected utility theory and prospects theory. Finally, the chapter introduces the research objectives to be explored in this research.

2.1 What is risk?

2.1.1 Concept of risk

Two main distinct groups argue the relationship between risk and uncertainty. These are the views of Knight (1921) and (Keynes, 1921a). Knight (1921) provides a clear distinction between risk and uncertainty. According to Knight (1921), "*Uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated*", "*it will appear that a*

measurable uncertainty or risk proper…is so far different from an immeasurable one that is not in effect an uncertainty at all." Knights has a clear differentiation between risk and uncertainty as he refers to risk to events to known or knowable probability distribution while uncertainty refers to events where it is not possible to state its probability (Leroy & Singell, 1987; Runde, 1998). Knight (1921) differentiates between subjective and objective probability as he treats subjective probability as a true probability. Researcher Runde (1998) suggest that knight's differentiation is based on trichotomy of probability situations as a priori probability; statistically probability and estimates. An a priori probability is derived purely from deductive reasoning. Such an instance is homogeneous, and the odds of an event occurring can be calculated through general principles. Statistical probability deals with empirical situations by evaluating the frequency of occurrence. The critical difference between these two probabilities is that the frequency evaluation for statistical probability cannot be analysed equally to the same degree (Abd Karim, 2014). Hence knight proposed a method of statistical grouping to enable the production of more meaningful probabilities and their frequency of occurrence.

Decision makers turn to intuition classified as estimates when the basis of categorising events is uncertain (Knight, 1921) to predetermine probability. Knight suggests that in economics, taking decisions depends on the forecast of the future if the information is available and when the future is unknown the laws of probability would determine the outcome. He further reiterated the difficulty of forecasting the future, and he states that it is impossible to apply mathematical propositions to it. He also doubts that much could be learnt from an empirical evaluation of the frequency of past occurrence (Bernstein, 1998). A priori reasoning cannot eliminate indeterminates from the future as an extrapolation of past frequencies is the go-to method of arriving at judgements about what lies ahead (Bernstein, 1998).

Keynes is a renowned theorist, and in his work with regards to economic decisions, he does not distinguish between risk and uncertainty as done by Knight (1921).

Keynes (1921a) suggest that the probability theory has little relevance to real-life situations. He further suggests that an objective probability of a future event does not exist, and when ignorance denies us the certainty of knowing what probability is, we then fall back on estimates. Even though the theory of probability is subjective the level of belief that is rational in given conditions is logical (Keynes, 1921b). As uncertainty arising in situations that there is no basis to calculate the probability Keynes developed the perspective of probability being measurable and as such Lawson (1988) suggest that economist should follow Keynes concept of uncertainty when there is no knowledge available regarding the mathematical probability.

Keynes (1921b) suggest that it does not mean that the probability can only be known when more evidence is available, but it is due to the lack of skill in arguing the given proof when there is an unknown probability. He goes a step further to acknowledge the general weakness of peoples' reasoning power and says it prevents them from knowing the degree of knowledge. As such, Keynes account of uncertainty arises when there is no knowledge available it is a situation where there is no basis to determine or to compare the probability that is known. Keynes (1921b) highlights the importance of judgement and relative perception in determining risk probabilities. Researcher Bernstein (1998) cites the work of Keynes and knight as disagreeing with decisions based on the frequency of past occurrences. Bernstein (1998) also rejected the analysis that was based on events and was open to predictions based on propositions.

Bernstein (1998) says that the works of knight and Keynes predates Arrow's proposition that the researchers of the past were merely concerned only with the establishment of laws of probability to tackles concerns of uncertainty. When we have a record of similar experiences to resemble the patterns of games of chance, probabilities can be calculated. Bernstein (1998) criticised the viewpoints of the theorist who argued that the laws of probability are successful when we have no control over the next throw of the dice and when the following error in measurement occurs. This suggests that people tend to make judgments even if they do not have

sufficient information to arrive at a decision. This is mainly because people fall back to inductive reasoning in such situations. It can be argued that in economic decision making, the mathematical or priori probability is not applicable as decision making involves judgement of future outcomes which tend to be more subjective than objective. Keynes (1936) mentions that humans are forced to act with knowledge which would provide a sufficient basis for calculating mathematical expectations (Keynes, 1936). Decisions deal with uncertain situations which are unique for statistical tabulations to have a value of guidance (Knight, 1921) and uncertainty is only to the unpredictability of economics, mainly when associated with time and information (Davidson, 1991; Shackle, 1949).

Project management deals with a variety of risk because projects are unique and temporary (Lechler, Edington, & Gao, 2012). As each project has a unique feature/characteristic that differentiates it from other projects, this makes the information gathered from past experiences not entirely reliable to new projects and as such uncertainty is introduced (Kutsch & Hall, 2009). Risks have the potential to hinder project managers from meeting the objectives of scope, time and cost (Iron triangle) (Kutsch & Hall, 2010; Kutsch & Hall, 2009). It has become essential to identify, assess and manage risk. The concept of risk is not a clearly defined concept, and it has been debated in the academic community. Researcher Ackermen et al. (2007) define risk based on its "systemicity" by stating that risk can be represented as a network of interconnected possible events by which the likelihood of one may have a repercussion on another event. The Project Management Institute (2013), risk "*an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives*". This definition is similar to that of the Association for Project Management as they state that "*risk is an uncertain event or set of circumstances that, should it occur, will affect the achievement of the project's objectives*" (Association for Project Management, 2012). From these definitions, a risk is a potential event that may change a project's baseline positively or negatively (Lechler, Edington, & Gao, 2012). In this research, the author adopts the definition of risk as provided by the Project Management Institute. This is because the institute is considered the most influential in the field of project

management (Lenfle & Loch, 2010) as they provide the best practices for project management (Kutsch & Hall, 2010; Kutsch & Hall, 2009). There is no consensus on the definition of risk, and this might be because different individuals would have a different perception of risk (Taroun, 2014; Hartono, Sulistyo, Praftiwi, & Hasmoro, 2014; Lehtiranta, 2013; Zhang, 2011; Adams, 2007; Adams, 1995). This is one of the reasons that motivated this research; it would be interesting to investigate the risk-taking behaviour of people who deliver projects.

2.1.1.1 Risk and uncertainty in economic theory

To help understand the concept of risk and uncertainty, economic theory was expanded to explain the relationship. This addition of risk and uncertainty into the economic theory was first done by Von Neumann and Morgenstern (1944) who also invented the game theory. They went a step further to expand on the process of decision making when in risky situations, due to the decision maker not having the required information his/her goal is to maximise expected utility. Utilities, in this case, tend to be substitutable and are restrictively transferable between parties (Von Neumann & Morgenstern, 1953). In that scenario, they assume that the decision maker is behaviourally risk neutral or a risk taker. On the other hand, Markowitz (1952a; 1952b) argues that this concept ignores the idea of risk aversion because insurance companies eliminate most of the risks (Markowitz, 1952a; Markowitz, 1952b). Game theory has influenced the use of inductive reasoning in making a decision when limited information is available (Marschak, 1946; Marschak, 1950; Simon, 1955; Simon, 1959). Researchers Von Neumann and Morgenstern (1944) have presented three types of uncertainty which are namely ignorance, risk/probability considerations and economic indeterminacy. Even though researchers have discussed different ideas and thought, they are currently still debates going on with regards to the problem of economic and probability theory.

2.1.2 Risk and uncertainty

The inclusion of risk and uncertainty into the economic theory and behaviour was first done by Von Neumann and Morgenstern (1944) which was later complemented by Savage (1954) (Winch, 2007). Their work suggests that when making decisions under risk, the decision maker makes his/her choice by maximising expected utility. Before deciding on an action, the decision maker has to consider the risk associated with future events that would propagate from the action he/she takes. This method had been defined as risk aversion, risk-taking and portfolio selection (Friedman & Savage, 1948; Savage, 1954).

The concept of risk and uncertainty has been discussed in research (Knight, 1921; Keynes, 1921a; Arrow, 1951; Ramsey, 1926; Friedman & Savage, 1948). They all have presented and defended their arguments with regards to the concept of risk and uncertainty. Overall, they are two distinctive views that emerge when discussing risk and uncertainty. In one hand, you have a group of researchers that suggest that risk and uncertainty are two different things and on the other hand, you have a group of researchers argue that risk and uncertainty are similar. The earlier suggest that risk involves probabilities that can be numerically assigned (Knight, 1921) and it is not subjective (Keynes, 1921b). Knight and Keynes both suggest that risk involves a classification of outcomes that are unknown, and they further divided this outcome into a priori probability and statistical probability. While uncertainty occurs when the likelihood of an event cannot be calculated (Keynes, 1921b) due to the lack of knowledge (Knight, 1921). This is an epistemological issue. They further state that uncertainty does not involve mathematical probabilities and it cannot be analysed (Arrow, 1951; Debreu, 1971; Knight, 1921). In decision making, decision takers usually overestimate the amount of information typically available to them (Arrow, 1951; Bernstein, 1998).

The second school of people disagreed with Knight, Keynes and Arrow suggesting that risk was a subjective probability (Ramsey, 1926). The research from Ramsey (1926) became the basis for other researchers. Marschak (1946) disagreed with

Knight (1921) explanations of risk and uncertainty, suggesting that people do not act upon probabilities as cardinal numbers but as merely probable events while the utility is the quantity of complete numerical explanations. Bernstein (1998) suggest that knight and Keynes disapproved of classical theories and they defined risk as it is understood today.

Risk and uncertainty are concepts that are confusing to project managers; this misconception has been identified in research (Lechler, Edington, & Gao, 2012). The two ideas are vast. Galbraith (1977) defined uncertainty as "*The difference between the amount of information required to perform the task and the amount of information already possessed by the organisation*". This definition is based on the need that more information is required before an individual or organisation can perform a specific task or activity (Krane, Olsson, & Rolstadås, 2012). Uncertainty can be understood as a knowledge gap between what we should know and what we know to ensure project success (Regev, Shtub, & Ben-Haim, 2006). Lecher et al. (2012) suggest that uncertainty is related to unpredictable situations that a project might have. This means that uncertainty may or may not have an impact on a project this is different from risk as risks are classified as having an impact (Krane, Rolstadås, & Olsson, 2010). The author goes a step further to state that unlike risk, uncertainty cannot be avoided and need to be handled in a different manner (Lechler, Edington, & Gao, 2012). The relationship between risk and uncertainty has been identified as having a cause, and consequence relationship as uncertainty is the origin of project risks and risk are present to a certain extent in projects (Thamhain, 2013; Perminova, Gustafsson, & Wikström, 2008). Risk are events that occur when uncertainty arises, the entail the possibility of affecting project objectives (Project Management Institute, 2013; Lechler, Edington, & Gao, 2012). Hilson (2010) states that risk is uncertainty that matters.

To manage risk correctly, it is paramount to identify where the risk lies (Uncertainty that causes effects on a project). As uncertainty and risk have to be managed differently, project management standards and practices do not concisely state how to deal with uncertainties. The lack of a clear distinction between risk and

uncertainty creates misconception and therefore leads to lack of opportunity realisation for efficient management of uncertainties (Lechler, Edington, & Gao, 2012).

2.1.2.1 Other approaches to risk and uncertainty

The relationship between expected utility theory and risk management have shaped our understanding of risk. Schoemaker (1982) suggest that the expected utility is the primary concept behind decision making. Peterson and Sandin (2010) indicate that those decision makers with technical backgrounds more readily accept that proposition to which they believe and moving away from such is considered as unreasonable. Even though the concept of risk management has its links to the maximisation of the expected unity theory, there is still criticism of the theory which suggests its inadequacy (Peterson & Sandin, 2010).

There are currently different approaches to risk in the area of project management. The standard method is project risk management which its methodology is drawn from the expected utility (Yang & Qiu, 2005). Project risk management is defined as "processes of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project (Project Management Institute, 2013)" and as such the risk management methodology ensures utility maximisation when it comes to risks in a project. Besides the project risk management methodology researcher Winch (2007) suggest that the INSEAD team have introduced a new method which is different from the expected utility theory. They argue that the uncertainty is not a set of categories, but it is continuously varying and any categorisation would make it subjective. They believe that the classification is changeable depending on what one is trying to highlight. They break uncertainty into four categories which are namely *variation, foreseen uncertainty, unforeseen uncertainty and chaos* (De Meyer, Loch, & Pich, 2002; Pich, Loch, & De Meyer, 2002; Loch, De Meyer, & Pich, 2006).

Variation entails having a variety of small risks which have minimal influence, and hence it's not worth manging a risk individually, and as such, it involves managing risks using an accumulated buffer. *Foreseen uncertainty* is easily identifiable and has a recognisable influence which requires risk management. As risk is an individual factor that might have a significant impact on some possible outcomes, it can easily be managed with the implementation of risk management. The main difference between this two is when making the decision. When implementing risk management, when risk is identified it would be decided which are worth taking actions on and which are manageable with a buffer. *Unforeseen uncertainty* arises from unexpected interaction with events which should have been foreseeable even if the existing decision mechanism in place does not address them (De Meyer, Loch, & Pich, 2002). *Chaos* is the final category, and this is when the return is different from what was expected due to being unaware. Even though the difference or similarity is not stated, their work does suggest that they do not entirely agree with Knight and Keynes views on expected utility with regards to risk and uncertainty.

To provide a solution for the different categories of uncertainties, the team have produced strategies/approaches which are learning strategy, instructions strategy and selections strategy which relates to project management. Project managers tend to implement a slack or a buffer when they are planning their activities; this provides them with ability/knowledge to predetermine what will happen. For each uncertainty managers need sufficient knowledge/information and skills before deciding for event/s that are yet to occur (Pich, Loch, & De Meyer, 2002; Sommer & Loch, 2004; Loch, De Meyer, & Pich, 2006).

Looking at expected utility theory, the theory introduced by the INSEAD team is open to criticism. The laws of probability acknowledge the inability to calculate probabilities using similar existing knowledge to determine what would happen in the future. Even though managers gain more knowledge from experience, they don't have control of the future subjective outcomes, the tendency being to revert to inductive reasoning to cope with risk and uncertainty (Bernstein, 1998; Abd Karim, 2014).

2.1.3 Ambiguity

As the availability of more data and information may have a positive effect and reduce uncertainty, having more data/knowledge does not reduce ambiguity. Ambiguity occurs in areas that suggest doubt in cases where different and divergent views of thinking and interpretations about risk and their circumstances are apparent (Zahariadis, 2003). There are two types of ambiguity which are namely interpretative and normative ambiguity (Measham & Lockie, 2012). They both relate to deviating or disputed perspective on the explanation, severity or broader meanings associated with a threat (Stirling, 2003; Renn, 2008).

Interpretative ambiguity denotes the variability of interpretations based on some observations or data assessment results. Variability of interpretation is however not restricted to expert dissent. Laypeople's perception of risk often differs from expert judgement because it is related to qualitative risk characteristics. On the other hand, normative ambiguity alludes to different concepts of what can be regarded as tolerable. Here, ambiguity emerges where the problem lies in agreeing on the appropriate values, priorities, assumptions or boundaries to be applied to the definition of the possible outcome (Measham & Lockie, 2012). Risk is characterised by a mixture of complexity, uncertainty and ambiguity (Measham & Lockie, 2012).

2.1.4 Complexity

Complexity looks at the difficulty in identifying and quantifying causal links between a multitude of potential candidates and specific adverse effects (Burnes, 2004; Underdal, 2010). A critical aspect concerns the applicability of probabilistic risk assessment techniques. If the chain of events between a cause and effect follows a linear relationship, then simple statistical models would be sufficient to calculate the probabilities of harm/impact. Such relationship may still be related to high uncertainty. The use of sophisticated models of probabilistic inferences is required if the relationship between cause and effect becomes complex (Renn &

Walker, 2008). Complexity involves sensitivity to nonlinear transitions as well as a scale. It also needs to consider the multitudes of exposure pathways and the composite effects of other agents present in the exposure situation. As stated earlier, Risk is characterised by a mixture of complexity, uncertainty and ambiguity (Measham & Lockie, 2012) as such in the aspect of this research, risk will be taken as stated by Measham & Lockie (2012).

2.2 Understanding risk management in a project management context.

2.2.1 Introduction to projects

2.2.1.1 Defining a project

There are many definitions of the term "project". The International Standard Organization (2003) defines a project as: "*A unique process, consisting of a set of coordinated and controlled activities with starts and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost and resources.*" The Project Management Institute (PMI) (2013) defines a project as: "*a temporary group activity designed to produce a unique product service or results*." The Association for Project Management (APM) (2006) defines a project as: "*a unique, transient endeavour, undertaken to achieve planned objectives, which could be defined in terms of outputs, outcomes or benefits.*"

From the above definitions, one can conclude that projects are planned activities with planned outcomes, they have a time duration, cost and outcome from a given set of activities undertaken. Projects have been undertaken for thousands of years, but recently projects have moved to become more complex and sophisticated, their popularity ranging from big international projects to small projects which can take only a couple of hours to complete (Williams, 1999).

Projects vary in many ways, especially in areas such as time and cost. Many are ambitious undertakings over an extended period; they use up a vast amount of

resources and require a high level of skills and complex management. According to Keeling (2000), all projects have the characteristics mentioned below:

- Separate undertakings.
- Have a unique purpose and objective.
- Have time constraints.

A number will also have:

- Clearly defined start and finish dates.
- Project specific resources.
- Project specific management structure.

Projects are separate operations, which might have a positive effect on long-term plans. Projects are planned, financed and managed as separate entities.

2.2.1.2 Benefits and features of a project

According to Keeling (2000),the most important features and benefits of a project include:

- **Simplicity of purpose**: A project has clear objectives and goals.
- **Clarity of purpose and scope**: The project can be described by its objectives, scope and quality of the project outcome.
- **Independent control**: Projects can easily be safeguarded against market fluctuations to minimise the effect on operations.
- **Ease of measurement**: A project can easily be monitored during its course based on the project objectives and standards.
- **Flexibility of employment**: Project management can easily acquire specialist and experts based on individual project contracts.
- **Conducive to team motivation and morale**: the process of project management is attractive to individuals and conducive to the formation of self-motivated project teams.

- **Sensitivity to management and leadership style**: the project team composition reacts differently to management styles and leadership.
- **Helpful to individual development**: Projects play a key role in improving personal development and capability.
- **Conducive to secrecy and security**: if required a project can incorporate acts of secrecy aimed at ensuring its sensitivity if necessary.
- **Portability**: Projects can be carried out anywhere e.g. remote locations.

2.2.1.3 Project lifecycle

All projects go through stages or phases from project conception to completion. Each of the project phases has its set of unique characteristics that makes that stage distinct. In the initial stage, as a project starts to consume resources and time, the project deliverable will gradually start to be built and at the end you would have a complete project deliverable. This process is known as the project life cycle.

In project management, a detailed understanding of the project lifecycle is an important factor to ensure project success (Keeling, 2000). It becomes essential that the phases adopt some sort of sequence to ease implementation, which makes it a necessity that each phase in the sequence is well managed and planned. All projects, no matter how big or small, follow the life cycle sequence no matter what development process is implemented. Examples of the development process include the waterfall (Balaji, 2012), agile method (Greer & Hamon, 2011), spiral (Boehm, 1988) and prototype model (Hampton, 1993).

Having an in-depth knowledge of the phases in the life cycle enables the stakeholders to have a better understanding of the sequence of events, recognise boundaries and milestones, and know exactly the current stage a project is at (Keeling, 2000). It further helps with the ability to know when and where to allocate scarce resources. The phases provide a point of reference for which stakeholders can easily progress and see what will happen during each phase.

There are different ways of classifying the stages of projects, see Table 1. The majority of them suggest a division of four (Keeling, 2000; Ruin, 2003; Nicholas, 2004) or five (Cooper, Edgbert, & Kleinschmidt, 2001; Project Management Institute, 2013; Kerzner, 2006) stages, but there are some that take a more in-depth approach (Morris, 1998). According to Field & Keller (1998) and PMI (2013), there is no single project lifecycle that applies to all projects and a similar problem arises in naming the stages in the lifecycle. Table 1 gives a summary of the existing project life cycle stages published by different project management authors.

Authors	No of Stages	Proposed Life Cycle Stages
(Morris, 1998)	10	Inception, feasibility, design, plan, procurement, detailed design, contracting, execution, commissioning and start up, post-completion evaluation.
(Lim & Mohamed, 1999)	6	Conceptual, planning, design, tender, construction, operation.
(Keeling, 2000)	4	Initiation, Planning, Execution and control, closure
(Cooper, Edgbert, & Kleinschmidt, 2001)	5	Scoping, build business case, development, testing & validation, launch/post-launch
(Ruin, 2003)	4	Initiating, specifying, producing, closing.
(Project Management Institute, 2013)	5	Initiating, planning, executing, controlling, closing.
(Nicholas, 2004)	4	Concept, design & development, production, operation
(Kerzner, 2006)	5	Conceptual, planning, definition, implementation, conversion.
(Association for Project Management, 2012)	7	Concept, definition, development, hand over and closure, benefits realisation, operation, termination.

Table 1: Variations of the project lifecycle

In general, projects adopt a 4-stage life project lifecycle as suggested by Keeling (2000) which are identified as:

1. **Initiation:** This is the first phase of the project life cycle; this stage starts with the initial idea and the realisation of the need for development and/or improvement. In this stage primary goals are expressed and ideas on cost, potential benefits, scope and feasibility are considered. Documents such as project proposal and feasibility studies are created.
2. **Planning:** Here project objectives are defined, and steps on how to accomplish the objectives are ironed out. Aspects such as finance and resource allocation are considered at this stage.
3. **Execution and control:** This is the stage where all the plans developed in the second phase are put into play. Here all the activities will be carefully monitored, coordinated and controlled to ensure the objectives of the project are realised. In this stage review of the project progress and plan is performed and where modifications have to be considered an update on the plans will be conducted.
4. **Closure:** This is the final phase of the project life cycle; here preparations for project handover are carried out, this involves activities such as determining what to do with purchased machinery and equipment, project assessment and evaluation and preparation of a final report.

All projects undergo the life cycle process, but each project will have its unique life cycle curve. **Figure 1** is a typical example of a project life cycle.

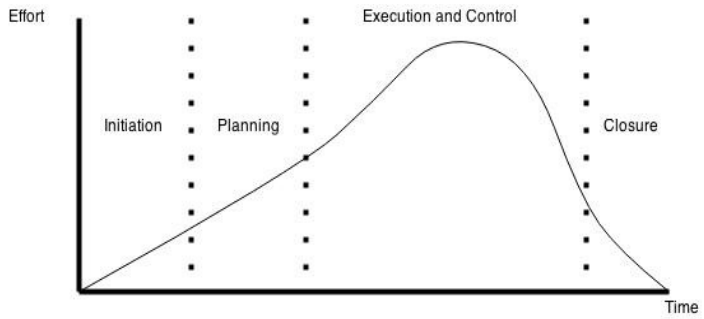

Figure 1: Project life cycle and stages (Keeling, 2000)

2.2.1.4 Project classification

All projects have different characteristics. When you implement a single set of rules to all projects, there is a high chance of failure (Kwak & Stoddard, 2004). Various factors help in classification of projects based on their characteristics:

1. **Project focus:** This is a key aspect in project classification; it entails analysing a project to determine the type of the project. Examples of project focus are joint ventures, commercial projects, or change projects (Turner, 2014). Based on the project focus, different aspects become key characteristics, and this will help in selecting an appropriate project classification and methodology.
2. **Project risk:** During the lifecycle of a project, the project will be exposed to all sorts of risk. Having a very good understanding of the level of risks that could occur in a project and its nature is a major factor in selecting the appropriate elements.
3. **Project size:** This factor is measured by the overall investment cost of the project. As a rule of thumb, the larger the investment involved, the more complicated its governance.
4. **Communication difficulty:** There are three aspects to this factor; the first is the number of people who are involved in the project, secondly the location of the project activities and finally the cultural make-up of the project team. The bigger the project team, the more complicated the communication process. The same effect will occur if the project teams are in different locations geographically or if the project team members have diverse backgrounds. In this case, extra efforts will have to be taken to ensure good communication

2.2.2 Introduction to project management

According to Harrison and Lock (2004), project management is one of the fastest growing profession in today's world. This is apparent from the recognition by

managers of the wide variety of development and change endeavours where a project management approach can be applied and yield positive outcomes. There has also been a continuous increase of members into project management professional organisations such as the Project Management Institute (PMI), Association for Project Management (APM) and International Project Management Association (IPMA).

2.2.2.1 Purpose of project management

The aim of project management is to help in the coordination and realisation of new endeavours. New projects are often carried out in a new environment with the use of new designs and implementation processes best suited for that environment under the constraints of time, cost and quality. Many projects fail to achieve their objectives (The Standish Group, 2013); this problem can be linked to the project's exposure to risk (The Standish Group, 2013; The Royal Academy of Engineering, 2004). The primary purpose of project management is to achieve all of the objectives in a project.

2.2.2.2 Constraints of project management

Most projects are set up with a vision of the end-product in mind (Collins & Porras, 1991; Amabile & Gryskiewicz, 1987; Robertson & Robertson, 2012). A possible exception is research projects, which can have no conclusive results or lead to discovery. The three primary constraints of a project are time, cost and technical performance or scope. They are also known as the project management iron triangle (see Figure 2) (Harrison & Lock, 2004; Ika, 2009; Atkinson, 1999). The three constraints are dependent upon one another. As soon as any of the three is modified, the other two will automatically be affected.

1. **Time**

This is the amount of time a project takes from start to completion. Project management deals with the tasks concerned with identifying, sequencing and

estimating activities needed to complete the project. Project management tries to determine a practical plan made in detail that would be the primary benchmark for controlling the process towards completion on time (Harrison & Lock, 2004). On-time project completion is a very important objective for all stakeholders, as delayed projects risk having quality and reliability sacrificed to compensate (Harrison & Lock, 2004), and late running leads to an increase in cost.

2. **Cost**

Costs represent the direct reductions to the authorised budget of a project. To develop an approximation of project cost, several variables are considered including resources, labour requirements and mitigating influencing factors that create cost variances.

3. **Scope**

The scope of the project identifies the outcome expected at the end of the project. It is always sent out in unambiguous terms that will allow all relevant stakeholders to know what to expect for the specified investment.

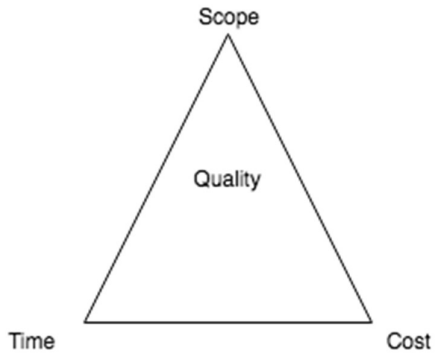

Figure 2: The iron triangle (Harrison & Lock, 2004; Ika, 2009; Atkinson, 1999)

2.2.2.3 Limitations of the constraints

From the viewpoint of the project manager, it is possible to assume once a project satisfies the three constraints it can be considered as a success. However, these three criteria do not consider the long-term and wider view of project success. Project

success cannot be measured by these factors alone. To determine if a project is successful the viewpoints of all relevant stakeholders must be considered (Atkinson, 1999; Wateridge, 1998). This is mainly because they all have different ideas as to how the constraints should be balanced and what is to be delivered. During a project, the deliverables are usually set and agreed. However, performance of the deliverables may be compromised or traded leading to different stakeholder benefit.

2.2.2.4 Project management areas

The Project Management Institute (2013) have divided the area of project management into ten key areas which are:

- **Integration:** Here the three main aspects of project management processes (planning, execution and control) are integrated with inputs from a variety of disciplines.
- **Scope management:** This entails all the processes that ensure the project covers all the necessary requirements to complete the project successfully.
- **Time management:** All the processes required that would ensure coordination and completion within the allocated time of the project.
- **Cost management:** This is the process that will ensure that the project is completed within the stipulated budget.
- **Quality management:** This deals with the aim of the project after its completion and the project satisfies its reason for being undertaken in the first place.
- **Human resource management:** This section deals with all the human aspects of projects aimed at ensuring efficient usage of the people under the project.
- **Communication management:** This section deals with the information flow during a project; it ensures the implementation of effective communication of project information.

- **Risk management:** This entails the process of identifying, analysing and responding to identified risk.
- **Procurement management:** This section overlooks the process involved in getting the goods and services needed to perform the undertaken project.
- **Stakeholder management:** This section highlights the importance and recognition of people and organisations that have an impact on a specific project. It also entails the analysis of stakeholder expectations, impact and implementation of strategies to efficiently engage the stakeholders.

There are currently ten critical areas suggested by the Project Management Institute (2013). These ensure the successful delivery of a project during the lifecycle of the project. Even with this well-established project management processes, a high number of a project still fail or are classified as unsuccessful. This failure has been attributed to inadequate risk management (Kutsch & Hall, 2010), over-optimism in project forecast (Flyvbjerg, 2013; Flyvbjerg, 2007), escalation of commitment (Alvarez, Pustina, & Hällgren, 2011; Van Oorschot, Akkermans, Sengupta, & VanWassenhove, 2013), and as such has led to further investigations into the aspect of risk decision making. The research objectives are stated later in the Chapter.

2.2.3 Measuring project success

Early works on project success focus on the achievement of time, cost and quality objectives. More recently greater appreciation of the issues, including the diversity of stakeholder perspectives, has led to the recognition that a broader set of measures is needed (Atkinson, 1999; Wateridge, 1998).

De Wit (1988) explains that a project is considered successful overall if it meets the technical performance specification and/or mission to be performed, and if there is a high level of satisfaction concerning the project's outcome among key people in the parent organization, key individuals in the project team and key users or clients of the project effort. Projects differ in size, uniqueness and complexity (Muller & Turner, 2007). Therefore, the criteria for measuring success vary from project to

project and industry to industry, making it difficult to establish a unique set of criteria for all projects (Westerveld, 2003).

To have a better understanding of project success, it is paramount to have a clear understanding of key project management concepts. Before we look at factors that influence project success, one key definition we should have clear in our minds is that of project objectives, which are means to measure the performance of a certain project.

Project objectives are also known as project goals. Wideman (2002) defines project objectives as concrete statements that specify the aims of the outcome of a project. Measuring project success based on the objectives of the iron triangle has been criticised by various researchers as inadequate and inaccurate (Shenhar, Levy, & Dvir, 1997; Wateridge, 1998). Other criteria, which will be discussed later in this section, have been introduced as dimensions to measure project success.

2.2.3.1 Project management success and product success

It is important to understand and differentiate between "project success" and "project management success" as these two terms are different. According to De Wit (1988) project management success is measured against a project's performance based on its initial estimates of cost, time and quality while project success is measured against the overall objectives of a project.

After the implementation of a project hierarchy framework, Baccarini (1999) provides a clear distinction between project management success and product success. The author explains that project management success focuses on project success with regards to the accomplishment of the iron triangle while product success deals with a project's final deliverable. The aftermath of the application of the author's concept implies that the project lifecycle encompasses both project process and project product. The two components are linked by smaller components

known as inputs, outputs, purpose and goal. Figure 3 gives a depiction of how success is to be measured regarding how the objectives have been reached.

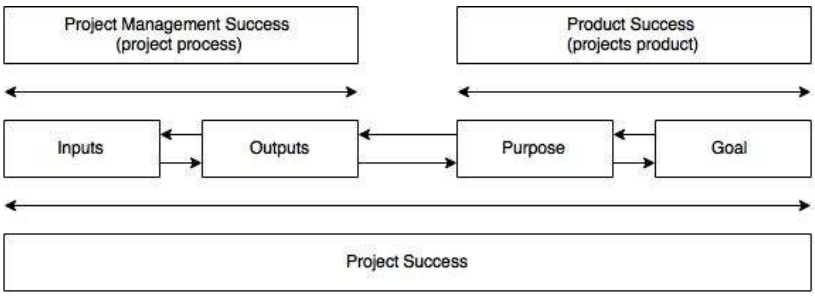

Figure 3: Logical framework method and project success (Baccarini, 1999)

The model is similar to that of Lim and Mohammad (1999) that depicts the complete project life cycle, and in each stage of the life cycle there are combinations of factors that contribute to the success of the project as depicted in Figure 4:

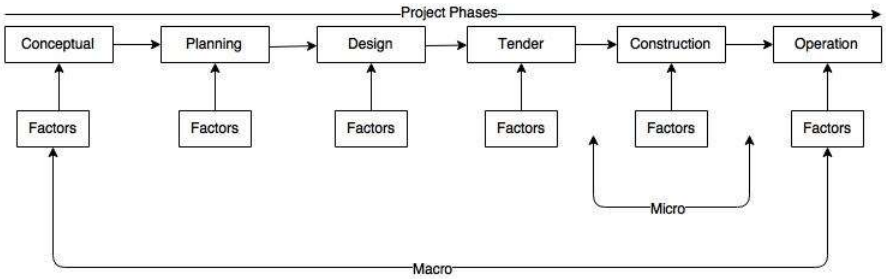

Figure 4: Project life cycle building blocks (Lim & Mohamed, 1999)

The above frameworks are based on the stages of the project lifecycle. As the factors that will influence the outcome of a project vary depending on the stage the project is in, the separation of a project into stages is very important. A successful project is one that achieves project management success and product success (Baccarini, 1999) but this scenario is sometimes difficult to achieve (Wateridge, 1998), it is something that is achievable if all parties are fully involved in a project.

A project can be a product success despite not being a project management success if its objectives, which are based on the iron triangle, are not achieved. Baccarini (1999) states that product success is ultimately of greater importance.

2.2.3.2 Success criteria and success factors

Another set of project management concepts that need to be differentiated is "success criteria" and "success factors". Cooke-Davies (2002) clearly defines success criteria as the measure by which the success or failure of a project will be judged while success factors are inputs in a project that need to be managed as they can lead to the success of a project. This view is also shared by researchers Lim and Mohammad (1999) as they define the success criteria as the set of principles by which project success is or can be judged, while success factors are the set of factors that contribute to the positive outcome of a project.

Having a clear definition of success criteria and success factors is very important because it is very easy to mix up the definitions. In most cases, a specific contributing factor could also be used as a measure to judge the other set of factors. As researchers such as Dyrhaug (2002) emphasise, project characteristics could influence the impact of a project success factors.

Various researchers (Shenhar, Levy, & Dvir, 1997; Wateridge, 1998) bring the notion that project success criteria should be clearly defined before a project starts. These criteria should be determined after considering inputs from key project stakeholders.

2.2.3.3 Criteria, factors and success

Researchers such as Cooke-Davies (2002), Belassi and Tukel (1996), and Fortune and White (2006) have highlighted the need to distinguish between criteria and factors. Lim and Mohammad (1999) clearly distinguish the two stating that a criterion is "a principle or standard by which anything is or can be judged" while factors are "'any circumstance, fact, or influence which contributes to a result."

Toor and Ogunlana (2009) provide a conceptual illustration of project management, and they try to depict the relationship between factors and criteria. Lim and

Mohammad (1999) criticise existing literature for failing to distinguish between critical factors and criteria. They reiterate that "criteria are the set of conditions sufficient for a judgment to be made or result in certain outcome." Success factors are those factors that have a direct or indirect connection to the success of a project while success criteria are the measures by which the success or failure of a project is measured (Cooke-Davies, 2002; Fortune & White, 2006).

According to Cooke-Davies (2002) even though project managers have a clear view and understanding of project success the concept remains an "enigma". Ahadzie et al. (2008) highlight the interpretations of the terms "project management" and "project success". Cooke-Davies (2002) says that to get the real critical success factors that can lead to project success the following three questions should be answered.

- *What factors are critical to project management success?*
- *What factors are critical to the success of an individual project?*
- *What factors lead to consistently successful projects?*

The answers to the questions above affect critical success factors; the variety of answers by researchers to these questions highlights the lack of consensus on definitions on key aspects of projects. In this research, the questions highlighted by Cooke-Davies (2002) were used to gather the factors from literature which was then used to look at the perceptual importance of risk management in projects.

2.2.3.4 Critical success factors

Critical success factors can help provide a better understanding of best practices to improve the success rate of projects. Smaller organisations that do not have the workforce or capabilities to invest heavily in all aspects of the project can focus their limited resources on the factors that will make the biggest difference (Bullen & Rockart, 1981).

Rockart (1982, p. 2) defines critical success factors as: "Those key areas of activity in which favourable results are absolutely necessary for a manager to reach his/her goals." Futrell et al. (2001) define critical success factors as those factors in which success is necessary so that each of the major project participants has the maximum chance of achieving their goals. The implementation of CSFs in project key areas ensures success is made explicit (Boynton & Zmud, 1984). A project manager can use critical success factors as a description, predictor, and as a guide to achieve success (Vedder, 1992).

CSFs have been used as a means to measure project success since the 1970s in a variety of disciplines such as project management (Muller & Jugdev, 2012; Pinto & Prescott, 1988), construction (Gudiene, Banaitis, Podvezko, & Banaitiene, 2014; Berssaneti & Carvalho, 2015; Yong & Mustaffa, 2013; Omran, Abdulbagei, & Gebril, 2012), information technology (Almajed & Mayhew, 2014; Finney & Corbett, 2007; Umble, Haft, & Umble, 2003), Petroleum (Tsiga, Emes, & Smith, 2017). Table 2 depicts a list of CSFs from different researchers.

Authors	Critical Success Factors
(Pinto & Slevin, 1989)	Top management support, Client Consultation, Personnel recruitment, Technical Tasks, Client acceptance, Monitoring and feedback, Communication, Trouble-shooting, Characteristics of the project team leader, Power and Politics, Environmental events, Urgency.
(Martin, 1976)	Define goals, select project organization philosophy, General management support, Organize and delegate authority, select project team, allocate sufficient resources, provide for control and information mechanisms, Require planning and review.
(Locke, 1984)	Make Project Commitments Known, Project Authority from the top, appoint competent project manager, set up communications and procedures, Set up control mechanism (Schedules, etc), Progress meetings.

(Cleland & King, 1983)	Project summary, Operational concept, Top management support, Financial support, Logistic requirements, Facility supports, Market intelligence (who is the client), Project schedule, Executive development and training, Manpower and organization, Acquisition, Information and communication channels, Project Review.
(Sayles & Chandler, 1971)	Project manager competence, Scheduling, Control systems and responsibilities, Monitoring and feedback, Continuing Involvement in the project.
(Baker, Murphy, & Fisher, 1983)	Top management support, Client consultation, Personnel recruitment, Technical tasks, Client acceptance, Monitoring and feedback, Communication, Trouble-shooting, Characteristics of the project team leader, Power and politics, Environment events, Urgency.
(Morris & Hough, 1987)	Project Objectives, Technical Uncertainty innovation, Politics, Community Involvement, Schedule duration urgency, Financial contract legal problems, Implement Problems.
(Belassi & Tukel, 1996)	Project Manager, Project team, The project, Project manager performance, External environment, Organization, Client consultation and acceptance, Project preliminary estimates, Availability of resources.
(Chan, Ho, & Tam, 2001)	Project team commitment, Contractor's competencies, Risk and liability assessment, Client's competencies, End-users' needs, Constraints imposed by end-users.
(Chan, Scott, & Chan, 2004)	Human Related, Project Related, External Environment, Project Procedures, Project management actions.
(de Wit, 1988)	Contractors, Government, Suppliers, Banks, Community groups, Regulatory agencies, Media, Trade associations.
(Gudiene, Banaitis, & Banaitiene, 2013)	External, Institutional, Project related, Project management/team member related, Project manager, Client related, Contractor related.
(Iyer & Jha, 2005)	Project manager competence, Top management support, Project manager's coordinating and leadership skill, Coordination among project participants, Owners competence, and Favourable climatic condition.

(Mathias, Oludayo, & Ray, 2014)	Individual, Social, Cultural, Vendor, Political and national level, Technical, Organizational.
(Omran, Abdulbagei, & Gebril, 2012)	Project management, Procurement, Client, Contractor, Design team, Project manager, Work Environment, Materials, Labour and productivity, External factors.
(Pinto & Mantel, 1990)	Project Mission, Top Management support, Project schedule/plan, Client consultations, Personnel, Technical task, Client acceptance, Monitoring and feedback, Communication, Trouble shooting.
(Chua, Kog, & Loh, 1999)	Project characteristics, contractual arrangements, project participants, interactive processes.
(Yu, Flet, & Bowers, 2005)	Project-related factors, human-related factors, process-related factors, input-related factors, output-related factors
(Fortune & White, 2006)	Goals and objectives, performance monitoring, decision-maker(s), transformations, communication, environment, boundaries, resources, continuity.
(Tsiga, Emes, & Smith, 2017)	External Challenge, Client knowledge and experience, Top management support, institutional factors, project characteristics, project manager competence. Project organization, contractual aspects, project team competence, project risk management, requirements management.

Table 2: CSFs determined by different researchers

Following an in-depth review of past work on CSFs, 58 CSFs were identified and grouped into 11 main categories as shown in Table 3: (1) external challenge; (2) client knowledge and experience; (3) top management support; (4) institutional factors; (5) project characteristics; (6) project manager competence; (7) project organization; (8) contractual aspects; (9) project team competence; (10) requirements management; and (11) project risk management. These 11 categories cover all the elements that have an impact on projects and include the additional area that the author is testing (project risk management) to see where it stands on the relative importance index. Table 3 gives a summary of the critical success factors and their grouped categories as identified in the literature.

Category	Critical Success Factors	Sources
External Challenge	The external challenges are the factors that have an influence on the project but are external to the project. The attributes under this factor are the economic environment, social environment, political environment, physical environment and the regulatory/legal environment.	(Gudiene, Banaitis, Podvezko, & Banaitiene, 2014; Omran, Abdulbagei, & Gebril, 2012; Tan & Ghazali, 2011; Toor & Ogunlana, 2009; Fortune & White, 2006; Iyer & Jha, 2005; Jugdev & Muller, 2005; Chan, Scott, & Chan, 2004; Belassi & Tukel, 1996; Morris & Hough, 1987).
Client knowledge and experience	The attributes concerned with the client's characteristics include nature of finance, experience, organization size, emphasis on costs quality and time, ability to brief, decision making, roles, and contribution, expectations and commitment, involvement and influence. All the factors deal with the client's ability to contribute to the success of the project.	(Gudiene, Banaitis, Podvezko, & Banaitiene, 2014; The Standish Group, 2013; Omran, Abdulbagei, & Gebril, 2012; Tan & Ghazali, 2011; Turner, Zolin, & Remington, 2009; Kulatunga, Amaratunga, & Haigh, 2009; Bryde & Robinson, 2005; Jugdev & Muller, 2005; Iyer & Jha, 2005).
Top management support	The variables in this factor are support given to project head, support to critical activities, understanding of project difficulty and stakeholder influence. The factors look at the amount of time devoted by high-ranking executives to ensure project success.	(Ram & Corkindale, 2014; Varajao, Dominguez, Ribeiro, & Paiva, 2014; Almajed & Mayhew, 2014; Berssaneti & Carvalho, 2015; The Standish Group, 2013; Toor & Ogunlana, 2009; Fortune & White, 2006; Iyer & Jha, 2005).
Institutional factors	The attributes under this factor are standards and permits. They deal with organizational processes and culture, which include how a business operates and its application of standards.	(Gudiene, Banaitis, Podvezko, & Banaitiene, 2014; Gudiene, Banaitis, & Banaitiene, 2013)
Project characteristics	The attributes under this factor are project type, size, nature, complexity, design, resources allocation time and level of technology; the factors detail the general characteristics of the project.	(Yong & Mustaffa, 2013; Omran, Abdulbagei, & Gebril, 2012; Fortune & White, 2006; Chan, Scott, & Chan, 2004; Akinsola, Potts, Ndekugri, & Harris, 1997; Belassi & Tukel, 1996).
Project manager competence	Variables under the umbrella of the project manager competence include experience, coordinating and motivating skills, leading skills, communication and feedback, management skills, conflict resolution skills and organizing skills.	(Toor & Ogunlana, 2009; Malach-Pines, Dvir, & Sadeh, 2009; Barclay & Osei-Bryson, 2009; Turner, Zolin, & Remington, 2009; Muller & Turner, 2007; Wang & Huang, 2006; Jugdev & Muller, 2005).
Project organization	A variety of attributes will affect this factor including planning and control effort, team structure and integration, safety and quality program, schedule	(Gudiene, Banaitis, Podvezko, & Banaitiene, 2014; Varajao, Dominguez, Ribeiro, & Paiva, 2014; Berssaneti & Carvalho, 2015;

	and work definition, budgeting, and oversight of subcontractors.	Almajed & Mayhew, 2014; The Standish Group, 2013; Yong & Mustaffa, 2013; Omran, Abdulbagei, & Gebril, 2012; Tan & Ghazali, 2011; Kulatunga, Amaratunga, & Haigh, 2009).
Contractual aspects	The factors under contractual aspects are contract type, tendering (procedures or steps for the selection of that service) and procurement (company selection to provide services) process.	(Yong & Mustaffa, 2013; Omran, Abdulbagei, & Gebril, 2012; Tan & Ghazali, 2011; Chan, Scott, & Chan, 2004).
Project team competence	The composition of the project team is integral to the success of the project hence the attributes covered in this factor include the team experience, technical skills, planning and organizing skills, commitment and involvement, teams' adaptability to changing requirements, working relationships, educational level, training availability and decision-making effectiveness.	(Gudiene, Banaitis, Podvezko, & Banaitiene, 2014; Varajao, Dominguez, Ribeiro, & Paiva, 2014; Almajed & Mayhew, 2014; Ram & Corkindale, 2014; Tan & Ghazali, 2011; Toor & Ogunlana, 2009; Kulatunga, Amaratunga, & Haigh, 2009; Turner, Zolin, & Remington, 2009; Barclay & Osei-Bryson, 2009; Shen, Prior, White, & Karamanoglu, 2007; Fortune & White, 2006).
Requirements management	The factors under requirement management are elicitation technique, identification, analysis and negotiation, modelling, validation and scope management.	(Varajao, Dominguez, Ribeiro, & Paiva, 2014; Mirza, Pourzolfaghar, & Shahnazari, 2013; The Standish Group, 2013; Kulatunga, Amaratunga, & Haigh, 2009; The Royal Academy of Engineering, 2004)
Project risk management	The factors under requirement management are elicitation technique, identification, analysis and negotiation, modelling, validation and scope management.	(Varajao, Dominguez, Ribeiro, & Paiva, 2014; Mirza, Pourzolfaghar, & Shahnazari, 2013; The Standish Group, 2013; Kulatunga, Amaratunga, & Haigh, 2009; The Royal Academy of Engineering, 2004)

Table 3: Grouped critical success factors

Previous studies have highlighted the importance of risk management in projects (Zwikael & Ahn, 2011). Bakker et al. (2012) emphasise the need to identify risk, and its effects on project success, and suggest that risk management activities contribute to project success. However, studies have also linked risk management to project outcomes (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013; Kutsch & Hall, 2010) but not to CSFs as would be

explored in this research. The factors under project risk management in this research are sub-divided into two: firstly, hard aspects including initiation, identification, assessment, response planning and response implementation, and secondly, soft aspects of risk, which are risk communication and attitude, monitoring and review (David, 2009).

After the in-depth review of past work on CSFs, two research objectives have been derived for investigation as shown. The first research objective looks at whether project practitioners perceive effective risk management to be a success factor and the second research objectives investigates the practitioners view of which aspect of risk management are perceived to be of most importance as if they are treating risk rationally, then the quantification of risk should be more important. A full depiction of the CSFs and the objectives to be tested can be seen in Figure 5.

Research Objective 1: Establish whether project practitioners perceive effective risk management to be a success factor

Research Objective 2: Establish which aspects of risk management are perceived to be of most importance

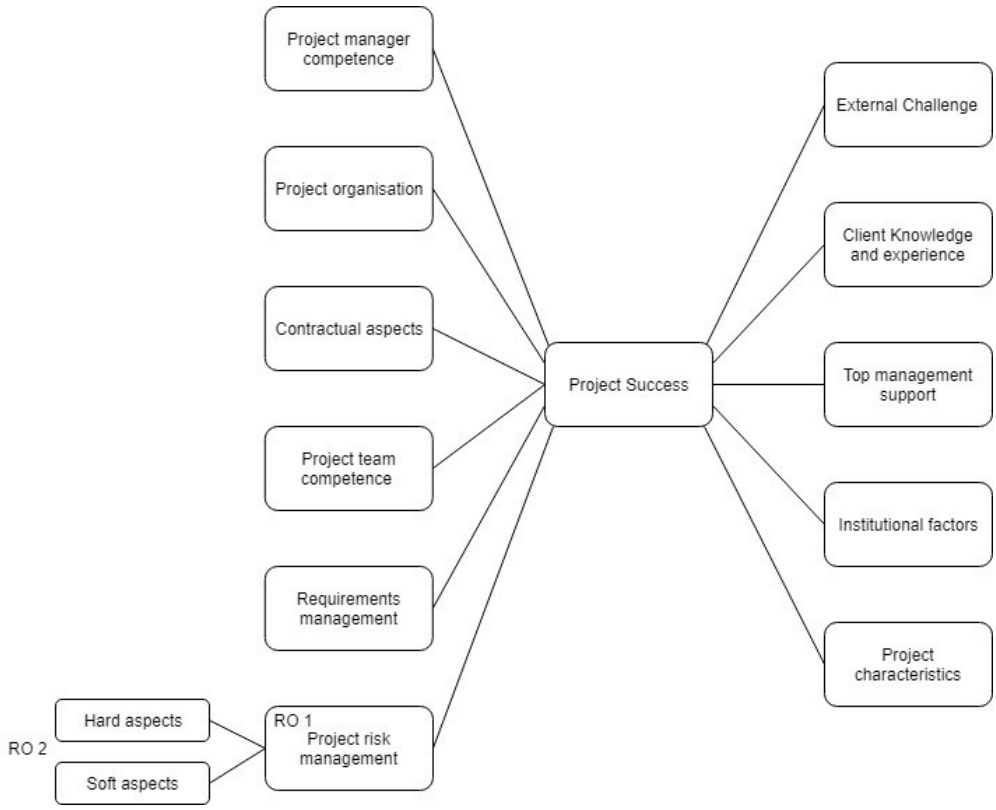

Figure 5: Linking proposed research objectives to CSF identified from literature

2.2.3.4.1 Measurement criteria for CSFs

The way the CSFs are managed can contribute to a project having a positive or negative result. There are many factors that researchers have proven can affect the success of projects, they have tried to improve our understanding of this factors. Table 2 depicts some CSFs determined by researchers. The word "dimensions" has been introduced to help in the grouping of the factors. A dimension has a set of factors associated with it.

2.2.3.4.2 Dimensions

Our understanding of projects has improved since the published definition of a project as "complex effort to achieve a specific objective within a schedule and

budget" (Cleland & King, 1983). According to Lashbrook (1992), a project is considered a success if the owner is satisfied and conforms to the predetermined budget and time. This perception has been changed because measuring the project performance based on cost, time and quality has been critiqued as inadequate and inaccurate. Researchers such as Cooke-Davis (2001) have emphasised taking into consideration product or service that the project creates. However, various authors have provided different lists of factors that should be used to judge project success. As project take on a multidimensional view, it is difficult to come up with a unique set of criteria for all projects. This becomes even more complicated when you introduce the different stakeholders and their different views on project priorities (Shenhar, Thisler, Dvir, Lipovetsky, & Lechler, 2002).

Several studies have proposed different ways on how the success of a project could be measured see Table 2. Pinto and Slevin (1987) state that project success is one that results in organisational change, this definition seems wrong as it does not take into account the outcome of the project. A popular project management paper by De Wit (1988) outlined six success criteria that are used to measure project success for the construction industry. It is apparent that these factors focus on stakeholder satisfaction. Wateridge (1998) also outlines six success criteria with a wider definition that almost encompasses all aspects of the project except for the exclusion of project lifecycle. This can be seen as a better list of factors as compared to that of De Wit (1988).

2.2.3.4.3 Perceptions

As discussed in this literature, there are various definitions of project success. This makes it difficult to come up with a unified definition of success criteria. This becomes even more elusive as they are different sets of stakeholders during the lifecycle of a project and each of their separate views should be considered. It becomes a necessity to be able to verify the extent of each of the different stakeholder involvement. In the project initiation stage, the stakeholders should be given the opportunity to state their views, and if they are any conflicts, they should

be resolved. Project input comes from a wide range of people with a different perception of success. A project could be deemed successful if a certain group of stakeholders are satisfied (Shenhar, Renier, & Wideman, 1996) and the project can easily be classified a failure if some stakeholders are not satisfied with the result of the project.

The study of project success can be seen as somewhat elusive as it is not an easy task to distinguish between key elements for example success factor and success criteria. In some cases, it can be observed that a particular variable can be a contributing factor to project success and also be a criterion used to measure a group of factors. A good example of such factor is "time" as it could contribute to stakeholder satisfaction and also as a criterion to measure project performance. In this case of gathering the critical success factors for this research have been carefully arranged, categorised and differentiated as shown in Table 2 and Table 3 to take into account the various perception and dimensions.

2.2.3.5 Advantages of identifying CSFs

Clarke (1999) suggests that there is evidence that highlights the importance and existence of critical success factors in the existing literature. Various researchers have highlighted the benefits that CSFs bring to projects as listed in Table 4. Having an agreed upon standard set of factors will allow monitoring and evaluation of a project effectively and also provide a framework that could assist in tracking key project results (Toor & Ogunlana, 2008; Chan, Ho, & Tam, 2001).

Benefits	Sources
CSFs assist in the determination of reasons for success or failure.	(Toor & Ogunlana, 2008)
They can help in the selection of core project members and highlight development areas in a project.	(Toor & Ogunlana, 2008; Chan, Ho, & Tam, 2001)
They provide fundamental framework for decision making	(Toor & Ogunlana, 2008)
They can enable effective resource allocation in a project	(Toor & Ogunlana, 2008; Chua, Kog, & Loh, 1999)
They can help to identify critical issues that can hinder the implementation of the project plan	(Toor & Ogunlana, 2008)

"Focusing on "important few" would have the greatest benefit" to a project.	(Toor & Ogunlana, 2008)
The process helps the manager to determine those factors on which he or she should focus management attention.	(Rockart J. F., 1979, p. 87)
The process forces the manager to develop good measures for those factors and to seek reports on each of the measures.	(Rockart J. F., 1979, p. 87)
The identification of CSFs allows a clear definition of the amount of information that must be collected by the organization and limits the costly collection of more data than necessary.	(Rockart J. F., 1979, p. 87)
It focuses attention on those data that might otherwise not be collected but are significant for the success of the particular management level involved.	(Rockart J. F., 1979, p. 87)

Table 4: Benefits of CSFs as determined by researchers

2.2.3.6 Difficulties in identifying CSFs

Fortune and White (2006) criticise the existing literature on critical success factors stating that there are issues that arise which are: firstly is that there is no agreed upon standard CSFs that affect project success; secondly, no mechanism addresses the interrelationship between the factors; finally, the factors approach views implementation as a static process and ignore the fact the factors could have varying importance through the stages of a project (Fortune & White, 2006; Larsen & Myers, 1999). Table 5 below depicts some criticism on CSFs from various researchers.

Disadvantage	**Sources**
No agreed upon definition of critical success factors	(Lim & Mohamed, 1999)
Disparity between key terms such as project management success and project success	(Jha & Iyer, 2007)
As there is an open list that determines success, anticipating project outcomes can be a bit hard.	(Lim & Mohamed, 1999)
Lack of understanding and knowing the CSFs can lead to problems in planning project resources	(Nguyen, Ogunlana, & Lan, 2004)
No agreed upon framework for measuring project success	(Ahadzie, Proverbs, & Olomolaiye, 2008)
Stakeholder perspectives on the project success and the success factors may vary.	(Toor & Ogunlana, 2009)
CSFs not directly linked to project outcome	(King & Burgess, 2006)
There is no adequate framework that looks at the relationships between identified CSFs	(Fortune & White, 2006; Belassi & Tukel, 1996)

Nature of a particular project can make the applications of CSFs not possible.	(Belassi & Tukel, 1996)

Table 5: Drawbacks of CSFs as determined by researcher

2.3 Approaches to managing risk in project management

2.3.1 Project risk management

Risk and uncertainty have the potential to hinder the delivery of projects (Lechler, Edington, & Gao, 2012) and they play an essential role in determining project success (Lehtiranta, 2013; Zhang & Fan, 2014). The management of risk is gaining more attention from academia and industry (Zhang & Fan, 2014; Thamhain, 2013). The importance of risk management has been highlighted in different sectors (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013; Kutsch & Hall, 2010; Tsiga, Emes, & Smith, 2017). Krane et al. (2010) suggest that project risk management is the heart of project management and it's also regarded as the primary process associated with project management (Ramgopal, 2003). As one of the critical areas in the project management book (Project Management Institute, 2013) it is defined as "processes of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project (Project Management Institute, 2013)". The objectives of project risk management are to decrease the likelihood and impact of negative events and to increase the likelihood and impact of positive events in a project (Project Management Institute, 2013). Risk management should be a consistent activity in every project phase, and risk should be managed at each step (Dikmen, Birgonul, Anac, Tah, & Aouad, 2008; Akintoye & MacLeod, 1997). The process of risk management focuses on the understanding the impact of known events (Thamhain, 2013). Effective risk management can transform threats in opportunities and increase project performance (Goh, Abdul-Rahman, & Samad, 2013). Risk management should be applied proactively and consistently during the entire project duration (Project Management Institute, 2013).

Despite the importance of risk management in literature, project managers fail to fully implement the risk management process (Cervone, 2006). Project risk management is seen as an activity aimed at having a more detailed quantification of risk impact and mitigation (Cervone, 2006). However, risk management should also be used to build risk knowledge to have a historical data view on how risk can be managed (Cervone, 2006; Dikmen, Birgonul, Anac, Tah, & Aouad, 2008).

People have a negative perception of risk which is incorrect. This perception can also be seen in the management practices as the opportunities are often overlooked, and hence project risk management is mainly viewed as threat management (Ward & Chapman, 2003; Olsson, 2007). This perception of risk being negative has been observed in various studies (Olsson, 2007; Bryde & Volm, 2009; Hartono, Sulistyo, Praftiwi, & Hasmoro, 2014). In situations that involve decision making both threats and opportunities are present, and both should be actively managed.

2.3.1.1 Introduction to risk management

During projects, all organisations manage risks in a variety of ways and sometimes risk management must be handled delicately and consistently, to ensure effective decision-making and project success. The aim of risk management is to provide a disciplined environment for risk-based decision-making.

The aim of risk management is to ensure that organisations have a better understanding and control of project outcomes through a better understanding of risks that arise during a project and the overall risk exposure during the project. Hence risk management according to Murrey-Webster (2010) refers to the "*systematic application of principles, an approach and a process to the tasks of identifying and assessing risk, and then planning and implementing risk response.*" According to Murrey-Webster (2010), for risk management to be effective, risks should be:

- **Identified:** This is the first stage of risk management; it involves having an in-depth knowledge of the project. These stage deals with highlighting and describing the possible events that can affect a project.
- **Assessed:** This step takes a deeper look at the individual risks identified in the first stage where each risk will be assessed quantitatively or qualitatively for prioritisation and further understanding of the risk exposure of the risk on the project.
- **Controlled:** This stage involves the act of identifying and implementing an appropriate response to a specific risk. This is achieved by assigning appropriate resources that can monitor and control the risk.

2.3.1.2 Importance of risk management

When it comes to projects, risk is inevitable. Organisations that initiate projects while implementing a formal/explicit risk management process have a better chance to foresee and manage potential risk (Chapman & Ward, 2003). Their ability to properly utilise this aspect can lead to project success, which is key to the growth of the business.

The benefits of effective risk management are not limited to the improvement of performance against aspects of project time, cost and quality but they also contribute to (Pryke & Smyth, 2012):

- Conflict resolution.
- Efficient use of resources.
- Sized opportunities.
- Reduced fraud.

These benefits apply to all organisations that implement the risk management process no matter their size or industry sector.

2.3.1.3 When to use risk management process

The main reason behind the risk management process is to manage exposure of the project to uncertainty over time (Pryke & Smyth, 2012). Risk exposure occurs because of various factors such as financial, economic or schedule; it can even be because of changes in relationships between stakeholders. The risk management process provides a structured way of mitigating uncertainties. The process is applied across all project phases in the project lifecycle.

The process is aimed at assisting project participants in identifying factors that can affect project delivery and developing strategies that would help in cushioning the risk effect on the project. The use of risk management in projects allows efficient allocation of resources to manage risk (Pryke & Smyth, 2012). This will help projects progress smoothly as effective control measures are in place to mitigate possible risks.

2.3.1.4 Risk management process

The risk management process is divided into phases, some require more in-depth analysis than others. Some of the phases are divided into sub-phases to aid implementation of risk management in projects.

Various factors can affect the implementation of the risk management processes such as the maturity and experience of the organisation itself. Organisations that have a good experience in applying the risk management process are generally in a better position to implement more sophisticated processes and vice versa. Explanations of the phases involved in the risk management processes are given below and depicted in Figure 6.

A. Initiate:

This is the first step of the risk management process; the aim of this phase is to develop key information about the project such as scope and objectives. According

to the Association for Project Management (2006) this stage is divided into two, which are:

- **Define a project**

This sub-phase aims to ensure understanding of the project among project participants. All projects that the risk management process is to be applied to should have clear and well-defined objectives. The objectives should be a direct expectation of the stakeholders and should be the means by which the project is measured for success (Association for Project Management, 2006).

The projects should have a clearly defined scope. The scope should clearly state what part of the real world is relevant to the project and how the project relates to other projects. The scope should be detailed to depict the expected output of the project, the project duration and stakeholders involved.

As this is a stage, any process for which the risk management process is to be applied has to have a well-defined strategy and an outline plan for the project execution. If any of this information is not clear, it should be ironed out before progressing to the next phase.

- **Focused risk management process**

This sub-phase entails mapping of the risk management process to the specific project objectives or requirements. The defined objectives of the project and risk management process should continuously be reviewed and updated throughout the project (Murray-Webster, 2010).

The risk management process should be applied from the starting stage of the project and should continue throughout the project. Another key aspect is the project risk management strategy, which should also be implemented at the start of the project (proactively). All key decisions made should be well documented. The level of implementation of the risk management process during the project lifecycle should depend on the project conditions (Murray-Webster, 2010).

When key decisions about a project are considered, the risk management principles should be used to establish an understanding of the level of risk and control measures at that time. The phasing of a project is a risk management activity since release of funds is controlled and a planned endeavour is undertaken. Adequate resources should be provided for the effective implementation of the risk management process.

B. Identify:

The aim of this phase is to ensure the identification of all possible risks for a project is as comprehensive as possible, practical and cost effective. When risks are identified, some mitigating options are sometimes identified at this stage (Murray-Webster, 2010).

A systematic approach should be implemented for risk identification that will ensure an adequate and full set of risks is identified covering all aspects of the project. See section 2.3.1.5.1 for explanation of risk identification techniques.

C. Assess:

In this phase**,** increasing the understanding of the risk identified in the earlier phase is paramount. To achieve this, risks should be broken down to a level that is more informative and enables a decision to be taken. The assessment of risk can be done using a quantitative or qualitative approach (Murray-Webster, 2010). This stage includes determination of risk ownership, estimation of cost and evaluation of each risk.

This phase allows implementers to view the risk exposure of a project at a given time. The assessment is used as an input variable in determining what decisions should be made regarding risk prioritisation and the level of concern it should be given. See section 2.3.1.5.2 for risk assessment techniques.

D. Plan response:

This phase has the function of determining the best response to an identified project risk and ensuring that the assessment of the overall project risk is used to modify project strategy (see section 2.3.1.5.3 for risk responses). According to the Association for Project Management (2006), this phase is divided into two sub-phases, which are 'plan risk event responses' and 'plan project risk responses.'

- **Plan risk event responses**

The aim of this sub-phase is to implement a strategy to resolve a risk that is appropriate, justifiable and practical, having in mind the goal of reducing or minimising risks, to ensure project success. In this phase, the responses identified for risks in the previous phases should be re-evaluated. If these are found to be no longer appropriate, new responses should be identified. All other risks that do not have a response must be considered in this phase, and a response must be provided.

- **Plan project risk responses**

This sub-phase uses the knowledge provided by earlier phases to improve project implementation. This includes taking account of the overall project risk in project planning and risk management planning. This sub-phase iterates back to the first phase (Initiate phase) of the risk management process. The key principle is the need to use a strategic level of planning to manage project risk effectively and efficiently early in the project.

E. Implement response:

This phase ensures that adequate actions are taken based on the decisions adopted in the previous phase (Plan Response). This includes the actions to implement risk responses targeting specific risks in the register and actions affecting the directions of the project based on the continuous assessment of risks.

The tasks for the implementation of the planned response should be well defined and easy to implement. Responses should be verifiable, and response owners should be accountable for the outcomes.

The conditions that led to the risk should be monitored so that if risk changes, risk responses can also be modified to resolve the risk. This will entail re-implementation of the previous approaches for that risk. Structured criteria should be available to enable explanation as to when a risk can be removed from the risk management process.

F. Manage response:

In this phase, the aim is to ensure that the risk management process remains effective in identifying, assessing and controlling the risks that could occur in a project. It gathers input throughout the risk management process and reviews each approach selected at each phase. The phase covers all aspects of the implementation of the process, which includes the tools and techniques, roles and responsibilities, communication and reporting requirements. It also ensures the integration of the risk management process with other project management activities.

The project manager oversees this process; they ensure that the risk management process adopted for the project is effective in addressing all the risk faced in the project. This process is performed in two ways: via a risk management review, or informally throughout the project.

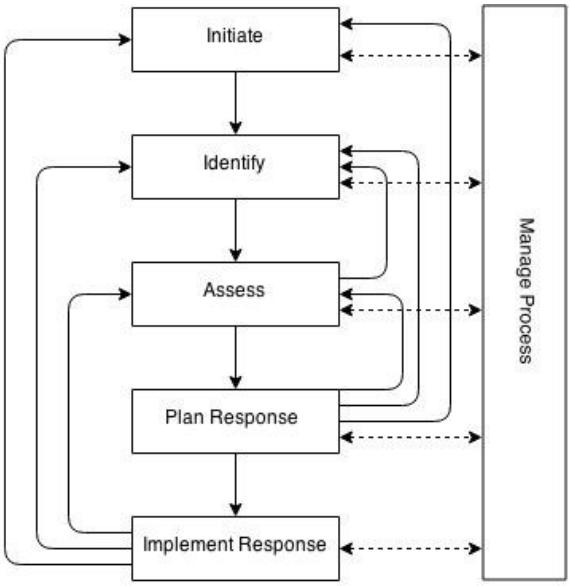

Figure 6: Risk management process (Association for Project Management, 2006)

By analysing the diagram in Figure 6**,** one can conclude that the risk management process is not a simple linear process. At the start of a project, the process adopts a swim lane model till project completion. As a project goes through its lifecycle and the risk management process is implemented, the areas of uncertainty in the project will start to decline.

2.3.1.5 Risk techniques

2.3.1.5.1 Risk identification techniques

- **Assumptions and constraint analysis**

In the initial stage of project planning, a lot of assumptions are taken on a project. Once these assumptions are written down, they can later be used to identify possible project risks by looking at the likelihood of that particular assumption occurring or not. The same procedures can also be applied to project constraints.

- **Checklists**

This approach is used to write down risks that have occurred in past or recent projects that have similarity. They are used to ensure that the experiences people

have gained in previous projects are utilised in the current project; another use for this approach is to act as a self-assessment tool for a project. Care should be taking when using this method, as lists can be project specific or possibly non-exhaustive.

- **Brainstorming**

This approach is basically to get the project stakeholders and the people involved in risk management for a project to come up with possible risk that could affect the project. This approach is commonly used in projects across various industries.

- **Interviews**

This process is a verbal technique, which is employed to assess the probability and impact of risks in a project. Getting input from key stakeholders and experts helps to achieve this. According to Hillson (2004), the use of structured interviews to get input from key stakeholders and experts can identify 60 to 80 percent of foreseen risk.

- **SWOT analysis**

This analysis consists of a breakdown of the strengths, weaknesses, opportunities and threats of a project. SWOT can be used in risk planning; it provides risk managers with the ability to capitalise on the identified risks by using the project's strengths and opportunities to reduce threats and weaknesses.

- **Stakeholder analysis**

This involves identifying the project stakeholders and their requirements, as stakeholder conflicts could occur because some stakeholders' have different objectives with others, these are risk areas and solution should be determined before proceeding.

- **Project monitoring**

During a project, proactive management and monitoring could lead to the realisation of risk at early stages before they occur. The process of identifying risk in this area helps in the incorporation of risk management in the project management activities.

- **Delphi techniques**

The Delphi method is conducted by gathering opinions from expert professionals and then giving them an opportunity to review each other's answers to converge on a more considered opinion (without being influenced by power and personality effects that will be present in a face-to-face brainstorm). This can be used to identify the set of possible risks that affects a project face.

- **Technology Readiness Levels (TRLs)**

Nasa developed TRLs (Mankins, 1995) as an approach to consider the technology required for the accomplishment of a certain project. Here the technology readiness of each subsystem and system is examined and assessed for its exposure. Risk identified in this process can easily be classified as a technology risk. There is a relationship between the technological maturity and project systems engineering lifecycles phases. Where technological maturity falls behind this expectation there is risk.

2.3.1.5.2 Risk assessment techniques

2.3.1.5.2.1 Quantitative risk techniques

- **Expected monetary value (EMV)**

According to the Project Management Institute (2009), the expected monetary value is a statistical method that calculates the average outcome when there are possibilities of not all events happening. It is a quantification tool that is the product of two numbers, which are the risk event value and its probability (Raftery, 1994).

Stefanovic and Stefanovic (2005) explain that the method takes into consideration all possible risks and the probability of all the alternative outcomes. When all the outcomes are calculated, it then adds up all the results together to obtain the total result. The formula for the expected monetary value is depicted in Equation 1.

$$EMV = \sum_{i=1}^{N} Value\ n * Probability\ n$$

Equation 1: Expected monetary value.

- **Probability distribution and three-point estimates**

Once a quantitative assessment approach is decided for risk assessment, variables such as the input parameters should be defined. The probability distribution techniques can either be discrete or continuous. The instability connected with non-uniform continuous likelihood conveyances is frequently depicted by the three-point estimates (optimistic, most likely and pessimistic values) (Association for Project Management, 2006). To achieve a reliable and accurate model the estimate of the three input values are key. A good three-point estimate is one based on deep thought and analysis. This results in providing a better understanding of project risks and uncertainties (Association for Project Management, 2006).

- **Bayesian method**

This method is based on a theorem, which was first presented by Reverend Thomas Bayes in 1764. The theory offers "the possibility to use personal and objective probability estimates changing as new data appear as elements of uncertainty are numerous, subjective and may be revised, following the acquisition of information" (Van Den Acker, 1996, p. 71). Anderson et al. (2010) explain that when the models have been depicted, they have the capability to change the initial values based on the results. The possibility of an event is conditional on another unknown or uncertain event.

- **Sensitivity analysis**

According to the Project Management Institute (2008), sensitivity analysis helps in determining which of the possible risks that could occur would have the most impact on the project. Saltelli (2004) says the sensitivity analysis is used to determine how sensitive a model is to various input conditions of the model and the changes in its structure. Manipulating the input value and monitoring the outputs to see if any changes occur to achieve this. It adopts a model that tries to rank inputs based on their individual contributions the model variability and uncertainty.

- **First pass quantitative models**

This model is designed to determine aspects of a project that have the highest effect on project risk, which would proactively prove the areas that should have be actively managed. This approach is achieved with probabilistic calculations on the main project aspects deemed risky (Association for Project Management, 2006).

- **Program evaluation and review technique (PERT)**

This tool is very important when it comes to scheduling, organising and coordinating different aspects in a project. Malcolm et al. (1959) say that it was developed to ease planning and scheduling of large complex projects. It is used as an estimation technique for time to completion of uncertain project activities. Typically used in projects that have uncertainty in their operations (Klastorin, 2003), the approach analyses and represents the tasks involved in a project as numbered nodes in a network diagram. The direction of the arrows on the lines indicates the sequence of tasks.

- **Failure mode and effect analysis (FMEA)**

This is a quantitative approach that evaluates potential failures, prioritise risk and analyses the impact of the risks. It has the aim of planning to avoid possible foreseen problems (Lutz & Woodhouse, 1999). Once a project team identifies a risk, they then need to cross check existing control methods and see how the risk emanates and see how it can be modified to resolve the risk from propagating (Snee &

Rodebaugh, 2008). According to Carbone and Tippett (2004), this approach is used because of two reasons, firstly to reduce the errors during project development and secondly, to prevent any extra cost during the project as risks have been identified in the beginning and resolved.

- **Analytic hierarchy process (AHP)**

This model was developed in the 1970s by Thomas Saaty (Saaty, 1980). It is an algorithm for organising and analysing complicated decision problems taking into consideration the tangible and intangible aspects, which makes it rely on the experience and knowledge of the decision makers (Forman & Gass, 2001). It constitutes the classification of decision elements and their alternatives, measuring each element and making a comparison between possible pairs of each of the groups. It aids in decision making if teams face complex decisions with high risks (Bhushan & Raj, 2004).

- **Decision tree analysis**

This technique is a graphical method that entails considering various situations and the implications of each. A comparison is then made, and the best option in each case is taken. Details to consider for each scenario include the cost of each scenario and the probability of it happening. A value is then assigned to each scenario (Olivas, 2007) . It provides the benefit of each possibility being investigated, and outcomes can quickly be investigated further. Dey (2002) highlights how decisions trees can be used to create a better understanding of risk and rewards, which can be obtained from the possible actions. Hulett (2006) explains how decision trees are best for the risks that occur in a sequential order.

- **Decision-making matrix / risk matrix**

This is a graphical representation that combines details of risk such as the possibility of an event happening and the impact of that event if it should occur. To quantify the risk, you multiply both terms together. Barringer (2008) explains that, because of its ease; it is the preferred method to use. The main aim of this method is for the

prioritisation of risk. The principle is based on expert judgment, and hence it's subjective to the person analysing the risk and his perception.

- **Monte-Carlo analysis**

In project management, Monte Carlo Analysis is a commonly used technique for quantitative risk assessment. It is utilised in the areas of project cost and time estimation. In this analysis, single values for activities are commonly replaced with distributions based on uncertainty estimation. The project is then simulated with many iterations to determine the probability distribution for the outcome cost and duration of the project or activity. Data obtained from the simulations are also used to focus management attention on the primary risk issues. The most vital aspect of this analysis is the quality of the input data. During the construction of the risk model and collection of risk estimates, experience and time play a vital role (Mooney, 1997).

2.3.1.5.2.2 Qualitative risk techniques

- **Risk description**

As risks events are identified, this approach encourages further understanding of the risks. The process would help in providing proactive solutions. In the risk description, information such as the cause, factors that it could affect, and the consequences of the risk are written down. It provides a uniform way of presenting the risk, which makes it easier for all the stakeholders to understand them (Association for Project Management, 2012).

- **Influence diagrams**

When risks occur in a project, there is usually an effect on the resources used in the project. The influence diagram is used in such a situation as it helps identify all affected parts of a project; this is critical in impact assessment. The techniques also allow for the identification of risk that might have occurred by tracing the sources of unknown problems that arise during a project (Sterman, 2000)

- **Risk breakdown structures**

This is a top to bottom breakdown of identified risk where each stage can individually be assessed. During the assessment of higher-level risk, factors that contribute to the risk may also be classified as individual risks. The breaking down of risk to lower levels can help improve control and mitigation plans. This process allows a project team to further understand possible risks and their nature (Association for Project Management, 2012).

- **Probability-impact matrices**

This approach is used for the prioritisation of risk. The assessment of each risk is done based on two categories: probability and impact. For each category, a scale is given between an agreed upon range such as from "very high" to "very low". Based on the given weight for each risk, they can easily be ranked. There are different ranking schemes for the probability and impact categories (Association for Project Management, 2012).

- **Risk impact window and bubble diagrams**

This approach aims to provide a graphical prioritisation technique for risk. Here risks are plotted on a graph where the size of the bubbles depicts the impact of the risk. On the graph, the x-axis shows an estimate as to when the risk would start, and the y-axis illustrates the probability of the risk. This technique uses an extra dimension of time (Sterman, 2000).

- **Expected value**

This approach produces an outcome of an estimate of what will happen if a risk is to occur. In probability distribution, it is obtained via multiplication of all possible values and their possibilities of happening (Sterman, 2000).

- **Risk registers**

A risk register is a standard template that is used to record individual risks and includes key information. The template typically includes a description of the risk, probability, impact, mitigations, etc. The information on the register various on the type of risk management technique employed in a project (Association for Project Management, 2012).

2.3.1.5.3 Risk response

- **Threat avoidance**

To prevent or circumvent a certain threat, one can modify their objectives or change the manner of approach to achieve that objective. By doing this one can eliminate a certain treat from occurring, but care should be taken to ensure that new threats do not arise based on the new approach taken (Association for Project Management, 2012).

- **Opportunity exploitation**

During a project, opportunities will sometimes arise that project managers can utilise to improve the state of the project, for example, reducing the cost of essential materials needed (Association for Project Management, 2012).

- **Reduction of threat probability**

This is an effective option for risk control; it's a preventive approach aimed at eliminating risk from its source before it occurs. Although this method may increase cost and time in projects, the need of such an approach can be overwhelming as compared to the cost of the risk if it eventually occurs (Association for Project Management, 2012).

- **Reduction of negative impacts**

This approach can be both proactive and reactive. To be proactive, the project manager should ensure flexibility in the approaches that could be taken to complete a certain project while in the reactive approach, the aim is to limit the impact of a risk when it occurs, and this is achieved by identifying and monitoring the source of the risk at an early stage. Fundamentally this technique aims to allow a change in approach so that the impact is reduced, or have a plan in place to deal with a situation which would in turn reduce the impact (Zhang & Fan, 2014)

- **Fall-backs**

When a risk is foreseen and is assessed as having a relatively high probability, the project manager should provide a solution or 'fall-back' that acts as a backup plan. The fall-back approach is similar to the reduction of negative impacts (Zhang & Fan, 2014).

- **Risk transfer**

This approach involves taking a risk in a project and passing the impact of the risk to other stakeholders involved in a project. This method is actively used when the bearer of the risk is unwilling or unable to bear and manage it. The manager of the risk should be the owner and should be in the best position to deal with it, especially having the necessary domain knowledge (Zhang & Fan, 2014).

- **Insurance**

This is a common approach when it comes to modern day projects; it is a form of risk transfer to a third party. This method provides financial support to risks that have a low chance of occurring with a high impact on a project if it occurs. This is a common approach, typically implemented by large organizations (Association for Project Management, 2012).

- **Risk acceptance**

In a project, there is sometimes no viable option for risk mitigation which is available or acceptable to the project manager. In this case, assuming the project is to continue, the risk must be accepted, and its consequences would then have to be actively managed to reduce the total risk exposure in the project. This method is typically applied to very low-level risks as a matter of course. Where high level risks exist that can't be economically mitigated then higher management sign-off is required (Zhang & Fan, 2014). In this case, non-mitigation of the risk provides the best option for maximising utility of project delivery.

2.3.2 Risk management in engineering projects

Risk management is about identifying, assessing and controlling risk as stated earlier in Section 2.3.1.4. The primary goal of risk management is to manage uncertainty by mitigating the risk with negative impacts and exploiting the ones that have a positive consequence.

Risk management in projects has grown from the implementation of simple risk analysis methods to more detailed implementation of risk management (Yanting & Liyun, 2011). Project managers continuously face important decisions with regards to the allocation of scarce resources in projects that encompass geological and financial risk and uncertainty. Risk management is an ongoing decision-making process, which includes feedback intended to increase the likelihood of project success (National Aeronautics and Space Administration, 2007).

Recently there has been increased use of analytic decision techniques to aid risk decision making in projects (Suslick & Schiozer, 2004). There are currently various standards, methods and tools that are used for risk management in different sectors for example the petroleum industry utilises various risk analysis and mitigation methods to minimise failures such as Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA) and Decision Tree Analysis (AlKazimi & Grantham, 2015) while the construction mostly implements a limited number of qualitative

techniques which are not appropriate for every situation (Goh, Abdul-Rahaman, & Abdul Samad, 2015). This indicates that qualitative methods are more used than quantitative methods. See section for 2.3.1.5.2.2 a list of qualitative approaches. In other sectors such as the Space industry, NASA projects have shaped the landscape of the global space sector, providing many of the most significant success, but also recording some of the most significant project failures, for example, the Mars Climate Orbiter, Space-Based Infrared System (SBIRS) and NASA Space Shuttle Challenger (Paté-Cornell & Robin, 2001; Sauser, Richard, & Aaron, 2009; Andreas, 1997). NASA has learnt from past experiences and developed its risk management process which includes Continuous Risk Management (CRM) and Risk-Informed Decision-Making process (RIDM) (National Aeronautics and Space Administration, 2010).

Risk can seriously affect the objectives of a project in the aspect of cost, time, scope and quality (Serpell, Ferrada, Rubio, & Arauzo, 2015). There have been several projects that have been affected and could not be delivered according to set parameters, e.g. the Sydney Opera House (Murray, 2003) while the London Olympic Stadium is an excellent example of a project that benefitted from proactive risk management which led to successful delivery (Davies & Ian, 2014).

Although models of risk management suggest a structured process (Association for Project Management, 2012; Project Management Institute, 2013), current risk management implementation in projects is reactive, semi-permanent, casual and unstructured (Serpell, Ferrada, Rubio, & Arauzo, 2015). This results in the lack of adequate risk management implementation. Choudhry and Iqbal (2013) state that the main barriers that prevent effective risk management implementation are the lack of formality and the absence of an integrative mechanism of risk management among the project stakeholders. Another limiting factor is that risk management is not applied with the same emphasis as other aspects of the project management process (Fan, Lin, & Chwen, 2008).

2.3.3 Decision making in projects

Making decisions is an essential part of the management of projects. There is currently an abundance of literature that provides guidance on rational decision-making process (Hazır, 2015). Even with the various tools, methods and research in behavioural decision making the actual decision behaviour deviate from the rational/choice. This prompted an additional area of study which looks at the possible reasons for the deviation from the rational choice?

Behavioural decision-making aims to understand or elaborate the actual influences on decision-makers on making choices (Mullaly, 2014). Decision making in projects have been recently researched and is gaining more momentum. Examples of recent works include research on over-optimism in project forecast (Flyvbjerg, 2013; Flyvbjerg, 2007), escalation of commitment (Alvarez, Pustina, & Hällgren, 2011; Van Oorschot, Akkermans, Sengupta, & VanWassenhove, 2013), or ineffective risk management (Kutsch & Hall, 2005; Kutsch & Hall, 2010).

Powell et al. (2011) presented three schools of thought on organising the research on behavioural strategy. They drew from several works of literature and based on their onto-epistemological foundations they identified three separate schools. These schools are fundamentally different in philosophy and adopt different methodologies. The three methodologies are namely Reductionist, Pluralist and Contextualist.

Researchers Powell et al. (2011) present the notion that the identification and acknowledgement of the paradigmatic differences of these three schools of thought where a necessary starting point to adopt a policy of methodological pluralism and multimethod research. Table 6 provides an overview of the characteristics and foundations of the three schools.

	Reductionist	Pluralist	Contextualist
Ontology in relation decisions	Decisions should be rational and deviations from rationality should be mitigated.	Decisions are negotiation arenas, prone for conflict of interest, bargaining and opportunistic behaviour	Decisions are sense making processes, intertwined in the negotiation of meaning before, during and even after the project.
Assumptions about decisions maker's behaviour	Decision makers make decisions consciously as 'events' but are bounded-rational, and hence cognitively limited.	Decision makers are rational and strongly influenced by personal and political interest, which can conflict with that of the project.	Decision makers do not make decision but are actors constructing narratives which will shape processes of attention, prioritization and ultimately decision.
Core processes of interest	Individual and intragroup decision making.	Intergroup bargaining, problem solving, politics, conflict resolution, organization learning, resource allocation.	Sense making, perception, enactment, action generation.
Caricature of project actors portrayed in research findings	The optimist: project actors suffer from pronounced optimism bias.	The opportunist: project actors have their own interest at heart.	The orchestrator: project actors surf on waves of meaning, in a highly ambiguous world.
Typical methodologies	Positivist research, marked by experimental research, modelling and simulation.	Critical realist, socio constructivist, marked by qualitative and multi-method tradition.	Socio constructivist, marked by qualitative in-depth studies, ethnography, grounded theorising.
Examples of classical contributors	Edwards, Simon, Von Neumann-Morgenstern, Tversky-Kahneman, Schelling, Bazerman,	March, Cyert, Simon, Fiske-Taylor, Bower, Miller. Kets de Vries, Hambrick, Levinthal,	Weick, Starbuck, Pettigrew, Brunsson, March, Staw, Mintzberg, Abrahamson, Reger,

	Loewenstein, Lovallo.	Denrell, Bromiley, Rumelt, Winter.	Huff, Fiol, Milliken, Hodgkinson, Bettis, Mitroff.
Examples of Contributors from project studies	Flyvbjerg, Jani, Keil, Shore, Martinsuo, Kutsch, Hallgren, Williams.	Flyvbjerg, Pinto, Kujala, Clegg, Winch, Chapman, Mullaly	Pitsis, Alderman, Musca, Winch.

Table 6: Overview of the three schools of Decision-making (Geraldi & Stingl, 2016; Stingl & Geraldi, 2017)

2.3.4 Decision making and uncertainty

Theories on decision making under risk have been dominated by utility and prospect theory (Koppenjan, Leijten, ten Heuvelhof, Veeneman, & van der Voort, 2010). Researchers Koppenjan et al. (2010) states that "Expected utility theory includes the gain, probability of occurrence, risk aversion and the different valued utility of the same gain to different actors as relevant issues in decision making in a case of risk" while the author states that "Prospect theory adds heuristics to this. This includes human behaviour as a relevant element of decision making." This helps explain why decision makers base their decisions on certain dominant values (Kahneman & Tversky, 1979).

A good strategy used as a response to uncertainty and risk is to elaborate the terms of reference in greater detail. This minimises the chance that changes have to be made at the later stages in a project which might increase the cost between the project manager and major stakeholder. Koppenjan et al. (2010) suggest that the more complex a project is, the more difficult it is to avoid scope changes. This is because it is difficult to foresee all impacts of events in the implementation of a project, so attempting to fix the scope at the outset can have adverse consequences.

To reduce the negative effects of risk, project managers may implement an extensive risk management strategy. This approach does not guarantee success as it requires interpretation of information by various project stakeholders and because

of their different background and experience they might each have different views. More often than not the less competent stakeholder may frame trade-offs on the basis of his/her value priorities and risks ignoring impact of other risks as a consequence (Koppenjan, Leijten, ten Heuvelhof, Veeneman, & van der Voort, 2010).

2.3.5 Probability theory and expected utility theory

Bernoulli provided the hypothesis of marginal utility by repeated coin tossing (Center for Economic Policy Analysis, 2007) and as such the principle of utility was developed through probability theory. According to Bernstein (1998), Bernoulli introduced the principle that the utility of wealth (satisfaction from wealth) increases in proportion to the number of goods possessed. This principle of wealth has been the basis of further research (Morgenstern, 1979; Von Neumann & Morgenstern, 1953; Savage, 1954; Friedman & Savage, 1948; Kahneman & Tversky, 1979) and has since become a critical aspect in risk aversion. The inventor of game theory (Von Neumann & Morgenstern, 1944) was of the view that the theory required more than mathematics, while Morgenstern (1963) believed people in business do not take precautions into consideration nor do they alter their decisions.

The relationship between human behaviour and decision making has been extensively discussed in economic theory. Researcher Markowitz (1952a; 1952b) presented the use of diversification as a method aimed at reducing investor risk in which investors who expected returns would select the portfolios that best suits them according to their objective. Such objectives may be aggressive or defensive to maximise their expectation of utility. The suggestion of some researchers was in line with Bernoulli's principle, which states that people are rational, they understand the choices they make and apply them consistently with subjective probability (Bernstein, 1998; Savage, 1954; Von Neumann & Morgenstern, 1953). In this case, underweighting suggests that the influence on the probability is less

than the influence of the actual probability (Holmes Jr, Bromiley, Devers, Holcomb, & McGuire, 2011).

2.4 Shortcomings of expected utility theory for risk-based decision-making

Expected utility theory assumes that a decision maker selects options or a path with known risk. This assumption can be violated because of the variability of certain key aspects in the decision. From the perspective of psychology, the attitude towards risk and uncertainty is an important aspect of decision making, particularly in projects where decisions can lead to different outcomes and a combination of those outcomes can lead to project success or failure. Decision making in a risky situation can easily be considered as a choice between prospects. A prospect can yield an outcome x_1 with probability p_1 $(x_1, p_1; \dots; x_n, p_n)$. In the application of expected utility theory, three principles were incorporated to explain decisions between choices (Kahneman & Tversky, 1979). These are:

1. ***Expectation***: This explains that the total utility of a prospect is the expected utility of all outcomes.
2. ***Asset Integration***: This suggests that the utility is a function of the final state (final wealth), instead of the gain or loss made from a reference point.
3. ***Risk Aversion***: The concavity of the utility function can represent this.

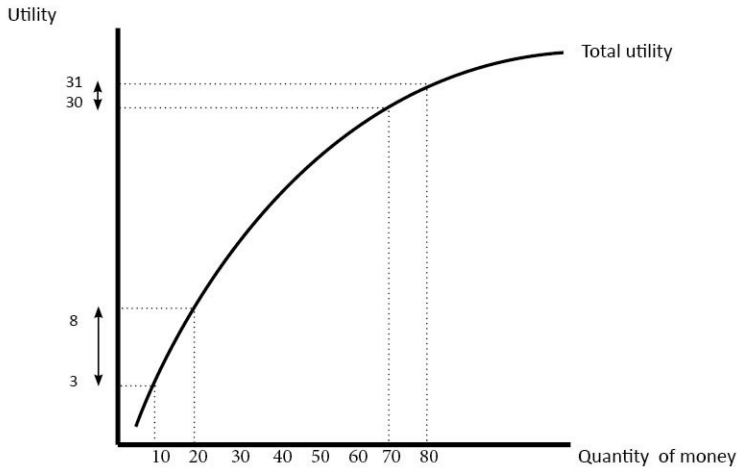

Figure 7: Risk aversion and diminishing marginal utility of wealth (Mongin, 1997)

As shown in the Figure 7, in expected utility theory, an increase in wealth from 10 to 20, leads to an increase in utility, while an increase in wealth from 70 to 80 leads to a smaller increase in utility. Figure 7 depicts diminishing marginal utility and justification for why people may exhibit risk aversion for potential large losses with small probabilities (Mongin, 1997).

In expected utility theory, the utilities of outcomes are weighted by theory-associated probabilities. There are several choice problems highlighted in behavioural economics and psychology that suggest that there are certain cases or situations where people's preferences systematically violate the principles of expected utility theory. An example is the counter-example of certainty effect exploited in expected utility theory (Allais, 1953; Avineri & Bovy, 2008).

Expected utility theory can be applied in project risk management to explain how an individual should make decisions in a project management context. However, evidence suggests that there are situations where decision makers deviate from expected utility theory (Bourgeois & Eisenhardt, 1988; Einhorn & Hogarth, 1986; Jaeger, Renn, Rosa, & Wehler, 2001; Allais, 1953; Neumann & Politser, 1992; Tversky & Kahneman, 1974).

Researchers Adler et al. (1992) highlight three possible reasons why people deviate from the choices that would be predicted by expected utility theory. These are: (i) uncertainty associated with any decision taken, and whether it encompasses negative outcomes as a result, (ii) emotional and cognitive overthinking that could arise from the awareness of risk and (iii) the complex dynamics associated with any given behaviour (Adler, Kegeles, & Genevro, 1992).

Researchers Yates and Stone (1992), suggest that the normality of rationality according to expected utility theory can make it difficult for one to make sense of risky choices in the context of uncertainty and group decision making. When more than one person is involved in decision making there is strong evidence that suggests that individuals do not use precise probabilities as they tend not to understand or trust the estimates (March & Shapira, 1987; Fischhoff, Lichtenstein, Slovic, Derby, & Keeney, 1981; MacCrimmon & Wehrung, 1986). March and Shapira (1987) further state that risks with low probability are ignored and others are compromised by a possible conflict between possible project stakeholders.

Another issue that arises is that the concepts of risk and uncertainty are not purely objective but entail elements of subjective judgement (Kutsch, 2005). Tversky and Kahneman (1974) investigated the impact of individuals' experiences of an event on their estimation of similar future events and concluded that those with a more recent experience of an event tended to overestimate the probability of its occurring. Other researchers such as Lichtenstein et al. (1978) suggest that individuals overestimate low risks and underestimate high risks. Kutsch (2005) suggests that deviations from expected utility theory may explain why project risk management may not be adequately applied or can be ineffective.

Expected utility theory states that the utilities of outcomes are weighted by their associated probabilities. However, there are systematic deviations from the principles of expected utility theory as shown in behavioural studies (Avineri & Bovy, 2008). Several frameworks have been presented with the aim of capturing

these deviations. Kahneman and Tversky (1979) present prospect theory and its successor cumulative prospect theory in (1992), which have been widely examined and researched in behavioural economics and psychology (Tversky & Kahneman, 1981; Thaler & Johnson, 1990; Tversky & Kahneman, 1992; Camerer & Ho, 1994; Wu & Gonzalez, 1996; Roberts, Boyer, & Lusk, 2008; Harrison, Humphrey, & Verschoor, 2010).

2.5 Prospect Theory as a theory to improve on Risk-Based Decision making

Although expected utility theory proposes that individuals are expected to maximise their utility, empirical evidence has shown that this is not generally the case. Prospect theory predicts individual choices in decisions that involve risk. The theory was developed by Kahneman and Tversky (1979) following studies that relied on controlled experiments that offered individuals choices between alternatives, which contained possible outcomes and their respective probabilities of occurrence. From the results of the experiments, Kahneman and Tversky (1979) suggest that people's choices could be described by a model that can convert the outcomes of gambles into subjective values and weight the subjective values by decision weights. In their research, they also developed a value function to describe how individuals determine the subjective values of outcomes and the weighting function to define the relations between probabilities and decision weights. This is the central component of prospect theory (Holmes Jr, Bromiley, Devers, Holcomb, & McGuire, 2011). The theory suggests that individuals choosing between two gambles will select the one with the highest value; prospect theory uses two equations to calculate the value of a gamble.

The first equation is used to calculate the values of mixed gambles. These are gambles that have both positive and negative outcomes, gambles that have 0 and probabilities that sum up to be less than 1 as an outcome. Prospect theory states that the value of such gambles is the weighted sum of the subjective values and decision weights for the possible outcomes. Considering a gamble with outcomes a and b

and probability c and d respectively. Prospect theory represents the value of the gamble as shown in the Equation 2. Where *x()* denotes the subjective value of an outcome and $y()$ denotes the decision weight for a probability.

$$Value\ of\ Gamble = x(a) * y(c) + x\ (b) * y(d)$$

Equation 2: Prospect theory first formula.

The second equation is used to calculate only values of gambles that are only positive or negative, and they have probabilities that sum up to 1. Prospect theory divides the gamble into a risky and riskless portion. In this case consider a gamble with outcomes a and b and probability c and d and assume a positive subjective value. If $x(b) < x\ (a)$, then the decision maker is guaranteed to receive at least $x(b)$ and $x\ (a)$ is the risky portion that could occur with the probability c. This gamble is represented in Equation 3.

$$Value\ of\ Gamble = x(b) * y(c) * [x\ (a) - x(b)]$$

Equation 3: Prospect theory second formula.

To calculate the value of the gamble in prospect theory, Equation 2 multiplies the risky portion by the decision weight for c and Equation 3 adds this product to the riskless portion. Prospect theory is mainly concerned with an individual's decision between two alternatives (Tversky & Kahneman, 1992).

To describe the behaviour of people when making decisions and to ensure that different systematic behavioural biases are captured, prospect theory comprises of four elements (Barberis, 2013; Kahneman & Tversky, 1979; Häckel, Pfosser, & Tränkler, 2017). Figure 8 depicts the hypothetical value function, and it illustrates the relationship between the outcomes and their subjective values. Kahneman and Tversky (1979) and Tversky and Kahneman (1992) suggest that four properties of the value function are essential. These elements are:

1. ***Reference dependence***: A decision maker's utility is described by reaction to changes in wealth (gains and losses) related to their current reference point rather than the total wealth. In other words, people tend to pay more attention to the change of wealth position. In areas with financial outcomes, the normative reference point is the status quo, but it can also be the outcome that you expect or feel entitled to. Outcomes that are deemed better than the reference points are gains and below the reference point are deemed losses (Kahneman & Egan, 2011).

2. ***Loss aversion***: Decision makers deem the impact of losses more significant than that of gains. This tells us that losses appear larger than gains (Kahneman & Tversky, 1979); people tend to have a preference towards avoiding losses over acquiring an equivalent amount of gain. This creates an asymmetry between the power of positive and negative expectations (Kahneman & Egan, 2011). Figure 8 shows an abrupt change in the slope of the value function where gains turns to losses. This is because there is a considerable loss aversion even when the amount of risk is low relative to wealth. This principle has been used to explain various violations of economic theory, including the endowment affect (Kahneman, Knetsch, & Thaler, 1991).

3. ***Diminishing sensitivity***: Decision makers are risk-averse in the domain of gains but risk seeking in the domain of losses and as such with increasing distance from the reference point, the impact of the said outcome diminishes. This means that people are more generally sensitive to changes near their status quo than to changes remote from it. The implication of diminishing marginal utility is consistent with natural intuition. Each additional dollar brings in less value added into the utility than the one before it. The subjective difference between 900 and 1000 is much smaller than the difference between 100 and 200 (Kahneman & Egan, 2011).

4. ***Probability weighting***: Decision-makers weight the probabilities of the outcomes instead of using statistical probabilities and underweight average events, but overweight events with low probabilities. This means that people tend to overreact to small probability events and underreact to large probability events (Kahneman & Egan, 2011). There is a general increase in decision weights as probabilities increase, the departure from linearity suggests that not all probabilities are assigned similar weights (Hess, 2015). The probability weighting function has the following characteristics: (1) the curve is steep at the low probability end of the scale, due to the overweighting of small probabilities, (2) the curve is less steep in the middle, indicating that it is less sensitive to intermediate probabilities, and (3) the slope becomes steeper for high probabilities, reflecting greater sensitivity to small differences in probabilities. These characteristics are depicted in Figure 9.

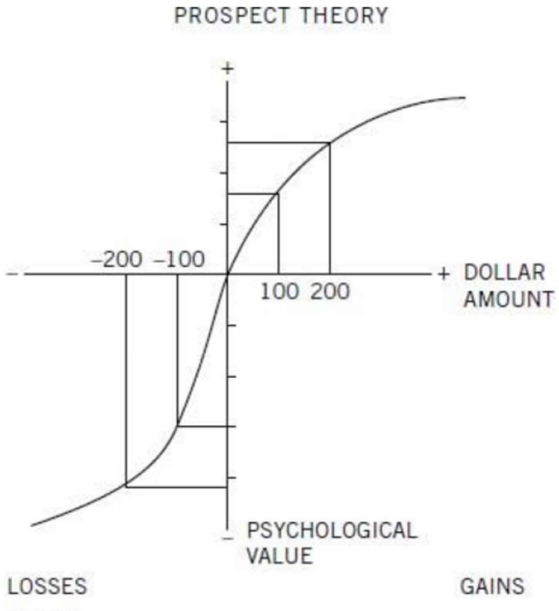

Figure 8: Prospect Theory Value Function (Kahneman & Egan, 2011)

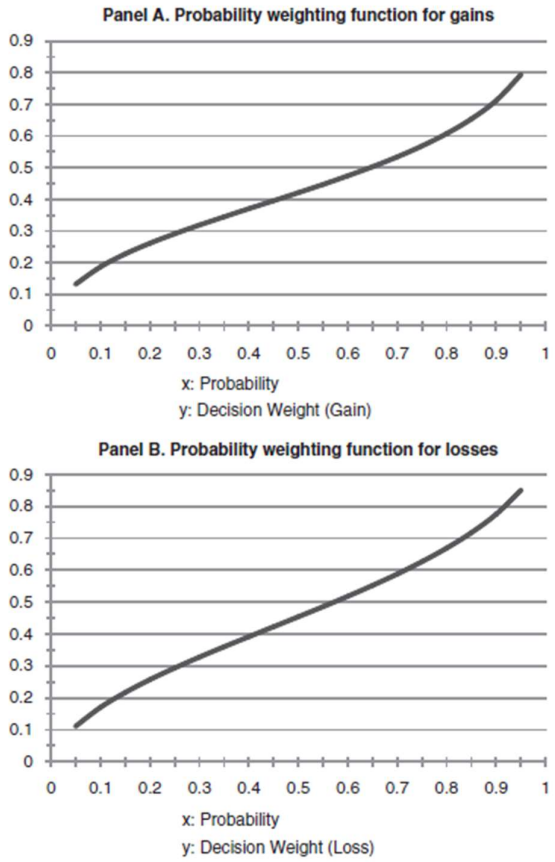

Figure 9: Probability weighting function (Tversky & Kahneman, 1992; Holmes Jr, Bromiley, Devers, Holcomb, & McGuire, 2011)

Since the development of prospect theory, various researchers have confirmed its validity and importance (Tversky & Kahneman, 1992; Kahneman & Tversky, 2013; Abellan-Perpiñan, Bleichrodt, & Pinto-Prades, 2009; Abdellaoui, Bleichrodt, & l'Haridon, 2008). Researchers Barberis et al. (2001) use the theory to explain why asset prices fell impulsively but rose slowly in specific markets. The results show that when stock prices started to fall, risk-averse investors become more willing to sell, accelerating the fall in market prices. This willingness to sell is not matched with the willingness to buy when the markets rise at an equivalent rate. List (2004) looks at market data to determine whether the neoclassical economic theory or prospect theory was more accurate. Here, List (2004), examines the indifference curve which is an indicator that shows when an investor acts or does not act when asset prices shift. The results show that investors had trigger points at which they

would make decisions that are not rational. This contradicts economic theory (expected utility theory in particular) and supports prospect theory.

Barberis (2013) reviews prospect theory to examine how well it applies. The results of the review state that the theory is a valid perspective and prediction tool. Li and Yang (2013) create a model to highlight the disagreement between disposition theory and prospect theory, and their research results show that asset price fluctuations will smooth out perceptions of investors over time and as such the investors would neither over/underweight a given asset price move. This, the authors claim, contradicted prospect theory and formed a model that takes both theories into account which was presented as a modified view of risk-averse behaviour.

Prospect theory has been shown to apply to non-economical situations. In their research, Liu et al. (2014) used cumulative prospect theory to examine the actions and behaviour of emergency responders when deciding whom to focus on in an emergency. Their results show that the responders were risk averse cumulatively in their short term and long-term goals. This indicates that the responders can select and chose to save someone's life even though the prospects were poor for such actions and their efforts would be better directed towards those persons who had a better chance of survival (Liu, Fan, & Zhang, 2014). This is also the case in a triage, where the decision on whom should be treated first might not be rational if made by a risk-averse person (Liu, Fan, & Zhang, 2014).

Cornish and Clarke (2014) propose that criminals are also rational actors as they make risk/reward calculations with regards to gain from the contemplated crime versus the risk of being caught and punished for the said crime. This could be seen as a cumulative prospect theory as a successful criminal will become more and more risk averse over time.

Bocqueho et al. (2013) investigate the behaviour of French farmers with regards to risk. Their results show that prospect theory is applicable to their case as the farmers

tend to move away from alternativities/options that had any risk of failure to a given crop and instead they opt for or prefer safer alternatives even if those alternatives provide less harvest/yield/utility. This could affect a farmer's decision to plant a new variety of crop even if there was a high demand for that crop (Bocquého, Jacquet, & Reynaud, 2013).

The research described has shown that prospect theory is a robust, predictive and analytical tool for examining the decisions that are made by people. The case that people are naturally risk averse to the extent that aversion overcomes any natural tendency towards acting in one's self-interest is powerful and helps explain many aspects of human behaviour.

In the context of this research, prospect theory can be applied in examining the decision-making process of project managers. Their individual behaviour may be skewed far more in the direction of risk avoidance than that of utility optimisation. It may be interesting to see if the decisions taken by project managers in the engineering field reflect such an attitude; the methods implemented in this research aim to shed some light on this. This leads to the identification of a further two objectives for this research.

Research Objective 3: Evaluate how well prospect theory can explain risk-based decision making in a project management context.

Research Objective 4: Evaluate how well the four key elements of prospect theory apply in the project management context.

2.5.1 Risk aversion and loss aversion

Loss aversion is a complex behavioural trait/bias where people express both risk aversion and risk-seeking behaviour. It entails the desire to reduce risk. To understand loss aversion, behavioural economists rely on prospect theory, which was developed by Kahneman & Tversky (1979). They identify loss aversion as a way to explain how people assess decisions under uncertainty. This can be seen as

a case when an individual's utility is concave over gains and convex over losses. For example, decision makers are quick to lock investment gains (risk averse) and yet they tend to hold on to a losing position in the hope that it will improve (risk seeking) (Mooreland, 2018).

Risk aversion is a preference for safety and certainty over uncertainty, and the potential for loss. Risk aversion affects investor preference for risky assets. A risk-averse investor will consider risky assets/portfolios only if they provide compensation for risk via a risk premium. To elaborate, when faced with two investments with similar expected returns (but different risks), a risk-averse investor will prefer the investment with lower risk (Bogan, 2010). This means that a gain contributes less to utility than an equal loss from utility. Example of risk aversion, People would prefer to receive $100 guaranteed rather than a 50% chance to win $10 and a 50% chance to win nothing. When decision makers are faced with a choice between two investments that have the same expected return, they choose the one with lower risk (Mooreland, 2018). It is important to understand that risk aversion and loss aversion are related but different concepts and have different influences on individuals.

2.5.2 Endowment effect

Prospect theory was developed as a theory explaining risk-based decisions. However, Richard Thaler (1980) suggests that several ideas proposed in prospect theory may be useful when thinking about riskless choice. The framework proposed by Tversky and Kahneman (1991) and Koszegi and Rabin (2006) suggests that individuals derive utility from consumption relative to some reference level of consumption, where the utility function shows loss aversion and diminishing sensitivity. Thaler (1980) argues that some research labelled under the umbrella of "endowment effect" provides strong support for prospect theory.

Endowment effect refers to two distinct findings: the first is known as "exchange asymmetries", and the second as "Willingness to accept (WTA) and Willingness to

pay (WTP)." In the aspect of exchange asymmetries, researcher Knetsch (1989) runs an experiment by providing half of the participants a mug and the other half a candy bar. After some time, Knetsch (1989) asked the participants who received the mug whether they would like to exchange the mug for the candy and vice versa for those who received the candy. Knetsch (1989) finds that the initial allocation to the participants has an effect on their subsequent choices. 89 percent of those who received a mug opt not to change and only 10 percent of those who received a candy bar opted to exchange it for a mug. This is not the case in the traditional economic analysis as preferences over goods does not depend on initial allocation or endowment (Barberis, 2013).

In the context of willingness to accept (WTA) and willingness to pay (WTP), in a study ('Experiment 5') by Kahneman, Knetsch and Thaler (1990), half of the participants are given a mug and asked if they would be willing to give up the mug for various stated cash values. This is the willingness to accept part of the experiment. The remaining participants are asked the inverse, where they are given the same list of prices and are asked if at each price they would be willing to pay the stated price for the mug. This is the willingness to pay part of the experiment. The results highlight a large difference as the median willingness to pay was $2.25, but the median willingness to accept was $5.75. This contradicts traditional economics, which would expect that there would be minimal difference between the two values (Barberis, 2013).

These two findings reflect the concept of loss aversion because in the exchange asymmetry experiment the respondents view an exchange as "losing" the item they initially had and "gaining" the other item. Since they are more sensitive to losses than gains, an exchange is deemed not acceptable by the respondents. This explains why most of the respondents stick to their initial endowment. In the willingness to accept/willingness to pay experiment, loss aversion states that people will demand much more for something they own; in this case, the mug given up is seen as a "loss" and the mug bought is a "gain" (Barberis, 2013).

List (2003; 2004) questions the robustness of exchange asymmetries and conducts a similar experiment in a sports card market where his participants are both dealers and non-dealers. The results reveal substantial evidence of exchange asymmetries in the first group, but this was not the case in the second group as dealers are much more willing to exchange an initial object they are given for others with similar value. List (2003; 2004) uses his results to suggest that prospect theory may be less useful in describing the behaviour of experienced economic actors. Researchers Koszegi and Rabin (2006) suggest that List's (2003; 2004) results may be entirely consistent with the theory, although with the implementation of prospect theory that takes the reference point to be a person's expectations about future outcomes. There are fewer exchange asymmetries among dealers because they expect to exchange items that come into their possession. Hence, they do not experience loss aversion when they are giving up items. This hypothesis has been formally tested (Marzilli Ericson & Fuster, 2011; Heffetz & List, 2011).

Plott and Zeiler (2005; 2007) bring the notion that a change in the experimental conditions can significantly affect the magnitude of exchange asymmetries and also the willingness to accept/pay gaps; this lead us to question the loss aversion interpretation of these effects. As argued and presented by Knetsch (1989), this may be due to the fact that participants consider the objects given to them as gifts in the first instance. As such, it may make the objects seem more valuable, and it would seem impolite to exchange them. Koszegi and Rabin (2006) argue that their results are consistent with loss aversion when the reference point is the decision makers' expectations.

2.5.3 Cumulative prospect theory

Deciding between prospects is a key aspect of expected utility theory and cumulative prospect theory; this can be denoted as $X_r = (x1, p1; \dots, x_s, p_s)$. Every outcome x_s has some probability p_s, such that $p_1 + p_2 + \cdots + p_s = 1$. The index '$s$' in this case means a specific event. A prospect/decision choice that has two potential outcomes can be stated as $(x1, p1;\ x_2, 1 - p_1)$. One of the outcomes is

often zero. Where a prospect has only one outcome, this can be deemed as riskless or certain, and the probability would always be 1.0.

Prospect theory can only be used on prospects that have a maximum of two outcomes, and cumulative prospect theory expands on this as being applicable to situations with multiple outcomes (Tversky & Kahneman, 1992). In this theory, the utility function and the probability weighting function is applied to the cumulative probability distribution function and not to the probabilities associated with individual outcomes as in the case of prospect theory. The $w(p)$ formula is used to determine decision weights for gains and losses. Each possible outcome has some marginal contribution to the probability of receiving a better or worse outcome. This evaluation for outcomes $x_1 \geq \cdots \geq x_k \geq 0 \geq x_{k+1} \geq \cdots \geq x_s$, is:

$$for\ i \leq k : \pi_i = \pi\left(p_i^{pi-1+\cdots+pi}\right) = w^+(p_i + \cdots + p_1) - w^+(p_{i-1} + \cdots + p_1)$$

$$for\ j > k : \pi_j = \pi(p_{j_{pj+1+\cdots+p_n}}) = w^-\left(p_j + \cdots + p_n\right) - w^+\left(p_{j+1} + \cdots + p_n\right)$$

Equation 4: Cumulative Prospect Theory formula (Marquis, 2016).

This modification addresses the "potential under prospect theory for a first order violation of stochastic dominance" (Marquis, 2016). There is a quadrant of risk attitudes, where a decision maker is risk-averse towards gains of high probability and losses with low probability, while being risk seeking for gains with low probability and losses with high probability. Research has observed asymmetry between gain and loss curvature which can't be explained by risk attitude alone but is due to loss aversion.

2.6 Conceptual framework

This research seeks to evaluate whether the importance of risk management is understood by practitioners and project managers, whether risk management is approached in a rational manner in projects, and whether prospect theory applies in a project context. As a first step in understanding this, it is helpful to establish the extent to which managers recognise the importance of doing risk management well, and whether they see hard aspects like risk quantification as more important than soft aspects like risk communication. This led to Research Objectives 1 and 2. As a second step, this research then examines how project participants behave in risky situations. This helps us to understand how rational they are and helps the researcher to identify possible reasons for decision makers' deviation from rational choice. Looking at how decision makers behave, the author then tests prospect theory to see if it provides a possible explanation for risk-based decision making in projects. By doing so, the author also looks at the four key elements of prospect theory and determines their applicability in the project management context. Evaluating prospect theory led to the formation of Research Objectives 3 and 4.

Figure 10 presents a conceptual framework that encapsulates the work which has been discussed and evaluated in this chapter. It links concepts that have been selected from the background literature which aids in the development of the research theory. Here the focus of the research is stated and possible relationships between concepts are identified. The model encompasses research areas that have not been adequately researched in the context of decision making in project management. This area has the potential of developing contributions to the further understanding of decision making in the project management context, especially in engineering projects.

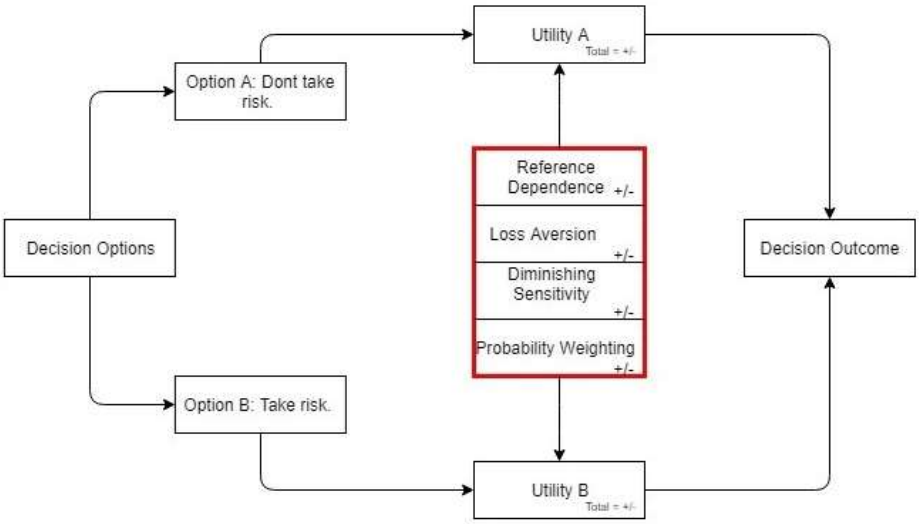

Figure 10: Proposed conceptual framework

Through the literature review, this research investigates how decision makers make decisions in a project context. Understanding the various links in this model, and in particular identifying how the elements of prospect theory highlighted in the red box influence the decision in practice is at the heart of this research. During the decision-making process, choices are evaluated based on possible utilities. Each aspect of prospect theory contributes to the total utility that determines which decision to take. This leads to a selection that could be rational or not. In the aspect of rational choice, utility maximisation plays a vital role; this is not the case with irrational choices (Bourgeois & Eisenhardt, 1988; Einhorn & Hogarth, 1986; Jaeger, Renn, Rosa, & Wehler, 2001; Allais, 1953; Neumann & Politser, 1992; Tversky & Kahneman, 1974).

2.7 Chapter summary

In this chapter, the author presents background concepts of projects and project management. In the aspect of projects, generic concepts such as definitions, benefits, lifecycle, classification and frameworks of projects are discussed. While in the aspect of project management the author presents and discusses the purpose,

constraints, limitations, environments, people and project management areas. The author explains the measurement of project success where aspects and key differences are discussed. Definitions and differences between key terms are explored including project management success, product success, success criteria, success factors and critical success factors. As far as critical success factors are concerned, some research objectives have been introduced which aim to determine (Research Objective 1) if project practitioners perceive effective risk management to be a success factor, and (Research Objective 2) if so which components of the risk management process are deemed to be of most importance.

This chapter then presents the background literature of risk and decision making in projects and explores possible explanations regarding the way people choose between probabilistic alternatives where the effect on the desired outcome is not known, including expected utility theory and prospect theory. The investigations in decision making and uncertainty show the possibility that decision makers might deviate from rational choice. This led the author to investigate this phenomenon in the project management context to explore (Research Objective 3) how well prospect theory can explain risk-based decision making in a project management context and (Research Objective 4) whether the four key elements of prospect theory apply in a project management context. The author uses prospect theory as a theoretical framework to investigate this phenomenon and examine the extent to which the four properties of prospect theory may influence decision making in projects. This chapter also discusses project risk management, and the procedures, methods and techniques that can be used to manage risk in projects.

Having reviewed risk and decision making, the next chapter establishes the research philosophy and methods to addresses the research question and objectives identified for this research.

3 Research methodology

3.1 Introduction

The previous chapter examined the available literature on project risk management, critical success factors, decision making and prospect theory. The information collected in that section guided the formulation of the data collection techniques to be implemented in this research. The methods implemented include two survey questionnaires and focus group discussions. This chapter discusses the research approach taken in this research. This includes research design, selection of participants, data collection methods, data analysis and the research procedures implemented to ensure validity and reliability of the results. This chapter also discusses the challenges that emerged during the data collection and analysis process, the steps taken by the author to ensure that they have been dealt with, and the ethical considerations that had to be addressed before the study took place.

3.2 Recap of research question and research objectives

As stated previously, the research question is to evaluate whether the importance of risk management understood and is prospect theory a good model of understanding risk management behaviour in a project context? The following research objectives were identified in Chapter 2:

Research Objective 1: Establish whether project practitioners perceive effective risk management to be a success factor

Research Objective 2: Establish which aspects of risk management are perceived to be of most importance

Research Objective 3: Evaluate how well prospect theory can explain risk-based decision making in a project management context

Research Objective 4: Evaluate how well the four key elements of prospect theory apply in the project management context

3.3 Philosophical views

Philosophical views are identified in research as they influence the practice of research (Creswell, 2014b), and determine the appropriateness of the various possible research methods. The philosophical view provides the worldview of research, which entails the basic set of beliefs that guide the actions of the researcher. The "worldviews" have been coined by other researchers as paradigms (Lincoln, Lynham, & Guba, 2011; Mertens, 2014), epistemologies and ontologies (Crotty, 1998). Creswell (2014b) identifies four philosophical worldviews, namely Post-positivism, Constructivism, Transformative and Pragmatism. The significant elements of the four views are shown in Table 7.

Post-positivism	**Constructivism**
• Determination • Reductionism • Empirical observation and measurement • Theory verification • Causal comparative • Quasi-experimental • Quantitative	• Understanding • Multiple participants meanings • Social and historical construction • Theory generation • Symbolic interaction • Interpretivist • Naturalistic • Qualitative
Transformative	**Pragmatism**
• Political • Power and justice oriented • Collaborative • Change oriented • Interventionist • Emancipatory • Critical theory • Qualitative model	• Consequences of actions • Problem- centred • Pluralistic • Real-world practice oriented • Mixed models

Table 7: Four Worldviews (Creswell, 2014b; Romm, 2015)

3.3.1 Post-positivism

Post-positivism builds on the traditional form of scientific inquiry and is mostly implemented for quantitative research rather than qualitative research. Postpositivist shows thinking that challenges the conventional notion of the absolute truth of knowledge (Phillips & Burbules, 2000) and recognises that we cannot be positive about our claims of knowledge when studying the behaviour and actions of people. This approach holds a deterministic philosophy in which causes determine effects or outcomes. It also encompasses a reductionist approach as it is intended to reduce ideas into a small discrete set to test such as variables that comprise hypotheses and research questions. In post-positivism even though the goal is to discover facts, these facts are deemed falsifiable and hence introduces the need to exhaustively test each hypothesis. Researchers Onwuegbuzie et al. (2009) state that post-positivist "asset that all observations is inherently theory – laden and fallible and that all theory can be modified."

3.3.2 Constructivism

The constructivist worldview is a perspective that is typically used in qualitative research (Lincoln, Lynham, & Guba, 2011). Social constructivists believe that individuals seek understanding of the world they live in. Individuals are driven by their experiences which they give subjective meanings to. It is recognised in this perspective that these meanings may naturally vary, so researchers seek a broad range of views rather than a narrow interpretation. The goal of this type of research is to rely on the participant's view of the situation being studied. Researchers with this view tend to address the processes of interaction among individuals and focus on the specific context where people live and work to understand the historical and cultural settings of the participants. A constructivist conception of reality refers to the idea that reality is constructed through social interaction and interaction with the environment (Creswell, 2014b). This implies that there are multiple accounts of reality and that reality is pluralistic (Onwuegbuzie, Johnson, & Collins, 2009).

Researchers who operate under this umbrella focuses on the unique qualities of individuals and socially constructed experience.

3.3.3 Transformative

Researchers with the transformative worldview hold the notion that research inquiry needs to be intertwined with politics and a political change agenda to confront social oppression at whatever level it occurs (Mertens, 2014). Hence this research agenda holds reforms that may change the lives of the participants, the institutions in which individuals work or live and the researcher's life. This worldview focuses on the needs of groups and individuals in our society that may be marginalised or disenfranchised. The transformative paradigm aligns well with qualitative research (Mertens, 2014; Creswell, 2014b) and it is a combination of several perspectives which include critical theory and participatory approaches to inquiry (Denzin & Lincoln, 2005). The key assumption here is the presumes existence of human oppression and the resulting need to alleviate such oppression. Creswell (Creswell, 2014a) explains that these perspectives necessarily link scientific inquiry with its historical and political roots and serve as foundations for empowerment of people through the discovery of knowledge. The transformative approach focuses on identifying the constraints placed on people by race, gender and socioeconomic status in order to increase awareness of inherent oppression.

3.3.4 Pragmatism

Pragmatism as a worldview arises out of actions, situations and consequences instead of antecedent conditions in the case of postpositivism. Instead of focusing on methods, researchers with this view emphasise the research problem and use all approaches available to understand the problem (Rossman & Wilson, 1985). As a philosophical underpinning for mixed-method studies, researchers Morgan (2007), Patton (1990) and Tashakkori & Teddlie (2010) suggest its importance for focusing attention on the research problem in social science research and then using pluralistic approaches to derive knowledge about the problem. Pragmatic

approaches to inquiry situate the researchers in a natural setting which allows for the use of all practical means to obtain knowledge, including the analysis of both quantitative and qualitative data. This approach to research acknowledges the tentative and tension-filled nature of human existence and knowledge is obtained within the context of research (Onwuegbuzie, Johnson, & Collins, 2009; Creswell, 2014b). Research Dewey (1986) defined this type of research approach as "the controlled or directed transformation of an indeterminate situation into one that is so determinate in it constitute distinctions and relations as to convert the elements of the original situation into a unified whole." In pragmatism, reality matters to practical effects of ideas, and knowledge is valued for enabling actions to be carried out successfully (Saunders, Lewis, & Thornhill, 2012).

3.3.5 Philosophical view in this research

Looking at the philosophical views stated in Section 0, the researcher automatically eliminates the implementation of transformative and constructivist paradigms. This is because the transformative approach is intertwined with politics and a political change agenda to confront social oppression. The constructivist approach, on the other hand, refers to the idea that reality is constructed through social interaction with the environment and implies that reality is pluralistic (i.e., multiple accounts of reality exist simultaneously). Therefore, these two approaches are not the fit for the context of this research as this research is not intertwined with politics and does not have a political change agenda nor those it deals with social interactions which would imply that reality is pluralistic. As for the other two approaches, post positivist and pragmatism, the post-positivist approach is eliminated by the researcher because it is no longer considered a philosophical approach appropriate for mixed method research because it advocates for a purely quantitative or qualitative approach to exploring social reality (Onwuegbuzie, Johnson, & Collins, 2009; Romm, 2015; Mackenzie & Knipe, 2006; Grant & Giddings, 2002). Researchers Onwuegbuzie et al. (2009) deconstruct the strong claim that analysis must be either qualitative or quantitative and they go a step further to illustrate that both qualitative and quantitative data can be jointly analysed using the pragmatic

approach. Brannen (2005) states that there are pressures to view research in terms of qualitative or quantitative research but there is more pressure to ignore such divide when studying the social world. This makes pragmatism seemingly the best option for this research as it allows for a mixed method approach (Onwuegbuzie & Leech, 2005; Brannen, 2005; Lund, 2012; Kelle, 2006; Onwuegbuzie, Slate, Leech, & Collins, 2009). The pragmatic approach puts a firm emphasis upon the practical aspect of answering the research question using the best tools available. As Creswell and Creswell (2018) state, "individual researchers have a freedom of choice. In this way, researchers are free to choose the methods, techniques, and procedures of research that best meet their needs and purposes." (Creswell & Creswell, 2018, p.10).

All research approaches have their weaknesses, and the pragmatic approach has raised concerns among some researchers [see (Giddings & Grant, 2007; Onwuegbuzie, Johnson, & Collins, 2009)] because it allows a free for all design approach with a "what works" attitude. However, even with that, the author believes that a flexible approach should be adopted for research in risk decision making. This is because the author looks to capture shared beliefs among members/experts of a speciality area, for which conducting research in a pragmatic paradigm is particularly suitable. The implementation of such a view also ensures that research in risk decision is not restricted by ontological and epistemological issues when deciding on how to address a variety of different research questions (Brierley, 2017). Researchers Morgan (2007), Patton (1990) and Tashakkori & Teddlie (2010) suggest the importance of pragmatism for focusing attention on the research problem in social science research and then using pluralistic approaches to derive knowledge about the problem. Tsoukas and Knudsen (2003) state that there is no one best philosophy for business management researchers. However, when implementing the desired approach, it is important to recognise that philosophical disagreements are intrinsic part of business and management research (Saunders, Lewis, & Thornhill, 2012).

Looking further, the pragmatic worldview is suitable as it allows for the implementation of a mixed method approach, and as the researcher is concerned with what is being practised in the real world in the aspect of risk decision making in projects. This approach gives the researcher the opportunity to offer a wider scope for constructive, contained and appropriate research because it has the potential to present a more complete and comprehensive research outcome (Whitehead & Schneider, 2007). The use of a mixed method approach not only expands the toolbox, but also provides the opportunity for synthesis of research traditions that give the researcher additional perspectives and insights that are beyond the scope of any single technique (Borkan, 2004). A quantitative approach is implemented to find answers from a large population, with the hope that this might allow for generalisation. These quantitative studies (surveys) are then complemented by qualitative studies (focus group) to get a detailed causal understanding of decision makers' behaviour. Taken together, the two sets of results are incorporated in a conceptual framework of the nature of the irrationalities and how people behave when faced with risk decision making in the context of engineering project management. Pragmatism recognises that there are multiple possible realities, and many different ways to conduct research with no single point of view giving the entire picture. This highlights the importance of implementing a mixed method approach to ensure that credible, well founded, reliable and relevant data are collected that advance the research (Saunders, Lewis, & Thornhill, 2012; Kelemen & Rumens, 2008). Further explanation on the research design and approach will be discussed in the coming sections.

3.4 Research approaches

Bryman (2012) suggests that the selection of the research design depends on the research problem, hence the type of research question asked will influence the choice of research strategy to be implemented. The research approach determines the methods that are used to frame the research to collect and analyse the data. A research approach can be a quantitative, qualitative or a mixed-method approach (Creswell, 2014b).

3.4.1 Quantitative approach

Quantitative research focuses on the use of scientific or mathematical data to understand a problem. This method is useful in comparing current results with that of other research findings. Bryman (2012) suggests that quantitative research methods are employed for the empirical and systematic investigations of quantitative properties. They rely on empirical data and the conclusions drawn from such data are based on statistical analysis. Quantitative research often uses surveys, which entail the use of various methods such as questionnaires or interviews, and can be conducted face-to-face, through the internet, by email or by telephone (Mertens, 2014).

3.4.2 Qualitative approach

Qualitative research involves the evaluations and analysis of non-numerical data. It is primarily exploratory, and it is used to get an understanding of the underlying reasons why respondents behave in a certain way (Denzin & Lincoln, 2005). It is used to uncover trends in thought and opinions. This approach employs various methods of data gathering and analysis of data such as interviews, observations, focus group, ethnography and open-ended questionnaires (Denzin & Lincoln, 2005). This approach allows researchers to uncover in-depth meanings and the complexities of human behaviour (Cohen, Manion, & Morrison, 2011). In this research, a focus group was conducted on respondents to validate and explain their views.

3.4.3 Mixed method approach

A mixed method approach is the process of collecting, analysing and integrating both quantitative and qualitative data at a particular stage of the research process in a single study with the purpose of gaining a better understanding of the research problem (Tashakkori & Teddlie, 2003; Creswell, 2014). There are a variety of mixed methods designs available (Tashakkori & Teddlie, 2003; Creswell, Fetters,

& Ivankova, 2004; Creswell, Plano Clark, Gutmann, & Hanson, 2003; Sandelowski, 2000; Creswell, 1999; Tashakkori, Teddlie, & Teddlie, 1998). Researcher Creswell (2014a) has identified the 4 major types of mixed methods design implemented by researchers. The 4 methods identified are the Triangulation Design, the Embedded Design, the Explanatory Design, and the Exploratory Design. Table 8 identifies the main characteristics of the 4 mixed method designs.

The Triangulation design has been identified as the most common and well-known approach (Creswell, Plano Clark, Gutmann, & Hanson, 2003). Morse (1991) states that the purpose of this design is to obtain different but complementary data on the same topic to enable researchers to more fully understand the research problem. The idea behind this method is to bring together the differing strengths and non-overlapping weaknesses of quantitative methods (Patton, 1990). This design method is used when a researcher aims to compare and contrast quantitative statistical results with qualitative findings or plan to validate or expand quantitative results with qualitative data (Jick, 1979; Brewer & Hunter, 1989; Greene, Caracelli, & Graham, 1989). The Triangulation design is a one phase design in which researchers implemented the quantitative and qualitative methods during the same time frame and with equal weights. When implementing this design, researchers attempts to merge the two datasets, this is done in the interpretation stage or by transforming the data to facilitate integrating the two data types during the analysis.

The Embedded design is a mixed method approach where one dataset provides a supportive, secondary role in a study primarily based on the other data type (Creswell, Plano Clark, Gutmann, & Hanson, 2003). The principle of this approach is that having a single dataset is not enough and sufficient, that different questions need to be answered and that each type of question requires different types of data (Creswell, 2014b). This approach is mostly implemented when researchers need to include qualitative or quantitative data to answer a research question within a largely quantitative or qualitative data. This approach is particularly useful in in cases of an experimental or correlation design. Researchers Greene and Caracelli (1997) state that the approach mixes the different dataset at the design level where

one type of data would be embedded within a methodology framed by the other type of data.

The Explanatory design is a two-phase approach with the purpose that qualitative data helps explain or build upon initial quantitative results (Creswell, Plano Clark, Gutmann, & Hanson, 2003). This design approach is helpful to researchers needs qualitative data to explain results from quantitative results. This approach can also be used in situations when the researcher wants to form groups based on quantitative results and follow up with the groups through a subsequent qualitative research or to use quantitative participants characteristics to guide purposeful sampling for a qualitative phase (Creswell, Plano Clark, Gutmann, & Hanson, 2003; Tashakkori, Teddlie, & Teddlie, 1998). This approach starts with the collection and analysis of quantitative data followed by the collection and analysis of qualitative data. The second phase of data gathering is designed in a manner that it connects the results of the first quantitative phase.

The Exploratory design is also a two-phase approach with the main purpose that the results of the first method (qualitative) informs the second method (quantitative). The aim of this approach is that an exploration is needed when measures/instruments are not available, the variables are unknown, or there is no guiding framework or theory available. As this design approach begins with a qualitative aspect, it is best suited for exploring a phenomenon or when a researcher plans to test an instrument because one is not available or identify important variables to study quantitively when the variables are unknown (Creswell, Plano Clark, Gutmann, & Hanson, 2003; Creswell, Fetters, & Ivankova, 2004).

Design Type	Variants	Timing	Weighting	Mixing
Triangulation	• Convergence • Data transformation. • Validating quantitative data	Concurrent: Quantitative and qualitative at the same time	Usually equal	Merge the data during interpretation or analysis

	• Multilevel			
Embedded	• Embedded experimental • Embedded correlational	Concurrent or sequential	Unequal	Embed one type of data within a larger design using the other type of data
Explanatory	• Follow-up explanations • Participant selection	Sequential: Quantitative followed by qualitative	Usually quantitative	Connect the data between the two phases
Exploratory	• Instrument development • Taxonomy development	Sequential: Qualitative followed by quantitative	Usually qualitative	Connect the data between the two phases

Table 8: The Major Mixed Methods Design Types (Creswell, 2014b)

3.4.4 Research approach for this research

As the research objectives formulated for this research consist mainly of questions that evaluate what people believe and would they would do in specific situations, a survey strategy was adopted as the primary research method (Crotty, 1998), with a questionnaire used to evaluate the decision making of people who deliver projects. This was followed by a focus group discussion to gain some additional insights by exploring the results from the questionnaire, allowing for the connection of ideas to understand cause and effect (Creswell, 2014b). Taken together, the two sets of results should give a model of the nature of the irrationalities in project risk management.

The research was implemented in three stages: (i) the literature review, (ii) the preparation and execution of the survey questionnaires and (iii) the preparation and execution of the focus group discussions. The literature review provided a theoretical basis for the research and the development of its research question and objectives. The next step was to determine who the audience for the questionnaires

and focus group would be. In selecting the participants, the author had to ensure that the participants had experience in projects. The questions implemented in the research were structured around the subject matter that had been deemed significant in the literature review.

The main study phase of the research was the conducting of the surveys. The questionnaires were distributed to people who had participated in and delivered various projects. The purpose of the questionnaires was to determine views on the importance of risk management and to gather and capture their individual choices in risky decisions. To avoid having a long survey/questionnaire which could be counterproductive as it would have a high dropout rate (Berdie, 1973; Galesic & Bosnjak, 2009; Deutskens, De Ruyter, Wetzels, & Oosterveld, 2004), the author then implemented the use of two questionnaires to address this. The first survey was focussed on risk management as a success factor. This survey addressed two research objectives which aimed to determine if project practitioners perceive effective risk management to be a success factor (Research Objective 1), and if so which components of the risk management process are deemed to be of most importance (Research Objective 2). The second survey aimed to investigate decision making and uncertainty to see how decision makers would behave when in a risky decision. This partially addressed (Research Objective 3) how well prospect theory can explain risk-based decision making in a project management context and (Research Objective 4) whether the four key elements of prospect theory apply in a project management context. For the author to easily evaluate prospect theory, the second questionnaire (risk decision) was designed based on expected gain ($1 million) across all the scenarios. Although expected utility theory proposes that individuals are expected to maximise their utility when deciding between choices, empirical evidence has shown that this is not generally the case in specific domains (Avineri & Bovy, 2008; Huck & Weizsäcker, 1999). This would be investigated in the project management context and the subsequent implementation of a focus group discussion would allow the author to gain a deeper understanding of what drives decision making in projects and if prospect theory provides a better explanation to risk-based decision making in project management.

The author used expected utility theory to evaluate prospect theory not only because they are the two dominate theories of choice under risk (Harrison & Rutström, 2009; Mongin, 1997; Ramos, Daamen, & Hoogendoorn, 2014) but expected utility is seen as a predecessor of prospect theory (Kahneman & Tversky, 1979). Also, Prospect theory has provided a foundation for understanding behaviour in a variety of domains (Barberis, 2013; Anantatmula & Thomas, 2013; Dhami & Al-Nowaihi, 2013). It is not yet known whether prospect theory generally works better than expected utility theory in a project context, where decisions may not reflect just a single individual's preferences, but also the preferences of other stakeholders.

Finally, following the analysis of all the gathered data, the results have been presented and discussed in the coming sections. With a combination of quantitative and qualitative methods, the research implements a mixed method design (Crotty, 1998). As qualitative data is mostly interpretative, quantitative data strengthens the reliability of the findings (Bryman, 2012; Mertens, 2014). Since the quantitative data was collected first and used to inform the qualitative research, the focus group allowed for further explanation and interpretation of the findings from the surveys (Ivankova, Creswell, & Stick, 2006), the project used a mixed method sequential explanatory design.

3.5 Data collection

3.5.1 Survey questionnaire

After the completion of the literature review, primary data was collected via a mixed method approach which combined both the qualitative (focus group) and quantitative (questionnaire) approaches. Two surveys were conducted first, and the findings of the analysis were used to guide the development of the focus group discussion. The questionnaire is a powerful data collection technique that can be used to get information from many people (Zohrabi, 2013); because of its importance in this study, careful attention was paid in the development of the surveys.

Questionnaires can also be tailored in a variety of ways (Bryman, 2012). Implementing a structured questionnaire allows for participants to select answers from a set of options which would enable precise responses. This makes it easier for the author to analyse the data. On the contrary, structured questionnaires do not allow the respondents to adequately express their opinions (Alston & Bowles, 2003). Implementing the survey in this research allowed the research to find answers from a large population, with the hope that they might allow for generalisation and supplementing the data obtained from the surveys with further focus group discussion that would enable the research to gather more in-depth thoughts/opinions from respondents and from this, new concepts would emerge.

3.5.2 Focus group

A focus group is a qualitative data gathering method where the participants are asked about their attitudes, perceptions and opinions towards the concept being investigated (Creswell, 2014b). In this research, the focus group is used as a method to get the opinions of experienced project managers on what might be the reasons why project managers deviate from the rational choice. This approach complements the data obtained during the survey which would provide more detailed information and deep insights towards the topic of research. Therefore, after identifying if project managers deviate or not from the rational choice when making decisions in a project, the focus group would complement the results of the survey by providing us with reasons as to way decision makers behave the way they do in projects and other answers to the research objectives.

Focus groups are made up of a small group of people, ranging from 6 to 12 per group. In this research, the focus group consisted of 12 participants who all had experience in the delivery of projects. The number of participants was sufficient to enable a rich discussion to be held but not so great that some participants were prevented from actively participating (Creswell, 2014b). This allowed in-depth views of the participants to be captured. Some of the participants that responded to the survey also participated in the focus group. The focus group moderator (the

author) facilitated the discussion to encourage an atmosphere for the generation of ideas and opinions within the time allocated for the discussion (two hours).

The questions asked during the discussions with the focus group were carefully designed to be answered collectively after being reflected on, and after a suitable discussion had taken place. The questions were designed to collect and gather the views of the experienced project participants with regards to decision making in projects. The majority of the questions were open-ended, direct and designed to gather the deep thought of the respondents. This research aimed to investigate the behaviour of project managers with regards to making decisions in projects when faced with uncertainty and to investigate if and why they deviated from rational choice with regards to decision making in projects.

Focus groups are useful methods for investigating complex behaviour, and they allow the researcher to investigate how different groups think and feel about a topic and why they hold certain opinions (Creswell, 2014b). The focus group is a method that can be used to clarify the results obtained from surveys as it allows for a deeper understanding of statistical data (Bryman, 2012). When administering the discussions, the moderator should ensure that the topic is clearly discussed and there is no room for irrelevant discussion. Thus, this tends to make focus groups sometimes hard to control and manage. The use of a focus group in this research study allowed the researcher to get a detailed causal understanding of why project participants behave the way they do and as such it played a valuable role in assisting the researcher provide both practical and theoretical contribution.

3.6 Instrumentation

3.6.1 Identifying the general purpose and specific requirements

The questionnaire is a crucial element during the data gathering phase of this research; the focus group provided a deeper understanding of the results. In the development of the questionnaire, the first approach was to determine the aims and need for the survey. The purpose of the survey was to obtain the perspective of the

respondents regarding their perceived importance of risk management and investigate the choices they make in risky situations in projects.

3.6.1.1 Formulating the questions (risk management as a critical success factor)

Previous researchers have focused on the implementation of risk management on project success (Zwikael & Ahn, 2011). Bakker et al. (2012) emphasise the need to identify risk, and its effects on project success, and suggest that risk management activities contribute to project success. However, studies have linked risk management to project outcomes (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013; Kutsch & Hall, 2010) but not to CSFs. The factors under project risk management are sub-divided into two: firstly, hard aspects including initiation, identification, assessment, response planning and response implementation, and secondly, soft aspects of risk, which are risk communication and attitude, monitoring and review (David, 2009).

After an in-depth review of past work on CSFs, two research objectives have been derived for investigation, and a survey was developed to investigate the two research objectives. This questionnaire developed was divided into 4 sections with 37 questions. The first section obtained general background information of the respondents with 11 questions. The second section contains 11 questions asking respondents to weigh each critical success factor based on a Likert scale. The third section considers specific critical success factors which are project risk management (also using a Likert scale). The Likert scale is all uniform in the questionnaire ranging from a scale of 1 to 10 which signifies a range from weak impact to strong impact. The final section is optional because it asks respondents to provide their names and email addresses if they are interested in discussing their responses in more detail or to be contacted for further research.

3.6.1.2 Formulating the questions (decision making survey)

Project participants often face decisions related to risk, where there is uncertainty over whether one or more events will happen that could impact the project objectives. The decision of which path to follow might seem relatively straightforward, but it can sometimes be very complicated. The decision is dependent on various factors, which this research has explored through a survey.
The survey was divided into five sections. The first section was designed to collect basic background information about the respondents. Details collected for each respondent include the country of residence, industry, number of years of project experience and number of years of project management experience.

Before the subsequent sections, a context is given of a hypothetical project by which scenarios are given for the second, third and fourth sections. The project context is designed to empower the respondents to make the decisions for themselves: to ensure that the decisions they take are not dependent on other stakeholders but based on the project circumstances. The project context also introduces the principal-agent relationship, with the project manager acting as the agent and the company owner (individual or shareholders) acting as the principal. The questions employed for both the project context and scenarios used in this study are stated in Table 9.

Note that although the scenarios are all different (the amount and probability of gain or loss varies across the scenarios), they have been deliberated balanced so that in each scenario, users had an *expected* gain of $1 million. For example, in Scenario 1, using the new material in the project has a 50% chance of saving $4m, and a 50% chance of costing $2m extra. (0.5 * $4m) - (0.5 * $2m) = $1m.

Project Context	You have been appointed as project manager of a research project that will be internally funded (from reinvested profits from previous projects). This is an important project for your company, and your ability to deliver within budget (and under budget if possible) is likely to affect your future career prospects.

	Please Note: All states and conditions affect project cost only. Please ignore any possible impact on schedule and technical performance. The **baseline cost** of the project is **$20m ($20,000,000)**. You have an opportunity to use a new material in your project that could reduce total project cost.	
Scenarios	**1**	In this situation using the new material in your project **could save $4m (50% chance) but might not work which would require rework costing $2m (50% chance)**.
	2	In this situation using the new material in your project **could save $4m (75% chance) but might not work which would require rework costing $8m (25% chance).**
	3	In this situation using the new material in your project **could save $10m (25% chance) but might not work which would require rework costing $2m (75% chance).**

Table 9: Survey primary and secondary scenarios

For each scenario, five questions are asked. The questions are designed to test how the projected cost performance of the project affects willingness to take risk. The five questions asked for each of the scenarios are stated in Table 10. The questions are binary and respondents are expected to answer yes or no for each of the stated questions.

Would you take the chance under each of the following situations…	
Number	**Situations**
1	... if your projected cost at completion is currently $30m ($10m over budget)?
2	... if your projected cost at completion is currently $24m ($4m over budget)?
3	... if your projected cost at completion is currently $22m ($2m over budget)?
4	... if your projected cost at completion is currently $20m (on budget)?
5	... if your projected cost at completion is currently $18m ($2m under budget)?

Table 10: Sub-questions for each secondary scenario

Once the results are collected, the scenarios in Table 9, and situations in Table 10 are taken into consideration. A diagram can be drawn as in Figure 11 to summarise the possible outcomes.

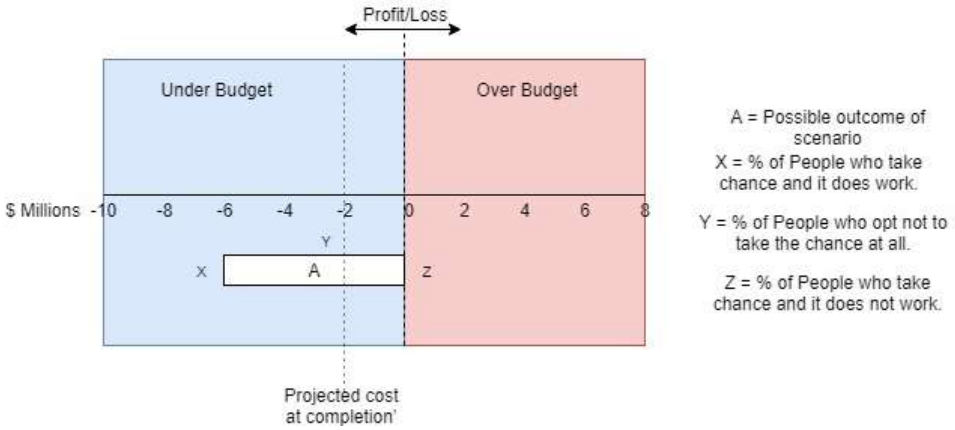

Figure 11: Situational diagram explanation.

In each of the five situations as stated in Table 10, there is a different projected cost at completion. This can be seen as the initial project position, and it introduces the concept of the endowment effect as discussed previously in Section 2.5.2. The endowment effect explains that people put more value on things that they own than they do equivalent items that they do not own (Kahneman, Knetsch, & Thaler, 1991). This is evident in the willingness to pay (WTP) behavioural model. The WTP model examines the maximum amount of money an individual is willing to pay to procure a good/service or to avoid something undesirable (Brown, 2005). It would be interesting to see how the respondents would act or decide which action to take as they are put in a situation that gives them the ownership of the project as stated in the project context. In reference to the principal-agent problem described above, note that although the projected cost at completion should clearly impact the project owner's (the principal's) financial endowment; it is not clear whether this will be perceived in the same way by the project manager (the agent).

The fifth and final section consists of only two (optional) questions asking for contact information of respondents who wished to be contacted for further study or to be notified of the results of the study. At the end of the data collection, the data was analysed with the Statistical Package for Social Sciences (SPSS) software, where various statistical analyses were carried out to give further insight on the data.

3.6.1.3 Constructing the questionnaires

During the development of the surveys, care was taken to construct the questionnaires in a way that made it easy for respondents to answer. Once the questionnaires were developed, they encompassed an introduction which informed the participants about the research being undertaken and information explaining how to fill out the questionnaire were given. After the introduction, the survey was presented.

3.6.1.4 Sampling method

The questionnaire was distributed online to potential respondents via their emails in relevant organisations and also via the use of the social networking site LinkedIn. Homogeneous sampling was implemented to ensure that every possible respondent who received the survey met the criteria required to fill out the questionnaire. LinkedIn played a vital role in getting the respondents, as their profiles were analysed before sending them the request to complete the survey. Apart from direct messages, a notice about the study was placed on LinkedIn groups. Such groups included that of project managers and project participants in the relevant industries. A total of 147 people participated in the first survey on critical success factors and 141 participated in the second survey on decision making.

3.6.1.5 Pilot testing of the survey

Before the surveys were launched, a pilot test occurred. This test was done to test the effectiveness of the study as a data collection tool. The surveys were given to 5 industry experts who have years of experience in the delivery of projects. The aim and structure of the questionnaires were explained to them verbally once they went through the survey, the comments and recommendations they had were then used to update the surveys before the final versions were sent out to respondents. Overall, the test group affirmed that the focus of the questionnaires was on the research topic and it was unambiguous. This ensured that the questionnaire would answer the

research objectives and question. After the pilot tests, the final versions of the questionnaires where developed. See Appendix A for the survey questionnaire on risk management as a critical success factors and Appendix B for the survey on decision making.

3.6.1.6 Focus group guide

The focus group was implemented to help the researcher to interpret the results from the questionnaire through in-depth discussion of the key topics. It was designed in particular to get the participants to give the reasons/justifications as to why they may sometimes not opt for the rational choice in the face of uncertainty in projects. The full focus group guide is given in Table 33 (Appendix E), with the main question areas summarised in Table 11. Under question area 5, consideration was given to what the relevant reference points were that participants felt influenced their decisions in the scenario.

No	Focus Group Questions areas
Q1	Importance of risk management in project management.
Q2	Do you make decisions with only the data at your disposal?
Q3	What drives your decision making in projects in the context of risk management?
Q4	Does your approach to risk management depend on the type of project you're undertaking?
Q5	What factors do you consider?
Q6	Explore whether it would make a difference if they were managing their own project or someone else's (principal-agent problem).
Q7	How do the four elements of prospect theory work in a project management context? Q5.1 Reference dependence Q5.2 Loss aversion Q5.3 Diminishing sensitivity Q5.4 Probability weighting
Q8	How does willingness to take a risk vary depending on the current projected cost at completion of the project?

Table 11: Focus group question areas

3.7 Ethical considerations

Following University College London's requirements, ethical approval was first required before the commencement of data gathering. Once the permission was given, the respondents were informed about the purpose of the research and what the information provided would be used for. The data was collected using UCL Opinio as an online tool for data gathering and ensuring the security of the data. The participants were reassured that all information given would be confidential and anonymous.

3.8 Data analysis

Once the data was collected for the surveys, the data obtained were entered into the Statistical Package for Social Science (SPSS) software. Here all items were transformed into variables. The answers and their alternatives were coded using labels and the variables inputted for analysis of the complete dataset. The use of descriptive analysis allowed the author to generate frequency tables and the charts were created using Microsoft Excel. Through the graphical presentation, these charts eased understanding of the results.

3.9 Validation of research

Validation involves collecting and analysing data to assess the accuracy of the research. To ensure the validity of a piece of research three aspects should be considered. These are validity, reliability and generalizability (Creswell, 2014b). Validity looks at the extent to which the aspects of this research highlight the concept, theory or variable under study (Golofshani, 2003). By understanding how the methodology was implemented and data gathered, people should be able to state if the correct information has been collected and whether the instrument has measured what it is supposed to measure without omission or digression (Golofshani, 2003). To ensure the validity of the research, it must be conducted in

an accurate, professional, transparent and systematic manner (Golofshani, 2003). Achieving validity, you must ensure that the data obtained during the research and the conclusions are as close as possible (Golofshani, 2003).

Validation is a powerful technique that facilitates authentication of data through cross verification from two or more sources (Denzin & Lincoln, 2005). Three validation techniques have been implemented in this research which are namely theory validation, methodological validation, and data validation were employed to enhance validity. Data validation was obtained by using several data sources. This was possible for both the literature review as it was vital in developing the research objectives and during the data gathering stage. Theory validation was achieved by comparing various theoretical perspectives from a variety of researchers, this complemented the literature review section. Methodological validation was achieved via the use of a mixed method sequential explanatory design, precisely via the implementation of the surveys and focus group discussions. The use of the survey and focus group discussion helped the researcher overcome the weakness in using only one method with the strengths of another.

Golofshani (2003) states reliability as the consistency of measurement in the research over time and whether the same results can be obtained in the test was repeated. To enhance the reliability of the dataset, the procedures taken during this research have been carefully stated in the research methodology section and then completed the respondent's data were then classified and analysed accordingly.

Generalizability looks at the extent by which results of certain research may be applied to other populations (Golofshani, 2003). As the results of the survey were gathered from a sample size of 141 for the survey, the findings are not generalizable to other settings. However, the size of the sample is comparable to that used in other similar studies (Kutsch, 2005; Montequina, Nieto, Ortega, & Villanueva, 2015; Shen, Prior, White, & Karamanoglu, 2007; Capretz, 2003; Peslak, 2006). This improves the confidence level and the margin of error in which the size of the

dataset allows the researcher to determine differences which can be valuable in the data analysis stage.

3.10 Chapter summary

In this chapter, the author presents an account of the methodology implemented in this research, the rationale for the selected research approach, the actions taken for data collection and how the data was analysed, and finally the strategies used in the collection of the data. The author implemented a mixed method sequential explanatory design with the use of the two questionnaires and focus group discussion as the primary data collection techniques. This research followed an explanatory path where results from the quantitative research were first analysed and the focus group was used to validate and give more insights into the results. Having set out a definitive methodology for this research, the next chapter presents the results of the data analysis.

4 Research results and discussion

4.1 Introduction

The previous chapter discussed the research approach taken in this research. This included research design, selection of participants, data collection methods, data analysis and the research procedures implemented to ensure validity and reliability of the results. The chapter also discussed the challenges that emerged during the data collection and analysis processes and the steps taken by the author to ensure that they had been dealt with and the ethical considerations that had to be addressed before the study took place. This chapter presents the results gathered after the implementation of the data gathering phase of this research study. The chapter presents the findings of the surveys conducted and the focus group discussions. The chapter also analyses the results gathered and reflects on the findings in the context of the objectives and the literature.

4.2 Explanatory research (risk management as a critical success factor)

This research seeks to answer Research Objective 1, "Establish whether project practitioners perceive effective risk management to be a success factor" and Research Objective 2, "Establish which aspects of risk management are perceived to be of most importance".

4.2.1 Study sample

The survey was distributed online to potential respondents via their emails in relevant organizations and via the use of the social networking site LinkedIn. Homogeneous sampling was implemented to ensure that every potential respondent who received the survey met the criteria required to fill the questionnaire.

LinkedIn played a vital role in obtaining respondents, as their individual profiles were analysed before sending them the request to complete the survey. In addition to direct messages, a notice about the survey was placed on LinkedIn groups. Such groups included those of project managers and project participants in the selected industries (space, construction, petroleum). Table 27 in Appendix C gives an overview of the demographics of all respondents that completed the survey; a further analysis on the background of the respondents is displayed as per the industries concerned with this research.

The full dataset shows that there were a total of 147 respondents. They are mostly project managers (50.3%) with 73.4% having masters or doctorate level education. Over 70% of the respondents have more than 5 years of project experience and some project management experience. The majority have participated in more than 5 projects with an average value of 1 million $/€/£, and are mostly geographically located in the United Kingdom, Nigeria, United States of America, Canada and Netherlands.

4.2.2 Results of the survey

4.2.2.1 Relative importance index

According to Tonidandel and LeBreton (2011, p. 1), the aim of the Relative Importance Index is to "partition explained variance among multiple predictors to understand better the role played by each predictor." The relative important index has been adopted by various project management research such as the works of Gudienė et al. (2013), Iyer and Jha (2005), Assaf and Al-Hejji (2006), and Kumaraswamy and Chan (1998). The formula is depicted in Equation 5:

$$\boldsymbol{RII = \frac{\Sigma W}{X * Y} = (0 \leq RII \leq 1)}$$

Equation 5: Relative importance index formula.

Where **W** is the weight given to one factor by each respondent, which ranges from 1 to 10, **X** is the highest score available (10 in this case) and **Y** is the total number of respondents that have answered the question. Table 12 presents the results of the relative importance index for the critical success factors and Table 13 presents the results for the ranking of aspects related to project risk management.

Ranking of critical success factors		
Sector	**All Respondents**	
Critical Success Factor	**RII**	**Rank**
Project Manager Competence	0.870	1
Project Organization	0.859	2
Project Team Competence	0.852	3
Project Risk Management	**0.83**	**4**
Requirements Management	0.826	5
Top Management Support	0.777	6
Contractual Aspects	0.768	7
Institutional Factors	0.744	8
Project Characteristics	0.724	9
External Challenge	0.715	10
Client Knowledge and Experience	0.708	11

Table 12: Ranking of CSFs

Ranking of aspects of project risk management		
Project Risk Management	**All Respondents**	
	RII	**Rank**
Communication and Culture	0.843	1
Monitoring and Review	0.824	2
Planning of Responses	0.807	3
Initiation	0.807	3
Implementation of Responses	0.806	5
Identification	0.796	6
Assessment	0.765	7

Table 13: Ranking of project risk management aspects

4.2.3 Sector comparison of survey results

4.2.3.1 Background of the sectors

The 147 respondents come from three target sectors. Table 28 in Appendix C shows the results of the background information for the sectors. Firstly, looking at the respondents from the space industry (N=49) shows that most respondents are currently project managers with doctoral degrees, have an average of more than 15 years' project experience and some project management experience. They have participated in more than 15 projects with an average magnitude of 10 million $/€/£, delivering subsystems and hardware, and are geographically located in the United Kingdom, Netherlands, United States of America, Germany, China, and Nigeria.

The study sample for the respondents from the petroleum industry (N=49) shows that most respondents are currently project managers with master's degrees, have an average of more than 15 years' project experience and some project management experience. They have participated in more than 15 projects with an average magnitude of 1 million $/€/£, delivering hardware and operational and service projects; they are mostly geographically located in the United Kingdom, the United States of America, Nigeria, Netherlands, and Russia.

Finally, the study sample for the respondents from the construction industry (N=49) shows that most respondents are currently project managers with master's degrees, have an average of more than 15 years' project experience and more than 15 years' project management experience. They have participated in more than 15 projects with an average magnitude of 100 million $/€/£, delivering service projects and other categories of projects; they are mostly geographically located in the United Kingdom, United States of America, Nigeria, Australia and Canada.

4.2.3.2 Results of the sector comparison

Considering individual sectors, Table 14 presents sector ranking for the critical success factors and Table 15 presents the results for the sector-specific ranking of aspects related to project risk management.

Ranking of critical success factors						
Sector	**Space subset**		**Petroleum**		**Construction**	
Critical Success Factor	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**
Project Manager Competence	0.831	2	0.890	1	0.890	2
Project Organization	0.812	4	0.873	2	0.892	1
Project Team Competence	0.859	1	0.853	3	0.843	4
Project Risk Management	**0.8**	**5**	**0.840**	**4**	**0.850**	**3**
Requirements Management	0.816	3	0.835	5	0.827	5
Top Management Support	0.692	9	0.816	6	0.824	6
Contractual Aspects	0.7	6	0.798	7	0.806	7
Institutional Factors	0.7	6	0.743	9	0.790	8
Project Characteristics	0.696	8	0.761	8	0.716	11
External Challenge	0.667	10	0.729	11	0.749	9
Client Knowledge and Experience	0.659	11	0.735	10	0.730	10

Table 14: Sector ranking of CSFs

Ranking of aspects of project risk management						
Project Risk Management	**Space**		**Petroleum**		**Construction**	
	RII	**Rank**	**RII**	**Rank**	**RII**	**Rank**
Communication and Culture	0.8	3	0.865	1	0.864	1
Monitoring and Review	0.806	1	0.842	2	0.823	4
Planning of Responses	0.765	4	0.821	4	0.834	3
Initiation	0.748	5	0.821	4	0.853	2
Implementation of Responses	0.802	2	0.806	7	0.809	6
Identification	0.735	6	0.831	3	0.823	4
Assessment	0.721	7	0.815	6	0.760	7

Table 15: Sector ranking of project risk management aspects

4.2.4 Discussion (risk management as a critical success factor)

The first objective of the research is to test and verify the relationship between project risk management and project success. This relationship was accepted based on the results of the hypotheses test on the data obtained from the survey respondents. As shown in Table 26 in Appendix C, the results obtained for the t-value and p-value test were 7.649 and .001 respectively. The rule states that to reject the null hypothesis and to accept the positive hypothesis, the t-value should be greater than 2.0 and the p-value should be less than 0.05. Based on this we can conclude that the survey respondents believe that there is a positive relationship between project risk management and project success, and Research Objective 1 has been answered in the affirmative. This outcome supports the existing literature that highlight the importance of risk management (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013).

Secondly, having established that risk should be considered a critical success factor, we can next gauge the relative importance of risk management as compared to the other factors discussed in the literature. Table 12 depicts the overall ranking of the critical success factors and Table 14 the standings of each factor based on the industries of the respondent's background. Consequently, from the results of the relative importance index, one can see that project risk management is the fourth most important critical success factor of the eleven considered. This is an important finding, as it indicates that risk-based decision making should be a major concern of project managers and suggests that risks should be managed in a rational manner.

From the results of the relative importance index across the three sectors, one can see that the top five factors in the three industries remain the same (although not always in the same order). This suggests that there is a possibility of having a universal set of critical success factors that may apply across industries contradicting Westerveld (2003), who suggests that the criteria for measuring success vary from project to project and from industry to industry.

With reference to Research Objective 2 "Establish which aspects of risk management are perceived to be of most importance", the ranking of the aspects of project risk management can be seen in Table 13 for the complete dataset and Table 15 for the sectors. The soft side of project risk management, which constitutes "communication & culture" and "monitoring and review" got higher scores and are consistently ranked in the top three aspects of project risk management. This suggests that the respondents believe that the soft side of project risk management is deemed of greater importance. The results of this study support findings of several previous studies that have also highlighted that the importance of the soft side of project risk management (Carvalho & Rabechini Junior, 2015; Cullen, Johnson, & Sakano, 2000; Teal & Blanchard, 1996; Pollack, 2007). This seems to be at odds with expected utility theory, which focuses on rationality and the hard side of risk management.

The results of the survey and the relative importance index analysis indicate that people find it easier to differentiate between the critical success factors than the factors involved in project risk management. This can be seen from the range of the lowest to highest scores across the three aspects in Table 12, Table 13, Table 14 and Table 15. The results show that people understand the importance of project risk management, and further research is necessary to investigate whether project participants act rationally in projects when faced with risk and uncertainty.

4.3 Explanatory research (risk decision making)

This research seeks to answer Research Objective 3, "Evaluate how well prospect theory can explain risk-based decision making in a project management context" and Research Objective 4 "Evaluate how well the four key elements of prospect theory apply in the project management context".

4.3.1 Study sample

This study was implemented in a similar manner to the CSFs study. The survey was distributed online via the use of social networking site LinkedIn and emails were sent out to respondents who left their contact information in the previous study on CSFs. The study was also distributed using the homogenous sampling method to ensure all potential respondents met the criteria required to fill the survey. Table 31 in Appendix D gives a detailed analysis on the background of the respondents and provides analyses for individual sectors. The data shows that of the 141 respondents, 89.3% have more than five years of project experience, with 73.7% having more than five years of project management experience. The respondents are geographically located all over the globe, but 80% of them are concentrated in the United Kingdom, United States, Nigeria, Australia and India.

4.3.2 Results of the Survey

The detailed data tables collected from the survey are presented in Appendix D, where Table 29 presents the cumulative results of the complete dataset and Table 30 presents the percentages of the cumulative results. The results have been converted to percentages to ease comparison. Once all the data had been collected, the data was analysed looking at the five individual situations as described previously in Table 10. In Figure 12, the proportion of respondents that were willing

to take the risk (use the unproven material) is plotted against the *excess* projected cost at completion, for each scenario as stated in Table 9.

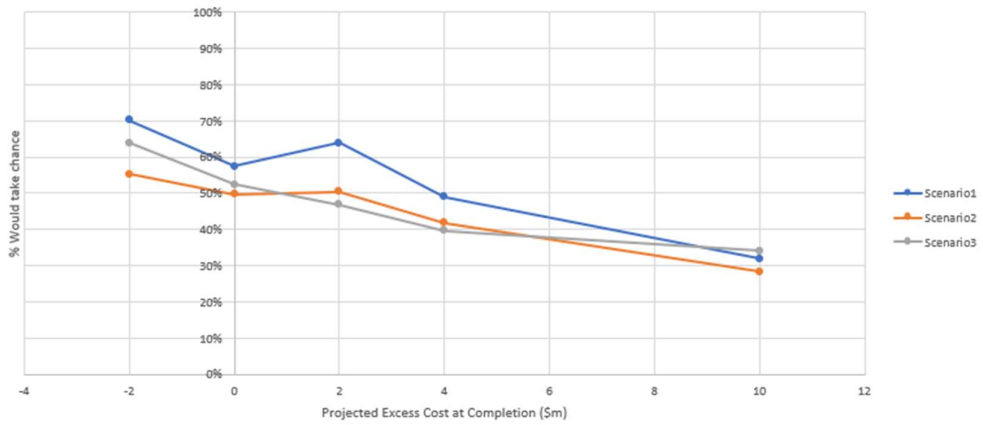

Figure 12: Complete results for the three scenarios

In Figure 27 to Figure 31 in Appendix D, the five situations are examined separately, with the diagrams depicting the possible change of the project outcome based on the conditions of the scenarios as stated in the survey. The figures show the number of respondents who decide to take the risk in which the project position does not change (these remain at the endowment point). For those who decide to take the risk (use the unproven material), the probabilities were considered and the percentages of the respondents who would end up improving or worsening their project have been determined.

4.3.3 Sector Comparison of survey results

4.3.3.1 Background of sectors

Once the complete dataset was analysed, the data was also broken down by sectors, so comparisons could be made at this level. Table 32 in Appendix D depicts the results of the background information for the sectors. Respondents that could not be classified into any of these three main sectors (space, petroleum and construction) are grouped as “others”. This group consists of respondents who

belong to a wide-variety of industries such as information technology and transportation.

4.3.3.2 Results of sector comparison

Figure 13 shows the results for the space sector, Figure 14 shows the results for the petroleum sector and Figure 15 shows the results for the construction sector.

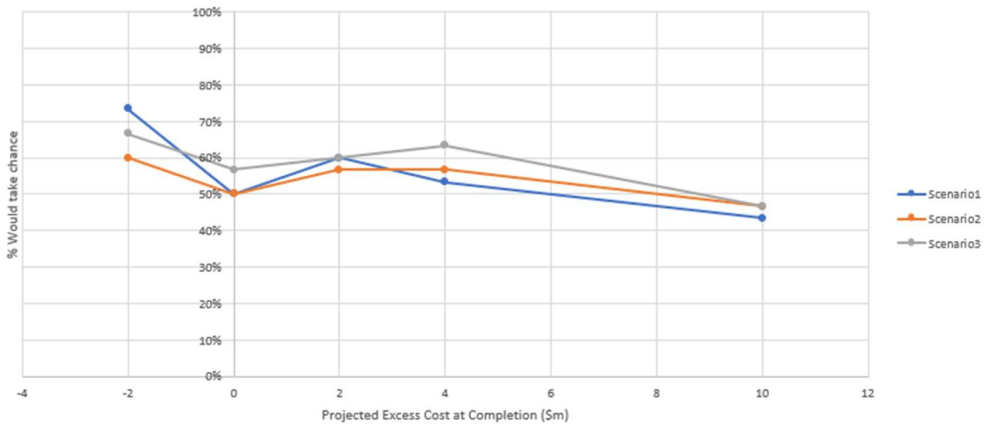

Figure 13: Respondents results for space industry

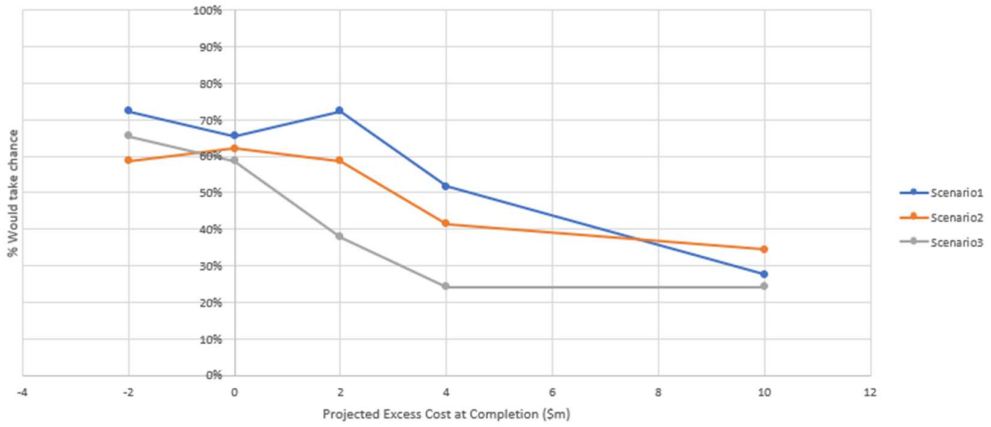

Figure 14: Respondents results for petroleum industry

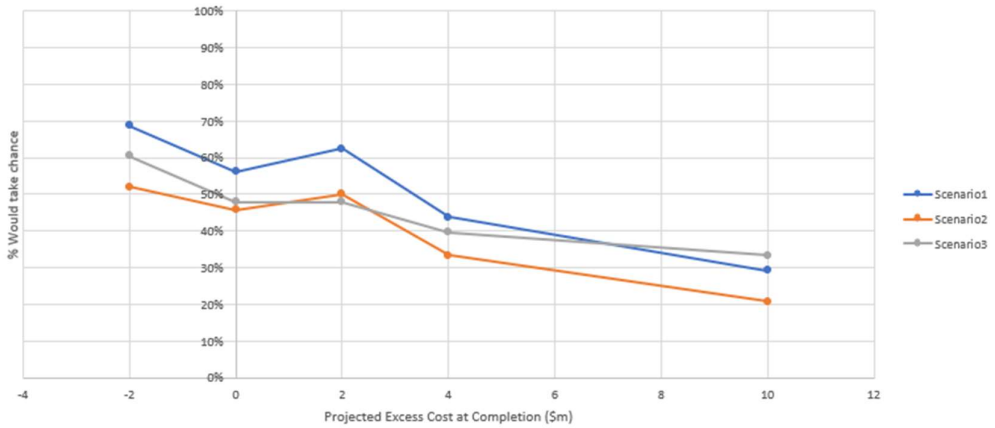

Figure 15: Respondents results for construction industry

The data can also be compared based on the scenarios. This is aimed at seeing the overall trend and to ease comparison between industries and across the scenarios. See Appendix D Figure 32 for Scenario 1, Figure 33 for Scenario 2 and Figure 34 for Scenario 3 results.

4.3.4 Discussion (risk decision making)

This study has a total of 141 respondents, and the results for the full dataset were shown in Figure 12 above. Focusing initially on Scenario 1, if we exclude the data point at a cost at completion of $2m over budget, we see a gradual, almost linear, reduction in willingness to take the risk as the project performance deteriorates from -2 to +10 on the x-axis, as shown in Figure 16.

In fact, a second order polynomial fits the data better than a straight line, as per the orange curve in the chart. This tendency to be less likely to take the risks as the project situation becomes worse could be called a ‘damage limitation’ effect, in which project managers know that things are bad, and they don’t want to take the risk that they will become worse, so act conservatively.

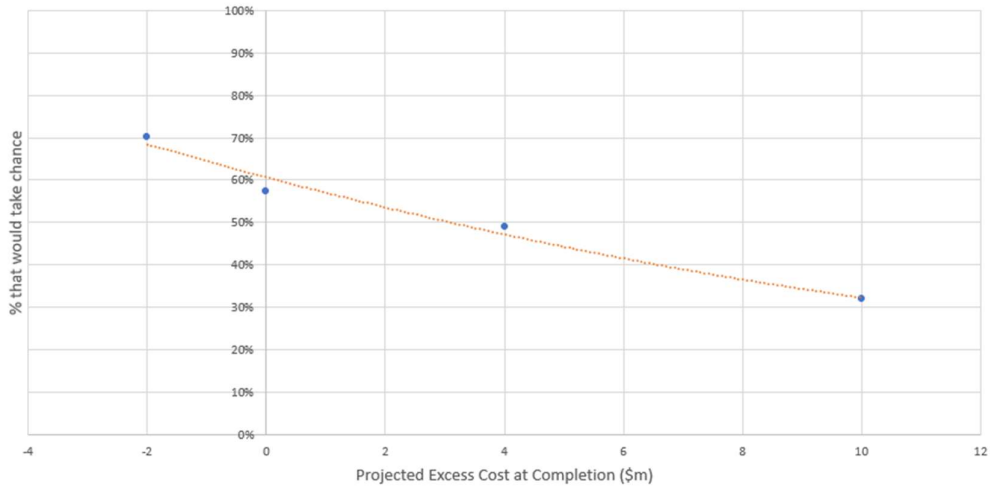

Figure 16: 'Damage limitation' effect (N = 141, excludes datapoint at excess CAC = $2m)

Then superimposed on this is a local effect in the range 0 to 4 (or more specifically at the +2m projected excess cost at completion), where it appears that project managers are willing to take a bigger risk than would have been expected from the general slope, due to the fact that there is a chance of being able to get back to a positive outcome if the gamble is successful. This could be called a 'double or nothing' effect as shown in Figure 17.

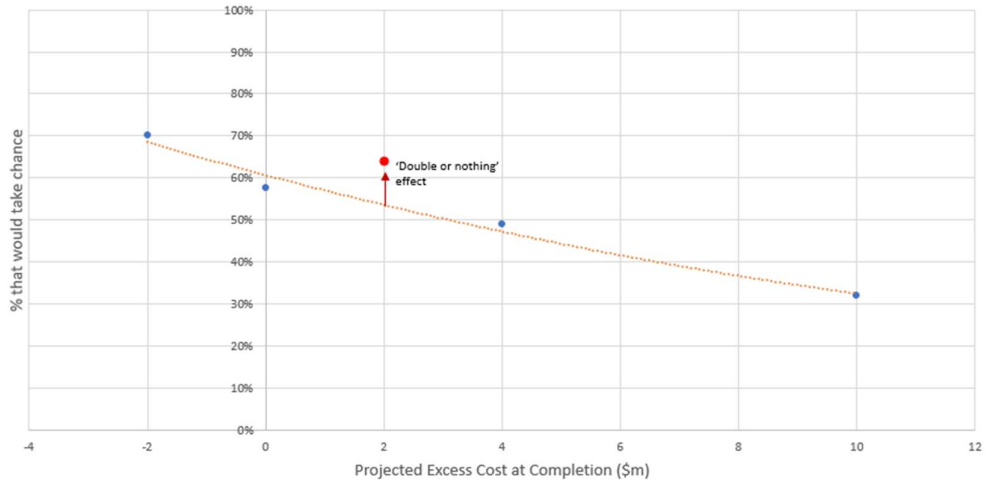

Figure 17: 'Double or nothing' effect (N = 141)

It is interesting to see the varying results between the three different scenarios, and to consider them through the lens of expected value, expected utility theory and prospect theory.

4.3.4.1 Expected value and research results

Recall that all three scenarios provide an expected gain of $1 million, so that logically the respondents should lean towards a "yes" and proceed with the risk if the aim were simply to maximise expected value. The results show that the participants do not always decide to proceed with the risk, however, showing that decision making in this study is not consistent with a crude calculation of expected value. Neither the 'damage limitation' nor the 'double or nothing' effect make sense when seeking to maximise expected value.

In fact, although taking the risk in order to maximise expected value might seem to be a rational strategy, this is only the case when there is no diminishing marginal utility and when the projects or risks are all relatively small compared to the whole business, e.g. for an insurance company with a big portfolio or a billion-dollar company. Where any one risk is big enough or the failure of the project is serious enough to affect the organization or its image, then a higher chance of failure becomes unacceptable. This would naturally incline the decision makers towards caution. Although in this case it was not explicitly stated to the respondents that the project was small relative to the overall business, it is likely that many of the respondents will have assumed this, since they were told that the project was internally funded.

It is interesting to see how project participants react in the face of uncertainty in a project. Different actors/stakeholders in a project have different ideas/views on deliverables, based on their experiences and interests. Researchers Koppenjan et al. (2010) distinguish the project client and its administrators. It is in the relationship between these two groups of actors that "watershed" moments exist as the client decides on the project's time, cost, scope and quality but lacks the experience or

knowledge on the actual implementation, while the administrators have this knowledge but lack the authority to make decisions on the project. This means that the client sets/defines the project requirements and the administrators should meet those requirements. This situation creates the principal agent relationship as there are divergent views and interests (Jensen & Meckling, 1976). This relationship environment creates the situation where the project client has to ensure that the project administrators have to respect the schedules while the project administrators have to convince the client of possible inconsistencies, lapses and impossibilities in the pursuit of the project deliverable. This is a stressful environment in the project as the project client wants to maximise the scope with the highest quality for the least cost and shortest time frame (Jensen & Meckling, 1976). The project administrators have the interest in expanding the minimum effort for the highest possible budget and over the longest period and as such the client lacking specialist knowledge isn't sure that the administrators are making/taking decisions in accordance with the client's interest (Koppenjan, Leijten, ten Heuvelhof, Veeneman, & van der Voort, 2010).The impact on the individual to deliver successful projects can be explored as ambition which is at the heart of the principal agent problem; the more ambitious project managers are, the more preference they would have for more demanding projects. This means they would be more focused on the possible reward or derived benefits from delivering a demanding project than its cost. As in the scenarios, the decision maker's utility is directly mapped to the performance of the project, even when the decision maker (agent) was not directly affected by losses/gains (which would have hurt the principal).

It is also possible that the project manager doesn't take the expected value into account at all, either because they do not understand the significance of this, or because they are unable to calculate it. If this is the case, then a tool would be very important to help project managers manage risk effectively, since, if they are having trouble with one risk, they would clearly struggle to compute the overall impact of a set of risks, as would be experienced in a real project.

Looking at the complete results for the entire dataset and all sectors, it is worth noting that most respondents would not take the chance when the $20 million project is already $10 million over budget. The percentage of respondents willing to take the chance increases when the cost over budget is decreased. The willingness to proceed with the risk is highest when the project is exactly on the budget or under budget. This is easily seen in Figure 12, Figure 13, Figure 14, and Figure 15.

In Figure 27 Appendix D, it is interesting that there is relatively little difference in the proportion of respondents taking the risk between Scenario 2 and Scenario 3. This suggests that the decision makers are not attracted much by the (admittedly slim) prospect of just breaking even – they are more driven by the overall expected financial performance.

It is worth mentioning that the respondents are more willing to take a chance when given a 50:50 chance (Scenario 1) than when the chance of gain is higher (at 75%) but the payoff is less (Scenario 2). This is consistent with diminishing marginal utility (as incorporated in both expected utility theory and prospect theory). Looking at Scenario 1, there is a decrease in the number of respondents willing to take a chance when the project is on budget than when it is $2 million over budget or $2 million under budget. That discrepancy means that there are those willing to take a risk when a project is under budget or slightly above budget but not on budget. This is slightly visible in the results for Scenario 2 also (see Figure 12). This might be because the respondents are trying to improve the project performance, and once it's already on budget they feel a sense of accomplishment as they have delivered what they were expected to.

4.3.4.2 Expected utility theory and research results

Expected utility theory shows how utility depends on the final state of wealth, as shown in Figure 7. We assume that zero utility corresponds to the worst possible outcome in the project, and utility rises with the budget performance. If there is no diminishing marginal utility, the slope would be constant (straight line with no

gradient). In this case, the expected utility of taking the risk will always be +1 for the 3 scenarios considered, and 100% of people should take the risk, just as described above when considering expected value.

Figure 12 shows that the respondents to the survey do not make decisions in this way, though, with many not choosing to take a risk that has positive expected value. Nevertheless, their decisions may still be rational according to expected utility theory, as expected utility theory includes the assumption of diminishing marginal utility (Stearns, 2000). With diminishing marginal utility, a reduction in expected utility may result when taking a risk even if there is an expected gain in wealth, due to the ever-reducing gradient of the utility curve. The point at which this happens will vary across the 3 scenarios due to the asymmetries in payoffs and probabilities.

We can model decision making based on expected utility theory as follows:

1. Calculate a utility U_1 if the risk is taken for each projected cost at completion, by assuming that the utility will be given by the probability that the risk pays off x value of utility using function in if the risk does pay off + probability the risk doesn't pay off x value of utility function in Equation 6 if the risk doesn't pay off.
2. Calculate the utility U_0 for the projected cost at completion if the risk isn't taken.
3. Calculate the increase in utility associated with taking the risk by the difference between U_1-U_0.

Assuming (following Wakker (2010, Chapter 9) that positive utility, U, is a power function of budgetary performance (gain), α, given by Equation 6.

$$U = U(\alpha) = \frac{(1+\alpha)^{\theta}}{\theta} - \frac{1}{\theta}$$

Equation 6: Utility function

For simplicity, the willingness to take the risk is then assumed to be given by a linear equation of the form as shown in Equation 7, where a and b are constants.

$$W = a + b[U_1(\theta) - U_0(\theta)]$$

Equation 7: Willingness to take risk function

The best fit between the survey data and the model is provided when θ=0.01, a = 0.48 and b = 0.77. This gives the results shown in Figure 18. The corresponding utility curve is as shown in Figure 21.

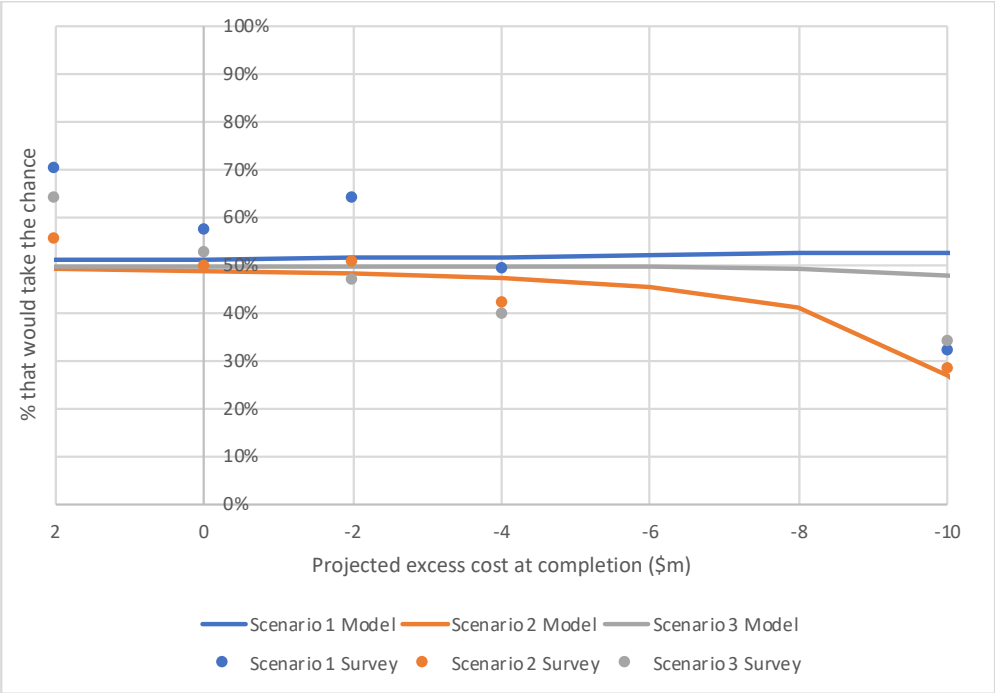

Figure 18: Willingness to take risk: EUT model vs survey results

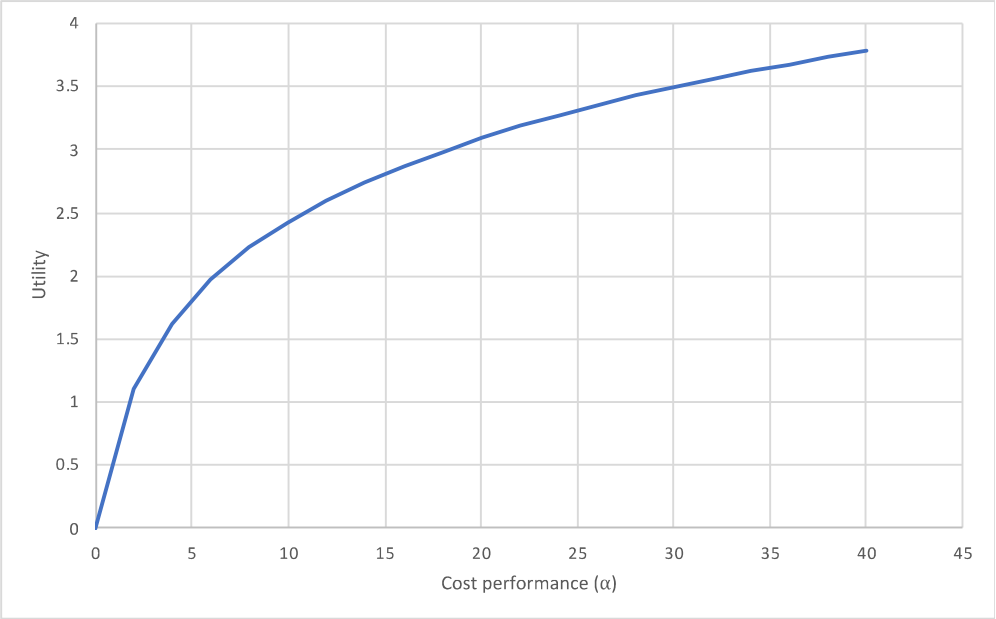

Figure 19: Utility function (θ = 0.01)

The R^2 coefficient of determination can be used to quantify the goodness of fit between the survey results and the model. The R^2 is a statistical measure of how close the data are to the regression line of the original data (survey results) (Miles, 2014), and is calculated as the percentage of the response variable variation where 0 indicates that the model explains none of the variability of the response data and 1 indicates that the model explains all of the variability of the response around its mean (Miles, 2014).

As shown in Table 16, the model (Figure 18) provides a good fit for Scenario 2, but is very poor for Scenarios 1 and 3 (no better than assuming that the percentage that would take the risk is constant, which would give $R^2 = 0$). Looking at Figure 18, the damage limitation effect and the double or nothing effect are not predicted by the model because there is no general downward slope of the lines for the scenarios as shown in the actual survey results.

	Goodness of fit (Coefficient of determination, R^2)
Scenario 1	-0.131
Scenario 2	0.826
Scenario 3	0.053
Mean R^2	0.249

Table 16: Goodness of fit - EUT

Note that both the utility to the organisation (principal) and the utility to the agent (project manager) should be considered as functions of the (cost) performance of the project. The project manager might logically choose not to accept the risk with positive expected value either because (1) he or she correctly recognises the potential disutility to the organisation (principal) that would be caused by failure, or because (2) he or she disregards the solution that maximises utility for the organisation, and favours the solution that they perceive to maximise their own utility (in terms of reputation, remuneration or future career prospects).

To reproduce the damage limitation effect, the willingness to take the risk equation can be adjusted to include an additional term to reflect the influence of the projected cost at completion, C_0, and a further constant, c, which can be described as a Damage Limitation Factor (DLF).

$$W = a + b[U_1(\theta) - U_0(\theta)] + c[C_0]$$

Equation 8: Modified willingness to take risk function

The closest fit to the survey data is now found with values of θ=0.73, a = 0.37, b = 0.5 and c = 0.025. This gives the results shown in Figure 20, and the corresponding utility curve is shown in Figure 21.

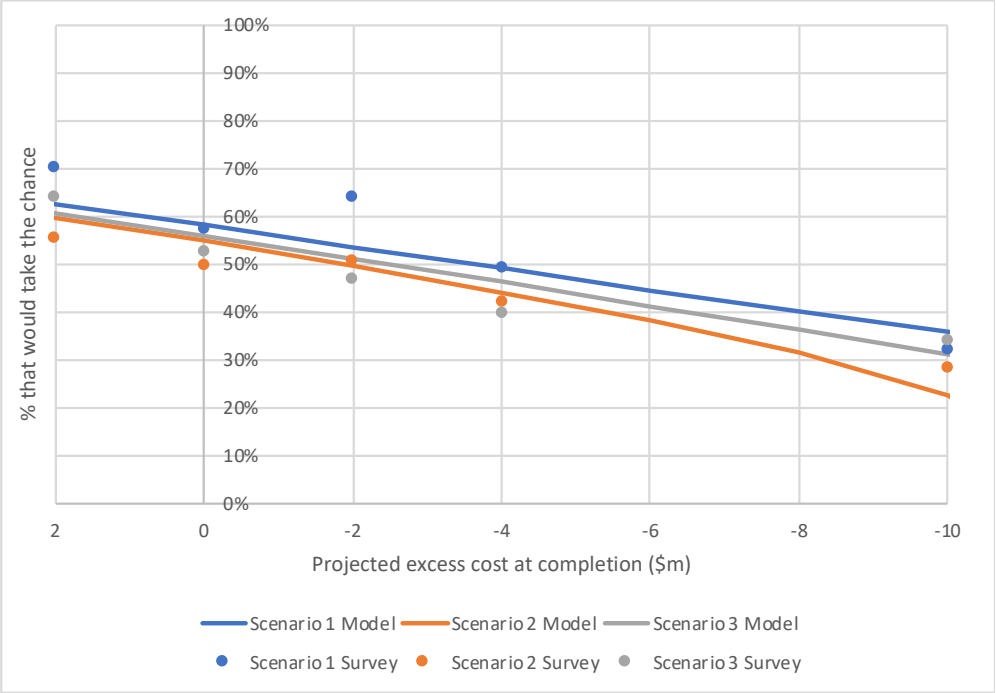

Figure 20: Willingness to take risk: modified EUT model vs survey results

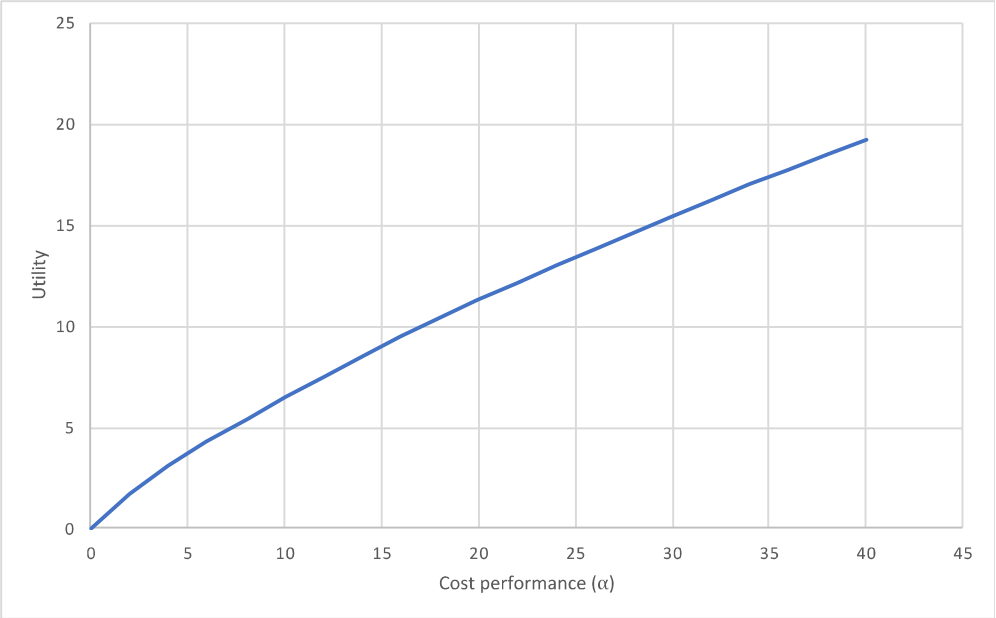

Figure 21: Utility function (θ = 0.73)

Adding the DLF to the model significantly improves the results, especially for Scenarios 1 and 3, as shown in the goodness of fit test tabulated in Table 17 and the scenarios are modelled in Figure 20.

	Goodness of fit (Coefficient of determination, R^2)
Scenario 1	0.797
Scenario 2	0.810
Scenario 3	0.835
Mean R^2	0.814

Table 17: Goodness of fit – EUT with damage limitation factor

4.3.4.3 Prospect theory and research results

Prospect theory tells us that decision makers' utilities depends not just on the end-points, but also on the changes to their wealth. This begs the question 'what is the equivalent concept to "changes to their wealth" in a project management context?'. It seems reasonable that respondents may consider both the current state of the project and the original baseline of the project as relevant reference points. The possibility of having multiple reference points has been highlighted by various researchers (Heath, Larrick, & Wu, 1999; Ordóñez, Connolly, & Coughlan, 2000; Sullivan & Kida, 1995; Costa & Clímaco, 1994; Saviluoto, 2011; Koop & Johnson, 2012; Lin, Huang, & Zeelenberg, 2006; Heath, Larrick, & Wu, 1999). Heath et al. (1999) provide evidence that goals inherit the properties of the value function not only for reference points, but also for loss aversion and diminishing sensitivity. They suggest that goals serve as reference points and systematically alter the value of outcomes (Heath, Larrick, & Wu, 1999). However, Koop & Johnson (2012) suggest that participants most often chose to maximise their chance of reaching their reference points even when a decision is riskier, resulting in lower expected value or lower expected utility (Koop & Johnson, 2012) but the results of this research suggests otherwise. Also, Wang & Johnson (2012) present three reference points in decision making under risk, which are minimum requirement, the status

quo and the goals in decision making under risk. These all seem relevant to the data shown in Figure 12.

In order to explain the shape of the curves using the loss aversion in terms of willingness to gamble. The willingness to take the risk can be explained by an equation of the form W = Const + Loss Aversion x Expected net utility gain from taking risk (from the 'value function' such as in Figure 23) + Damage Limitation x the current projected Cost at Completion (CAC). If the expected net utility is zero and the projected cost at completion is on budget, the starting assumption is that Const should be 0.5, since if people have zero expected net utility they will be indifferent to taking the risk. The assumption here is that the value function already captures risk aversion/diminishing marginal utility of wealth. There are two possible reference points in this case, the reference point of the current projected CAC, and the reference point of the original budget (projected CAC overrun = 0).

The utility associated with choosing to take the risk is the sum of:

(i) utility relative to CAC reference point if risk pays off x probability risk pays off
(ii) utility relative to CAC reference point if risk doesn't pay off x probability risk doesn't pay off
(iii) utility relative to 0 reference point if risk pays off x probability risk pays off
(iv) utility relative to 0 reference point if risk doesn't pay off x probability risk doesn't pay off.

The utility associated with choosing not to take the risk is just 0 relative to the CAC reference point + the utility of the current projected CAC relative to the 0-reference point. The expected net utility gain from taking the risk is then easy to calculate as the sum of (i) to (iv) minus this utility of the current projected CAC relative to the zero-reference point. Since we don't know the relative importance of the two

reference points, we assign them weights WtCAC for the weight of the current projected CAC, and WtBE for the weight of the break-even reference point.

To calculate the utility as a function of loss or gain, the author uses the pragmatic variation of the power family (Vendrik & Woltjer, 2007; Wakker, 2010). See Equation 9.

$$U = U(\alpha) = \frac{(1+\alpha)^{\theta}}{\theta} - \frac{1}{\theta} \qquad for\ \alpha > 0$$

$$U = U(\alpha) = 0 \qquad for\ \alpha = 0$$

$$U = U(\alpha) = -\frac{\lambda(1-\alpha)^{\theta'}}{\theta'} + \frac{\lambda}{\theta'} \qquad for\ \alpha < 0$$

Equation 9: Utility functions for prospect theory

Assuming these equations, and the willingness to take risk function as shown in Equation 7, the model fits the survey data best with the following parameters: θ=1.33, θ'=0.77, λ=1.4, a = 0.25 and b = 0.12, WtCAC=0, WtBE=1. This gives the results shown in Figure 22. Looking at the parameters, no weight is given to the current projected cost at completion (CAC). Prospect theory tells us that utilities depend on the changes in wealth as such decision makers would consider their current state when faced with a decision. Having a different set of values for the parameters suggest that even though prospect theory applies in the project management context there is a variation in behaviour decisions exhibit.

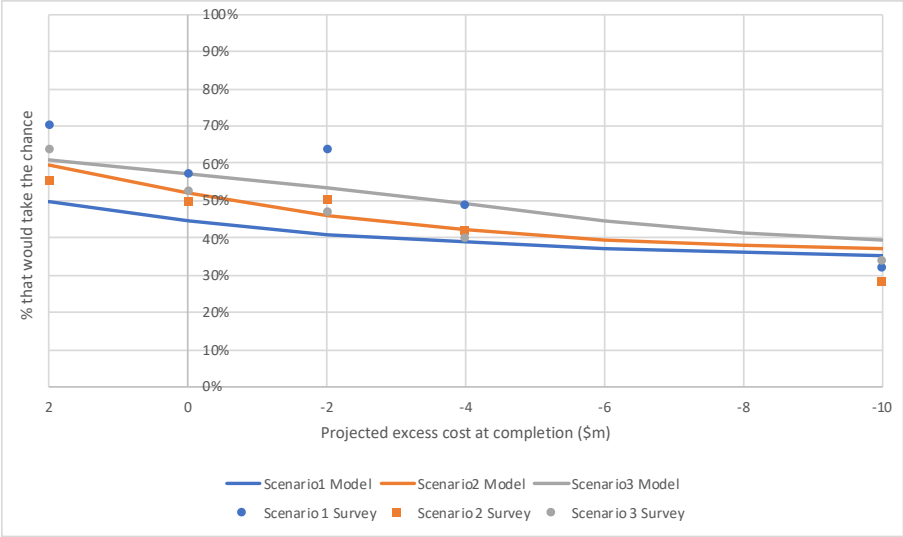

Figure 22: Willingness to take risk: Prospect theory model vs survey results

As shown in Table 18, the model provides a reasonable fit for Scenarios 2 and 3 but is very poor for Scenario 1 (no better than assuming that the percentage that would take the risk is constant, which would give $R^2 = 0$). Looking at Figure 22, the downward slope characteristic of the damage limitation effect is reproduced to some extent by the model, but the double or nothing effect, particularly evident for Scenario 1, is not demonstrated in the model.

	Goodness of fit (Coefficient of determination, R^2)
Scenario 1	-0.250
Scenario 2	0.729
Scenario 3	0.642
Mean R^2	0.374

Table 18: Goodness of fit – Prospect Theory

Prospect theory normally expects the utility as a function of loss or gain to be of the shape as shown in Figure 23.

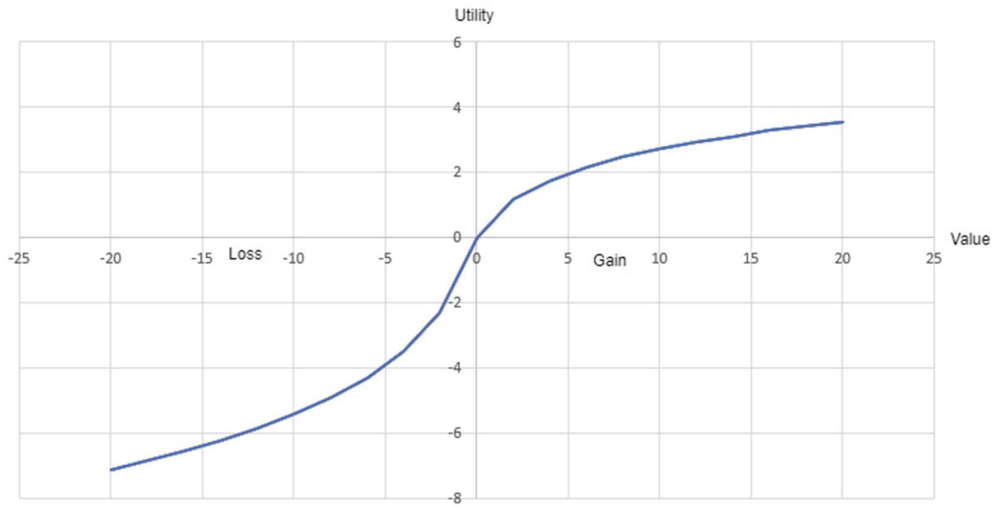

Figure 23: Utility Vs Gain or Loss

The shape of the utility curve that best fits the survey data here is given in Figure 24, however, which is not consistent with the assumptions of prospect theory as shown in Figure 23. This shows that the participants are more risk seeking in the position of gain and risk averse in the position of loss in the project management context. This finding is contrary to that of Kahneman & Egan (2011), as they suggest that people are risk seeking when in a position of loss and risk averse in position of gain.

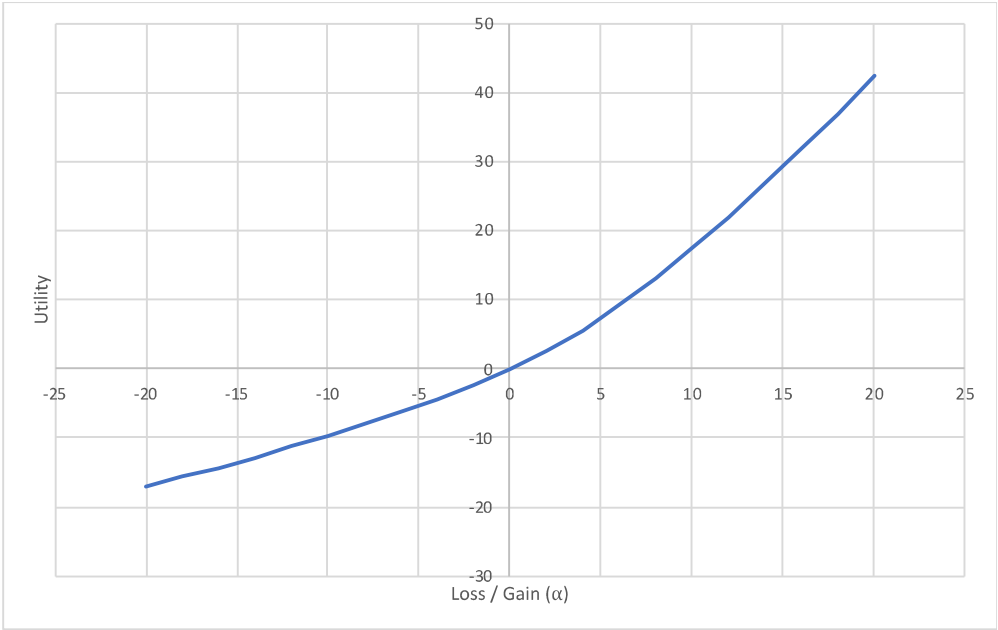

Figure 24: Utility Vs Gain or Loss (θ = 1.33, θ' = 0.77, λ= 1.4)

As before, the observed damage limitation effect can be reinforced by using the modified version of the willingness to take risk function as shown in Equation 8, which gives a much better fit to the data. Here, the author has again introduced the DLF, to improve the fit between the prospect theory model and the survey data.

The model now fits the survey data best with the following parameters: θ=0.73, θ'=1.05, λ=1.57, a = 0.61 and b = 0.12, c = 0.037, WtCAC=0.52, WtBE=0.48. The utility curve is now as shown in Figure 26. The parameters are consistent with prospect theory except for θ' which is slightly greater than 1. Prospect theory tells us that decision makers' utilities depend not just on the end-point, but also on the changes to their wealth. Looking at Figure 24 and Figure 25, its shows that with the survey data. respondents give different weights to utility when in a position of gain and loss. This gives the results summarised shown graphically in Figure 26.

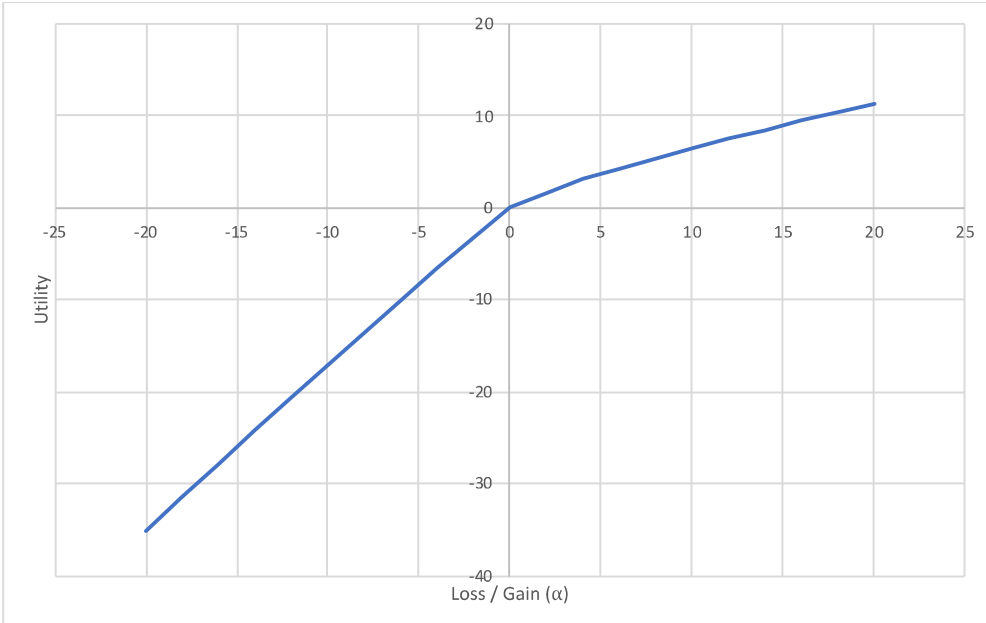

Figure 25: Utility Vs Gain or Loss (θ=0.73, θ'=1.05, λ=1.57)

	Goodness of fit (Coefficient of determination, R^2)
Scenario 1	0.907
Scenario 2	0.895
Scenario 3	0.922
Mean R^2	0.908

Table 19: Goodness of fit – Prospect Theory with damage limitation factor

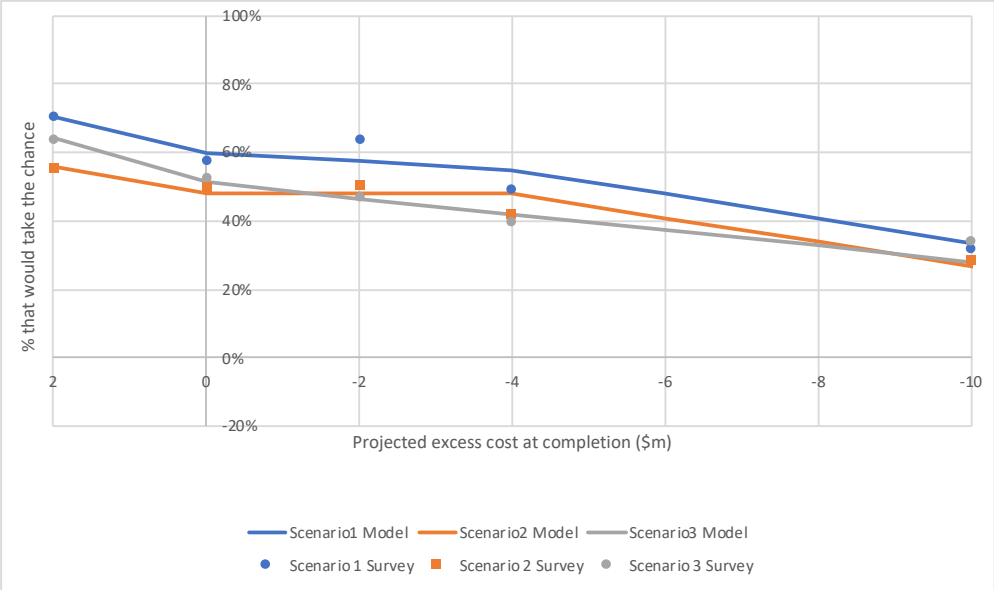

Figure 26: Willingness to take risk: Modified prospect theory model vs survey results

The kink in Scenario 1 and 2 curves appears later in the theory as shown in Figure 26 than in the data collected (see Figure 12) (4 excess CAC in the model, 2 in Figure 12), and it occurs earlier in the theory than in the charts for Scenario 3 (0 projected CAC in theory, and 4 in Figure 12). This shows deviation and the participants in the project management field behave differently as such further research needs to be done to determine if the assumption of losses is twice as much as gain for loss aversion holds in the field of project management or the multiplier between loss and gain is different between sectors (Rabin, 2013; De Martino, Camerer, & Adolphs, 2010; Ariely, Huber, & Wertenbroch, 2005; Tom, Fox, Trepel, & Poldrack, 2007; Harinck, Van Dijk, Van Beest, & Mersmann, 2007; Boyce, Wood, Banks, Clark, & Brown, 2013). Prospect theory is saying that, with the damage limitation effect, more respondents should have taken the chance, but we are not currently seeing this. The need for the DLF arises possibly because the worse the current position in the project becomes, the more of an expected benefit from gambling would be necessary to justify the gamble, given the scrutiny the project would be under.

Looking at the four elements of prospect theory outlined in the red box in the conceptual framework (see Figure 10), firstly in the aspect of reference dependence this is confirmed by the fact that the starting point of the decision ('endowment point') seems to matter significantly, otherwise we would see a straight line (as maximising expected value would predict). Secondly, loss aversion (shown in the models by $\lambda>1$) can be seen as even though each decision has a positive expected value, respondents generally do not take the risk which suggests they give more weight to the possibility of loss than to the possibility of gain. Thirdly, because of the concave shape of the curve, the projected excess cost at completion has to increase by more and more to achieve a given drop in the percentage that would take the risk. This supports the idea of diminishing sensitivity to gains (shown in model by $0<\theta<1$) but not for losses (diminishing sensitivity to loss implies $0<\theta'<1$). This suggest that diminishing sensitivity is not applicable in the project context as diminishing sensitivity implies $0<\theta<1$ and $0<\theta'<1$. Current research suggests that risk attitutes for losses can be different and to some extent unrelated to those of gains (Cohen, Jaffray, & Said, 1987; Laury & Holt, 2008; Weller, Levin, Shiv, & Bechara, 2007). This is supported to some extent by the results of this research. Finally, in the aspect of probablility weighting, this is shown on Figure 12, where the 3 scenarios are shown together, since all 3 scenarios reflect the same basic expected gains, but 2 and 3 have more extreme distributions. The proportions taking the risk under Scenarios 2 and 3 are consistently below Scenario 1. From the data collected, there is no evidence of the existence of the possibility effect, as people don't seem to value the low probability high gain gamble that has a chance of getting them to break even from a bad initial position. The results show that people prefer taking risk in a position of certainty, as when in good positions already, they do seem to be willing to gamble to make their position even more secure. Looking at the probabilities of the scenario and gain between Scenario 2 (25% chance of gain) and 3 (75% chance of gain) this is clearly evident as to how the respondents behaved.

Considering the probability weighting and utility curvature as shown in Figure 8 and Figure 9 suggests the following four-fold pattern of preferences. This pattern suggests (i) risk aversion for moderate and high probability gains, (ii) risk seeking for moderate and high probability losses, (iii) risk seeking for small probability gains and (iv) risk aversion for small probability losses. Kahneman & Egan (2011) state that this four-fold pattern of preferences is considered one of the core achievements of prospect theory. Looking at the results and the four-fold pattern of preference, it seems that it does not fully hold in the project management context as the respondents are not risk seeking for moderate high probability losses as the decisions makers become more risk averse as project performance deteriorates and it is not clearly evident the decision makers are risk seeking for small probability gains and losses from the survey data. Researchers Abdellaoui et al (2008) state that utility is steeper for losses than for gains, they reflect loss aversion (λ>1). However, studies have also shown that it is volatile (Ert & Erev, 2008; Plott & Zeiler, 2005). This research finds that to best explain the data obtained from the survey results, the loss aversion parameter should be λ=1.57. Some studies that made it likely for loss aversion to appear suggest that the loss aversion parameter is approximately 2.25 (Gächter, Johnson, & Herrmann, 2007; Abdellaoui, Bleichrodt, & l'Haridon, 2008). This is not definitive, however, as loss aversion cannot have the status of a universal consent, and some decision scenarios are more likely than others to reveal loss aversion (Huber, Ariely, & Fischer, 2001; Wakker, 2010).

4.3.4.4 Comparison between expected utility theory, prospect theory, and research results

Looking at the three scenarios, a comparison can be made between the survey results, expected utility and prospect theory results. Adding the damage limitation factor to the model significantly improves the results, especially for Scenarios 1 and 3, as shown in the goodness of fit test tabulated in Table 20.

	Expected Utility Theory without DLF	**Expected Utility Theory with DLF**	**Prospect Theory without DLF**	**Prospect Theory with DLF**
Scenario 1	-0.131	0.797	-0.250	0.907
Scenario 2	0.826	0.810	0.729	0.895
Scenario 3	0.053	0.835	0.642	0.922
Mean R^2	**0.249**	**0.814**	**0.374**	**0.908**

Table 20: R-Squared Test on extrapolated expected utility theory and prospect theory results.

4.3.4.5 Justification for Damage Limitation Factor (DLF)

It is clear from Table 22 that inclusion of the DLF makes a significant improvement in the fit between the model results and the survey results. Although this could in part be simply due to the addition of an extra variable to help with curve fitting, there may be a real-world explanation for the phenomenon that this factor represents. We might consider that when a project is doing well, people are more willing to take a gamble because of the 'house money' effect (Thaler & Ganser, 2015). The house money effect explains the tendency of decision makers who take on greater risk when reinvesting earned gains than they would with their own personal savings. Thaler and Ganser (2015) suggest that decision makers who were in a negative position are more attracted to smaller risk that offered a slim chance for a big gain than bigger risk with a substantial gains because of the possibility of the substantial increase to the size of their loss, even though it offered a higher probability of breaking even as evidenced in the survey results (see Figure 12). When the project is close to breaking even, you see the interesting behaviour of the 'house money' effect because of the reference points. Thaler and Ganser (2015)

suggest that this occurs whenever there is more than one reference point (for example where you started and your current state). When the project is doing significantly badly, decision makers consider the chance of breaking even as too remote, and then they worry about how they will be judged. In such cases gambling would be seen as reckless. Here, the principal-agent problem comes in and the incentives for improving performance are seen as lower than the disincentives for making things worse as people worry about their career prospects. Kahneman & Lovallo (1993) explain this as 'timid choices', as decision makers are loss averse regarding any outcome that will be attributed to them in an organisational setting, with the natural feeling of loss aversion exacerbated by the system of rewards and punishment. They further state that in most companies, creating an equal sized gain can lead to modest rewards while creating equal sized loss can lead to job loss (Thaler & Ganser, 2015). Being put in a situation such as this, a decision maker who starts out as being risk neutral will become highly risk averse. The decision makers are unintentionally put in a situation that prevents them from being innovative and experimentational when it comes to decision making. The system (workplace) does not incentivise decision makers to take risk. In order to get decision makers willing to take risks, it is important to create an environment where they would be rewarded for decisions that were value maximizing based on the information available at the time, even if the decisions turn out to lose money. Thaler and Ganser (2015) state that such a policy is made difficult with hindsight bias; whenever there is a time lapse between the time a decision is taken and when the results are presented, the project owner may have trouble remembering that they originally thought the decision was a good idea.

4.3.4.6 Variation across sectors

Once the results have been analysed, individual sectors can be discussed. The aim is to see the overall trend and ease comparison between industry and scenario. Overall there is consistency between the results for Scenario 1 (Figure 32 in Appendix D) and Scenario 2 (Figure 33 in Appendix D) between the sectors, however the space industry stands out from the others because of the higher

percentage of respondents willing to take the chance when the project is already over budget. This could be because of how projects are organised in the space industry (with project managers generally having greater experience (see Table 32)) or to do with how funding is provided for space sector projects. Looking at the results for the sectors, Scenario 3 (Figure 34 in Appendix D) stands out in the space industry because even with the 75% chance of loss there is a high number of respondents willing to take on the additional risk. This could easily be because of their awareness of the $1 million expected gain, or because exceeding the budget is more acceptable to participants in the space sector than in other sectors.

In the petroleum sector (Figure 14), respondents behaved inversely to normal behaviour for Scenario 3 as compared to their general positive reaction to proceed with the risk when a project is between on budget delivery and $4 million over budget. This behaviour is consistent with the loss aversion theory which states that people prefer avoiding losses to acquiring equivalent gains (Kahneman, Knetsch, & Thaler, 1991). It is consistent because they are not willing to worsen the situation of the project because of the possibility of expected gain. This might be because the chances are not in favour of gain in this scenario.

A deeper comparison for the results of the sectors can be seen in Appendix D Figure 32, Figure 33, and Figure 34. In Scenario 1, there is a general similarity in trend between the behaviour of the respondents in the three industries. However, the respondents in the petroleum sector are outliers when the project is on budget and $2 million over budget. Here they are more willing to proceed with the risk as compared to their counterparts in other sectors.

Looking at a comparison between sectors for Scenario 2, there are divergent views on whether to proceed with a risk when a project is under budget or from $2 million to $2 million over budget. This view can be more evident when a project is $10 million over budget as the space sector stands out in this situation. This is because the majority of the respondents are not willing to proceed with the risk across the sectors, except for the space industry. It is difficult to ascertain why this might be

so. In Scenario 3, Looking at the comparison between the sectors, the space sector also stands out since in this scenario a higher number of the respondents are willing to take the risk compared to the other sectors. This can be seen from when a project is $2 million to $10 million over budget.

4.3.4.7 Reflections on the principal-agent relationship

Note that in the context of the decision-making scenarios introduced in this research, respondents are assumed to act as the agents for the company in the hypothetical project. The principal-agent relationship is therefore present in this project, with the company as the principal. It seems that loss aversion is demonstrated quite strongly in almost all situations, as decision makers are on average about more likely to take the risk across all sectors and all scenarios. This means that they see the gain on average as about equivalent to the loss, when in fact the gain is on average about twice the expected loss. In fact, looking at Scenario 1, where the odds are 50/50 and the expected gain is twice the expected loss, the respondents are quite close to being 50% likely to take the risk across the five starting points. This seems to echo some of the previous literature on loss aversion (Kahneman, Knetsch, & Thaler, 1991). Still on Scenario 1, looking at Figure 32 in Appendix D on the left-hand three 'endowment points', i.e. when $2m under budget, on budget, or $2m over budget, it is interesting to note that the respondents don't want to gamble when significantly over budget but are willing to gamble when under budget.

The results suggest that in the delivery of projects, there is the idea that we value things more when we own them. One question for this research is 'when do we consider the projected losses (cost at completion over budget) as part of our endowment?'. If we are the owner/principal, then as soon as we get reliable data telling us this, we should start planning on that basis. That $10m loss then becomes part of our expected value of the company, and we are therefore likely to make decisions in the future on that basis – i.e. with the current set of project/programme performance measures as part of our endowment. But as a project manager, do we

think similarly, and effectively treat the current over budget cost at completion as a sunk cost (already lost and cannot be recovered), in which case we would expect all of the decisions of whether to take the risk to be independent of projected cost at completion? Or do we assume until the project is complete that the project performance is on baseline (do not treat the $10m loss as a given)? If we make the assumption that there will be no other opportunities to recover cost, then we can see the decision of whether to use the new material as equivalent to a decision between losing $10m (for certain) or gambling and either losing $6m (50% chance) or $12m (50% chance). In this case, it is interesting that only 32% of people would take the gamble. The fact that this percentage increases as the projected cost at completion falls, reveals that project managers are not thinking of the -$10m alone when defining their endowment. Instead their concept of endowment point is still influenced by the baseline of the project and the projected cost at completion. This suggests a principal-agent problem exists, since in most cases (i.e. other than when the project is very large compared to the business), the right decision for the principal is likely to be to encourage the managers to take risks that have a positive expected value. The principal and the agent have different utility curves, and each specific project might seem smaller for the principal than for the agent. So in reference to the utility curve or the loss/gain curve, the changes seen on a given project are effectively closer to the origin, so the slope of the curve is greater. This means that the benefit of taking risk is seen as greater.

Further research needs to be carried out to determine why the respondents behave the way they do and if there is a difference between the respondents' view and that of the public, as suggested by researchers Kahneman, Knetsch & Thaler (1991), since in the context of project management there is the element of the principal/agent problem.

4.4 Exploratory research (focus group)

Having presented the results and discussion for the surveys (importance of risk management and risk-based decision making), this section presents the results and discussion of the focus group. The focus group addressed all four research objectives, i.e. Research Objective 1 'Establish whether project practitioners perceive effective risk management to be a success factor?', Research Objective 2 'Establish which aspects of risk management are perceived to be of most importance?', Research Objective 3, "Evaluate how well prospect theory can explain risk-based decision making in a project management context?" and Research Objective 4 "Evaluate how well the four key elements of prospect theory apply in the project management context?".

4.4.1 Focus group participants

The focus group discussion consisted of 12 participants. This focus group's responses enabled the researcher to gain a causal understanding of why project participants behave the way they do. The participants work and deliver various engineering projects. Table 34 in Appendix E shows the background of the focus group participants.

Looking at the backgrounds of the participants, participants were again selected with experience in the space industry, the petroleum industry, and the construction industry. They are mostly current project managers (58%) with 58% having masters or doctorate level education. 75% of the respondents have more than five years of project experience and all have some project management experience (66% have managed more than five projects).

4.4.2 Results and discussion of focus group

Looking at the guiding questions for the focus group discussion in Table 11, the first set of questions aimed to collect the opinions of the participants on the findings

of both surveys, which looked at the perceived importance of risk management and risk-based decision making respectively. After having a lengthy decision, the focus group unanimously agreed that the results seemed credible and applicable to engineering projects.

4.4.2.1 Focus group results: Research Objective 1

The focus group concluded that, for engineering projects, project risk management should be considered as a critical success factor and is in the top 5 critical success factors; it should be considered as one of those key areas of activity in which favourable results are absolutely necessary for a manager to reach his/her goals (Rockart, 1982, p. 2). The implementation of CSFs in project key areas ensures success is made explicit (Boynton & Zmud, 1984). This reinforces the survey result and confirms the perceived importance of effective risk management with regards to Research Objective 1. This outcome supports the existing literature that highlight the importance of risk management (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013).

4.4.2.2 Focus group results: Research Objective 2

Looking at project risk management, the focus group participants again agreed with the results of the survey which is shown in Table 13, believing that the soft side of project risk management (constituting "communication & culture" and "monitoring and review") is deemed of greater importance than the hard side. This highlights the importance of the soft side of risk management with regards to Research Objective 2. Looking at Figure 6, it seems that the soft side of risk management supports the hard side and as such to fully implement the hard side of risk management one must rely on the soft side of risk management. This is in line with the works of Carvalho & Rabechini (2015) who investigate the impact of risk management on project performance.

4.4.2.3 Focus group results: Research Objectives 3 and 4

Having relatively quickly addressed Research Objective 1 and 2, the focus group spent most of its time discussing the more challenging Research Objectives 3 and 4.

4.4.2.3.1 Extent of rationality

Participants believed that project participants behave irrationally as highlighted in the risk decision survey, as even though the scenarios in the survey are all different (the amount and probability of gain or loss varies across the scenarios), they have been deliberately balanced so that in each scenario, users had an expected gain of $1 million. They felt that this means that logically the respondents should lean towards a "yes" and proceed with the risk to maximise expected value. However, this is not the case as the results shown in Figure 12 show that the further away you are from remaining within the initial project budget, the more risk averse project participants become. The focus group felt that this was irrational.

4.4.2.3.2 Causes of irrationality

After various discussions with the group, participants were able to highlight in descending order (most important first) the key justifications for deviating from the rational choice in general. As such the key reasons are: 1) relying on intuition drawn from experience, 2) fear of worsening project state, 3) interference from direct stakeholders, 4) government interference, 5) having the wrong information, 6) assuming that everything is under the control of the project manager, 7) instability of project materials (market instability), 8) change of project scope/deliverable, and 9) lack of understanding and knowledge.

Research looking at why people deviate from the rational choice when it comes to decision making is gaining momentum in the project management context (Flyvbjerg, 2013; Flyvbjerg, 2007; Alvarez, Pustina, & Hällgren, 2011; Van

Oorschot, Akkermans, Sengupta, & VanWassenhove, 2013; Kutsch & Hall, 2010). This research gives an insight of the possible reasons behind such deviation and explores the correlation between past research in decision making and the results found in this research.

In the literature, deviations from the right decision are labelled as biases and errors, and their causes are investigated. Simon (1982) suggest that roots are found in the decision makers bounded rationality. Shore (2008) and McCray et al. (2002) provide a theoretical analysis of the relevance of cognitive bias in project decisions. Shore (2008) looks at 8 case studies of failed projects and links them with nine systematic biases obtained from generic literature while the work of McCray et al. (2002) is conceptual.

There are two main project phenomena studied in the project management context with regards to individual biases. These are firstly overoptimistic plans and forecast (Flyvbjerg, 2013; Kutsch, Maylor, Weyer, & Lupson, 2011; Son & Rojas, 2011), and secondly escalation of commitment (Du, Keil, Mathiassen, Shen, & Tiwana, 2007; Hällgren, 2010; Keil, et al., 2000; Martinsuo, Suomala, & Kanniainen, 2013; Meyer, 2014; Jani, 2011; Jani, 2008). Other areas of individual bias are inefficient resource allocation (Eweje, Turner, & Müller, 2012), gold plating (Shmueli, Pliskin, & Fink, 2015), lack of learning (Sengupta, Abdel-Hamid, & Van Wassenhove, 2008) or failure to communicate early warning signs (Ekrot, Rank, & Gemünden, 2015) .

Looking at the reasons given by the focus group participants as to why project managers might behave irrationally, some of the points they gave overlap with other factors in the literature. These reasons are explored in the sections below.

4.4.2.3.2.1 Intuition drawn from experience

This entails the decision where the project manager deviates from the rational choice because they draw from their experience in delivering projects and as such

opt to proceed in a particular direction. The more decisions they have taken in the past using such an approach, the more likely they are to continue using their intuition, especially if the previous decisions taken have been perceived to be positive or in the right decision (this creates an internal self-reassurance mechanism that they are doing the right thing).

4.4.2.3.2.2 Fear of worsening project state

This point easily relates to the escalation of commitment problem in projects (Ross & Staw, 1993) as project managers fear to worsen the project state. Delay in risk decision-making situations as the project progresses can cause delays and cost overruns in a project. So indirectly, the project managers being afraid of worsening the project state can directly affect it negatively due to the delay in making the decision.

Escalation of Commitment (EoC) is known to be a problem in projects (Ross & Staw, 1993). Escalation of Commitment describes situations in which a project progresses even though 'objective' criteria lie delays and cost overruns indicate project failure. Researchers provide various explanations for such phenomena. Jani (2008) states that it could be self-justification theory, agency theory or prospect theory while Keil et al. (2000) suggests sunk cost effect and project completion effect as an explanation. Project management research adds explicitly the long-term impact of the early formation of value judgements (Martinsuo, Suomala, & Kanniainen, 2013), optimism bias (Du, Keil, Mathiassen, Shen, & Tiwana, 2007; Meyer, 2014; Jani, 2011) and groupthink (Hällgren, 2010).

4.4.2.3.2.3 Interference from direct stakeholders

This problem persists in a project when the project manager has direct interference from the stakeholders. This affects the project negatively as the project manager is not fully allowed to utilise his/her skills for project delivery. This point is a clear case of the principal-agent problem where the project owner micromanages a

project as they believe that the project manager is not making decisions that fully cover their interests.

4.4.2.3.2.4 Government interference in projects

This can cause the project managers to deviate from the rational choice or best alternative due to unfavourable political interventions. These could come at any time and could easily be unfavourable for the project. This interference is more evident in developing nations were government are unstable (Rui, et al., 2017).

4.4.2.3.2.5 Having the wrong information

This point is related to the failure to communicate early warning signs (Ekrot, Rank, & Gemünden, 2015). As project managers would make decisions with information currently at their disposal, it is vital that always they have the must up to date information to assist them in decision making; failure of this can adversely affect the project.

4.4.2.3.2.6 Assuming everything is under the control of the project manager

This point relates to the overoptimistic plans and forecast as identified in the literature (Flyvbjerg, 2013; Kutsch, Maylor, Weyer, & Lupson, 2011; Son & Rojas, 2011). The focus group believe that project managers who have high success rate from their past work will be more willing to take on new projects without carefully looking at the finer details. As such, they see themselves as invincible or god-like, thinking that they can deliver a project no matter the conditions. Once they are slightly overbudget and they realise that they would be unable to deliver the project as per the budget they become prone to deviation as such making decisions that are not always rational with the hope of positively delivering the projects.

Optimism bias explains situations where the underestimation of negative outcomes or overestimation of positive outcomes. It is a key cause for various cognitive biases

such as the illusion of control, outcome desirability and self-efficacy theory. Current research has shown particular interest in the area of the illusion of control especially when perceived control over specific project risks leads to underestimating and downplaying (Du, Keil, Mathiassen, Shen, & Tiwana, 2007; Jani, 2008; Jani, 2011). Researcher Keil et al. (2000) linked have linked risk perception and the willingness to continue a risky project with culturally moderated risk propensity and uncertainty. Jani (2011) found a potential additional explanation for continued optimism which in their case stated as anchoring. Over-optimistic initial plans and forecast is another concern. Flyvbjerg (2007) has highlighted the relevance of this issue in the infrastructure sector. Flyvbjerg (2007; 2013) developed a strong focus on political behaviour as reasons for such biased plans and forecasts; he has also discussed the influence of optimism bias and the resulting phenomena of planning fallacy. Researchers Kutsch et al. (2011) have shown the influence of optimism bias on project forecast. This was done using a simulation environment which was substantiated with interviews. There they provided data on the quantitative effect of optimism bias and indication if potential drivers such as motivated reasoning, outcome attribution and egocentricity bias, and outcome desirability.

4.4.2.3.2.7 Instability of project materials (market instability)

This point can directly affect a project outcome as it can have a direct impact on the planning capability of a project manager; as such, market instability introduces a risk that can directly affect the bottom line of the project. This issue can impact resource allocation (Eweje, Turner, & Müller, 2012).

4.4.2.3.2.8 Change of project scope/deliverable

This point can be related to overoptimistic plans and forecasting (Flyvbjerg, 2013; Kutsch, Maylor, Weyer, & Lupson, 2011; Son & Rojas, 2011), inefficient resource allocation (Eweje, Turner, & Müller, 2012), and gold plating (Shmueli, Pliskin, & Fink, 2015) as identified in literature. Changing the project scope can directly affect

decision-making by causing project managers to deviate from the rational choice as increasing the project scope would add dimensions to the project that have not been considered on the project initiation stage.

Gold plating is also known as over specification. This issue arises where an uncontrolled addition of potentially unnecessary features leads to cost overruns, delays and high complexity. Shmueli et al. (2015) discovered that having a high emotional attachment to design elements and involvement in the design lead to a higher valuation of the elements hence there is a higher propensity for gold plating. Flyvbjerg (2013) suggests de-biasing strategies to provide a more accurate forecast; one of the key strategies is applying a framework that adopts the 'outside-view' based on the work of Kahneman and Tversky (1979). By taking this view, the project team remove themselves from the project and evaluate it from a neutral position. This is done with the aid of benchmarks and historical data, and this would in turn reduce optimism bias. Researchers Sengupta et al. (2008) present a more mechanical de-biasing approach that is based on elaborate forecasting and risk identification tools to minimize the technical aspects of this form of bias.

4.4.2.3.2.9 Lack of understanding and knowledge

This point is related and contributes to the lack of learning (Sengupta, Abdel-Hamid, & Van Wassenhove, 2008) and failure to communicate early warning signs (Ekrot, Rank, & Gemünden, 2015) as identified in the existing literature. Due to the lack of understanding and knowledge project participants can easily misjudge situations that are vital to a project. This can cause them to make decisions without fully understanding project context or state.

4.4.2.3.3 Risk management process

The next step in the discussions involved discussing with the group to determine if the risk management process they normally go through when working on their projects is approached rationally. The consensus was that the participants agreed

that this is not always the case, as even though they do implement the risk management process from the onset of the projects. They rarely update the risk register and tend to handle risk as they arise. Their implementation of risk management is a firefighting-style approach as even though they agree that risk management was an important aspect in projects its implementation is mostly as an afterthought or for documentation purposes. However, the bigger the project, the more time is dedicated to risk management. This means that the type of risk management approach implemented in a project is dependent on factors such as size, complexity, focus and level of risk.

This led to a further discussion as to whether the project participants would make the same decision or implement risk management in a similar way if they were managing their own personal project. This question removes the notion of the principal-agent problem as is vital to see the consensus of the group. The group agreed that if it was their personal investment in a project they would be more risk-averse (even more risk averse than the results of the survey). They would therefore be less likely to take a particular risk as the financial implication or burden would be carried by them, and with personal projects they are few instances when one adopts or uses insurance. This suggests that there is a real financial implication of success/failure even though this was already stated the decision survey context "This is an important project for your company, and your ability to deliver within budget (and under budget if possible) is likely to affect your future career prospects". This suggests that to the focus group participants this was seen as more indirect that losing your own money. This makes it clearly evident of the existence of the principal-agent effect as they are more willing to take risk with the company's money than they would be with their own. This finding is contrary to that of Kahneman & Egan (2011), as they suggest that people are risk seeking when in a position of loss and risk averse in position of gain.

4.4.2.3.4 Predictions of prospect theory

The second phase of the discussions was to look at Research Objectives 3 and 4 which focus on how well prospect theory can explain risk-based decision making in a project management context, and whether the four key elements of prospect theory are applicable in a project management. These elements are outlined in the red box in the conceptual framework (see Figure 10). The four elements are 1) reference dependence, 2) loss aversion, 3) diminishing sensitivity, and 4) probability weighting.

4.4.2.3.4.1 Reference dependence

In the aspect of reference dependence, the consensus was that reference dependence does play a vital role in projects as project managers are always concerned about the current state/financial position of a project as such project managers are very aware and look at a project in terms of what is the current position, how can the project be completed with what is disposable, what measures can be taken etc. Researcher Hardie et al. (1993) suggest that consumer choice is influenced by the position of brands relative to multi-attribute reference points, and that consumers weigh losses from a reference point more than equivalent sized gains (loss aversion). The role of reference dependence was investigated to see how it affects communication strategy and how reference dependence gives rise to credible information transmission (Grillo, 2013). Bhatia and Golman (2013) present a model of reference dependence for riskless choice, they assume that reference points affect choice by directing the decision makers attention towards the attributes associated with the reference object. The model generates a type of loss aversion and can explain behavioural anomalies related to reference dependence. Wakker (2005) provides a formalisation of reference dependence as a concept that is central to prospect theory and shows that utility of income is part of prospect theory and not expected utility. Kőszegi & Rabin (2007) study preferences over monetary risk and they present specific ways by which environmental influences attitudes towards modest scale risk.

From the discussion, the focus group believe that, when faced with a risky decision in an ongoing project, decision makers take into account the two reference points (break-even and the current projected cost at completion reference point). However, the further away (the better) the position of the project (under budget), the more willing they would be to take on a risk which would better the position of the project. This indicates that the decision makers have the 'maximise profits' objective in mind (Steffan, 2008; Chan & Chan, 2004). The further away they become from the break-even point (over budget), the more they become disillusioned that the break-even objective is not possible and as such the internal weight they give to the break-even point reduces. This makes them weigh the projected cost at completion reference point more than that of the break-even point.

The respondents believe that the cost at completion and break-even point (baseline cost) is considered throughout the project lifecycle stages, as in every stage/task there is an estimated approved cost for that tasks; as such, the decision makers are always aware of the current project state and projected cost at completion. Once they see the project moving towards overbudget threshold, they are keener to implement more cost cutting measures and would be willing to take on more risky decisions that have the possibility to bring the project back on track. However, as the projected cost at completion worsens, you get to a point that the willingness to proceed with a risk reduces, since the project is already seriously over budget. Decision makers are then less likely to make a decision that worsens the state of the project, as this would have a negative effect on the company and their individual prospects in the future. This finding further justifies inclusion of the DLF and is evidence that the predictions of prospect theory are not fully supported because prospect theory supports a risk-seeking behaviour as the decision makers' position in a project worsens. This downward slope in the willingness to take a risk can be explained by recognising that (1) decision makers have multiple reference points, (2) decision makers worry about audit, scrutiny and justification of decisions (damage limitation effect); this increases as the project goes into a weaker position (over budget). The decision makers have to have a level of confidence in the state

of the project before a risky decision is taken. This can be seen as a form of status quo bias as when decision makers are in a situation where they have mixed prospect (possible win or loss) they would have an emotional bias where their preference would be for the current state (Kahneman & Egan, 2011). Conservativeness leads to this status quo effect for risky decision making in projects that seems to outweigh the desire to deliver on budget.

From the discussions, the focus group believe that the break-even point is important and that they do consider it as an objective for project delivery. That said, decision makers look at the initial estimates at all times, and when they are over budget and risk decisions have to be taken, they would lean towards taking the risk because of the possibility of returning the project to break even. When the project is going well and a risk presents itself with a high probability, they would also be very willing to take the risk because of the state of the project and the possibility to better position the project.

4.4.2.3.4.2 Loss aversion

Looking at loss aversion, the participants believe that it plays a role in the delivery of projects in the project management context, as project managers always want to reap the rewards of successful project delivery. This competing nature makes project managers believe that losses are bigger than gains as it seems to them that the only outcome acceptable is the successful delivery of the project. As such the project managers would tend to avoid making risky decisions that can lead to losses even when the potential of acquiring an equivalent amount of gain is high; the project manager would generally tend to prefer making risky decisions when the conditions are favourable, i.e. when the project is underbudget. Hartono et al. (2014) investigate project risk and stakeholder perspectives. Their finding is that risk is widely viewed by practitioners from a negative perspective. This view is not consistent with the theory based on utility maximisation, which would suggest a more neutral perspective. This position is consistent with the finding of Novemsky & Kahneman (2005), who consider both emotional attachment to the good and

cognitive focus during evaluation as potential mediators of the effects of intentions on loss aversion. Camerer (2005) looks at the psychological, theoretical and empirical implications of loss aversion where the researcher uses loss aversion to explain the St Petersburg paradox. The St. Petersburg paradox presents a situation where a naïve decision criterion which takes only the expected value into account predicts a course of action that no sensible person would be willing to take (Shafer, 2004).

4.4.2.3.4.3 Diminishing sensitivity

The third aspect of prospect theory is diminishing sensitivity. Diminishing sensitivity suggests that the further you get from the break-even point, the less you care about the possibility of further gain/loss – i.e. the utility vs cost position curve has a reducing gradient as you go away from the break-even point (positive or negative). This is to do with the shape of the loss/gain curve. Diminishing sensitivity means a flattening gradient as you move further from the origin – risk averse to gains and risk seeking for losses. The consensus is that the participants believe that this aspect of prospect theory is not applicable in project management, as in projects the project managers are more willing to take risk (risk seeking) if the project is going well (under budget), as even if the risky decision does not work out, the odds are that the project would be delivered on budget or slightly over budget. In positions of loss, however, decision makers are more risk-averse and prospect theory seems less applicable. Both the results of the model and focus group discussion show that this is not applicable. This is the opposite of the predictions of prospect theory. It is also clearly evident in the survey data for Scenarios 1 and 3 as depicted in Figure 32 and Figure 34 in Appendix D. This finding complements the work in other industries/sector such as that of Wakker et al. (2007) who studied the changes in intrinsic value while keeping numbers constant and changes in numbers while keeping intrinsic value constant during the introduction of the euro in Belgium. Nicolau (2008) investigates diminishing sensitivity in Spanish tourism and shows how applicable it is in the industry, while Masiero & Hensher (2010) shows how diminishing sensitivity is applicable in the transportation industry. The

results show the wide applicability of diminishing sensitivity in project management.

4.4.2.3.4.4 Probability weighting

The fourth aspect is the probability weighting function. Here, the participants believe that in projects this is sometimes applicable as project managers do not always stick to statistical probabilities and sometimes tend to underweight risks they believe are not applicable and then tend to overweight risk with low probabilities. Here, people are not overestimating the probabilities of events, they are just subjectively over or under weighting them in their decision-making process. The respondents don't perceive the probabilities in an objective way. That's not to say that people don't overestimate probabilities as well. It is important to keep in mind that people could be making both errors at the same time. This would compound the deviation from rationality in the decision-making process. This occurs psychologically, as even when decision makers are given the probability, they still would tend to overweight things that are particularly salient to them or as they do not understand the probabilities they would come up with some heuristics for it which would in turn cause decision makers over weight/underweight given properties i.e. use experience to judge. This suggests that with reference to Figure 9 if people were rational with no diminishing marginal utility, the mapping from objective probability and decision weights would be a straight 45-degree line.

Looking at the explanation from the focus group, Figure 9 explains why people overweight when they are above the 45-degree line and underweight the probabilities when they are below the 45-degree line. This creates a certainty effect when the probability of 1 is over-weighted. To overweight risk with low probabilities gives the perception that they are able to deliver the project or manage the project in the right direction. This shows how the respondents' underweight outcomes with high probabilities relative to actual certainty. However, if the decision makers were to make a rational choice, they must confirm to the expectation principle which states that values are weighted by their probability and

nothing else (Kahneman & Egan, 2011). The certainty effect highlights how decision makers reduce the probabilities from certainty to probable. A reduction in the probability of winning creates a psychological effect which leads to the perception of loss from the original probability as such this would incline the decision makers to be risk averse. Conversely, a similar reduction results in a larger psychological effect when it is done from certainty than from uncertainty. The possibility effect, on the other hand, looks at low probability environments, where people tend to value or weight events that are remotely possible to a greater degree than they should (Kahneman & Egan, 2011).

Looking at the survey results, there was no evidence to support the specific claim of prospect theory about probability weighting in terms of overweighting low probability events. With hindsight this may have been because the author did not investigate low enough probability events to identify a possibility effect. As such author can only claim partial support for the probability weighting aspect of prospect theory in the project context.

4.4.2.3.5 What drives decision making?

In the aspect of decision making the respondents believe that, before making a decision, they consider things like the organizational values (how each outcome affects the organization), and the project owner (whom the project belongs to). However, in the aspect of cost, the aim is to minimise the risk of exceeding the original approved budget. As such, they are more prone to make risky decisions that, if successful, would bring the project closer to its original budget, and are not keen to take a risky decision that would put the project in a worse state, especially if the calculated probabilities are not favourable towards success.

The respondents suggest that in the decision-making process they solely base their decision on the drive to deliver the project. The reward/impact of the project is known to them as they believe both are intertwined, but the level of impact is not actually realised until after the project has been delivered.

When it comes to risk-based decision making, the focus group suggests that in an ongoing project they believe that the project would be exposed to more risks as the project goes on and mitigating would be costlier. As such, they believe that they won't be able to make further savings later in the project as the project goes. However, a key area the respondents believe they can save cost in is at the point of purchase/supply of materials for the project. This belief is questionable, however, as risk can occur at any stage of a project and the impact may also vary at any stage (Han & Huang, 2007; Al-Bahar & Crandall, 1990; Zhi, 1995; Smith, Merna, & Jobling, 2009; Loch, DeMeyer, & Pich, 2011).

The respondents believe that in decision making the current performance of the project does affect decision making. They believe that more inexperienced project managers are more prone to fall victims and more experienced managers are less likely to be affected when it comes to decision making, as they believe that more experienced decision makers are more rational and intuitive. This belief is similar to the findings of other researchers who suggest that the two groups implement very different processes when making the same strategic decision (Fredrickson, 1985; Eisenhardt & Zbaracki, 1992; Starbuck & Milliken, 1988; Papadakis, Lioukas, & Chambers, 1998).

4.4.2.3.6 Conclusion of focus group

Finally, at the end of the discussion with the group, they believed that overall the results of the discussions are plausible and applicable to engineering projects. The respondents believed that certain elements of prospect theory appears to be applicable to project management as discussed, and that comparison can be carried out with other sectors to see if sector-specific solutions need to be developed or the results of this study are applicable to other sectors.

4.5 Chapter summary

This chapter presents the results and discussion of the data gathered during this research study. The first section presents the results and discussion of the first study and determined that project risk management should be considered as a critical success factor and, indeed, is in the top 5 critical success factors. It should therefore be considered as one of those key areas of activity in which favourable results are absolutely necessary for a manager to reach his/her goals (Rockart, 1982, p. 2). CSFs have been a key topic of discussion in project management for decades (Bullen & Rockart, 1981; Vedder, 1992; Futrell, Shafer, & Shafer, 2001), but there is still no accepted standard set of factors. The implementation of CSFs in project key areas ensures success is made explicit (Boynton & Zmud, 1984). The results highlight the perceived importance of effective risk management with regards to Research Objective 1. Looking at Project risk management, the research found that the soft side of project risk management, which constitute "communication & culture" and "monitoring and review" is deemed of greater importance as they got higher scores and are consistently ranked in the top three aspects of project risk management. This underlines the importance of the soft side of risk management with regards to Research Objective 2. The results of this study complement work of other researchers whom have suggested that the importance of the soft side of project risk management (Carvalho & Rabechini Junior, 2015; Cullen, Johnson, & Sakano, 2000; Teal & Blanchard, 1996; Pollack, 2007).

Secondly, the study looks at risk decision making in projects, here a set of scenarios were derived that put the participants in situations of gain or loss and then asked respondents what they would do in each scenario. The results show that project participants behave irrationally and were most likely to proceed with risk decisions in a project when already in a 'winning position.' This means that the practitioners do not always decide to proceed with the risk as stated by expected value. The results of this research show the presence of the elements of prospect theory in the project management context.

Thirdly, the focus group participants believed that project participants behave irrationally as highlighted in the risk decision survey, as even though the scenarios in the survey are all different (the amount and probability of gain or loss varies across the scenarios), they have been deliberated balanced so that in each scenario, users had an expected gain of $1 million. This means that logically they felt that the respondents should lean towards a "yes" and proceed with the risk if the aim is to maximise expected value. However, this was not the case as the results shown suggest that the further away you are from the initial project budget the more irrational project participants behave when it comes to risk-based decision making. The results of the focus group discussion suggest that the overall results are reliable and applicable to engineering projects. The respondents also believe that prospect theory applies to project management as discussed and that comparison can be carried out with other sectors to see if sector-specific solutions need to be developed or the results of this study are applicable to other sectors.

Fourthly, to answer Research Objective 3, this research looks at how the elements of prospect theory apply in the project management context, with some comparisons to expected utility theory. This study concludes that expected utility does not always apply in the project management context and prospect theory provides a better explanation as to why project participants select options/decision that do not comply with expected utility. Looking at the key findings of the survey results and focus group discussion, this research finds that prospect theory provides a better prediction of project-based decision making than expected utility theory. In particular, prospect theory's concept of reference dependence applies, with the dual reference points of the current expected cost at completion and the original budget both significantly influencing decisions. When project performance is only slightly below expectations, project managers' decisions reflect a 'double-or-nothing' effect as they take risks to try to get back within budget. As performance deteriorates further, however, decision makers become more risk averse, fitting a pattern of 'damage limitation', contradicting the predictions of prospect theory, which predicts increasingly risk-seeking behaviour when in an unfavourable position. This addresses Research Objective 3.

Finally, we can reflect on findings in relation to Research Objective 4, which evaluates the four elements of prospect theory. This research finds that:

i. Reference dependence is applicable in the project management context and as prospect theory tells us that decision makers' utility depends not just on the end-point, but also on the changes to their wealth. The results show that the respondents do consider the break-even and the current projected cost at completion as reference points when making a decision.
ii. In the aspect of loss aversion, project managers tend to avoid making risky decisions that can lead to more losses even though the potential of acquiring an equivalent amount of gain is high, the project manager generally tends to prefer making risky decisions when the conditions are favourable.
iii. Diminishing sensitivity suggests that the further you get from the break-even point, the less you care about the possibility of further gain/loss – i.e. the utility vs cost position curve has a reducing gradient as you go away from the break-even point (positive or negative). The participants believe that this aspect of prospect theory is not applicable in project management as in projects, the project managers are more willing to take risk (risk seeking) if the project is going well (under budget) because even if the risky decision does not work-out, the odds are that the project would be delivered on budget or slightly over budget. In the domain of losses, however, they are more risk-averse and this aspect is not applicable in a position of loss as they are not risk seeking when the project is in loss.
iv. As far as the probability weighting function is concerned, even though the focus group participants believe that in projects this is sometimes applicable there was no evidence to support the specific claim of prospect theory in the survey data in terms of the respondents overweighting low probability events. With hindsight this may have been because the author did not investigate low enough probability events to identify a possibility effect. As such the author can only claim partial support for the probability weighting aspect of prospect theory in the project management context.

Due to differences in behaviour in the respective industries, more solutions and strategies need to be developed to assist project participants in performing better in the delivery of projects. There is also need for the solutions to be both domain specific and versatile to ease adoption.

5 Conclusion

5.1 Introduction

This is the final chapter of this research; the previous 4 chapters have presented the research introduction, literature review, research methodology and research results. This chapter aims to: (1) provide a summary of the research conducted, (2) present key findings and contributions to knowledge, (3) address the limitations of this research, (4) provides recommendations for future research, and (5) provide an overall conclusion.

5.2 Summary of the research

The successful delivery of projects is important because of various benefits that can be utilised from delivery. The need to improve current project management techniques can lead to better utilisation of the workforce and provide strategic advantages to project professionals and organisations.

Critical success factors are used to assess projects (Nixon, Harrington, & Parker, 2012). It is interesting to note that project management literature does not include risk management as a critical success factor. Risk management has been considered as important but not as a critical success factor (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013). So, in this research, risk management was tested to see if it could be included as a critical success factor.

To address the identified research question and objectives, an investigation was carried by reviewing the most relevant literature about decision making and project risk management in general. The findings of this research were supported by both quantitative and qualitative methods.

Various critical success factors have been identified in the literature which should be considered to achieve success in projects. However, these factors are limited and do not include project risk management as a factor. To decrease this deficit in the current set of critical success factors, this research highlights the perceived importance of risk management in project success.

This research goes steps further looking at decision making in face of risk and uncertainty in the project context. Due to limited research in this aspect, this research provides an insight on project professionals.

The research contributes to the project management practice by (1) updating the established critical success factors for projects (2) stating the aspects of the risk management process that are deemed to be of greatest importance, (3) establishing that project participants deviate from rational choice when making risk-based decisions in projects, (4) stating some possible reasons behind the deviations, (5) stating how well prospect theory explains risk-based decision making and (6) specifying how the elements of prospect theory apply in the project management context.

Considering the perceived importance of risk management in projects, project professionals can use the data gathered, or methods implemented in improving risk decision making understanding. This would contribute to achieving project success and project management success.

This research went through the following process:

1. Questionnaires were adopted and distributed online to ensure it reached the highest number of possible participants.
2. A focus group discussion was carried out with selected participants in different sectors.
3. The data were collected and analysed to understand critical success factors and decision making in projects.

4. The data collected were analysed using various statistical methods to ensure validity and help in interpreting the data.
5. The background literature and results obtained from data gathering enabled the presentation of the results found in this study.
6. Before the questionnaires were deployed, they underwent a pilot study to get feedback and final improvement before deployment.
7. The results of this research have been presented and published in various international conferences and journal articles.

5.3 Addressing the research question and research objectives

This research study was set out to understand whether the importance of risk management is understood and whether risk management is approached in a rational manner in projects. The answer is that the importance of project risk management is perceived to be understood by practitioners and it is approached irrationally in projects. To further elaborate, each research objective would be addressed. Early works on project success focus on the achievement of time, cost and quality objectives. More recently greater appreciation of the issues, including the diversity of stakeholder perspectives, has led to the recognition that a broader set of measures is needed (Atkinson, 1999; Wateridge, 1998). To investigate the perceived importance of effective project risk management the author links effective project risk management to critical success factors using an explanatory study.

The findings of the first explanatory study show that there is a positive relationship between project risk management and project success. Overall, the data shows that Project risk management is very important and should be considered as a critical success factors in the future. This outcome supports the existing literature that highlight the importance of risk management (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013). Looking at the results of the relative importance index project risk management is considered one of the top five factors. This implies that the importance of project risk management

is understood amongst project practitioners and it should be considered a success factor. The results also show that the soft side of project risk management, which constitute “communication & culture” and “monitoring and review” got higher scores and are consistently ranked in the top three aspects of project risk management. This suggests that the respondents believe that the soft side of project risk management is deemed of greater importance. This highlights the importance of the soft side of project risk management. The results of this study support findings of several previous studies that have also highlighted that the importance of the soft side of project risk management (Carvalho & Rabechini Junior, 2015; Cullen, Johnson, & Sakano, 2000; Teal & Blanchard, 1996; Pollack, 2007).

Project participants often face decisions related to risk, where there is uncertainty over whether one or more events will happen that could impact the project objectives. The decision of which path to follow might seem relatively straightforward, but it can sometimes be very complicated. The decision is dependent on various factors, which this research has explored through a second explanatory study. The results of the show that the participants behave irrationally as they do not always decide to proceed with the risk to gain the highest expected value. As the scenarios in the survey are all different (the amount and probability of gain or loss varies across the scenarios), they have been deliberated balanced so that in each scenario, users had an expected gain of $1 million.

Expected utility theory shows how utility depends on the final state of wealth. Assuming that zero utility corresponds to the worst possible outcome in the project, utility can be thought to rise with the budget performance. If there is no diminishing marginal utility, the slope would be constant (straight line with no gradient). In this case, the expected utility of taking the risk will always be +1 for the 3 scenarios considered, and 100% of people would logically take the risk. This is not observed in the survey results (Figure 12), however, suggesting that there must be diminishing marginal utility. If the rate at which marginal utility diminishes is quite high, there will come a point where the appeal of taking the risk becomes less than

the appeal of not taking the risk. The point at which this happens will vary across the 3 scenarios due to the asymmetries and probabilities.

Prospect theory tells us that decision makers' utilities depend not just on the end-point, but also on the changes to their wealth. The results of this research find that the respondents consider the current state of the project as an endowment point and the original baseline of the project as shown in the models in Section 4.3.4. Prospect theory tells us that the further the respondents are from the reference point, the less sensitive to changes they become. Since they consider the current state of the project as the endowment point they are not willing to proceed with additional risk in a project. Looking further, this suggest the possibility of having multiple reference points in a project, this idea has also been highlighted by various researchers (Heath, Larrick, & Wu, 1999; Ordóñez, Connolly, & Coughlan, 2000; Sullivan & Kida, 1995; Costa & Clímaco, 1994; Saviluoto, 2011; Koop & Johnson, 2012; Lin, Huang, & Zeelenberg, 2006; Heath, Larrick, & Wu, 1999). As the respondents do not only consider the baseline of the project as their endowment point, they also make decisions based on the current state of their project as they deem it to be an endowment point at that time.

Looking at the survey results and the aspects of prospect theory in the red box of the conceptual framework (see Figure 10), firstly in the aspect of reference dependence this is confirmed by the fact that the starting point of the decision ('endowment point') seems to matter significantly, otherwise we would see a flat line (line with no gradient) when focusing only on expected value. Secondly, Loss aversion is not fully applicable, as even though each decision has a positive expected value, respondents generally would tend to avoid making risky decisions that can lead to more losses even though the potential of acquiring an equivalent amount of gain is high. Thirdly, because of the concave shape of the curve, the projected excess cost at completion has to increase by more and more to achieve a given drop in the percentage that would take the risk. This supports the idea of diminishing sensitivity to gains (shown in model by $0<\theta<1$) but not for losses (diminishing sensitivity to loss implies $0<\theta'<1$). This suggest that diminishing

sensitivity is not applicable in the project context as diminishing sensitivity implies $0<\theta<1$ and $0<\theta'<1$. Current research suggest that risk attitutes for losses can be different and to some extent unrelated to those of gains (Cohen, Jaffray, & Said, 1987; Laury & Holt, 2008; Weller, Levin, Shiv, & Bechara, 2007) this is supported also by the results of this research. Finaly in the aspect of probablility weighting, where the 3 scenarios are shown together (Figure 12), since all 3 scenarios reflect the same basic expected gains, but 2 and 3 have more extreme distributions. And the proportions taken the risk under 2 and 3 are consistently below Scenario 1. This suggest that probability weighting is possibly applicable in the project manageent context.

The results of the exploratory study (focus group) show that for Research Objective 1, project risk management should be considered a critical success factor and is in the top 5 critical success factors. This reinforces the survey result and confirms the perceived importance of effective risk management with regards to Research Objective 1. This outcome supports the existing literature that highlight the importance of risk management (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013).

Looking at Research Objective 2, the data obtained from the participants suggests that that the soft side of project risk management (constituting "communication & culture" and "monitoring and review") is deemed of greater importance than the hard side. This highlights the importance of the soft side of risk management with regards to Research Objective 2. It seems that the soft side of risk management supports the hard side and as such to fully implement the hard side of risk management one must rely on the soft side of risk management. This is in line with the works of Carvalho & Rabechini (2015) who investigate the impact of risk management on project performance.

Having focused on the more challenging Research Objective 3 and 4 during the focus group discussion, it was observed that the possible reasons decision makers behaved irrationally when it comes to decision making are 1) intuition drawn from

experience, 2) fear of worsening project state, 3) interference from direct stakeholders, 4) government interference in projects. 5) having the wrong information, 6) assume everything is under your control, 7) instability of project materials (market instability), 8) change of project scope/deliverable, and 9) Lack of understanding and knowledge.

Looking at risk management implementation in projects, the finding of the exploratory study show that risk management is implemented in a firefighting-style, as even though they agree that risk management is an important aspect in projects its implementation is mostly as an afterthought or for documentation purposes. However, the bigger the project, the more time is dedicated to risk management. This means that the type of risk management approach implemented in a project is dependent on factors such as size, complexity, focus and level of risk. Further discussion on this matter that tried to eliminate the principal agent problem showed that the participants agreed that if it was their personal investment in a project, they would be more risk-averse (even more risk averse than the results of the survey). They would therefore be less likely to take a particular risk as the financial implication or burden would be carried by them, and with personal projects they are few instances when one adopts or uses insurance.

The second phase of the focus group discussions was carried out to see how the elements of prospect theory apply in the project management context. As such, each of the four elements of prospect theory are outlined in the red box of the conceptual framework (see Figure 10) would be discussed to address Research Objective 4. The four elements are 1) reference dependence, 2) loss aversion, 3) diminishing sensitivity, and 4) probability weighting. Evidence shows that reference dependence is applicable in the project management context and as prospect theory tells us that decision makers' utility depends not just on the end-point, but also on the changes to their wealth, the results show that the respondents do consider the break-even and the current projected cost at completion as reference points when making a decision. In the aspect of loss aversion, the project managers would tend to avoid making risky decisions that can lead to more losses even though the

potential of acquiring an equivalent amount of gain is high, the project manager would generally tend to prefer making risky decisions when the conditions are favourable. Diminishing sensitivity suggest that the further you get from the break-even point, the less you care about the possibility of further gain/loss – i.e. the utility vs cost position curve has a reducing gradient as you go away from the break-even point (positive or negative). The participants believe that this aspect of prospect theory is not applicable in project management as in projects the project managers are more willing to take risk (risk seeking) if the project is going well (under budget) as even if the risky decision does not work-out the odds is that the project would be delivered on budget or slightly over budget but in the domain of losses they are more risk-averse and not applicable in a position of loss as they are not risk seeking when the project is in loss. In the aspect of probability weighting function, even though the focus group participants believe that in projects this is sometimes applicable there was no evidence to support the specific claim of prospect theory in the survey data in terms of the respondents overweighting low probability events. With hindsight this may have been because the author did not investigate low enough probability events to identify a possibility effect. As such the author can only claim partial support for the probability weighting aspect of prospect theory in the project management context.

Finally, looking at decision making it was evident that before making a decision, managers consider things like the organizational values (how each outcome affects the organization) and the project owner (whom the project belongs to). However, in the aspect of cost, the aim is to minimise the risk of exceeding the original approved budget and as such they are more prone to make risky decision that, if successful, would bring the project closer to its original budget and are not keen to take the risk decision that would put the project in a worse state, especially if the calculated probabilities are not favourable towards success. The respondents suggest that in the decision-making process, they solely base their decisions on the drive to deliver the project and the reward/impact of the project is known to them as they believe both are intertwined, but the level of impact is not actually realised till after the project has been delivered. When it comes to risk decision making, the

focus group suggest that in an ongoing project they believe that the project would be exposed to more risks as the project goes on and mitigating would be costlier. As such they believe that they won't be able to make further savings later in the project as the project goes. However, a key area the respondents believe they can save cost is at the point of purchase/supply of materials for the project. Even though this believe is wrong as risk can occur at any stage of a project and the impact may also vary at any stage (Han & Huang, 2007; Al-Bahar & Crandall, 1990; Zhi, 1995; Smith, Merna, & Jobling, 2009; Loch, DeMeyer, & Pich, 2011). The respondents believe that in decision making, the current performance of the project does affect decision making. They believe that more inexperienced project managers are more prone to fall victim and more experienced managers are less likely to be affected when it comes to decision making, as they believe the more experienced, the more rational and intuitive a decision maker becomes. This believe is similar to the findings of other researchers who suggest that the two groups implement very different processes when making the same strategic decision (Fredrickson, 1985; Eisenhardt & Zbaracki, 1992; Starbuck & Milliken, 1988; Papadakis, Lioukas, & Chambers, 1998).

Looking at the deviations in the survey results, it shows that the respondents in the project management field behave differently from other studies as current research and findings of prospect theory have come from individuals who do not make tough risk-based decisions for a living (Kahneman & Tversky, 2013; List, 2004; Wakker, 2010; Grinblatt & Han, 2005). From this research an overall comparison can be done between the predictions of expected utility theory, prospect theory and the results obtained from this research. The comparison table is shown in Table 21.

	Expected Utility	**Prospect Theory**	**Research Results**
1	Rational to maximise expected utility, with diminishing marginal utility leading to risk aversion	Individuals are not universally risk averse	Irrational in risk decision making

2	Decision makers are risk averse	Risk averse for gains and risk seeking for losses.	Risk seeking for gains and risk averse for losses
3	Assumes that choices only reflect final outcomes	Loss aversion: losses loom larger than gains.	Loss aversion: losses loom larger than gains.
4	Assumes that preference between prospects do not depend on the manner which they are described.	Demonstrates that the same choices can be framed in different ways to produce dramatically different preferences.	Suggest the possibility of having multiple reference points in a project and considering them when making a decision.
5	Adding a common consequence to two prospects should not change which alternative the decision maker prefers	Common consequence to two options changes preference.	Common consequence to two options changes preference.

Table 21: Comparison table (EUT Vs Prospect Theory Vs Research results)

Looking at the key findings of the survey results and the focus group discussion, we see that prospect theory provides a better prediction of project-based decision making than expected utility theory. In particular, prospect theory's concept of reference dependence applies, with the dual reference points of the current expected cost at completion and the original budget both significantly influencing decisions. When project performance is only slightly below expectations, project managers' decisions reflect a 'double-or-nothing' effect, as they take risks to try to get back within budget. As performance deteriorates further, however, decision makers become more risk averse, fitting a pattern of 'damage limitation', contradicting the predictions of prospect theory, which predicts increasingly risk-seeking behaviour when in an unfavourable position. This addresses Research Objective 3.

5.4 Contribution of project to knowledge

This research has contributed to the growing body of knowledge within the project management domain. The research has focused on risk decision making and the aspects as to how rational decision makers are when faced with decisions in projects. Even though studies exist exits on risk decision making, there is little that is specific to engineering projects and projects in general. Furthermore, the researcher has not come across adequate studies that provide practical insight into risk decision making in projects. It was important to focus on engineering projects as this now account for the majority of projects. Knowing if and why people deviate from rational choice can help explain behaviour and also help create frameworks that may ultimately enable performance to be improved in project-based decision making. This research has tested and ranked risk management as a critical success factor and looked at if risk decisions are approached in a rational manner in the project context. This study also states the reasons why project participants behave the way they do when it comes to the choices they make. This research contributes to the area of decision making in the aspect of uncertainty particularly in the area of project management.

5.4.1 Theoretical implications

The theoretical contributions of this research add to the existing body of knowledge especially in the understanding of the concept of risk and uncertainty with regards to decision making. The theoretical contributions are reflected according to the finding and methodologies adopted, this reinforced the interrelationship of the concept of risk and uncertainty. The theoretical contributions of this research are:

- Fundamental concepts of risk and uncertainty.

  Through the review of the background literature on project, project management, risk and uncertainty in Chapter 2, this research has highlighted and explained existing thinking and theories that relate to the concept of risk and uncertainty.

- Standards, frameworks and guidelines related to project risk management. Various standards, frameworks and guidelines relating to project management, risk management have been reviewed.

    i. There is need to develop a common terminology and practices in the context of project management. This has been discussed and identified in Chapter 2. Professional bodies have tried to tackle this issue by calling for certification in project management to ensure ease of understanding, sharing of information and promoting the profession. This research tries to tackle this issue within the context of project management in engineering projects by using and clearly defining key terminologies.
    ii. From the literature review it was found that there is no streamlined definition for risk provided by the standards, frameworks and guidelines. As in certain areas risk is defined to be in consistence with Knight and Keynes proposition while in other areas it is not. This research found out that the definitions are linked/related to one another.
    iii. It has been found that risk and uncertainty are affiliated to one another as risks results from uncertainty, and they can be quantified. This relationship has been discussed in the literature (Chapter 2) and it has been noted that the practitioners understanding of risk and uncertainty differs from that of Knight and Keynes proposition. This is also evident in the data gathered as respondents opt for a decision to realise its possible opportunity in order to better position the project.

- Quantitative study – Implementation of surveys.

    The research has contributed to the quantitative stream of research, drawing from the rich quantitative data obtained from the implementation of surveys. The researcher adopts the use of a quantitative study to find

answers from a large population, with the hope that this might allow generalisation. Previous studies have focused on the implementation of risk management on project success (Zwikael & Ahn, 2011). Bakker et al. (2012) emphasise the need to identify risk, and its effects on project success, and suggest that risk management activities contribute to project success. However, studies have linked risk management to project outcomes (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013; Kutsch & Hall, 2010) but not to CSFs. The factors under project risk management are sub-divided into two: firstly, hard aspects including initiation, identification, assessment, response planning and response implementation, and secondly, soft aspects of risk, which are risk communication and attitude, monitoring and review (David, 2009). After an in-depth review of past work on CSFs, the first survey was developed to investigate this. Looking at the background literature on decision making and risk another survey was developed. This is because project participants often face decisions related to risk, where there is uncertainty over whether one or more events will happen that could impact the project objectives. The decision of which path to follow might seem relatively straightforward, but it can sometimes be very complicated. The decision is dependent on various factors, which this research has explored through a survey. This has currently not been researched and investigated in the context of engineering project management [see (Almajed & Mayhew, 2014; Rabechini Junior & Monteiro de Carvalho, 2013; Didraga, 2013; Kutsch & Hall, 2010; David, 2009; Zwikael & Ahn, 2011)] and by so doing the research has contributed to the body of empirical literature in the area of risk and rationality.

- Qualitative study – focus group methodology.

The research has contributed to the qualitative stream of research, drawing from the rich qualitative data obtained from the focus group discussions. The research was partly conducted through the use of focus group

discussions. The focus group discussion was implemented to help the researcher get a different set of data to triangulate with the results from the questionnaire. It was designed in particular to get the participants to give the reasons/justifications as to why they may sometimes not opt for the rational choice in the face of uncertainty in projects and to examine to which extent do the predictions of expected utility theory and prospect theory apply in the project management context. This complemented the quantitative data and helped the author get a causal understanding of why project participants behave the way they do. Looking back at the literature review on risk and rationality [see (Kutsch & Hall, 2009; Abd Karim, 2014; Al Harthi, 2015; Atika, 2011)], none of these researchers investigated and compared the practice in the context of engineering project management. By doing so, the research has contributed to the body of empirical literature in this research area.

- Prospect theory in the project management context.

    I. Looking at the key findings of the survey results and focus group discussion, we see that prospect theory provides a better prediction of project-based decision making than expected utility theory. In particular, prospect theory's concept of reference dependence applies, with the dual reference points of the current expected cost at completion and the original budget both significantly influencing decisions. When project performance is only slightly below expectations, project managers' decisions reflect a 'double-or-nothing' effect, as they take risks to try to get back within budget. As performance deteriorates further, however, decision makers become more risk averse, fitting a pattern of 'damage limitation', contradicting the predictions of prospect theory, which predicts increasingly risk-seeking behaviour when in an unfavourable position.

II. This research contributes some understanding of the applicability of prospect theory to risk-based decisions faced by professionals in engineering projects. Of particular importance is the finding that prospect theory does not apply in the same way in projects as standard prospect theory suggests.

III. Looking at the four elements of prospect theory, this research finds that (i) reference dependence is applicable in the project management context and as prospect theory tells us that decision makers' utility depends not just on the end-point, but also on the changes to their wealth, the results show that the respondents do consider the break-even and the current projected cost at completion as reference points when making a decision. (ii) In the aspect of loss aversion, the project managers would tend to avoid making risky decisions that can lead to more losses even though the potential of acquiring an equivalent amount of gain is high, the project manager would generally tend to prefer making risky decisions when the conditions are favourable. (iii) Diminishing sensitivity suggest that the further you get from the break-even point, the less you care about the possibility of further gain/loss – i.e. the utility vs cost position curve has a reducing gradient as you go away from the break-even point (positive or negative). The participants believe that this aspect of prospect theory is not applicable in project management, as in projects, the project managers are more willing to take risk (risk seeking) if the project is going well (under budget) as even if the risky decision does not work-out, the odds is that the project would be delivered on budget or slightly over budget but in the domain of losses they are more risk-averse and not applicable in a position of loss as they are not risk seeking when the project is in loss. (iv) In the aspect of probability weighting function, even though the focus group participants believe that in projects this is sometimes applicable there was no evidence to support the specific claim of prospect

theory in the survey data in terms of the respondents overweighting low probability events. With hindsight this may have been because the author did not investigate low enough probability events to identify a possibility effect. As such the author can only claim partial support for the probability weighting aspect of prospect theory in the project management context.

IV. From this research an overall comparison can be done between the predictions of expected utility theory, prospect theory and the results obtained from this research. The comparison table is shown in Table 21 Section 5.3.

5.4.2 Practical implications

The research has practical contributions to the field of project management, which looks at the issue of decision making in the face of risk and uncertainty. The practical contributions of the is research are:

- This research provides an insight on decision making in engineering projects in the aspects of tools and techniques that can be used to address risk.
- The process of risk decision making in projects can be formulated from the data collection methods and findings of this research which can be used as a generic framework for comparison with other industries/sectors.
- The current understanding of decision making in risk and uncertainty contradicts what the literature of economic and management theory states and prospect theory explains why project participants make the choices they make in the project management context.
- The background literature revised in Chapter 2 are not mandatory to be used. They are however, existing practices for risk management. They do not provide specific tools to manage or explain how an organisation can/should manage the process of risk management. The findings of this

research should be used to foster/grow sound project risk management in the context of decision making in engineering projects.

- The results of the critical success factors survey and the relative importance index analysis indicate that people find it easier to differentiate between the critical success factors than the factors involved in project risk management even though practitioners highlighted the importance of risk management in projects. This prompts the need for more training/awareness on risk management and its implementation in projects to project practitioners.
- This research finds that decision makers become more risk averse than risk seeking as project performance deteriorates, this gives an insight as to how decision makers choose between risks being faced in on-going projects. As such, more research needs to be carried out to assist decision makers in decision making. Tools need to be developed that would help them keep track of the effects of a prior decision taken on project performance.
- The results of this research show that the project participants behave differently when making decisions in projects. As such, there is need for further research to be done to determine if the assumption of losses is twice as much as gain for loss aversion and if it holds in the field of project management or the multiplier between loss and gain is different between sectors as the results of this research supports this.
- This research has highlighted some of the reasons decisions makers deviate from the rational choice when making decision. The key reasons identified are 1) relying on intuition drawn from experience, 2) fear of worsening project state, 3) interference from direct stakeholders, 4) government interference, 5) having the wrong information, 6) assuming that everything is under the control of the project manager, 7) instability of project materials (market instability), 8) change of project scope/deliverable, and 9) lack of understanding and knowledge. These identified areas act as focus points for project managers regarding concerns highlighted by other experienced project managers to consider when making future decisions in projects.

- The finding of this research provides a foundation for potential project managers to have more understanding on risk decision making process and as such enable the decision makers in selecting the best alternatives.
- The insights of this research provide project managers and practitioners the ability to evaluate risk decision making performance in current and past projects. This could be used as learning curve in future risk decision making situations.
- Understanding risk and rationality in decision making provides project manager and practitioners with an indispensable tool that can ensure not only utility maximisation but also ensure project success.
- This research aids project managers and participants with possible explanations as to why people make the decisions they do and with possible explanations as to why they opt for a certain decision in a risky situation.
- Looking at the principal agent relationship this research adds value to sponsors and the managers of the project managers (the 'Principals'). If they have a better understanding of the tendencies of project managers (the 'Agents'), they can perhaps take action to ensure appropriate incentives are in place so that the project managers act in a way that is aligned to the interests of the sponsors or the organisation.

5.5 Challenges experienced during project execution

It is not possible to conduct a research project without facing some difficulties. The main problems faced while conducting this research project revolved around the collection of the data from the respondents. Getting respondents to complete and submit the questionnaires was very difficult, it seemed some of the respondents were concerned about how their information would be used. Time was spent convincing the respondents that the information provided would be confidential and they need not to worry about any ethical problems. A thorough consideration of ethical procedures helped the researcher overcome the problem.

The second problem was the amount of time it took to collect the data from the respondents who participated in this research especially during the focus group discussions. This took longer than expected as some of the respondents missed and had to reschedule appointments for the meetings. This problem was caused due to different work schedules and availability.

5.6 Limitations of research

There are several limitations that have been identified during this research, especially during the data collection and analysis phase:

- Most of the data collected were online, so it's difficult to validate the results or check the authenticity of the data given.
- Due to limited time, more respondents for the surveys would have been helpful.
- The study was developed in the United Kingdom, and the respondents were mostly from Europe, United States of America and Nigeria. This indicates that there is some basis that makes it difficult to generalize.
- The research covers various industries, but it is limited in its applicability to the organisations that produce clear engineered products, or have design, engineering and construction processes via the use and implementation of project management techniques.
- The people who participated in the focus group discussions were representing organizations, and they are people involved in the management of projects and risks. Their understanding of prospect theory was limited, so this had to be explained to them during the focus group

Nonetheless, the results provide important insight from experienced professionals and creates a foundation for cross-industry or cross-country comparison aimed at better understanding if decision making is approached in a rational manner in projects.

5.7 Future research

Researchers examining critical success factors and decision making in projects can consider the following research suggestions to expand this current work:

- Lack of empirical research in the area critical success factors, especially in certain sectors. This research will act as a foundation for which further industry research can be conducted for the improvement of the other industries or deeper studies in the currently selected industries.
- There is a vast amount of research on decision making in the context of economic and financial behaviour, but limited work has been done in the field of project management. This research takes steps towards that and forms a basis for further research in the project management field.
- It is recommended that the methodology used in this research should be applied to other industries, this would increase the current data available for future comparisons for critical success factors and risk decision making.
- The majority of the respondents who participated in the focus group were managers and experienced professionals. Including lower level employees at the qualitative stage would allow the researcher measure whether they perceive risk in the face of uncertainty the same way.
- This study focused on investigating if risk management is approached in a rational manner in projects. A future study might focus to producing a framework that can ensure that utility maximization is at the front of decision making.
- The researcher recommends a follow up study to test whether the proposed results is applicable to other sectors.
- Most research on behavioural decision making was based on studies of failing projects. It would be important to explore those projects that are successful and understand how decision behaviour can lead to project success.

- Project participants experience political and strategic behaviour as a strong determinant in project decisions, there is very limited research on this sensitive area.
- This research focuses on the making of decisions, there is the need to study the problem of indecisiveness and delayed decisions making.
- A more comprehensive survey on the possible circumstances people can find themselves in when making risk decision in projects.
- Further research needs to be carried out to see if there is a difference between the respondent's view and that of the public as in the aspect of projects there is the case of the principal-agent problem as in projects the participants act as agents to spend the principal's investment.
- Further research needs to be carried out on the applicability of prospect theory in the project management context as the result of this research shows that some elements are applicable. The extent of applicability needs to be further determined to fully confirm the results.

5.8 Chapter Summary

This is the end of this chapter and the end of the research. The main purpose of this chapter is to present and summarise the research, provide the key findings and contributions of this research, limitations of the research and recommendations for future research. In its totality, the research has set out to understand whether the importance of risk management is understood and is prospect theory a good model for understanding risk management behaviour in a project context. Consequently, the results of this study help us further understand the concept of risk and uncertainty with regards to decision making in projects. This understanding may result in a better application of project risk management by engineering project practitioners.

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Appendix A: Research questionnaire (critical success factors)

Introduction

At UCL, we're conducting research into the determinants of project success. We'd love to hear from you about your experience of critical success factors for projects in your industry. The survey should only take 15 to 20 minutes, and your responses are completely anonymous.

You should only take the survey once.

If you have any questions about the survey, please email me: zakari.tsiga.13@ucl.ac.uk.

Thanks very much for your input!

Background Information

This section gathers background information of your experience in projects

1. Which country are you based in?

2. What is your Highest Educational Qualification?

- ○ Bachelor's degree
- ○ Master's degree
- ○ Doctorate degree
- ○ Other

3. Please state the Industry you are working in (select all that apply).

- ☐ Aerospace
- ☐ Information Technology
- ☐ Oil and Gas
- ☐ Construction
- ☐ Other

4. What is your most frequent role in previous projects?

- Project Manager
- Systems Engineer
- Technical Specialist
- Project Administrator
- Other

5. How many years of project experience do you have?

- 0 to 2 years
- 2 to 5 years
- 5 to 10 years
- 10 to 15 years
- more than 15 years

6. How many years of project management experience do you have?

- None
- Less than 2 years
- 2 to 5 years
- 5 to 10 years
- 10 to 15 years
- more than 15 years

7. How many projects have you managed?

- None
- Fewer than 5 Projects
- 5 to 10 Projects
- 10 to 15 Projects
- More than 15 Projects

8. How many projects have you participated in?

- Fewer than 5 Projects
- 5 to 10 Projects

- ◯ 10 to 15 Projects
- ◯ More than 15 Projects

9. What is the (rough order of magnitude) average value of the projects you have worked on (in £, € or $)?

- ◯ Up to 100,000
- ◯ 1 million
- ◯ 10 million
- ◯ 100 million
- ◯ 1 billion +

10. What are your typical type of project deliverables? (Select all that Apply)

- ☐ Hardware Deliverables
- ☐ Software Deliverables
- ☐ Launcher
- ☐ Services / Operations
- ☐ Other [ ]

11. What is the typical system hierarchy you have delivered? (Select all that apply)

- ☐ Complete Systems
- ☐ Sub Systems
- ☐ Equipment/Unit/Module
- ☐ Other [ ]

Critical Success Factors

Below is a list of factors that might relate to Project Success. For each one, based on your own project experience, please indicate how strongly the factor impacts project success (using a score from 1 to 10).

12. Project Manager Competence (The skills, knowledge and experience of the project manager)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Strong Impact

13. Project Organization (The planning and organization of the project e.g. schedule and work definition, team structure and integration)

1	2	3	4	5	6	7	8	9	10

Weak Impact ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Strong Impact

14. Contractual Aspects (Contract type, payment profile, tendering and procurement processes)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

15. Project Team Competence (Project team experience, technical skills and working relationships – not including the project manager)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

16. Project Risk Management (The process of identifying, assessing, prioritising and mitigating risks)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

17. Requirement Management (The process of identifying, documenting, analyzing and tracing, prioritizing and agreeing requirements, controlling requirements change and communicating with relevant stakeholders)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

18. External Challenge (The involvement of important economic, political or legal dimensions that are external to the project team and unpredictable random events)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

19. Client Knowledge and Experience (The clients ability to contribute to the success of the project.)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

20. Top Management Support (The amount of time devoted by high ranking executives to ensure project success.)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

21. Institutional Factors (Organisational processes and culture, including how a business performs and operates, including application of standards.)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

22. Project Characteristics (The nature of the project to be completed such as size, duration, availability of resources, domain, geographic location, complexity etc.)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

23. Are there any other factors you believe are important and not mentioned above? Please specify and give an impact score in brackets, for example: Length of project manager's name (1).

Project Risk Management Process

In this section, the processes involved in **project risk management** are listed. For each one based on your past project experience, please indicate how strongly the factor impacts the **outcomes of the project risk management process**.

24. Initiation (Getting the people involved and developing process).

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

25. Identification (Compile the list of project risks)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

26. Assessment (Scoring of each risk, including probability and impact)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

27. Planning of Responses (Coming up with ways to react to the identified risks)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

28. Implementation of Responses (Resolving risks with best possible responses)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

29. Communication and culture (Behaviour and attitude of members towards the risk process)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

30. Monitoring and Review (Constantly managing changes to risks during the course of the project)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

Requirements Management

In this section, the processes involved in **requirements management** are listed. For each one based on your past project experience, please indicate how strongly the factor impacts the **outcomes of the requirements management process**.

31. Identification (Identifying relevant stakeholders and requirements)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

32. Analysis and Negotiation (Checking and prioritising requirements and resolving stakeholder conflicts)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

33. Modelling (Layering of requirements and deriving models of how the system would be used)

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

34. Validation (Mapping between requirements and stakeholder needs and ensuring completeness, consistency and comprehension of requirements).

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

35. Scope Management (Managing changes to the requirements during the project to ensure stability of requirements).

	1	2	3	4	5	6	7	8	9	10	
Weak Impact	○	○	○	○	○	○	○	○	○	○	Strong Impact

Further Information

We might like to contact some respondents to discuss your responses in more detail. If you would be willing to be contacted, please give your name and email address.

36. Please provide us with your name?

37. Please provide us with your Email address?

Thank you for your time and support.

Appendix B: Research questionnaire (decision making)

Introduction

At UCL, we're currently conducting research into the decision making of people who participate in projects. We'd love to hear from you about your experience in your industry. The survey should only take 15 minutes and your responses are completely anonymous.

If you have any questions about the study, please feel free to email me: zakari.tsiga.13@ucl.ac.uk .

Thanks for your time and input.

Background Information

1. **What country are you currently based in?**

2. **Please state the industry you are working in?**

   - Aerospace
   - Oil and Gas
   - Construction
   - Other. Please specify?

3. **How many years of project experience do you have?**

   - 0 to 2 years
   - 2 to 5 years
   - 5 to 10 years
   - 10 to 15 years
   - more than 15 years

4. **How many years of project management experience do you have?**

   - None
   - Less than 2 years
   - 2 to 5 years

- ○ 5 to 10 years
- ○ 10 to 15 years
- ○ more than 15 years

Decision making

You have been appointed as project manager of a research project that will be internally funded (from reinvested profits from previous projects). This is an important project for your company, and your ability to deliver within budget (and under budget if possible) is likely to affect your future career prospects.

Below are states of the project. For each one, please indicate what action you would recommend.

Please Note: All states and conditions affect project cost only. Please ignore any possible impact on schedule and technical performance.

The **baseline cost** the project is **$20m ($20,000,000)**. You have an opportunity to use a new material in your project that could reduce total project cost.

Scenario 1: In this situation using the new material in your project **could save $4m (50% chance) but might not work which would require rework costing $2m (50% chance)**. Would you take the chance under each of the following situations?

5. **...** if your projected cost at completion is currently $30m ($10m over budget)?

- ○ Yes
- ○ No

6. **...** ... if your projected cost at completion is currently $24m ($4m over budget)?

- ○ Yes
- ○ No

7. **...** ... if your projected cost at completion is currently $22m ($2m over budget)?

- ○ Yes
- ○ No

8. **...** if your projected cost at completion is currently $20m (on budget)?

- ○ Yes
- ○ No

9. **...** if your projected cost at completion is currently $18m ($2m under budget)?

- ○ Yes
- ○ No

Scenario 2: Now the potential saving **could save $4m (75% chance) but might not work which would require rework costing $8m (25% chance).** Would you take the chance under each of the following situations?

10. **...** if your projected cost at completion is currently $30m ($10m over budget)?

- ○ Yes
- ○ No

1. **...** if your projected cost at completion is currently $24m ($4m over budget)?

- ○ Yes
- ○ No

12. **...** if your projected cost at completion is currently $22m ($2m over budget)?

- ○ Yes
- ○ No

13. **...** if your projected cost at completion is currently $20m (on budget)?

- ○ Yes
- ○ No

14. **...** if your projected cost at completion is currently $18m ($2m under budget)?

- ○ Yes
- ○ No

Scenario 3

Scenario 3: Now the potential saving **could save $10m (25% chance) but might not work which would require rework costing $2m (75% chance).** Would you take the chance under each of the following situations?

15. **...** if your projected cost at completion is currently $30m ($10m over budget)?

- ○ Yes
- ○ No

16. **...** if your projected cost at completion is currently $24m ($4m over budget)?

- ○ Yes
- ○ No

17. ... if your projected cost at completion is currently $22m ($2m over budget)?

- Yes
- No

18. **...** ... if your projected cost at completion is currently $20m (on budget)?

- Yes
- No

19. **...** if your projected cost at completion is currently $18m ($2m under budget)?

- Yes
- No

Further Information

We might like to contact some respondents to discuss your responses in more detail. If you would be willing to be contacted, please give your name and email address.

20. **Please provide us with your name?**

21. **Please provide us with your email address?**

Appendix C: Research questionnaire (critical success factors) result analysis

Reliability of scale

To ensure reliability and consistency, the reliability of scale was implemented. According to Santos (1999), it aims to calculate the stability of a scale from the internal consistency of an item by measuring the construct. As discussed by Nunnally and Bernstein (1994), to ensure high reliability and internal consistency the Cronbach's alpha value has to be greater than 0.7. This value has also been supported by (Hair, Anderson, Tatham, & William, 1998), as anything above 0.7 is presumed to have a high internal consistency and be highly reliable. Table 22 depicts the results of the reliability of scale test.

Constructs	No of Items	Cronbach's Alpha
Critical Success Factors	11	**.847**
Project Risk Management	7	**.891**

Table 22: Reliability of scale test results.

Factor analysis

Factor Analysis can be done with the aid of Bartlett's Sphericity; here the constructs are considered acceptable only if their individual factor loading is above 0.5 (Tabachnick & Fidell, 2007). In the case of this study, all the questions had a factor loading of above 0.5 as shown in Table 23. The lowest factor loading for a given question in the survey was 0.540. This is considered to be excellent.

Category	Items	Factor Loading
Critical Success Factors	Project Manager Competence	0.781
	Project Organization	0.789
	Contractual Aspects	0.736
	Project Team Competence	0.610
	Project Risk Management (PRM)	**0.661**

	Requirements Management (RM)	0.540
	External Challenge	0.671
	Client Knowledge and Experience	0.688
	Top Management Support	0.800
	Institutional Factors	0.583
	Project Characteristics	0.577
Aspects of Project Risk Management.	PRM (Initiation)	0.727
	PRM (Identification)	0.720
	PRM (Assessment)	0.771
	PRM (Planning of responses)	0.799
	PRM (Implementation of responses)	0.671
	PRM (Communication and culture)	0.698
	PRM (Monitoring and review)	0.736

Table 23: Factor analysis test results.

Regression analysis

Linearity assumption

To measure the relationships between variables using regression analysis, both dependent and independent variables must be linear as suggested by Osborne and Waters (2002). They also explain that to achieve linearity among the variables the residual values of the data has to be between the ranges of -3 to 3. As the minimum and maximum value fall between both ranges this means if there is the need to extrapolate from the data, there will be minimal risk of the data being prone to errors. Table 24 shows the results of the linearity assumption test.

	Minimum	**Maximum**	**Mean**	**Std. Deviation**	**N**
Predicted Value	5.9113	9.1655	7.8779	.72815	147
Residual	**-1.57628**	**2.00514**	.00000	.66582	147
Std. Predicted Value	-2.701	1.768	.000	1.000	147
Std. Residual	-2.350	2.990	.000	.993	147

Table 24: Linearity assumption test results.

Multicollinearity

Multicollinearity is a situation that arises when high correlation exists between the variables of study; this is not wanted because it can cause errors to occur. To avoid multicollinearity, the tolerance and variation inflation factor (VIF) have to be greater than 0.1 and less than 10 respectively (Garson, 2010). Table 25 shows the results of the multicollinearity test and indicates that there is no issue with multicollinearity.

Predictor Variables	**Tolerance**	**VIF**
Critical Success Factors	.477	2.096
Project Risk Management	.556	1.800

Table 25: Multicollinearity test results.

Hypothesis test

For a hypothesis to be true and the null hypothesis rejected, the t- value and p-value have to be considered. The t-value should be >2.0 and p-value should be <0.05 respectively. Table 26 depicts the results of the hypothesis test. As both hypotheses meet the stated conditions, the null hypotheses can be rejected.

Hypotheses	**Beta**	**t-value**	**p-value (Sig)**	**Outcome**
H1: Project Risk Management	.518	7.649	.001	**Accepted**

Table 26: Hypotheses test results.

Background of CSF survey respondents

Characteristics of Respondents			
Background Question	**Characteristics**	**All Respondents (N=147)**	
		Nº	%
Education	Bachelor's	30	20.41
	Master's	74	50.34
	Doctorate	34	23.13
	Other	9	6.12
	Total	**147**	**100**
Industry	Space	49	33.3

	Petroleum	49	33.3
	Construction	49	33.3
	Total	**147**	**100**
Most Frequent Role	Project Manager	74	50.34
	Systems Engineer	22	14.97
	Technical Specialist	23	15.65
	Project Administrator	10	6.8
	Other	17	11.56
	Total	**147**	**100**
Project Experience	0 to 2 years	10	6.8
	2 to 5 years	19	12.93
	5 to 10 years	23	15.65
	10 to 15 years	17	11.56
	More than 15 years	73	49.66
	Unanswered	5	3.4
	Total	**147**	**100**
Project Managemen t Experience	None	10	6.8
	0 to 2 years	19	12.93
	2 to 5 years	31	21.09
	5 to 10 years	24	16.33
	10 to 15 years	19	12.93
	More than 15 years	37	25.17
	Unanswered	5	3.4
	Total	**147**	**100**
Projects Managed	None	16	10.88
	Fewer than 5 projects	50	34.01
	5 to 10 projects	18	12.24
	10 to 15 projects	19	12.93
	More than 15 projects	39	26.53
	Unanswered	5	3.4
	Total	**147**	**100**
Project Participated	Fewer than 5 projects	23	15.65
	5 to 10 projects	35	23.81
	10 to 15 projects	16	10.88
	More than 15 projects	67	45.58
	Unanswered	5	3.4
	Total	**147**	**100**

Average Project Value	Up to 100,000	28	19.05
	1 million	29	19.73
	10 million	33	22.45
	100 million	30	20.41
	1 billion +	21	14.29
	Unanswered	6	4.08
	Total	**147**	**100**
Type of Project Deliverables	Hardware	60	40.82
	Software	18	12.24
	Launcher	31	21.09
	Service/Operation	33	22.45
	Other	3	2.04
	Unanswered	1	0.68
	Total	**147**	**100**
Typical System Hierarchy	Complete	65	44.22
	Sub System	47	31.97
	Unit/Module	14	9.52
	Other	19	12.93
	Unanswered	2	1.36
	Total	**147**	**100**

Table 27: Study 1 (CSF) background of respondents

CSF survey respondents by sector

Characteristics of Respondents							
Background Question	**Characteristics**	**Space subset (N=49)**		**Petroleum subset (N=49)**		**Construction subset (N=49)**	
		Nº	%	Nº	%	Nº	%
Education	Bachelor's	13	26.5	11	22.4	6	12.2
	Master's	15	30.6	29	59.2	30	61.2
	Doctorate	18	36.7	8	19.3	8	16.3
	Other	3	6.1	1	2.0	5	10.2
	Total	**49**	**100**	**49**	**100**	**49**	**100**
Industry	Space	49	100	0	0	0	0
	Petroleum	0	0	49	100	0	0
	Construction	0	0	0	0	49	100
	Total	**49**	**100**	**49**	**100**	**49**	**100**
	Project Manager	16	32.7	26	53.1	32	65.3
	Systems Engineer	15	30.6	6	12.2	1	2.0

Most Frequent Role	Technical Specialist	9	18.4	11	22.4	3	6.1
	Project Administrator	3	6.1	5	10.2	2	4.1
	Other	5	10.2	1	2.0	11	22.4
	Total	**49**	**100**	**49**	**100**	**49**	**100**
Project Experience	0 to 2 years	3	6.1	4	8.2	3	6.1
	2 to 5 years	7	14.3	8	16.3	4	8.2
	5 to 10 years	10	20.4	7	14.3	6	12.2
	10 to 15 years	6	12.2	9	18.4	2	4.1
	More than 15 years	20	40.8	19	38.8	34	69.4
	Unanswered	3	6.1	2	4.1	0	0
	Total	**49**	**100**	**49**	**100**	**49**	**100**
Project Managemen t Experience	None	4	8.2	4	8.2	2	4.1
	0 to 2 years	13	26.5	6	12.2	0	0
	2 to 5 years	11	22.4	13	26.5	7	18.4
	5 to 10 years	9	18.4	8	16.3	7	14.3
	10 to 15 years	6	12.2	3	6.1	10	20.4
	More than 15 years	3	6.1	13	26.5	21	42.9
	Unanswered	3	6.1	2	4.1	0	0
	Total	**49**	**100**	**49**	**100**	**49**	**100**
Projects Managed	None	5	10.2	9	18.4	2	4.1
	Fewer than 5 projects	28	57.1	16	32.7	6	12.2
	5 to 10 projects	4	8.2	8	16.3	6	12.2
	10 to 15 projects	5	10.2	5	10.2	9	18.4
	More than 15 projects	4	8.2	9	18.4	26	53.1
	Unanswered	3	6.1	2	4.1	0	0
	Total	**49**	**100**	**49**	**100**	**49**	**100**
Project Participated	Fewer than 5 projects	12	24.5	9	18.4	2	4.1
	5 to 10 projects	16	32.7	13	26.5	6	12.2
	10 to 15 projects	4	10.2	7	14.3	5	10.2
	More than 15 projects	13	26.5	18	36.7	36	73.5
	Unanswered	3	6.1	2	4.1	0	0
	Total	**49**	**100**	**49**	**100**	**49**	**100**
Average Project Value	Up to 100,000	12	24.5	7	14.3	9	18.4
	1 million	8	16.3	13	26.5	8	16.3
	10 million	12	24.5	8	16.3	13	26.5
	100 million	6	12.2	11	22.4	13	26.5
	1 billion +	7	14.3	8	16.3	6	12.2
	Unanswered	4	8.2	2	4.1	0	0
	Total	**49**	**100**	**49**	**100**	**49**	**100**
Type of Project Deliverables	Hardware	21	42.9	26	53.1	13	26.5
	Software	10	20.4	7	14.3	1	2.0
	Launcher	11	22.4	1	2	19	38.8
	Service/Operation	3	6.1	15	30.6	15	30.6
	Other	2	4.1	0	0	1	2.0
	Unanswered	1	2.0	0	0	0	0
	Total	**49**	**100**	**49**	**100**	**49**	**100**
	Complete	18	38.3	22	44.9	25	51.0
	Sub System	21	44.7	16	32.7	10	20.4

Typical System Hierarchy	Unit/Module	3	6.4	10	20.4	1	2.0
	Other	5	10.6	1	2.0	13	26.5
	Unanswered	2	4.1	0	0	0	0
	Total	**49**	**100**	**49**	**100**	**49**	**100**

Table 28: Study 1 (CSF) background of respondent's sector comparison

Appendix D: Research questionnaire (decision making) result analysis

Primary Scenario	You have been appointed as project manager of a research project that will be internally funded (from reinvested profits from previous projects). This is an important project for your company, and your ability to deliver within budget (and under budget if possible) is likely to affect your future career prospects. **Please Note:** All states and conditions affect project cost only. Please ignore any possible impact on schedule and technical performance. The **baseline cost** the project is **$20m ($20,000,000)**. You have an opportunity to use a new material in your project that could reduce total project cost.											
Secondary Scenario 1	In this situation using the new material in your project **could save $4m (50% chance) but might not work which would require rework costing $2m (50% chance)**. Would you take the chance under each of the following situations?											
	No	**Question**	**Complete (141)**		**Space (30)**		**Petroleum (29)**		**Construction (48)**		**Other (34)**	
			Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
	5	... if your projected cost at completion is currently $30m ($10m over budget)?	45	96	13	17	8	21	14	34	10	24
	6	... if your projected cost at completion is currently $24m ($4m over budget)?	69	72	16	14	15	14	21	27	17	17
	7	... if your projected cost at completion is currently $22m ($2m over budget)?	90	51	18	12	21	8	30	18	21	13
	8	... if your projected cost at completion is currently $20m (on budget)?	81	60	15	15	19	10	27	21	20	14
	9	... if your projected cost at completion is currently $18m ($2m under budget)?	99	42	22	8	21	8	33	15	23	11
Secondary Scenario 2	Now the potential saving **could save $4m (75% chance) but might not work which would require rework costing $8m (25% chance).** Would you take the chance under each of the following situations?											
	No	**Question**	**Complete (141)**		**Space (30)**		**Petroleum (29)**		**Construction (48)**		**Other (34)**	
			Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
	10	... if your projected cost at completion is currently $30m ($10m over budget)?	40	101	14	16	10	19	10	38	6	28
	11	... if your projected cost at completion is currently $24m ($4m over budget)?	59	82	17	13	12	17	16	32	14	20
	12	... if your projected cost at completion is currently $22m ($2m over budget)?	71	70	17	13	17	12	24	24	13	21
	13	... if your projected cost at completion is currently $20m (on budget)?	70	71	15	15	18	11	22	26	15	19

	14	... if your projected cost at completion is currently $18m ($2m under budget)?	78	63	18	12	17	12	25	23	18	16
Secondary Scenario 3	Now the potential saving **could save $10m (25% chance) but might not work which would require rework costing $2m (75% chance).** Would you take the chance under each of the following situations?											
	No	**Question**	**Complete (141)**		**Space (30)**		**Petroleum (29)**		**Construction (48)**		**Other (34)**	
			Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
	15	... if your projected cost at completion is currently $30m ($10m over budget)?	48	93	14	16	7	22	16	32	11	23
	16	... if your projected cost at completion is currently $24m ($4m over budget)?	56	85	19	11	7	22	19	29	11	23
	17	... if your projected cost at completion is currently $22m ($2m over budget)?	66	75	18	12	11	18	23	25	14	20
	18	... if your projected cost at completion is currently $20m (on budget)?	74	67	17	13	17	12	23	25	17	17
	19	... if your projected cost at completion is currently $18m ($2m under budget)?	90	51	20	10	19	10	29	19	22	12

Table 29: Study 2 (Decision making) results analysis.

Primary Scenario	You have been appointed as project manager of a research project that will be internally funded (from reinvested profits from previous projects). This is an important project for your company, and your ability to deliver within budget (and under budget if possible) is likely to affect your future career prospects. **Please Note:** All states and conditions affect project cost only. Please ignore any possible impact on schedule and technical performance. The **baseline cost** the project is **$20m ($20,000,000)**. You have an opportunity to use a new material in your project that could reduce total project cost.											
Secondary Scenario 1	In this situation using the new material in your project **could save $4m (50% chance) but might not work which would require rework costing $2m (50% chance)**. Would you take the chance under each of the following situations?											
	No	**Question**	**All Respondents (%)**		**Space (%)**		**Petroleum (%)**		**Construction (%)**		**Other (%)**	
			Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
	5	... if your projected cost at completion is currently $30m ($10m over budget)?	31.9	68.1	43.3	56.7	27.6	72.4	29.2	70.8	29.4	70.6
	6	... if your projected cost at completion is currently $24m ($4m over budget)?	48.9	51.1	53.3	46.7	51.7	48.3	43.8	56.2	50.0	50.0
	7	... if your projected cost at completion is currently $22m ($2m over budget)?	63.8	36.2	60.0	40.0	72.4	27.6	62.5	37.5	61.8	38.2

	8	... if your projected cost at completion is currently $20m (on budget)?	57.4	42.6	50.0	50.0	65.5	34.5	56.3	43.7	58.8	41.2
	9	... if your projected cost at completion is currently $18m ($2m under budget)?	70.2	29.8	73.3	26.7	72.4	27.6	68.8	31.2	67.6	32.4
Secondary Scenario 2	Now the potential saving **could save $4m (75% chance) but might not work which would require rework costing $8m (25% chance).** Would you take the chance under each of the following situations?											
	No	**Question**	**All Respondents (%)**		**Space (%)**		**Petroleum (%)**		**Construction (%)**		**Other (%)**	
			Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
	10	... if your projected cost at completion is currently $30m ($10m over budget)?	28.4	71.6	46.7	53.3	34.5	65.5	20.8	79.2	17.6	82.4
	11	... if your projected cost at completion is currently $24m ($4m over budget)?	41.8	58.2	56.7	43.3	41.4	58.6	33.3	66.7	41.2	58.8
	12	... if your projected cost at completion is currently $22m ($2m over budget)?	50.4	49.6	56.7	43.3	58.6	41.4	50.0	50.0	38.2	61.8
	13	... if your projected cost at completion is currently $20m (on budget)?	49.6	50.4	50.0	50.0	62.1	37.9	45.8	54.2	44.1	55.9
	14	... if your projected cost at completion is currently $18m ($2m under budget)?	55.3	44.7	60.0	40.0	58.6	41.4	52.1	47.9	52.9	47.1
Secondary Scenario 3	Now the potential saving **could save $10m (25% chance) but might not work which would require rework costing $2m (75% chance).** Would you take the chance under each of the following situations?											
	No	**Question**	**All Respondents (%)**		**Space (%)**		**Petroleum (%)**		**Construction (%)**		**Other (%)**	
			Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
	15	... if your projected cost at completion is currently $30m ($10m over budget)?	34.0	66.0	46.7	53.3	24.1	75.9	33.3	66.7	32.4	67.6
	16	... if your projected cost at completion is currently $24m ($4m over budget)?	39.7	60.3	63.3	36.7	24.1	75.9	39.6	60.4	32.4	67.6
	17	... if your projected cost at completion is currently $22m ($2m over budget)?	46.8	53.2	60.0	40.0	37.9	62.1	47.9	52.1	41.2	58.8
	18	... if your projected cost at completion is	52.5	47.5	56.7	43.3	58.6	41.4	47.9	52.1	50.0	50.0

		currently $20m (on budget)?										
	19	... if your projected cost at completion is currently $18m ($2m under budget)?	63.8	36.2	66.7	33.3	65.5	34.5	60.4	39.6	64.7	35.3

Table 30: Study 2 (Decision making) result percentages

Background of Decision-making survey respondents

Characteristics of Respondents			
Background Question	**Question Options**	**All Respondents (N=141)**	
		Number	**%**
Project Experience	0 to 2 years	7	5
	2 to 5 years	8	5.7
	5 to 10 years	25	17.7
	10 to 15 years	27	19.1
	More than 15 years	74	52.5
	Total	**141**	**100**
Project Management Experience	None	3	2.1
	Less than 2 years	12	8.5
	2 to 5 years	22	15.6
	5 to 10 years	37	26.2
	10 to 15 years	25	17.7
	More than 15 years	42	29.8
	Total	**141**	**100**

Table 31: Background of respondents who participated in the survey

Decision-making survey results analysis by situation

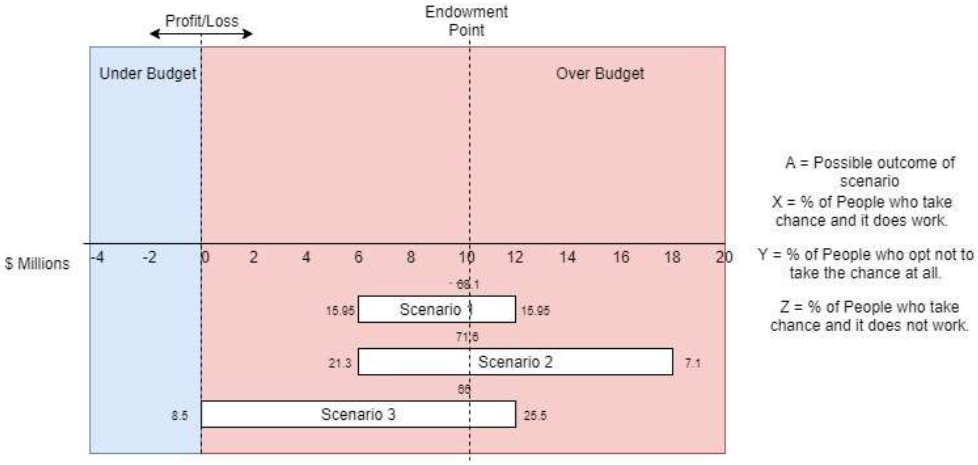

Figure 27: Situation one (project is $10 million over budget)

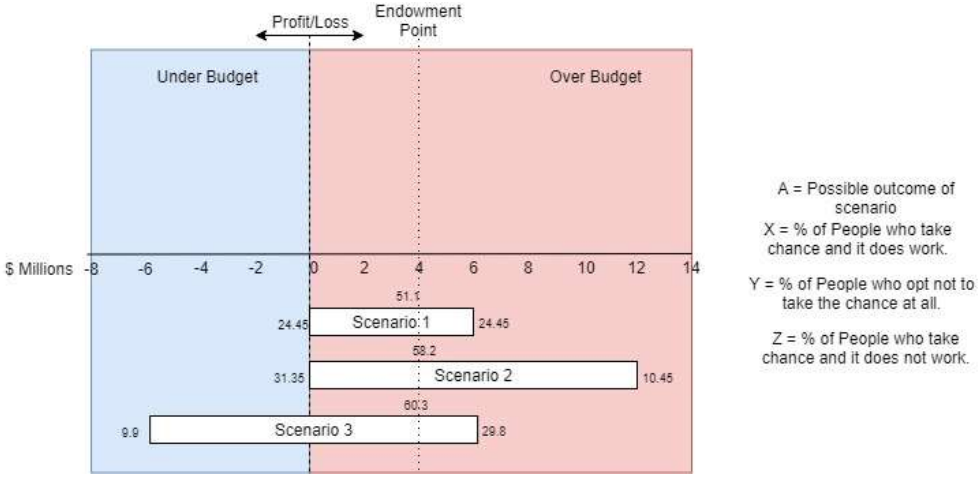

Figure 28: Situation two (project is $4 million over budget)

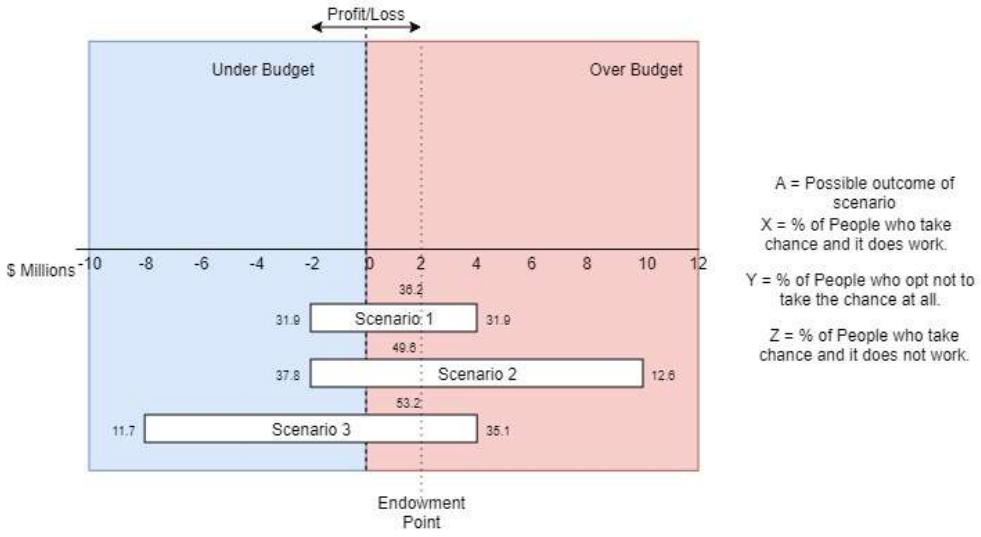

Figure 29: Situation three (project is $2 million over budget)

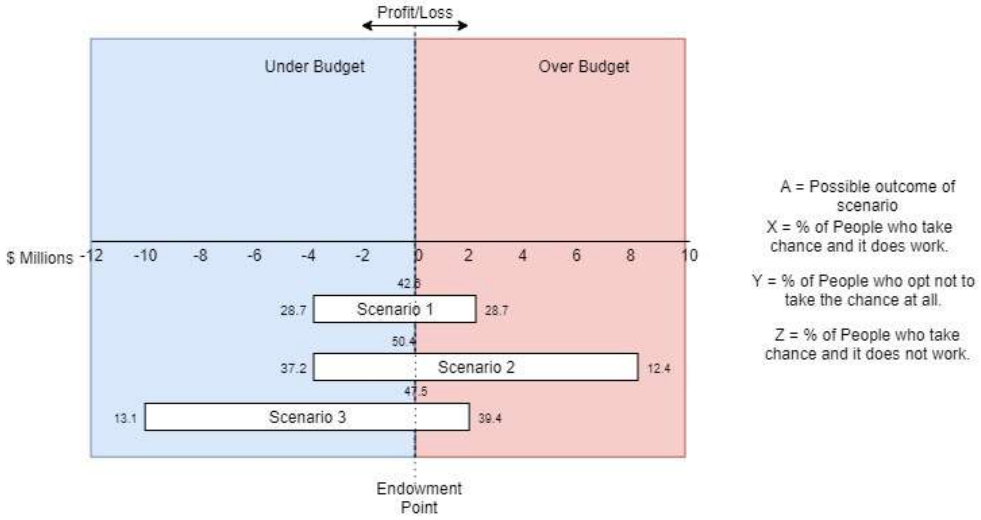

Figure 30: Situation four (project is on budget)

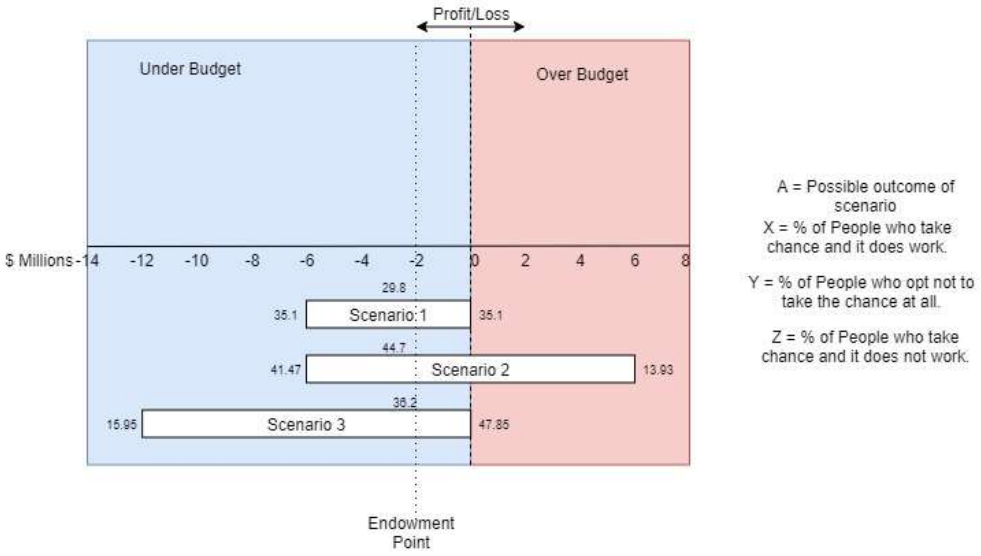

Figure 31: Situation five (project is $2 million under budget)

Background of Decision-making survey respondents (Sector specific)

Characteristics of Respondents									
Background Question	**Characteristics**	**Space subset (N=30)**		**Petroleum subset (N=29)**		**Construction subset (N=48)**		**Others subset (N=34)**	
		Num	%	Num	%	Num	%	Num	%
Project Experience	0 to 2 years	0	0	1	3.4	5	10.4	1	2.9
	2 to 5 years	1	3.3	2	6.9	0	0	5	14.7
	5 to 10 years	2	6.7	6	20.7	11	22.9	6	17.6
	10 to 15 years	8	26.7	10	34.5	4	8.3	5	14.7
	More than 15 years	19	63.3	10	34.5	28	58.3	17	50.0
	Total	**30**	**100**	**29**	**100**	**48**	**100**	**34**	**100**
Project Management Experience	None	0		0	0	3	6.3	0	0
	Less than 2 years	3	10.0	1	3.4	4	8.3	4	11.8
	2 to 5 years	3	10.0	7	24.1	6	12.5	6	17.6
	5 to 10 years	13	43.3	6	20.7	11	22.9	7	20.6
	10 to 15 years	1	3.3	6	20.7	11	22.9	7	20.6

	More than 15 years	10	33.3	9	31.0	13	27.1	10	29.4
	Total	**30**	**100**	**29**	**100**	**48**	**100**	**34**	**100**

Table 32: Sector specific background of respondents who participated in the survey

Decision-making survey results sector comparison

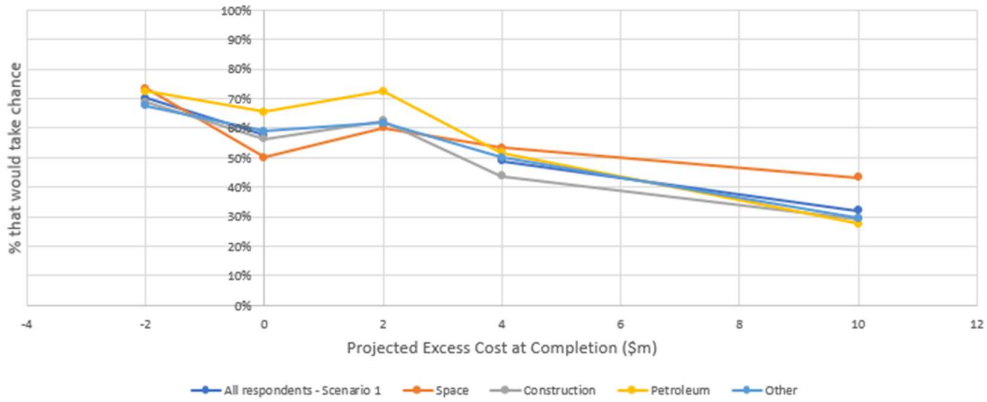

Figure 32: Sector comparison of Scenario 1 results

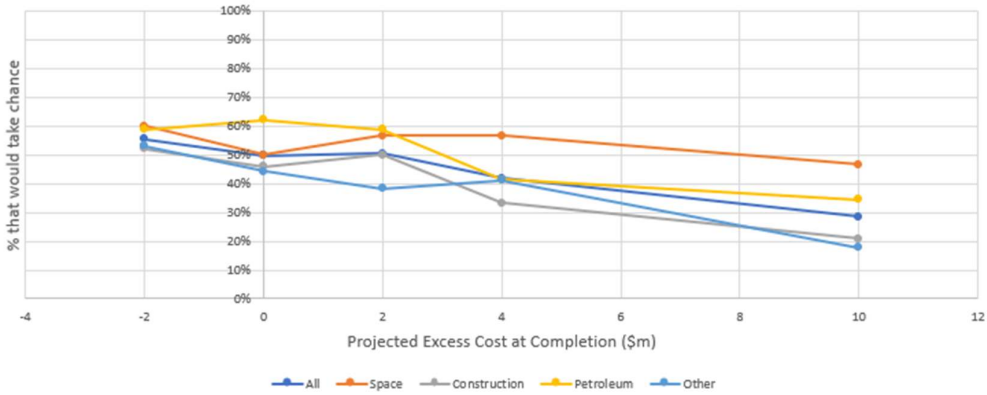

Figure 33: Sector comparison of Scenario 2 results

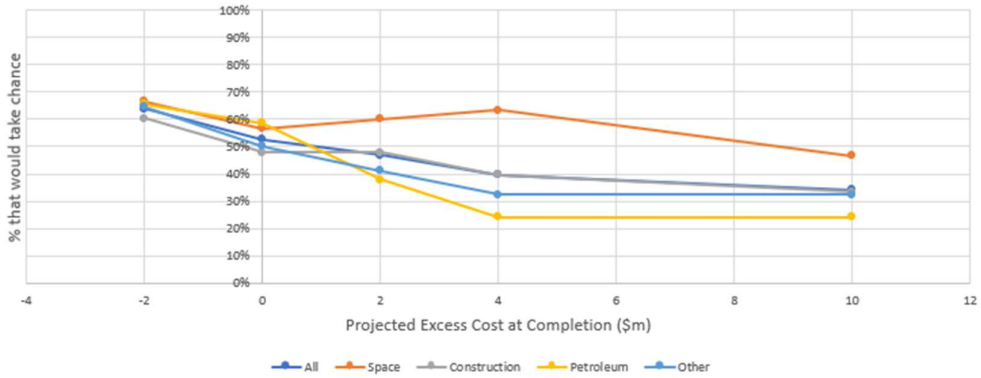

Figure 34: Sector comparison of Scenario 3 results

Appendix E: Focus group question guide

No	Questions	Possible Answers	Frequency	Percentage
1	What do you think about the results of the survey (perception of risk management)?	Easy to understand		
		Difficult to understand		
		Neither easy nor difficult to understand		
2	What do you think about the results of the survey (risk decision making)?	Easy to understand		
		Difficult to understand		
		Neither easy nor difficult to understand		
3	Do you think the results of the surveys are applicable to Engineering projects?	Yes		
		No		
		Not Sure		
4	Do you think the results are applicable to other sectors?	Yes		
		No		
		Not Sure		
5	Do you think project participants behave rationally? In your experience do	Yes		
		No		
		Not Sure		
6	If they don't, what are the reasons they deviate?	Open Ended	NA	NA
7	Do you think the process you go through when managing risk is rational (risk management process)? Why not?	Open Ended	NA	NA
8	Can you think of any other way people don't behave rationally? Why not?	Open Ended	NA	NA
9	Does your approach to risk management depend on the type of project your undertaking?	Open Ended	NA	NA
10	Would your decision make a difference if you were managing your own personal project?	Yes		
		No		
11	If yes, why would your decision change if your managing your own project?	Open Ended	NA	NA
12	Looking at the elements of prospect theory, how does reference dependence affect project management?	Open Ended	NA	NA

13	Looking at the elements of prospect theory, how does Loss aversion affect project management?	Open Ended	NA	NA
14	Looking at the elements of prospect theory, how does diminishing sensitivity affect project management?	Open Ended	NA	NA
15	Looking at the elements of prospect theory, how does probability weighting affect project management?	Open Ended	NA	NA
16	Overall, do you think the results are applicable to Engineering projects?	Yes.		
		No.		
		Not Sure.		
17	Are there multiple reference points in project?	Open Ended	NA	NA
18	How do respondents weight the relative importance of the two reference points, and does this vary depending on the current projected Cost at Completion (CAC)?	Open Ended	NA	NA
19	Why are respondents generally less willing to take the risk as the projected Cost at Completion (CAC) worsens (i.e. why is there a positive 'damage limitation effect'?	Open Ended	NA	NA
20	Do you take any notice of the projected CAC when making the decision? To what extent do you 'believe' the projected CAC and treat that as a given position. Or do you question this?	Open Ended	NA	NA
21	Do you take any notice of the objective of breaking even?	Open Ended	NA	NA
22	What is driving your decision of whether to take the risk? Do you feel that you are seeking to maximise profit, to minimise the risk of exceeding the original budget, to minimise the risk of making things worse relative to the current projections? Why?	Open Ended	NA	NA
23	How do you weigh the impact of pride/career vs the impact to the company?	Open Ended	NA	NA

24	What assumptions do you make about performance in the project in the future? Do you assume you might be able to make further savings later? Or you might incur further unexpected costs later?	Open Ended	NA	NA
25	How does the current performance of the project (projected CAC) affect their decision making?	Open Ended	NA	NA

Table 33: Focus group question guide and results

Background of focus group participants

Characteristics of Respondents			
Background Question	**Characteristics**	**All Respondents (N=12)**	
		Nº	%
Education	Bachelor's	5	41.67
	Master's	6	50
	Doctorate	1	8.33
	Other	0	0
	Total	**12**	**100**
Industry	Space	4	33.3
	Petroleum	4	33.3
	Construction	4	33.3
	Total	**12**	**100**
Most Frequent Role	Project Manager	7	58.33
	Systems Engineer	2	16.67
	Technical Specialist	0	0
	Project Administrator	3	25
	Other	0	0
	Total	**12**	**100**
Project Experience	0 to 2 years	0	0
	2 to 5 years	3	25
	5 to 10 years	5	41.67
	10 to 15 years	3	25
	More than 15 years	1	8.33
	Total	**12**	**100**
	None	0	0
	0 to 2 years	1	8.33

Project Managemen t Experience	2 to 5 years	3	25
	5 to 10 years	6	50
	10 to 15 years	2	16.67
	More than 15 years	0	0
	Total	**12**	**100**
Projects Managed	None	0	0
	Fewer than 5 projects	4	33.33
	5 to 10 projects	5	41.67
	10 to 15 projects	3	25
	More than 15 projects	0	0
	Total	**12**	**100**
Project Participated	Fewer than 5 projects	1	8.33
	5 to 10 projects	5	41.67
	10 to 15 projects	6	50
	More than 15 projects	0	0
	Total	**12**	**100**

Table 34: Background of focus group discussion participants