ANALYSIS OF CLIENT-LED INNOVATION ENABLERS IN CONSTRUCTION PROJECTS

A thesis submitted by

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Abstract

"There is no doubt that creativity is the most important human resource of all. Without creativity, there would be no progress, and we would be forever repeating the same patterns."

— Edward de Bono

Creativity is the single most important factor that distinguishes humans from other species, and putting creativity into practice, i.e. innovation, has contributed to all the progress that human civilisation has achieved. Innovation has gone through the fabric of all aspects of human life, bringing in all the improvements with which we live today. For the construction industry, which is responsible for providing much of the infrastructure to the world, the benefits of innovation are enormous.

However, innovation has not brought much benefits to construction projects up to now, mainly due to the difficulty in finding ways to promote innovation within projects. The complex dynamics happening within projects have been a barrier to improving our understanding of the innovation process within projects. The fact that no two projects are identical to each other has exacerbated this difficulty. Therefore, there is a compelling need to study the innovation related dynamics within projects helping us to identify the ways to promote innovation in projects to achieve enhanced outcomes. The research seeks studying innovation related to projects and deriving a model that depicts the actions that can be taken to promote innovation in projects, focussing on client activities in construction projects.

This study was inspired by the importance of innovation within the construction context, the capability of clients to enhance innovative outcomes in construction projects and the difficulty in identifying the innovation process at the project level. This abstract explains the model derived, how it was developed, benefits from the proposed model and other key findings of the research.

It was possible in this research to derive a simple and easy to use model identifying the groups of activities to promote innovation in project situation. The model developed was based on four innovation enabler categories (i.e. model constructs) of idea harnessing (use of new and beneficial ideas), relationship enhancement

(employing actions to improve relationships between parties to the project), incentivisation (providing incentives/rewards to promote innovative activities) and project team fitness (deliberate actions taken to strengthen the project team and improve its capacity to focus on innovative activities).

The identification of what promotes innovation possible in projects was approached first by studying the fundamental research on actions that make innovation possible in workplace situations as executing a project is a workplace endeavour. The model was tested in the space of construction environment confining to client's action, first by using the findings of other researchers through literature review, followed by undertaking a survey of project personnel working on construction projects. The data obtained from the questionnaire survey was analysed through rigours statistical procedures using a sophisticated software computer package SPSS Version 23. This followed in refining the conceptual model to a new model, termed as the Australian-specific model, as it contained data from Australia. Although looked different, this contained all the constructs of the conceptual model as it was derived using the questionnaire based on the conceptual model constructs. Both models were validated using case studies in construction projects. The conceptual model was recommended to use for the identification of actions that clients (or any other party) to promote innovation in projects due to the following reasons:

- It was derived using the findings of fundamental research, which has no bearing on the geographic locations, type of industry or the enabling body of the project.
- The model was tested through literature review, case studies and expert interviews with industry practitioners, both in the construction industry and out of the construction industry.
- It is a simple and easy to use model.
- It can be applied to any project irrespective of the industry, by any party such as the client, project manager, contractor and the designer.
- On the other hand, the Australian-specific model contained characteristics believed to be specific to the Australian construction industry and was somewhat complex and not easy to interpret and use. In addition, the model was developed using the factor analysis, and the selection of factors in factor analysis is subject to individual interpretation.

The derivation of this model is pioneering work and the model developed is the first in the world in this area as revealed by the comprehensive literature review. The thesis was written to contribute to both the theory and practice as it provides value to the academic community as well as to industry practitioners. There is a long list of recommendations for industry practitioners to adopt, if interested in using innovation in their projects to enhance outcomes.

As the fundamental research findings that used to derive the model were independent of the project area and the party promoting innovation, the model was tested using the findings of other researchers through literature review and through case studies and expert interviews, which reaffirmed the inference that it could be used for projects in general by any party interested in promoting innovation. This opens up wide benefits to the area of project management.

Many researchers have pointed out that contemporary project management approaches contribute to achieve only limited project goals. With this breakthrough, project owners and project managers have found a new tool to achieve enhanced outcomes from their projects. It may compel contemporary project management approaches to integrate innovation management for greater benefit to project owners and project managers.

In addition to deriving a model to depict actions to promote innovation in projects, this research introduced a definition to describe project level innovation, for the first time in the world.

Innovation can result in ideas to improve productivity and sustainability, and to reduce greenhouse gas emissions in projects. Therefore, it is not an exaggeration to state that this research has the potential to bring immense benefits to the world.

Certification of Thesis

This thesis is entirely the work of Samson Fernando except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

Principal Supervisor: Associate Professor David Thorpe

Associate Supervisor: Dr Steven Goh

Student and supervisors signatures of endorsement are held at the University.

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I wish to dedicate the contribution from this academic effort to my two beautiful granddaughters, Amaya and Aavya.

List of Publications

1. Fernando, S, Panuwatwanich, K, & Thorpe, D 2019, ‘Analyzing client-led innovation enablers in Australian construction projects’, *International Journal of Managing Projects in Business* [Accepted for publication].
2. Fernando, S, Thorpe, D, Panuwatwanich, K, & Goh, S 2015, ‘Looking Beyond Contemporary Project Management’, *EPPM2015 conference,* September 2015, Gold Coast, Australia.
3. Fernando, S, Abeysekera, V, & Thorpe, D 2013, ‘Role of Clients in driving innovation in construction projects’, *38th Annual AUBEA Conference on Managing Construction in a Global Market*, Auckland, New Zealand.
4. Fernando, S, 2009, ‘Enhancing outcomes from infrastructure through Innovation’, *Southern Engineering Conference: Infrastructure Investment for a New Economy*, Engineers Australia, Ipswich, Australia.
5. Fernando, S, 2006, ‘Innovation through harnessing Constructive Ideas of Construction Personnel’, *Conference on Clients Driving Innovation: Moving Ideas into Practice*, CRC for Construction Innovation, Gold Coast, Queensland, Australia.
6. Fernando, S, 2005, ‘Harnessing Innovative Ideas of Our Members for a Sustainable Prosperous Future’, *Southern Engineering Conference*, Engineers Australia, Toowoomba, Australia.

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List of Acronyms

ANOVA	Analysis of Variance
AUD	Australian Dollar
CEO	Chief Executing Officer
CFA	Confirmatory Factor Analysis
CI	Construction Industry
CV	Coefficient of variation
df	Degree of Freedom
ECI	Early Contractor Involvement Contract
EFA	Exploratory Factor Analysis
GDP	Gross Domestic Product
GPR	Ground penetrating radar
ICT	Information and Communication Technology
IT	Information Technology
KMO	Kaiser-Meyer-Olkin Measure of Sampling Adequacy
KPI	Key Performance Indicator
MAR	Missing at Random
MCAR	Missing Completely at Random
NMAR	Not missing at random
OECD	Organisation for Economic Co-operation and Development
PAF	Principal axis factoring
PCA	Principal Component Analysis
PM	Project Manager
PPP	Public Private Partnership
R&D	Research and Development
SD	Standard Deviation
SE	Standard Errors of the Mean
VE	Value Engineering
VM	Value Management

CHAPTER 1
INTRODUCTION

1.1 Chapter overview

As the purpose of this research is to find ways of using innovation to enhance outcomes in projects, it is appropriate to know the benefits of innovation. In this modern world, the key to success in any area of life is innovation. Whether running a business or executing a project, innovation helps to find better ways to get improved results. Innovation is the tool used by humankind to achieve great strides in almost all spheres of life. In any dynamic economy, innovation is the catalyst for development and growth (Murphy et al. 2011). Innovation can drive productivity improvement across all industrial sectors (Gans & Stern 2003).

Although innovation seems to have penetrated many areas of life, the fruits of innovation are yet to be tasted fully in the area of project execution, especially in the area of construction. This study on finding ways for clients to promote innovation in construction projects is an attempt to reach the hitherto mostly uninhabited area of construction innovation at the project level, and open it for innovation.

This first chapter is an overview of this thesis, providing an introduction to the research as well as an introduction to the thesis. The introduction to the research includes the reasons for selecting the research area and explaining the need for the research. In addition, research objectives, scope and boundaries are discussed. This is followed by the thesis layout, which consists of brief descriptions of each chapter. The thesis begins with an introduction to the research.

1.2 Introducing the research

The purpose of the research is to develop a model to assist clients of construction projects to identify actions for promoting innovation in their projects. It is hoped to develop this model by investigating the actions of Australian construction clients. This is the first time that such a model is presented for the benefit of construction clients.

1.2.1 Research area selection

The area selected for this study is the construction industry. The construction industry facilitates the creation of dwellings and infrastructure needs for communities such as roads, bridges, communication networks and water infrastructure. This industry is vital for the comfortable living of people and is an important activity contributing to economies all over the world, especially the developed world. Horta et al. (2013) identified construction as a major industry worldwide, accounting for a sizeable proportion of most countries' gross domestic product (GDP). According to them, the global construction industry (CI) makes up approximately 9% of the world's GDP. This sector is the largest industrial employer in most countries, accounting for around 7% of total employment worldwide (Horta et al. 2013). According to Australian Bureau of Statistics (2012), the construction industry's share of the total production of goods and services in the Australian economy was 7.7% in 2010–2011, as measured by industry gross value added. Therefore, if the productivity of the construction industry is raised, it would contribute to substantial economic gains and the prosperity of nations. The best way to raise productivity is through innovation.

According to the Australian Innovation System Report published by the Australian Department of Innovation, Industry, Science and Research, there are a number of avenues to increase productivity, but innovation is the most significant factor (DIISR 2011). Gans & Stern (2003) confirmed this by stating that innovation can drive productivity improvement across all industrial sectors. Innovation can drive productivity in the construction industry, and the research topic, promoting innovation in construction projects, is vital for bringing prosperity to nations. Therefore, it is a worthy topic to concentrate on.

As noted by Serrat (2009), there is no simple universal formula for successful innovation. It is nonlinear, works at many levels, and is too complex to be pinned down in that way. It is uniquely human and cannot be done by machines. Nevertheless, innovations are not random. They occur in relation to the past, present, and future conditions of an organisation (Serrat 2009). In this case, Serrat was referring to organisational innovation. Extending the same argument, innovation can be promoted in construction projects by taking appropriate actions. Apart from improving productivity, there are many other benefits to clients in promoting innovation in their projects. They include: decreased cost, competitive advantage, and higher quality (Gambatese & Hallowell 2011); increased organisational commitment and higher organisational motivation (Lu & Sexton 2006); improved organisational effectiveness (Dulaimi et al. 2005); and additional cost savings in future projects due to gained experience, health and safety improvements, minimised waste, reduced carbon emissions, enhanced corporate image and recognition, future collaboration along the supply chain, knowledge transfer to inform future projects, client and end user satisfaction, and improved quality of life for local people (Ozorhon 2013). As Robbins (1994) pointed out, innovation is the process of taking a creative idea and turning it into a useful product, service, or method of operations. There is no limit to the ideas of people and, therefore, it can be argued that there is no limit to the benefits from innovation to construction clients. This research looks at the actions (or enablers) that clients can use in construction projects, either directly or through the project team, to generate and foster innovative activities.

1.2.2 Research perspective

Although there are many players, the client is considered to have the capacity to exert influence and foster innovation in a construction project. According to Blayse and Manley (2003), many players are required to execute a construction project. They include the client, major contractor, subcontractors and suppliers. However, the most important role in a construction project is played by the client as the organiser of the project. Blayse & Manley (2003) support this argument by stating that clients are commonly considered to have enormous capacity to exert influence on firms and individuals involved in construction in a manner that fosters innovation. As clients can have such an influence in construction projects, this study aims to find the actions that clients can take to foster innovation in their projects.

1.2.3 Need for the research

Although the clients are interested in promoting innovation in their projects, a lack of adequate knowledge in the subject area has been a barrier. Not much research has been conducted at the execution level of construction projects. The execution level or stage, as used in this thesis, refers to the concept planning, detailed planning, designing and construction stages of a construction project, and excludes the maintenance stage.

With respect to innovation in the construction industry, there are two aspects to consider: innovation in firms engaging in the construction industry and innovation at the project level. Many researchers have looked at the innovation performance of construction firms. However, not much focus has been given to innovation at the execution level. Citing other researchers, Ozorhon (2012) commented that much of construction innovation is co-developed at the project level. However, most of the literature has focused on investigating innovation at the firm level, and the project level has largely been ignored. This is primarily because of the difficulties in monitoring the different activities conducted by different parties in each stage of a construction project (Ozorhon 2012). Chen (2014) added that, despite the panoply of studies that use a wide variety of measures to describe innovation outcomes and the input characteristics that affect those outcomes as well as firm performance, most studies focus on firms engaged in innovation and relatively a few studies explore projects engaged in innovation.

According to Keegan and Turner (2002), project management research has focussed largely on practical issues pertaining to 'getting projects done' rather than on strategic or conceptual issues such as innovation. They also reported that a review of articles published in the main project management journals (a total of 663 papers) made no mention of innovation as an important topic.

Uchitpe et al. reported in 2016 of a study conducted to predict the potential research areas that could appear in the foreseeable future of project management research using a quantitative approach. This study utilised different keywords that had been extracted from all publications of a reputed project management journal over a period of five years (i.e. 2009-2013). Innovation was not among the research areas that was found in this study.

However, a burst analysis from 2006 to 2012 conducted by Pollack and Adler (2015) to understand more recent developments in project management found that ‘Innovation’ and ‘New Product Development’ were among most frequently used keywords when searching for ‘project management’. They searched keywords of research publications in the ISI and Scopus databases, in response to the search term

'Project Management'. With this finding, they suggested that project management is more recently being viewed as a potential way of driving or managing change and innovation within organisations. However, there was no mention about project level innovation in this research paper suggesting that project level innovation in project management area is still not identified as a key focus area.

As part of this research, the researcher has undertaken a comprehensive literature review, and found that much of the focus in construction innovation research has been on organisational innovation. For example, scholars such as Blayse and Manley (2004), Dulaimi et al. (2005), Hardie et al. (2005), Kulatunga et al. (2011) and Ling (2003) have investigated construction innovation at the organisational level. The aspects they investigated included knowledge management, management skills, organisational culture, organisational structure and processes, commitment of top management towards innovation, organisational climate and leadership characteristics supportive of innovation. On the other hand, project level innovation focuses on innovations undertaken by project personnel during the execution of the project (from the inception to construction and handover phases). The project personnel can include the client's team, designers, contractors and suppliers (both service suppliers and material and equipment suppliers). The literature review undertaken has shown limited research on project level innovation with no comprehensive research attempting to identify a framework with factors that could promote innovation in projects. This study attempts to bridge the knowledge gap of researching the project level innovation.

Some believe that innovation happens haphazardly. However, it is proven that more innovative activities happen only when innovation is promoted. Shalley et al. (2004) found that when individuals feel supported and encouraged, it results in enhanced intrinsic motivation and subsequent creativity. Creativity, which leads to the generation of ideas, is the first stage in innovation. Therefore, increased creative activity leads to more innovative activities.

According to Keegan and Turner (2002), it is now well accepted that certain organisational contexts provide support for innovation. Therefore, facilitation leads to more innovative activities in a project. The client is the person or the entity that can leads the innovation facilitation process. The client can take deliberate actions to harness the energies of all project personnel, including contractors, service providers and suppliers, to enhance innovative activities in a project. Therefore, finding the client's intentional actions to promote innovation in construction projects was chosen as the aim of this research.

In projects where a team representing the client is managing the project with other parties such as designers and contractors executing the work, the role of the client in relation to innovation is mostly to encourage, promote and motivate other parties to innovate and provide necessary support for their innovative activities. This research provides a useful tool for such client teams attempting to facilitate innovation in their projects.

1.2.4 Research objectives and scope

The following are the research objectives to be examined in this study:

1. Explore clients' influence in promoting innovation in their construction projects.
2. Explore actions that construction clients can take to promote innovation in their projects.
3. Group these actions (also called innovation enablers) into major categories for easy identification.
4. Develop a model using identified categories as constructs that encapsulate their relationship with innovative outcomes which can then be used to depict the mechanisms of enhancing innovation promotion in construction projects.
5. Empirically-test the model using the data from Australia.
6. Validate the developed model through case studies of selected construction projects.
7. Contribute knowledge to the research area of project level innovation in the context of the construction industry, and provide practical recommendations for clients and policy makers to use in promoting innovation in construction projects.

The research is constrained within boundaries which are discussed next.

1.2.5 Research boundaries

Having research boundaries is essential to focus more attention to the subject matter being investigated. Defining a scientific problem involves the task of laying down boundaries within which a researcher shall study the problem with a pre-determined objective in view (Kothari 2004). Stipulating boundary conditions is also essential in developing theories. A theory is a set of systematically interrelated constructs and propositions intended to explain and predict a phenomenon or behaviour of interest, within certain boundary conditions and assumptions (Bhattacherjee 2012).

In this study, a theory is to be developed which requires the stipulation of boundary conditions. The following are the boundary conditions identified for the research:

1. Only data from Australia will be used to test the conceptual model.
2. The research covers all the phases in a construction project except the maintenance phase. Compared to other phases, the maintenance phase activities tend to be more repetitive (there can be exceptions), providing limited opportunities for innovation in general. Therefore, having the maintenance activities included may not provide the opportunity to identify relevant enablers. However, major rehabilitation work, which may require innovative solutions, are included.
3. Residential construction activities are generally repetitive, therefore, not considered in the study due to the same reason of providing limited opportunities for innovation. However, major building constructions such as construction of shopping complexes, hospitals etc. and some residential constructions which can be considered to be unique, are included.

This research looks at the innovation in projects from the point of view of clients or client's representatives (such as contract administrators, designers).

Having gone through the importance of this research and its objectives, the next section provides an overview of the thesis.

1.3 Thesis structure

Unlike many other research documents, this thesis was written to benefit both the academic community and the practicing world. While the academic aspects such as methodology, theory, analysis and processes are explained in detail, the aspects beneficial to industry practitioners are also explained in detail culminating with a lengthy recommendation for any practitioners who prefer to use innovation to enhance outcomes in their construction projects.

The thesis layout, which provides a framework for the overall document, is illustrated in *Fig.1.1*. It is explained below summarising each chapter starting with the Chapter 2.

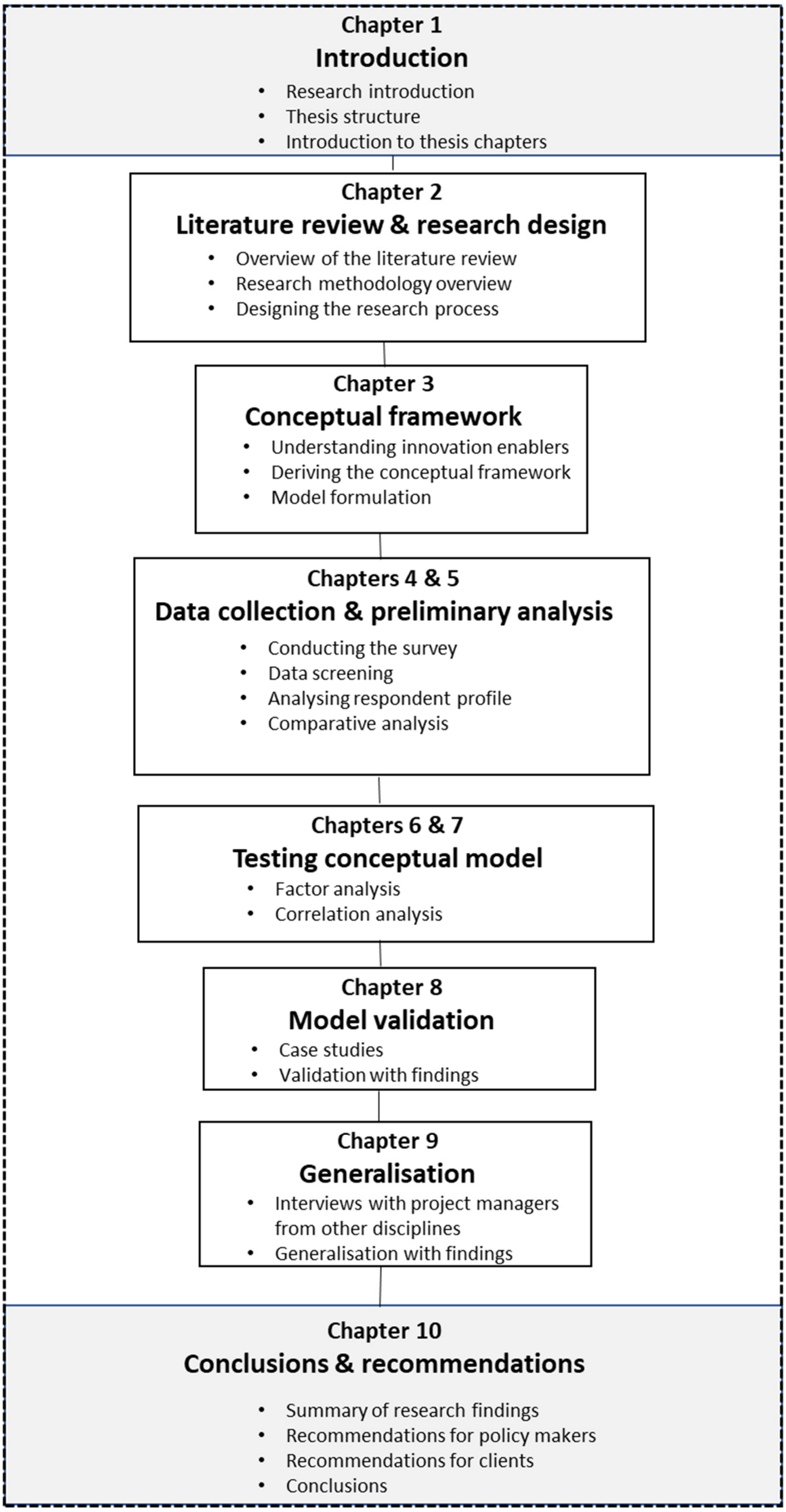


Figure 1.1 Thesis layout

1.3.1 Chapter 2

Chapter 2 on Literature review and research design provides details of the literature review undertaken, research methodology considered, and ends with the research design adopted. It covers information on the importance of the literature review, the results of the literature review conducted to understand research and background to this subject area, and the development of the research design.

Understanding how to conduct research includes looking at different categories of research such as natural science and social science and approaches to research design such as quantitative and the qualitative approaches.

Philosophical aspects of research such as positivism, interpretivism, realism and criticalism under different research concepts such as ontology, epistemology and axiology, are discussed next. This understanding leads to the consideration of the research process including the methodology and data collection.

As the research is in the area of innovation, it is necessary to understand innovation in general and construction innovation in particular, narrowing down to project level innovation. These topics are covered in the chapter. While exploring project level innovation, it was soon realised that there was no proper definition to describe project level innovation. Therefore, an attempt was made to develop a definition for project level innovation, and this definition was tested with industry experts. The chapter describes the new definition and how it was developed.

Having understood how scientific research is conducted and the background of the research to be conducted, it was possible to develop a research design, which is given towards the end of the chapter.

1.3.2 Chapter 3

Chapter 3 is dedicated to identifying a conceptual framework to describe client-led actions to promote innovation in construction projects. A two-fold approach was used. First conducting a general literature review to identify the innovation enablers that previous research has found which can be used in the construction area. Another literature review was then conducted to get a deeper understanding into what motivate people interested in engaging in innovative activities in workplace situations, and relate these findings to construction projects. Both these approaches led to the development of a framework and a model to describe main categories of client-led actions to promote innovation in construction projects. The chapter describes how this framework and the model were developed.

1.3.3 Chapter 4

Having developed the research design and the framework to describe main categories of client-led actions to promote innovation in construction projects leading to a model, it was time to collect data to test the model. The first task of the research design was to conduct a survey of project personnel involved in construction projects in Australia that collected their perceptions on innovative aspects. The chapter describes how the survey questionnaire was prepared, pilot tested and conducted, and how the data was screened for further analysis. It also includes the finalised survey questionnaire and how the missing data was dealt with. The respondent profile was analysed including gender, education level, age group, experience, engineering area of organisation, occupation and the type of organisation they worked. The survey questionnaire also included details of their selected projects and the details of the project profiles such as the project engineering area, project delivery type, project cost and project complexity. These were statistically analysed and the results are given in the chapter.

1.3.4 Chapter 5

Having completed initial screening of data for the statistical analysis and analysed the respondents' profile and project information, this chapter on comparative analysis is dedicated to describing the detailed analysis conducted to understand the characteristics of the construction industry as shown by collected data.

The survey collected information on the use of idea generation techniques in construction projects and the form of relationship of the client's team with the contractor. These were analysed and the chapter provides details of the following:

- Types of idea generation techniques widely used in construction projects; and
- Widely used types of relationships between the client team and the contractor in construction projects.

The survey also collected information on client-led innovation enablers on the following five scales: idea harnessing, relationship enhancement, incentivisation, project team fitness and innovation performance. The innovative performance of construction projects with respect to the above categories are detailed in the chapter. In addition, the survey provided the opportunity to make several comparisons between groups regarding the innovative performance. The chapter provides details of the analysis of the following:

- Comparison between public and private sector organisations;
- Comparison between different delivery types;
- Comparison between different categories of project costs; and
- Comparison between different categories of project complexity.

With the analysis of survey data, the chapter provides an understanding of the innovative characteristics of the Australian construction industry.

1.3.5 Chapter 6

This chapter addresses statistically testing of the developed model using the Australian data collected through the questionnaire survey. It was necessary to undertake a factor analysis to reduce the large number of variables to fewer unobserved factors in order to enhance general interpretability and to detect hidden structures in the data. The chapter describes how the factor analysis was conducted. It explains the theoretical aspects behind factor analysis, how the data was prepared to undertake the factor analysis and the details of the process undertaken. The chapter also deals with non-normality of data and the testing of data for scale reliability and internal consistency.

1.3.6 Chapter 7

After undertaking the factor analysis in Chapter 6, eight different groupings (factors) were found, which represented independent variables. The next step was to find out whether these factors have any influence on innovation promotion. In addition, the relationships of these factors between themselves (if existed) also needed to be found.

This chapter explains the analysis undertaken to identify the association/s (if any) using correlation analysis. It describes the non-parametric tests used for correlation analysis such as Spearman’s rank correlation coefficient and Kendall’s tau tests, how the analysis was conducted, and the results obtained.

1.3.7 Chapter 8

Up to this point, the chapters focused on developing a theory using the literature review and testing it with the data collected through the questionnaire. This chapter discusses validation of the findings through case studies. It explores the theoretical aspects of using case studies for validating research, factors to be considered when designing a case study, and how the case studies were to be conducted. Details of each case study is given separately, and the results are discussed in relation to the findings from the literature review, data collection and the data analysis.

1.3.8 Chapter 9

Having found a model applicable to construction projects for clients to identify actions that can promote innovation, there was evidence that the model could be applied to any project irrespective of whether it is in the construction industry or not. Therefore, an attempt was made to test whether the developed model could be applicable in other project management areas. This was done through interviewing project managers in areas other than construction, the details of which are given in this chapter. The results from these interviews and other evidence clearly showed that the model developed could be used for any project, irrespective of the industry area.

1.3.9 Chapter 10

As the final chapter, this is dedicated to providing a brief summary of the research undertaken, commenting on its findings, and making conclusions. Unlike many other research projects, which are only of academic importance, findings of this research would be beneficial both for the academic world and for the practising world. While elaborating on the academic significance of the findings, this chapter also provides a number of recommendations for both policy makers and clients interested in promoting innovation in their projects. Following these recommendations would enable clients to achieve enhanced benefits from their projects, something that is impossible to achieve through conventional project management practices.

This completes the summary of each chapter which would give an understanding of the research undertaken. Detailed discussions are provided from here onwards. The next chapter will concentrate on the literature review and the research design.

CHAPTER 2

LITERATURE REVIEW & RESEARCH DESIGN

2.1 Chapter overview

The essential first step and foundation when undertaking a research project is the review of literature. Therefore, a literature review was undertaken to uncover the sources relevant to the topic under study and to avoid the reinvestigation of what is already known. It covered information on undertaking research in the subject area and the background to the subject area. This was later extended to cover other areas such as identifying the conceptual framework and identifying different research processes and techniques. The understanding gained through the literature review was used to develop the research process. This chapter covers the details of the literature review undertaken and the research design adopted.

The details of the literature review undertaken is given first.

2.2 Literature review

As explained by Rowley (2002), descriptive and explanatory studies need propositions. Research questions need to be translated into propositions. The researcher has to make a speculation, on the basis of the literature and any other earlier evidence as to what they expect the findings of the research to be. The data collection and analysis can then be structured in order to support or refute the research propositions (Rowley 2002).

Literature review is essential for research. The production of new knowledge is fundamentally dependent on past knowledge (O ' L e a r y 2004). Past knowledge can be acquired through the literature review. The purpose of a literature review is three-fold: (1) to survey the current state of knowledge in the area of inquiry, (2) to identify key authors, articles, theories, and findings in that area, and (3) to identify gaps in knowledge in that research area (Bhattacherjee 2012).

In this study, the literature review is used to understand how to conduct scientific research, to identify the research background related to the topic to be studied, especially what is meant by innovation and how it can be related to construction projects, to identify enablers that clients can use in augmenting innovative activities in construction projects, and how to categorise identified enablers into major groups.

In the literature review over 300 papers, the majority from peer-reviewed journals, were studied including subject areas such as the following:

- General information on innovation;
- Organisational innovation;
- Construction innovation;
- Project level innovation;
- Innovation models; and
- Innovation related project aspects such as procurement, communication, relationship contracting, the management role, project manager characteristics, organisational climate and culture and regulatory structure.

During the literature review process, several databases were searched including the following:

- American Society of Civil Engineers
- EconLit
- Emerald Engineering Library
- Engineering Collection
- MyJSTOR
- Science Citation Index
- Scopus
- Science Direct
- Tailor & Francis online.

Using these databases, a keyword search was carried out to identify relevant research papers. When relevant research papers were found, their authors were also searched to identify any other publications relevant to the research. In addition, the relevant references cited by the authors were also searched. All the papers relevant to the research were collected and catalogued using EndNote software for further scrutiny.

Although the literature review was conducted on many areas, only the information gathered on undertaking research and the background to the subject area are given below. Other information gathered from the literature review is given under relevant sections to facilitate better readability.

2.3 Understanding research

To ensure its effectiveness, this investigation was carefully planned in the most appropriate manner. Research is a specialised field requiring considerable knowledge. Undertaking a study without adequate knowledge of research processes can lead to difficulties later on. There are many pitfalls which can be avoided with a proper understanding of research. Therefore, in order to ensure the success of the research, a proper understanding of the following was required:

- What is research?
- What research methods are available?
- What is the most suitable approach to this study?

Once a proper understanding of research is gained, the background of the research area needs to be explored. As Bhattacherjee (2012) pointed out, the first phase of research is exploration. This phase includes exploring and selecting research questions for further investigation, examining the published literature in the area of inquiry to understand the current state of knowledge in that area, and identifying theories that may help answer the research questions of interest (Bhattacherjee 2012). This exploration will lead to the identification of a suitable approach to conduct the study, enabling the formulation of research questions and the research design. First, it is necessary to understand what research is.

2.3.1 Scientific research

As explained by Bhattacherjee (2012), the goal of scientific research is to discover laws and postulate theories that can explain natural or social phenomena, or in other words, build scientific knowledge. Depending on the purpose of research, scientific research projects can be grouped into three types: exploratory, descriptive, and explanatory. Exploratory research is often conducted in new areas of inquiry, where the goals of the research are: (1) to scope out the magnitude or extent of a particular phenomenon, problem, or behaviour, (2) to generate some initial ideas about that phenomenon, or (3) to test the feasibility of undertaking a more extensive study regarding that phenomenon. Descriptive research examines the what, where, and when of a phenomenon, and explanatory research seeks answers to why and how types of questions. Explanatory research seeks explanations of observed phenomena, problems, or behaviours (Bhattacherjee 2012).

The objective of this research is to investigate innovation in construction projects in order to find out whether construction clients have any influence in promoting innovation, and if so, identify actions that clients can take to promote innovation. It falls into explanatory group.

2.3.2 Categories of research

Bhattacherjee (2012) refers science to a systematic and organised body of knowledge in any area of inquiry. Science can be grouped into two broad categories: natural science and social science. Natural science is the science of naturally occurring objects or phenomena, such as light, objects, matter, earth, celestial bodies, or the human body. In contrast, social science is the science of people or collections of people, such as groups, firms, societies, or economies, and their individual or collective behaviours. Social sciences can be classified into disciplines such as psychology (the science of human behaviours), sociology (the science of social groups), and economics (the science of firms, markets, and economies) (Bhattacherjee 2012). This research falls into social science area under the sociology group.

2.3.3 Approaches to research

As Kothari (2004) explained, there are two basic approaches to research, viz., the quantitative approach and the qualitative approach. The former involves the generation of data in quantitative form which can be subjected to rigorous quantitative analysis in a formal and rigid fashion. On the other hand, qualitative approach to research is concerned with subjective assessment of attitudes, opinions and behaviour (Kothari 2004).

According to Johnson and Onwuegbuzie (2004), quantitative purists believe that social observations should be treated as entities in much the same way that physical scientists treat physical phenomena. Quantitative purists maintain that social science inquiry should be objective. That is, time and context-free generalisations are desirable and possible, and real causes of social scientific outcomes can be determined reliably and validly (Johnson & Onwuegbuzie 2004).

However, there is the third research paradigm according to Johnson and Onwuegbuzie (2004), i.e. mixed methods research which has unique benefits to social science researchers. Mixed methods research is defined as the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study. Philosophically, mixed research makes use of the pragmatic method and system of philosophy. Its logic of inquiry includes the use of induction (or discovery of patterns), deduction (testing of theories and hypotheses), and abduction (uncovering and relying on the best of a set of explanations for understanding one's results) (Johnson & Onwuegbuzie 2004).

Commenting on research design, Bhattacherjee (2012) noted that sometimes, joint use of qualitative and quantitative data may help generate unique insight into a complex social phenomenon that are not available from either types of data alone, and hence, mixed-mode designs that combine qualitative and quantitative data are often highly desirable.

This research uses the mixed method, where a survey of industry practitioners will be used for data collection which will be statistically analysed (quantitative approach). The validation is through case studies (qualitative approach).

Understanding research also requires the understanding of research philosophy, which will be discussed next.

2.4 Research philosophy

When undertaking research, it is of paramount importance to consider research philosophy to determine the research strategy. As explained by Kulatunga et al. (2007), thinking through philosophies can help to determine the most suitable method to conduct the research at the very early stages. Research philosophy can help to identify the type of evidence required, how to gather it and how to interpret it in order to find an answer to the basic problem under investigation.

Kulatunga et al. (2007) explained three paradigms to research philosophy. They are: positivism, interpretivism and realism. According to Håkansson (2013), there is another important paradigm, i.e. criticalism. These form the basis for contrasting views taken on the ontological, epistemological and axiological assumptions, explained below.

2.4.1 Positivism

O ' L e a r y (2004) has described positivism as the paradigm that social phenomena can be approached with scientific method and makes a number of assumptions about the world and the nature of research. Positivists believe that the world is knowledgeable, predictable, and singular in truth and reality. For positivists, social research is a purely scientific endeavour that needs to follow set of rules and procedures. The methodologies are usually hypothesis-driven, reliable, and reproducible. The findings are generally quantitative, statistically significant, and generalisable (O ' L e a r y 2004).

2.4.2 Interpretivism

Sexton (2003) described interpretivism as a search for explanations of human action by understanding the way in which the world is understood by individuals. According to Flower (2009), the focus of this paradigm is on understanding the meanings and interpretations of 'social actors' and to understand their world from their point of view. Understanding what people are thinking and feeling, as well as how they communicate, verbally and non-verbally, are considered important, and given the subjective nature of this paradigm, and the emphasis on language, it is associated with qualitative approaches to data gathering. This position is also described as constructivist, as anti-positivist and as post-positivist (Flower 2009).

2.4.3 Realism

Explaining realism, Flower (2009) noted that it takes aspects from both positivist and interpretivist positions and holds that real structures exist independent of human consciousness, but that knowledge is socially created. Realism accepts that reality may exist in spite of science or observation, and so there is validity in recognising realities that are simply claimed to exist or act, whether proven or not. Realists take the view that the underlying mechanisms are simply the powers or tendencies that things have to act in a certain way, and that other factors may moderate these tendencies depending upon circumstances, and hence the focus is more on understanding and explanation than prediction. The realist researcher enquires into the mechanisms and structures that underlie institutional forms and practices, how these emerge over time, how they might empower and constrain social actors, and how such forms may be critiqued and changed (Flower 2009).

2.4.4 Criticalism

As Håkansson (2013) explained, criticalism assumes that the reality is socially, historically, and culturally constituted, produced and reproduced by people. The critical assumptions focus on the oppositions, conflicts and contradictions in society and seek to find and eliminate the causes of alienations, dominations, injustice and so on. The criticalism assumption can be used when learning about users' culture and how it might affect the usages of computer systems.

This research falls on to the realism paradigm as the focus of the research is to enquire into the mechanisms and structures that underlie institutional forms and practices in the area of construction innovation. In addition, the perceptions of industry practitioners will be studied to examine client-led innovations in construction projects. Therefore, the study area belongs to interpretivism as well since the search for explanations of human action is by understanding the way in which the world is understood by individuals.

2.5 Research concepts

Research activity is epitomised by two concepts according to Resca (2009). They are: epistemology and ontology. Ontology is the study of being, of what exists and of what is think-able. It determines what types of entities constitute reality. Ontology questions the real nature of entities, how they come into being and why. Epistemology refers to how we know what we know. Therefore, rather than focusing on the object of the investigation, it concentrates on how knowledge can be acquired on the entities being examined. This means that epistemology has to do with methods: theories, concepts, rules and the procedures applied within a discipline in order to derive at knowledge (Resca 2009).

Sexton (2003) explained the addition of another dimension to research philosophy, axiology. Ontology is the what? - the assumptions that are made about the nature of reality; epistemology is the how? – the general set of assumptions about how knowledge is acquired and accepted about the world; and axiology is the why? – the assumptions about the nature of values and the foundation of value judgement (Sexton 2003). These concepts are explained below.

2.5.1 Ontology

Burrell and Morgan (1994) described two ontological positions used in social science research: nominalist and realism. According to them, the nominalist position revolves around the assumption that the social world external to individual cognition is made up of nothing more than names, concepts and labels which are used to structure reality. The nominalist does not admit to there being any 'real' structure to the world which these concepts are used to describe. The 'names' used are regarded as artificial creations whose utility is based upon their convenience as tools for describing, making sense of and negotiating the external world. On the other hand, realism postulates that the social world external to individual cognition is a real world made up of hard, tangible and relatively immutable structures. Whether or not these structures are label and perceive, the realists maintain, they still exist as empirical entities. We may not even be aware of the existence of certain crucial structures and therefore have no 'names' or concepts to articulate them. For the realist, the social world exists independently of an individual's appreciation of it. The individual is seen as being born into and living within a social world which has a reality of its own. It is not something which the individual creates-it exists 'out there'; ontologically it is prior to the existence and consciousness of any single human being. For the realist, the social world has an existence which is as hard and concrete as the natural world (Burrell & Morgan 1994).

This research project analyses the perceptions of industry practitioners about factors that promote innovation in construction projects. It assumes that critical structures exist for enablers promoting innovation, and that there is an opportunity to explore them. Therefore, the research takes the ontological position of realism.

2.5.2 Epistemology

Sexton (2003) used positivism and anti-positivism to explain epistemology. According to Sexton, positivism is used to characterise epistemologies which seek to explain and predict what happens in the social world by searching for regularities and causal relationships between its constituent elements. The epistemology of anti-positivism may take various forms but is firmly set against the utility of a search for laws or underlying regularities in the world of social affairs. For the anti-positivist, the social world is essentially relativistic and can only be understood from the point of view of the individuals who are directly involved in the activities which are to be studied (Sexton 2003).

This research uses industry practitioners, who are directly involved in the activities that are to be studied. As the position of anti-positivism is that one can only 'understand' by occupying the frame of reference of the participant in action, the research uses the anti-positivism position with regard to epistemology.

2.5.3 Axiology

Axiology, the third component of the research philosophy, is classified based on whether the reality is value free or value driven. In value neutral research, the choice of what to study and how to study, can be determined by objective criteria, whilst in value laden research choice is determined by human beliefs and experience which marks the two extreme ends of a continuum (Pathirage et al. 2008). This research uses the knowledge and experience of industry practitioners within the context of construction innovation that can give a value-laden aspect to the research in respect of axiology. Kulatunga et al. (2007) undertook similar research on construction clients and innovation and they followed a similar research philosophy. Having looked into the philosophy of the research, the research process can now be discussed.

2.6 Research process

According to Kothari (2004), the research process consists of the following steps:

1. Formulating the research problem;
2. Extensive literature survey;
3. Developing the hypothesis;
4. Preparing the research design;
5. Determining sample design;
6. Collecting the data;

7. Execution of the project;
8. Analysis of data;
9. Hypothesis testing;
10. Generalisations and interpretation; and
11. Preparation of the report or presentation of the results, i.e., formal write-up of conclusions reached (Kothari 2004).

Fig. 2.1 is a representation of the research process suggested by Kothari.

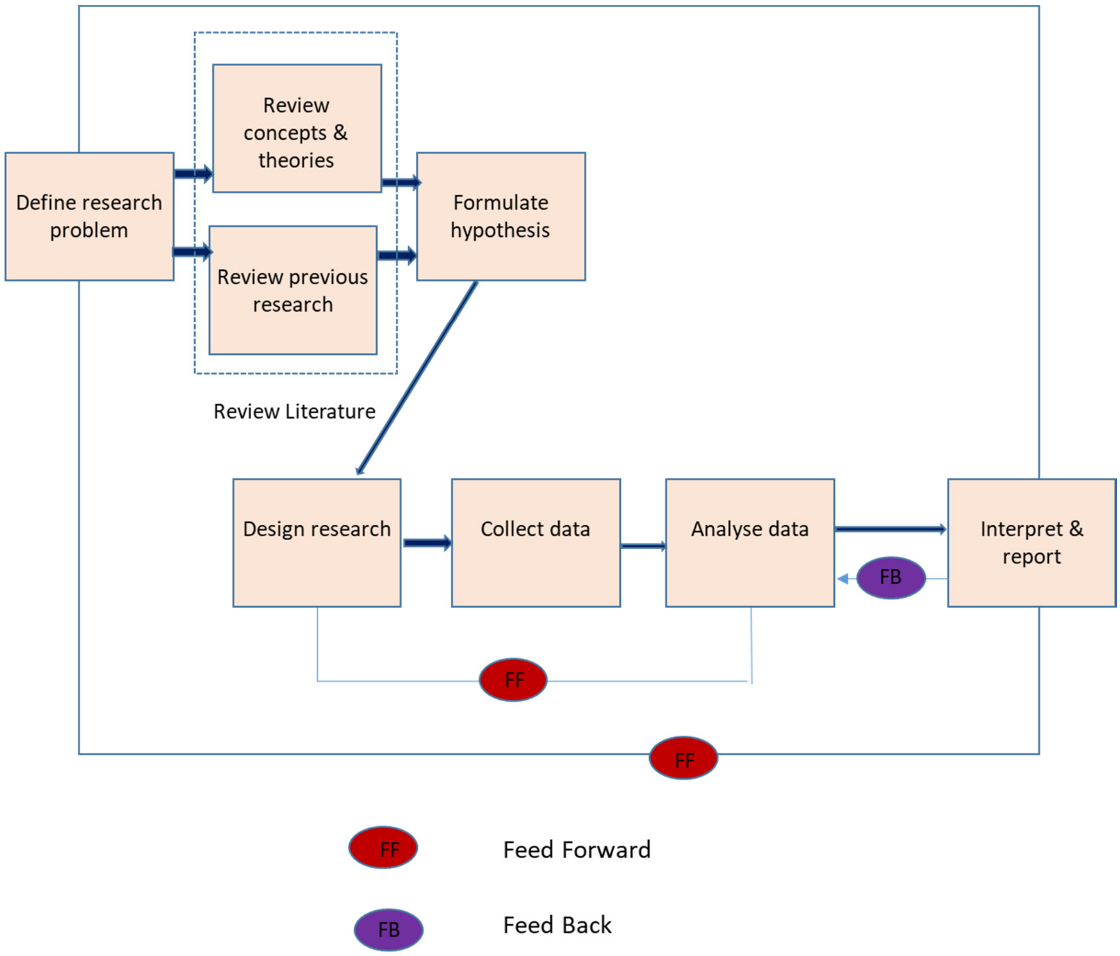


Figure 2.1 Representation of the research process adopted from Kothari (2004, p. 11)

According to O ' L e a r y (2004), a research undertaking requires the following:

1. Methodology: the framework associated with a particular set of paradigmatic assumptions that will be used to conduct the research, i.e. scientific method, ethnography, action research.
2. Methods: the techniques that will be used to collect data, i.e. interviewing,

surveying, participative observation.

3. Tools: the devices that will be used to help collect data, i.e. questionnaires, observation checklists, interview schedules.
4. Methodological design: the plan for conducting the study that includes all of the above.

These will be discussed next, beginning with research methodology.

2.6.1 Research methodology

Research methodology is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically (Kothari 2004). Careful design of research methodology enables to prepare a sound research design which is a comprehensive plan for data collection in an empirical project. It is a “blueprint” for empirical research aimed at answering specific research questions or testing specific hypotheses, and must specify at least three processes: (1) the data collection process, (2) the instrument development process, and (3) the sampling process (Bhattacherjee 2012).

Summarising the research philosophy and the research process, Håkansson (2013) has produced a portal of research methods and methodologies which is given in *Fig. 2.2.* The left side of the portal belongs to the quantitative research methodologies using experiments and large data sets to reach a conclusion. The right side is the qualitative research using investigations (or development) in an interpretative manner on, commonly, rather small data sets, to create theories or artefacts.

It also can be seen in *Fig. 2.2* that the research spectrum is divided into four sectors using dotted lines. The research process for this study belongs to the middle two sectors where data collection methods are case study, questionnaire, observations and interviews. These collection methods have been widely used in the study. For example, the observations made by the researcher while referring to research findings of others are given in the thesis where relevant and helped to come to conclusion in some instances. In addition, observing the persons who were interviewed has given the researcher some clues about the strengths of their arguments. These observations are given in several places when referring to individual interviews.

Justification for using the data collection methods of case study, questionnaire, observations and interviews are given under respective sections to facilitate better reading. They are given below:

- Case studies – Section 8.2
- Questionnaire– Section 4.2
- Interview – Section 2.10.1

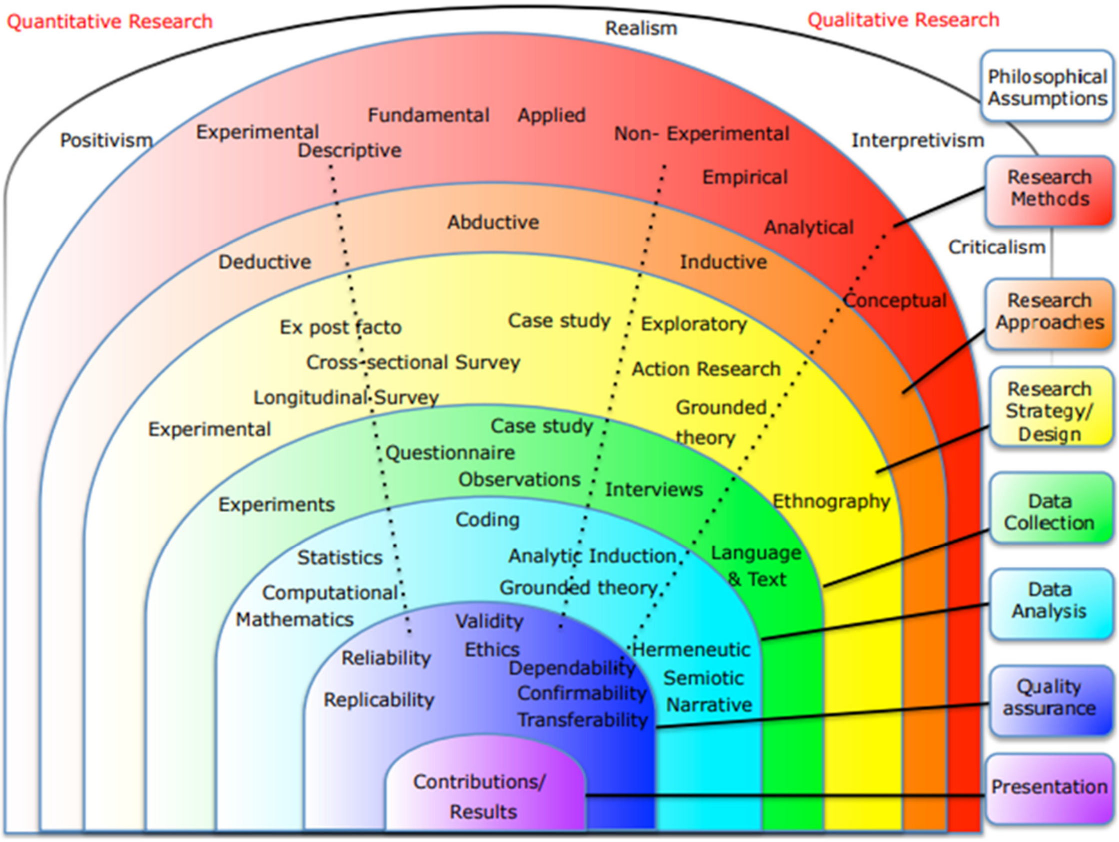


Figure 2.2 Portal of research methods and methodologies (Håkansson 2013, p. 2)

2.6.2 Research ethics

When undertaking research, it is of paramount importance that the research is conducted in an ethical manner. The university of Southern Queensland follows a rigid procedure on research ethics. The research methodology and processes are to be informed and permission needs to be obtained prior to commencing the research. In addition, progress reports on ethics need to be submitted regularly with a final report after completing the research. This research project had no issues with regard to matters relating to research ethics.

The sections of this chapter up to now have been devoted to understanding research, especially research philosophies, methods and strategies. With this understanding, attention can now be focussed on establishing the current state of knowledge of the study area.

2.7 Understanding research background

To determine the research process, it is first necessary to understand the research background. This research is on innovation. Therefore, it is necessary to have a clear understanding of what innovation is, especially in relation to the subject area project level innovation.

The proceeding sections will discuss innovation in general terms, construction innovation, and project level innovation. First, innovation is explained in general terms.

2.7.1 Innovation in general

As explained by Barker and Coy (2004), innovation is the practical application of imagination. Creativity and innovation are unique human features which have favoured the differentiation of the human species in the course of evolution from all the other living species. The capacity to put these features to productive use continues to be of fundamental importance within the social and economic structure of human society (Barker & Coy 2004).

Innovation is closely related to creativity. Creativity, in general, means the ability to combine ideas in a unique way to make unusual associations between ideas. Innovation is the process of taking a creative idea and turning it into a useful product, service, or method of operations (Robbins 1994).

Creativity and innovation are two human characteristics, closely connected to each other. Innovation begins with creativity. According to Serrat (2009), creativity is the mental and social process—fuelled by conscious or unconscious insight—of generating ideas, concepts, and associations. Innovation is the successful exploitation of new ideas: it is a profitable outcome of the creative process which involves generating and applying in a specific context products, services, procedures, and processes that are desirable and viable. Naturally, people who create and people who innovate can have different attributes and perspectives (Serrat 2009).

Many scholars have come up with different definitions for innovation. The UK Cabinet Office (2003) defined successful innovation as the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes efficiency, effectiveness or quality. According to Baregheh et al. (2009), innovation is the generation, acceptance and implementation of new ideas, processes products or services.

The Oslo Manual for measuring innovation (OECD/Eurostat, 2018) defines four types of innovation: product innovation, process innovation, marketing innovation and organisational innovation.

- Product innovation: A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics.
- Process innovation: A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
- Marketing innovation: A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- Organisational innovation: A new organisational method in business practices, workplace organisation or external relations.

Engineers Australia's Innovation in Engineering Report (2012) described innovation as involving the following:

- Creating or generating new activities, products, processes and services;
- Seeing things from a different perspective;
- Moving outside the existing paradigms;
- Improving existing processes and functions;
- Disseminating new activities or ideas; and
- Adopting things that have been successfully tried elsewhere.

As stated in this report, innovation covers the area from minor quality improvements to 'cutting edge' products and services. Incremental innovation is the making of small improvements to existing technologies and practices. Such innovation often occurs through the process of practise, and while it is sometimes predictable in the short term, it can lead to immense changes in the long term. Radical (or "breakthrough") innovation is making breakthroughs that change the way we do things altogether. It tends to result from basic research, and tends to be much more unpredictable (UK Government 2014).

2.7.2 Innovation theories

Many theories and models have been developed to explain innovation. Prominent among them is the innovation diffusion theory which has dominated the social science for a long time. In his book on 'Social Science Research: principles, methods, and practices', Bhattacherjee (2012) has explained the innovation diffusion theory as follows:

> *"Innovation diffusion theory (IDT) is a seminal theory in the communications literature that explains how innovations are adopted within a population of potential adopters. The four key elements in this theory are: innovation, communication channels, time, and social system. Innovations may include new technologies, new practices, or new ideas, and adopters may be individuals or organisations. At the macro (population) level, IDT views innovation diffusion as a process of communication where people in a social system learn about a new innovation and its potential benefits through communication channels (such as mass media or prior adopters) and are persuaded to adopt it. Diffusion is a temporal process; diffusion process starts off slow among a few early adopters, then picks up speed as the innovation is adopted by the mainstream population, and finally slows down as the adopter population reaches saturation. The cumulative adoption pattern therefore an S-shaped curve and the adopter distribution represents a normal distribution. All adopters are not identical, and adopters can be classified into innovators, early adopters, early majority, late majority, and laggards based on their time of their adoption. The rate of diffusion also depends on characteristics of the social system such as the presence of opinion leaders (experts whose opinions are valued by others) and change agents (people who influence others' behaviour s).*
>
> *At the micro (adopter) level, innovation adoption is a process consisting of five stages: (1) knowledge: when adopters first learn about an innovation from mass-media or interpersonal channels, (2) persuasion: when they are persuaded by prior adopters to try the innovation, (3) decision: their decision*

to accept or reject the innovation, (4) implementation: their initial utilisation of the innovation, and (5) confirmation: their decision to continue using it to its fullest potential.

Five innovation characteristics are presumed to shape adopters' innovation adoption decisions: (1) relive advantage: the expected benefits of an innovation relative to prior innovations, (2) compatibility: the extent to which the innovation fits with the adopter's work habits, beliefs, and values, (3) complexity: the extent to which the innovation is difficult to learn and use, (4) trialability: the extent to which the innovation can be tested on a trial basis, and (5) observability: the extent to which the results of using the innovation can be clearly observed. The last two characteristics have since been dropped from many innovation studies. Complexity is negatively correlated to innovation adoption, while the other four factors are positively correlated. Innovation adoption also depends on personal factors such as the adopter's risk-taking propensity, education level, cosmopolitanism, and communication influence. Early adopters are venturesome, well educated, and rely more on mass media for information about the innovation, while later adopters rely more on interpersonal sources (such as friends and family) as their primary source of information. IDT has been criticized for having a "pro-innovation bias," that is for presuming that all innovations are beneficial and will be eventually diffused across the entire population, and because it does not allow for inefficient innovations such as fads or fashions to die off quickly without being adopted by the entire population or being replaced by better innovations" (Bhattacherjee 2012, p. 31).

Barrett and Sexton (2006) developed a simple generic innovation model (see *Fig.2.3)* for corporate, firm or organisational innovation. This model suggests that enhanced performance, owing to successful innovation, is achieved by first taking an appropriate innovation focus. This focus should reflect organisational capabilities, but must also be responsive to contextual factors, so that energy is channelled through e□ective innovation processes (Barrett & Sexton 2006).

Ozorhon (2013) developed another innovation framework to explain the innovation process in a construction project setting. This is given in *Fig. 2.4*. It defines innovation as a system with several components relating to the participating organisations and to project-specific factors. The components of the innovation process lie on one side and the project participants on the other within a three-dimensional project environment. The primary components of the innovation system are the drivers, inputs, enablers, barriers, innovative activities, benefits, and impacts.

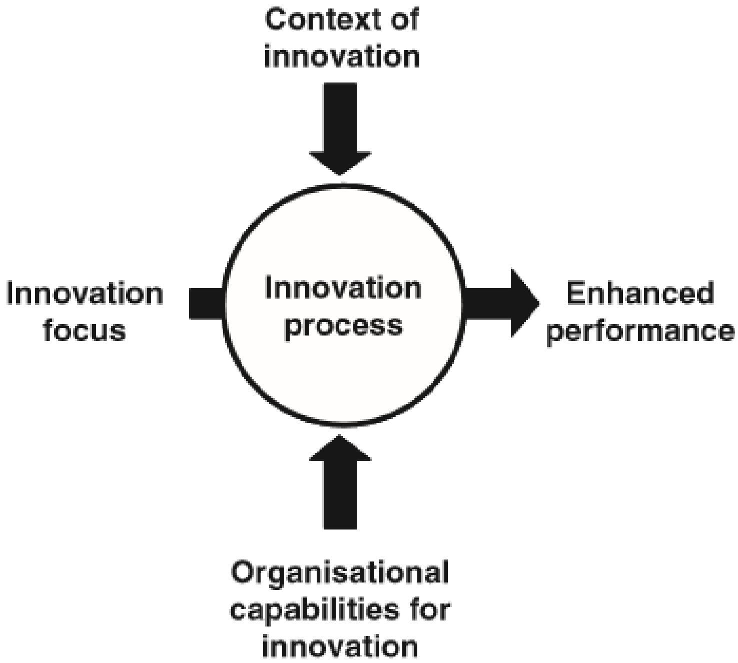


Figure 2.3 A simple generic innovation model (Barrett and Sexton 2006, p. 332)

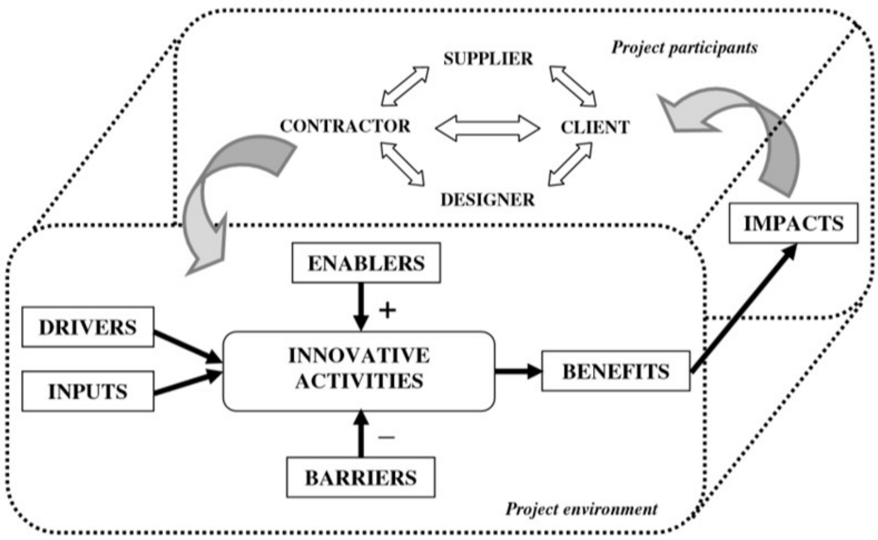


Figure 2.4 Framework to explain the innovation process in a construction project setting (Ozorhon 2013, p. 457)

2.7.3 Corporate innovation

Corporate innovation is about creating new products, services, or processes that enable an organisation to solve a problem, satisfy a customer need, or achieve a predetermined goal (Price & Davis 2002). The Organisation for Economic Co-operation and Development (OECD) defined organisational innovation as a new organisational method in business practices, workplace organisation or external relations (OECD/Eurostat, 2018).

As Beales (2004) pointed out, successful organisations innovate. Innovation in operational and business practice is essential in any organisation wishing to increase efficiency and profitability, and adapt rapidly to changing external conditions. It is one of the primary forces of economic improvement (Beales 2004). The literature is inundated with research findings on corporate innovation, some of which have been used in this research. The reason for incorporating relevant findings of corporate innovation research is that construction projects are executed by organisations.

Although an understanding of corporate innovation is essential, the subject area of the research falls into construction innovation. Therefore, it is also necessary to understand construction innovation which will be discussed next.

2.8 Construction innovation

The organisations managing the construction industry belong to either the public or private sector. The mode of operations of these organisations is somewhat different from traditional organisations. Due to their mode of operation, they belong to the so-called ‘project-based’ organisations. In order to understand construction innovation, it is worth exploring the characteristics of project-based organisations.

Project-based organisations focus on the production and/or delivery side of a firm’s business, and is characterised by ‘the coexistence of a continuing organisation structure, typically based on functional departments with a temporary organisational structure based on project teams’ (Barrett & Sexton 2006). According to Keegan and Turner (2002), project-based firms are engaged in unique, novel and transient work, delivering bespoke outputs to clients and working to customised specifications in both capital and new product development projects. All project-based firms use teams, usually multi-disciplinary, to achieve their goals. Because no two projects are the same, project-based firms deal with change as a matter of their daily commercial reality. Further, because they produce one-off offerings rather than commodities (project-based firms do not mass produce and stockpile bridges, advertisements or hospitals), customer orientation is always a strategic concern (Keegan & Turner 2002).

Project-based firms use projects to provide unique services to their clients. These services can be combinations of custom-designed products and related services. Examples are engineering and construction companies, consultancies and system integrators (Blindenbach-Driessen & Ende 2006). The construction industry is generally driven by single and unique projects, each creating and disbanding project teams (Barrett & Sexton 2006).

Although innovation in 'conventional' organisations has been widely researched, it is apparent that not much research has been conducted on project-based organisations. Discussing firms operating in design, engineering and construction, Gann and Salter (2000) argued that they are not adequately addressed in the innovation literature. Keegan and Turner (2002) also noted that there remains a dearth of studies on innovation in project-based firms. They singled out the main reason for this as project management is a relatively new area which first came to be in the 1950's (Keegan & Turner 2002).

As Kissi et al. (2012) pointed out, the construction industry has been subjected to criticisms for delivering products and services which fall below clients' expectation of quality, price certainty and assured delivery and the performance can be improved through the promotion of innovation. However, many researchers believe that, compared to many other industries, the construction industry has not made use of innovation for its improvement. The need to improve innovation in the construction industry received a boost world-wide when the high-profiled Egan Report (Egan 1998) was published in the UK. This was the report of the Construction Task Force on improving the quality and efficiency of the UK construction industry. The report highlighted areas for improvement in the construction industry, and identified innovation as the way to improve and made many recommendations about how it can be done. This bold initiative was an eye opener, and the adaptation of some of these recommendations subsequently accelerated the rate of innovation in the construction industry, not only in the UK but in the world.

A similar bold initiative was undertaken in 2002 in UK, this time preparing a report on UK Government research and development policies and practices with regard to the construction industry (Fairclough 2002). This review focussed on the importance of research and development as a catalyst for promoting innovation in the construction industry, highlighting the role of the government. Not only did it initiate changes in the policies of the UK government, it provided a revelation to many other countries in the world.

However, in spite of all these efforts, it appears that innovation in the construction industry is still at a low level compared to other industries. For example, Thomson and Munns (2010) said that over the past decade the construction sector has increasingly recognised the potential damage that low innovation levels has had on the long-term future and sustainability of the industry. According to them, traditionally a low priority, a lack of value or importance has been assigned culturally to innovation, and despite recent improvements, its levels still lag behind other sectors.

2.8.1 Benefits from construction innovation

Benefits from innovation to the construction industry have been highlighted by numerous researchers. These benefits include: improvement of working conditions, quicker construction times and better value for clients (Eaton et al. 2006); increased organisational commitment and higher organisational motivation (Lu & Sexton 2006); developing solutions to problems encountered on site, aspirations towards improved performance and organisational effectiveness (Dulaimi et al. 2005); decreased cost, competitive advantage, higher quality and increased productivity (Gambatese & Hallowell 2011); responding to conflicting expectations from clients (Kissi et al. 2012); profit maximisation (Lim & Ofori 2007); and productivity improvement and improvement of client satisfaction (Ozorhon 2012). There is a significant amount of anecdotal information that suggests that innovation is the underpinning driver that leads to enhanced outcomes across different kinds of projects (Duffield & Maghsoudi 2013).

Commenting on the importance of innovation in construction projects, Tawiah and Russel (2008) found that the delivery of infrastructure projects as long-term capital investments is impacted in most cases by critical issues of budget constraints, program delays, quality and safety concerns, and an increasingly complex stakeholder environment. Innovation, as it relates to the physical, process, organisational/ contractual, and financial/revenue dimensions of a project, has a central role to play in, not only contributing to the requirements set for a wide variety of project performance metrics, but also improving upon them (Tawiah & Russel 2008). Newton (1999) went even further stating that innovation has been advanced as the fourth dimension of competition in construction, along with cost, quality and time.

2.8.2 Construction innovation research

Research into construction innovation started around 1986 with a series of contributions from Tatum (Christian Brockmann et al. 2016). During the journey up to now, it has taken a few approaches including looking at construction organisations, procurement processes and construction projects. Manley (2006), for example, looked at the innovation competence of public sector construction clients and implementation of innovation by manufacturers subcontracting to construction projects. Along with others, the same author also explored the drivers of firm-level innovation in the construction industry (Manley & Mcfallan 2006). Panuwatwanich (2008) examined the innovation diffusion process in Australian architectural and engineering design organisations. However, most of these studies were on the construction industry as a whole, and organisations working in the industry in particular.

2.8.3 Client's role in promoting construction innovation

Scholars seem to unite behind the idea that clients are influential in construction projects and have the ability to promote innovation. Explaining construction projects, Blayse & Manley (2003) noted that many players are required to execute a construction project such as the client, major contractor, subcontractors and suppliers. However, the most important role in a construction project is played by the client as the organiser of the project. Clients are commonly considered to have an enormous capacity to exert influence on firms and individuals involved in construction in a manner that fosters innovation (Blayse & Manley 2003). In construction, it is well known that the owner is not a mere buyer of the end product the owner is one of the key players before and during project execution (Nam &

Tatum 1997). According to Kulatunga et al. (2011), it is evident that client's personal characteristics such as competence, value judgment on innovation, foresight and vision towards innovation promotion, self-motivation, flexibility and receptiveness to change and receptiveness to risks has an empowering effect on the client's roles, thus influencing all aspects of innovation. These show that clients have an influence in construction projects to shape outcomes.

It is also apparent that there is a strong positive correlation between the client's activities and innovation in the construction process. Many researchers have provided evidence to support this claim. According to Nam and Tatum (1997), a high level of owner involvement in the project, including risk sharing, commitment to innovation and leadership in project planning and execution, appear to be critical for the success of the innovation process. Kulatunga et al. (2011) supported this finding by stating that there is compelling evidence from other industries to confirm the influence that a client can exert on the generation of innovation. According to Asad et al. (2005), clients can act as a catalyst to foster innovation by exerting pressure on the supply chain partners to improve overall performance, and by helping them to devise strategies to cope with unforeseen changes, by demanding high standard of work and by identifying specific novel requirements for a project. Blayse and Manley (2003) stated that the more demanding, experienced and technically competent the client, the more likely it is to stimulate innovation in the projects it commissions.

Therefore, to facilitate innovation in a construction projects, clients need to take a leadership role. This research focuses on the actions that clients can take to enhance project level innovation in construction projects.

Having understood innovation relevant to the construction industry, it is now time to go to the subject area, project level innovation. The section below discusses project level innovation.

2.8.4 Project level innovation

According to Russell et al. (2006), innovation can occur at the project delivery level at one or more of the project stages/phases—design, construction, and operation and maintenance. Innovations appear to be ubiquitous in design and construction (Russell et al. 2006). Research conducted by Noktehdan et al. (2019) on innovations in different phases of infrastructure projects revealed the following:

- Technology innovations were largest during the starting of the project (Phase 1);
- The organising and preparing phase (Phase 2), which include detail design, created the most method, product, and design types of innovations; and
- Process innovations were predominant during the construction and handover phase (Phase 3).

The developed a phase-based innovation framework is given as *Fig. 2.5.* In order to promote innovation in construction infrastructure projects, they recommended building innovative KPIs (Key Performance Indicators) in contract and tender documents.

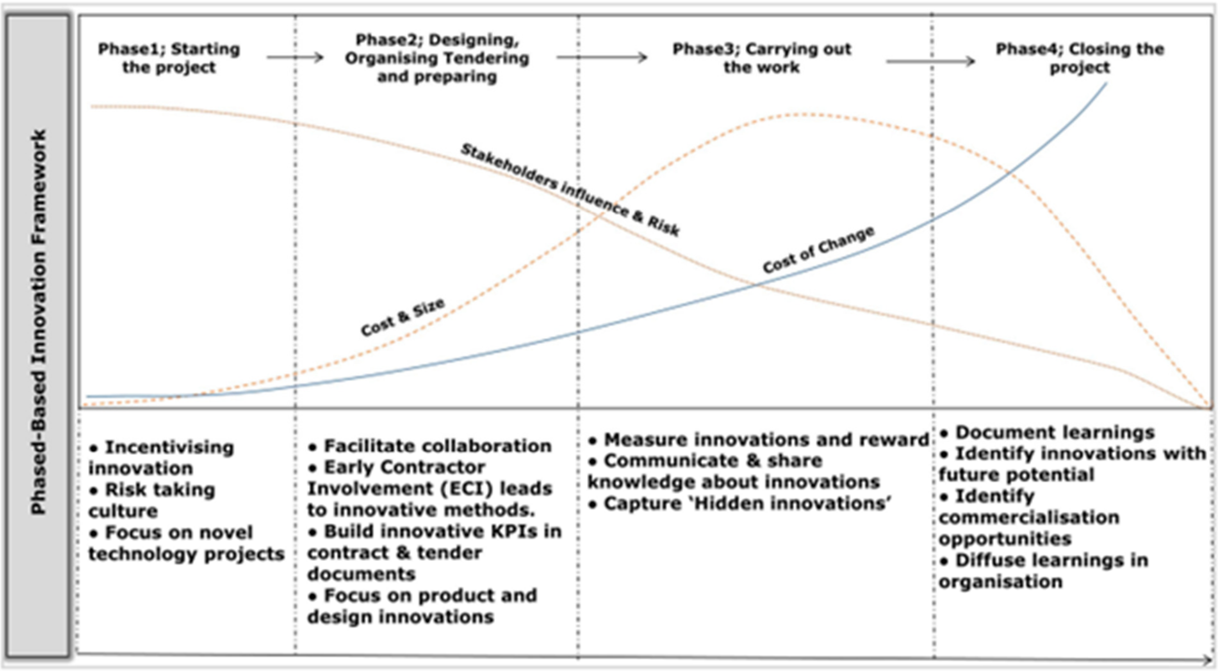


Figure 2.5 Phase-based innovation framework (Noktehdan et al. 2019, p. 7)

Citing other researchers, Ozorhon (2012) commented that much of construction innovation is codeveloped at the project level. However, most of the literature has focused on investigating innovation at the firm level, and the project level has largely been ignored. This is primarily because of the difficulties in monitoring the different activities conducted by different parties in each stage of a construction project (Ozorhon 2012). Chen (2014) added that, despite the panoply of studies that use a wide variety of measures to describe innovation outcomes and the input characteristics that affect those outcomes as well as firm performance, most studies focus on firms engaged in innovation and relatively a few studies explore projects engaged in innovation. Brockmann et al. (2016) and Christian Brockmann et al. (2016) also supported this argument by stating that we are lacking knowledge on the details of innovation in construction projects.

The broader literature review undertaken in support of this research failed to uncover comprehensive studies carried out on client-led enablers that promote innovation at the project level. This research is an attempt to fill this knowledge gap and focusses on construction innovation at the project level.

Before commencing the research on project level innovation, it is necessary to know whether there is a clear understanding of what project level innovation is. In other words, whether or not we have a definition for project level innovation. As noted by Baregheh et al. (2009), it could be argued that each discipline requires its own discipline-specific definition. Whilst the definitions of innovation cover a wide-ranging scope of industries, investigations into construction innovations are less prolific and attempts to define construction innovation are scant and insubstantial (Murphy et al. 2011). Whilst this being the case for construction innovation, it is apparent that a definition for project level innovation is not available. While discussing infrastructure projects, Duffield & Maghsoudi (2013) confirmed the same by stating that current definitions of innovation are incomplete. The comprehensive literature review undertaken for this study failed to find a suitable definition for project level innovation. Therefore, it was considered necessary to develop a definition for project level innovation.

2.9 Defining project level innovation

The process used to develop a definition for project innovation was four fold: (a) collect information from available research on innovation definitions to find whether suitable definition exists (b) If not in existence, suggest a suitable definition (c) consult a group of experts to obtain their input on the proposed definition and change accordingly (d) test the definition with industry practitioners. These steps are explained below.

The attention was focussed first on to find a suitable definition to describe the project level innovation.

2.9.1 Listing of innovation definitions

The literature review undertaken is explained in Chapter 2, under *Section 2.2*. Although the purpose of this literature review was to gain an understanding of the research background and current knowledge of the research problem, the same review provided an opportunity to collect definitions developed by previous scholars.

The following is the list of definitions on construction innovation *(Table 2.1),* identified through the literature review along with a comment on their suitability to be used as a definition on project level innovation.

Table 2.1 List of definitions on innovation and their suitability to adopt for project level innovation.

Defined/ cited by	Definition	Comment
Riedl, May et al. (2009)	An idea, practice or object that is perceived as new by an individual or other unit of adoption.	This is a general definition not describing project level innovation.
Riedl, May et al. (2009)	A new way of doing things (termed invention by some authors) that is commercialised.	This is also a general definition. Has nothing specifically to do with project level innovation.
Riedl, May et al. (2009)	An explicit description of an invention or problem solution with the intention of implementation as a new or improved product, service, or process within an organisation.	This definition is aimed at describing corporate innovation.
Lampel, Miller et al. (1996)	Technological solutions embedded in a power plant project which are widely perceived as novel by the industry.	This definition is aimed at describing innovation relevant to power plants.
Manley, McFallan et al. (2009)	New or significantly improved product (good or service), process (production or delivery method), marketing method (packaging, promotion, or pricing) or managerial method (internal practice).	This definition is more suitable to describe corporate innovation.

Defined/ cited by	Definition	Comment
Panuwatwanich (2008)	Any ideas, practices and technologies perceived to be new by the organisation involved.	This definition is more suitable to describe corporate innovation.
Panuwatwanich (2008)	Any idea, practice, or material artefact perceived to be new by the relevant unit of adoption.	This is a general definition not describing project level innovation.
Panuwatwanich (2008)	Introduction of a new product or a qualitative change in an existing product; process innovations new to an industry; the opening of a new market; the development of new sources of supply for raw materials or other inputs; and changes in industrial organisations.	This definition is more suitable to describe innovation related to industries.
Sexton and Barrett (2005)	The effective generation and implementation of a new idea, which enhances overall organisational performance.	This definition is more suitable to describe corporate innovation.
Kulatunga, Amaratunga et al. (2008)	Application of knowledge to a given context in order to implement significantly new processes, products or management approaches that will lead to increase efficiency and enhance rate of return.	This is a general definition.
Slaughter (1998)	The actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change.	This definition is more suitable to describe corporate innovation.
Ling (2003)	A new idea that is implemented in a construction project with the intention of deriving additional benefits although there might have been associated risks and uncertainties. The new idea may refer to new design, technology,	This is the closest definition to project level innovation. See the discussion below.

Defined/ cited by	Definition	Comment
	material component or construction method deployed in a project.	
Sharifirad and Ataei (2012)	The intentional introduction and application within a role, group, or organisation of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, organisation, or wider society.	This definition is more suitable to describe innovation in general.
Sharifirad and Ataei (2012)	A marked departure from traditional management principles, processes, and practices or a departure from customary organisational forms that significantly alter the way the work of management is performed.	This definition is more suitable to describe corporate innovation.
Sharifirad and Ataei (2012)	A state of being, one that ranges from being disruptive to environments that are mildly benign.	This definition is more suitable to describe innovation in general.

2.9.2 Discussion on the proposed definition

The next step was to assess the definitions identified in the literature review for their suitability in the project level context. Therefore, the individual definitions given by experts were studied and commented on in *Table 2.1* for their suitability as a definition for project level innovation.

It can be seen that most definitions presented are describing innovation in general terms or corporate/ organisational innovation.

As can be seen from *Table 2.1*, only the definition given by Ling (2003) is closer to project level innovation. Ling defined innovation as a new idea that is implemented in a construction project with the intention of deriving additional benefits although there might have been associated risks and uncertainties. Ling's definition refers to new design, technology, material component or construction method. However, the term 'additional benefits' does not provide a meaning without first identifying the 'default' benefits (if such benefits do exist). Therefore, this definition is not complete and there is a need to develop a definition for project level innovation. This need was confirmed by Maghsoudi et al. (2016), who stated that innovation needs to be defined properly, specifically in the field of infrastructure projects, to be understood and managed better.

For evaluating definitions of construction innovation, Murphy et al. (2011) used the following criteria:

1. Newness – uniqueness of concept;
2. First use within the industry;
3. Ability to effect change to standard practice;
4. Derived benefits for all stakeholders; and
5. Associated risk.

According to Maghsoudi et al. (2016), innovation has four main characteristics: (a) newness; (b) implementation;(c) making change; and (d) creating value. It means the practice not only should be new (or significantly improved) at least to the organisation but also needs to be implemented or planned for implementation. Moreover, this implementation will impact the organisations and/or projects and may lead to the creation of value to themselves and/or their customers (Maghsoudi et al. 2016).

With respect to corporate innovation, Shalley et al. (2004) commented that ideas are considered novel if they are unique relative to other ideas currently available in the organisation. Ideas are considered useful if they have the potential for direct or indirect value to the organisation, in either the short- or long-term.

When deriving a definition for project level innovation using the criteria suggested by Murphy et al. (2011), newness needs to be identified as first use within the project. Although all the five requirements are important in defining project level innovation, the definition needs to be short and these requirements could be subtly included. Any new change has associated risks, and therefore, it is considered not important to purposely mention it in the definition. This is evident from the list given in *Table 2.1.* Out of the 15 definitions given, only Ling's definition (No. 12) had a mention of risk. The same argument goes with the requirement of the ability to effect change to standard practice which is also implied. None of the 15 definitions given in the table had a specific mention of this requirement.

Therefore, the following definition was proposed and presented to industry experts to comment on:

> *"With respect to projects, innovation can be regarded as the application of ideas for new or improved products (including materials, plant and equipment) or software, technologies, methods, practices and systems that benefit the project".*

Although not expressively given, this implies the novelty of the idea to the project through the use of the phrase 'new or improved'. It also mentions the types of innovations that can benefit a project.

After analysing 60 innovation definitions in different disciplines from 1934 to 2007 to develop a definition for organisational innovation, Baregheh et al. (2009) came up with six attributes considered necessary to define innovation. They are:

- Nature (such as change, new, improve);
- Type (such as product, service, process, technical);
- Stage (such as introduction, implementation, development);
- Environment (such as group, organisation);
- Means (such as ideas, inventions, creativity, and market); and
- Aims (such as economy, need, success).

The proposed definition has all these attributes: nature (new, improve); type (products, software, technologies, methods, practices and systems); stage (application); environment (project); means (ideas); and aims (benefit the project).

2.10 Testing project level innovation definition

This proposed definition was tested with industry experts through interviews. The expert interview technique has been used for many other purposes in this study, including for testing the questionnaire and using the technique in case studies. Therefore, it is appropriate to have a good explanation of the expert interview technique before proceeding further.

2.10.1 Expert interview as a research technique

Expert interview is a kind of interviews carried out between interviewers and respondent – a specialist in the subject in question. Unlike an ordinary person this type of respondent is a carrier of deep knowledge of the research object (Libakova & Sertakova 2015).

> There are many advantages in using expert interviews in research. Talking to experts in the exploratory phase of a project is a more efficient and concentrated method of gathering data than, for instance, participatory observation or systematic quantitative surveys. Conducting expert interviews can serve to shorten time-consuming data gathering processes, particularly if the experts are seen as 'crystallization points' for practical insider knowledge and are interviewed as surrogates for a wider circle of players (Bogner et al. 2009). Due to the fact that respondents are highly qualified in the analysed question, it eliminates the need to use additional screening and clarifying questions aimed at revealing true, but hidden from the interviewer respondent views (Young et al. 2018). They also allow researchers to focus on the interviewees' perspective of what is important or relevant, thereby potentially highlighting issues that the interviewer might not have considered (Young et al. 2018). The organisational structures behind the experts in institutions can often serve as an easy point of entry to the field of research. Furthermore, if the targeted expert is not only willing to participate, but also holds a key position in the organisation, opportunities for expanding the researcher's access to the field may well also be unearthed in the interview. Sometimes, the expert will even indicate additional potential interviewees with expertise in a particular field during the interview itself. Equipped with the added bonus of the support of an expert in a key position, the researcher may then often find it easier to gain access to an extended circle of experts *(Bogner et al. 2009).*

Expert interviews can be conducted either face to face, by telephone or using web-based techniques. One of the interview techniques used in this research was face to face interviews, which had the above advantages. However, face to face interviews also have some disadvantages. The following section discusses advantages and disadvantages of using face to face interviews for research purposes.

2.10.2 Face to face interviews

Opdenakker (2006) has identified the following advantages and disadvantages of using face to face interviews for research purposes:

- Face to face interviews are characterised by synchronous communication in time and place. Due to this synchronous communication, face to face interviews can take its advantage of social cues. Social cues, such as voice, intonation, body language etc. of the interviewee can give the interviewer a lot of extra information that can be added to the verbal answer of the interviewee on a question. When the interviewer interviews an expert about things or persons that have nothing to do with the expert as a subject, then social cues become less important. On the other hand, this visibility can lead to disturbing interviewer effects, when the interviewer guides with his or her behaviour the interviewee in a special direction. This disadvantage can be diminished by using an interview protocol and by the awareness of the interviewer of this effect.
- In face to face interviews there is no significant time delay between question and answer; the interviewer and interviewee can directly react on what the other says or does. An advantage of this synchronous communication is that the answer of the interviewee is more spontaneous, without an extended reflection. But due to this synchronous character of the medium, the interviewer must concentrate much more on the questions to be asked and the answers given. Especially when an unstructured or semi structured interview list is used, and the interviewer has to formulate questions as a result of the interactive nature of communication.
- Face to face interviews can be tape recorded with the permission of the interviewee. Using a tape recorder has the advantage that the interview report is more accurate than writing out notes. But tape recording also brings with it the danger of not taking any notes during the interview. Taking notes during the interview is important for the interviewer, even if the interview is tape recorded: (1) to check if all the questions have been answered, (2) in case of malfunctioning of the tape recorder, and (3) in case of 'malfunctioning of the interviewer'. Another disadvantage of tape recording the interview is the time a transcription of the tape recording consumes.
- The synchronous communication of time and place in a face to face interview also has the advantage that the interviewer has a lot of possibilities to create a good interview ambience. In other words, the interviewer can make more use

of a standardisation of the situation. On the other hand, this synchronous communication of time and place can bring with it a lot of time and costs, including travelling and interviewing.

- The last advantage of this interview method is that termination of a face to face interview is easy. In the interaction between interviewer and interviewee enough clues can be given that the end of the interview is near, for example by shuffling the papers and turning off the tape recorder. An explicit way to terminate the interview is by thanking the interviewee for cooperation and asking him or her if there are further remarks that might be relevant to the topic or the interview process.

Having discussed the use of expert interview as a research tool, the process undertaken to test the proposed definition for project level innovation is discussed below.

2.10.3 Testing the proposed definition for project level innovation

First, the interviewees were given the list of definitions prepared (as given in *Table 2.1)* to provide an idea of the definitions. Then, the proposed definition was given to the interviewees to comment on.

How these industry experts were selected is explained below. It needs to be emphasised here that these experts were selected not only to comment on the definition of project level innovation, but also to comment on the survey questionnaire (see *Section 4.3*).

The following procedure was adopted in identifying the industry experts:

- A list of engineers (total of 17) in the area of construction was produced (all working in Australia) through personal contacts using the following criteria:
  - All should have at least 25 years of experience in construction projects.
  - All should have contributed to construction projects of over AUD100 million in value.
  - All should have played major roles in construction projects such as the project manager or as a representative of an organisation providing specialised services (e.g. Chief Geotechnical Engineer, Chief Designer).
- The list was reduced to ten to have a better spread of expertise and

disciplines, i.e. to have some directly representing the client team, others representing supporting roles as designers and geotechnical engineers, with varied experience from 25 years onwards.

- Their willingness to participate in the interviews as well as their commitment to innovation were also taken into consideration.

Face to face interviews ranged from 45 to 120 minutes as they were on both the definition of project level innovation, and to comment on the questionnaire. Two were interstate participants and phone interviews were held.

The definition accepted after testing with industry experts was slightly different from the proposed definition. The proposed definition was **"**with respect to projects, innovation can be regarded as the application of ideas for new or improved products (including materials, plant and equipment) or software, technologies, methods, practices and systems that benefit the project" and the accepted definition used the term 'designed to benefit the project' instead of the proposed term 'that benefit the project'. This conveyed the meaning that innovation is an activity intentionally undertaken.

The following was the accepted definition after undergoing the procedure mentioned above:

> *"With respect to projects, innovation can be regarded as the application of ideas for new or improved products (including materials, plant and equipment), software, technologies, methods, practices and systems designed to benefit the project".*

Looking at this definition it can be seen that it is applicable to any type of project, although it was developed in the context of the construction project environment. This is because products (including materials, plant and equipment) and software, technologies, methods, practices and systems are common to any project, irrespective of the type of industry. This definition was tested with 11 project managers in areas outside construction (IT, oil and gas, mining, electrical power generation, steel manufacturing and mineral processing). All agreed that this definition was applicable to their projects (see Chapter 9 – 'Generalisation' for details). **This is an important finding.**

So far in this chapter, the discussion has focussed on gaining an understanding about scientific research and the background situation with respect to the study area. With this understanding, it is now possible to decide the research approach and formulate the research questions.

2.11 Research approach

The proceeding sections will discuss the formulation of the research questions and the design of the research approach. First, the research questions.

2.11.1 Research questions

The purpose of research is to discover answers to questions through the application of scientific procedures. The main aim of research is to find out the truth which is hidden and which has not been discovered as yet (Kothari 2004). For the truth to be discovered, the research questions need to be sound. Well-articulated research questions will properly:

- define the topic;
- define the nature of the research endeavour; and
- indicate relationships between concepts exploring (O ' L e a r y 2004).

The following are the research questions to be explored in this study:

RQ1: Is it possible for clients of construction projects to influence promoting innovation in their projects?

RQ2: If this is possible, what actions can construction clients take to promote innovation in their projects?

RQ3: Is it possible to group these actions (also called innovation enablers) into major categories?

RQ4: If possible, what are the enabler categories?

RQ5: What are the relationships of these categories with innovative performance?

RQ6: Do these categories have relationships among themselves?

Out of these, the last question 'Do these categories have relationships among themselves?' is only of academic interest as the purpose of the research is to develop a model to assist clients of construction projects to identify actions to promote innovation in their projects as mentioned in *Section 1.2*. For the purpose of this research, the relationships of model constructs with innovation promotion is sufficient.

Already, the first question has been answered through the literature review. Scholars hold the view that clients do influence innovation promotion in their own projects. Before discussing the research strategy, it is necessary to identify the boundaries of this research.

2.12 Research design

Having understood how to conduct proper scientific research and the background situation with respect to the study area, it is now possible to determine the research strategy. The proposed research design is shown in *Fig. 2.6.*

The proposed research design includes the following:

1. Compilation of knowledge using a literature review to ascertain the knowledge gap and identify research questions;
2. Development of the conceptual model based on knowledge gathered;
3. Development of a questionnaire for the survey (primary data collection);
4. Conduct of the questionnaire survey in Australia;
5. Descriptive data analysis to describe the characteristics of the survey sample;
6. Further statistical analysis to develop a model for the Australian-specific data;
7. Use of the case study approach to validate (or not) research findings, compare the conceptual model and the Australian-specific model and reach conclusion; and
8. Provide recommendations.

2.13 Chapter Summary

This chapter on the literature review and research design discussed the knowledge required to conduct proper scientific research and explored the background of the situation of the research problem, paving the way to formulate the research questions and the research strategy.

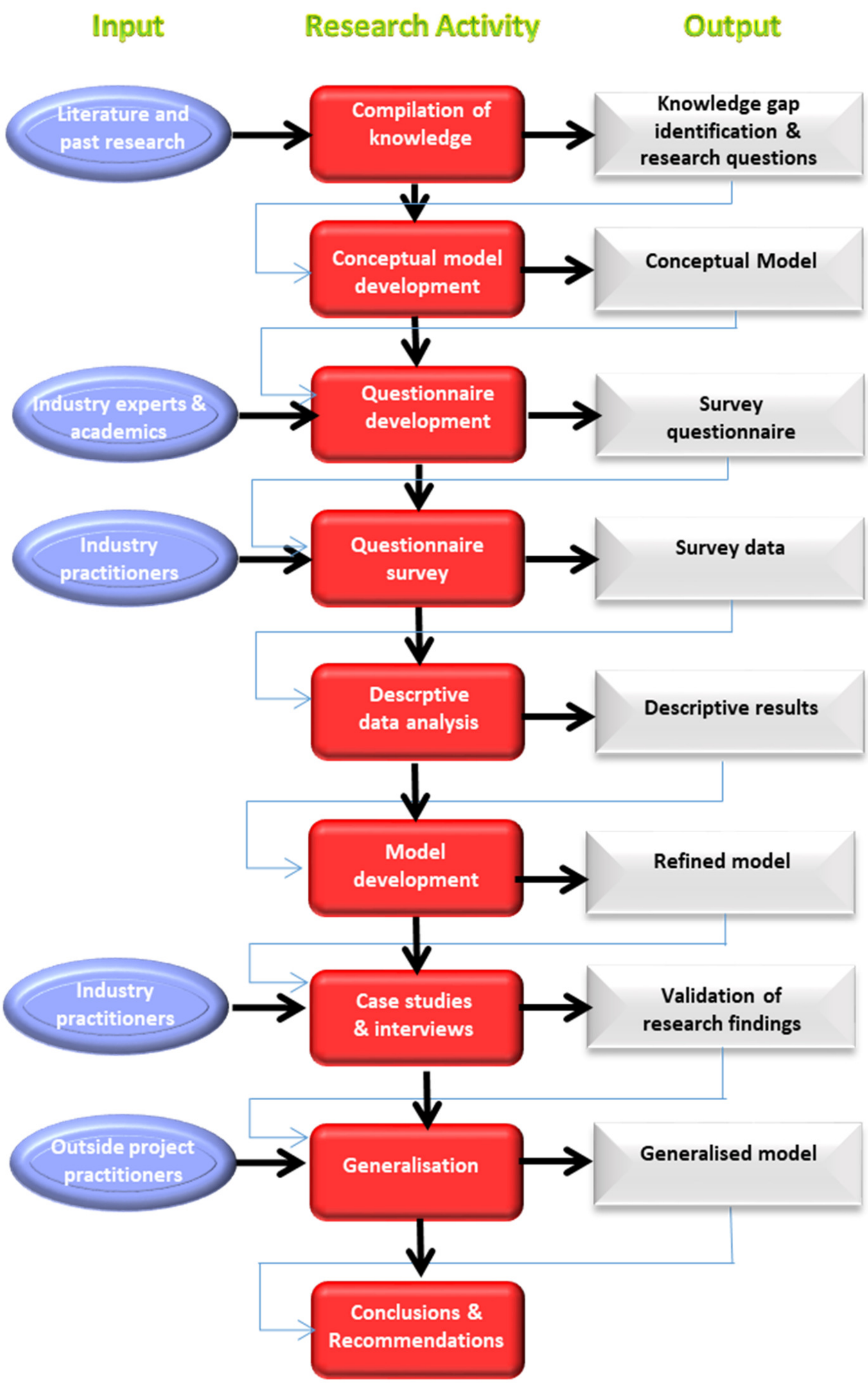


Figure 2.6 Proposed research design

Understanding scientific research including research paradigms, research concepts and research process led to the identification of the research strategy which included the following steps:

- Follow a mixed method of research, first quantitative approach to collect primary data, followed by a qualitative approach for collecting secondary data for validation purposes.

- The primary data collection to be a questionnaire survey and the validation to be through the case studies.

While exploring the background of the research situation, it was revealed that:

- The majority of the investigations that were reviewed has been on organisations related to the construction industry.
- Limited research has been conducted on project level innovation.
- No comprehensive research has been undertaken to explore client-led enablers in construction projects.

Therefore, there is a clear knowledge gap in the area of project level innovation to investigate the possible actions that clients can implement to promote innovation. Such actions can lead to substantial benefits to clients as shown by previous researchers, including the following:

- Decreased cost;
- Quicker construction times;
- Higher quality;
- Profit maximisation;
- Increased productivity;
- Competitive advantage;
- Responding to conflicting expectations from clients;
- Better value for clients;
- Improved client satisfaction;
- Developing solutions to problems encountered on site;
- Aspirations towards improved performance;
- Organisational effectiveness;
- Increased organisational commitment;
- Higher organisational motivation; and
- Improved working conditions.

The discussion in this chapter provided answers to some of the following research questions:

- Clients are influential in shaping the outcomes in construction projects.
- Clients have the capacity to promote innovation in construction projects.

While discussing innovation, it was found out that currently there is no proper definition for project level innovation. Therefore, a new definition has been developed. The following is the new definition:

> *"With respect to projects, innovation can be regarded as the application of ideas for new or improved products (including materials, plant and equipment) and software, technologies, methods, practices and systems designed to benefit the project"*.

This new definition was tested through industry expert input. It was found that this definition could be applied to projects in general, irrespective of the project area.

With this knowledge on research and innovation and the identification of the research strategy, it is now possible to extend the exploration of the research area further to develop a theory which will be discussed in the next chapter.

CHAPTER 3
CONCEPTUAL FRAMEWORK

3.1 Chapter overview

Having explored the research background leading to knowledge on innovation in general and construction innovation in particular, and deriving a definition for project level innovation, attention can now be focussed on identifying enablers that clients can use in construction projects to promote innovation, grouping them into major categories and deriving a conceptual framework to explain the dynamics that promote innovation in a construction project.

This chapter discusses how the conceptual framework was developed. The topics discussed in the chapter include the following:

- A general literature review to identify the broader innovation enablers that clients can use in construction projects;
- A targeted literature review identifying influences that contribute to workplace innovation which led to the identification of major innovation enabler groups;
- Testing of the findings with expert interviews; and
- The development of a framework and a model to describe clients' innovation enablers in construction projects.

The details of the literature review undertaken to identify the broader innovation enablers that clients can use in construction projects is given first.

3.2 Literature review for innovation enablers

This is the general or the broader literature review undertaken to get an appreciation of the factors that promote innovation in projects. The types of literature studied was of general nature covering areas such as procurement, communication, relationship contracting, management support, performance-based construction, role of project participants, drivers, barriers and benefits of innovation. This review provided an understanding of factors that can be used by clients to facilitate innovation in their projects. However, it was found difficult to allocate these factors into major groups using this general literature review.

Therefore, this was followed by a targeted literature review where deliberate action was taken to identify literature related to enhancing innovation in workplace situations. Details of the targeted literature review will be given later in Section 3.3.

As reported in *Section 2.2*, over 300 papers, the majority from peer-reviewed journals, were studied. The research papers that were considered most relevant to the research were singled out and their details were tabulated. These included papers on topics such as organisational innovation, but related to the enablers relevant to the research, construction innovation, project level innovation, and other enablers related to areas such as procurement, communication, relationship contracting, management support, performance-based construction, role of project participants, drivers, barriers and benefits of innovation. They were tabled with the title, author, aspects covered and what aspect they did not cover in relation to the client's enabler categories identified in the research. The list contained 84 papers. This list is given in *Appendix 1.*

After analysing the contents of these short-listed papers, the following were revealed:

1. All except three papers were on construction innovation. The other three were studies on general aspects of innovation, but were also related to research as they discussed some aspects of project team fitness.
2. Only five papers could be identified as discussing project level innovation directly. All the others addressed organisational level innovation (but related to the enabler categories identified in the research).
3. The five papers on project level innovation also discussed factors such as management support, performance-based construction, role of project participants, drivers, barriers and benefits of innovation.
4. None of the short-listed papers showed any comprehensive attempt to research client implemented enabler categories at the project level.
5. Whenever innovation was defined, most papers used the organisational innovation related definitions.
6. In 2000, Slaughter used the definition for innovation as a nontrivial improvement in a product, process, or system that is actually used and which

is novel to the company developing or using it. This general definition was adopted by many later researchers to define innovation in relation to construction.

7. In 2003, Ling suggested the first definition which can be identified as directly relating to project level innovation. It defined innovation as a new idea which a construction client adopts in a project with the intention of deriving additional benefits, although there might have been associated risks and uncertainties. The new idea may refer to a new design, technology, material component, or construction method used in the project.

From this literature review, it is apparent that:

1. The research on construction innovation is substantially outnumbered by research on organisational innovation.
2. Papers on construction innovation also discussed innovation related to organisations.
3. From over 300 papers reviewed, only five papers could be identified as discussing project level innovation directly, indicating that project-level innovation research is scarce.
4. Project level innovation research concentrated mainly on general factors such as project size and complexity, market conditions, government policies and regulations, most of which are difficult for clients to change at the project level.
5. When analysing all the papers reviewed, there was no single paper that comprehensively researched the enabler categories that can be implemented by clients to facilitate innovation in projects.
6. Ling's (2003) definition seems to be the only definition that can be considered as directly relevant to project level construction innovation but, it had some elements diminishing its relevance as mentioned in *Section 2.8*.

This general literature review facilitated the identification of different enablers that can be used by clients to promote innovation in construction projects.

3.2.1 Innovation enablers

Appendix 1 provides a list of journal papers studied and the types of innovation enablers identified. The innovation enablers identified include the following:

- Idea generation, development, commercialisation
- Procurement methods, attitudes and processes
- Client leadership, relationship with manufacturers, knowledge management, innovative procurement systems, regulations and standards, organisational resources
- Technological capability, knowledge exchange, boundary spanning
- Early supplier involvement
- Leadership and team behaviour
- Barriers to innovation such as risk averse, adversarial attitude
- Role of the project manager
- Incentives and rewards, contract conditions
- Owner/client support, organisation culture

Tawiah and Russel (2008) are a few leading researchers who looked for innovation enablers in construction projects. Their research provides a better understanding of some of innovation enablers that can be used in projects. They came up with a list of drivers/ inhibitors of project innovation. Some of the drivers/ inhibitors relevant to this research extracted from this list are given in *Table 3.1.*

They designated the main areas of enablers as 'Factors' and identified the extent up to which the innovation enablers were effective using three different 'states'. For any given factor, State 3 represented the highest/strongest ability to drive innovation (i.e. the highest state a factor can assume for maximum innovation potential), whereas State 1 implied the lowest ability to drive innovation or the potential for the factor to be an inhibitor to drive innovation. State 2 indicated a mild or moderate ability to drive innovation.

Having investigated the general literature to identify client-led innovation enablers, a targeted literature review (explained below) was conducted to support the identification of the enablers and group them into major categories.

Factors (drivers/ inhibitors) of innovation	States, descriptors, values of innovation factors (relative ability to drive project innovation)		
	High/strong	Moderate/mild	Low/inhibitor
	3	2	1
Project type	Heavy civil infrastructure projects—bridges, tunnels, roads, nuclear plants	Industrial/commercial facilities, utilities projects	Residential projects, student housing projects.
Project scale/scope (monetary terms)	>$100 million	$25–100 million	<$25 million
Project complexity/uniqueness	Large resource requirements	Moderate resource requirements	Low resource requirements
Responsibility integration	Complete integration of all project functions e.g., finance–design–build–operate–maintain–full service delivery	Integration of two or more major project functions/roles with value engineering	Fragmented process— sequential project phases/sections contracted out to distinct and different parties, with no value engineering
Nature/composition of project team	Innovation champions in project team with broad technical knowledge, long track record or experience (>10 years) of project excellence with a high absorptive capacity	Some innovation champions, moderate technical knowledge, track record or experience (5–10 years) of project excellence	No innovation champions, little technical competence, little or no track record or experience (<5 years) of project excellence, little or no absorptive capacity
Statement of product	Performance or	Functional	Technical/prescriptiv

solution	object-based specifications that define the required product output (such as service and availability levels, capacities, rates, etc.), use of benchmarks	specifications that only state the set of functions expected to be performed making optimization difficult to pursue	e specifications giving detailed product (physical) description (number, dimensions, color, material constituents, etc.)
Statement of process solution	Performance specifications that define the required process output and rates (set using key project milestones), benchmarks	Functional specifications that only state the set of functions expected to be performed making optimization difficult	Technical/prescriptive specifications giving detailed process description
Penalties for inadequate project performance	Performance-based payment and reward schemes based on prudence and fairness in a win–win arrangement	Performance-based payment and reward schemes that reward all parties for overperformance but selectively punish a party for underperformance	Draconian or extremely punitive schemes based on unconscionable contracts
Reasonableness of risk assignment	Appropriate/balanced allocation of risk among parties	Asymmetrical and/or lopsided risk allocation structure	Complete transfer or off-loading of risks to one party irrespective of their ability to manage the risks assigned
Certainty of	Highly flexible	Moderately flexible	Fixed or rigid

regulatory system/environment	standards and codes allowing room for trying new concepts; stable statutes— certainty and enforceability of specific regulatory provisions of project agreements over the longer term >20 years	standards and codes ensuring partial adherence to existing system; fairly stable statutes—specific regulatory provisions of project agreements certain and enforceable over the medium term, 5–20 years	standards and codes ensuring strict adherence to existing system; unstable statutes— certainty and enforceability of specific regulatory provisions of project agreements only over the short term <5 years

Table 3.1 Definition/designation of states of drivers/inhibitors of project innovation extracted from Tawiah and Russel (2008, p. 178-179)

3.3 Targeted literature review

In the targeted literature review, an attempt was made to gain a deeper understanding into what make people interested in engaging in innovative activities in workplace situations. This is an inductive approach to discover the actions clients can take to promote innovation in construction projects through fundamental reasoning through research findings. As stated by Gabriel (2013), the main difference between inductive and deductive approaches to research is that whilst a deductive approach is aimed and testing theory, an inductive approach is concerned with the generation of new theory emerging from the data. In this case, whilst looking at what prompts innovation in workplace situation in general, an attempt is made to interpret them in the light of client actions to promote innovation in construction projects.

Although ample research has been conducted on workplace innovation, there appears to be little research undertaken on people working on construction projects. As the construction workplace is yet another workplace, the research available on workplace innovation gave a good understanding of what to expect in the construction work situation. As creativity begins the innovation process, the search for deeper understanding began by seeking research material on creativity.

3.3.1 Workplace creativity and innovation

Innovation is closely related to creativity. As noted by Robbins (1994), creativity in general, means the ability to combine ideas in a unique way to make unusual associations between ideas. Innovation is the process of taking a creative idea and turning it into a useful product, service, or method of operations (Robbins 1994). As creativity is the first phase of the innovation process, an investigation into workplace innovation must begin with an understanding of workplace creativity.

Although the research on creativity relevant to construction projects is rare, there is an abundance of literature on workplace creativity. Teresa Amabile has conducted extensive research on workplace creativity and innovation and is one of the authorities on this subject.

Citing Amabile's research, Adams (2006) stated that creativity arises through the confluence of the following three components:

- Knowledge – all the relevant understanding that an individual brings to bear on a creative effort;
- Creative thinking –how people approach problems and depends on personality and thinking/working style; and
- Motivation –generally accepted as key to creative production, and the most important motivators are intrinsic passion and interest in the work itself.

On the importance of knowledge for innovative activities, Beales (2004) pointed out the following:

- Innovation is a knowledge intensive process which demands the straightforward application of knowledge; and
- Innovation is dependent on exchange of knowledge between different groups or individuals.

Motivation to innovate can be grouped as intrinsic and extrinsic. According to Amabile (1996), people are intrinsically motivated when they seek enjoyment, interest, satisfaction of curiosity, self-expression, or personal challenge in the work. On the other hand, people are extrinsically motivated when they engage in the work in order to obtain some goal that is apart from work itself. Intrinsic motivation is identified as a key requirement for creativity (Amabile 1996).

However, extrinsic motivation is not ruled out entirely as hindering innovation. Extrinsic motivation can be grouped into synergistic (motivations that are informational or enabling) and non-synergistic (motivations that are controlling). While non-synergistic motivations such as expected evaluations, being watched while working (surveillance), contracted for reward, and competitions for prize winning are hindering innovations, synergistic motivations such as reward and recognition for creative ideas, clearly defined overall project goals, frequent constructive feedback on work, degree of autonomy in the work, work that the individual perceives as challenging and important, sense of interest and excitement in the work, recognition and rewards that confirm a person's competence or the value of the person's work support creativity (Amabile 1996).

Discussing on synergistic extrinsic motivations, Adams (2006) stated that they may play a role in persistence, help an individual sustain energy through the difficult times to gain skills in a domain and may serve to bring people in contact with a topic to engage their intrinsic interest.

Innovation is the successful implementation of creative ideas. In workplace situations, creative ideas can come from either individuals or teams. However, implementation of these ideas is often a team effort. By combining knowledge, skills and abilities of individuals with different perspectives and backgrounds, teams provide ideal conditions for stimulating creativity and innovation via social and psychological processes (Panuwatwanich et al. 2008). These findings suggest that effective teamwork is essential for innovative work, especially for implementing creative ideas. However, there will be no effective teamwork if there are adversarial relationships between team members. Therefore, cordial relationships between members is essential for innovation.

In addition to teamwork, an environment conducive to innovation is essential to implement new and beneficial ideas. Creativity theory suggests that when a working environment facilitates idea generation, knowledge sharing and creative problem solving, individuals in that environment are more likely to generate creative ideas that involve unique concepts or new applications of existing concepts (Neck et al. 2006). In particular, a conducive environment provides recognition and reward for innovative activities. Amabile (1996) found that the rewards and recognition appear to support creativity by confirming a person's competence or the value of the person's work enabling the person to further pursue intrinsically interesting work. This research suggests that an environment conducive to innovation, which include providing incentives for creative activities, facilitates innovation in a workplace.

Panuwatwanich et al. (2008) stated that the organisational culture for innovation is a major determinant of innovation, having major facilitating and constraining effects on the successful implementation and maintenance of innovation. Without a culture for innovation, they stated that it is unlikely that creative ideas will be transformed into innovative products. In the same manner, even though an organisation decides to adopt a particular innovation, such innovation is not likely to be fully utilised if the employees perceive no encouragement and support from the firm (Panuwatwanich et al. 2008). Therefore, a conducive environment is vital for innovation.

The research findings quoted above can be graphically explained in *Figure 3.1* showing the necessities for workplace creativity and innovation with their interrelationships.

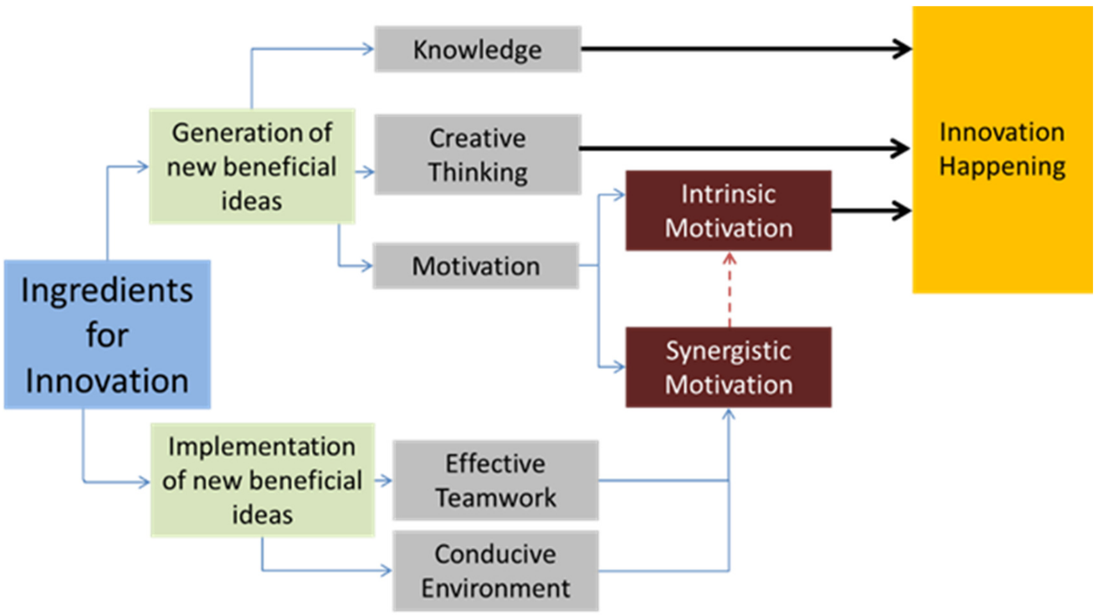


Figure 3.1 Vital requirements for workplace creativity and innovation

3.3.2 Ingredients for project level innovation

With this understanding of the vital requirements for innovation in a workplace, it is now possible to identify the fundamental groups of enablers that can be adopted by clients who are eager to promote innovation in projects. The following logical reasoning help to identify these categories of enablers:

1. Idea creation and implementation are fundamental requirements for innovation. They are connected to knowledge and creative thinking. Clients can implement strategies to enhance creative thinking and the acquisition of

knowledge to facilitate innovation in projects and their subsequent implementation. This fundamental category is termed as 'idea harnessing'.

2. Motivation is another fundamental requirement for innovation and clients can undertake strategies to provide incentives and rewards to promote motivation. This category is termed as 'incentivisation'.
3. The next ingredient for innovation is effective teamwork which requires improved relationships between parties involved in the project. Actions and strategies that can be taken by the client to achieve improved teamwork are categorised as 'relationship enhancement'.
4. A conducive environment is the remaining ingredient for innovation. In a project, the client has the most control over its project team and its own organisation. Strategies can be implemented in relation to the client's project team and the client's organisation to create a conducive environment for innovation. Such strategies help the client's project team understand the concept of innovation better, encourage and motivate the team to facilitate innovation and obtain the support and facilities from the client organisation to deal with innovative activities. This category can be termed as 'project team fitness' as it strengthens the client team to deal with innovative activities.

The identification of fundamental enabler categories to facilitate innovation through the understanding of primary prerequisites for workplace creativity and innovation is represented graphically in *Figure 3.2*. Therefore, the targeted literature review undertaken has enabled to identify client led actions to promote innovation in construction projects. It is also to be noted here that the word 'client' can be replaced by 'any enabling body' without any changes to the reasoning.

It is interesting to note that this fundamental reasoning and the subsequent identification of enabler categories that clients (or an enabling body) can implement to enhance innovation has nothing to do with construction projects, meaning that **these fundamental categories of enablers can be applied to any project by any party.**

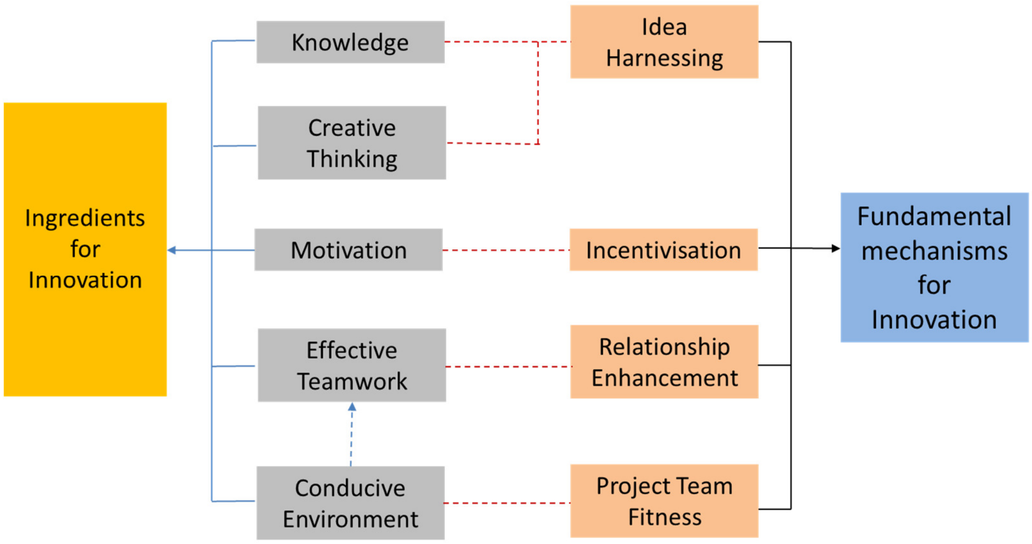


Figure 3.2 Graphical representation of factors contributing to project innovation

3.3.3 Proposed framework

The proposed framework is based on the following client-led innovation enablers:

1. Idea harnessing (use of new and beneficial ideas);
2. Relationship enhancement (employing actions to improve relationships between parties to the project);
3. Incentivisation (providing incentives/rewards to promote innovative activities); and
4. Project team fitness (deliberate actions taken at the project level to strengthen the project team and improve its capacity to focus on innovative activities).

Innovation enablers at the project level have been included in some studies. But some of the enablers identified are not under the control of clients. For example, Manley (2008) identified some regulatory conditions that promote innovation outcomes. However, implementation of regulations is outside the control of clients. To be more useful for clients, the innovation enablers need to be implemented by them, without depending on external conditions and parties such as market conditions and governments.

The enablers shown in the framework do not depend on external conditions and parties for implementation. Therefore, they can be implemented directly by clients interested in enhancing project outcomes through innovation.

The sections below explain the identified enabler categories in detail, with associated theoretical supports.

3.4 Idea harnessing

Idea harnessing is the generation and implementation of new and beneficial ideas. It forms the core characteristic of innovation. As noted by Shalley et al. (2004), innovation is the successful implementation of novel ideas. In a project setting where all members are willing to create new ideas and implement these to find solutions to the problems, innovation is more likely (Ozorhon & Oral 2017). Commenting on idea harnessing in her book on 'Innovation and Ontologies: structuring the early stages of innovation management', Angelika Bullinger (2008) noted that an innovative idea marks the starting point of any innovative activity. In construction projects, innovations generally happen within teams. For teams to be innovative, team members need to generate creative ideas and must critically process them so as to discard those ideas that seem useless and implement those with promise (Somech & Drach-Zahavy 2013). Therefore, idea harnessing is extremely important to managing innovation in projects.

3.4.1 Idea generation

Sources for novel ideas can come from anywhere. Tawiah and Russel (2008) mentioned some idea sources such as:

- Design concept and details that can influence the innovativeness of project bids and proposals;
- Innovations in construction methods and technologies centred on the use of advanced equipment and off-site prefabrications/ precast factory style mass production of components;
- Technology adaptation and input from other industries such as global positioning systems, robotic technologies; and
- Alternative ways of delivering services.

An important source for beneficial ideas in construction projects is stakeholders. Not only could they provide beneficial new ideas, they could also identify potential risks to the project. In addition, a close cooperation between stakeholders is vital for the implementation of innovative ideas (Murphy et al. 2011).

According to the literature on construction innovation, there are several ways of generating new and beneficial ideas in a construction project. They include the following:

1. Expose project team members to outsiders who have different backgrounds and experience. According to Núñez (2011), it has been shown that more new ideas are generated when people are exposed to others who do not belong to their cohesive group. Furthermore, those organisations that want to foster innovation should provide an environment where people from different backgrounds and experiences can interact and build on others' knowledge (Núñez 2011).
2. Seek ideas from others who are not directly involved with the project at the start, especially in the planning and design phases, but may join later. Tatum (1989) highlighted the importance of this by saying that the early involvement of construction representatives is a vital part of a supportive context for innovation in construction projects. Briscoe et al. (2004) highlighted the benefits of using strategies that involve suppliers earlier on in the process. Rahman and Alhassan (2012) have identified early contractor involvement contracts (a form of contracts where the input of a contractor is sought at the early stage to develop the design to a point where it can be confidently estimated) as an innovative form of contracts, highlighting the importance of the contractor's expertise, experience and understanding of the construction process, and the consideration of buildability issues earlier in the design process.
3. Ideas can come from anybody. Kulatunga et al. (2011) identified the clients' willingness to listen not only to other construction professionals but also to other skilled and unskilled workers as an incentive for the generation of new and innovative ideas.
4. A competitive bidding (or investment decision making) process can be another way to encourage contractors to introduce innovative ideas (Duffield & Maghsoudi 2013).

3.4.2 Idea generation tools and techniques

Several tools can be used to generate ideas in construction projects. For example, Barker and Coy (2004) have identified some tools which can be used to generate new ideas, especially during the planning and design phases of construction projects.

According to them, it is a disappointing reality that many people are aware of these tools and yet do not use them for the exploration of new ideas. These tools are:

- Brainstorming which is based on the principle of free and associative thinking.
- 'Thinking hats' tool introduced by Edward de Bono to explore ideas from a range of perspectives by allowing participants to concentrate on one aspect of an issue at a time.
- Scenario planning which involves speculation regarding the interplay and impact of a number of driving forces and generation of stories based on information.

(Barker & Coy 2004).

Brainstorming is based on two principles: (a) judgement should be deferred while ideas are being generated, and (b) quantity of ideas proposed breeds the quality of the outcome (Robinson & Stern 1997). When undertaking brainstorming, Gallagher (2015) recommended the following guidelines:

- Give the brain time to think alone by providing pre-work for participants prior to the session;
- Try come-and-go brainstorming allowing participants the opportunity to informally contribute thoughts, insights, and ideas over a period of time;
- Encourage discussion and dissent; and
- Consider 'brainwriting', which is an alternative method to traditional brainstorming, that encourages a more uniform participation within a group by providing the opportunity for attendees to put their thoughts in writing.

According to Tatum (1984), value engineering is one method that fosters innovative approaches, by offering a critical analysis of the functional requirements for a facility and selection of the least-cost alternative that meets those requirements. This method opposes the engineer's tendency to routinely apply design standards and experience from previous projects rather than investigate innovative approaches with potential cost savings (Tatum 1984). Researching innovation diffusion processes in Australian architectural and engineering design organisations, Panuwatwanich et al. (2008), identified the following additional tools in relation to innovation in construction projects: value management; quality function deployment; constructability review; and life cycle costing. Salter and Gann (2003) identified further strategies including the following: talking to colleagues, working with others on projects, visits to other buildings and/ or worksites, reading trade or professional magazines, talking to clients, work of competitors, on-line databases, in-house libraries, working with new equipment/software, fairs or exhibitions.

Capturing project learnings, often referred to as "post-mortem analysis", is another idea generation technique. This is a structured ritual according to Schieg (2007), conducted at the end of a project to identify strengths and weaknesses in the project operation. Post-mortem analysis is an effective knowledge sharing strategy. According to Ozorhon et al. (2016), knowledge sharing is essential, not only for bringing the right ideas into a project, but also for ensuring that these ideas are communicated to the entire project team and diffused to future projects.

Generating ideas is not sufficient. It is necessary to develop and implement them. Some ideas carry potential risk. In general, the more radical the innovation the higher the level of risk, and the greater the possible benefits (Mulgan & Albury 2003). Therefore, a high level of risk management is required to harness innovative ideas. While pointing out that there is a significant relationship between trust and risk allocation that can result in cost savings in the construction industry, Owen (2013) recommended the following guidelines to deal with risk in a contract:

- Develop a clear understanding of the risks being born by each party, and who can best own or manage that risk;
- Invest significant time and effort at the front end of a project and significant experience to manage or mitigate the risks, and to administrate the contract;
- Include a negotiation phase prior to the start of the contract; and
- Promote an adequate risk sharing or risk reward system to share the benefits if the risk does not occur during the project life cycle.

Researching mega projects, Caldas & Gupta (2017) recommended conducting a pilot test and plan for scale-up requirements and limitations when using a new or unproven technology. In addition, they recommended that project teams need to allocate sufficient time and resources to plan and execute the integration of new or unproven technologies.

In addition, idea development and implementation require a capable team, consisting of highly motivated and well-experienced team members. These will be discussed later.

The next category is relationship enhancement which will be discussed below.

3.5 Relationship enhancement

Construction is largely considered to be a team industry where many parties come together to complete a project. According to Li et al. (2000), construction projects rely on the integrated efforts of several hierarchically linked parties. Due to the fragmented nature of construction, problems such as communication and co-ordination are encountered frequently which can affect the performance and productivity of projects (Li et al. 2000). As a result, adversarial behaviour between parties associated with construction projects is common. This was confirmed by Bower et al. (2002), who said relationships in the construction industry are often adversarial with the parties resorting to contractual claims and litigation which lengthen time scales and increase costs. Research conducted by Ling (2003) on Singaporean construction companies showed that an adversarial relationship between parties hinders innovation.

According to Eriksson et al. (2007), successful innovation often requires effective cooperation, coordination and working relationships between the different parties in specific projects. Asad et al. (2005) added that contractor-client cooperation can act as a catalyst to promote innovative thinking and collaborative culture. For the promotion of innovation, strong positive relationships should extend beyond the contractor. From their study on clients' championing characteristics that promote construction innovation, Kulatunga et al. (2011) concluded that, strong relationships with project members and other external stakeholders is a factor for successful innovation in construction projects. Ozorhon et al. (2016) also identified cooperation as an innovation enabler and stated that successful innovation requires effective cooperation, coordination, and integration among contractors, subcontractors, suppliers, architects, engineers, and clients in construction projects. All these of these studies point out that strong relationships between parties to construction projects is vital for innovation.

Relationship enhancement concerns the employment of actions to improve relationships between parties at the project level of a construction project. At the lowest end of the spectrum of improving relationships, this is removing adversarial behaviour between parties. At the high end, this means establishing a culture of trust, free and open communication, cooperation and collaboration and joint problem resolution, creating a shared vision, working towards common objectives and the betterment of the project, active search for continuous improvement, and adopting a win-win philosophy where relevant parties receive gains from their efforts.

In recent years, different forms of contracts have been formed to enhance relationships between parties engaged in contracts. They fall into the group of relational or relationship contracting. According to Cheung and Rowlinson (2011), relationship contracting is based on the recognition of, and striving for, mutual benefits and win-win scenarios through more cooperative relationships between the parties. Relationship contracting embraces and underpins various approaches such as partnering, alliancing, joint venturing, and other collaborative working arrangements and equitable risk sharing mechanisms (Cheung & Rowlinson 2011).

Partnering and alliancing are two forms of relationship contracting popular in the construction industry. It is worth looking at these in some detail.

Partnering

Partnering is a relationship between parties in which:

- Trust and open communications are encouraged and expected from all;
- Issues and problems are resolved promptly and at the lowest possible level;
- Solutions are developed that strive to be agreeable and meet the needs of everyone involved (win-win approach);
- Common goals are identified for the project; and
- All seek input from each other in an effort to find better solutions to the problems and issues at hand.

It is a process applied outside the contract (in most contracts) to align goals and objectives and to facilitate good communication, teamwork and joint problem solving. Li et al. (2000) explained that partnering is generally established through a structured, facilitated process that is designed to provide an environment, especially the use of workshops, for developing a co-operative atmosphere within the partnership. Essentially, a partnering process is a method systematically initialising, implementing and internalising partnering concepts.

The partnering process is associated with the following tools and techniques:

- Charters and dispute resolution mechanisms;
- Teambuilding exercises and facilitation workshops;

- Continuous improvement processes;
- Total quality management;
- Business process mapping; and
- Benchmarking (Bresnen & Marshall 2000).

Alliancing

Anvuur and Kumaraswamy (2007) described project alliancing as a deeper form of partnering which contractually links the financial success of each of the parties directly to the overall success of the project. The alliance agreement is drawn up as an overarching legal agreement or constitutes the sole contract which binds the parties to agreed targets, risk sharing, and reward mechanisms (Anvuur & Kumaraswamy 2007). Davis and Love (2011) identified an alliance as a form of innovative contracts and underlined the importance of collaboration and improved relationship in enhancing innovative outcomes.

If the client can use improved contract types, leadership qualities or other means to improve relationships between parties, it will contribute substantially to enhanced innovative outcomes of the project. Therefore, relationship enhancement is a vital mechanism which can be used by the client to facilitate innovation in a construction project.

3.6 Incentivisation

The category of incentivisation enables the client to provide incentives and rewards to enhance the motivation of those engaged in the project to work on innovative activities. These can be in the form of monetary or non-monetary incentives and rewards. Although look similar, incentives and rewards are two different processes. Incentives are given to motivate or encourage people to do better. A reward is what people receive for doing better.

The importance of providing incentives and rewards is highlighted in the innovation literature. Price and Davis (2002) found that rewards encourage team members to work harder and compete more effectively since they directly benefit from their efforts. Rewards also expose the organisation's priorities and show its commitment (Price & Davis 2002). Researching on the construction industry, Dulaimi et al. (2002 b) found that successful innovation may come about if companies establish a reward system to recognise innovators and to promote innovation. Commenting on the management of innovation in construction, Winch (1998) said that the essence of incentive structures that favour innovation is the appropriation of the rewards of innovation by those that take the risks of innovation (Winch 1998). Discussing the use of incentives in construction contracts, Bower et al. (2002) commented that:

- The role of incentives is to motivate the contractor to adopt the client's project objectives.
- It creates more proactive, cooperative relationships between the contracting parties and reinforces the cultural shift away from the traditional, adversarial approach to contracting.
- The basic principle of incentive contracting is simply to take advantage of a contractor's general objective to maximise his profits by giving him the opportunity to earn a greater profit if he performs the contract efficiently.

Looking at rewards and incentives used in construction projects, Winch (1998) said that incentives for innovation in construction cannot be improved without the development of a gain-sharing approach, where rewards are split between clients and the actors in the project coalition. Those in a position to innovate need to be rewarded for taking such risks. According to Eriksson et al. (2007), contracts can also be designed on a win-win basis to include incentives and rewards for all participants involved in innovation. Ozorhon et al. (2016) also highlighted the importance of rewards in promoting innovation in construction projects.

Alliance is a delivery type that promotes incentivisation. Alliancing is being identified as having specific relationship elements (e.g. trust, leadership and commitment) established among partners as a driver for collaborative behaviours and identity, hence strengthening the sources towards innovation (Ibrahim et al. 2017).

A major component of the alliance framework is the use of risk/reward model to encourage project team members to work together in a cooperative and integrated way so that rewards match performance. After studying the incentive aspects of this risk/ reward model, Love et al. (2010) found that the model led to positive and constructive behaviours occurring due to their perceived fairness and equity of payment structure. Tawiah and Russel (2008) also found that the projects with complete integration of all functions and the projects with performance-based payment and reward schemes based on prudence and fairness in a win-win agreement have a high/strong ability to drive project innovation. Alliance projects have these characteristics.

It is also to be noted that not all types of rewards equally promote innovation. Commenting on the types of rewards, Ahmed (1998) noted that rewarding individuals for their contribution to the organisation is widely used by corporations. However, while recognition can take many forms there is a common distinction: rewards can be either extrinsic or intrinsic. Extrinsic rewards are things such as pay increases, bonuses and shares and stock options. Intrinsic rewards are those that are based on internal feelings of accomplishment by the recipient. For example, being personally thanked by the CEO, or being recognised by the peer group, being awarded an award or trophy. Innovative companies appear to rely heavily on personalised intrinsic awards, both for individuals as well as groups. Less innovative companies tend to place almost exclusive emphasis on extrinsic awards. It appears that when individuals are motivated more by intrinsic desires than extrinsic desires, there is greater creative thought and action. Nevertheless, it has to be stated that extrinsic rewards have to be present at a base level in order to ensure that individuals are at least comfortable with their salary. Beyond the base salary thresholds, it appears that innovation is primarily driven by self-esteem level rather than external monetary rewards. It appears that extrinsic rewards often yield only temporary compliance. Extrinsic rewards promote competitive behaviours which disrupt workplace relationships, inhibit openness and learning, discourage risk-taking, and can effectively undermine interest in work itself. When extrinsic rewards are used, individuals tend to channel their energies into trying to get the extrinsic reward rather than unleashing their creative potential (Ahmed 1998).

Discussing incentivisation practiced in construction projects, Bower et al. (2002) said that cost incentives are generally thought of as a combination of inducement and threat. However, with regard to promoting innovation, the use of threat is not conducive at all. It is also to be noted that mere provision of incentives in construction contracts may not contribute to enhanced performance with respect to innovation. Rose and Manley (2005) found that if incentives are implemented in a project relationship that is plagued by underlying suspicions, the incentives are unlikely to induce a deep level of motivation and commitment, and could be seen as exploitation (a psychological response), causing their effectiveness to suffer significantly.

The last category is project team fitness which will be discussed next.

3.7 Project team fitness

All the strategies mentioned above may not work unless the client's team is capable of, and focused on, enhancing innovation. Supporting this conclusion, Khalfan and McDermott (2006) found that implementing innovative processes may result in failure without any motivation and efforts from the people actually responsible to carry out those processes. One of the most important factors driving innovation is the presence of a well-integrated team exhibiting collaborative behaviour (Ibrahim et al. 2017).

Therefore, the client's team should be highly motivated, experienced and knowledgeable about promoting innovation within the project. 'Project team fitness' concerns the deliberate actions that can be taken by the client to strengthen the project team, improving its capacity to facilitate innovation and providing support for innovative activities.

Client actions for project team fitness can be broadly grouped into the following components:

1. Create a capable project team by appointing suitable team members and develop the team so that it can undertake activities to enhance innovation performance.
2. Establish a strong supportive environment for the project team to undertake innovative activities.

Creating a capable project team includes the following actions:

- Appointing a project manager who recognises the importance of innovation and has necessary skills and experience to lead the innovation facilitation process;
- Appointing a capable project team by recruiting technically knowledgeable and experienced project team members from diverse backgrounds; and
- Developing the project team by inculcating team innovative culture and developing the team as a high-performing team.

The three actions are explained below.

3.7.1 Project manager

As noted by Gallagher (2015), innovation has become a core competency for project managers. From their study on client's championing characteristics that promote construction innovation, Kulatunga et al. (2011) found that the following client characteristics promote innovation in construction projects:

- Client's foresight and vision;
- Demand for innovation;
- Client's support to innovation;
- Client needs to be an effective team player;
- Client needs to develop mutual trust and understanding between individuals;
- Client's respect for people is vital;
- Client's professional competence;
- Ability for effective dissemination of information;
- Client's value judgment;
- Ability to maintain strong relationships between project members and other external stakeholders;
- Ability to maintain up-to-date knowledge about project development;
- Flexible and receptive to change;
- Establishing reasonably firm goals and priorities; and
- Ability to manage risk.

The client is represented by the project manager at the construction project. Therefore, it is vital for the client to appoint a project manager with the above values to lead the project. Nepal (2004) identified demonstrating commitment for innovation and stimulating project team members for innovation as innovative qualities of an effective project manager.

According to Cheng et al. (2005), highly effective project managers (whom they call superior managers) demonstrate a higher level of:

- Achievement orientation - showing improvement in performance, more entrepreneurial behaviour and provide more innovation ideas for new services;
- Initiative - proactive actions to avert problems in order to enhance job results;
- Information seeking - proactive exploration of issues and solutions outside their immediate environment;
- Focus on client's needs - effort to meet their client's requirements;
- Impact and influence - proficiency in coordinating, inspiring and directing the

team;

- Directiveness - effort to ensure that individual subordinates comply with his/her wishes in the way that was intended;
- Teamwork and cooperation - influencing the team to perform in a desirable manner;
- Team leadership - recognising when and when not to act authoritatively if they are to get the best out of their colleagues;
- Analytical thinking - conception, analysis and reasoning in order to make appropriate management decisions;
- Conceptual thinking - being able to see the bigger picture;
- Self-control - staying calm and maintaining performance under stressful conditions; and
- Flexibility - remaining adaptable and flexible to solve the problems in hand.

All these attributes help in promoting innovation. Those clients interested in promoting innovation need to either recruit project managers with above qualities or provide training to upskill their project managers.

Undertaking innovative activities is difficult in risk-averse organisations. However, Gallagher (2015) recommends that project managers, operating in such organisations, 'pilot' ideas and improvements in a controlled environment before recommending wider implementation.

3.7.2 Project team

A motivated, knowledgeable and experienced project team is vital for innovation in projects. Individual contributions can be critical in several roles and at several stages of the innovation delivery process (Hardie 2009).

According to Somech and Drach-Zahavy (2013), team composition has a powerful influence on innovation. Individuals who have access to a range of alternatives are more likely to make connections, use wider categorisations, and generate more divergent solutions which could lead to higher team creativity. In addition, creativity can be fostered in the work group itself, according to them, through diversity in team members' roles.

Functionally heterogeneous teams assemble people from different disciplines and functions who have pertinent expertise in the proposed course of action. Assembling people with different organisational roles, who possess a broad array of skills, knowledge, and expertise, helps the team solve the complex task of developing new products or procedures. Team diversity triggers communication with members outside the team which in turn leads to the incorporation of diverse kinds of information, broadens team members' perspectives, and facilitates the generation of new approaches and ideas (Somech & Drach-Zahavy 2013). Hardie (2009) added that innovation can be fostered through management practices that encourage multi-disciplinary teams.

Citing other research and their own, Blindenbach-Driessen and Ende (2006) stated that teams that focus their external interaction both to persuade others of the importance of a team's work and to coordinate, negotiate and obtain feedback from outside groups, make these teams move quickly on budgets and schedules in the short term, and manage to produce the most innovative products over the course of the development process.

3.7.3 Team environment

Many researchers have identified different characteristics in the team environment that contribute to innovation. These include creating a psychologically safe environment to expresses ideas freely and a cohesive environment where sharing of values exists. According to Barrett et al. (2013), a psychologically safe environment created by a more inclusive, socially cohesive group dynamic is more likely to promote creativity. Citing other researchers, Scott and Bruce (1994) suggested that, the cohesiveness of a work group determines the degree to which individuals believe that they can introduce ideas without personal censure. They also noted that collaborative effort among peers is crucial to idea generation.

While emphasising the importance of the cohesiveness of a team towards innovation, Barrett et al. (2013) also stated that if opportunities for innovation are omitted from shared values or receive low priority, then a group norm will have developed in which innovation does not form part of the accepted focus or task effort. An innovative team climate is identified as a predictor of innovation outcomes by many authors according to Panuwatwanich et al. (2008).

Somech and Drach-Zahavy (2013) also emphasised that the success or failure of a work team depends greatly upon the team's context or environment. Their research showed that team creativity would translate to innovation implementation only under high levels of climate for innovation. A climate in which it is safe to speak up and take risks is suggested to complement the adaptation and implementation of innovation (Somech & Drach-Zahavy 2013).

Risks are inherent in innovation as the goal is to travel into unchartered waters. Barrett et al. (2013) found that project participants are more likely to take risks if they are part of a cohesive team which promotes psychological safety and adopts a shared value of risk acceptance.

After conducting research on mega projects, Caldas & Gupta (2017) concluded that organisations should continuously conduct team-building sessions during front-end planning and execution. They recommended that these meetings include all levels of the team and be facilitated.

The above discussion highlights the importance of an innovative climate for the project team to engage in innovative activities, particularly focussing on the cohesiveness of a work group providing psychological safety and adopting a shared value of risk acceptance.

Establishing a strong supportive environment for the project team to undertake innovative activities is also vital and includes the following actions:

- Providing encouragement and support to the project team; and
- Taking actions for the client organisation to be innovative.

These factors are discussed next.

3.7.4 Supportive environment for the project team

A supportive environment is necessary for the project team to engage in innovative activities. Scott and Bruce (1994) noted that adequate supplies of such resources as equipment, facilities, and time are critical to innovation, and the supply of such resources is another manifestation of organisational support for innovation. Commenting on the subject, Somech and Drach-Zahavy (2013) mentioned that support for innovation means the expectation, approval, and practical support for attempts to introduce new and improved ways of doing things in the work environment. Support for innovation varies across teams to the extent that it is both articulated, by personnel documents, policy statements, or word of mouth, and enacted, by the active promotion of innovative behaviour such as sufficient time for producing novel work in the domain or availability of training. Aside from the obvious practical support required to implement new products or methods, perceptions of the adequacy of resources may affect teammates psychologically by leading to beliefs about the intrinsic value of the projects they have undertaken which in turn enhance their willingness to dedicate time, share resources, and cooperate in implementing their creative ideas (Somech & Drach-Zahavy 2013).

Blindenbach-Driessen and Ende (2006) also reiterated the importance of support (both tangible and intangible) from the senior management of the client team as crucial for the success of projects. However, they emphasised this should be without too much control or disturbing the project on a daily basis.

Managers in the client organisation, especially the middle management, can provide a lead role in promoting innovation. Kissi et al. (2012) reported that leaders can support creativity and innovation in the workplace through intellectual stimulation and helping to establish an environment that encourages staff to seek new approaches to addressing old problems without being concerned about recrimination in the event of a negative outcome and provide motivation to pursue organisational goals. Their studies concluded that middle managers have a significant role to play in facilitating innovation and improving performance in construction professional services firms and advocated recognition of the role of middle managers in organisational performance (Kissi et al. 2012).

Support for innovation needs to be given by management at all levels of the client's organisation. For example, supervisors supportive of entrepreneurship and innovation can promote employees' feelings of self-determination and personal initiative at work, allowing employees to consider, develop, and ultimately contribute more creative outcomes (Palmer 2005). Scott and Bruce (1994) found that when managers expect subordinates to be innovative, the subordinates will perceive the managers as encouraging and facilitating their innovative effort. These behaviours will be seen as representative of their organisations at large, and therefore the organisations will be perceived as supportive of innovation (Scott & Bruce 1994).

In addition to providing material support, clients can introduce innovation-friendly policies to encourage project level innovation. Manley (2006) identified the following policies:

- Instituting value-based selection of tenders;

- Designing prequalification systems that assess innovation history;
- Employing performance-based standards and regulations; and
- Providing financial incentives within contracts.

Encouraging alternative bids in the bidding process is another policy identified by Fernando et al. (2013).

3.7.5 Client organisation

The task of promoting innovation is easy if the client organisation, itself, is innovative. Research by Dulaimi et al. (2005) showed that construction organisations could foster innovation on projects by creating proper organisational climate. Tatum (1989) found that the firms producing construction innovations appeared to contain several common elements of an innovation culture. This included persistent pursuit of improved productivity, the arrogance to question everything, and a pride in winning competitions to find ways to improve.

Quoting many others researching architecture and engineering design firms, Panuwatwanich et al. (2008) emphasised the important role of the organisation in the successful management and diffusion of innovation. They concluded that such innovative organisations have the culture and climate conducive to innovation (Panuwatwanich et al. 2008).

3.7.6 Characteristics of an innovative organisation

An organisation with a culture oriented to facilitate innovation has distinguishing characteristics. Some of the characteristics identified in the literature are given below:

- Acknowledgement of and reward for creativity;
- Value innovation and change and has a clear strategic vision for the company;
- Understanding and a belief of management that creativity, imagination and innovation are intrinsic to their roles;
- Persistent pursuit of improved productivity;
- The arrogance to question everything;
- Pride in finding ways to improve;
- Encouragement and support for the development and exploration of ideas;

- Willingness to entrust employees with a degree of freedom of thought and action to act in the direction of organisational goals;
- Toleration of failures and mistakes if done in the process on innovation;
- Careful risk consideration and management;
- Commitment of necessary resources (manpower, money, information and time);
- Recognition, encouragement and support from all levels of employees towards innovative activities;
- High level of knowledge flow within the organisation;
- Effective knowledge content management;
- Availability of networking facilities within and outside the organisation; and
- Strong relationships with clients and stakeholders (Dulaimi et al. 2005), (Fernando 2006), and (Tatum 1989).

To promote innovation in an organisation, an innovation system needs to be established. Serrat (2009) has listed the following components of an effective innovation system:

- Clarity in mission statements and goals which invariably feature a commitment from senior managers to assume responsibility for the risk of failure;
- An organisational culture that values innovation, where there is encouragement for personnel to think differently, take calculated risks, and challenge the status quo. Major forces such as leadership, attitudes to risk, budgeting, audit, performance measurement, recruitment, and open innovation are aligned in support;
- A systems approach to management that understands innovation as one part of a wider context, appreciates interconnections, and can conduct systematic analyses of how a problem interacts with other problems, parts of the organisation, projects, etc. Management fosters coordination across these interconnections and stresses integration rather than compartmentalisation;
- The adequate resourcing of innovation in line with strategy;
- The placing of responsibility for innovation on all staff;
- Understanding that creativity is desirable but insufficient. Innovation ambassadors must still take responsibility for follow-through;

- An enriched physical workplace that enhances creativity by providing accessible, casual meeting spots; physical stimuli; space for quiet reflection; a variety of communication tools, e.g., white boards, bulletin boards; contact space for clients, audiences, and partners; and room for individual expression, among others;
- Human resource systems that ensure staff have diverse thinking (or learning) styles, giving them a variety of perspectives on single problems;
- Team setups that avoid groupthink and balance the beginner's mind with experience, freedom with discipline, play with professionalism, and improvisation with planning. Teams embody divergent and convergent thinking, diverse thinking styles, and diversity of skills; and handle conflict;
- High levels of decentralisation and functional differentiation and a range of specialised areas within the organisation;
- Honed knowledge management systems and processes that constantly bring new ideas, concepts, data, information, and knowledge into the organisation;
- Numerous and empowered members of relevant communities and networks of practice;
- Processes and methodologies that identify and share good practice;
- A performance measurement system that measures the innovative pulse of the organisation; ensures monitoring and evaluation of inputs, activities, outputs, outcomes, and impacts; and feeds lessons back to the system;
- The instigation of incentives and rewards for innovative individuals and teams;
- Plentiful space for creative thinking and reflective practice, e.g., away-days, brainstorming sessions, peer assists, after-action reviews and retrospects, problem-solving groups, discussion groups and forums;
- Linkages with the marketing function, in ways that involve stakeholders and seek regular feedback;
- Effective dissemination systems;
- Dedicated information systems that ensure positive coverage and publicise success; and
- Structured intellectual property management systems that identify, protect, value, manage, and audit the organisation's intellectual property (Serrat

2009).

In addition, Hardie (2009) found that an organisational structure that encourages monitoring of new ideas and practices and the careful evaluation of innovations creates an atmosphere in which further innovation is quite likely to occur.

In the context of innovation, risk is a possibility as pointed out by Gallagher (2015), who said that an organisation's attitudes toward risk will heavily influence a project manager's ability to drive innovation forward. In risk-averse organisations, compliance with best practice is usually preferred above innovation and experimentation.

Discussing innovation and risk, Stone and Keating (2010) pointed out that the challenge confronting leaders is how to structure their organisation’s approach to innovation so that exposure to risk arising from innovation activities is managed and mitigated. All these factors point to the fact that high level risk management procedures are essential for those organisations interested in promoting innovation.

The above sections provided detailed information on the major categories of client-led innovation enablers identified during the literature review. However, identification is not sufficient and these need to be tested for confirmation. The testing was done through interviews with industry experts. The section below provides details about the testing process.

3.8 Testing with expert interviews

The identified main categories of innovation enablers were tested using expert interviews. The following procedure was adopted in identifying the industry experts:

1. A list of construction engineers (total of 17, all working in Australia) was prepared selected from personal contacts using the following criteria:

- Each should have at least 25 years of experience in construction projects.
- Each should have contributed to construction projects of over AUD100 million in value.
- Each should have played major roles in construction projects such as the project manager or as a representative of an organisation providing specialised services (e.g. Chief Geotechnical Engineer, Chief Designer).

2. The list was then reduced to ten to have a better spread of expertise and disciplines, i.e. to have some participants directly representing the client

team, and others representing supporting roles such as designers and geotechnical engineers. Their willingness to participate in the interviews as well as their commitment to innovation were also taken into consideration.

3. Most participated through face to face interviews. The interviews ranged from 45 to 120 minutes. Each participant was asked to identify fundamental enabler categories that could be initiated by clients generating innovative activities in construction projects. Later they were shown a note with the identified enabler categories, asking them to comment on the categories with regard to their adequacy. The interviews were generally held in participant's workplaces. Two were interstate participants and phone interviews were held with them.

The following is a summary of key points identified during the interviews:

- Although most of them were unable to identify the categories of enablers in full as appeared in the note, they were able to identify strategies or actions that resulted from the enabler categories.
- A few identified idea harnessing as a category of enablers, but none were able to identify the other categories on their own.
- When discussing the identified categories in the note given, they all accepted the categories as proper and complete. No participant was able to identify additional enabler category.

Some of the specific areas identified by participants included the following:

- Many identified some contract types such as Early Contractor Involvement Contracts and Alliance as those promoting innovation. When prompted for reasons for facilitating innovation, it was possible to identify incentivisation and relationship enhancement as categories of enablers that lead to innovation promotion.
- Some participants identified partnering as contributing to facilitate innovation which they later agreed to group under relationship enhancement.
- Some highlighted the role of the project manager to facilitate innovation. Also, the climate and the culture of the client organisation were highlighted by some who agreed to group these under the category of project team fitness.
- The other key strategies identified by interviewees included the following:

encouraging alternative bids when tendering for construction projects; use of non-price criteria for selecting contractors; specifying performance-based deliverables when preparing tender documents; purchase of best ideas of unsuccessful contractors in Design and Build contracts; use of relationship contracting; and using past innovation history.

Participants used the interviews to identify barriers to innovation as well. These barriers helped to guide them to identify relevant enabler categories as those which could help to reduce the barriers. The following are some of the barriers identified:

- The selection of service providers based on lowest bid by some public sector organisations, especially by city councils;
- The risk aversion by some public sector clients;
- Adversarial relationships between the clients and the contractors; and
- Time pressure not allowing project personnel to engage in innovative activities.

The interviews validated the identification of enabler categories for the clients to facilitate innovation in construction projects.

3.9 Theoretical framework

Based on the above analysis, a framework consisting of the following enabler categories that can be implemented by clients to augment innovation in construction projects was developed:

1. Idea harnessing (strategies for the generation of new and beneficial ideas and their implementation);
2. Relationship enhancement (employing actions to improve relationships between parties engaged in a project);
3. Incentivisation (providing incentives/rewards to promote innovative activities); and
4. Project team fitness (deliberate actions taken to strengthen the project team and improve its ability to focus on innovative activities).

The identified framework is given in *Figure 3.3.*

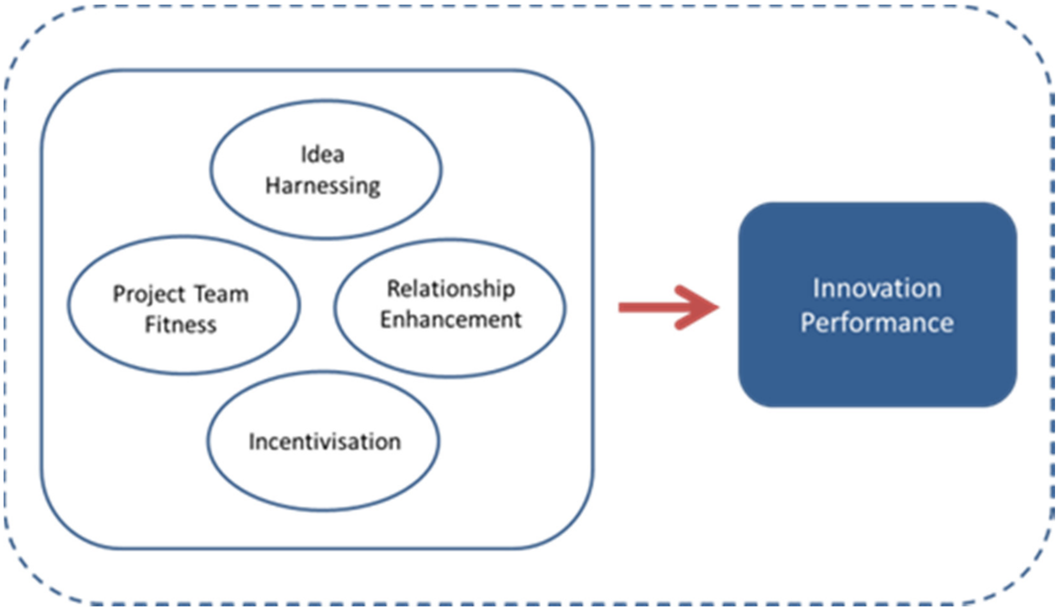


Figure 3.3 Conceptual framework

3.9.1 Development of a model

Information gained from the literature review provided the opportunity to develop the theory and a model to represent the new knowledge relevant to this study area. A theory is a set of systematically interrelated constructs and propositions intended to explain and predict a phenomenon or behaviour of interest, within certain boundary conditions and assumptions. A model is a representation of all or part of a system that is constructed to study that system. While a theory tries to explain a phenomenon, a model tries to represent a phenomenon (Bhattacherjee 2012). The model developed is shown in *Fig. 3.4.*

The model consists of the following constructs: idea harnessing; relationship enhancement; incentivisation; project team fitness; and innovation performance. As explained by Bhattacherjee (2012), a construct is an abstract concept that is specifically chosen (or "created") to explain a given phenomenon.

The model has the following characteristics:

- It uses idea harnessing, relationship enhancement, incentivisation and project team fitness as independent constructs and innovation promotion as the dependent construct.
- Idea harnessing, relationship enhancement, incentivisation and project team fitness each promote innovation in a construction project.
- These constructs promote each other.

- The model is uncomplicated and is easy to understand and use.

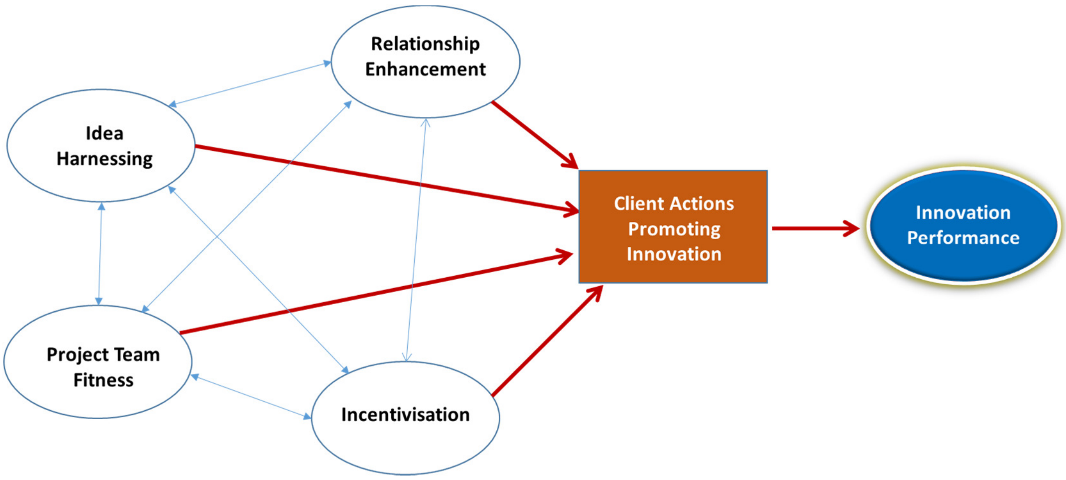


Figure 3.4 Conceptual model

The empirical evidence and logical reasoning that led to the development of model characteristics are explained below.

Relationships of constructs with innovation performance

Justifications for each construct promoting innovation performance are given in *Sections 3.4 to 3.7* with empirical evidence.

Relationships of constructs with each other

Unfortunately, not much empirical evidence can be found on the relationships between constructs due to the limited research undertaken on project level innovation as described in *Section 2.9*. In addition, these constructs have never been identified as major categories contributing to the promotion of innovation in construction projects. However, there are strong logical reasons indicating the inter-relationships between constructs. The empirical evidence and logical reasoning that support the relationships between constructs are given below.

Relationships of other constructs with idea harnessing

- Relationship enhancement promotes idea harnessing because when parties work in a friendly encouraging environment, it is easy for people in these parties to come up with new and beneficial ideas related to the project. On the other hand, in an adversarial relationship with limited positive communication, parties hesitate to contribute to the project with good ideas. This was confirmed by Murphy et al. (2011), who found that a close cooperation between stakeholders is vital for the implementation of innovative ideas. Asad et al. (2005) also added that contractor-client cooperation can act as a catalyst to promote innovative thinking and a collaborative culture.

- Incentivisation is providing incentives and rewards to improve motivation of project personnel. Highly motivated personnel tend to contribute for the betterment of the project by giving good ideas and implementing them.
- The purpose of project team fitness is to strengthen the capabilities of the client team and support it to undertake innovative activities. In such a strong project team, new ideas can come up frequently and can be implemented. Therefore, project team fitness promotes idea harnessing. Commenting on the cohesiveness of a work group, which comes under project team fitness, Scott and Bruce (1994) noted that it determines the degree to which individuals believe that they can introduce ideas without personal censure. Furthermore, they found that collaborative effort among peers is crucial to idea generation. Somech and Drach-Zahavy (2013) also commented on the contribution of project team fitness to promote idea harnessing. According to them, aside from the obvious practical support required to implement new products or methods, perceptions of the adequacy of resources may affect teammates psychologically by leading to beliefs about the intrinsic value of the projects they have undertaken which in turn enhance their willingness to dedicate time, share resources, and cooperate in implementing creative ideas.

Relationships of other constructs with relationship enhancement

- Idea harnessing requires the use of techniques such as brainstorming which provides an opportunity for project personnel to meet with each other and express ideas. This has the potential for the project personnel to develop better relationships between themselves.
- Incentivisation makes parties happy with each other which contributes to the improvement of relationships. Bower et al. (2002) supported this by stating that incentivisation creates a more proactive, cooperative relationship between the contracting parties and reinforces the cultural shift away from the traditional, adversarial approach to contracting. On the other hand, Rose and Manley (2005) found that if incentives are implemented in a project relationship that is plagued by underlying suspicions, the incentives are

unlikely to induce a deep level of motivation and commitment, and could be seen as exploitation (a psychological response), causing their effectiveness to suffer significantly.

- A highly motivated project team in pursuit of innovation would be inclined to receive more support from other parties to undertake innovative activities, thereby, enhancing its relationship with other parties.

Relationships of other constructs with incentivisation

- Idea harnessing is the generation and implementation of new and beneficial ideas for the project. If beneficial ideas come from parties other than the client's team, there is a likelihood of the client team (or the client) reciprocating by providing incentives. Some incentives may be trivial such as inviting the project personnel to celebrate project milestones or recognising the contributions at events.
- A friendlier client team is more inclined to provide incentives to other parties to improve performance. On the other hand, if the relationships between the client team and other parties is adversarial, it is less likely to provide incentives to other parties.
- Project team fitness can provide the project team with a better understanding of the innovation process happening in the project. This understanding can lead them to provide incentives for innovation. Effective project managers use incentivisation to motivate project personnel.

Relationships of other constructs with project team fitness

- Generation of more beneficial ideas, enhanced relationships between parties and incentivisation will lead to more innovative activities which may require the client (or the project manager) to strengthen the project team, especially improving technological and other relevant skills in the client's team to enable the implementation of such innovations.

The above reasoning supports the development of the two model characteristics, i.e. constructs promoting innovative outcomes and constructs promoting each other, in construction projects.

The development of the framework and the model completes the formation of the theory designed to solve the research problem. However, it needs to be tested and validated to be meaningful.

3.9.2 Research questions

At this juncture, it is worth revisiting the research questions identified earlier (*Section 2.11.1*). The following were the research questions identified:

RQ1: Is it possible for clients of construction projects to influence promoting innovation in their projects?

RQ2: If this is possible, what actions can construction clients take to promote innovation in their projects?

RQ3: Is it possible to group these actions (also called innovation enablers) into major categories?

RQ4: If possible, what are the enabler categories?

RQ5: What are the relationships of these categories with innovative performance?

RQ6: Do these categories have relationships among themselves?

With the literature review undertaken thus far, it is possible to answer these questions as follows:

1. Is it possible for clients of construction projects to influence promoting innovation in their projects? Answer: yes
2. If this is possible, what actions can construction clients take to promote innovation in their projects? Answer: a large number of actions identified in the *Appendix 1*, some of which are given under *Sections 3.4* to *3.7.*
3. Is it possible to group these actions (also called innovation enablers) into major categories? Answer: yes.
4. If possible, what are the enabler categories? Answer: The main categories are idea harnessing, relationship enhancement, incentivisation and project team fitness.
5. What are the relationships of these categories with innovative performance? Answer: They all promote innovative performance.
6. Do these categories have relationships among themselves? Answer: Yes. Their relationships are shown in *Figure 3.4* Conceptual model.

3.10 Chapter summary

In this chapter, client-led enablers that augment innovation in construction projects were investigated through a literature review. After a general review, which identified a number of enablers, a targeted review was undertaken to assign these enablers into major groups. The major groups thus identified were:

1. Idea harnessing (strategies for the generation of new and beneficial ideas and their implementation);
2. Relationship enhancement (employing actions to improve relationships between parties to a project);
3. Incentivisation (providing incentives/rewards to promote innovative activities); and
4. Project team fitness (deliberate actions taken to strengthen the project team and improve its ability to focus on innovative activities).

These major groups of enablers were tested using expert panel interviews.

The literature review was extended to develop a conceptual model illustrating the association of the groups of enablers to innovation promotion and also the association of the groups of enablers with each other.

The conceptual model was developed using the findings of fundamental research on factors contributing to innovative outcomes in workplace situations using the targeted literature review. It has no bearing on whether the initiator should be the client or not and whether the findings are confined to construction projects or not. Therefore, it can be stated that the conceptual model, developed for the client, is also applicable to any other party, such as the designer or the contractor, to promote innovation in a project. The only change that needs to be made is that the name 'owner organisation' is to be replaced by 'parent organisation'. In addition, the model developed can be used in any project irrespective of the project area.

It is now necessary to test the framework and the model. A survey was conducted to collect data from Australian construction projects and details are given in the next chapter.

CHAPTER 4
DATA COLLECTION & PRELIMINARY SCREENING

4.1 Chapter overview

Having discussed the research background and the research approach, this chapter discusses the data collection and preliminary screening. It explains why the questionnaire survey method was selected to collect primary data for the research and how the questionnaire was prepared and tested. The chapter also provides information on the type of data collected. The information provided by participants are analysed to understand the general nature of their personal profiles and the projects selected by them to provide response to the survey.

The chapter commences with the explanation of the data collection method used in the study.

4.2 Data collection

As stated by Kothari (2004), here are two types of data, i.e. primary and secondary. The primary data are those which are collected afresh and for the first time, and thus happen to be original in character. Secondary data, on the other hand, are those which have already been collected by someone else and which have already been passed through the statistical process.

The methods of collecting primary data, particularly in surveys and descriptive researches, include: (1) observation method, (2) interview method, (3) questionnaires, (4) schedules, and (5) other methods which include (a) warranty cards; (b) distributor audits; (c) pantry audits; (d) consumer panels; (e) using mechanical devices; (f) projective techniques; and (g) depth interviews (Kothari 2004). This research used the methods of questionnaire and interviews to collect primary data. This chapter will be focussed on questionnaire. Interviews were discussed in Section 2.10 Testing project level innovation definition.

Invented by Sir Francis Galton, a questionnaire is a research instrument consisting of a set of questions (items) intended to capture responses from respondents in a standardised manner (Bhattacherjee 2012).

4.2.1 Selection of questionnaire survey

Kothari (2004) has identified the advantages and disadvantages of using the questionnaire surveys for research studies. The advantages include the following:

- There is low cost.
- It is free from the bias of the interviewer; answers are in respondents' own words.
- Respondents have adequate time to give well thought out answers.
- Respondents, who are not always easily approachable, can also be reached conveniently.
- Large samples can be made use of and thus the results can be made more dependable and reliable.

The disadvantages include the following:

- Low rate of return of the duly filled in questionnaires; bias due to no-response is often indeterminate.
- It can be used only when respondents are educated and cooperating.
- The control over the questionnaire may be lost once it is sent.
- There is inbuilt inflexibility because of the difficulty of amending the approach once questionnaires have been despatched.
- There is also the possibility of ambiguous replies or omission of replies altogether to certain questions; interpretation of omissions is difficult.
- It is difficult to know whether willing respondents are truly representative.
- This method is likely to be the slowest of all (Kothari 2004).

To investigate the research question, it was necessary to collect the perceptions of a large number of practitioners on innovation enablers applicable to construction projects. Methods such as observation and interviews were not suitable to this research as they were not practical when a large number of participants were involved in. On the other hand, questionnaire survey allows to obtain the perceptions of a large number of practitioners with less time and effort. The questionnaire survey was, therefore, considered and adopted as the best primary data collection method for this research.

Having discussed the data collection method, the section below explains the preparations and testing of the survey questionnaire.

4.3 Survey preparation

Under this section, the questionnaire development and testing are discussed.

4.3.1 Development of the survey questionnaire

The questionnaire was developed using the following:

- Findings of a comprehensive review of literature mentioned in *Chapter 2*;
- Questionnaire items used in previous similar research; and
- The suggestions provided by industry experts through interviews (the same interviews used for identifying innovation enablers as mentioned in *Section 3.8* were extended to cover the survey questionnaire).

For example, some of the factors influencing the innovative potential of construction projects identified by Tawiah and Russel (2008) were used in the questionnaire. The list of the factors identified by Tawiah and Russel as relevant to this research is given in *Table 3.1*. The following are the factors extracted from this list and included in the questionnaire:

- Project cost;
- Project complexity;
- Nature/ composition of the project team;
- Requirements for broader socioeconomic benefits; and
- Incentive payments for project performance.

When preparing the questionnaire, guidance was received from the following research questionnaires of previous researchers:

- The innovation competence of repeat public sector clients in the Australian construction industry by Manley (2006).
- Modelling the Innovation Diffusion Process in Australian Architectural and Engineering Design Organisations (Panuwatwanich 2008).

In the questionnaire, the respondents were requested to answer questions based on an innovative construction project that each of them was involved with during the last five years. It was emphasised that the project could have used new or significantly improved technologies, methods, services, practices, materials, products, plant and equipment, advanced computer software/ hardware and models etc. that generated noteworthy benefits. It was also mentioned that the ideas for these may have either been generated within or adopted from elsewhere.

The respondents were requested to provide information relating to any phase of a project except the maintenance phase. In addition, residential construction was excluded. However, the construction of large public, commercial and industrial buildings (such as museums, shopping complexes) were included. These restrictions were in line with the boundary conditions stipulated and given in *Section 1.2.5*.

4.3.2 Questionnaire composition

The questionnaire consisted of three parts: project information; client-led enablers under major categories (identified in the framework) and innovative performance of the project; and background information about the participants and their organisations.

Project information (Part 1) requested information of the project such as the main engineering area, delivery type, cost and the complexity.

The questions related to client-led enabler categories requested in Part 2 were under the following categories: idea harnessing (Group A), relationship enhancing (Group B), incentivisation (Group C) and project team fitness (Group D). This section also included the participant's perception of the project's innovative performance (Group E). The following were the areas questioned under each section:

- Idea Harnessing: use of idea generation techniques, idea generation and implementation strategies.
- Relationship enhancement: form of relationship with the contractor, nature of the relationship.
- Incentivisation: incentivisation strategies.
- Project team fitness: project manager; project team facilities, team environment and culture; client organisation perception.
- Project innovative performance: project usage; outcomes; project recognition.

Altogether, the Part 2 had 63 questions.

The last section (Part 3) consisted of questions related to the background of participants and their organisations such as gender, level of education, age group, professional experience, main engineering area of the organisation, occupation and type of the organisation.

The questionnaire is given as *Appendix 3*.

4.3.3 Testing of questionnaire

Before using the survey, it was necessary to test the questionnaire. Pilot tests help identify redundant or poor questions and provided an early indication of the reproducibility of the responses (Passmore et al. 2002). According to Bhattacherjee (2012), pilot testing helps detect potential problems in the research design and/or instrumentation, and to ensure that the measurement instruments used in the study are reliable and valid measures of the constructs of interest.

After developing the questionnaire, it was tested with ten highly experienced industry practitioners. The ten industry practitioners were selected on the basis of their experience in undertaking construction projects. They all had at least 25 years of project management experience in high-cost construction projects, generally costing more than AUD100 Million each.

First, they were provided with the questionnaire and requested them to go through the questions carefully and fill a feedback form on the face validity of the questionnaire. The Expert Panel Briefing Sheet given to interviewees is given as *Appendix 2*. It consisted of questions such as:

1. Whether the relationships of the model developed through the literature review reflected in the questions?
2. Were the questions being repeated?
3. Were the questions easy to understand?
4. Were the questions relevant?
5. Were the questions easy to answer?

This was followed by face to face interviews with each of them to discuss their feedback. After receiving feedback from each expert panel member, the questionnaire was revised and refined based on the feedback received. The refined feedback was tested with the next panel member.

It is to be noted that this testing only validates the appropriateness and the ease of use of the questionnaire. However, it would have been better if the questionnaire was pilot tested by collecting sample data, test the proposed model and check whether or not the intended outcome is achieved.

4.4 Conducting the survey

After completing the questionnaire, it was posted on the University of Southern Queensland website. Selection of the survey participants was done carefully to reflect the purpose of the research. They were identified through google search and included all engineering statutory bodies at federal, state and local government levels (example: all road authorities, city councils), construction companies, other engineering service suppliers such as consultants, designers, and geotechnical service providers.

One of the barriers in receiving a good response rate in surveys involving construction industry professionals is that they are very busy in their day-to-day work. Therefore, the use of a gift was considered necessary in this survey.

Emailing was the main method of sending the information for prospective respondents, giving the webpage link to the questionnaire. In addition, printed survey forms were posted to some prospective respondents. The posted material included an “Instant-Scartch-It” ticket (a ticket where the relevant numbers can be found by scratching an area on the ticket) each, as a token gesture for completing the survey. This ticket had the potential to win a prize of AUD25,000. This form of incentive was considered to improve the response rate.

Literature shows the benefits of using incentives in surveys. For example, in mail surveys, consistent evidences indicate that pre-paid incentives boost response rates but post-paid incentives do not (Fan & Yan 2010). According to Singer (2012), prepaid incentives yielded significantly higher response rates than promised or no incentives, monetary incentives yielded higher response rates than gifts, and response rates increased with increasing amounts of money, though not necessarily linearly. In his survey on modelling the innovation diffusion process in Australian architectural and engineering organisations, Panuwatwanich also posted an “Instant-Scartch-It” ticket which had the potential to win a Coles Myer Gift Card worth AUD100 (Panuwatwanich 2008).

Special ethical clearance was obtained from the university to use “Instant-Scartch-It” ticket. However, the use of this method had no ethical issues and it was not brought to the notice of the researcher that any person won the AUD25,000 prize money.

Another barrier encountered in this survey was the difficulty in accessing the survey form by some public sector organisation personnel due to the practice of using firewalls by such organisations to limit the use of unwanted internet sites.

4.4.1 Survey response

The questionnaire was distributed to over 300 construction industry practitioners. In total, 131 valid responses were received, representing about 44% effective response rate. Given below is an assessment of this response rate.

As pointed out by Bhattacherjee (2012) survey research is generally notorious for its low response rates. A response rate of 15-20% is typical in a mail survey, even after two or three reminders (Bhattacherjee 2012). Sills and Chunyan Song (2002) reported of response rates varying from 70% to 0% for internet surveys.

This response rate is better than some of the surveys conducted in the area of construction. For example, Manley conducted a survey to assess the innovation competence of repeat public sector clients in the Australian construction industry, with a distribution of 1371 questionnaires and receiving a response rate of 29% (2006). Panuwatwanich also conducted a survey to model the innovation diffusion process in Australian architectural and engineering organisations and had a response rate of 34.81%. He has sent questionnaire to 520 individuals (2008). On the other hand, Hughes and Thorpe (2014) had a better response rate of 40.4%, with a survey to review enabling factors in construction productivity in Australia. However, they distributed questionnaires to a smaller sample of 89 selected individuals. Therefore, the response rate of this survey is considered satisfactory.

4.4.2 Information gathered

The survey provided information under three parts: project information (Part 1); client-led enablers under different groups and innovative performance of the project (Part 2); and background information about the participants and their organisations (Part 3). Initially, there were 132 sets of data derived from completed survey forms.

After collecting the set of data, it was first checked for missing entries. The process used for dealing with missing values is described below.

4.5 Dealing with missing data

It is not common to find any data set resulting from a survey questionnaire without missing data. If the effect of missing data is not taken into account, the results of the statistical analyses will be biased and the amount of variability in the data will not be correctly estimated (Bennett 2001). When dealing with missing data, two aspects need to be considered: the amount of data missing; and the type of data missing.

4.5.1 Amount of data missing

Three survey forms had substantial amount of incomplete data and therefore, removed from the data set. The remaining data was analysed using missing value analysis. *Table 4.1* shows the missing value analysis undertaken. From the table it can be seen that the percentage of missing values for each variable was low, the maximum being 3.9%. According to Bennett (2001), when the amount of missing data is large (greater than 10%), the results of subsequent statistical analyses may be biased. Therefore, the amount of missing values in this survey was not excessive.

4.5.2 Type of missing data

The missing values were checked to see whether there were any recording errors and it was concluded that all missing values were due to survey respondents not filling in. Then the attention was focussed on the type of missing data. According to Bennett (2001), there are three types of missing data that can occur when the data are being collected: Missing completely at random (MCAR); Missing at random (MAR); and Not missing at random (NMAR). Bennett's explanation of these three types is as follows:

Missing completely at random

The participants with complete data cannot be distinguished from participants with incomplete data. When data are MCAR, the missing values can be thought of as a random sub-sample of the actual values.

Missing at random

The participants with incomplete data differ from participants with complete data, but the pattern of 'missingness' is traceable or predictable from other variables in the dataset, rather than being due to the specific variable on which the data are missing.

Table 4.1 Missing value analysis

Variable	N	Count	Missing Percent	Mean Statistic	Std. Deviation Statistic	Std. Error of mean
Q2A2.1	128	1	0.8	4.30	0.69	0.06
Q2A2.2	126	3	2.3	3.52	0.90	0.08
Q2A2.3	125	4	3.1	3.42	0.84	0.08
Q2A2.4	127	2	1.6	3.83	0.79	0.07
Q2A2.5	128	1	0.8	3.92	0.71	0.06
Q2A2.6	124	5	3.9	3.29	1.01	0.09
Q2B2.1	129	0	0	4.13	0.67	0.06
Q2B2.2	129	0	0	3.84	0.80	0.07
Q2B2.3	129	0	0	3.95	0.65	0.06
Q2B2.4	128	1	0.8	3.77	0.72	0.06
Q2C1.1	129	0	0	3.60	0.75	0.07
Q2C1.2	128	1	0.8	3.52	0.75	0.07
Q2C1.3	128	1	0.8	2.32	0.94	0.08
Q2C1.4	129	0	0	2.55	1.01	0.09
Q2C1.5	128	1	0.8	3.41	0.86	0.08
Q2C1.6	128	1	0.8	3.27	0.84	0.07
Q2C1.7	127	2	1.6	3.09	0.88	0.08
Q2C1.8	129	0	0	2.84	1.01	0.09
Q2C1.9	126	3	2.3	2.54	0.93	0.08
Q2D1.1	128	1	0.8	3.87	0.66	0.06
Q2D1.2	129	0	0	3.95	0.65	0.06
Q2D1.3	128	1	0.8	3.61	0.76	0.07
Q2D1.4	128	1	0.8	3.69	0.75	0.07
Q2D1.5	128	1	0.8	3.73	0.80	0.07
Q2D2.1	129	0	0	3.54	0.93	0.08
Q2D2.2	127	2	1.6	3.26	0.94	0.08
Q2D2.3	127	2	1.6	3.39	0.91	0.08
Q2D2.4	128	1	0.8	3.09	1.01	0.09
Q2D2.5	129	0	0	2.75	0.89	0.08
Q2D3.1	128	1	0.8	4.07	0.60	0.05
Q2D3.2	129	0	0	3.99	0.58	0.05
Q2D3.3	127	2	1.6	3.96	0.62	0.06
Q2D3.4	129	0	0	4.18	0.59	0.05
Q2D3.5	129	0	0	3.67	0.69	0.06
Q2D3.6	128	1	0.8	3.95	0.67	0.06
Q2D3.7	128	1	0.8	3.37	0.88	0.08
Q2D4.1	128	1	0.8	3.88	0.86	0.08
Q2D4.2	127	2	1.6	3.93	0.67	0.06
Q2D4.3	127	2	1.6	3.85	0.59	0.05
Q2D4.4	126	3	2.3	3.68	0.68	0.06
Q2D4.5	128	1	0.8	3.66	0.88	0.08
Q2D5.1	128	1	0.8	3.62	0.81	0.07

Not missing at random

The pattern of 'missingness' is non-random and it is not predictable from other variables in the dataset (Bennett 2001).

It was necessary to find out to which type out of data the survey questionnaire has resulted in. The common test for this is Little's MCAR test which could determine whether the missing cases belong to missing completely at random or not (Rhoads 2012). If the p value for Little's MCAR test is not significant, then the data may be assumed to be MCAR (Little 1988).

Little's MCAR test was carried out with the following results:

Chi-Square = 1587.203, DF = 1662, Sig. (p value) = .904

As the p value for Little's MCAR test was not significant, the data was assumed to be MCAR.

When the data are missing completely at random, the missing values are a random sample of all values and are not related to any observed or unobserved variable. Thus, results of the data analyses will not be biased, because there are no systematic differences between respondents and non-respondents, and problems that arise are mainly a matter of reduced statistical power (Leeuw & Hox 2008). Mean substitution was considered, since the amounts of missing values of all the variables were less than five percent (Tabachnick et al. 2001).

After dealing with missing values in the data set, attention was focussed on understanding the data which included studying the respondent profile and the types of projects, for which details were given.

4.6 Respondent profile

The information analysed with respective to respondent profile belonged to Parts 1 and 3 of the questionnaire.

The information on respondents consisted of their personal information, i.e. gender, highest level of education and age, and professional information, i.e. professional experience, main engineering area of their organisation, occupation and the type of their organisation. They are analysed below.

4.6.1 Gender

Table 4.2 shows the gender details of the participants.

Table 4.2 Gender of survey participants

Gender	Percentage
Male	89%
Female	11%
Total	**100%**

It can be seen from the results of gender distribution of survey participants that males outnumber females. This result supports the well-established notion of less participation of women in the construction industry as the female respondents were only 11%. Less participation of women in the construction is a long running phenomenon. For example, According to Wells from the International Labour Organisation, it has been shown that the construction labour market is clearly segmented along sexual lines. In all countries, skilled and supervisory tasks are undertaken almost exclusively by men (Wells 1990). Construction is historically described as a non-traditional occupation for women (Yilmaz & Shelley 2011).

4.6.2 Education level

Details on the education level of survey participants are given in *Table 4.3.*

Table 4.3 Education Level of survey participants

Education Level	Percentage
Diploma	9%
Bachelor's Degree	47%
Master's Degree	40%
Doctoral Degree	4%
Total	**100%**

According to this table, most survey respondents had bachelor's degree, closely followed by those having Masters. This shows that the personnel managing construction projects in Australia are highly educated as 91% of the participants had either bachelor's or higher degrees. In fact, 4% had doctoral degrees. It is apparent that the Australian project management personnel are highly educated compared to others in many countries. However, this is an observation only and can be verified after studying the educational levels of personnel managing construction projects in other countries.

4.6.3 Age group (Years)

Details on the age groups of survey participants are given in *Table 4.4.*

Table 4.4 Age Groups of survey participants

Age Group (Years)	**Percentage**
26-35	12%
36-45	17%
46-55	26%
56-65	41%
Over 65	4%
Total	**100%**

Respondents were mainly middle-aged group from 56 to 65 years of age.

4.6.4 Experience

The experience of survey participants in years is given in *Table 4.5.*

Table 4.5 Experience of survey participants

Experience (Years)	**Percentage**
Under 5	3%
5-15	17%
16-25	17%
26-35	30%
36-45	32%
Over 45	2%
Total	**100%**

The experience of 26 to 45 years represented the majority. It is interesting to see with this results that 62% survey participants were highly experienced from 26 years to 45 years. It is not known whether this reflects the type of personnel engaged in construction project management in Australia or whether personnel with less experience were reluctant to participate in the survey. However, if this reflects the type of personnel engaged in construction project management in Australia, it can create a problem with a shortage of experienced personnel in the future and the policy makers need to act fast to face this potential problem.

4.6.5 Engineering area of organisation

Table 4.6 shows the details of the engineering area belonging to the participant's organisation. The other engineering areas mentioned in this table include civil and geotechnical engineering, telecommunication and transport. It could be seen that most respondents worked for organisations involved in roads and bridges.

Table 4.6 Engineering area of survey participants

Engineering area of organisation	Percentage
Roads and bridges	47%
Water resources	3%
Railways	3%
Airports	1%
Sanitation	2%
Power and electrical	3%
Mining, oil and gas	11%
Construction of large buildings	5%
Public utilities	17%
Other	8%
Total	**100%**

4.6.6 Occupation

The details of survey participant's occupation are given in *Table 4.7.*

Table 4.7 Survey participant's occupation

Occupation	Percentage

Engineer	63%
Architect	3%
Project Manager	26%
Other	9%
Total	**100%**

Apart from identifying as Engineer, Architect and Project Manager, some respondents identified themselves as Division Director, Engineering & Process Improvement Manager, Portfolio Manager, Program Manager, Project Development Manager, Quality Advisor, Quality Manager, Quality technical support manager and Senior Manager.

Most respondents preferred to call them as engineers, followed by those who described their occupation as project managers.

4.6.7 Type of organisation

Table 4.8 The type of organisation of survey participants

Type of organisation	Percentage
State Authority	28%
Local Government Authority	37%
Government owned company	3%
Private company dealing in one state	8%
Private company dealing in several states	17%
Other	7%
Total	**100%**

As shown in *Table 4.8,* the majority of respondents worked for local government authorities, followed by those who worked for state authorities.

Oher than those listed above, there were respondents from public companies dealing in Australia and internationally, international companies, multinational private companies and oil and gas operators.

Having analysed the respondent's personal profiles, the project profiles will be analysed next.

4.7 Project profile

The questionnaire requested the following information of projects which were selected by participants:

1. The engineering area belonging to the project;
2. The delivery type of the project;
3. Cost of the project; and
4. The complexity of the project.

4.7.1 Project engineering area

Some organisations, although working in identified engineering areas, also undertook projects in other areas. Therefore, it was necessary to identify the engineering area of the project.

Table 4.9 Engineering area of the project

Main engineering area of the project	**Percentage**
Roads and bridges	46%
Water resources	6%
Railways	4%
Airports	3%
Power and electrical	3%
Mining, oil and gas	11%
Construction of large buildings	6%
Public utilities	15%
Other	7%
Total	**100%**

As shown in *Table 4.9,* the respondents were involved mainly on projects belonging to roads and bridges, followed by public utilities and mining, oil and gas. The other engineering areas mentioned in the table include the construction of industrial manufacturing plants, waste management centres and land reclamation.

4.7.2 Project delivery type

The delivery types of the projects selected by participants to provide information on innovation enablers are given in *Table 4.10.*

Table 4.10 Delivery type of the project

Project Delivery Type	Percentage
Design, Bid and Build	34%
Design and Build	50%
Early Contractor Involvement	4%
Alliance or other collaborative contracts	13%
Total	**100%**

Most of the projects on which the details were given belonged to Design and Build followed by Design, Bid and Build.

4.7.3 Project cost

Table 4.11 Cost of the project

Project Cost	Percentage
Less than AUD100,000	7%
AUD100,000 to AUD1 Million	17%
Over AUD1 Million to AUD100 Million	56%
Over AUD100 Million to AUD200 Million	7%
Over AUD200 Million	14%
Total	**100%**

As shown in *Table 4.11*, the cost of most of the projects on which the details were given were in the range of AUD1 Million to AUD100 Million. AUD100, 000 to AUD1 Million projects and over AUD200 Million projects came second, but far behind the previous group.

4.7.4 Project complexity

Table 4.12 Complexity of the project

Project Complexity	Percentage
Not complex	5%
Somewhat complex	31%
Fairly complex	2%
Very complex	39%
Extremely complex	18%
Total	**100%**

According to respondents, most of the project were very complex, closely followed by projects considered as somewhat complex as shown in *Table 4.12.*

4.8 Chapter summary and discussion

This chapter discussed the data collection and preliminary screening. It explained the questionnaire survey method used to collect primary data for the research and how the questionnaire was prepared and tested. The chapter also provided information on the type of data collected. This included the personal profiles of respondents and the details of the projects selected by them to provide response to the survey.

With the analysis of respondent details, the following were found about the respondents:

- The percentage of females participated in the survey was much less than males.
- Most survey respondents had bachelor's degree, closely followed by those having Masters.
- Respondents were mainly middle-aged from 56 to 65 years of age.
- Most respondents worked for organisations involved in roads and bridges.
- Most respondents preferred to call themselves as engineers, followed by those who described their occupation as project managers.
- Majority respondents worked for Local Government Authorities, followed by those who worked for state authorities.

- The respondents were involved mainly on projects belonging to roads and bridges followed by public utilities and mining, oil and gas.

It is apparent that Australian project personnel are well-educated. This may be one of the reasons for the above average innovative performance of project teams as shown later in *Section 5.4*.

Another interesting finding is that the respondents were mainly middle-aged from 56 to 65 years of age and the majority were from the experience group of 26 to 45 years. While such experienced personnel working in the industry contribute to produce above average performance, this finding, if true, may not go well with the future of the industry and the government intervention may be required to attract more young people to the industry. However, it may also be possible that this do not represent the true nature of the industry as many young project personnel did not take part in the survey.

The following information was found on the projects selected by attendees to comment on innovation enablers:

- Most of the projects on which the details were given belonged to Design and Build followed by Design, Bid and Build.
- The cost of most projects on which the details were given were in the range of AUD1 Million to AUD100 Million. AUD100, 000 to AUD1 Million projects and over AUD200 Million projects came second, but far behind the first.
- According to respondents, most of the project were very complex, closely followed by projects considered as somewhat complex.

It needs to be noted that the projects mentioned here were not projects selected at random but selected by respondents as they perceived as innovative projects.

With this initial screening, it is now possible to analyse the data in detail. This analysis is covered in the next chapter.

CHAPTER 5
COMPARATIVE ANALYSIS

5.1 Chapter overview

Following the completion of initial screening of data for the statistical analysis and having analysed the respondents profile and project information, it is now possible to discuss the innovative characteristics of the Australian construction industry and construction projects, based on the information provided by survey respondents.

The survey collected information on the use of idea generation techniques in construction projects and the form of relationship of the client's team with the contractor. These will be analysed to assess the following:

- The types of idea generation techniques widely used in construction projects; and
- The widely used types of relationships between the client team and the contractor in construction projects.

The survey also collected information on client-led innovation enablers on the following five scales: idea harnessing, relationship enhancement, incentivisation, project team fitness and innovation performance. This data will be analysed to understand the innovative performance of construction projects with respect to above categories.

In addition, the survey provided the opportunity to make the following comparisons between groups regarding the innovative performance:

- Between public and private sector organisations;
- Between different delivery types;
- Between different categories of project costs; and
- Between different categories of project complexity.

Before discussing the findings, it is necessary to explain the statistical approach used to analyse the data.

5.2 Analytical procedure

The analysis used in the research consisted of simple comparison as well as detailed statistical examination. This section describes the statistical approach, the criteria and the statistical tests used in the analysis. First, the statistical approach used for the analysis is explained.

5.2.1 Statistical approach

In this analysis, the comparison of means was used to assess the performance of variables. This method was chosen as the objective was to compare individual and groups of variables. In a statistical data analysis, standard deviation (SD) is a measure of how a set of data is clustered or distributed around its mean. The more spread out or dispersed the data, the value of the standard deviation increases. On the other hand, the more concentrated or homogeneous the data is, the value of standard deviation decreases (Berenson et al. 2006). Therefore, a large SD indicates that the scores cluster more widely around the mean, thus the mean is not a good representation of the data. A small SD, on the other hand, indicates less dispersed data points about the mean, thus adequately represents the data. The coefficient of variation (CV) can be used to assess whether the SD is high or low. Coefficient of variation is defined as Standard Deviation /Mean. As a rule of thumb, CV>1 indicates a relatively high variation, while CV<1 can be considered as low (Stine & Foster 2011).

Table 5.1 shows the variables analysed and their mean, standard deviation and the computed values of CV.

Table 5.1 Mean, standard deviation and CV values of variables

Variable	Mean	Std. Deviation	CV
2A2.1 We used inputs from experienced personnel	4.32	0.60	0.14
2A2.2 We looked for practices	3.59	0.87	0.24
2A2.3 We followed new research	3.40	0.79	0.23
2A2.4 We captured project learnings	3.84	0.70	0.18
2A2.5 We followed up team ideas which had	3.97	0.60	0.15

Variable	Mean	Std. Deviation	CV
merit until completion			
2A2.6 We had implementers to help idea generators	3.34	0.94	0.28
2B2.1 Respected each other teams	4.15	0.63	0.15
2B2.2 Had conducive culture within teams	3.89	0.76	0.19
2B2.3 Had good relationships with key stakeholders	3.97	0.61	0.15
2B2.4 Had excellent relationships with other teams	3.85	0.67	0.17
2C1.1 We recognised idea generators	3.65	0.73	0.20
2C1.2 We recognised idea implementers	3.57	0.71	0.20
2C1.3 Rewarded with financial incentives	2.41	0.92	0.38
2C1.4 Rewarded with personal incentives	2.60	0.97	0.37
2C1.5 Selecting designers and contractors - used innovative proposals	3.45	0.82	0.24
2C1.6 Selecting designers and contractors - used innovation history	3.30	0.78	0.24
2C1.7 Selecting designers and contractors - used innovation performance	3.14	0.84	0.27
2C1.8 Included contract clauses to share savings	2.92	0.96	0.33
2C1.9 Selected contract types such as alliances	2.68	0.86	0.32
2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes	3.90	0.62	0.16
2D1.2 PM experienced and technologically competent	3.95	0.65	0.16
2D1.3 PM earned respect	3.66	0.74	0.20
2D1.4 PM made quick decisions	3.71	0.74	0.20
2D1.5 PM protected the team	3.76	0.79	0.21
2D2.1 Project team was provided with training to improve team skills	3.57	0.86	0.24
2D2.2 Project team was provided with training to	3.30	0.86	0.26

Variable	Mean	Std. Deviation	CV
improve knowledge			
2D2.3 Project team had opportunities to be exposed to others	3.44	0.86	0.25
2D2.4 Project team had opportunities to be exposed to best national and international practices	3.17	0.95	0.30
2D2.5 Project team was provided with training to implementers	2.79	0.83	0.30
2D3.1 Project team members helpful	4.08	0.56	0.14
2D3.2 Project team members motivated	4.01	0.54	0.13
2D3.3 Project team members diverse persons	3.97	0.58	0.15
2D3.4 Project team members had considerable knowledge and experience	4.15	0.55	0.13
2D3.5 Project team members had exposure to innovation	3.69	0.67	0.18
2D3.6 Project team members had strong relationships with customers	3.98	0.58	0.14
2D3.7 Project team members considered innovation as a day-to-day duty	3.41	0.85	0.25
2D4.1 All were treated equally	3.93	0.79	0.20
2D4.2 Felt free to talk	3.99	0.57	0.14
2D4.3 Ideas became team ideas	3.90	0.54	0.14
2D4.4 No difficulty in forming teams	3.71	0.62	0.17
2D4.5 No blame game	3.73	0.85	0.23
2D5.1 Client organisation supported innovative activities	3.63	0.78	0.21
2D5.2 Client organisation relaxed technical regulations/ specifications	3.17	0.90	0.28
2D5.3 Client organisation had characteristics of an innovative organisation	3.34	0.89	0.27
2E1.1 We used improved technologies, methods	3.76	0.66	0.17

Variable	Mean	Std. Deviation	CV
and practices			
2E1.2 We used improved materials, products, plant, and equipment	3.76	0.67	0.18
2E1.3 We used improved computer software/ hardware, models and communication systems	3.46	0.85	0.25
2E1.4 We used improved advanced business or procurement techniques, processes and systems	3.40	0.83	0.24
2E1.5 We used construction resources efficiently	3.72	0.70	0.19
2E1.6 We used sustainable practices	3.77	0.67	0.18
2E2.1 Achieved operational goals	3.97	0.62	0.16
2E2.2 Achieved satisfied customers	4.10	0.56	0.14
2E2.3 Achieved sustainable outcomes and reduced waste	3.88	0.60	0.15
2E2.4 Achieved satisfied project team	3.94	0.67	0.17
2E2.5 Achieved increased productivity and competitive advantage	3.68	0.70	0.19
2E2.6 Achieved positive organisational and professional learning	3.82	0.66	0.17
2E2.7 Achieved positive economic impact	3.99	0.72	0.18
2E3.1 Project personnel received internal recognition	3.69	0.80	0.22
2E3.2 Project received internal recognition	3.72	0.84	0.23
2E3.3 Highly commended in the media	2.91	0.90	0.31
2E3.4 External recognition in professional bodies	2.87	0.95	0.33
2E3.5 Industry has started using the practices	2.96	0.83	0.28

It can be seen from *Table 5.1* that the CV values changed from 0.13 to 0.38. This indicates that all variables have comparatively low values of standard deviation. Therefore, it can be assumed that the data is spreading closer to the mean and the mean can be used to interpret the data.

As a result, the mean value was used to compare the performance of variables and categories. The variables belonging to each of the four independent scale categories (i.e. idea harnessing, relationship enhancement, incentivisation, project team fitness) and innovative performance were averaged and compared with each other to assess their respective performance.

5.2.2 Criteria used for the analysis

The survey was based on innovative attributes of client's project teams engaged in construction projects in Australia. The survey respondents were given the choice to answer whether they strongly disagree, disagree, neutral, agree and strongly agree to the positive innovative attributes. These were ranked from 1 to 5, indicating 1 is worst performer (strongly disagree) and 5 is the best performer (strongly agree). Being 3 as the median value representing the neutral position, therefore, the cut-off value from good performance and bad performance, the following measure was used to interpret the results.

- Mean value <2 extremely unsatisfactory performance
- Mean value 2-3 unsatisfactory performance
- Mean value 3-4 satisfactory performance
- Mean value >4 extremely satisfactory performance

5.2.3 Statistical tests used

The assessment of the performance of individual variables also included the statistical examination to determine whether the sample mean values represent the relevant population mean values. As the data was in Likert scale, therefore discrete, it was not possible to use the standard student's t test for this purpose. Therefore, nonparametric tests had to be used.

The purpose of using nonparametric tests was to compare between different groups of variables. For example, public and private sector organisations had two levels (public and private) to compare with, the other two, delivery types and project cost groups had three level comparisons. As a result, two different nonparametric tests had to be used, one for the two-level group and the other for the three-level group.

A popular nonparametric test to compare outcomes between two independent groups is the Mann Whitney U test. The Mann Whitney U test, sometimes called the Mann Whitney Wilcoxon Test or the Wilcoxon Rank Sum Test, is used to test whether two samples are likely to derive from the same population.

The null and two-sided research hypotheses for this nonparametric test are as follows:

H_0: The two populations are equal versus

H_1: The two populations are not equal. (LaMorte 2017 a)

The Mann Whitney U test measures asymptotic significance (2-tailed) p-value. If the asymptotic significance (2-tailed) p-value is less than or equal to 0.05, the null hypothesis is not rejected at 95% confidence interval.

As the Mann Whitney U test is limited to testing two levels, another nonparametric test, the Kruskal Wallis test, was used for the comparison of more than two levels. It compares medians (not the mean value) among k comparison groups ($k > 2$) and is sometimes described as an ANOVA with the data replaced by their ranks.

The null and research hypotheses for the Kruskal Wallis nonparametric test are as follows:

H_0: The k population medians are equal versus

H_1: The k population medians are not all equal

(LaMorte 2017 b)

The Kruskal Wallis test also measures asymptotic significance (2-tailed) p-value. If the asymptotic significance (2-tailed) p-value is less than or equal to 0.05, the null hypothesis is not rejected at 95% confidence interval.

With this explanation on the procedure adopted to analyse the data, attention can be focussed to discuss the findings using these procedures.

5.3 Analysing idea harnessing and relationship enhancing

The aspects analysed under this section were related to idea harnessing (Group A) and relationship enhancing (Group B) in the questionnaire. The survey collected information on the use of idea generation techniques in construction projects and the form of relationship of the client's team with the contractor. They are discussed below. The analysis was based on using the comparison of data.

5.3.1 Use of idea generation techniques

In the survey, the respondents were requested to provide information on the types of idea generation techniques used in their projects. Some of the idea generation techniques identified are explained below:

- **Brainstorming:** process for generating creative ideas and solutions through intensive and freewheeling group discussion with ideas spontaneously contributed by its members.
- **Online idea database:** web-based system for people to contribute and record their ideas, generally on a specific topic.
- **Scenario planning:** process of visualising what future conditions or events are probable, what their consequences or effects would be like, and how to respond to, or benefit from, them.
- **Risk assessment planning:** process of evaluating risks, estimate impacts, and define responses.
- **Constructability review:** This is the review exploring the extent to which a design is facilitating the efficient use of construction resources and enhancing the ease and safety of construction on site whilst meeting the client's requirements.
- **Life cycle costing**: process of determining the most lifetime cost-effective option among different competing alternatives, when each is equally appropriate to be implemented on technical grounds.
- **Sustainable design:** The consideration of issues related to sustainability such as energy efficiency, water efficiency, the indoor environment, site locations, material usage and atmospheric consideration in the design.
- **Value management:** A strategy of examining every aspect of the whole project to ensure that all the expectations can be delivered in a most economical way.
- **Value engineering:** A systematic approach for enhancing value by eliminating unnecessary costs while maintaining function.

Table 5.2 provides information on the use of idea generation techniques as reported by the survey respondents when executing construction projects.

Table 5.2 Use of idea generation techniques

Use of idea generation techniques	**Percentage**
Scenario planning	27%
Risk assessment planning	19%
Brainstorming/ innovation workshops	16%
Online idea database	14%
Life cycle costing	14%
Constructability review	7%
Sustainable design	2%
Value Management or Value Engineering	2%

The above results show that scenario planning is the widely used idea generation technique practiced in construction contracts while constructability review, sustainable design, value management or value engineering were least utilised.

5.3.2 Form of relationship with the contractor

Different types of relationships were mentioned in the survey and the respondents were requested to identify the types relevant to their projects. They are explained below.

- **Traditional**: The traditional or the conventional approach to projects involves discrete design development, tender and contract award and construction delivery phases. Example: Design, Bid and Build. No attempt to improve relationships between parties to the project.
- **Partnering**: Parties voluntarily agree to co-operate in a partnering relationship without any legal effect.
- **Extended Partnering**: This is a formal process. Although not legally binding, the partnering process may be included in the tender documents as an option. Usually, this includes a series of meetings, workshops and reviews.
- **Collaborative**: relationship based on legally binding agreement to work co-operatively, on the basis of sharing project risk and reward, for the purpose of

achieving agreed outcomes based on principles of good faith and trust and an open book approach towards costs.

The analysis of the form of relationship with the contractor is given in Table 5.3.

Table 5.3 Form of relationship with the contractor

Form of relationship with the contractor	Percentage
Traditional, but collaboration taken seriously	81%
Partnering	15%
Extended partnering	4%
Collaborative	1%

It can be seen from *Table 5.3* that:

1. Most clients resort to the traditional form of contracts, with collaboration taken seriously into the behaviour between parties during the execution of the contract.
2. Partnering is also popular up to some extent, but extended partnering is not much used.
3. Alliance or similar relationships are not being used much.

The survey also collected information on client-led innovation enablers which were analysed to understand the innovative performance of construction projects and the details of the analysis are given below.

5.4 Analysis of variables to assess the innovative performance

Under this section, the performance of variables belonging to five major categories, i.e. idea harnessing, relationship enhancement, incentivisation, project team fitness and innovative performance, was analysed, comparing their mean values and translating results into practical observations. Analysis was done for major categories as well as for subcategories. The analysis of major categories is explained first.

5.4.1 Performance of major categories

The results of the performance of major categories are given in *Table 5.4.*

Table 5.4 Mean values of five categories of variables

Category	Mean
Idea harnessing	3.74
Relationship enhancement	3.97
Incentivisation	3.08
Project team fitness	3.68
Innovation performance	3.63

The major findings from the above results is that the project innovative performance scored a relatively high value of 3.63, indicating satisfactory performance. This is expected as the questionnaire respondents were requested to provide information on a project they thought was innovative. However, the above *Table 5.4* shows that incentivisation has the lowest mean of 3.08. It appears from this that clients are less inclined to provide rewards/incentives to improve performance.

All the other categories had mean values ranging between 3.5 and 4.0, indicating satisfactory performance. The results indicate that clients take relationship enhancement seriously and the use of idea harnessing is at a high level.

Compared to idea harnessing, relationship enhancement and incentivisation, questions related to project team fitness and innovation performance had more subcategories. Therefore, project team fitness and innovation performance were further analysed as given below.

5.4.2 Project team fitness

Project team fitness has subcategories of project manager attributes, project team facilities (facilities provided by the client for the project team), project team environment, project team culture and client organisations perspective (how respondents view the client organisation). *Table 5.5* shows the performance of these subcategories under project team fitness.

Table 5.5 Project Manager attributes

Project Manager Attributes	**Mean**
2D1.1 Sought out, encouraged and promoted new ideas/ technology/ processes	3.90
2D1.2 PM experienced and technologically competent	3.95
2D1.3 PM earned respect	3.66
2D1.4 PM made quick decisions	3.71
2D1.5 PM protected the team	3.76
Mean value	**3.80**
Project team facilities	**Mean**
2D2.1 Project team was provided with training to improve team skills	3.57
2D2.2 Project team was provided with training to improve knowledge	3.30
2D2.3 Project team had opportunities to be exposed to others	3.44
2D2.4 Project team had opportunities to be exposed to best national and international practices	3.17
2D2.5 Project team was provided with training to implementers	2.79
Mean value	**3.25**
Project team environment	**Mean**
2D3.1 Project team members helpful	4.08
2D3.2 Project team members motivated	4.01
2D3.3 Project team members diverse persons	3.97
2D3.4 Project team members had considerable knowledge and experience	4.15
2D3.5 Project team members had exposure to innovation	3.69
2D3.6 Project team members had strong relationships with customers	3.98
2D3.7 Project team members considered innovation as a day-to-day duty	3.41
Mean value	**3.90**
Project team culture	**Mean**
2D4.1 All were treated equally	3.93

2D4.2 Felt free to talk	3.99
2D4.3 Ideas became team ideas	3.90
2D4.4 No difficulty in forming teams	3.71
2D4.5 No blame game	3.73
Mean value	**3.85**
Client organisation perspective	**Mean**
2D5.1 Client organisation supported innovative activities	3.63
2D5.2 Client organisation relaxed technical regulations/ specifications	3.17
2D5.3 Client organisation had characteristics of an innovative organisation	3.34
Mean value	**3.38**

The results indicate that the project managers handling construction projects have considerable positive attributes. In addition, the client project team environment and team culture have considerably high scores. However, the project personnel who responded to the survey perceived that the facilities provided for the teams were low and the role provided by the client organisations in support of projects was low. In particular, it can be noted that the training provided to those who implement good ideas was less satisfactory and the project personnel were less exposed to national and international best practices.

5.4.3 Perception about client organisations

The survey provided valuable insight into participant's perception of client organisations. The question 2D5.3 requested participants to rank whether they believed that the client organisation had characteristics of an innovative organisation. The innovative organisational characteristics referred to above were:

- Trusting employees and providing them with a degree of freedom of thought and action with no blame culture, especially with regard to mistakes done in the process of innovation.
- Providing recognition, encouragement, support and robust incentives towards innovative activities.
- Providing opportunities for networking facilities within and outside the

organisation.

- Top management showing its commitment to promoting innovation through their actions.
- Having a separate unit dedicated to promoting innovation in the organisation and a strong focus on knowledge management.
- Allocating funds for research and development.
- Organisation having processes to recognise and reward innovators.
- Organisation having management systems to capture good ideas and monitor the progress of their implementation.
- Employees encouraged to have strong relationships with customers and other stakeholders.

The mean value for this question was 3.34, which was satisfactory, but not high. Another variable, "2D5.1: The client organisation supported innovative activities of the project" had a mean value of 3.63 which was also not high.

5.4.4 Innovative performance of projects

Innovative performance of projects (Group E) had the subcategories of project usage (how respondents view the usage of technologies, materials etc.), project outcomes (respondent's view of achieved project outcomes) and project recognition (respondent's view of the recognition received for the project). Mean values for the variables under innovative performance of projects are given in *Table 5.6.*

Table 5.6 Mean values for the variables under innovative performance of projects

Project usage	**Mean**
2E1.1 We used improved technologies, methods and practices	3.76
2E1.2 We used improved materials, products, plant, and equipment	3.76
2E1.3 We used improved computer software/ hardware, models and communication systems	3.46
2E1.4 We used improved advanced business or procurement techniques, processes and systems	3.40
2E1.5 We used construction resources efficiently	3.72
2E1.6 We used sustainable practices	3.77
Mean value	3.65

Project outcomes	**Mean**
2E2.1 Achieved operational goals	3.97
2E2.2 Achieved satisfied customers	4.10
2E2.3 Achieved sustainable outcomes and reduced waste	3.88
2E2.4 Achieved satisfied project team	3.94
2E2.5 Achieved increased productivity and competitive advantage	3.68
2E2.6 Achieved positive organisational and professional learning	3.82
2E2.7 Achieved positive economic impact	3.99
Mean value	3.91
Project Recognition	**Mean**
2E3.1 Project personnel received internal recognition	3.69
2E3.2 Project received internal recognition	3.72
2E3.3 Highly commended in the media	2.91
2E3.4 External recognition in professional bodies	2.87
2E3.5 Industry has started using the practices	2.96
Mean value	3.23

It can be seen from the table on the analysis of project innovative performance that for the projects selected by survey participants:

- project outcomes are high at the mean value of 3.91, followed by project usage (3.61).
- project recognition is at a lower level at 3.23. This is understood as a few projects are being recognised for their performance.

5.4.5 Analysis of high and low performers

When looking at the individual variables, the analysis showed that there were no variables with <2 mean value, indicating that there were no extremely unsatisfactory performers. However, the following variables had mean values between 2 and 3, indicating low performance.

Table 5.7 Low performing variables

Variables	Mean
2C1.3 Rewarded with financial incentives	2.41
2C1.4 Rewarded with personal incentives	2.60
2C1.9 Selected contract types such as alliances	2.68
2D2.5 Provided training to implementers	2.79
2E3.4 External recognition in professional bodies	2.87
2E3.3 Highly commended in the media	2.91
2C1.8 Included contract clauses to share savings	2.92
2E3.5 Industry has started using the practices	2.96

These results show that providing personal and financial incentives for promoting innovation is not practiced much in the Australian construction industry. However, the low mean values for variables belonging to the Group E variables appear to be justifiable. This category relates to the recognition of innovative projects. Only a few projects, which are far superior in performance compared to others, belong to this category. Therefore, the low mean values can be expected indicating the number of projects deserving high recognition is low.

On the other hand, the following variables scored high for the projects selected by survey participants:

Table 5.8 High performing variables

Variables	Mean
2D1.2 PM experienced and technologically competent	3.95
2A2.5 We followed up team ideas which had merit until completion	3.97
2B2.3 Had good relationships with key stakeholders	3.97
2D3.3 Project team members diverse persons	3.97
2E2.1 Achieved operational goals	3.97
2D3.6 Project team members had strong relationships with customers	3.98
2D4.2 Felt free to talk	3.99
2E2.7 Project outcome: Positive economic impact	3.99

2D3.2 Project team members motivated	4.01
2D3.1 Project team members helpful	4.08
2E2.2 Project outcome: Satisfied customers	4.10
2B2.1 Respected each other teams	4.15
2D3.4 Project team members had considerable knowledge and experience	4.15
2A2.1 We used inputs from experienced personnel	4.32

These results show that project teams (client's) are generally high performing teams achieving strong project outcomes. They also receive the input from experienced personnel. In addition, construction projects tend to achieve better outcomes such as achieving operational goals.

Data collected also permitted to compare between different types of groups which will be discussed next.

5.5 Comparison between different types of groups

Comparing the data within groups provided the opportunity to come out with interesting practical explanations. Therefore, further statistical examination was undertaken to find out:

- Whether there were any differences between innovative performance of construction projects undertaken by public sector and private sector organisations.
- Whether the delivery types and different cost types affect the innovation performance.

While the public sector and private sector analysis was a two group comparison, delivery types and different groups of cost fell into three group comparison.

The statistical examination conducted included the comparison of main categories and the assessment of the performance of individual variables.

5.5.1 Comparison between public and private sector organisations

There has been much discussion among researchers on the innovative performance of public sector organisations compared to private sector organisations. Citing the fact that the public sector globally characterised as conservative, bureaucratic and reluctant to change, many researchers argue that the public sector is not as innovative as it should be. On the other hand, this position has been questioned by others arguing it is a view that is either unsubstantiated or simply incorrect (Kay & Goldspink 2016). Therefore, it is interesting to find out how public and private sector organisations belonging to the construction industry perform with respect to innovation.

An analysis was performed to compare the means of variables belonging to above two sectors of organisations. The number of cases considered in the analysis included 75 public sector organisations and 40 private sector organisations. *Table 5.9* shows the results of this analysis.

First, the variables belonging to each of the five scale categories representing four client-led enabler categories (i.e. idea harnessing, relationship enhancement, incentivisation, project team fitness) and innovative performance were averaged, and mean values were tested to find out whether there was a statistical difference between their mean values between public sector and private sector groups.

Table 5.9 Comparison between public and private sector performance

Category	Sector	Mean
Idea harnessing	Public	3.72
	Private	3.82
Relationship enhancement	Public	4.05
	Private	3.83
Incentivisation	Public	3.04
	Private	3.19
Project team fitness	Public	3.67
	Private	3.72
Innovation performance	Public	3.61

	Private	3.66

Table comparing the public and private sector performance (*Table 5.9*) indicates the private sector performance is better in all categories except for relationship enhancement. Possible explanations for this lower performance by public sector organisations can include the following:

- In business, organisations need to innovate – or die. In the public sector it is unlikely that organisations will collapse due to lack of innovation (Mulgan & Albury 2003).
- The obligation to maintain continuity, the need to provide acceptable standards in key services and accountability to taxpayers through Parliament and Local authorities can induce a culture of risk aversion which impedes or blocks innovation (Mulgan & Albury 2003).
- Innovation is not an elemental context for the public sector. Failure to innovate rarely has devastating consequences; it is effectively just more work and the first thing jettisoned when time or budget pressures mount (Pott & Kastelle 2010).
- Failure is particularly expensive in the public sector due to competitive media and opposition monitoring. The avoidance of failure is thus an organisational priority (Pott & Kastelle 2010).

The above reasons possibly play a part in low innovation performance of public sector clients. It is apparent that the public sector organisations are looking mostly for achieving time, cost and quality outcomes in general, thus ignoring innovative outcomes. On the other hand, it is apparent that private sector clients look for all benefits made possible through innovation.

However, the public sector clients performed better in relationship enhancement category. Possible reason for this can be that most public sector organisations have a bargaining power due to the possibility of awarding repetitive work. The service providers, therefore, may take extreme care to maintain good relationships with public sector clients. Such constraints may not exist in general for private sector contracts, which are generally ‘one-off’, and the service providers could go for maximising their profit margins in such cases, which may not favourably impact on relationships.

In addition to this analysis, the mean values for both public and private sector groups were tested using the Mann-Whitney U test. The research question considered for this test was that whether there is a difference between the mean values of different innovation characteristic variables between public sector and private sector groups.

It was revealed that none of the public and private sector levels had asymptotic significance (2-tailed) p-values less than or equal to 0.05, therefore not rejecting the null hypothesis that the mean values are same for both public and private sector groups tested at 95% confidence interval.

Then the same test was undertaken to assess individual variables belonging to the two levels under consideration. The results show that 7 variables (out of 62 variables) had p values less than or equal to 0.05 rejecting the null hypothesis that the mean values are same for both public and private sector groups tested at 95% confidence interval. They are given below with their respective mean values and possible explanations.

Table 5.10 Mann-Whitney U test results of individual variables of public & private sector groups with p < or = to 0.05

Variable	**Mean**		**Possible Explanation**
	Public	Private	
2B2.1 Respected each other teams.	4.23	3.89	This indicates that the public sector client's project teams respect other teams more than the private sector. Respecting each other teams is a two-way process. It could be that the service suppliers try to maintain good relationship with the client's team due to their bargaining power and client's teams reciprocating the goodwill due to Australian culture of maintaining good relationships with others.

2B2.4 Had excellent relationships with other teams.	3.94	3.57	This shows that the public sector project teams are having better relationship with other parties compared to the private sector. Possible reason for this could be the same as the previous, that most public sector organisations have a bargaining power due to the possibility of awarding repetitive work. The service providers, therefore, may take extreme care to maintain good relationship with public sector clients. Such constraints may not exist in general for private sector contracts which are generally 'one-off', and the service providers could go for maximising their profit margins in such cases which may not favourably impact on relationships.
2C1.9 Selected contract types such as alliances.	2.82	2.25	One possible reason for the higher mean value for the public sector could be that the public sector clients are more concerned about avoiding failures due to public perception and collaborative contract types such as alliances have a high probability of avoiding project failures. On the other hand, the private sector could be more concerned about the cost of such contracts which some consider high. However, it should be noted that the number of collaborative contracts was low in the sample surveyed.
2D3.5 Project team members had exposure to innovation.	3.75	3.50	A possible explanation could be that the due to the repetitive nature of public sector contracts, the client's team members are more experienced and would have exposure to innovation in previous projects.

2E1.3 We used improved computer software/ hardware, models and communication systems.	3.36	3.79	This result is in agreement with the statement that Australian private sector organisations are more innovative in the area of construction management which will be discussed later.
2E2.2 Project outcome: Satisfied customers.	4.15	3.93	A possible explanation could be that the public sector organisations are very sensitive to the opinions of the public and take extra precautions to make the public happy. The amount spent for the project is generally not a major concern. On the other hand, the private sector would spend the minimum expenditure which may not guarantee satisfied customers.
2E2.3 Project outcome: Sustainable outcomes and reduced waste.	3.68	3.86	The reduced waste may be linked to the fact that the private sector organisation's effort to reduce unnecessary expenditure.

As mentioned in *Table 5.10,* the result for the variable "2E1.3 We used improved computer software/ hardware, models and communication systems" supports the notion that the private sector is more innovative than the public sector.

5.5.2 Delivery type comparison

The survey collected information on the delivery type of projects including the following: (a) Design and Build (the design is done by one party and the construction is carried out by another party after completing the design); (b) Design, Bid and Build (the design and construction by one party); and (c) collaborative contracts (the delivery using collaborative contracts such as alliance and Early Contractor Involvement Contracts).

Design and Build delivery type was the most reported in the survey (57 out of 115), followed by Design, Bid and Build (39 out of 115). Alliance or other collaborative contracts (15 out of 115) constituted the other group. There were only 4 Early Contractor Involvement contracts. For comparison purposes, Early Contractor Involvement type were added to Alliance or other collaborative contracts naming them as Collaborative Contracts.

Statistical analysis was undertaken to study delivery types using the following procedure. The variables belonging to each of the five scale categories representing four client-led enabler categories (i.e. idea harnessing, relationship enhancement, incentivisation, project team fitness) and innovative performance were averaged and tested to find out whether there is a statistical difference between their mean (or median) values between different delivery types. As the data to be examined was in Likert scale and therefore discrete, the Kruskal Wallis test was used. It was not possible to use the Mann-Whitney U test which was only used to test groups of two. Kruskal Wallis test is a non-parametric test. However, this test only compares the medians.

The test results showed that none of the groups had asymptotic significance p values less than or equal to 0.05, therefore not rejecting the null hypothesis that the median values are same for three delivery types tested at 95% confidence interval.

After this, a further statistical analysis was carried out on individual variables using the same Kruskal Wallis test. The results showed that 5 variables (out of 62 variables) had p values less than or equal to 0.05 rejecting the null hypothesis that the median values are same for different delivery types tested at 95% confidence interval. They are given in *Table 5.11* with their respective mean values and possible explanation. Please note that the mean values are used for comparison purposes.

Notations: DB&B: Design, Bid and Build, D&B: Design and Build and Collab.: Collaborative contracts.

Table 5.11 Kruskal Wallis test results for delivery types of individual variables with p < or = to 0.05

Variable	Mean			Possible Explanation
	DB&B	D&B	Collab.	
2A2.2 We looked for	3.9	3.37	3.63	In this case, the client's project team of the Design, Bid and Build delivery type scored much

practices of external organisations to generate new ideas for projects.				above others, possibly because the responsibility of the client's team is high for taking independent decisions. Therefore, the client team may look for practices of external organisations to generate new ideas for projects. In other cases, the client's team may receive advice from the contracting and other teams.
2C1.9 Selected contract types such as alliances	2.56	2.53	3.37	As the name suggests, the collaboration delivery type scores higher for selecting contract types such as alliances.
2D3.2 Project team members motivated	4.13	3.86	4.21	As expected, the client team is motivated in a collaborative situation where collaboration is given highest priority.
2D5.1 Client organisation supported innovative activities	3.74	3.42	4.00	The client team felt more support from its parent organisation in a collaborative delivery type. Collaborative delivery type needs more input from the client and those organisations capable of providing such support generally undertake this delivery type which may be the explanation.
2D5.2 Client organisation relaxed technical regulations/ specifications	3.15	3.02	3.68	Collaborative delivery type requires flexibility from the client which could involve relaxation of technical regulations/ specifications and this could be the explanation.

While interpreting these results, it needs to be noted that the survey looked at construction projects from the perspective of a project team member working for the client (or owner) of the project. The member may be from a team representing the owner such as the consultant, design, superintendent team.

Some of the above findings are supported by researchers. For example, Rahman et al. (2012) have identified Early Contractor Involvement contracts as an innovative form of contracts. They also have highlighted the importance of contractor's expertise, experience and understanding of the construction process and the consideration of buildability issues earlier in the design process. Meanwhile, Davis and Love (2011) have identified Alliance as a form of innovative contracts and underlined the importance of collaboration and improved relationship in enhancing innovative outcomes.

5.5.3 Project cost comparison

As per the survey, the following numbers of projects fell under different cost groups:

- Less than AUD100,000: 8 numbers;
- 100,000 to AUD1 Million: 19 numbers;
- Over AUD1 Million to AUD100 Million: 64 numbers;
- Over AUD100 Million to AUD200 Million: 8 numbers; and
- Over AUD200 Million: 16 numbers.

In order to simplify the analysis, the groups were rearranged as follows: Less than AUD1 Million: 27; Over AUD1 Million to AUD100 Million: 64; Over AUD100 Million: 24.

Similar to the delivery type analysis, the variables belonging to each of the five scale categories were averaged and tested to find out whether there was a statistical difference between their mean (or median) values between different cost groups using the Kruskal Wallis test. It was revealed that idea harnessing and innovative performance had p values less than or equal to 0.05 rejecting the null hypothesis that the median values are same for different cost groups tested at 95% confidence interval. Table below shows mean values for each category which were used for comparing purposes.

Table 5.12 Kruskal Wallis test results for cost types of variables belonging to different categories with p < or = to 0.05

Category	Cost groups	Mean
Idea harnessing	Less than AUD1 Million	3.54
	Over AUD1 Million to AUD100 Million	3.78
	Over AUD100 Million	3.91
Innovation performance	Less than AUD1 Million	3.46
	Over AUD1 Million to AUD100 Million	3.66
	Over AUD100 Million	3.74

It can be observed from the results shown in *Table 5.12,* as the project is costing more, the performance under each category gets better, indicating that clients have provided in more efforts to improve the performance. Most remarkable improvement is seen in idea harnessing.

Similar to the delivery types, the individual variables were further analysed using the Kruskal Wallis test. The results show that 11 variables had p values < or = to 0.05 rejecting the null hypothesis that the population medians are equal for different delivery types tested at 95% confidence interval. They are given in *Table 5.13.*

Table 5.13 Kruskal Wallis test results for cost types of individual variables with p < or = to 0.05

Variable	Mean		
	<1M	**1-100M**	**>100M**
2A2.4 We captured project learnings.	3.56	3.94	3.92
2A2.5 We followed up team ideas which had merit until completion.	3.67	4.02	4.21
2C1.8 Included contract clauses to share savings.	2.56	2.89	3.42
2D2.3 We had opportunities to be exposed to others.	3.37	3.34	3.79
2D3.3 Project team members diverse persons.	3.67	4.03	4.13
2D3.6 Project team members had strong relationships with customers.	3.74	4.02	4.17
2D4.3 Ideas became team ideas.	3.67	3.97	3.96
2D5.1 Client organisation supported innovative activities	3.3	3.73	3.71
2E1.1 We used improved technologies, methods and practices.	3.56	3.7	4.13
2E3.1 Project personnel received internal recognition.	3.3	3.7	4.08
2E3.2 Project received internal recognition.	3.37	3.77	4.00

Similar to the results shown in *Table 5.12,* as the project is costing more, generally the performance of the variable gets better, indicating that clients have provided in more efforts to improve the performance. However, cases in 2A2.4, 2D2.3 and 2D4.3 showed minor differences to this statement.

These findings are in agreement with the findings of Tawiah and Russel (2008), who reported that the relative ability to drive project innovation increases with the increased cost of the project.

5.5.4 Project complexity comparison

Survey participants reported most of their projects as very complex (39%), followed by somewhat complex (31%) and extremely complex (18%). Only 5% was considered as not complex and 2% as fairly complex. For comparison purposes these groups were rearranged, not complex was considered as low complexity (5%), somewhat complex and fairly complex as moderate complexity (33%) and very complex and extremely complex as high complexity (57%).

Statistical analysis was undertaken to study the complexity using the following procedure. The variables belonging to each of the five scale categories representing four client-led enabler categories (i.e. idea harnessing, relationship enhancement, incentivisation, project team fitness) and innovative performance were averaged and tested to find out whether there was a statistical difference between their mean (or median) values between different complexity groups. As the data to be examined was in Likert scale and therefore discrete, and the fact that three groups needed to be examined, the Kruskal Wallis test was used.

The test results showed that none of the groups had asymptotic significance p values less than or equal to 0.05, therefore not rejecting the null hypothesis that the median values are same for three complexity types tested at 95% confidence interval.

After this, a further statistical analysis was carried out on individual variables using the same Kruskal Wallis test.

The results showed that 10 variables (out of 62 variables) had p values less than or equal to 0.05 rejecting the null hypothesis that the median values are same for different delivery types tested at 95% confidence interval. They are given in *Table 5.14* with their respective mean values and possible explanation.

Table 5.14 Kruskal Wallis test results for complexity types of individual variables with p < or = to 0.05

Variable	**Mean**			**Remarks**
	Low	Moderate	High	
2A2.3 We followed new research.	3.71	3.38	3.36	Low complex projects seem to be doing better than complex projects.

2A2.5 We pursued ideas	3.86	3.99	3.95	Moderately complex projects seem to do better.
2A2.6 We had implementors to help idea generators.	3.43	3.27	3.59	High complex projects seem to better.
2D1.5 PM protected the team.	3.86	3.71	3.91	High complex projects seem to better.
2D3.2 Project team members motivated.	4.14	3.97	4.14	Low and high complex projects seem to better.
2D4.2 Felt free to talk.	4.29	4.00	3.86	Higher the complexity, the performance goes down.
2E1.2 We used improved materials, products, plant, and equipment.	3.86	3.72	3.86	Moderately complex projects seem to do worse.
2E3.1 Project personnel received internal recognition.	3.57	3.70	3.68	Moderately complex projects seem to do better.
2E3.2 Project received internal recognition.	3.57	3.74	3.68	Moderately complex projects seem to do better.
2E3.4 External recognition in professional bodies.	2.86	2.94	2.59	Moderately complex projects seem to do better. Highly complex projects perform the worst.

The results from the examination of project complexity indicated a mixed picture. Low complex project seems to perform well with regard to the following variables:

- 2A2.3 We followed new research.
- 2D3.2 Project team members motivated.
- 2D4.2 Felt free to talk.

Moderately complex project seems to perform well with regard to the following variables:

- 2A2.5 We pursued ideas.
- 2E3.1 Project personnel received internal recognition.
- 2E3.2 Project received internal recognition.
- 2E3.4 External recognition in professional bodies.

Highly complex project seems to perform well with regard to the following variables:

- 2A2.6 We had implementors to help idea generators.
- 2D1.5 PM protected the team.
- 2D3.2 Project team members motivated.
- 2E1.2 We used improved materials, products, plant, and equipment.

It is difficult to provide explanations to these as the complexity depends on many factors.

5.6 List of findings

In the questionnaire, the respondents were requested to consider the most innovative project that they were part of during the last five years and comment on the project chosen. Given below are the main findings from the above analysis on the projects selected by the questionnaire respondents:

Use of idea generation techniques:

- Scenario planning is the highest idea generation technique used in the construction industry followed by risk assessment planning, brainstorming/ innovation workshops, life cycle costing and online idea database/ suggestion box.
- The use of constructability review, sustainable design and scenario planning and life cycle costing is low compared to other techniques.
- The use of online idea database or the 'Suggestion Box' is not much practiced in construction industry as a way of generating new ideas.

Form of relationship with the contractor:

- Most clients resort to the traditional form of contracts, with collaboration taken seriously into the behaviour between parties during the execution of the contract.
- Partnering is also popular up to some extent, but extended partnering is not

much used.

General performance of categories:

- Project innovative performance in Australian construction industry is relatively satisfactory with regard to the projects selected by questionnaire respondents.
- It appears that clients are less inclined to provide personal and financial rewards/ incentives to improve performance.
- Clients take relationship enhancement seriously and the use of idea harnessing is at a fairly high level.
- Project managers handling construction projects have considerable positive attributes.
- The client project team environment and team culture are considerably high.
- The facilities provided for the team are relatively low and the role provided by the client organisation in support of project is less satisfactory.
- Project teams (client's) are generally high performing teams achieving strong project outcomes.
- Construction projects tend to achieve higher project outcomes such as achieving operational goals.

Project innovative performance:

- Out of the three components under project innovative performance, project outcomes are performing better, followed by project usage.

Comparison between public and private sector organisations:

- *The private sector performance is better in all categories except for the* relationship enhancement.
- The public sector clients performed better in relationship enhancement.

Comparison between delivery types:

- Design, Bid and Build contracts perform better in idea harnessing closely followed by collaborative contracts.
- Design and Build delivery type performs poorly in relationship enhancement.
- Collaborative contracts provide more incentivisation.

Project cost comparison:

- As the project is costing more, the performance under each category gets better.

- Most remarkable improvement is seen in idea harnessing.
- However, the improvement of relationship enhancement is marginal.

Project complexity comparison:

- The statistical tests revealed a mixed picture without showing a trend which indicates that the complexity, taken separately, does not influence the innovative performance much.

5.7 Chapter Summary

The results reported in this chapter, which are based on the perceptions of project personnel engaged in construction projects who participated in the survey, paints a picture of how the Australian construction industry is performing with respect to innovation at the project level.

The innovative performance of construction projects in Australia appears to be above average, although the perceived level is not too high. One of the factors appear to contribute to somewhat higher innovative performance of Australian construction projects is that Australian project teams (clients) are generally high performing teams achieving strong project outcomes with high levels of team environment and team culture. On the other hand, it appears that the lesser consideration given in providing rewards/ incentives to promote innovative outcomes of projects remains a barrier to achieving higher innovative performance.

Much discussion has taken place among the research community whether the public sector organisations innovative or not compared to private sector organisations. The results here show that the projects belonging to public sector organisations in Australia in the construction industry perform poorly compared to those in private sector organisations, when it comes to innovation. However, results also show that the public sector is ahead in areas such as respecting other teams and having better relationships with stakeholders.

When comparing different delivery types, it is apparent that collaborative contracts perform better in the area of innovation, followed by Design, Bid and Build delivery type. The performance of Design and Build delivery type appears to be least performing out of the three delivery types.

As the cost of projects increase, generally the innovative performance gets better, indicating that clients are providing more efforts to improve the performance.

Overall, the research reported in this chapter provides a mixed picture about the innovative performance of Australian construction projects. The main finding of the chapter is that Australian clients can achieve higher outcomes from construction projects by promoting innovativeness in their projects, especially by promoting innovativeness in their own organisations and providing incentives/rewards and other support for innovative activities in projects.

With this analysis, the next step is to test the conceptual framework and the model using the survey data. This will be covered in the next two chapters.

CHAPTER 6
FACTOR ANALYSIS

6.1 Chapter overview

Having examined the innovative performance of Australian construction projects, attention will now be focussed on statistically analysing the data in order to examine the model developed using the literature review.

The statistical analytical procedure adopted consisted of the following steps:

1. Undertake a factor analysis to reduce the large number of variables to fewer unobserved factors in order to enhance general interpretability and to detect hidden structures in the data; and
2. Assess whether there are any relationships between the constructs through a correlation analysis.

This chapter explains the procedure adopted for the factor analysis and discusses the results found. First, the factor analysis is introduced and explained.

6.2 Introduction to factor analysis

According to Bhattacherjee (2012), among competing explanations that sufficiently explain the observed evidence, the simplest theory (i.e., one that uses the smallest number of variables or makes the fewest assumptions) is the best and therefore, a theory should be simplified and generalisable explanations of reality. This research has a large number of variables which needs to be reduced to arrive at a simple theory. This can be done by subjecting the variables through the factor analysis.

As found by Treiblmaier and Filzmoser (2010), factor analysis has been one of the most widely used statistical techniques in psychological research which is of paramount importance for all social sciences investigating human behaviour. The broad purpose of factor analysis is to summarise data so that relationships and patterns can be easily interpreted and understood. It is normally used to regroup variables into a limited set of clusters based on shared variance (Yong & Pearce

2013). It is a data reduction technique that is used to statistically aggregate a large number of observed measures (items) into a smaller set of unobserved (latent) variables called factors based on their underlying bivariate correlation patterns. This technique is widely used for assessment of convergent and discriminant validity in multi-item measurement scales in social science research (Bhattacherjee 2012).

Commenting on the applications of factor analysis, Garrett-Mayer (2006) has identified the following:

- clusters variables into homogeneous sets;
- identifies groupings allowing to describe many variables using a few factors;
- helps selecting small group of variables of representative variables from larger set; and
- allows to gain insight to categories.

According to Williams et al. (2010), the reason for thorough and systematic factor analyses is to isolate items with high loadings in the resultant pattern matrices. In other words, it is a search to find those factors that taken together explain the majority of the responses.

The purpose of undertaking a factor analysis in this research is to reduce the large number of variables into a few, which are statistically sound, and group them for further analysis and interpretation. However, as Trninić et al. (2013) stated, the ultimate result of factor analytical research partially depends upon the decisions and interpretations of the researcher.

6.2.1 Mathematical representation of factor analysis

As explained by Cornish (2007), the factor analysis model can be written algebraically as follows.

If there are p variables $X_1, X_2, \ldots, X_p$ measured on a sample of n subjects, then variable i can be written as a linear combination of m factors $F_1, F_2, \ldots, F_m$

$$X_i = a_{i1}F_1 + a_{i2}F_2 + a_{i3}F_3 + \ldots\ldots + a_{im}F_m + e_i \quad \ldots\ldots\ldots\ldots\ldots \mathbf{6.1}$$

where the a_is are the factor loadings (or scores) for variable i and e_i is the part of variable X_i that cannot be 'explained' by the factors.

It should be noted that m needs to be $< p$ (Cornish 2007).

6.2.2 Types of factor analysis

According to Williams et al. (2010), there are two major classes of factor analysis: Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA). In EFA, the investigator has no expectations of the number or nature of the variables and as the title suggests, is exploratory in nature. It allows the researcher to explore the main dimensions to generate a theory, or model from a relatively large set of latent constructs, often represented by a set of items. Whereas, in CFA the researcher uses this approach to test a proposed theory (CFA is a form of structural equation modelling), or model and in contrast to EFA, has assumptions and expectations based on priori theory regarding the number of factors, and which factor theories or models best fit. The usage of these two types of factor analysis in this research is explained in *Sections 6.3.1*.

6.3 Data screening

Before discussing the procedure adopted in undertaking the factor analysis, it is necessary to explain the type of data collected in the study and how the data was prepared for the analysis.

6.3.1 Type of data

Data used in this research was measured on a 5-point Likert scale (typically "strongly agree", "agree", "neutral", "disagree", "strongly disagree"). As noted by Carifio and Perla (2007), in Likert scale one has to write a series of verbal statements that express a range of positive expressions, views, sentiments, claims or opinions about the "attitude object (underlying construct)" that ranged from mildly positive to strongly positive and then the same relative to a range of negative statements.

There has been discussion on using Likert scale items for the factor analysis as they violate the assumption of interval-level measurement of the observed variables. However, this is not a barrier for using Likert scale items for the factor analysis. As pointed out by Cornish (2007), although factor analysis is designed for interval data, it can also be used for ordinal data (e.g. scores assigned to Likert scales) as well. Researchers increasingly use Likert scale items for the factor analysis. For example, a similar research on modelling the innovation diffusion process in Australian architectural and engineering design organisations, Panuwatwanich (2008) used Likert scale items to undertake the factor analysis.

In this study, the analysis was performed separately for independent variables (i.e., those came under idea harnessing, relationship enhancing, incentivisation and project team fitness) and dependent variables coming under innovative performance.

In analysing independent variables, there were no expectations of the number or nature of the variables and therefore, Exploratory Factor Analysis (EFA) was used to identify the latent factors of data items. On the other hand, the dependent variables coming under innovative performance were to test a proposed theory and therefore, the CFA was used.

6.3.2 Outliers

One of the requirements for the data to be suitable for the factor analysis is that the data should be free of outliers (Yong & Pearce 2013). Removal of outliers was done using the Mahalanobis distance measure. Mahalanobis distances measure the distances of cases from the means of predictor variables. These distances have a chi-square distribution with degrees of freedom equal to the number of predictors and the p value <0.05 are treated as outliers (Field 2013).

By measuring the Mahalanobis distances, 14 outliers were detected. They are given in *Appendix 5* (highlighted).

These outliers were removed from the data set before undertaking further analysis.

6.3.3 Variables considered in the research

Appendix 6 shows the variables used for the factor analysis with their grouping, identification numbers and names. The names of these variables were shortened for easy identification in the subsequent chapters.

6.3.4 Normality of data

This is somewhat a controversial area where some researchers insist on the data being normal for the factor analysis. Yong and Pearce (2013), Zygmont and Smith (2014) are some of the researchers who consider the data to be normal for factor analysis. Therefore, normality was checked before undertaking the statistical analysis.

For checking normality, techniques such as graphical observations (checking histograms, stem-and-leaf plots, box plots, percent-percent (P-P) plots, quantile-quantile (Q-Q) plots, plots of the empirical cumulative distribution function etc.) and analytical testing such as Kolmogorov-Smirnov Test, Shapiro-Wilk Test, Anderson-Darling Test, D'Agostino-Pearson Omnibus Test and Jarqua-Bera Test could be used (Das & Imon 2016). The Shapiro-Wilk test is based on the correlation between the data and the corresponding normal scores. Some researchers recommend the Shapiro Wilk test as the best choice for testing the normality of data (Ghasemi & Saleh Zahediasl 2012).

The data set was subjected to graphical observations using histogram and statistical testing using the Shapiro Wilk test. It can be clearly seen form the histograms that variables generally did not follow a normal distribution.

The details of the Shapiro Wilk test undertaken are given in *Appendix 7.* According to Shapiro and Wilk (1965), this test is quite sensitive against a wide range of alternatives even for small samples (n<20). The statistic is also responsive to the nature of the overall configuration of the sample compared with the configuration of expected values of normal order statistics (Shapiro & Wilk 1965). In the Shapiro-Wilk test, the null hypothesis is that the data are normally distributed. The null hypothesis is rejected if p value is below 0.05. It can be seen that all the p values were extremely small and below 0.05.

These results clearly show that data are not normally distributed. Histograms show that they are skewed to the right.

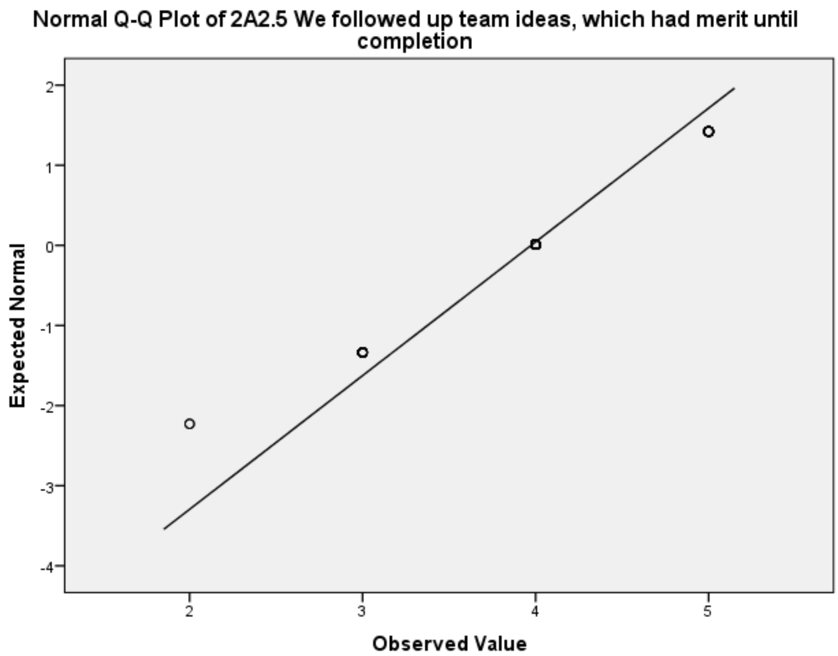
QQ plots were analysed to confirm the above fact of non-normality of data. Most of the QQ plots were similar to the example shown in *Fig. 6.1.*

Non-normality of data is not a surprise, as it is clearly seen from *Chapter 5* (See *Section 5.7*) that Australian construction projects are innovative up to some degree.

6.3.5 Dealing with non-normality of data

There is evidence to suggest that real data are often not normally distributed (Blanca et al. 2013). Also, it is necessary to note that in exploratory factor analysis, multivariate normality is not required (CompleteDissertation 2018). Statistical procedures have been made available to undertake the factor analysis even in cases where the data is not normally distributed. If the assumption of multivariate normality is “severely violated”, Fabrigar et al. recommended to use one of the principal factor methods in SPSS: this procedure is called "principal axis factors" (Fabrigar et al. 1999). This is confirmed by SAS software Hand Book on Exploratory Factor Analysis, allowing the software to be used for the data even in cases of severely violating multivariate normality by using iterated Principal Axis Factoring (PAF) or ULS Factoring (Osborne & Banjanovic 2016). Therefore, if the correct procedures are followed, non-normal data can be used to the factor analysis.

Figure 6.1 Q-Q Plot for Variable 2A2.5



6.4 Testing data for factor analysis

Before undertaking the factor analysis, the data was checked for scale reliability by examining internal consistency and item-total correlations. They are explained in the section below.

6.4.1 Scale reliability

The following five scales were used in the survey questionnaire to measure the constructs proposed in the conceptual model: idea harnessing, relationship enhancement, incentivisation, project team fitness and innovation performance.

It was necessary to ensure that such a set of measurement scales consistently and accurately captured the meaning of the model constructs. This was done by ensuring that:

1. these scales indeed measure the unobservable construct that needs to be to measured (i.e., the scales are "valid"); and
2. they measure the intended construct consistently and precisely (i.e., the scales are "reliable").

A measure can be reliable but not valid, if it is measuring something very consistently but is consistently measuring the wrong construct. Likewise, a measure can be valid but not reliable if it is measuring the right construct, but not doing so in a consistent manner (Bhattacherjee 2012).

An analysis of scale reliability was performed to ensure that the set of measurement scales consistently and accurately captured the meaning of the model constructs which consisted of examining internal consistency and item-total correlations. The assessment procedure and results are discussed below.

6.4.2 Internal consistency

The internal consistency for a single item compared to all other items in a group can be calculated using Cronbach's Alpha (Gennarelli & Goodman 2013). According to Tavakol and Dennick (2011), internal consistency describes the extent to which all the items in a test measure the same concept or construct and hence it is connected to the inter-relatedness of the items within the test. If the items in a test are correlated to each other, the value of alpha is increased (Tavakol & Dennick 2011). While there is no definitive value for showing internal consistency using the Cronbach's Alpha statistic (represented by α), it is widely accepted that in the early stages of validation research, α should exceed 0.70 (Gennarelli & Goodman 2013).

As a guideline, Hair et al. (2006) suggested that an alpha coefficient around 0.70 is adequate but recommended that values of 0.60 to 0.70 are at the lower limit of acceptability. However, according to Schmitt (1996), there is no sacred level of acceptable or unacceptable level of alpha and in some cases, measures with (by conventional standards) low levels of alpha may still be quite useful.

Table 6.1 shows the Cronbach's Alpha Based on Standardised Items. It can be seen that this value is in the range of 0.9 which can be considered as high.

Table 6.1 Reliability Test results

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.952	.954	62

6.4.3 Item-total correlations

An item-total correlation test was performed to check if any item in the set of tests is inconsistent with the average behaviour of the others, and thus can be discarded. Corrected Item-Total Correlation measures the correlation of the relevant variable with the total score (Panuwatwanich 2008). When analysing with SPSS software, the column 'Corrected Item-Total Correlation' has the correlations between each item and the total score from the questionnaire. If any of these values is less than 0.30, then the particular item needs to be dropped (Field 2013).

The test results are given in *Appendix 8*. This test checks the value of Cronbach's Alpha if an item is deleted which is in the range of 0.9. However, there is one item, '2A2.2 We looked for practices' which has Corrected Item-Total Correlation value less than 0.30 (highlighted). Therefore, this item was dropped from further analysis.

Having checked for scale reliability by examining internal consistency and item-total correlations, factor analysis can be performed now. The procedure adopted for conducting the factor analysis is discussed in the next section.

6.5 Procedure for conducting factor analysis

To undertake Exploratory Factor Analysis, Williams et al. (2010) recommended a 5-steps procedure as mentioned below.

1. Step 1: Is the data suitable for factor analysis?
2. Step 2: How will the factors be extracted?
3. Step 3: What criteria will assist in determining factor extraction?
4. Step 4: Selection of Rotational Method
5. Step 5: Interpretation

This procedure was adopted in the analysis and discussed below.

6.5.1 Step 1: Is the data suitable for factor analysis?

Suitability of the data for the factor analysis depends on a number of considerations. They are described below.

Sample size

One of the main considerations in employing factor analysis is the sample size of the data. According to Hair et al. (2006), the minimum sample size for factor analysis should be 50 and a sample size of 100 or more is preferable. The sample size of the data from the survey was 131 which was in the preferable range. They also suggest the variables to observation ratio of five times. The number of variables in this case was 62 and this condition was not satisfied. However, Field (2013) noted that the cases-to-variables ratio makes little difference to the stability of factor solutions. In addition, researchers also differ in opinion with regard to optimum sizes for factor analysis. For example, citing other researchers, Williams et al. (2010) found that rules of thumb can at times be misleading and often do not take into account many of the complex dynamics of a factor analysis. Therefore, the data used was considered suitable for the factor analysis.

There are some other considerations to find out whether the data is suitable for factor analysis. These tests are explained below with guidelines for accepting the data for the analysis. The adequacy of the data to fulfil these requirements will be discussed later when presenting results of the tests.

Sampling Adequacy and Test of Sphericity

Other tests that used to assess the suitability of the respondent data for factor analysis included Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. The formula for the KMO test is:

$$MO_j = \frac{\Sigma_{i \neq j} r_{ij}^2}{\Sigma_{i \neq j} r_{ij}^2 + \Sigma_{i \neq j} u} \qquad \text{..... 6.2}$$

where:

$R = [r_{ij}]$ is the correlation matrix and

$U = [u_{ij}]$ is the partial covariance matrix.

(StatisticsHowto.com 2018)

According to Williams et al. (2010), the KMO index, in particular, is recommended when the cases to variable ratio are less than 1:5. They consider KMO index of 0.50 suitable for factor analysis and the Bartlett's Test of Sphericity should be significant ($p<0.05$) for factor analysis to be suitable.

Test for communality

In addition to the tests mentioned above, it is necessary to test for communality which is the total amount of variance an original variable share with all other variables included in the analysis. The communality is the variance accounted for by the common factors. A particular set of factors is said to explain a lot of the variance of a variable if it has a high communality (Yong & Pearce 2013).

Communality is given as $\sum_{j=1}^{m} a_{ij}^2$ for the variable X_i in the Equation 6.1.

Small communalities show that a substantial portion of the variable's variance is not accounted for by the factors. According to Costello and Osborne (2009) item communalities are considered high if they are all 0.8 or greater. But they point out that this is unlikely to occur in real data and more common magnitudes in the social sciences are low to moderate communalities of 0.40 to 0.70. Yong and Pearce (2013) recommend 0.2 as the lower level for the analysis.

The above tests were carried out during the factor analysis and the results are given.

6.5.2 Step 2: How will the factors be extracted?

There are many ways to extract factors, some of which are listed below:

- Principal components analysis (PCA);
- Principal axis factoring (PAF);
- Maximum likelihood;
- Unweighted least squares;
- Generalised least squares;
- Alpha factoring; and
- Image factoring.

Summarising the work of a number of researchers on the method to extract factors, Williams et al. (2010) stated the following:

- PCA and PAF are used most commonly in the published literature.

However, the practical differences between the two are often insignificant, particularly when variables have high reliability or where there are 30 or more variables.

- PCA is the default method in many statistical programs, and thus, is most commonly used in factor analysis.
- PCA is also recommended when no priori theory or model exists.

Quoting other researchers, Yong and Pearce (2013) recommends Principal Axis Factor when the data violate the assumption of multivariate normality. The methods of extraction used in this analysis are explained when discussing the extraction method during the analysis.

6.5.3 Step 3: What criteria will assist in determining factor extraction?

When determining factor extraction, it is necessary to pay attention to considerations mentioned below.

Number of factors to be extracted

The aim of the data extraction is to reduce a large number of items into factors. In order to produce scale unidimensionality and simplify the factor solutions, several criteria are available to researchers. They include Kaiser's criteria (eigenvalue > 1 rule), the Scree Test, the cumulative percent of variance extracted, and parallel analysis. Williams et al. (2010) suggested that multiple approaches be used in factor extraction. Although the point of inflection in the scree plot provides an indication, Eigenvalues greater than 1 is generally used to identify the factors to be retained (Field 2013). The Scree Plot has Eigen value in the vertical axis and the corresponding variable (factor) number in the horizontal axis, so it is essentially a graphical representation of Kaiser's criteria. Both Eigenvalues and Scree Plots were used in this analysis to determine the number of factors to be extracted.

Factorability

A correlation matrix is used in the factor analysis process displaying the relationships between individual variables. Williams et al. (2010) provided the guideline to limit the factorability to 0.3, beyond which it becomes impractical to determine if the variables are correlated with each other or the dependent variable (multicollinearity).

6.5.4 Step 4: Selection of rotational method

As explained by Williams et al. (2010), rotation maximises high item loadings and minimises low item loadings, therefore producing a more interpretable and simplified solution. There are two common rotation techniques: orthogonal rotation and oblique rotation. Orthogonal Varimax rotation is the most common rotational technique used in factor analysis, which produce factor structures that are uncorrelated. In contrast, oblique rotation produces factors that are correlated, which is often seen as producing more accurate results for research involving human behaviours, or when data does not meet priori assumptions (Williams et al. 2010). Usually in social sciences, there is a certain amount of correlation between the factors, thus relying only on the outcomes of orthogonal rotation is the loss of valuable information if there is a correlation between factors (Hadi et al. 2016). This research comes under social sciences and involves analysing variables related to the human behaviour. Therefore, the oblique rotational method was used for rotation.

The common oblique rotation techniques are Direct Oblimin and Promax. Promax involves raising the loadings to a power of four which ultimately results in greater correlations among the factors and achieves a simple structure (Yong & Pearce 2013). In this analysis, the oblique rotation technique of Promax was used.

6.5.5 Step 5: Interpretation

When interpreting factors, the following aspects are to be considered:

Loadings

When interpreting the factors, it is necessary to look at the loadings to determine the strength of the relationships; loadings are the coefficients a_{ij} of the factor F_j for each variable X_i in Equation 6.1. Ford et al. (1986) suggested to consider loadings of more than 0.4 on a factor. However, Hair et al. (2006) recommended the factor loading of 0.5. According to them 0.3 or 0.4 are minimally acceptable. A factor has four or more loadings greater than 0.6 then it is reliable regardless of sample size (Field 2013).

Crossloadings

Another aspect to consider when interpreting results is crossloadings. According to Yong and Pearce (2013), a crossloading is when an item loads at .32 or higher on two or more factors. Depending on the design of the study, a complex variable (i.e., an item that is in the situation of crossloading) can be retained with the assumption that it is the latent nature of the variable, or the complex variable can be dropped when the interpretation is difficult. There should be a few item crossloadings so that each factor defines a distinct cluster of interrelated variables (Yong and Pearce 2013).

Interpretability

It is also important that factors are decided to provide a meaningful explanation. Hair et al. (2006) strongly recommend using conceptual understanding to determine factors rather than interpreting purely on empirical basis.

Total Variance explained

Williams et al. (2010) reported that, in the humanities, the explained variance as given in the Total Variance explained table, is commonly as low as 50-60%.

Number of factors

According to Costello and Osborne (2009), a factor with fewer than three items is generally weak and unstable; 5 or more strongly loading items (.50 or better) are desirable and indicate a solid factor.

At the same time, Fabrigar et al. (1999) advocated against specifying too few factors in a model. According to them, when too few factors are included in a model, substantial error is likely. Therefore, deliberate action was taken not to have too few factors.

Taking into consideration of the above, the factor analysis was undertaken using the SPSS Version 23. Two separate procedures were adopted when analysing independent variables and dependent variables. They are explained in the next sections.

6.6 Factor analysis on independent variables

The analysis was performed separately for independent variables (i.e., those came under idea harnessing, relationship enhancing, incentivisation and project team fitness). As mentioned in the *Section 6.2.2*, Exploratory Factor Analysis (EFA) was used for the analysis.

The following procedure as recommended by Field (2013) was adopted:

1. Principal axis factoring (PAF) was used to extract factors;
2. Used Promax for rotation; and
3. To ensure that factor scores are uncorrelated, Anderson-Rubin Method was used.

A few iterations were carried out until an acceptable solution is achieved which can be explained using the conceptual understanding.

6.6.1 First Round results

The first round results are discussed below.

Table 6.2 shows the communalities. It can be seen that all items satisfy the recommended 0.2 lower level. In fact, 0.3 was the minimum level.

It can be seen from *Table 6.3*, the KMO and Bartlett's Test value is 0.794, which is well above the minimum criterion of 0.5, confirming the sampling size is adequate for factor analysis (Field 2013). It is also noted that the Bartlett's Test measure is significant ($p<0.001$). Therefore, the KMO and Bartlett's Test indicates that the data is suitable for factor analysis.

It can be seen from the Total Variance Explained *Table 6.4* that SPSS has initially identified 43 factors which were reduced to 11 after extraction based on the criterion of Eigenvalues greater than 1.

The Scree plot shown in Fig 6.2 is difficult to be interpreted as most values are scattered between 0 and 2.5.

Field (2013) recommends using the Pattern Mix to interpret results. The Pattern Matrix is given in *Table 6.5.* When considering the Pattern Matrix, factor loadings less than 0.3 and those items with crossloadings were dropped. Observations from the Pattern Matrix are given below.

The following items had crossloadings (highlighted in green):

- 2D3.2 Project team members motivated

The following had crossloadings (highlighted in grey). But they had no loadings of more than 0.32 on two occasions. Most of their loadings were small.

- 2D4.5 No blame game

- 2C1.7 Selecting designers and contractors – used
- 2A2.3 We followed new research

Three factors had only two items each. However, they had considerably high factor loadings of more than 0.6. They were:

- 2C1.5 Selecting designers and contractors – used innovative proposals and 2C1.6 Selecting designers and contractors – used innovation history
- 2C1.2 We recognised idea implementers and 2C1.1 We recognised idea generators
- 2C1.9 Selected contract types such as alliances and 2C1.8 Included contract clauses to share savings. The following two had three factors each:

Table 6.2 Communalities for independent variables - Round 1

Variables		
	Initial	Extraction
2A2.1 We used inputs from experienced personnel	0.596	0.435
2A2.3 We followed new research	0.511	0.320
2A2.4 We captured project learnings	0.583	0.371
2A2.5 We followed up team ideas which had merit until completion	0.542	0.384
2A2.6 We had implementers to help idea generators	0.550	0.526
2B2.1 Respected each other teams	0.829	0.749
2B2.2 Had conducive culture within teams	0.783	0.763
2B2.3 Had good relationships with key stakeholders	0.674	0.603
2B2.4 Had excellent relationships with other teams	0.785	0.732
2C1.1 We recognised idea generators	0.737	0.636
2C1.2 We recognised idea implementers	0.733	0.776
2C1.3 Rewarded with financial incentives	0.797	0.731
2C1.4 Rewarded with personal incentives	0.710	0.643
2C1.5 Selecting designers and contractors - used innovative proposals	0.753	0.699
2C1.6 Selecting designers and contractors - used innovation history	0.776	0.709
2C1.7 Selecting designers and contractors - used innovation performance	0.650	0.469
2C1.8 Included contract clauses to share savings	0.566	0.493
2C1.9 Selected contract types such as alliances	0.687	0.722
2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes	0.761	0.759

2D1.2 PM experienced and technologically competent	0.765	0.718
2D1.3 PM earned respect	0.743	0.686
2D1.4 PM made quick decisions	0.745	0.664
2D1.5 PM protected the team	0.700	0.601
2D2.1 Project team was provided with training to improve team skills	0.810	0.769
2D2.2 Project team was provided with training to improve knowledge	0.780	0.728
2D2.3 Project team had opportunities to be exposed to others	0.631	0.492
2D2.4 Project team had opportunities to be exposed to best national and international practices	0.787	0.680
2D2.5 Project team was provided with training to implementers	0.664	0.578
2D3.1 Project team members helpful	0.721	0.702
2D3.2 Project team members motivated	0.676	0.533
2D3.3 Project team members diverse persons	0.540	0.461
2D3.4 Project team members had considerable knowledge and experience	0.713	0.666
2D3.5 Project team members had exposure to innovation	0.724	0.683
2D3.6 Project team members had strong relationships with customers	0.726	0.679
2D3.7 Project team members considered innovation as a day-to-day duty	0.774	0.660
2D4.1 All were treated equally	0.710	0.659
2D4.2 Felt free to talk	0.626	0.620
2D4.3 Ideas became team ideas	0.638	0.459
2D4.4 No difficulty in forming teams	0.617	0.565
2D4.5 No blame game	0.673	0.566
2D5.1 Client organisation supported innovative activities	0.802	0.789
2D5.2 Client organisation relaxed technical regulations/ specifications	0.667	0.545
2D5.3 Client organisation had characteristics of an innovative organisation	0.773	0.765
Extraction Method: Principal Axis Factoring.		

Table 6.3 KMO and Bartlett's Test results for independent variables - Round 1

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.794

Bartlett's Test of Sphericity	Approx. Chi-Square	3088.997
	df	903
	Sig.	0

Table 6.4 Total Variance Explained results for independent variables - Round 1

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	12.884	29.962	29.962	12.521	29.117	29.117	6.954
2	4.124	9.590	39.552	3.776	8.781	37.899	7.077
3	2.143	4.983	44.535	1.819	4.231	42.129	6.815
4	1.965	4.569	49.104	1.604	3.729	45.859	6.120
5	1.783	4.146	53.250	1.412	3.284	49.143	8.521
6	1.700	3.952	57.202	1.353	3.147	52.290	5.939
7	1.448	3.367	60.569	1.102	2.562	54.852	5.668
8	1.336	3.107	63.676	0.977	2.273	57.125	4.805
9	1.215	2.827	66.502	0.848	1.972	59.097	3.107
10	1.116	2.596	69.098	0.695	1.617	60.714	3.315
11	1.028	2.392	71.490	0.684	1.590	62.304	4.506
12	0.964	2.243	73.733				
13	0.873	2.030	75.763				
14	0.777	1.807	77.570				
15	0.732	1.701	79.271				
16	0.697	1.620	80.891				
17	0.670	1.558	82.450				
18	0.614	1.428	83.878				
19	0.565	1.313	85.191				
20	0.528	1.228	86.418				
21	0.496	1.154	87.572				
22	0.469	1.091	88.663				
23	0.462	1.074	89.737				
24	0.439	1.020	90.758				

25	0.417	0.971	91.729				
26	0.381	0.886	92.614				
27	0.367	0.853	93.467				
28	0.312	0.725	94.192				
29	0.280	0.651	94.843				
30	0.266	0.619	95.462				
31	0.257	0.599	96.060				
32	0.236	0.549	96.609				
33	0.215	0.500	97.109				
34	0.198	0.460	97.569				
35	0.185	0.430	98.000				
36	0.149	0.346	98.346				
37	0.144	0.335	98.681				
38	0.136	0.316	98.997				
39	0.119	0.277	99.274				
40	0.095	0.221	99.495				
41	0.090	0.210	99.706				
42	0.073	0.170	99.875				
43	0.054	0.125	100.000				

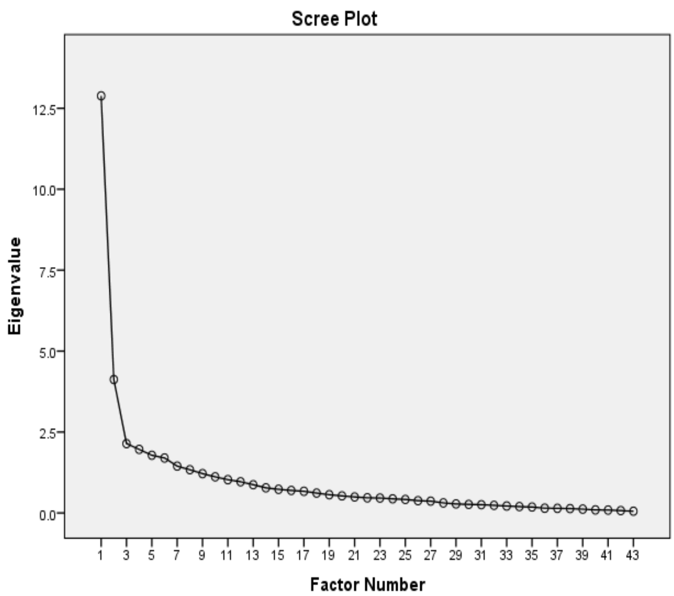


Figure 6.2 Scree plot for independent variables - Round 1

The following two had three factors each:

- 2D5.3 Client organisation had characteristics of an innovative organisation, 2D5.1 Client organisation supported innovative activities and 2D5.2 Client organisation relaxed technical regulations/ specifications
- 2A2.6 We had implementers to help idea generators, 2D3.5 Project team members had exposure to innovation and 2D3.7 Project team members considered innovation as a day-to-day duty

There are 8 factors with three or more items (highlighted in yellow). Therefore, it was decided to attempt 8 factors in subsequent iterations.

Table 6.5 Pattern Matrix for independent variables - Round 1

	Factor										
	1	2	3	4	5	6	7	8	9	10	11
2D2.1 Project team was provided with training to improve team skills	0.946	0.106				-0.131					-0.135
2D2.2 Project team was provided with training to improve knowledge	0.868			-0.243	-0.113		0.171				
2D2.4 Project team had opportunities to be exposed to best national and international practices	0.810	-0.178			0.173	0.146	-0.301				
2D2.3 Project team had opportunities to be exposed to others	0.695		0.110	0.119					0.145		-0.186
2D2.5 Project team was provided with	0.495			-0.218						0.158	0.254

training to implementers											
2B2.2 Had conducive culture within teams		0.902				0.111				-0.115	-0.180
2B2.4 Had excellent relationships with other teams		0.845				0.134	-0.121	0.200			
2B2.1 Respected each other teams		0.718			0.134		-0.119			0.145	
2B2.3 Had good relationships with key stakeholders		0.681	-0.131	0.142		-0.112		0.103	-0.163	0.123	0.117
2D4.2 Felt free to talk			0.802			0.130				0.118	-0.149
2D4.3 Ideas became team ideas		-0.128	0.595						-0.134		0.235
2D4.1 All were treated equally		0.321	0.587	-0.163			0.108	-0.153			
2D4.4 No difficulty in forming teams		-0.118	0.575	-0.128	0.164			0.194		-0.102	0.227
2D3.2 Project team members motivated	-0.196		0.441	0.407		0.134					
2D4.5 No blame game		0.213	0.361			0.208			0.141	-0.110	
2D3.4 Project team members had considerable knowledge and experience	-0.112		-0.126	0.863						0.133	
2D3.3 Project team members	-0.178			0.663					0.186	0.137	-0.126

diverse persons											
2D3.6 Project team members had strong relationships with customers	0.176	0.273		0.628			-0.190	-0.111			0.153
2D3.1 Project team members helpful	0.196	-0.148	0.534	0.553		-0.185					-0.148
2D1.4 PM made quick decisions			0.120	-0.110	0.805		-0.222	-0.160			0.119
2D1.5 PM protected the team					0.768	-0.119	-0.112	-0.238	0.170		
2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes					0.706		0.283				-0.171
2D1.3 PM earned respect					0.652		0.180	0.222		-0.102	
2D1.2 PM experienced and technologically competent		0.226		0.201	0.522	-0.151	0.151	0.132			-0.128
2D5.3 Client organisation had Characteristics of an innovative organisation	0.133					0.869			-0.242		
2D5.1 client organisation supported innovative activities				0.178	-0.102	0.849	0.197				-0.107
2D5.2 client organisation's		0.159		-0.112		0.560		0.145	0.175		

relaxation of technical regulations/ specifications supported innovative activities											
2C1.5 Selecting designers and contractors – used innovative proposals	-0.111	-0.117				0.152	0.887	-0.158		0.107	0.138
2C1.6 Selecting designers and contractors – used innovation history							0.805		0.267		
2C1.7 Selecting designers and contractors – used innovation performance	0.280			-0.121			0.300				
2C1.2 We recognised idea implementers			0.147		-0.149		-0.193	0.887			0.181
2C1.1 We recognised idea generators	0.109	0.116		0.102				0.625		0.102	
2C1.9 Selected contract types such as alliances	0.128			0.157			0.166	0.102	0.778		-0.134
2C1.8 Included contract clauses to share savings					0.184	-0.126	0.164		0.620		0.151

2C1.4 Rewarded with personal incentives	0.123		-0.154	0.167	0.125	0.234			0.147	0.542	
2C1.3 Rewarded with financial incentives	0.277	-0.206				0.183		0.104	0.112	0.491	0.148
2A2.5 We followed up team ideas which had merit until completion		0.114	0.119	0.106				0.106		0.371	0.215
2A2.1 We used inputs from experienced personnel			0.345	0.230					-0.165	0.347	
2A2.4 We captured project learnings	0.153	0.170	0.195				0.157	-0.249		0.338	
2A2.3 We followed new research			0.158		0.164			0.145		0.208	0.172
2A2.6 We had implementers to help idea generators	-0.198		0.156	-0.209		-0.133		0.219		0.220	0.716
2D3.5 Project team members had exposure to innovation			-0.203	0.424		0.192	0.233	-0.123		-0.106	0.451
2D3.7 Project team members considered innovation as a day-to-day duty	0.222			0.274			0.155	0.146		-0.163	0.423
Extraction Method: Principal Axis Factoring.											
Rotation Method: Promax with Kaiser Normalization.											

6.6.2 Subsequent iterations

Several subsequent iterations were carried out limiting the number of factors to 8, but dropping one or several crossloading items until a satisfactory solution was obtained which could be conceptually understood. *Table 6.9* shows the Pattern Matrix of the acceptable solution. The results of this solution are explained below.

Table 6.6 shows the communalities. It can be seen that all items satisfy the recommended 0.2 lower level. In fact, 0.3 is the minimum level.

Table 6.6 Communalities for independent variables

	Initial	Extraction
2A2.1 We used inputs from experienced personnel	0.596	0.325
2A2.3 We followed new research	0.511	0.318
2A2.4 We captured project learnings	0.583	0.307
2A2.5 We followed up team ideas which had merit until completion	0.542	0.313
2A2.6 We had implementers to help idea generators	0.55	0.318
2B2.1 Respected each other teams	0.829	0.743
2B2.2 Had conducive culture within teams	0.783	0.76
2B2.3 Had good relationships with key stakeholders	0.674	0.564
2B2.4 Had excellent relationships with other teams	0.785	0.733
2C1.1 We recognised idea generators	0.737	0.617
2C1.2 We recognised idea implementers	0.733	0.592
2C1.3 Rewarded with financial incentives	0.797	0.705
2C1.4 Rewarded with personal incentives	0.71	0.613
2C1.5 Selecting designers and contractors - used innovative proposals	0.753	0.642
2C1.6 Selecting designers and contractors - used innovation history	0.776	0.725
2C1.7 Selecting designers and contractors - used innovation performance	0.65	0.469
2C1.8 Included contract clauses to share savings	0.566	0.361
2C1.9 Selected contract types such as alliances	0.687	0.475
2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes	0.761	0.635
2D1.2 PM experienced and technologically competent	0.765	0.694
2D1.3 PM earned respect	0.743	0.591
2D1.4 PM made quick decisions	0.745	0.532
2D1.5 PM protected the team	0.7	0.474
2D2.1 Project team was provided with training to improve team skills	0.81	0.761
2D2.2 Project team was provided with training to improve knowledge	0.78	0.734

2D2.3 Project team had opportunities to be exposed to others	0.631	0.459
2D2.4 Project team had opportunities to be exposed to best national and international practices	0.787	0.637
2D2.5 Project team was provided with training to implementers	0.664	0.565
2D3.1 Project team members helpful	0.721	0.611
2D3.2 Project team members motivated	0.676	0.526
2D3.3 Project team members diverse persons	0.54	0.442
2D3.4 Project team members had considerable knowledge and experience	0.713	0.682
2D3.5 Project team members had exposure to innovation	0.724	0.479
2D3.6 Project team members had strong relationships with customers	0.726	0.649
2D3.7 Project team members considered innovation as a day-to-day duty	0.774	0.604
2D4.1 All were treated equally	0.71	0.640
2D4.2 Felt free to talk	0.626	0.466
2D4.3 Ideas became team ideas	0.638	0.461
2D4.4 No difficulty in forming teams	0.617	0.552
2D4.5 No blame game	0.673	0.559
2D5.1 Client organisation supported innovative activities	0.802	0.661
2D5.2 Client organisation relaxed technical regulations/ specifications	0.667	0.539
2D5.3 Client organisation had characteristics of an innovative organisation	0.773	0.561
Extraction Method: Principal Axis Factoring.		

Table 6.7 shows the KMO and Bartlett's Test values. It can be seen from this table that the KMO and Bartlett's Test value is 0.794 (same as the first round), which is well above the minimum criterion of 0.5, confirming the sampling size is adequate for factor analysis (Field 2013). It is also noted that the Bartlett's Test measure is significant ($p<0.001$) indicating that the original correlation matrix is an identity matrix (Field 2013). Therefore, the KMO and Bartlett's Test indicates that the data is suitable for factor analysis.

Table 6.7 KMO and Bartlett's Test results for independent variables

KMO		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.794
Bartlett's Test of Sphericity	Approx. Chi-Square	3088.997
	df	903
	Sig.	0

It can be seen from the Total Variance Explained *Table 6.8* that SPSS has initially identified 43 factors and reduced this to 8 (as requested) after extraction.

Table 6.8 Total Variance Explained for independent variables

Factor	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**
1	12.884	29.962	29.962	12.459	28.975	28.975	9.279
2	4.124	9.590	39.552	3.725	8.662	37.637	6.752
3	2.143	4.983	44.535	1.784	4.148	41.785	6.826
4	1.965	4.569	49.104	1.550	3.605	45.390	6.430
5	1.783	4.146	53.250	1.367	3.180	48.570	7.343
6	1.700	3.952	57.202	1.297	3.017	51.587	3.214
7	1.448	3.367	60.569	1.015	2.361	53.948	6.182
8	1.336	3.107	63.676	0.899	2.090	56.038	4.797
9	1.215	2.827	66.502				
10	1.116	2.596	69.098				
11	1.028	2.392	71.490				
12	0.964	2.243	73.733				
13	0.873	2.030	75.763				
14	0.777	1.807	77.570				
15	0.732	1.701	79.271				
16	0.697	1.620	80.891				
17	0.670	1.558	82.450				
18	0.614	1.428	83.878				
19	0.565	1.313	85.191				
20	0.528	1.228	86.418				
21	0.496	1.154	87.572				
22	0.469	1.091	88.663				
23	0.462	1.074	89.737				
24	0.439	1.020	90.758				
25	0.417	0.971	91.729				
26	0.381	0.886	92.614				
27	0.367	0.853	93.467				
28	0.312	0.725	94.192				
29	0.280	0.651	94.843				
30	0.266	0.619	95.462				
31	0.257	0.599	96.060				
32	0.236	0.549	96.609				
33	0.215	0.500	97.109				
34	0.198	0.460	97.569				
35	0.185	0.430	98.000				
36	0.149	0.346	98.346				
37	0.144	0.335	98.681				
38	0.136	0.316	98.997				

39	0.119	0.277	99.274				
40	0.095	0.221	99.495				
41	0.090	0.210	99.706				
42	0.073	0.170	99.875				
43	0.054	0.125	100.000				

Extraction Method: Principal Axis Factoring.

The relevant Pattern Matrix Table is given under *Table 6.9* which shows the variables coming under each factor. They are highlighted for easy identification.

Table 6.9 Pattern Matrix for independent variables

	1	2	3	4	5	6	7	8
2D4.2 Felt free to talk	0.765			-0.108				
2D4.1 All were treated equally	0.725		0.277	-0.174	-0.205	0.112		
2D4.4 No difficulty in forming teams	0.716		-0.159	-0.148	0.226	0.224		
2D4.3 Ideas became team ideas	0.715		-0.180					-0.218
2D1.4 PM made quick decisions	0.683		0.103				-0.230	0.212
2D1.5 PM protected the team	0.614						-0.103	0.266
2D3.2 Project team members motivated	0.500	-0.219		0.389		0.186		
2D4.5 No blame game	0.442		0.202			0.369		
2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes	0.423				0.214	-0.149	0.295	
2A2.1 We used inputs from experienced personnel	0.349			0.192		-0.165		
2A2.4 We captured project learnings	0.319	0.220	0.130		-0.214			0.162
2A2.3 We followed new research	0.297				0.261			0.114
2D2.1 Project team was provided with training to improve team skills	-0.111	0.923	0.115			-0.145		
2D2.2 Project team was provided with training to improve knowledge		0.876	0.100	-0.226			0.172	
2D2.4 Project team had opportunities to be exposed to best national and international practices		0.756	-0.137				-0.290	
2D2.3 Project team had opportunities to be exposed to others		0.636		0.119	-0.208			
2D2.5 Project team was provided with training to implementers		0.526		-0.205	0.188	0.194		0.204
2B2.2 Had conducive culture within teams			0.937		-0.138	0.222		
2B2.4 Had excellent relationships with other teams			0.861		0.239	0.283	-0.132	
2B2.1 Respected each other teams	0.227		0.715			0.112	-0.136	0.128

2B2.3 Had good relationships with key stakeholders			0.669	0.155	0.190			-0.112
2D3.4 Project team members had considerable knowledge and experience	-0.173	-0.117		0.881				0.128
2D3.6 Project team members had strong relationships with customers		0.229	0.227	0.650	-0.125		-0.213	
2D3.3 Project team members diverse persons		-0.198		0.636	-0.104		0.147	0.214
2D3.1 Project team members helpful	0.486	0.134	-0.133	0.496	-0.132	-0.130		-0.171
2D3.5 Project team members had exposure to innovation				0.471	0.101	0.292	0.145	
2D3.7 Project team members considered innovation as a day-to-day duty		0.262	-0.102	0.314	0.292	0.239	0.109	-0.201
2C1.2 We recognised idea implementers		-0.103			0.799	0.250	-0.111	
2C1.1 We recognised idea generators	-0.188		0.148		0.710			
2A2.6 We had implementers to help idea generators	0.286		-0.138	-0.178	0.422	0.158		
2D1.3 PM earned respect	0.295		0.154		0.413	-0.123	0.184	
2D5.2 Client organisation relaxed technical regulations/ specifications			0.196	-0.106	0.141	0.619		0.239
2D5.1 Client organisation supported innovative activities			0.154	0.221		0.612	0.204	0.201
2D5.3 Client organisation had characteristics of an innovative organisation		0.131			0.178	0.506		
2D1.2 PM experienced and technologically competent	0.185		0.310	0.201	0.250	-0.327	0.154	
2C1.6 Selecting designers and contractors - used innovation history						0.118	0.859	
2C1.5 Selecting designers and contractors - used innovative proposals			-0.121				0.835	
2C1.7 Selecting designers and contractors - used innovation performance		0.265	0.110	-0.114	0.130		0.307	
2C1.4 Rewarded with personal incentives		0.127		0.146	0.119	0.113		0.649
2C1.3 Rewarded with financial incentives		0.298	-0.215		0.220	0.132		0.548
2C1.9 Selected contract types such as alliances	-0.189				-0.116	0.312	0.281	0.500
2C1.8 Included contract clauses to share savings	0.114					0.233	0.210	0.467
2A2.5 We followed up team ideas which had merit until completion	0.134				0.142			0.219
Extraction Method: Principal Axis Factoring.								
Rotation Method: Promax with Kaiser Normalization.								

The factors identified were given names to reflect their representation. Factors derived, and names assigned to them are given in *Table 6.10*. Individual factors are highlighted for easy identification.

Table 6.10 Factors and assigned names for independent variables

2D4.2 Felt free to talk	Project team attributes
2D4.1 All were treated equally	
2D4.4 No difficulty in forming teams	
2D4.3 Ideas became team ideas	
2D1.4 PM made quick decisions	
2D1.5 PM protected the team	
2D3.2 Project team members motivated	
2D4.5 No blame game	
2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes	
2A2.1 We used inputs from experienced personnel	
2A2.4 We captured project learnings	
2A2.3 We followed new research	
2D2.1 Project team was provided with training to improve team skills	Support to the project team
2D2.2 Project team was provided with training to improve knowledge	
2D2.4 Project team had opportunities to be exposed to best national and international practices	
2D2.3 Project team had opportunities to be exposed to others	
2D2.5 Project team was provided with training to implementers	
2B2.2 Had conducive culture within teams	Nature of relationship
2B2.4 Had excellent relationships with other teams	
2B2.1 Respected each other teams	
2B2.3 Had good relationships with key stakeholders	
2D3.4 Project team members had considerable knowledge and experience	Project team member attributes
2D3.6 Project team members had strong relationships with customers	
2D3.3 Project team members diverse persons	
2D3.1 Project team members helpful	
2D3.5 Project team members had exposure to innovation	
2D3.7 Project team members considered innovation as a day-to-day duty	
2C1.2 We recognised idea implementers	Internal recognition
2C1.1 We recognised idea generators	
2A2.6 We had implementers to help idea generators	

2D1.3 PM earned respect	
2D5.2 Client organisation relaxed technical regulations/ specifications	Client organisation
2D5.1 Client organisation supported innovative activities	
2D5.3 Client organisation had characteristics of an innovative organisation	
2C1.6 Selecting designers and contractors - used innovation history	Designers & contractors
2C1.5 Selecting designers and contractors - used innovative proposals	
2C1.7 Selecting designers and contractors - used innovation performance	
2C1.4 Rewarded with personal incentives	Incentivisation
2C1.3 Rewarded with financial incentives	
2C1.9 Selected contract types such as alliances	
2C1.8 Included contract clauses to share savings	

It can be seen that:

- Factors can be interpreted in practical terms;
- Factor 1, named 'Project team attributes', includes variables from project team fitness and idea harnessing.
- Factor 2, named 'Support to the project team', includes variables from project team fitness.
- Factor 3, named 'Relationship', includes variables from relationship enhancement.
- Factor 4, named 'Project team member attributes', includes variables from project team fitness.
- Factor 5, named 'Recognition', includes variables from incentivisation.
- Factor 6, named 'Client organisation', includes variables from project team fitness.
- Factor 7, named as 'Designers & contractors', includes variables from project team fitness.
- Factor 8, named 'Incentivisation', includes variables from incentivisation.

Therefore, all the constructs under dependent variables, i.e. idea harnessing, relationship enhancement, incentivisation and project team fitness, which were identified during the literature review, are included in the identified factors.

6.7 Factor analysis on dependent variables

A similar analysis was done with dependent variables coming under innovative performance. The only the change was to use Principal components analysis (PCA) to extract factors compared to Principal axis factoring (PAF) used in the case of independent variables as mentioned in *Section 6.2.2*. This is because it was necessary to find a representative factor for all possible dependent variables and Principal components analysis facilitates this.

Table 6.11 shows the communalities. Due to the use of Principal components analysis (PCA), the initial communality for each item is 1. After extraction, this value goes down, but still remains higher than 0.5 showing all items are acceptable in terms of communality for factor analysis.

Table 6.11 Communalities for dependent variables- Round 1

2E1.1 We used improved technologies, methods and practices	1	0.693
2E1.2 We used improved materials, products, plant, and equipment	1	0.742
2E1.3 We used improved computer software/ hardware, models and communication systems	1	0.602
2E1.4 We used improved advanced business or procurement techniques, processes and systems	1	0.676
2E1.5 We used construction resources efficiently	1	0.786
2E1.6 We used sustainable practices	1	0.752
2E2.1 Project outcome: Operational goals	1	0.698
2E2.2 Project outcome: Satisfied customers	1	0.742
2E2.3 Project outcome: Sustainable outcomes and reduced waste	1	0.670
2E2.4 Project outcome: Satisfied project team	1	0.667
2E2.5 Project outcome: Increased productivity and competitive advantage	1	0.619
2E2.6 Project outcome: Positive organisational and professional learning	1	0.581
2E2.7 Project outcome: Positive economic impact	1	0.353
2E3.1 Project personnel received internal recognition	1	0.792
2E3.2 Project received internal recognition	1	0.740
2E3.3 Highly commended in the media	1	0.696
2E3.4 External recognition in professional bodies	1	0.667
2E3.5 Industry has started using the practices	1	0.564
Extraction Method: Principal Component Analysis.		

The KMO and Bartlett's Test results are given in *Table 6.12*. It can be seen that the KMO and Bartlett's Test value is 0.820, which is well above the minimum criterion of 0.5, confirming the sampling size is adequate for factor analysis (Field 2013). It is also noted that the Bartlett's Test measure is significant ($p<0.001$) indicating that the original correlation matrix is an identity matrix (Field 2013). Therefore, the KMO and Bartlett's Test indicates that the data is suitable for factor analysis.

Table 6.12 KMO and Bartlett's Test for dependent variables- Round 1

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.820
Bartlett's Test of Sphericity	Approx. Chi-Square	990.484
	df	153
	Sig.	0

Next test carried out was on Total Variance Explained, the results of which are given in *Table 6.13.*

Table 6.13 Total Variance Explained for dependent variables- Round 1

Total Variance Explained							
Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.618	36.765	36.765	6.618	36.765	36.765	5.306
2	1.673	9.292	46.058	1.673	9.292	46.058	4.578
3	1.412	7.844	53.902	1.412	7.844	53.902	3.301
4	1.248	6.935	60.838	1.248	6.935	60.838	1.834
5	1.090	6.055	66.892	1.090	6.055	66.892	3.256
6	0.997	5.539	72.432				
7	0.841	4.675	77.106				
8	0.764	4.247	81.354				

9	0.588	3.264	84.618				
10	0.504	2.801	87.419				
11	0.476	2.642	90.061				
12	0.360	2.000	92.061				
13	0.348	1.931	93.991				
14	0.285	1.582	95.573				
15	0.250	1.389	96.962				
16	0.231	1.282	98.244				
17	0.179	0.995	99.239				
18	0.137	0.761	100.000				
Extraction Method: Principal Component Analysis.							

The Scree plot shown in *Fig. 6.3* is difficult to be interpreted as most values are scattered.

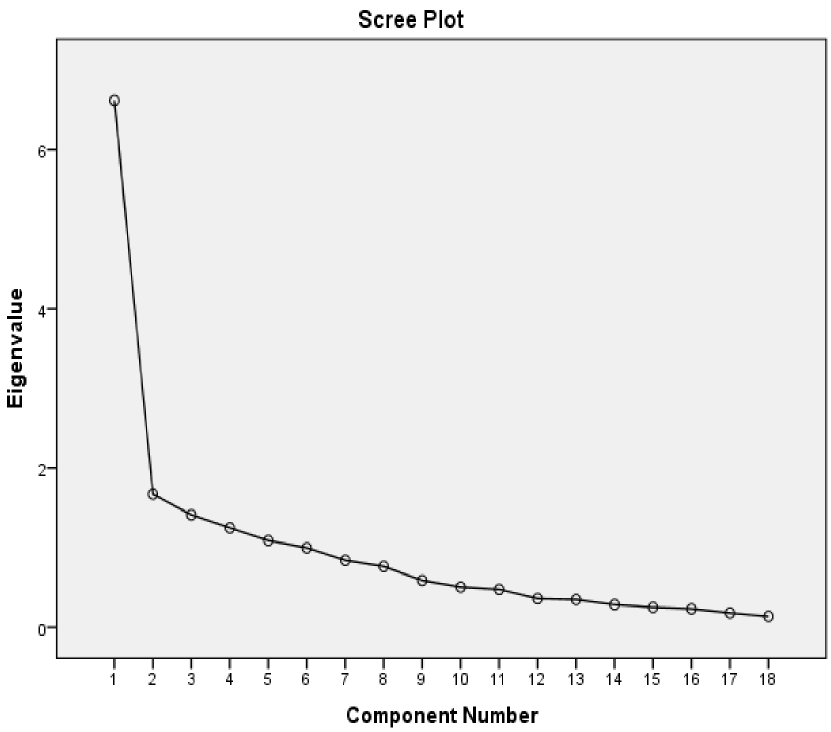


Figure 6.3 Scree Plot for dependent variables- Round 1

Table 6.14 shows the Pattern Matrix. Different factors are highlighted for easy identification.

Table 6.14 Pattern Matrix for dependent variables- Round 1

	1	2	3	4	5
2E2.2 Project outcome: Satisfied customers	0.940		-0.179	0.112	-0.183
2E2.3 Project outcome: Sustainable outcomes and reduced waste	0.832	-0.157	0.235	-0.196	-0.152
2E2.1 Project outcome: Operational goals	0.800	-0.130	-0.214		0.240
2E2.4 Project outcome: Satisfied project team	0.621		0.240	-0.132	0.131
2E2.5 Project outcome: Increased productivity and competitive advantage	0.604	0.204			
2E2.6 Project outcome: Positive organisational and professional learning	0.559	0.211	0.132	0.159	
2E2.7 Project outcome: Positive economic impact	0.296	0.262			0.176
2E3.4 External recognition in professional bodies		0.846		0.274	-0.229
2E3.3 Highly commended in the media		0.837		0.208	-0.131
2E3.1 Project personnel received internal recognition		0.737		-0.277	0.293
2E3.2 Project received internal recognition	0.101	0.733		-0.146	0.169
2E3.5 Industry has started using the practices		0.488	0.464		
2E1.2 We used improved materials, products, plant, and equipment		-0.136	0.857	0.291	
2E1.1 We used improved technologies, methods and practices			0.764	0.152	0.156
2E1.4 We used improved advanced business or procurement techniques, processes and systems			0.289	0.745	0.152
2E1.3 We used improved computer software/ hardware, models and communication systems		0.203	0.152	0.672	0.120
2E1.6 We used sustainable practices	-0.104		0.232		0.837
2E1.5 We used construction resources efficiently			-0.223	0.416	0.814
Extraction Method: Principal Component Analysis. Rotation Method: Promax with Kaiser Normalization.					

According to the Pattern Matrix there are 5 factors. However, 3 of these are with two items each. Therefore, a few iterations were done to avoid factors with less than 3 items. The iteration which satisfied this condition, together with factors that can be interpreted in conceptual terms, is explained below.

6.7.1 Subsequent iterations

KMO and Bartlett's Test results of the acceptable solution are given in *Table 6.15.* It can be seen that the KMO and Bartlett's Test value is 0.820, which is well above the minimum criterion of 0.5, confirming the sampling size is adequate for factor analysis.

Table 6.15 KMO and Bartlett's Test results for dependent variables

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.803
Bartlett's Test of Sphericity	Approx. Chi-Square	775.701
	df	91
	Sig.	0

In addition, the communality test results given in *Table 6.16* are also satisfactory as all values are higher than 0.5.

Table 6.16 Communality test results for dependent variables

	Initial	Extraction
2E1.1 We used improved technologies, methods and practices	1	0.508
2E1.2 We used improved materials, products, plant, and equipment	1	0.581
2E1.3 We used improved computer software/ hardware, models and communication systems	1	0.514
2E1.4 We used improved advanced business or procurement techniques, processes and systems	1	0.589
2E2.1 Project outcome: Operational goals	1	0.597
2E2.2 Project outcome: Satisfied customers	1	0.591
2E2.3 Project outcome: Sustainable outcomes and reduced waste	1	0.610
2E2.4 Project outcome: Satisfied project team	1	0.663

2E2.5 Project outcome: Increased productivity and competitive advantage	1	0.598
2E2.6 Project outcome: Positive organisational and professional learning	1	0.545
2E3.1 Project personnel received internal recognition	1	0.737
2E3.2 Project received internal recognition	1	0.765
2E3.3 Highly commended in the media	1	0.669
2E3.4 External recognition in professional bodies	1	0.587
Extraction Method: Principal Component Analysis.		

The Pattern Matrix is given in *Table 6.17*. Total number of factors now reduced to 3 with all having 4 or more items in each factor. Factors are highlighted.

Table 6.17 Pattern Matrix for dependent variables

	1	2	3
2E2.3 Project outcome: Sustainable outcomes and reduced waste	0.858	-0.213	
2E2.1 Project outcome: Operational goals	0.819		
2E2.4 Project outcome: Satisfied project team	0.788		
2E2.2 Project outcome: Satisfied customers	0.732		
2E2.5 Project outcome: Increased productivity and competitive advantage	0.582	0.197	0.142
2E2.6 Project outcome: Positive organisational and professional learning	0.471	0.182	0.263
2E3.3 Highly commended in the media	-0.143	0.812	0.163
2E3.1 Project personnel received internal recognition	0.223	0.807	-0.291
2E3.4 External recognition in professional bodies	-0.298	0.790	0.200
2E3.2 Project received internal recognition	0.233	0.788	-0.143
2E1.4 We used improved advanced business or procurement techniques, processes and systems			0.794
2E1.2 We used improved materials, products, plant, and equipment	0.150	-0.162	0.738
2E1.3 We used improved computer software/ hardware, models and communication systems		0.226	0.650
2E1.1 We used improved technologies, methods and practices	0.221		0.562
Extraction Method: Principal Component Analysis.			

Rotation Method: Promax with Kaiser Normalization.

Table 6.18 shows the factors derived (highlighted) and their assigned names.

Table 6.18 Factors and assigned names for dependent variables

2E2.3 Project outcome: Sustainable outcomes and reduced waste	Project outcomes
2E2.1 Project outcome: Operational goals	
2E2.4 Project outcome: Satisfied project team	
2E2.2 Project outcome: Satisfied customers	
2E2.5 Project outcome: Increased productivity and competitive advantage	
2E2.6 Project outcome: Positive organisational and professional learning	
2E3.3 Highly commended in the media	Project recognition
2E3.1 Project personnel received internal recognition	
2E3.4 External recognition in professional bodies	
2E3.2 Project received internal recognition	
2E1.4 We used improved advanced business or procurement techniques, processes and systems	Project usage
2E1.2 We used improved materials, products, plant, and equipment	
2E1.3 We used improved computer software/ hardware, models and communication systems	
2E1.1 We used improved technologies, methods and practices	

6.8 Chapter findings

The Part 2 survey data under idea harnessing, relationship enhancing, incentivisation, project team fitness and innovative performance were analysed in this chapter using the factor analysis to achieve the following objectives:

- To cluster variables into homogeneous sets;
- To identify groupings allowing to describe many variables using a few factors;
- To help selecting small groups of variables of representative variables from larger set; and
- To allow gaining insight into latent structure of groupings.

The analysis was performed separately for independent variables (i.e. those came under idea harnessing, relationship enhancing, incentivisation and project team fitness) and dependent variables coming under innovative performance. The findings are given below, separately for independent and dependent variables.

6.8.1 Independent variables

Independent variables coming under idea harnessing, relationship enhancing, incentivisation and project team fitness, initially had 44 variables.

These were reduced to 41, under 8 separate factors named project team attributes, support to the project team, nature of relationship, project team member attributes, internal recognition, client organisation, designers & contractors and incentivisation. The variables that grouped under these factors are given below:

Project team attributes

- 2D4.2 Felt free to talk
- 2D4.1 All were treated equally
- 2D4.4 No difficulty in forming teams
- 2D4.3 Ideas became team ideas
- 2D1.4 PM made quick decisions
- 2D1.5 PM protected the team
- 2D3.2 Project team members motivated
- 2D4.5 No blame game
- 2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes
- 2A2.1 We used inputs from experienced personnel
- 2A2.4 We captured project learnings
- 2A2.3 We followed new research

Support to the project team

- 2D2.1 Project team was provided with training to improve team skills
- 2D2.2 Project team was provided with training to improve knowledge
- 2D2.4 Project team had opportunities to be exposed to best national and international practices
- 2D2.3 Project team had opportunities to be exposed to others
- 2D2.5 Project team was provided with training to implementers

Nature of relationship

- *2B2.2 Had conducive culture within teams*
- 2B2.4 Had excellent relationships with other teams
- 2B2.1 Respected each other teams
- 2B2.3 Had good relationships with key stakeholders

Project team member attributes

- 2D3.4 Project team members had considerable knowledge and experience
- 2D3.6 Project team members had strong relationships with customers
- 2D3.3 Project team members diverse persons
- 2D3.1 Project team members helpful
- 2D3.5 Project team members had exposure to innovation
- 2D3.7 Project team members considered innovation as a day-to-day duty

Internal recognition

- 2C1.2 We recognised idea implementers
- 2C1.1 We recognised idea generators
- 2A2.6 We had implementers to help idea generators
- 2D1.3 PM earned respect

Client organisation

- 2D5.2 Client organisation relaxed technical regulations/ specifications
- 2D5.1 Client organisation supported innovative activities
- 2D5.3 Client organisation had characteristics of an innovative organisation

Designers & contractors

- 2C1.6 Selecting designers and contractors - used innovation history
- 2C1.5 Selecting designers and contractors - used innovative proposals
- 2C1.7 Selecting designers and contractors - used innovation performance

Incentivisation

- 2C1.4 Rewarded with personal incentives
- 2C1.3 Rewarded with financial incentives
- 2C1.9 Selected contract types such as alliances
- 2C1.8 Included contract clauses to share savings

The Fig 6.4 shows the relationship between the innovation enabler categories identified though the literature survey (called conceptual grouping) and the factors identified through the factor analysis (called factorial grouping).

These factors can be collapsed further into the following 3 categories:

1. Nature of relationship;
2. Incentivisation (collapsing internal recognition, designers & contractors and incentivisation); and
3. Project team fitness (project team attributes, support to the project team, project team member attributes and client organisation)

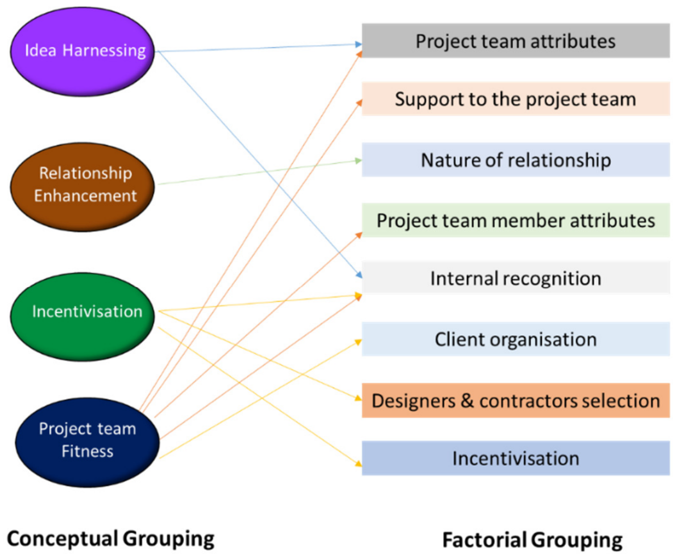


Figure 6.4 Relationship between different categories

With these findings, it is worth revisiting the research questions identified earlier (*Section 2.11.1*). The following were the research questions identified:

RQ1: Is it possible for clients of construction projects to influence promoting innovation in their projects?

RQ2: If this is possible, what actions can construction clients take to promote innovation in their projects?

RQ3: Is it possible to group these actions (also called innovation enablers) into major categories?

RQ4: If possible, what are the enabler categories?

RQ5: What are the relationships of these categories with innovative performance?

RQ6: Do these categories have relationships among themselves?

The Answers for RQ 5 and 6 can be shown as in Figure 6.5.

6.8.2 Dependent variables

Dependent variables coming under innovative performance, initially had 18 variables. These were reduced to 14, under 3 separate factors named project outcomes, project recognition and project usage. The variables that grouped under these factors are given below:

Project outcomes

- 2E2.3 Project outcome: Sustainable outcomes and reduced waste

- 2E2.1 Project outcome: Operational goals
- 2E2.4 Project outcome: Satisfied project team
- 2E2.2 Project outcome: Satisfied customers
- 2E2.5 Project outcome: Increased productivity and competitive advantage
- 2E2.6 Project outcome: Positive organisational and professional learning

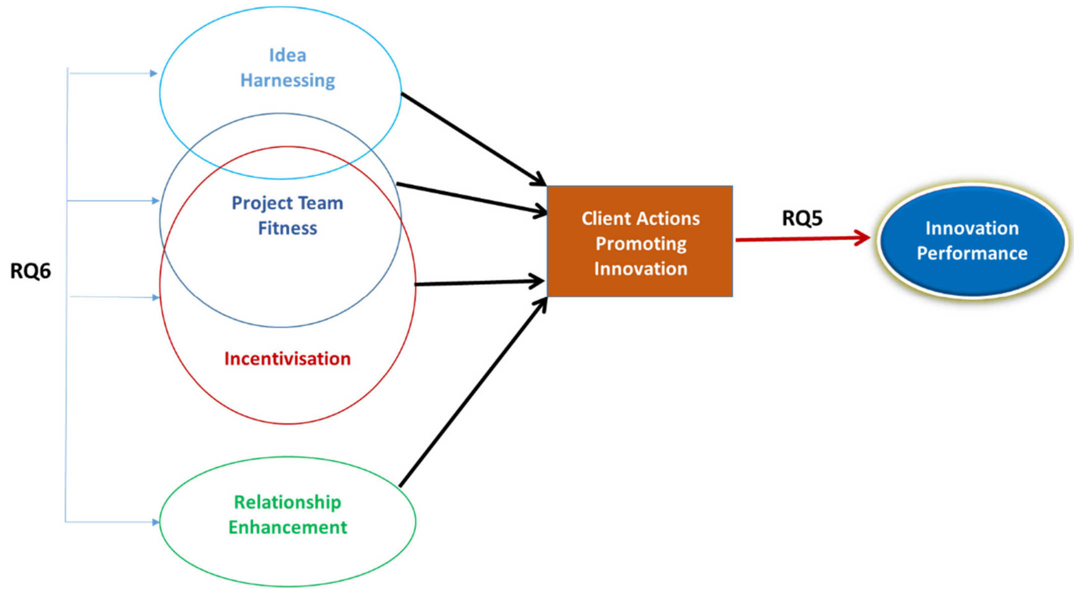


Figure 6.5 Findings of research questions RQ 5&6.

Project recognition

- 2E3.3 Highly commended in the media
- 2E3.1 Project personnel received internal recognition
- 2E3.4 External recognition in professional bodies
- 2E3.2 Project received internal recognition

Project usage

- 2E1.4 We used improved advanced business or procurement techniques, processes and systems
- 2E1.2 We used improved materials, products, plant, and equipment
- 2E1.3 We used improved computer software/ hardware, models and communication systems

- 2E1.1 We used improved technologies, methods and practices

In the next chapter, factors under independent variables will be analysed to find out whether they have any relationships: (a) with innovation promotion and (b) between themselves.

CHAPTER 7
CORRELATION ANALYSIS

7.1 Chapter overview

The literature review undertaken in *Chapter 3* has identified a number of innovation enablers which were grouped into the following: idea harnessing, relationship enhancement, incentivisation and project team fitness. These were further analysed and regrouped in *Chapter 6* using the factor analysis, for reducing the large number of variables to fewer unobserved factors. Now it is necessary to find out whether the eight different groupings found after the factor analysis (namely; project team attributes, support to the project team, nature of relationship, project team member attributes, internal recognition, client organisation characteristics, designers & contractors selection and Incentivisation) have any relationships: (a) with innovation promotion and (b) between themselves.

This chapter explains the analysis undertaken to find out the association/s (if any) between these variables, both independent and dependent variables. The type of association would determine the future direction for further analysis.

First, it is necessary to understand about investigating associations between variables.

7.2 Investigating associations between variables

The type of association can be investigated through visual techniques or through analytical techniques. They are discussed below.

7.2.1 Visual techniques

As noted by Asuero et al. (2006) the mandatory first step in all data analysis is to make a plot of the data in the most illustrative way possible. Scatter diagram is a popular visual technique which can be used to detect associations between different variables. They explained scatter diagrams as a two dimensional representation of n pairs of measurements (x_i, y_i) made on two random variables x and y. Such plots are particularly useful tools in exploratory analysis conveying information about the association between x and y, the dependence of y on x where y is a response variable, the clustering of the points, the presence of outliers, etc. A scatter plot matrix can be a better summary of the data than a correlation matrix, since the latter gives only a single number summary of the linear relationship between variables, while each scatterplot gives a visual summary of linearity, non linearity, and separated points (Asuero et al. 2006).

7.2.2 Analytical techniques

Although scatter plots are more informative than analytical tables when analysing correlation, they also have some disadvantages. Two scatterplots with the same statistical information can appear different because our ability to process and recognise patterns depends on how the data are displayed (Asuero et al. 2006). Therefore, analytical techniques are necessary when analysing association between variables.

As Field (2013) explained, covariance is a good measurement to assess whether two variables are related to each other or not. A positive covariance indicates that as one variable deviates from the mean, the other variable deviates in the same direction. On the other hand, a negative covariance indicates that as one variable deviates from the mean, the other variable deviates in the opposite direction.

Sample covariance is given by the equation 7.1.

$$COV(x,y) = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{n-1} \qquad \text{........ 7.1}$$

Where,

x = the independent variable,

y = the dependent variable,

n = number of data points in the sample,

$\bar{x}$ = the mean of the independent variable x, and

$\bar{y}$ = the mean of the dependent variable y

(Field 2013).

Associations between variables are analysed using correlation which is based on covariance. Correlation is explained below.

7.2.3 Correlation

In statistical terms, correlation is a method of assessing a possible two-way linear association between two continuous variables. Correlation is measured by the correlation coefficient which represents the strength of the putative linear association between the variables in question. It is a dimensionless quantity that takes a value in the range -1 to +1. A correlation coefficient of zero indicates that no linear relationship exists between two continuous variables, and a correlation coefficient of -1 or +1 indicates a perfect linear relationship (Mukaka 2012).

The Standardised covariance is known as correlation coefficient. The sample correlation coefficient (r) is defined as

$$r = Cov_{xy}/s_x s_y$$

Where s_x and s_y are sample standard deviations of x and y respectively (Field 2013).

When discussing correlation, it is also important to discuss partial correlation as well.

Partial correlation

As explained by Wikipedia. (2018), if we are interested in finding whether or to what extent there is a numerical relationship between two variables of interest, using their correlation coefficient will give misleading results if there is another, confounding, variable that is numerically related to both variables of interest. This misleading information can be avoided by controlling for the confounding variable which is done by computing the partial correlation coefficient (Wikipedia. 2018). Partial correlation is the correlation of one variable with another, controlling for a third or additional variables (Asuero et al. 2006).

In probability theory and statistics, partial correlation measures the degree of association between two random variables, with the effect of a set of controlling random variables removed. In this study, both correlation and partial correlation analysis were done.

Correlation analysis

There are different correlation coefficients to handle the special characteristics of variables. Most popular correlation coefficients are the Pearson's correlation coefficient, the Spearman's rank correlation coefficient and the Kendall's tau correlation coefficient (Chok 2010). Pearson's is calculated if the two variables are continuous and at least one is distributed normally. Spearman's rank correlation coefficient would be calculated if neither variable was distributed normally or if one of the variables was discrete. Spearman's rank correlation coefficient is a non-parametric equivalent to Pearson's correlation coefficient. It has similar properties to Pearson's correlation coefficient. In addition to above, Kendall's tau is also popular among researchers to investigate measures of monotone association (Sedgwick 2012). As the data were not normally distributed, the Pearson's correlation coefficient was not used in the analysis. Instead, the Spearman's rank correlation coefficient and the Kendall's tau were used. These coefficients are explained below.

7.2.4 Spearman's rank correlation coefficient

The Spearman's rank correlation coefficient is a non-parametric measure of correlation between variable which assess how well an arbitrary monotonic function can describe the relationship between two variables, without making any assumptions about the frequency distribution of the variables. Frequently the Greek letter ρ (rho) is used to abbreviate the Spearman correlation coefficient (Bolboaca & Jäntschi 2006).

For a correlation between variables x and y, the formula for calculating the sample Spearman's correlation coefficient is given by Equation 7.2.

$$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)} \qquad \text{..... 7.2}$$

where d_i is the difference in ranks for x and y and n is the number of observations (Mukaka 2012).

For the Spearman test to work, the underlying relationship must be monotonic: that is, either the variables increase in value together, or one decreases when the other increases.

The proximity of Spearman's to Pearson's correlation coefficient in bivariate normal data, and the appropriateness of Spearman's statistical test for any type of interval data makes Spearman's correlation coefficient overall more preferable (Chok 2010).

7.2.5 Kendall's tau

Kendall-tau is another non-parametric correlation coefficient that can be used to assess and test correlations between non-interval scaled ordinal variables. It is considered to be equivalent to the Spearman rank correlation coefficient (Bolboaca & Jäntschi 2006).

Kendall's tau correlation coefficient is designed to capture the association between two ordinal (not necessarily interval) variables. Its estimate (denoted τ) can be expressed as follows for any two pairs of ranks (x_i, y_i) and (x_j, y_j) with n number of observations:

$$\tau = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} sgn(x_i - x_j) sgn(y_i - y_j)}{n(n-1)} \qquad \text{.....7.3}$$

Where,

$$sgn(x_i - x_j) = \begin{cases} 1 & if\ (x_i - x_j) > 0 \\ 0 & if\ (x_i - x_j) = 0 \\ -1 & if\ (x_i - x_j) < 0 \end{cases}; \quad sgn(y_i - y_j) \begin{cases} 1 & if\ (y_i - y_j) > 0 \\ 0 & if\ (y_i - y_j) = 0 \\ -1 & if\ (y_i - y_j) < 0 \end{cases}$$

(Chok 2010).

According to Field (2013), Kendall's tau is preferred over Spearman's correlation coefficient, for smaller data sets with a large number of tied ranks. Compared to Pearson's correlation coefficient and the Spearman's correlation coefficient, Kendall's tau is even less sensitive to outliers and is often preferred due to its simplicity and ease of interpretation (Chok 2010).

7.2.6 Calculating correlation coefficients

The correlation coefficients calculated using the sample data is an estimate of the population correlation coefficients. Researchers are interested in the values of actual population correlation coefficients. So statistical tests need to be done to ascertain whether the actual population correlations have specific values of interest based on the sample correlation coefficients.

The null hypothesis vs. the alternative hypothesis for any correlation coefficients are:

H_0: Population correlation coefficient = 0

Alternative hypothesis

H_1: Population correlation coefficient < > 0

(Bolboaca & Jäntschi 2006).

Statistical significance of the correlation coefficient was tested using the Z-test, at a significance level of 5% as explained by Bolboaca and Jäntschi (2006).

7.2.7 Interpretation of results

When interpreting the values of Spearman's correlation coefficient and Kendall's tau obtained in the analysis, the approach taken by Kumar et al. (2018) was adopted. In their research in medical area using the Spearman's correlation coefficient (r), they adopted the convention as given in *Table 7.1.*

Table 7.1 Spearman's Correlation Coefficient Classification

Degree of association	Value of 'r'
Strong	1- 0.7
Moderate	0.7- 0.5
Low	0.7- 0.3

Prior to deriving correlation coefficients, the nature of the underlying relationships, whether monotonic or not, were determined with visual observation using Scatter Plots. It was found that the data were monotonic.

7.2.8 Facts about correlation coefficients

With regard to correlation coefficients, Asuero et al. (2006) noted the following:

- If two random variables x and y are statistically independent, their correlation coefficient is zero. However, the converse is not true; i.e., the correlation coefficient zero does not necessarily imply that x and y are statistically independent.
- A positive correlation simply means that y is believed to increase when x increases. However, it must not be considered necessarily to indicate a causal relationship. There must be something that causes both to change. One should be keenly aware of the common occurrence of spurious correlations due to indirect causes or remote mechanisms.

7.2.9 Preparation of data for the analysis

In this research, both the independent and dependent variables were identified through the factor analysis, the details of which were given in the previous chapter (*Chapter 6*).

Tables 7.2 and 7.3 show the independent and dependent variables derived through the factor analysis (named factors) and the variables under each factor. To undertake the correlation analysis, it is necessary to convert these variables under each factor to one single variable.

This was done by replacing the groups of variables under each factor with their average values.

Table 7.2 Independent variables grouped after factor analysis

Factor Name	Variables under factors
Project team attributes	2D4.2 Felt free to talk
	2D4.1 All were treated equally
	2D4.4 No difficulty in forming teams
	2D4.3 Ideas became team ideas
	2D1.4 PM made quick decisions
	2D1.5 PM protected the team
	2D3.2 Project team members motivated
	2D4.5 No blame game
	2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes
	2A2.1 We used inputs from experienced personnel
	2A2.4 We captured project learnings
	2A2.3 We followed new research
Support to the project team	2D2.1 Project team was provided with training to improve team skills
	2D2.2 Project team was provided with training to improve knowledge
	2D2.4 Project team had opportunities to be exposed to best national and international practices
	2D2.3 Project team had opportunities to be exposed to others
	2D2.5 Project team was provided with training to implementers
Nature of relationship	2B2.2 Had conducive culture within teams
	2B2.4 Had excellent relationships with other teams
	2B2.1 Respected each other teams
	2B2.3 Had good relationships with key stakeholders
Project team member attributes	2D3.4 Project team members had considerable knowledge and experience
	2D3.6 Project team members had strong relationships with customers
	2D3.3 Project team members diverse persons
	2D3.1 Project team members helpful
	2D3.5 Project team members had exposure to innovation
	2D3.7 Project team members considered innovation as a day-to-day duty
Internal recognition	2C1.2 We recognised idea implementers
	2C1.1 We recognised idea generators
	2A2.6 We had implementers to help idea generators
	2D1.3 PM earned respect

Client organisation	2D5.2 Client organisation relaxed technical regulations/ specifications 2D5.1 Client organisation supported innovative activities 2D5.3 Client organisation had characteristics of an innovative organisation
Designers & contractors selection	2C1.6 Selecting designers and contractors - used innovation history 2C1.5 Selecting designers and contractors - used innovative proposals 2C1.7 Selecting designers and contractors - used innovation performance
Incentivisation	2C1.4 Rewarded with personal incentives 2C1.3 Rewarded with financial incentives 2C1.9 Selected contract types such as alliances 2C1.8 Included contract clauses to share savings

Table 7.3 Dependent variables grouped after factor analysis

Factor Name	Variables under factors
Project outcomes	2E2.3 Project outcome: Sustainable outcomes and reduced waste 2E2.1 Project outcome: Operational goals 2E2.4 Project outcome: Satisfied project team 2E2.2 Project outcome: Satisfied customers 2E2.5 Project outcome: Increased productivity and competitive advantage 2E2.6 Project outcome: Positive organisational and professional learning
Project recognition	2E3.3 Highly commended in the media 2E3.1 Project personnel received internal recognition 2E3.4 External recognition in professional bodies 2E3.2 Project received internal recognition
Project usage	2E1.4 We used improved advanced business or procurement techniques, processes and systems 2E1.2 We used improved materials, products, plant, and equipment 2E1.3 We used improved computer software/ hardware, models and communication systems 2E1.1 We used improved technologies, methods and practices

The purpose of the correlation analysis is to find associations of innovation enablers with innovation performance. Innovation enablers here are: project team attributes, support to the project team, nature of relationship, project team member attributes, internal recognition, client organisation, designers & contractors selection and incentivisation. As the innovation performance had three variables, i.e. project outcomes, project recognition and project usage, they were turned into one variable by replacing with the average values.

7.2.10 Checking the relationships between variables

Table 7.4 shows the names given to each factor (now they have become single variables) when analysing with SPSS as it is required to rename the variables as per the requirements of this software package.

Table 7.4 Assigned names for SPSS analysis

Variable Name	**Assigned name in SPSS**
Project team attributes	IPTAttributes1
Support to the project team	IPTASupport2
Nature of relationship	INRelat3
Project team member attributes	IMAttributes4
Internal recognition	I_IntRecog5
Client organisation	IClientOrg6
Designers & contractors selection	ID_C7
Incentivisation	I_Incen8
Innovation performance	InnPerformance

In addition to calculating correlation coefficients, SPSS also has the facility to use bootstrap to estimate confidence intervals which was used in this analysis. As explained by Haukoos and Lewis (2005), bootstrap is a computationally intensive statistical technique that allows to estimate confidence intervals for statistics that do not have simple sampling distributions.

Both the Spearman's and Kendall’s Correlation Tests were used to find correlation. One of the requirements for using these tests is that the underlying relationship should be monotonic which was checked through observation of scatter plots. This was done systematically taking each factor (i.e. variable) and checking against another using scatter plots. Due to space restrictions, the scatter plots for all cases are not given here. All the scatter plots showed a linear relationship between each pair of variables, thus confirming the monotonic relationship which is a prerequisite for the correlation analysis. Only one scatter plot, which is indicative of others, is shown in Fig 7.1.

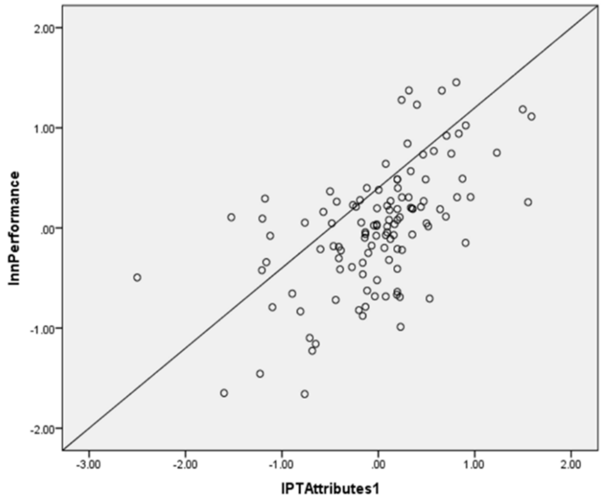


Figure 7.1 Scatter Plot Project team attributes Vs Innovation performance

7.3 Correlation Analysis results

The results are given below for the following tests: Spearman’s Correlation Test and Kendall's Correlation Test.

7.3.1 Spearman’s Correlation Test results

The results of the Spearman’s Correlation Test are given in *Table 7.5.* The significance levels are highlighted for easy reference.

Table 7.6 is a summarised version of *Table 7.5,* where only the correlation coefficients are given. The strengths of correlation coefficients are highlighted with different colours as per the classification mentioned in *Table 7.1*.

Correlation analysis using the Spearman's Correlation Test revealed the following:

1. The significance (p) value of all the correlation coefficients were <0.05, rejecting the null hypothesis that there is no association between the variables in the underlying population. This means that all the variables are correlated to each other.
2. All the correlation coefficients were positive indicating a positive association between variables.
3. All Bootstrap 5% upper and lower confidence levels were positive, indicating further that the associations are in the positive territory.

4. Most coefficients can be considered as low (up to 0.5), but there were a few with moderate values (between 0.5 and 0.7).

7.3.2 Kendall's Correlation Test results

Kendall's Correlation Test results are given in *Tables 7.7 and 7.8.* The same highlighting process used for the Spearman's test results was used in these tables. The tables revealed results similar to the Spearman's test.

Kendall's Correlation Test results showed the following:

1. The significance (p) value of all the correlation coefficients were <0.05, rejecting the null hypothesis that there is no association between the variables in the underlying population. This means that all the variables are correlated to each other.
2. All the correlation coefficients were positive indicating a positive association between variables.
3. All Bootstrap 95% upper and lower confidence levels were positive, indicating further that the associations are in the positive territory.

One notable difference between Spearman's and Kendall's test results was that the correlation coefficients produced in Kendall's test were low in value, none exceeding 0.5.

7.3.3 Partial correlation

Partial correlation was analysed using the Spearman's Correlation Coefficient. As the SPSS software has no readily available procedure to do partial correlation for nonparametric data, the analysis was done by coding script into the SPSS Syntax Editor. The first procedure was carried out to find the association between project team attributes and innovation performance while controlling all other variables (namely; support to the project team, nature of relationship, project team member attributes, internal recognition, client organisation, designers & contractors selection and incentivisation). The results are shown in *Table 7.9.*

Table 7.5 Spearman's Correlation Test results

				IPTAttributes1	IPTASupport2	INRelat3	IMAttributes4	I_IntRecog5	IClientOrg6	ID_C7	I_Incen8	InnPerformance
IPTAttributes1	Correlation Coefficient			1.000	.335**	.467**	.513**	.495**	.425**	.437**	.322**	.593**
	Sig. (2-tailed)				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap	Bias		0.000	-0.003	-0.001	-0.001	-0.005	-0.002	-0.003	-0.001	-0.005
		Std. Error		0.000	0.091	0.087	0.084	0.079	0.084	0.087	0.088	0.067
		95% Confi	Lower	1.000	0.140	0.291	0.342	0.323	0.246	0.245	0.142	0.448
			Upper	1.000	0.504	0.624	0.665	0.637	0.578	0.588	0.485	0.707
IPTASupport2	Correlation Coefficient			.335**	1.000	.244**	.292**	.423**	.391**	.363**	.489**	.359**
	Sig. (2-tailed)			0.000		0.009	0.002	0.000	0.000	0.000	0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap	Bias		-0.003	0.000	0.000	0.003	-0.008	-0.003	-0.004	-0.002	-0.003
		Std. Error		0.091	0.000	0.098	0.090	0.083	0.088	0.083	0.079	0.091
		95% Confi	Lower	0.140	1.000	0.041	0.110	0.246	0.214	0.199	0.323	0.178
			Upper	0.504	1.000	0.431	0.472	0.569	0.544	0.525	0.630	0.529
INRelat3	Correlation Coefficient			.467**	.244**	1.000	.348**	.386**	.333**	.320**	.198*	.324**
	Sig. (2-tailed)			0.000	0.009		0.000	0.000	0.000	0.000	0.034	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap	Bias		-0.001	0.000	0.000	-0.004	-0.001	-0.001	-0.002	0.002	-0.003
		Std. Error		0.087	0.098	0.000	0.089	0.090	0.097	0.090	0.092	0.088
		95% Confi	Lower	0.291	0.041	1.000	0.159	0.206	0.134	0.142	0.007	0.151
			Upper	0.624	0.431	1.000	0.510	0.555	0.509	0.494	0.375	0.485
IMAttributes4	Correlation Coefficient			.513**	.292**	.348**	1.000	.356**	.446**	.385**	.361**	.529**
	Sig. (2-tailed)			0.000	0.002	0.000		0.000	0.000	0.000	0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap	Bias		-0.001	0.003	-0.004	0.000	-0.001	0.003	-0.003	0.000	-0.003
		Std. Error		0.084	0.090	0.089	0.000	0.088	0.084	0.086	0.083	0.075
		95% Confi	Lower	0.342	0.110	0.159	1.000	0.181	0.281	0.196	0.185	0.366
			Upper	0.665	0.472	0.510	1.000	0.515	0.620	0.543	0.512	0.666
I_IntRecog5	Correlation Coefficient			.495**	.423**	.386**	.356**	1.000	.475**	.442**	.418**	.410**
	Sig. (2-tailed)			0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap	Bias		-0.005	-0.008	-0.001	-0.001	0.000	-0.002	-0.007	-0.005	-0.007
		Std. Error		0.079	0.083	0.090	0.088	0.000	0.074	0.085	0.084	0.088
		95% Confi	Lower	0.323	0.246	0.206	0.181	1.000	0.322	0.254	0.236	0.224
			Upper	0.637	0.569	0.555	0.515	1.000	0.608	0.596	0.566	0.559
IClientOrg6	Correlation Coefficient			.425**	.391**	.333**	.446**	.475**	1.000	.478**	.501**	.527**
	Sig. (2-tailed)			0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap	Bias		-0.002	-0.003	-0.001	0.003	-0.002	0.000	-0.005	-0.003	-0.006
		Std. Error		0.084	0.088	0.097	0.084	0.074	0.000	0.074	0.077	0.070
		95% Confi	Lower	0.246	0.214	0.134	0.281	0.322	1.000	0.329	0.328	0.369
			Upper	0.578	0.544	0.509	0.620	0.608	1.000	0.611	0.645	0.647
ID_C7	Correlation Coefficient			.437**	.363**	.320**	.385**	.442**	.478**	1.000	.462**	.461**
	Sig. (2-tailed)			0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap	Bias		-0.003	-0.004	-0.002	-0.003	-0.007	-0.005	0.000	-0.007	-0.005
		Std. Error		0.087	0.083	0.090	0.086	0.085	0.074	0.000	0.079	0.082
		95% Confi	Lower	0.245	0.199	0.142	0.196	0.254	0.329	1.000	0.288	0.296
			Upper	0.588	0.525	0.494	0.543	0.596	0.611	1.000	0.595	0.604
I_Incen8	Correlation Coefficient			.322**	.489**	.198*	.361**	.418**	.501**	.462**	1.000	.429**
	Sig. (2-tailed)			0.000	0.000	0.034	0.000	0.000	0.000	0.000		0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap	Bias		-0.001	-0.002	0.002	0.000	-0.005	-0.003	-0.007	0.000	-0.005
		Std. Error		0.088	0.079	0.092	0.083	0.084	0.077	0.079	0.000	0.090
		95% Confi	Lower	0.142	0.323	0.007	0.185	0.236	0.328	0.288	1.000	0.231
			Upper	0.485	0.630	0.375	0.512	0.566	0.645	0.595	1.000	0.587
InnPerformanc	Correlation Coefficient			.593**	.359**	.324**	.529**	.410**	.527**	.461**	.429**	1.000
	Sig. (2-tailed)			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	N			115	115	115	115	115	115	115	115	115
	Bootstrap	Bias		-0.005	-0.003	-0.003	-0.003	-0.007	-0.006	-0.005	-0.005	0.000
		Std. Error		0.067	0.091	0.088	0.075	0.088	0.070	0.082	0.090	0.000
		95% Confi	Lower	0.448	0.178	0.151	0.366	0.224	0.369	0.296	0.231	1.000
			Upper	0.707	0.529	0.485	0.666	0.559	0.647	0.604	0.587	1.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 7.6 Strengths of Spearman's Correlation Coefficients

	IPTAttributes1	IPTASupport2	INRelat3	IMAttributes4	I_IntRecog5	IClientOrg6	ID_C7	I_Incen8	InnPerformance
IPTAttributes1	1.000	.335**	.467**	.513**	.495**	.425**	.437**	.322**	.593**
IPTASupport2	.335**	1.000	.244**	.292**	.423**	.391**	.363**	.489**	.359**
INRelat3	.467**	.244**	1.000	.348**	.386**	.333**	.320**	.198*	.324**
IMAttributes4	.513**	.292**	.348**	1.000	.356**	.446**	.385**	.361**	.529**
I_IntRecog5	.495**	.423**	.386**	.356**	1.000	.475**	.442**	.418**	.410**
IClientOrg6	.425**	.391**	.333**	.446**	.475**	1.000	.478**	.501**	.527**
ID_C7	.437**	.363**	.320**	.385**	.442**	.478**	1.000	.462**	.461**
I_Incen8	.322**	.489**	.198*	.361**	.418**	.501**	.462**	1.000	.429**
InnPerformance	.593**	.359**	.324**	.529**	.410**	.527**	.461**	.429**	1.000

Correlation Coefficient (r) strength	
(red)	strong (r between 1 and 0.7)
(peach)	moderate (r between 0.7 and 0.5)
(blue)	low (r between 0.5 and 0.3)
(grey)	very low (r up to 0.3)

This procedure was repeated with all variables and the summarised results are shown in *Table 7.10*. The significance levels >0.05 are highlighted.

The results of the partial correlation analysis revealed the following:

- Only project team attributes, project team member attributes and client organisation characteristics showed significant partial correlations with Innovation performance.
- The project team attributes variable showed the strongest association (correlation coefficient of 0.335).
- The associations of project team member attributes and client organisation characteristics were somewhat similar (correlation coefficients of 0.217 and 0.210 respectively).
- All significant associations were positive.

7.4 Discussion on chapter findings

In this chapter, the data were analysed using correlation. As stated by Mukaka (2012), relationships identified using correlation coefficients should be interpreted for what they are: associations, not causal relationships.

Correlation analysis was carried out using both Spearman's and Kendall's tests. Both tests gave similar results. However, the correlation coefficients produced in Kendall's test were low in value, none exceeding 0.5.

Table 7.7 Kendall's Correlation Test results

				IPTAttributes1	IPTASupport2	INRelat3	IMAttributes4	I_IntRecog5	IClientOrg6	ID_C7	I_Incen8	InnPerformance
IPTAttributes1	Correlation Coefficient			1.000	.239**	.352**	.385**	.356**	.310**	.316**	.223**	.421**
	Sig. (2-tailed)				0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap[c]	Bias		0.000	-0.001	0.001	0.002	-0.002	0.001	0.000	0.001	-0.001
		Std. Error		0.000	0.065	0.070	0.067	0.061	0.064	0.067	0.063	0.055
		95% Confidence Interval	Lower	1.000	0.108	0.215	0.254	0.230	0.176	0.175	0.098	0.309
			Upper	1.000	0.366	0.486	0.512	0.470	0.431	0.439	0.341	0.524
IPTASupport2	Correlation Coefficient			.239**	1.000	.184**	.210**	.304**	.292**	.258**	.354**	.251**
	Sig. (2-tailed)			0.000		0.006	0.001	0.000	0.000	0.000	0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap[c]	Bias		-0.001	0.000	0.001	0.003	-0.004	-0.001	-0.001	0.001	-0.001
		Std. Error		0.065	0.000	0.073	0.064	0.062	0.068	0.062	0.061	0.066
		95% Confidence Interval	Lower	0.108	1.000	0.032	0.080	0.176	0.158	0.134	0.232	0.119
			Upper	0.366	1.000	0.329	0.344	0.416	0.420	0.383	0.469	0.379
INRelat3	Correlation Coefficient			.352**	.184**	1.000	.264**	.295**	.251**	.247**	.148*	.234**
	Sig. (2-tailed)			0.000	0.006		0.000	0.000	0.000	0.000	0.029	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap[c]	Bias		0.001	0.001	0.000	-0.002	0.001	0.000	0.000	0.003	-0.001
		Std. Error		0.070	0.073	0.000	0.070	0.071	0.078	0.070	0.069	0.065
		95% Confidence Interval	Lower	0.215	0.032	1.000	0.120	0.152	0.093	0.112	0.007	0.107
			Upper	0.486	0.329	1.000	0.394	0.431	0.397	0.385	0.281	0.357
IMAttributes4	Correlation Coefficient			.385**	.210**	.264**	1.000	.266**	.342**	.279**	.259**	.384**
	Sig. (2-tailed)			0.000	0.001	0.000		0.000	0.000	0.000	0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap[c]	Bias		0.002	0.003	-0.002	0.000	0.001	0.004	-0.001	0.001	0.000
		Std. Error		0.067	0.064	0.070	0.000	0.066	0.066	0.065	0.063	0.059
		95% Confidence Interval	Lower	0.254	0.080	0.120	1.000	0.137	0.217	0.141	0.129	0.266
			Upper	0.512	0.344	0.394	1.000	0.394	0.480	0.399	0.377	0.495
I_IntRecog5	Correlation Coefficient			.356**	.304**	.295**	.266**	1.000	.352**	.326**	.309**	.296**
	Sig. (2-tailed)			0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap[c]	Bias		-0.002	-0.004	0.001	0.001	0.000	0.001	-0.003	-0.002	-0.003
		Std. Error		0.061	0.062	0.071	0.066	0.000	0.058	0.067	0.064	0.067
		95% Confidence Interval	Lower	0.230	0.176	0.152	0.137	1.000	0.237	0.184	0.179	0.158
			Upper	0.470	0.416	0.431	0.394	1.000	0.463	0.453	0.425	0.417
IClientOrg6	Correlation Coefficient			.310**	.292**	.251**	.342**	.352**	1.000	.356**	.364**	.383**
	Sig. (2-tailed)			0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap[c]	Bias		0.001	-0.001	0.000	0.004	0.001	0.000	-0.001	0.000	-0.002
		Std. Error		0.064	0.068	0.078	0.066	0.058	0.000	0.058	0.061	0.054
		95% Confidence Interval	Lower	0.176	0.158	0.093	0.217	0.237	1.000	0.243	0.234	0.265
			Upper	0.431	0.420	0.397	0.480	0.463	1.000	0.466	0.479	0.482
ID_C7	Correlation Coefficient			.316**	.258**	.247**	.279**	.326**	.356**	1.000	.337**	.336**
	Sig. (2-tailed)			0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap[c]	Bias		0.000	-0.001	0.000	-0.001	-0.003	-0.001	0.000	-0.002	-0.001
		Std. Error		0.067	0.062	0.070	0.065	0.067	0.058	0.000	0.062	0.063
		95% Confidence Interval	Lower	0.175	0.134	0.112	0.141	0.184	0.243	1.000	0.208	0.211
			Upper	0.439	0.383	0.385	0.399	0.453	0.466	1.000	0.447	0.449
I_Incen8	Correlation Coefficient			.223**	.354**	.148*	.259**	.309**	.364**	.337**	1.000	.308**
	Sig. (2-tailed)			0.001	0.000	0.029	0.000	0.000	0.000	0.000		0.000
	N			115	115	115	115	115	115	115	115	115
	Bootstrap[c]	Bias		0.001	0.001	0.003	0.001	-0.002	0.000	-0.002	0.000	-0.002
		Std. Error		0.063	0.061	0.069	0.063	0.064	0.061	0.062	0.000	0.067
		95% Confidence Interval	Lower	0.098	0.232	0.007	0.129	0.179	0.234	0.208	1.000	0.160
			Upper	0.341	0.469	0.281	0.377	0.425	0.479	0.447	1.000	0.429
InnPerformance	Correlation Coefficient			.421**	.251**	.234**	.384**	.296**	.383**	.336**	.308**	1.000
	Sig. (2-tailed)			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	N			115	115	115	115	115	115	115	115	115
	Bootstrap[c]	Bias		-0.001	-0.001	-0.001	0.000	-0.003	-0.002	-0.001	-0.002	0.000
		Std. Error		0.055	0.066	0.065	0.059	0.067	0.054	0.063	0.067	0.000
		95% Confidence Interval	Lower	0.309	0.119	0.107	0.266	0.158	0.265	0.211	0.160	1.000
			Upper	0.524	0.379	0.357	0.495	0.417	0.482	0.449	0.429	1.000

Table 7.8 Strengths of Kendall's Correlation Coefficients

	IPTAttributes1	IPTASupport2	INRelat3	IMAttributes4	I_IntRecog5	IClientOrg6	ID_C7	I_Incen8	InnPerformance
IPTAttributes1	1.000	.239**	.352**	.385**	.356**	.310**	.316**	.223**	.421**
IPTASupport2	.239**	1.000	.184**	.210**	.304**	.292**	.258**	.354**	.251**
INRelat3	.352**	.184**	1.000	.264**	.295**	.251**	.247**	.148*	.234**
IMAttributes4	.385**	.210**	.264**	1.000	.266**	.342**	.279**	.259**	.384**
I_IntRecog5	.356**	.304**	.295**	.266**	1.000	.352**	.326**	.309**	.296**
IClientOrg6	.310**	.292**	.251**	.342**	.352**	1.000	.356**	.364**	.383**
ID_C7	.316**	.258**	.247**	.279**	.326**	.356**	1.000	.337**	.336**
I_Incen8	.223**	.354**	.148*	.259**	.309**	.364**	.337**	1.000	.308**
InnPerformance	.421**	.251**	.234**	.384**	.296**	.383**	.336**	.308**	1.000

Correlation Coefficient (r) strength

(red)	strong (r between 1 and 0.7)
(light orange)	moderate (r between 0.7 and 0.5)
(light blue)	low (r between 0.5 and 0.3)
(grey)	very low (r up to 0.3)

Table 7.9 Partial correlation test results for project team member attributes and innovation performance

Controlling variables	Testing variables	Test	Testing variables: Project team attributes	Testing variables: Innovation performance
Support to the project team, Nature of relationship, Project team member attributes, Internal recognition, Client organisation, Designers & contractors selection and Incentivisation	Project team attributes	Correlation	1	0.335
		Significance (2-tailed)		0.000
		df	0	106
	Innovation performance	Correlation	0.335	1
		Significance (2-tailed)	0.000	
		df	106	0

Table 7.10 Partial correlations with innovation performance.

Controlling Variables	Testing variable	Test	Testing variable	Innovation Performance
Support to the project team, Nature of relationship, Project team member attributes, Internal recognition, Client organisation, Designers & contractors selection and Incentivisation	Project team attributes	Correlation	1	0.335
		Significance (2-tailed)		0.000
		df	0	106
Project team attributes, Nature of relationship, Project team member attributes, Internal recognition, Client organisation, Designers & contractors selection and Incentivisation	Support to the project team	Correlation	1	0.047
		Significance (2-tailed)		0.626
		df	0	106
Project team attributes, Support to the project team, Project team member attributes, Internal recognition, Client organisation, Designers & contractors selection and Incentivisation	Nature of relationship	Correlation	1	-0.028
		Significance (2-tailed)		0.775
		df	0	106
Project team attributes, Support to the project team, Nature of relationship, Internal recognition, Client organisation, Designers & contractors selection and Incentivisation	Project team member attributes,	Correlation	1	0.217
		Significance (2-tailed)		0.024
		df	0	106
Project team attributes, Support to the project team, Nature of relationship, Project team member attributes, Client organisation, Designers & contractors selection and Incentivisation	Internal recognition	Correlation	1	-0.014
		Significance (2-tailed)		0.886
		df	0	106
Project team attributes, Support to the project team, Nature of relationship, Project team member attributes, Internal recognition, Designers & contractors selection and Incentivisation	Client organisation	Correlation	1	0.210
		Significance (2-tailed)		0.029
		df	0	106
Project team attributes, Support to the project team, Nature of relationship, Project team member attributes, Internal recognition, Client organisation and Incentivisation	Designers & contractors selection	Correlation	1	0.108
		Significance (2-tailed)		0.267
		df	0	106
Project team attributes, Support to the project team, Nature of relationship, Project team member attributes, Internal recognition, Client organisation and Designers & contractors selection	Incentivisation	Correlation	1	0.102
		Significance (2-tailed)		0.292
		df	0	106

The results derived in this chapter are discussed under the following topics: (1)

association between independent variables (or factors) and innovation promotion; (2) independent variable's association with each other: (3) partial correlation results; (4) general discussion.

7.4.1 Association between independent variables and innovation promotion

The conclusions below are based on Spearman's Test results as Kendall's Test is mostly suited for a smaller data set with a large number of tied ranks (Field 2013).

- All the eight independent variables considered in the analysis showed positive associations with innovation performance. In addition, bootstrap analysis showed that they never fell into negative category, even within the 95% confidence level intervals.
- Project team attributes, project team member attributes and client organisation characteristics showed higher associations with innovation performance (all coefficients more than 0.5 in Spearman's test results).
- Even among independent variables, (a) project team attributes and project team member attributes, (b). incentivisation and client organisation characteristics showed higher positive associations (coefficients more than 0.5 in Spearman's test results).

It is to be noted that the correlation analysis showed only the association between the above variables with innovation promotion. However, the scatter plots showed that increased performance of variables result in increased innovative outcomes. Therefore, the associations can be given as a framework as shown in Fig 7.2. This framework was further refined to find more associations between variables.

7.4.2 Association of independent variables with each other

The following independent variables showed significant positive associations (coefficients more than 0.4 in Spearman's test results) with other independent variables:

- Internal recognition and project team attributes.
- Internal recognition and client organisation characteristics.
- Internal recognition and designers & contractors selection.
- Internal recognition and incentivisation.

- Internal recognition and support to the project team.
- Client organisation characteristics and project team attributes.
- Client organisation characteristics and project team member attributes.
- Client organisation characteristics and designers & contractors selection.
- Designers & contractors selection and project team attributes.
- Project team attributes and nature of relationship.

The above showed that the internal recognition and client organisation characteristics were two prominent variables promoting innovation promotion in association with other variables.

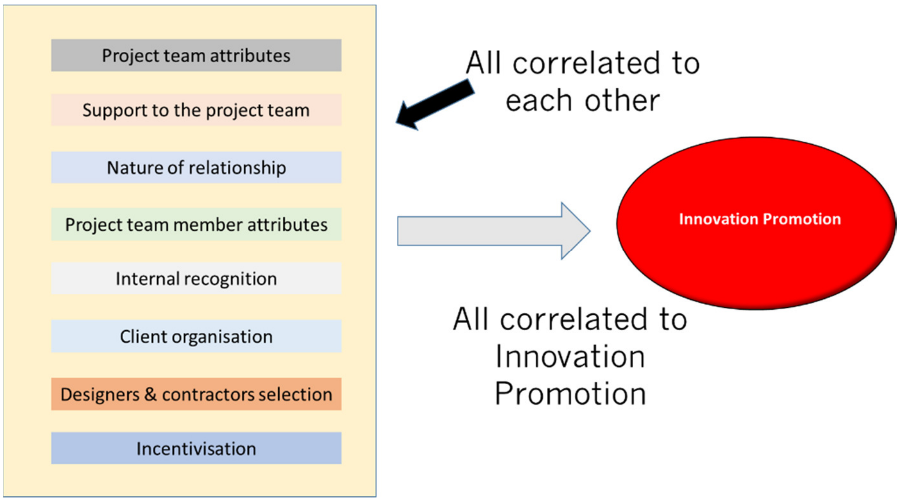


Figure 7.2 Associations between groups of variables

7.4.3 Partial correlation results

The partial correlation analysis revealed that the project team attributes, project team member attributes and client organisation characteristics had positive significant association with innovation performance even without the contribution of other variables.

These results provided a meaningful interpretation of the practical world although a few variables have not come prominently as could be expected. As Myers et al. (2010) pointed out, even if the design of the study is sound, statistical tests may fail to reveal effects that are present in the sampled population if measures are very variable, or if too few data collected.

7.4.4 General discussion

Figure 7.3 provides a broader picture of the results so far which include the results from the conceptual model, factor analysis and correlation analysis.

The conceptual model identified four major groupings (namely; idea harnessing, relationship enhancement, incentivisation and project team fitness). These were converted to eight different groupings after the factor analysis (namely; project team attributes, support to the project team, nature of relationship, project team member attributes, internal recognition, client organisation, designers & contractors selection and incentivisation). They are named in the figure as Factorial Grouping. The different colour arrows between these two groups show their relationships, indicating the link between the conceptual grouping item and the corresponding factorial grouping item. The thin blue arrows between factorial grouping items and the innovation promotion indicate a positive association between them. The items in the factorial grouping connected to innovation promotion with thick red arrows indicate that they are associated to innovation promotion without the contribution of other variables as found though partial correlation analysis. As shown in this figure, the three factors, i.e. project team attributes, project team member attributes and client organisation characteristics can be considered as dominant factors contributing to innovation promotion even without the association of other factors.

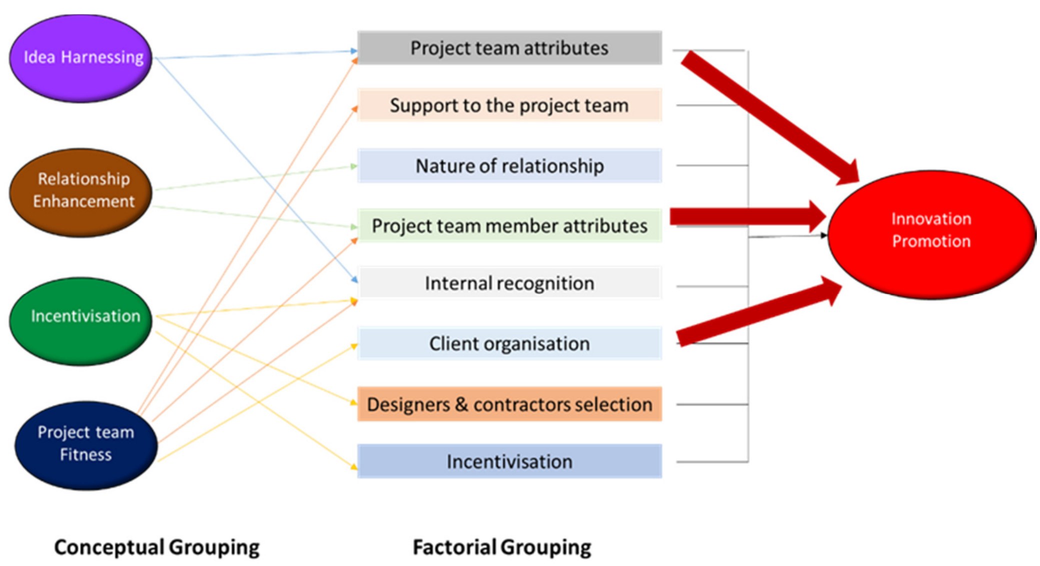


Figure 7.3 Broader picture of associations between groups of variables

It is interesting to note that all three factors, i.e. project team attributes, project team member attributes and client organisation characteristics, are not connected to the conceptual grouping factor of incentivisation. This is an interesting observation. While the conceptual groupings were arrived at using established findings from world-wide research, the factorial grouping was based on the analysis of Australian construction projects. This observation suggests that incentivisation is not given due recognition in Australia. This was found to be true during the comparative analysis (See *Section 5.7*). This finding that Australia's failure to provide adequate incentives for innovation in construction has been highlighted by Stone (2010), who pointed out that the procurement focus in Australia is on delivering the project and there are no incentives to encourage identifying and developing multi project innovations.

The associations shown in *Fig. 7.2* can be given as an Australian-specific model to describe actions that Australian clients can take to promote innovation in their projects. This model is given in *Fig. 7.4.*

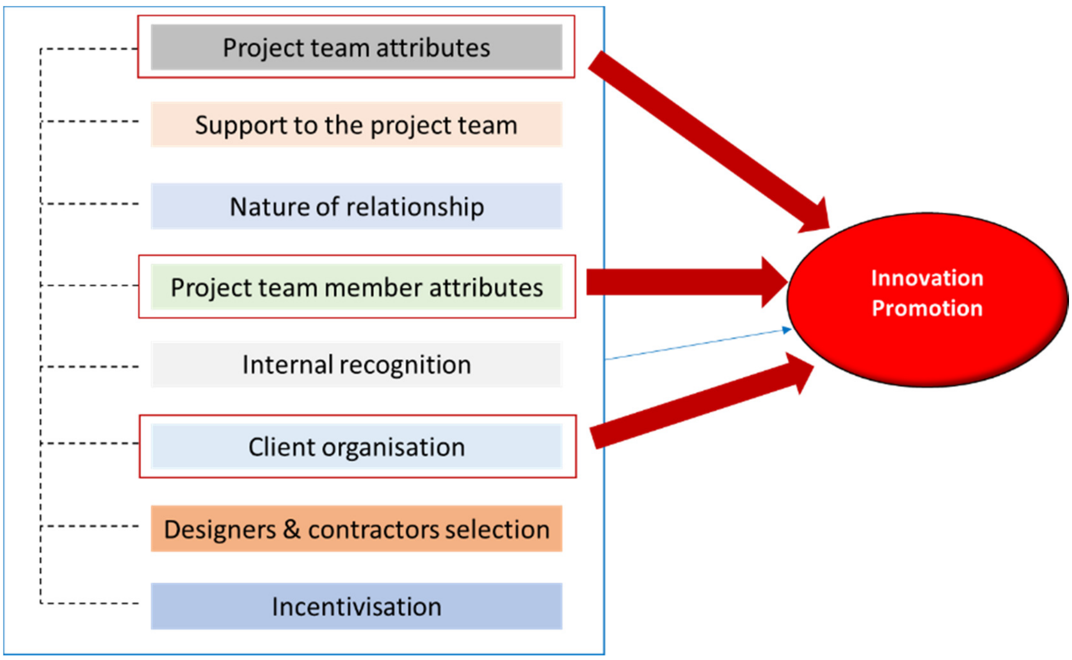


Figure 7.4 Australian-specific model

Due to the correlation between variables, no further statistical analysis was undertaken. For example, regression analysis is not recommended when variables are correlated as the interpretation of and conclusions based on the size of the regression coefficients, their standard errors, or the associated t-tests may be misleading because of the potentially confounding effects of collinearity (Mason &

Perreault Jr 1991). As mentioned in *Section 1.2*, the purpose of the research is to develop a model to assist clients of construction projects to identify actions to promote innovation in their projects. The correlation analysis fulfils this purpose. However, these findings need to be validated.

As found by Asuero et al. (2006), a measure of statistical relationship, such as a correlation coefficient, should never be used to deduce a causal connection and the ideas on causation must come from outside statistics. Therefore, these findings need to be validated using a technique, preferably outside statistics. One of the effective validation techniques is case studies which will be used to confirm the results from the statistical analysis. Validation using the case studies will be covered in the next chapter.

CHAPTER 8
VALIDATION

8.1 Introduction

The preceding chapters provided details of the literature review undertaken, the preliminary data collection and the data analysis. With the research work undertaken for these tasks, it was possible to develop a conceptual model and an Australian-specific model to explain the enablers that clients can implement to promote innovation in construction projects.

Explaining the research process of social science, Bhattacherjee (2012) stated that all scientific research, at its core, is an iterative process of observation, rationalisation, and validation. In the validation phase, we test our theories using a scientific method through a process of data collection and analysis, and in doing so, possibly modify or extend our initial theory (Bhattacherjee 2012). Therefore, validation is required to confirm research findings. The approach used to validate findings of this research is case studies.

This chapter discusses the validation process. The reasons why the case study approach was selected for validating the research and the types of case studies that were used in the research will be discussed first. Next, the discussion will focus on the process of undertaking the case studies including the data collection, the quality criterion used for the study and the case study selection. Details of each case study is given including the performance of innovation enablers as described by the two models, followed by a discussion of results.

Use of case studies as a research technique is discussed first to get a clear understanding about case studies and why they are used for the purpose of validation in this research.

8.2 Case studies as a research technique

As explained by Rowley (2002), a case study is an empirical inquiry that investigates a contemporary phenomena within its real life context, especially when the boundaries between phenomenon and context are not clearly evident. Harrison et al. (2017) added further stating that the fundamental goal of case study research is to conduct an in-depth analysis of an issue, within its context with a view to understand the issue from the perspective of participants. According to Crowe et al. (2011), the central tenet of a case study is the need to explore an event or phenomenon in depth and in its natural context. It is for this reason sometimes referred to as a "naturalistic" design; this is in contrast to an "experimental" design in which the investigator seeks to exert control over and manipulate the variable(s) of interest (Crowe et al. 2011).

Case study research as a strategy for methodological exploration has been around as long as recorded history. Most attribute the origins of case study research to studies undertaken in anthropology and social sciences in the early twentieth century when lengthy, detailed ethnographic studies of individuals and cultures were conducted using this design. It has grown in reputation as an effective methodology to investigate and understand complex issues in real world settings (Harrison et al. 2017).

Schell (1992) considered the case study as unparalleled, as a form of research, for its ability to consider a single or complex research question within an environment rich with contextual variables. According to this researcher, observation, experiments, surveys and secondary information (archival) have the advantage of producing sets of independent and dependent variables suitable for quantitative analysis and the case study is best suited to considering the how and why questions, or when the investigator has little control over events. Case studies usually take selected examples of a social entity as their principal subject within its normal context. At the simplest level, the case study provides descriptive accounts of one or more cases, yet can also be used in an intellectually rigorous manner to achieve experimental isolation of one or more selected social factors within a real-life context (Schell 1992).

In case studies research, the researcher will seek to explore, understand and present the participants' perspectives and get close to them in their natural setting. Interaction between participants and the researcher is required to generate data which is an indication of the researcher's level of connection to and being immersed in the field (Harrison et al. 2017). Therefore, case studies provide the opportunity to look at the innovation process in the actual construction world where innovation happens.

8.2.1 Why select case studies?

Case studies provide a best research validation method for this study due to the following reasons:

- The research is focussed on how clients could promote innovation in construction projects and why some client's actions promote innovation. Case studies is the preferred way of exploring research questions involving 'how' and 'why' or 'who' (Crowe et al. 2011).
- In innovation research, it is difficult to have a practical control of factors and to assess their impact on innovation due to the complex and unique nature of construction projects. As found by Schell (1992), case study approach is preferred when there is no practical form of control of the events or phenomenon and if there is a high likelihood of focus on contemporary events.
- As already mentioned in *Chapter 7* on correlation, Asuero et al. (2006) noted that a measure of statistical relationship, such as a correlation coefficient, should never be used to deduce a causal connection and the ideas on causation must come from the practical world, outside statistics. Case studies give the opportunity to test the findings in a real world situation.
- Another validation technique available is to use a new survey questionnaire and compare results. This was ruled out as finding new survey respondents is difficult and the method is time consuming. The use of case studies is a less time consuming alternative.

8.2.2 Common characteristics of case study research

As explained by Harrison et al. (2017), despite variation in the approaches of the different exponents of case study, there are characteristics common to all of them. Case study research is consistently described as a versatile form of qualitative inquiry most suitable for a comprehensive, holistic, and in-depth investigation of a complex issue (phenomena, event, situation, organisation, program individual or group) in context, where the boundary between the context and issue is unclear and contains many variables. The essential requisite for employing case study stems from one's motivation to illuminate understanding of complex phenomena. Primarily exploratory and explanatory in nature, case study is used to gain an understanding of the issue in real life settings and recommended to answer how and why or less frequently what research questions. Interviews and focus groups, observations, and exploring artifacts are most commonly employed to collect and generate data with triangulation of methods and data, however, this is not exclusive (Harrison et al. 2017).

Case study research relies on theoretical sampling rather than statistical sampling. Under the theoretical sampling, the cases are selected based on a theory rather than based on statistical selection or random selection (Kulatunga et al. 2011).

Harrison et al. (2017) has given a table showing case study elements and descriptors which is shown in *Table 8.1*.

Table 8.1 Case study elements and descriptors (Harrison et al. 2017, p. 12)

Element	Description
The case	Object of the case study identified as the entity of interest or unit of analysis.
	Program, individual, group, social situation, organisation, event, phenomena, or process.
A bounded system	Bounded by time, space, and activity.
	Encompasses a system of connections.
	Bounding applies frames to manage contextual variables.
	Boundaries between the case and context can be blurred.
Studied in context	Studied in its real life setting or natural environment.
	Context is significant to understanding the case.
	Contextual variables include political, economic, social, cultural, historical, and/or organisational factors.
In-depth study	Chosen for intensive analysis of an issue.
	Fieldwork is intrinsic to the process of the inquiry.
	Subjectivity a consistent thread—varies in depth and engagement depending on the philosophical orientation of the research, purpose, and methods.
	Reflexive techniques pivotal to credibility and research

	process.
Selecting the case	Based on the purpose and conditions of the study. Involves decisions about people, settings, events, phenomena, social processes. Scope: single, within case and multiple case sampling. Broad: capture ordinary, unique, varied and/ or accessible aspects. Methods: specified criteria, methodical and purposive; replication logic: theoretical or literal replication.
Multiple sources of evidence	Multiple sources of evidence for comprehensive depth and breadth of inquiry. Methods of data collection: interviews, observations, focus groups, artifact and document review, questionnaires and/ or surveys. Methods of analysis: vary and depend on data collection methods and cases; need to be systematic and rigorous. Triangulation highly valued and commonly employed.
Case study design	Descriptive, exploratory, explanatory, illustrative, evaluative single or multiple cases. Embedded or holistic. Particularistic, heuristic, descriptive. Intrinsic, instrumental, and collective.

8.2.3 Types of case studies

As explained by Crowe et al. (2011), there are three main types of case study: intrinsic, instrumental and collective. An intrinsic case study is typically undertaken to learn about a unique phenomenon. The researcher should define the uniqueness of the phenomenon which distinguishes it from all others. In contrast, the instrumental case study uses a particular case (some of which may be better than others) to gain a broader appreciation of an issue or phenomenon. The collective case study involves studying multiple cases simultaneously or sequentially in an attempt to generate a still broader appreciation of a particular issue.

The information sources for case studies can be either single or multiple. Single

sources of information provides a holistic overview of the phenomena, while multiple sources allow for the use of methodological triangulation (Schell 1992).
According to Rowley (2002), single case studies are appropriate when the case is special (in relation to established theory) for some reason. This might arise when the case provides a critical test to a well-established theory, or where the case is extreme, unique, or has something special to reveal. Single case studies are also used as a preliminary or pilot in multiple case studies. Multiple cases can be regarded as equivalent to multiple experiments. The more cases that can be marshalled to establish or refute a theory, the more robust are the research outcomes (Rowley 2002). Multiple subject cases are especially useful for especially complex cases, or those which involve a large number of actors (Schell 1992).
The collective case study approach with multiple sources will be used in this research. While the use of multiple case studies will improve the robustness of the research, the use of multiple sources will allow for the use of methodological triangulation.

8.2.4 Factors to be considered when designing a case study

In order to achieve satisfactory results, case studies need to be designed carefully. Case studies are prone to methodological pitfalls due to its flexibility and Schell (1992) identified the following factors that need to be taken into account when designing a case study:

- A case study research design is inherently more time consuming at each stage of the study and is likely to be more skill-intensive than other forms of research. Researchers for this type of study are likely to require more training and ability than those controlling other forms of research, a condition demanded by the requisite flexibility of the method.
- Execution of the case study research may lead to practical problems such as:
    - access to information;
    - value imputation by different actors;
    - manipulation by actors; and
    - bias introduced due to inter/ intra-organisational political processes.
- There may be certain difficulties generalising case information to other situations. This is especially true when there are few cases of a critical

phenomenon, and little delineation of the phenomenon by the use of deviant examples.

Having understood to use case studies for research, attention can now be focussed on conducting the case studies.

8.3 Conducting case studies

This section will provide details on how the case studies were conducted including data collection, quality criterion used for the study, case study selection and interview procedure used.

8.3.1 Data collection

Semi-structured interviews have the ability to facilitate an in-depth inquiry into the issues (Kulatunga et al. 2011). Therefore, semi-structured interviews were used as the main method of data collection.

The interview process used in the research followed the approach used by Kulatunga et al. (2011), where the interviews were kept open ended to the maximum possible extent to allow the interviewees to feel free to express their views. The interviews centred on the theme "why those things happened". However, at the same time, care also was taken not to restrict new themes or concepts from emerging. At least two persons were interviewed for each case. This process enabled to understand issues from at least two distinctive perspectives as well as to triangulate findings. All the interview transcripts were audio tape-recorded and manually transcribed.

8.3.2 Quality criterion used for the study

The case study approach used in the research generally followed the quality criterion adopted by Kulatunga et al. (2011). The quality aspects considered, and the actions taken are given in *Table 8.2*.

Table 8.2 Quality aspects and actions taken

Test	Aspect	Action taken
Reliability	Participant error	Case selection from a data rich environment. Selection of correct interviewees by analysing

		the information flow patterns and relationship held with the client's project team.
	Participant bias	Selection of participants from various parties (e.g. project manager, client's team member and contractor) to minimise bias. The same questionnaire used each time. However, interviewees were allowed to talk freely extending into other areas of their choice.
	Observer error	Use of semi-structured interviews to understand perspective from the participant's point of view. Audio recording of interviews.
Construct validity	Multiple sources of evidence	Collection of data from different participants to understand different perspectives. Document reference where relevant.
Internal validity	Pattern matching	Generated conclusions supported by literature where applicable.
	Explanation building	Establishment of link between client's behaviour and the innovation process with the support of the direct quotations from the interviewees.
Descriptive and interpretive validity		Direct quotation from the interviewees used in case description and concept building to ensure accurate description and to ensure transparency of interpretations.
External validity		Undertake cross-case analysis.

Each interview for a case study was based on a pre-prepared questionnaire. *Appendix 4* gives a typical questionnaire for interviewing a member of the client's project team. All the interviews followed the same questions to maintain the integrity of the interview process.

8.3.3 Case study selection

The cases were selected to cover a wide spread of areas such as the following:

- Large and small (cost wise) projects;
- Different delivery types such as traditional, Design & Build, PPP; and
- Different types of clients such as public and private.

Depending on the project, the persons interviewed included the following:

- Project manager of the team representing the client;
- Member/s of the team representing the client;
- Member/s of the contractor's team;
- Member/s of a team assisting the client.

All case studies were from Australia.

The following were the case studies considered:

1. Construction of a large hospital building in Queensland, cost around AUD2 Billion;
2. Major rehabilitation of a bridge in Queensland, cost around AUD30 Million;
3. Construction of a bikeway in Queensland, cost around AUD500,000; and
4. Major intersection upgrade in Queensland, cost around AUD300 Million.

8.3.4 Interview procedure

Generally, an interview took around one hour and held in interviewee's office. Although individual interviews were preferred, group interviews were also held due to the requests of interviewees. Group interviews had the advantage of free flowing ideas - when one person stops, another commenting on the same issue providing more insight into the subject area. As no confidential matters were discussed, group interviews proved beneficial for the research. The only disadvantage of the group interviews was when one of the interviewees was the project manager, the information provided about the project manager by another could be biased. In such a case, individual interviews were preferred to find more information about the role the project manager played in the project.

Prior to commencing interviews, the interviewees were requested to provide information about the project. Some interviewees provided documents such as submissions for excellence awards and project plans which included details of the projects. The information provided on projects were thoroughly studied to have a clear understanding of the project before each interview.

The same questions were asked from each interviewee during interviews to minimise potential bias. The interviewees were allowed to talk freely without interruption. Further questions were asked only when clarifications were needed. When discussing some matters, it could clearly be seen that the interviewee was excited and enthusiastic through body language and voice variation. Such areas were noted.

The following sections provide information on each case study. The facts uncovered through the interviews are given under conceptual categories of idea harnessing, relationship enhancement, incentivisation and project team fitness. No identifiable details are given to maintain confidentiality.

8.4 Details of case studies

Individual case studies are explained in this section.

8.4.1 Case Study 1

Project details

Project: Construction of a large hospital building in Queensland, Australia

Project cost: around AUD2 Billion

Project description:

Project included the construction of several buildings. The main building comprised of over 150, 000 sq. m. space with around 7000 rooms.

This was a fixed-priced, Public Private Partnership (PPP) contract. The builder was selected during the tender process and then a company was formed with the client and the contractor to build the work.

Significant achievements of the project:

- Was delivered and commissioned on time and budget.
- The Local Council estimated that the project injected nearly AUD2 Billion into the local economy during the delivery.
- Results of a comparative Life Cycle Assessment study showed that this project demonstrated an overall reduction in environmental impacts across all indicators when compared to a reference case healthcare development. These improvements included a 20% reduction in operational energy consumption

from energy efficient lighting design and a significant reduction in Ozone Layer Depletion Potential that resulted from using concrete with lower Portland cement content.

- Achieved 6-Star Green Star ‘Design’ and a 6-Star ‘As Built’ rating under the Green Building Council of Australia’s sustainability rating system.
- An engineer who worked in the project received national recognition for his innovative contribution.
- Received a number of regional and national awards for excellence and innovation.
- Received world recognition and presentations were made in a few countries.

Significant innovations:

- This is considered to be one of the first billion dollar health projects in Australia where Building Information System (BIM) was applied so extensively, including the collaborative use of dRofus (Room database software linked to the 3D model) to its full extent.
- Innovative renewable and energy efficient infrastructure which used an innovative twin duct system. This increased the chiller NPLV efficiency by approximately 8-10% compared to a traditionally installed plant.
- 19 million litres of water per annum saved via condensate reclamation.
- Buildings were constructed from non-toxic materials and is considered to be a ‘healthy’ hospital, offering fresh air and natural light.

Level of innovation of the project:

This project can be considered as a highly innovative project.

Persons interviewed:

Two project managers from the company that provided design services were interviewed, one responsible for the structural design and the other responsible for electrical works. Both had project management experience between 16 to 25 years, with working in projects up to AUD2 Billion in value.

<u>Innovative aspects of the project</u>

Idea Harnessing

Idea generation techniques

The project has used the following techniques for idea generation:

- Brainstorming;

- Scenario planning;
- Risk assessment planning;
- Life cycle costing;
- Constructability review;
- Sustainable design; and
- Value Management or Value Engineering.

Many parties with expertise were hired to do different work such as architectural work, civil, mechanical and electrical designs. These parties provided good ideas. In addition, potential subcontractors were engaged from the beginning to obtain ideas.

The team always looked for best practices elsewhere. For example, during the interview the structural engineer said that he had to design a car park. Before designing, he went to an existing car park to get some ideas. The design team also learned about volumetric construction which was new at that time.

Learnings from previous projects

The same company constructed another hospital building previously and the project learnings were used in this project.

The structural engineer said that after each lesson learning meeting, he would write to the attendees requesting them to add further to what was said in the meeting. Then he would receive at least three times more good ideas. This, he said, was because some people do not like to talk openly with only a few people dominating in meeting situations.

Relationship enhancement

The interviewees said that they had excellent relationships with the client's representative although there was no formal partnering arrangement. Their relationship was based on trust and open communication.

Giving an example, the structural engineer said that they had a problem of containing vibration of the structure to the level required in specifications. They could not prove how much vibration control would be in their design. The team discussed the matter with the client's representative, who said he believed in their approach and approved the design based on trust. When measured later, the vibration level was within specifications.

The team members from client and contractors sides have previously worked in similar situations and have built strong relationships.

Incentivisation

Past innovation history has been considered when appointing the designer. The design team had no financial incentives. One motive for innovation was to reduce time delays to avoid liquidation damages. However, being a PPP, the company received financial benefits for achieving selected outcomes through the PPP contractual arrangements.

The main reason for innovations in this project was the desire to do the best by individuals. The team members were proud of the work they did. As the structural engineer said enthusiastically, "we build monuments for the future generations. People will see our products for ever".

Project team fitness

Project Manager

According to interviewees, their project manager was excellent. He resolved all the issues quickly. When things go wrong, he took the responsibility, but got the team to find solutions to the problems. One of his strong characteristics was to select good heads of teams to assist him. He not only supported good ideas but also drove good ideas himself. An example was to support and promote modular construction and Building Information System (BIM). He bought a 3D printer which helped to explain things in a practical way to client's representatives and to other stakeholders.

Project team

The team members selected for this project were highly skilled and appointed from many parts of the company which was a large international organisation. Due to the heavy workload, usually no additional training was provided, and on-the-job training was the preferred way to enhance skills. However, from time to time, the team members were sent on special courses. Training included workshops on new thinking. In addition, there were weekly information sharing meetings. The company had a strong peer review system with experts from other parts of the organisation scattered throughout the world. For example, seismic design was helped by another staff member from New Zealand, who designed buildings after the recent earthquake. They also had an independent design team to check designs.

Team environment

The team had a tolerable culture; anybody can come out with any idea. There was no blaming if something fails, but they preferred to fail fast. There were measures to reduce failures with high level of risk management processes. The company promoted diversity and the team had diverse members.

Parent organisation

Both agreed that their parent organisation was an innovative organisation. The company recognises innovation as a business strategy. Employees are given sufficient freedom to work. There are no fixed workstations in the office. Staff has the choice to come to the office with any dress, they prefer. If a staff member wants to do something new, the idea will be put for vote in the company by other employees. If selected, the staff member has to make a presentation in front of the senior management and if the idea is good, the staff member is given funds and time to proceed with the idea.

The company has a monthly recognition system to recognise high performers. There is also a performance review system and those receiving high ratings are given performance bonus. Once a year, most innovative project is selected and awarded in a corporate event.

According to interviewees, the company is not a risk-averse organisation. However, the company had well-established risk assessment and management strategies. Any new idea would be assessed by highly experienced practitioners in the company for their suitability, before being implemented.

The company has a research and development arm and a dedicated team to promote innovation.

8.4.2 Case Study 2

Project details

Project: Major rehabilitation of a bridge in Australia

Project cost: Around AUD30 Million.

Project description:

The project consisted of servicing joints and bearings of an expressway bridge deck including cleaning, repairing and replacing damaged items to ensure 20 years maintenance free period. The client was a state road authority and the contractor was the construction arm of the same organisation. The project duration was 15 months. The major challenge was that the existing conditions of bearings and joints were unknown before commencing work. Similar work on this bridge section a few years ago has resulted in major delays, increased costs and inconvenience to road users resulting in a bad reputation for the client.

Significant achievements of the project:

- Was completed 6 months ahead (out of 15 months).
- Original cost AUD30 million, but completed cost was only AUD11 Million.
- Some innovations introduced became standard practices within the organisation.
- There was high stakeholder satisfaction due to the less road user discomfort.
- Achieved internal recognition within the organisation and team members received recognition by way of promotions.

Significant innovations:

- A new method to clean the joints was used for the first time in the organisation. The traditional method was to wash and clean joints with water resulting in heavy costs, delays and environmental issues with the disposal of water after washing. The new method was to vacuum the dirt instead of washing.
- Another new method was used for cleaning the bearings. Traditional method was to clean with water. The new method was cleaning with thinner, which had similar benefits.
- A new jacking system was used in the project. When working at the same bridge a couple of years ago, jacking was done from the ground using a single jack system. This time, jacking was done above the ground, such as from abutments, using a number of small jacks. As a result, it was possible to allow light traffic all throughout the work, except for few hours, thus reducing the number of hours for road closure. This saved a significant money as one night diverting traffic would have cost AUD2 Million.
- Some friction plates had to be replaced. A new material was used for the first time in bridges in Australia for the new friction plates.

Level of innovation of the project:

This project can be considered as a significantly innovative project.

Persons interviewed:

Client's project manager and the contractor's project director were interviewed. They were both highly experienced with more than 35 years of experience. Both had engineering degrees up to the masters level. While the client's project manager had managed project up to AUD300 Million, the contractor's project director had managed project up to AUD75 Million.

<u>Innovative aspects of the project</u>

Idea Harnessing

Idea generation techniques

Brainstorming was heavily used by the contractor to obtain new ideas. Most of the innovative ideas came from operating level staff. Ideas also came during project management meetings. The idea for the use of new friction plates came from investigating best practices.

Learnings from previous projects

Learnings from previous projects were heavily used here. Similar work on this bridge section a few years ago resulted in major delays, increased costs and inconvenience to road users resulting in bad reputation for the client. The learnings showed not to repeat the techniques and practices used in the past.

Relationship enhancement

Although this was a traditional contract, partnering approach was followed. There were leadership team meetings every week (in general, these meetings are held once a month). There was trust and open communication between the client and contractor teams. Being both teams from the same organisation with common values and good understanding, and profit was not a main criterion for the contractor, helped improving their relationship.

The contractor was enthusiastic when talking about the relationship with the client's team. He said it was extremely good and there was open and honest communication. He said "The time was critical, and the team had to make decisions without waiting from the top level. We had weekly meetings and decisions were taken then and there". He emphasised that good communication was a factor contributed to the success of the project.

Incentivisation

There were two motivations for innovations; one was the reputation of the contractor. At that time, the contractor's reputation was not so good. The contractor's team wanted to demonstrate their expertise in bridge rehabilitation. The other motivation was facing challenges posed by constraints, i.e. to complete within a tight time frame.

This was a Cost Plus contract and there was negative financial incentive for the contractor to complete the project below the budget. However, this work gave the contractor good reputation and excellent training to its crew.

Project team fitness

Project Manager

It was apparent that the project manager was very enthusiastic, technically competent, highly capable who was not reluctant to take difficult decisions. For example, when the top management was reluctant to approve the use of the new bearing material, the project manager authorised it. The project manager was particularly knowledgeable on project management having obtained project management qualifications and becoming the only person in the organisation to do so. The project manager said that most engineers managing projects in the organisation actually do only contract management and not project management.

The contractor said that the project manager showed a lot of enthusiasm, attended all the meetings and took quick decisions whenever possible. When talking about the project manager, the contractor was enthusiastic and kept on talking about the good qualities of the project manager such as being very supportive, wanted to do things right and fast, encouraging innovative ideas.

Team environment

There was very flexible team environment. Project meetings were often held with the operational level staff and the freedom was given for anybody to talk spontaneously. This team environment resulted in many innovations. It was a collaborative environment, each helping the other. The contractor attributed the success of the project to two factors, good teamwork and communication.

Parent organisation

Interviewees acknowledged that the client organisation was innovative up to some extent. There was a supportive environment for new ideas. When new good ideas came, they were implemented even if they came from consultants. The client organisation gave flexibility for the project manager to take decisions. The organisation had well-established strategies and procedures to manage risks, some of which were applied on the project.

8.4.3 Case Study 3

Project details

Project: Construction of a bikeway in Queensland

Project cost: around AUD500,000.

Project description:

This is a joint local and state government initiative to build a bikeway in a complex difficult environment. Project was funded and constructed by a state agency for a local council. It included earthworks, pavements with concrete and asphalt, elevated structures, retaining structures and landscape works. The proposed alignment was across a park and a heritage listed site. There were many constraints including imposing minimum impacts on the root zone of the hoop pine trees along the proposed alignment, minimum impacts on other plants, time restrictions with only a 6 week construction window and the need to abide by the restrictions placed on the part of the heritage listed section on the alignment. Construction period was 3 months.

Significant achievements of the project:

- The constraints were successfully managed, and the project was completed on time.
- Satisfied customers.
- Less wastage due to the use of prefabricated components.
- Project was nominated for excellence awards.
- The project team members received internal recognition.

Significant innovations:

- Innovative construction to protect the roots of hoop pine trees by making a bridge with fibre composite material. According to interviewees, this was the second time the organisation had used fibre composite material for a bridge.
- Use of ground penetrating radar (GPR) to finding out the root locations of hoop pine trees, normally not done for a project of this nature.

Level of innovation of the project:

This project can be considered as a low to moderately innovative project.

Persons interviewed:

The project manager and the project director from the state authority, who were responsible for the construction. The project manager had up to 6 years in experience, but the project director had experience between 16 to 25 years, having worked on projects up to AUD300 Million.

<u>Innovative aspects of the project</u>

Idea Harnessing

Idea generation techniques

The existence of the root system of hoop pine trees meant that no pile foundations, no stockpiling of material, no use of heavy vehicles and no construction activities allowed on the ground near the trees. With so much constraints, the project team had to look for new solutions and talk to many people knowledgeable on the subject area. One such person had known about the application of fibre composite bridges. The project manager contacted the supplier and found further information regarding the use of fibre composites and decided to use it. As no working was permitted under trees, all the items were prefabricated and assembled on site.

Relationship enhancement

The consultants to the project such as horticultural and heritage experts, who provided advice from the concept stage, were kept with the project during the construction stage. They were all enthusiastically contributed to the project success. The contractor had a very good relationship with the project manager which also contributed to the success of the project. The personnel involved with the project was a small team, who worked collaboratively for the project.

Incentivisation

Facing complexities and constraints were the challenges that promoted innovative thinking. The openness of the client to new ideas and less red tape of the client also contributed to the final outcome. No other forms of incentives or rewards were offered.

Project team fitness

Project Manager

The project manager was less experienced, but enthusiastic and highly motivated. Due to the constraints of the project, the project manager was allowed to take on-site decisions regarding the project.

Team environment

The client had trust in the project team. The project team was motivated which worked for the benefit of the project.

Parent organisation

Interviewees thought the client organisation was innovative. The client's openness to new ideas contributed to make this project successful. The contractor's parent organisation was also considered innovative to some extent.
The team was given opportunities to be exposed to others and to look for best practices.

8.4.4 Case Study 4

Project details

Project: Major intersection upgrade in Australia

Project cost: Around AUD300 Million

Project description:

Project included the following:

- Grade separation of two highly-trafficked roads;
- Construction of bridged underpass; and
- Intersection upgrades.

This was one of the busiest intersections in the state. The constraints were that the traffic flow needed to be maintained all the time and there should not be any disruptions to the bus flow. This was a Double ECI (Early Contractor Involvement) contract. Owner was the state road authority.

Significant achievements of the project:

- Significant cost and time savings. Final cost was AUD100 Million instead of the estimation of AUD300 Million. Time to completion was 20 months against the estimated 24 months.
- There were no traffic incidents which is rare in working around such a busy corridor. In addition, there was no business losses due to construction, saving a considerable amount of money. Keeping the two lanes opened all the time was considered not possible at the start.
- Satisfied customers, especially the heavy vehicle industry.

Significant innovations:

- An effective new way of staging of work.
- The maximum possible bypass height as determined by the designer was 5.3m due to terrain posed restrictions. But this was considered less satisfactory for the traffic corridor. It was possible to increase this to 6.1m

which was considered adequate for the corridor.

Persons interviewed:

The persons interviewed were the client's project manager and a member of the client's project team. The client's project manager was highly experienced person with more than 35 years of experience and had engineering degrees up to the masters level. The project manager also had project management qualifications. The client team member had 16 to 25 years' experience and had worked in projects up to the value of AUD450 Million.

<u>Innovative aspects of the project</u>

Idea Harnessing

Idea generation techniques

Idea generation techniques such as scenario planning, whole of cost assessment, risk assessment, constructability review were used in the project. The use of the Double ECI (Early Contractor Involvement) contract, i.e. two proponents work on the detailed design independently and one would be selected, created opportunities for generating new ideas. One proponent developed a design with the bypass to be built first with the piers and the slab, and then removing the earth underneath. The second proponent had a conventional approach to remove earth first and construct the structure. The first design was accepted as it facilitated better traffic management. However, this design had the height of the bypass as 5.3 m (the designer had a difficulty in increasing more due to terrain posed restrictions) which was not sufficient for the traffic corridor. The client paid for the design which was not accepted and borrowed its ideas to increase the height to 6.1m.

Learnings from previous projects

The owner is a repeat client of similar projects and the knowledge from previous projects were used heavily.

Relationship enhancement

This was a collaborative contract with the contractor. From the beginning, workshops were held with representatives from all the parties to discuss relationship matters and devising ways of improving relationships. In addition, team building workshops and exercises were conducted with the contractor and the contract administrator. Open discussion sessions were often held. During the construction stage, all participants celebrated success when milestones were completed.

All the parties worked in the same building that helped building better relationships through increased interactions and personal connections. However, there were relationship problems at a time when the constructing company was taken over by another company, which introduced new personnel and the new constructor, was eager to look for ways to increase profits.

Incentivisation

During the execution of the project, there were no incentives given to the project team. However, after the completion, the project got nominated for various awards and individual team members got promotions. The project manager was internally recognised by the head of the organisation. The client's project team knew about the existence of such incentives in the organisation during the project execution.

Project Manager

The project manager had a very high reputation for being effective, hardworking and providing good leadership. The project manager was highly experienced and technically competent and took proper quick decisions. The fact that the project manager was new to the organisation at the time and didn't follow traditional approaches of a public sector organisation also contributed to the project success.

Project team fitness

The project manager took extra effort to place less experienced team members under suitably experienced staff to receive knowledge and experience.

Team environment

Altogether there were nine members in the client team. All team members were close to each other and worked hard for the project. The contract administrator was an outside party with well-experienced people. A good team environment existed where open communication was encouraged.

Parent organisation

The client organisation was somewhat innovative. It was open for ideas and was willing to take calculated risks. The management hierarchy supported the team with quick decisions and helped the project manager by not obstructing decisions taken by the project manager. The team was given opportunities to be exposed to others and to look for best practices.

This completes individual details of case studies. Findings of these case studies are summarised below, separately with respect to the conceptual model and Australian-specific model constructs.

8.5 Conceptual model related findings

Table 8.3 shows the performance of each construct of the conceptual model (i.e., idea harnessing, relationship enhancement, incentivisation and project team fitness) for each case study.

Table 8.3 The performance of conceptual model constructs

No.	Idea harnessing	Relationship enhancement	Incentivisation	Project team fitness
1*	Very strong in idea harnessing. A large number of idea harnessing techniques were used and strategies adopted.	No formal relationship enhancement agreements. However, it is evident that all parties had strong relationships with each other. Most of the client's project team members have worked previously with the contractor's project management team, establishing good relationships. As the client team and the contractor's team represented one organisation helped closer bonding of team members.	Past innovation history has been considered when appointing the designer. No personal or financial incentives provided. However, it is evident that there was a strong desire to do best work by each team member. Challenges due to constraints also provided motivation for innovation.	Technically competent, highly experienced project team members drawn from different areas of the organisation to represent the client's team. Very effective, strong, technically competent project manager who encouraged innovation. Innovative parent organisation.
2*	Brainstorming and learnings from past projects were heavily used. Operational level staff contributed mostly with novel ideas.	Strong relationship between the client's and contractors' teams evident. Both teams coming from the same organisation would have contributed.	Challenges due to constraints and the need to show excellence by the contractor provided motivations for innovations.	Technically competent, highly experienced project team of the contractor. Very effective, strong, technically competent project manager who encouraged innovation. Moderately innovative parent organisation.
3*	Project team investigated	Fairly strong relationship	Challenges due to	Less experienced

	solutions to the constraints imposed on the project. Small project team.	between the client's and contractors' teams was evident. However, the project team consisted of members from two state organisations, therefore, were not close enough in relationships.	constraints provided motivations for innovation. No other incentives were provided.	project manager with average skills and moderately innovative client organisation.
4*	Most of idea harnessing techniques and strategies adopted. The nature of Double ECI contract contributed to generating beneficial ideas, especially because the client bought the design of the unsuccessful bidder.	This was a collaborative contract with strong relationship between parties initially. However, when the contract company was bought over by another company, the relationship became poor. All parties working in the same building helped building fairly good relationships.	The motivation to win the contract provided incentive to bidding parties to look for innovative solutions.	Very effective, strong, technically competent project manager who encouraged innovation. Moderately innovative client organisation.

***Notes:**

Project 1: Construction of a large hospital building, project cost very high (AUD 2 Billion), PPP project, highly innovative.

Project 2: Major rehabilitation of a bridge, project cost low to moderate - around AUD30 Million, Cost Plus project, significantly innovative.

Project 3: Construction of a bikeway, project cost low around AUD500,000, Design and Build project, moderately innovative.

Project 4: Major intersection upgrade, project cost moderate to high - around AUD300 Million, significantly innovative.

From *Table 8.3,* a trend can be seen that more idea harnessing efforts are contributing to better innovative outcomes. It is apparent that good relations existed in all cases between parties, showing that strong relationship is a pre-requisite for innovation. It is also apparent in the limited data set that Australian construction clients offer little or no monetary or personal incentives for innovation. The innovations happening in these projects could be attributed mostly to the desire of the project team to overcome challenges and to the self-satisfaction of team members of doing best of their abilities. However, the two most innovative projects had some incentives. In the most innovative project, the past innovation history has been considered when appointing the designer, conveying the message that innovation is important and could be considered when selecting designers for future projects. The next most innovative project used a competitive bidding strategy which provided incentives to bidding parties to look for innovative solutions for winning the contract. When considering the project team fitness, it can be seen that higher project team fitness resulted in higher innovation performance, especially with the increased effectiveness of the project manager.

Therefore, it is apparent that with increased performance of constructs (i.e., idea harnessing, relationship enhancement, incentivisation and project team fitness), the innovation performance of the project gets better. It needs to mention here that although the innovative level of each case study assumed was subjective, it had no bearing on the finding that increased performance of model constructs increases the innovative performance of projects.

These results validate the conceptual model for promoting innovation in construction projects by clients, where it was shown that the constructs of idea harnessing, relationship enhancement, incentivisation and project team fitness contribute to innovation performance of construction projects. However, this validation technique could not be used to assess the inter-relationship between constructs.

In the most innovative project of the case studies, the AUD2 Billion hospital construction project, the interviewees were from the contractor's side. However, it could be clearly seen that the four constructs of the conceptual model were applicable to the innovations initiated by the contractor with a minor change. Instead of the client organisation was innovative, in this case, the contractor's parent organisation was innovative. It is to be remembered here that the conceptual model was developed using the findings of fundamental research on factors contributing to innovative outcomes in workplace situations using the targeted literature review. It had no bearing on whether the initiator was the client or not. Therefore, it can be stated that the conceptual model, developed for the client, is also applicable to the contractor. This is validated by the significantly innovative AUD30 Million major rehabilitation of a bridge project. Similar to the previous case, most of the significant innovations in this project were initiated by the contractor validating the applicability of the conceptual model. Therefore, the case studies validate the previous findings given in *Section 3.10* that the conceptual model can also be used by parties other than the client.

8.6 Australian-specific model related findings

The same case studies were also used to assess the innovative performance in relation to the Australian-specific model (*Fig. 7.4*) constructs, namely; project team attributes, support to the project team, nature of relationship, project team member attributes, internal recognition, client organisation, designers & contractors selection and incentivisation. Each of these constructs contained a number of items. It was not possible to assess some of these items using the case study approach. The findings are given in the sections below for each construct. *Fig. 7.4* is reproduced in *Fig. 8.1* for easy reference.

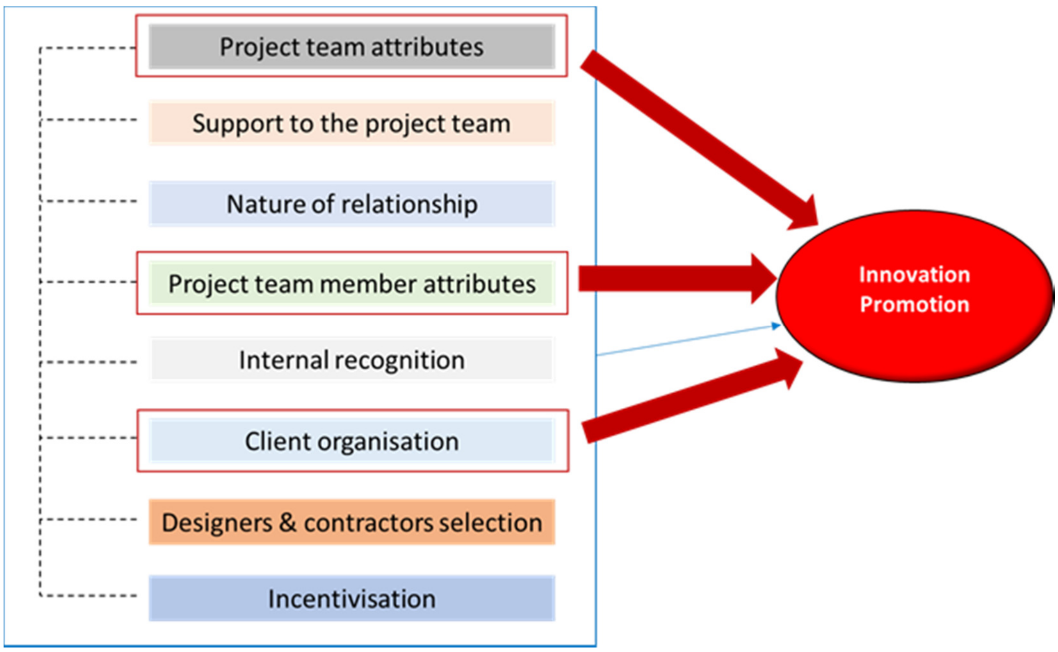


Figure 8.1 Australian-specific model

8.6.1 Project team attributes

The construct under the project team attributes consisted of the following items:

- Team members felt free to talk;
- All were treated equally;

- There was no difficulty in forming teams;
- Ideas from team members became team ideas;
- PM made quick decisions;
- PM protected the team;
- Project team members were motivated;
- There was no blame game;
- PM sought out, encouraged and promoted new ideas/ technology/ processes;
- Team members used inputs from experienced personnel;
- Team members captured project learnings; and
- Team members followed new research.

Given below in *Table 8.4* is an assessment of project team attributes with respect to the findings of the case studies.

Table 8.4 Comments on project team attributes

Case Study No.	**Comments**
1 Highly innovative project	Project: Construction of a large hospital building Very strong team environment, facilitating beneficial idea generation without a blaming culture. Highly motivated team members. Very effective, strong, technically competent project manager who encouraged innovation. Sought inputs from experienced personnel, captured and used project learnings and followed new research.
2 Significantly innovative project	Project: Major rehabilitation of a bridge Strong team environment involving a range of members from management to operational level positions, all having the freedom to expresses ideas. Most ideas came from members holding operational level positions. Very effective, strong, technically competent project manager who encouraged innovation. Sought inputs from experienced personnel, captured and used project learnings and followed new research. Sought inputs from experienced personnel, used captured project learnings heavily and followed new research.

3 Moderately innovative project	Project: Construction of a bikeway A small project team with dedicated members, project manager was open to innovations, who sought inputs from experienced personnel. Project manager was less experienced.
4 Significantly innovative project	Project: Major intersection upgrade Strong team environment of the client's team. Very effective, strong, technically competent project manager who encouraged innovation. Collaborative type contract generating innovative ideas from bidders. The owner buying the design of the unaccepted tenderer also brought in new ideas.

8.6.2 Support to the project team

Support to the project team construct consisted of the following items:

- Project team was provided with training to improve team skills;
- Project team was provided with training to improve knowledge;
- Project team had opportunities to be exposed to best national and international practices;
- Project team had opportunities to be exposed to others; and
- Project team was provided with training to implementers.

Given below in *Table 8.5* is an assessment of this construct with respect to the findings of the case studies.

Table 8.5 Comments on Support to the project team

Case Study No.	Comments
1 Highly innovative project	Project: Construction of a large hospital building A project of this nature requires considerable effort from each team member. The project team was not provided with much facilities to improve skills. Instead, highly-skilled team members were recruited from different areas of the organisation to work in the project. However, from time to time, the team members were sent to special courses. Training included workshops on new thinking. In

	addition, there were weekly information sharing meetings. Project team had opportunities to be exposed to best national and international practices. Highly motivated project team.
2 Significantly innovative project	Project: Major rehabilitation of a bridge As the client was a state organisation, regular training was provided to enhance skills of the client team members. Highly experienced and knowledgeable team worked for the contractor, who were responsible for many innovations in the project.
3 Moderately innovative project	Project: Construction of a bikeway As the client was a state organisation, regular training was provided to enhance skills of the client team members. The team was given opportunities to be exposed to others and to look for best practices.
4 Significantly innovative project	Project: Major intersection upgrade As the client was a state organisation, regular training was provided to enhance skills of the client team members. The team was given opportunities to be exposed to others and to look for best practices.

8.6.3 Nature of relationship

The construct, nature of relationship, consisted of the following items:

- Had conducive culture within teams
- Client's team had excellent relationships with other teams
- Respected each other teams
- Client's team had good relationships with key stakeholders

Given below in *Table 8.6* is an assessment of the nature of relationship with respect to the findings of the case studies.

Table 8.6 Comments on the nature of relationship

Case Study No.	**Comments**

1 Highly innovative project	Project: Construction of a large hospital building There was a very strong relationship with strong conducive culture within teams, excellent relationships based on respect with other teams and good relationships with key stakeholders. The team members from client's and contractors' sides have previously worked in similar situations and have built strong relationships which was one of the contributory factors.
2 Significantly innovative project	Project: Major rehabilitation of a bridge There was a strong relationship with strong conducive culture within teams, excellent relationships based on respect with other teams and good relationships with key stakeholders. Being the client and the contractor from the same organisation was a contributory factor. Another contributory factor was that the contractor gave priority to enhance reputation instead of focussing on profits.
3 Moderately innovative project	Project: Construction of a bikeway It can be said that the nature of the relationship has been modest in this project as the client and the contractor were from different public sector organisations which had their own differences. However, project personnel worked hard to overcome these differences and worked for the success of the project.
4 Significantly innovative project	Project: Major intersection upgrade Strong relationship with the contractor due to the collaborative type contract. However, relationship suffered when the contract company was bought over by another company which replaced the previous staff.

8.6.4 Project team member attributes

Project team member attributes consisted of the following items:

- Project team members had considerable knowledge and experience;
- Project team members had strong relationships with customers;
- Project team members were diverse persons;
- Project team members were helpful;

- Project team members had exposure to innovation; and
- Project team members considered innovation as a day-to-day duty.

Given below in *Table 8.7* is an assessment of project team member attributes with respect to findings of the case studies.

Table 8.7 Comments on project team member attributes

Case Study No.	Comments
1 Highly innovative project	Project: Construction of a large hospital building High-performing team members were selected to work on this project from different parts of the organisation. Providing diversity is one of the company's goals and there was intentional attempt to provide diversity in the team. The team members were highly motivated and dedicated. This can be seen from the statement of the structural engineer, who enthusiastically said that "they built monuments for the future generations. People will see their products for ever". Because of this, they all wanted to do their best from the day one.
2 Significantly innovative project	Project: Major rehabilitation of a bridge In this project, high-performing team members contributed much to the success of the project. Project success was the motivation behind team members. Each team member contributed with ideas and actions for the success of the project. Summing up the most contributory factors for the success of the project, the contractor pointed out to teamwork and communication.
3 Moderately innovative project	Project: Construction of a bikeway Not much evidence was uncovered in this project about positive project team member attributes. However, it could be seen that the attitudes of both the project director and the project manager have been focussed on project success and the project director provided all the encouragement and facilities required by the project manager.
4 Significantly	Project: Major intersection upgrade In this project, high-performing team members contributed much to

innovative project	the success of the project. Project success was the motivation behind team members.

8.6.5 Internal recognition

Internal recognition construct consisted of the following items:

- Project team recognised idea implementers
- Project team recognised idea generators
- Project team had implementers to help idea generators
- PM earned respect

Given below in *Table 8.8* is an assessment of internal recognition with respect to findings of the case studies.

Table 8.8 Comments on internal recognition

Case Study No.	Comments
1 Highly innovative project	Project: Construction of a large hospital building Not much evidence could be gathered on internal recognition through interviews. However, it could be clearly seen that the project manager has earned significant respect within the project team. In addition, the idea generators were highly recognised within the team. For example, interviewees talked highly about the engineer, who came out with the idea of an innovative twin duct system.
2 Significantly innovative project	Project: Major rehabilitation of a bridge In this project too, the project manager was highly respected. There were idea implementors readily available to put ideas into action. For example, when the idea came up to use vacuuming instead of watering to remove dirt, the idea implementors made a machine in quick time to do it with parts assembled from different machines.
3 Moderately innovative	Project: Construction of a bikeway Not much evidence could be gathered on internal recognition through interviews.

project	
4 Significantly innovative project	Project: Major intersection upgrade The project manager has earned significant respect within the project team. When ideas were selected for implementation, the project team made elaborate plans and worked hard to put them into practice. The project manager and the team members were internally recognised by the parent organisation.

8.6.6 Client organisation

Client organisation construct consisted of the following items:

- Client organisation relaxed technical regulations/ specifications;
- Client organisation supported innovative activities; and
- Client organisation had characteristics of an innovative organisation.

Given below in *Table 8.9* is an assessment of the performance of client organisation construct with respect to findings of the case studies.

Table 8.9 Comments on client organisation

Case Study No.	Comments
1 Highly innovative project	Project: Construction of a large hospital building The interviewees agree that their parent organisation was an innovative organisation. They provided the following information regarding the parent organisation. “The company recognises innovation as a business strategy. Employees have been given enough freedom. If a staff member wants to do something new, it will be put for vote in the company. If selected, the staff member has to make a presentation in front of the senior management and if the idea is good, they are given funds and time to proceed with. The company has a monthly recognition system to encourage and award high performers. There is also a performance review system and those receiving high ratings are given performance bonus. Once a year most innovative project is selected and awarded in a

	ceremony. The company has a research and development arm and a dedicated team to promote innovation." The above provides evidence that the organisation was highly innovative.
2 Significantly innovative project	Project: Major rehabilitation of a bridge Interviewees acknowledged that the client organisation was innovative up to some extent. According to them, there was a supportive environment for new ideas. When new good ideas came, they were implemented even if they came from consultants. Client organisation gave flexibility for the project manager to take decisions.
3 Moderately innovative project	Project: Construction of a bikeway Interviewees thought the client organisation was innovative. According to the project manager, the client's openness to new ideas made it possible to implement innovations in this project.
4 Significantly innovative project	Project: Major intersection upgrade Interviewees acknowledged that the client organisation was innovative up to some extent. According to them, there was a supportive environment for new ideas. Client organisation gave flexibility for the project manager to take decisions.

8.6.7 Designers & contractors selection

Designers & contractors construct consisted of the following items:

- Selecting designers and contractors - used innovation history;
- Selecting designers and contractors - used innovative proposals; and
- Selecting designers and contractors - used innovation performance.

Given below in *Table 8.10* is an assessment of designers & contractors selection with respect to the findings of the case studies.

Table 8.10 Comment on designers & contractors selection

Case Study No.	**Comments**

1 Highly innovative project	Project: Construction of a large hospital building In this project, the designers were appointed considering both innovation history and innovative proposal. The proposal put forward by the contractor was accepted among other bidders. The designer worked for the contractor, who was a party in the PPP project.
2 Significantly innovative project	Project: Major rehabilitation of a bridge Innovation was not considered in appointing designers & contractors for the project.
3 Moderately innovative project	Project: Construction of a bikeway Innovation was not considered in appointing designers & contractors for the project.
4 Significantly innovative project	Project: Major intersection upgrade Due to the competitive nature, the designer selection process contributed to generate innovative ideas.

8.6.8 Incentivisation

Incentivisation construct consisted of the following items:

- Team members were rewarded with personal incentives;
- Team members were rewarded with financial incentives;
- Selected contract types such as alliances that provided financial incentives; and
- Included contract clauses to share savings resulting from innovations.

Given below in *Table 8.11* is an assessment of the incentivisation with respect to findings of the case studies.

Table 8.11 Comments on incentivisation

Case Study No.	Comments
1	Project: Construction of a large hospital building

Highly innovative project	No financial or personal rewards were given for innovations. The project team was motivated only by facing challenges due to difficult constraints and the personal satisfaction of doing a good job. However, the project team knew that innovation was encouraged by the organisation. In addition, the idea generators and implementers were recognised within the team and the organisation. Although the project team did not receive individual incentives and rewards, the company which constructed the hospital received financial incentives as the project was a public private partnership (PPP).
2 Significantly innovative project	Project: Major rehabilitation of a bridge No cost sharing in the project and no financial or personal rewards were given. The project team was motivated only by facing challenges due to difficult constraints and the need to maintain reputation. The idea generators and implementers were recognised within the team and the organisation.
3 Moderately innovative project	Project: Construction of a bikeway No cost sharing in the project and no financial or personal rewards were given. The project team was motivated only by facing challenges due to difficult constraints.
4 Significantly innovative project	Project: Major intersection upgrade Double ECI contract type offered financial incentives for proponents to use innovative ideas. The idea generators and implementers were recognised within the team and the organisation.

Given above are the details on the performance of each Australian-specific model constructs. These results are discussed below.

8.6.9 Discussion on the performance of the Australian-specific model

Project team attributes

Case studies results show that positive project team attributes contributed to higher innovative outcomes. Project manager's role was highlighted especially - technically competent, effective and experienced project managers contributing to higher innovative outcomes. It could be seen that those projects with higher level of project team attributes, such as the hospital construction, performing better in terms of innovation.

Support to the project team

It is also apparent that when highly experienced, knowledgeable and motivated project team is working on the project, the innovative outcomes are higher and the additional support to the project team in terms of training may not be necessary. However, if team members are less experienced, they need training. More innovative outcomes seem to be happening when the team receives opportunities to be exposed to others and to best national and international practices.

Nature of relationship

Results also showed that conducive culture within teams, excellent relationships based on mutual respect with other teams and good relationships with key stakeholders contribute to innovation outcomes in a proportional manner, i.e. higher levels of these attributes contributing to higher innovative outcomes.

Project team member attributes

It was observed that the project personnel of highly innovative projects were experienced and selected individually based on their skill levels, whom contributed to higher innovative outcomes. In addition, it could be seen that the project personnel of highly innovative projects were highly motivated.

Internal recognition

Results showed that internal recognition, especially recognition of and respect to the project manager and the internal recognition of idea generators and implementors within teams, contributed to higher innovative outcomes.

Client organisation

The case studies clearly showed the importance of an innovative client/ organisation for achieving innovative outcomes. It was apparent that the innovation level of the client or the parent organisation contributed to a positive impact on innovative outcomes of projects.

Designers & contractors selection

Case studies indicated that innovation history was not generally considered in appointing designers & contractors for projects. However, the most innovative project in the case studies used innovation history to appoint designers & contractors. In addition, one of the case studies, i.e. the major intersection upgrade, which was a significantly innovative project, had benefitted from the innovative proposals of both competing designers.

Incentivisation

Although the project team did not receive individual incentives and rewards, the company which constructed the hospital received financial incentives as the project was a public private partnership (PPP). There were also financial benefits to the designer in the major intersection upgrade as it was a double ECI contract type.

These results validate the Australian-specific model. However, as was for the conceptual model, this validation technique could not be used to assess the inter-relationship between constructs.

Having gone through the findings related to both the conceptual model and the Australian-specific model, it can be seen that the case studies validated both the models.

8.6.10 Other findings

One of the previous findings from comparative analysis (see *Section 5.5.3*) was that as the project is costing more, the performance under each category gets better, indicating that clients have provided in more efforts to improve the performance. The case studies validated this finding.

Case studies consisted of the following contract types: Design and Build; Cost Plus; Double ECI (Early Contractor Involvement); and Public Private Partnership (PPP). Out of these contract types, PPP seems to generate more innovative solutions due its collaborative relationship between parties. Double ECI (Early Contractor Involvement) contract type contributed to more design innovations due to the competitive nature of the delivery type as the motivation of bidders is to win the contract. Buying the design of the unsuccessful tenderer also contributed in innovative ideas.

8.7 Chapter findings

This chapter was devoted to validating the previous research findings using the case study approach. The literature review resulted in deriving a conceptual model showing the relationships of major categories of client's innovation enablers to promote innovation in construction projects. The case studies validated that the model constructs promote innovation performance. However, it was found from the case studies that Australian clients generally do not prefer to provide personal or financial incentives to promote innovation. It appears that innovation do happen mainly due to intrinsic motivation of the project personnel. This is in agreement with the results from the comparative study undertaken previously as given in *Section 5.7.*

The statistical data analysis using the factor analysis and the correlation analysis led to the development of an Australian-specific model with eight constructs namely, project team attributes, support to the project team, nature of relationship, project team member attributes, internal recognition, client organisation, designers & contractors selection and incentivisation. The model predicted that these constructs promote each other and at the same time collectively promote innovation performance. The case studies validated the fact that the model constructs promote innovation. However, it was not possible to validate the finding that the constructs promote each other due to the limitation of the case studies approach. A separate in-depth study may be needed to validate (or not) this finding. Another model prediction was that three constructs, namely: project team attributes, project team member attributes and client organisation, predominantly contribute to innovative performance, even without the contribution of other constructs. Although the interviewees highlighted the importance of these three constructs, the limitations of the case study approach prevented identifying that they contributed to promote innovation performance even without the contribution of other constructs.

The case studies showed that a major driver for innovation in construction projects in Australia is the challenge to face constraints. This is in agreement with findings by other researchers. For example, Mitropoulos and Tatum (2000) identified 'process problems' as one of the four forces which drive construction innovation. Doree and Holmen (2004) presented a case study where a significant technical innovation was delivered by a contractor as a result of particularly severe project conditions. In addition, Salter and Gann (2003) noted that project level innovations are motivated by a sense of professionalism, problem-solving and opportunities to be creative. However, it is accepted beyond doubt that incentivisation, especially personal and financial incentivation, helps to promote innovation in construction projects. *Section 3.6* provided ample evidence from previous studies on the importance of incentivisation, especially personal and financial incentivation, for promoting innovation in construction projects. Therefore, it can be concluded that innovative performance can be improved further if the clients do resort to personal and financial incentives.

From the case studies conducted, it is apparent that no client has attempted to promote innovation deliberately in their projects, as the author has not discovered any evidence of purposeful actions to promote innovation. All the innovations seem to have happened on ad hoc basis. This shows that the importance of innovation to enhance project outcomes is still not embedded in the minds of construction clients in Australia.

The case studies consisted of the following contract types:

- Design and build;
- Cost Plus;
- Double ECI (Early Contractor Involvement); and
- Public Private Partnership (PPP).

Out of the above contract types, PPP seems to generate more innovative solutions due its collaborative relationship between parties. Double ECI (Early Contractor Involvement) contract types contribute to more design innovations due to the competitive nature of the contract as the motivation of bidders is to win the contract. Buying the design of the unsuccessful tenderer also contributes in innovative ideas. With the case studies considered, it was difficult to assess the impact of Design and build and Cost Plus contract types on the generation of innovative ideas.

Having completed a major milestone of the research, i.e. validating the research findings, it is appropriate at this juncture to examine the achievement of research objectives and answering research questions with respect to findings from the case studies.

8.7.1 Achievement of research objectives

As stated in *Section 1.2.4* on research objectives and scope, the following were the research objectives examined in this study:

RQ1 To explore clients' influence in promoting innovation in their construction projects;

RQ2 To explore actions that construction clients can take to promote innovation in their projects;

RQ3 To group these actions (also called innovation enablers) into major categories for easy identification;

RQ4 To develop a model using identified categories as constructs that encapsulates their relationships with innovative outcomes which can be used to depict the mechanisms of enhancing innovation promotion in construction projects;

RQ5 To empirically-test the model using the data from Australia;

RQ6 To validate the developed model through case studies of selected construction projects; and

RQ7 To contribute knowledge to the research area of project level innovation in the context of construction industry, and to provide practical recommendations for clients and policy makers to use in promoting innovation in construction projects.

The case studies showed that clients have a strong influence in promoting innovation in their construction projects. The validation process made it possible to identify a number of actions that construction clients can take to promote innovation in their projects. They are given in *Section 10.4* along with the actions identified during the literature review. During the validation process, it was not attempted to identify new categories to group these actions, but checked whether the previous categories identified in the literature review process were adequate to group them. It was found that the categories identified were describing client-led innovations enablers for construction projects. In addition, case studies validated the conceptual model and the Australian-specific model.

8.7.2 Limitations of the case study approach

Although the case study approach provided an excellent technique to validate the findings of the research, it was not ideal to validate (or not) all the findings. There were some of the variables which could not be satisfactorily assessed due to the fact that interviewees apparently refrained from talking about them. Although specific questions directed at them would have revealed more details about these matters, it also would have introduced bias to the findings from case studies. Therefore, no such direct questions were asked during the interview process.

One of the reasons for interviewees to refrain on commenting on certain areas could be that they did not consider such matters were important. Some of the characteristics identified in the literature review could have been embedded in the Australian construction industry and the interviewees could have taken them for granted. For example, individual attributes of project team members were not discussed in general, but it is apparent that Australian project personnel have positive attributes contributing to success of projects. Another limitation of the case study is the time factor where each interviewee can be interviewed for a reasonable length of time and all relevant details cannot be covered within the time available.

As mentioned in this section before, due to its own limitations, the case study approach did not find much information on the following areas:

- Information to validate the finding that the constructs of the conceptual model and the Australian-specific model promote each other with respect to each model.
- Information to validate the finding that the three constructs, namely: project team attributes, project team member attributes and client organisation, predominantly contribute to innovative performance, even without the contribution of other constructs.

It is highly unlikely that a single validation technique could be found to validate (or not) all the findings of the research. This is because research techniques have their own limitations. Notwithstanding the above limitations, the case study approach provided an excellent technique to validate most of the findings and the case studies approach could be described as the best technique to validate the findings of this research. The validation technique did not hinder achieving the purpose of the research which was to find client-led innovation enablers that enhance innovative outcomes of construction projects as mentioned in *Section 1.2.*

8.7.3 Selection of a preferable model

The work undertaken in this research so far enabled to derive a conceptual model and refine it to a specific model using Australian data (called Australian-specific model).

Although they look different to each other (from the variables included in the models which are not the same), the Australian-specific model contained all the constructs identified in the conceptual model. However, the analysis that led to the development of the Australian-specific model found that the influence of incentivisation on innovation performance was low. This shows that the Australian-specific model contained Australian specific characters. In addition, it was derived using the factors analysis and the selection of factors in factor analysis is subjected to individual interpretation. The model is more complex with eight constructs. On the other hand, the conceptual model is simple with only four constructs and easy to use for guidance. There is strong evidence to suggest that it can be used by any other party, such as the designer or the contractor, to promote innovation in a project as mentioned in *Section 8.5*. Therefore, the conceptual model was recommended to explain the dynamics of client-led innovation enablers in construction projects.

This leaves another important question, whether these findings are only applicable to construction projects as reported in *Section 3.10* or whether they could be applied to any other project in general. This will be explored in the next chapter.

CHAPTER 9
GENERALISATION

9.1 Introduction

Having developed a conceptual model to describe client-led innovation enablers to promote innovation in construction projects, testing it with the data from Australian construction projects and validating the findings with Australian case studies, the study is now complete.

However, the following facts related to the development of the model provide indications that this model could be applied to any project, irrespective of the project area:

- None of the model constructs are specific to the construction industry and can be applied to projects in general;
- When developing the conceptual model, a closer investigation was undertaken to examine the drivers that lead to innovative activities in workplace situations and translate the findings to project situations. In this process, it was observed that the drivers were not specific to construction projects, but were applicable to any project; and
- The definition of project level innovation does not depend on the type of project and is generic in nature, suggesting that drivers to promote innovation in projects are generic in nature as well.

With these strong reasons suggesting that the model developed for construction projects can be applied to any project, it was necessary to test this hypothesis. The research strategy adopted for this purpose was to examine projects in areas outside the construction industry through interviews.

Eleven project managers in areas such as mining, oil and gas, information technology (IT) and power generation were interviewed to assess the applicability of the research findings to other project management areas. These interviews also paved the opportunity to test the project level innovation definition on projects outside the construction area. The research method used here was a single case study using a single information source as described in *Section 8.2.3*. The details of the interviews conducted are given below.

9.2 Interview process

As the purposes of the interviews were to ascertain the applicability of the project level innovation definition and the conceptual model, there were no restrictions placed as to how the interviews should be conducted. Project managers from all possible industries were considered. However, to make the interviews easy to conduct, a typical questionnaire was adopted. Unlike in previous interviews, which were on construction projects, no interruptions were made, and questions were asked freely where required to clarify and to obtain more details. The questions were more in line with the conceptual model constructs, but at the end of the interviews the participants were asked to add any other innovation enablers not covered in the interview.

There were face to face interviews as well as phone interviews. All interviews were audio recorded. All interviewees were from Australia.

9.2.1 Interview questionnaire

The following was the typical questionnaire used for the interviews:

1. **Nominated Project**

Requested interviewee to nominate one of his/her projects, considered to be innovative, and give details of the project.

2. **Why the project is being considered innovative?**

Comment on whether the project used improved/advanced:

- technologies, methods and practices;
- materials, products, plant, and equipment;
- computer software/hardware, models and communication systems;
- business or procurement techniques, processes and systems;

and achieved outstanding outcomes [identify these outcomes].

3. **Innovation definition**

Comment on the applicability of the following innovation definition to this project:

"With respect to projects, innovation can be regarded as the application of

ideas for new or improved products (including materials, plant and equipment) and software, technologies, methods, practices and systems designed to benefit the project".

4. **Idea harnessing**

Comment on the following under idea harnessing:

- Use of brainstorming, scenario planning, risk assessment planning, life cycle costing, value engineering and value management;
- Exposing project team members to outsiders who have considerable knowledge;
- Seeking ideas from others who are not directly involved with the project;
- Receiving inputs from experienced personnel, key stakeholders, contractors and suppliers and fellow staff and workers;
- Engaging suppliers earlier on in the process;
- Following up on new research in the field of work; and
- Using best practices and using captured project learnings from completed projects.

5. **Relationship enhancement**

Comment on deliberate actions taken to enhance relationship between parties which may consist of partnering, alliancing, joint venturing, and other collaborative working arrangements.

6. **Incentivisation**

Comment on deliberate actions to improve incentivisation such as:

- Giving incentives or rewards;
- Being personally thanked by the top management;
- Being recognised by the peer group;
- Being presented an award or trophy; and
- Financial incentives such as salary increase, payment of a bonus and payment by company shares.

7. **Project team fitness**

Comment on deliberate actions taken to improve project team fitness such as:

- Creating a capable project team by appointing suitable team members and develop the team to undertake activities to enhance innovation performance;
- Appointing a project manager who recognises the importance of innovation

and has necessary skills and experience to lead the innovation facilitation process;

- Appointing a capable project team by recruiting technically knowledgeable and experienced project team members from diverse backgrounds;
- Developing the project team by inculcating team innovative culture and developing it as a high-performing team;
- Creating a team environment in which it is safe to speak up and take risks;
- Providing adequate supplies such as money, equipment, facilities, and time; and
- Creating a supportive and encouraging environment for the project team.

Comment on the client organisation on being innovative with all or some of the following characteristics:

- Trusting employees and providing them with a degree of freedom of thought and action with no blame culture, especially with regard to mistakes done in the process of innovation;
- Providing recognition, encouragement, support and robust incentives towards innovative activities;
- Providing opportunities for networking facilities within and outside the organisation;
- Top management showing its commitment to promoting innovation through their actions;
- Having a separate unit dedicated to promoting innovation in the organisation and a strong focus on knowledge management;
- Allocating funds for research and development;
- Organisation having processes to recognise and reward innovators; and
- Organisation having management systems to capture good ideas and monitor the progress of their implementation.

8. **Other innovation enabler category**

Comment whether there are any other categories to promote innovation not covered up to now.

The details of each individual interview and a summary of the information provided by interviewees with respect to model constructs are listed in *Sections 9.2.2 to 9.2.12*. The innovation level of each case study was categorised as low, moderate and high depending on the novelty and the impact of innovations.

9.2.2 Interview 1

This project was from the IT industry. It was for providing IT infrastructure and setting up a new operational centre for the police to control activities for an international sporting event. The interviewee was the project manager for the project. The client was the state police department. The interviewee was reluctant to give the cost of the project. However, being a very high profile project, cost could be high, running into several millions of dollars.

A reputed private company was selected by the Police Department to identify IT requirements, purchase hardware and software and install these in an operational centre to control the activities of this international sports event from a single location. The project was completed successfully three weeks ahead of the scheduled twelve months duration. It was also completed under budget. Several new technologies were introduced and used in the project. These included a new desktop system using new docking technology, high video camera technology and advanced video conferencing facilities.

The innovation level of the project can be considered as low to moderate. The project manager was an IT expert with over 30 years of industry experience.

When asked whether the project level innovation definition was applicable to this project, the interviewee agreed to the definition.

The interview was a telephone interview. The information given by the interviewee on model constructs are given below.

Idea harnessing:

Several idea harnessing techniques were used in the project. Brainstorming is one which has been used extensively. Another is the project learnings from another international event (not sport) done recently. In addition, suppliers were engaged early on to find ideas. Stakeholder meetings generated a large number of ideas as well. Ideas also came from the preparation of an extensive resource requirement list and technical panel forums with client representatives, technical experts and vendor representatives. Risk management was given a very high priority to minimise the risk of failure. The new ideas were tested through several practice sessions.

Relationship enhancement

There were ten people in the project manager's team. They had daily meetings where individuals were talked about the responsibilities and challenges. Both the project manager's team members and client representatives were highly motivated and focussed heavily on project success. There was harmonious relationship between parties. To prevent misunderstandings, which could adversely affect the strong relationships, special care was taken to explain technical aspects in layperson's language for those stakeholders who were not used to technical terms.

Incentivisation

No monetary or personal incentives were provided to team members. However, there was post project recognition. Idea generators and implementors received recognition within the team. Project milestones were celebrated by the team with the client. The CEO personally thanked the best achievers.

Project team fitness

The project team received good support from the parent organisation as well as from the client. Even the vendors provided extra support due to the high profile nature of the project. The project team was diverse consisting of male and female with different skill sets coming from the government, and external contractors. The project manager was strong on communication and teamwork, trying always to make the team happy. The parent organisation can be considered innovative, with the CEO personally encouraging innovation. Opportunities were available to upskill the staff with regular training. A good team environment existed where any idea could be discussed, and mistakes were tolerated.

When asked whether he could recommend any other categories, the interviewee was satisfied with the current categorisation.

9.2.3 Interview 2

The project belonged to the oil and gas industry. It involved the design and installation of a new mechanism to improve the seal of a gas pipeline to minimise the release of gas from a joint.

With the help of the operating staff, the interviewee designed, installed and tested a new mechanism to the gas pipeline to prevent leakage. This mechanism involved in sucking the released gas at the seal, mixing the gas coming from the pipe with nitrogen and connecting to the same pipeline (mixing with nitrogen counterbalanced the harmful effect of the released gas being contaminated with oxygen from air sucked at the seal). The cost of the project was about AUD50,000. While solving a significant deficiency of the system, this new device made considerable monetary savings to the company.

The innovation level of the project can be considered as low to moderate.

The interviewee was the Senior Reliability Engineer. He had over 15 years of engineering experience.

When asked whether the project level innovation definition was applicable to this project, the interviewee initially considered that the project involved was a re-design which was not included in the definition, but later agreed that it could be taken as new or improved plant/equipment, method or a practice or a technology, therefore, accepting the definition for the relevant project.

Idea harnessing:

Brainstorming was heavily used in this project. When the idea to improve the seal leakage came up, the improvement strategy was discussed with the team and there was a good support from the team to implement the selected process.

Relationship enhancement

The installation was carried out by the operators from another division. The good relationship the project manager had with the operator made the installation easier as there were many obstructions and delays to overcome.

Incentivisation

The self-motivation to improve the seal operation was a major incentive to do this work. However, the company had a culture of recognising innovative activities and awarding personal rewards (AUD250 each) which had an impact on the work completed.

Project team fitness

Although the client supported the project in general, there was no special attention given. No specific activities were done to strengthen the project team. However, the client did not discourage the project.

Although the project team fitness did not contribute specifically in this case, the interviewee agreed that project team fitness would have been a major component to promote innovation in his project.

When asked whether it is possible to identify any further innovation enabler categories, the interviewee was not able to suggest any further categories applicable to the project.

9.2.4 Interview 3

Interview 3 was about a project from the mining industry. The project envisaged providing a solution to constant breakdowns of moving machinery in an underground mine which were subjected to a dynamic situation of moving material.

In an underground mine, it was noticed that the plants working with moving material constantly broke down. It was necessary to come up with an improved mechanism to withstand conditions experienced around the wheels. A successful device was produced at a cost about AUD50,000 which took 12 months to perfect. The mechanism produced was novel to this type of machines. Within one year of perfecting this mechanism, the mine achieved the best output since it was opened, and the new device became popular in the industry.

The interviewee was the project manager who perfected this mechanism. He had over 35 years of mechanical engineering experience.

The innovation level of the project can be considered as moderate.

When asked whether the project level innovation definition was applicable to this project, the interviewee wanted to add risk mitigation to the definition.

The interview was a telephone interview. The information given by the interviewee on model constructs are given below.

Idea harnessing:

Faced with the need to find a solution to constant breakdowns, the interviewee realised that a modified version of the mechanism used in motorcycles could be used for the wheel drive. This mechanism was used in Japanese motorbikes. He gave this idea to the mechanics working under him who devised an improved mechanism that works in dynamic surroundings.

Relationship enhancement

There were five trade level people working on this project. The interviewee had very good relationship with them as he respected their ideas. The trade people in turn were very happy with the respect they were given and were highly motivated, always trying to contribute to the project.

Incentivisation

No monetary or personal incentives were provided to team members. However, the team realised that any solution could improve safety and enhance productivity in the mine. There was a risk of closing down the mine for a considerable period if no solution was found, endangering the jobs of many people working in the mine.

Project team fitness

The project team members were all highly experienced and knew what was expected and how to do the job in hand. The team received all the support for the project from the parent company. However, the interviewee was not sure whether such support would be extended to any other innovative project as this was a special case involving safety and productivity.

When asked whether he could recommend any other category, he said encouraging people is important.

9.2.5 Interview 4

This project was from the oil and gas industry. It involved designing and installing impact-proof gas pipelines in a liquid gas extraction and purification facility, 250 Km offshore. This gas facility had to be constructed to withhold impact from blasts such as rocket or gun fire as the facility was situated close to a small country with internal political problems.

This was an alliance project. The cost of the project was about AUD4 Billion. The project envisaged designing pipelines for the facility and the interviewee was the gas pipe design manager.

Although the total project, i.e. the construction of the gas extraction and purification facility, was over budget and completed late, this blast proofing was the first to be introduced to such a facility in Australia and therefore, was considered innovative.

The interviewee was the project manager for this task. He had 35 years of engineering experience.

The innovation level of the project can be considered as moderate to high.

When asked whether the project level innovation definition was applicable to this project, the interviewee replied yes.

The interview was a telephone interview. The information given by the interviewee on model constructs are given below.

Idea harnessing:

The following idea harnessing techniques were used in the project:

- Scenario planning, risk assessment planning, life cycle costing, value engineering and value management.
- Followed up on new research in the field of work.
- Used best practices and captured project learnings from completed projects.

Most of the piping design was done by a young graduate engineer with only three years' experience in the field. The interviewee talked highly about the creativity and enthusiasm of this young engineer.

Relationship enhancement

There was a very good team environment, open communication and freedom to talk. There were excellent relationships between members of all parties.

Incentivisation

No monetary or personal incentives were provided to team members. However, the company had a culture of personally encouraging and congratulating innovative staff.

Project team fitness

It was not possible to collect information on the project manager's role as the project manager was the interviewee. However, it was apparent that the encouragement given to the young engineer by the project manager has stimulated innovative work. The project team consisted of people from many countries making it a diverse team. They were technically knowledgeable and highly experienced. The parent organisation encouraged innovation.

When asked whether it was possible to identify any further innovation enabler categories, the interviewee was not able to suggest any further categories applicable to the project.

9.2.6 Interview 5

This episode is concerned with a project from the electrical power generation industry. It is to undertake turbine upgrade to improve the efficiency and to reduce greenhouse gas emissions of an Australian power station. The cost of the project was about AUD50 Million. The power station owner wanted a far superior design to be undertaken using modern technology to upgrade the turbines.

The interviewee was the project manager responsible for the turbine design. He had 35 years of engineering experience.

The innovation level of the project can be considered as moderate.

When asked whether the project level innovation definition was applicable to this project, the interviewee replied yes.

The interview was a telephone interview. The information given by the interviewee on model constructs are given below.

Idea harnessing:

Brainstorming was heavily used in idea harnessing. Prior to commencing the design, the power station sent its turbine designer to a foreign country to gather further knowledge and improve expertise which helped in gaining new ideas. The designers also discussed with several potential turbine manufacturers to find new ideas to be included in the design.

Relationship enhancement

There were excellent relationships with members of all parties.

Incentivisation

No monetary or personal incentives were provided to team members.

Project team fitness

The interviewee believed that the parent company was innovative. It has inculcated a culture where each employ considered innovation as their day-to-day duty. The company provided incentives for innovation from recognising innovators to giving promotions.

When asked whether he could recommend any other category for promoting innovation, the project manager was satisfied with the current categorisation.

9.2.7 Interview 6

This interview is on a project from the steel manufacturing industry. A blast furnace stove of a steel manufacturing plant had a section of a chimney badly damaged due to corrosion. The chimney was 70m high and the top 30m section had to be replaced with a new steel section. The project had a limited timeframe of 45 hours, the damaged section was about 27 Tonne heavy and the two sections needed to be connected about 40m. above ground, all of which were challenges to overcome. Due to these constraints, it was necessary to build a working platform 40m. above the ground. The normal practice of welding the two sections could not be done as it would take a long time. Also, there was the difficulty of holding the top section for a long time on air as the operation depended on wind conditions. Therefore, an alternative method of fixing with flanges had to be used.

The replacement work was done successfully without any undesirable incident. Although the scheduled completion time was 45 hours, the work was completed in 18 hours. The cost of the project was about AUD900,000.

The interviewee was the project manager for this task. He had over 35 years of mechanical engineering experience and worked for this steel manufacturer for over 20 years.

Innovation of the project was the use of a flanging method with gaskets to connect the old and new sections of the chimney, instead of welding. This is the first time that such a job has been done in the plant. The innovation level of the project can be considered as low to moderate.

When asked whether the project level innovation definition was applicable to this project, the interviewee replied yes.

The interview was a telephone interview. The information given by the interviewee on model constructs are given below.

Idea harnessing:

Two contractors worked on this project, a crane supplier responsible for lifting work and another contractor undertaking other work. These suppliers were engaged from the beginning to decide on the plan of action. Brainstorming was used extensively in meetings which involved the supplier representatives and the project team of the steel manufacturer. The idea of using flanges came during these brainstorming sessions. There were other associated problems discussed in these meetings and proper procedures were identified using risk management processes.

Relationship enhancement

There was an excellent relationship between the project team and the contractor teams. They worked harmoniously to make the project successful.

Incentivisation

No personal rewards or incentives were given to project personnel. The reputation was a high motivation for all including the contractors. As the project manager pointed out, the chimney could be seen many kilometres from the site, and they could not afford to be without a part of the chimney for any extended time.

Project team fitness

The project team members were all highly experienced and knew what was expected from them and how to undertake the work. The team received all the support for the project from the parent company. The project manager ensured good communication between parties. The ability to undertake detailed planning of the project manager also contributed to the success of the project. The parent organisation encouraged and supported new ideas.

When asked whether it was possible to identify any further innovation enabler categories, the interviewee was not able to suggest any.

9.2.8 Interview 7

This is another project from the mining industry. It involved repairs to a mill in a copper mine using a simple solution, making considerable savings to the miner.

In this copper mine, there were 6 mills operating. In each of these mills, there were frequent breakdowns due to the failure of a bolting arrangement. It was repaired with a flange arrangement. This has become an industry practice now, saving millions to mine owners.

The innovation level of the project can be considered as low.

The project manager was a mechanical engineer with over 35 years of industry experience.

When asked whether the project level innovation definition was applicable to this project, the interviewee wanted to add risk mitigation in the definition.

The interview was a telephone interview. The information given by the interviewee on model constructs are given below.

Idea harnessing:

Having seen the frequent breakdowns of mills due to a recurring problem, a tradesman came out with the new idea of a flange arrangement and informed the interviewee. The idea included redesigning the system with the inclusion of a flange and replacing the current system with the new system.

Relationship enhancement

The reason for the trade person to come out with the new idea and share with the interviewee was that the interviewee always had very good relationships with trade people as he respected their ideas.

Incentivisation

No monetary or personal incentives were provided to team members.

Project team fitness

The mine provided all the support for this project.

When asked whether it was possible to identify any further innovation enabler categories, the interviewee requested to consider risk mitigation as another enabling category.

9.2.9 Interview 8

This project belongs to the mineral processing industry. It involved improvement to the drive chain mechanism of a grinding mill used for mineral processing.

The interviewee, who was with over 20 years of experience in the area, worked as a mechanical engineer for a company manufacturing grinding plants for mineral processing industry. The cost of a plant was about AUD10 Million. These plants have been sold to many buyers across the world. It was noted that the bearings of the grinding machines attached to these plants were overheating, resulting in breakdowns. These machines were costly in the range of about AUD1.5 Million each. This problem was common to many machines produced by the company and correcting this problem was challenging. A team of experts from the company which made the machine, together with component suppliers tried to solve this problem. Interviewee was the project manager representing the company which produced the machine who was entrusted to solve this problem. He was operating from Australia and the machine to be repaired was located in South Africa.

After completing the project, it was possible to satisfactorily solve the problem, enhancing company reputation and improving client relationships. The project cost was about AUD400,000.

The innovation level of the project can be considered as moderate.

When asked whether the project level innovation definition was applicable to this project, the interviewee replied yes.

The interview was a face to face interview. The information related to the project is given below.

Idea harnessing:

The project team consisted of parts manufacturers from different countries. Most of the time they were connected via teleconferencing. Brainstorming was heavily used by the project team. Team members were given free opportunity to talk in a conducive environment. Many solutions were discussed and debated. Input from others who were not directly involved with the project was also sought.

Relationship enhancement

The relationship with the client was not good at the start, not knowing whether the manufacturer would undertake the repair under the product guarantee. Once this became clear, relationship improved. Other team members had good strong relationships with the project manager and the team.

Incentivisation

No monetary or personal incentives were given to team members. They all were motivated by the challenge to solve the problem.

The project manager's company had a scheme to recognise annual best projects and this was nominated as one of the entrants.

Project team fitness

The project teams were technically knowledgeable and experienced. They were from diverse backgrounds as they represented different component manufacturers from different parts of the world. The parent organisation provided adequate support such as money, equipment, facilities, and time for the project. The parent organisation had few characteristics of an innovative organisation, but there were no obstacles to the project.

When asked whether it was possible to identify any further innovation enabler categories, the interviewee was not able to recognise any further categories applicable to the project.

9.2.10 Interview 9

The project for the Interview 9 is also from the IT industry. It is for providing IT infrastructure facilities to a new building of a leading bank. The interviewee was the project manager for the project who was from a leading telecommunication company. The cost of the project was AUD7 Million, considered high in the context of IT projects.

The client wanted the new building to be furnished with an IT system that eliminates the traditional concept of fixed office table approach. With the new system, desks would be provided in an open office environment, but would not be allocated to individuals. Anybody can sit in an unoccupied desk and would be able to use his or her laptop computer using cloud connection system. The connection would be available all throughout the office space, even in the cafeteria. This technology was new to the client and to the parent organisation of the provider. It was a performance-based contract where the client provided the performance requirements and the contractor was to design and build the system. The project was completed within the stipulated time and within cost limitations. Several new technologies have been introduced and used in the project.

The project manager was an IT expert with over 15 years of industry experience.

The project could be described as a moderately innovative project.

When asked whether the project level innovation definition would be applicable to the project, the interviewee agreed to the definition.

The interview was a telephone interview. The information given by the interviewee on model constructs are given below.

Idea harnessing:

Several idea harnessing techniques were used in the project. Brainstorming is one which was used extensively. Subject experts from the parent organisation held several meetings to identify the approach to solve the problem. These experts had considerable external and overseas experience including best practices in the industry. The parent company provided opportunities for them to travel overseas to get international exposure, in addition to gaining an understanding of best local practices. The company also held frequent trade exhibitions attended by vendors who provided details about their up-to-date IT systems. In addition to subject expert meetings, there were meetings with vendors about possible solutions to challenges to the project.

Relationship enhancement

There were about 50 people in the project manager’s team. They were diverse people from different backgrounds (from different countries as well). Both the project manager’s team members and the client representatives were highly motivated and focussed heavily on project success. There were harmonious excellent relationships among all.

Incentivisation

Both monetary and personal incentives were provided to best performers. In addition, the best performers received pay increments, travel opportunities and other forms of rewards and incentives.

Project team fitness

The project team received good support from the parent organisation as well as from the client. The project manager was highly skilled in communication and teamwork, trying always to make the team happy. He was approachable. A good team environment existed where any idea could be discussed within a no-blame environment.

When asked whether he could recommend any other category, the interviewee was satisfied with the current categorisation.

9.2.11 Interview 10

The project concerned with this episode is from the electricity generation industry. It is on measuring greenhouse gas emissions from a coal power station. The interviewee was directed to implement a plan to measure greenhouse gas emissions from the power plant. This is the first time that such a measurement is taken at this power plant and therefore, could be considered as novel. The interviewee was the project manager for the project, who had a PhD with 20 years' experience in the industry. The cost of the project was about AUD50,000. The innovation level of the project could be considered as low to moderate.

When asked whether the project level innovation definition was applicable to this project, the interviewee said that it appeared to be too long.

The interview was a telephone interview. The information given by the interviewee on model constructs is given below.

Idea harnessing:

The project manager devised the original idea to use up-to-date equipment for measuring the emissions. This plan was improved by a young engineer with only one years' experience. The project manager was pleased with the role played by the young engineer in perfecting and implementing the idea and the level of motivation shown by the engineer. The plan was checked by the experts in the head office of the company and was given the approval to proceed with. The ideas for designing the project came from talking to personnel experienced in the subject area and looking for best practices elsewhere. The discussions with potential equipment suppliers also helped.

Relationship enhancement

The was done by a group of three persons. There was harmonious relationship between them as with stakeholders, including the top management of the company.

Incentivisation

There were no rewards and incentives, but the top management praised the efforts of the team for their good work.

Project team fitness

The project team received good support from the parent organisation. The project manager concentrated on open and honest communication, encouraging and receiving high performance from the team. A good team environment existed where any idea could be discussed within a no-blame environment.

When asked whether he could recommend any other category, the interviewee was satisfied with the current categorisation.

9.2.12 Interview 11

This project is from the IT area. It envisages establishing a cloud-based correspondence management system for a city council. The council already had a locally operated correspondence management system which is to be transferred to a cloud-based system. The reason is to minimise the cost of operating the system and reducing the need for having specialists in that area. The interviewee was the project manager for the work and was a consultant to the council.

The project was new to the council as there was no cloud-based correspondence system before. It required the use of new software and equipment. The council had a preferred service provider to maintain the system once completed. The cost of the project was around AUD600,000. The project manager had over 15 years' experience in the area.

The project considered to be low to moderately innovative.

When asked whether the project level innovation definition was applicable to this project, the interviewee agreed.

The interview was a telephone interview. The information given by the interviewee on model constructs are given below.

Idea harnessing:

The ideas for the project came from the potential service provider, internal consultants and the owner representatives through brainstorming. As the proposed system needed to align with the service provider's operating systems, not much of new ideas were needed.

Relationship enhancement

There were strong relationships between the team members and stakeholders. Team building exercises were done regularly to improve the relationships.

Incentivisation

There were no rewards and incentives provided to the team. Most of the members of the project team were contractors. The promise of giving them a new project was an incentive used in the project.

Project team fitness

The parent organisation was innovative with a structured program to promote innovation and recognise innovation promoters. A good support was received from the parent organisation. The project manager was experienced who had good technical knowledge and skills. The project manager's technical knowledge and skills helped the project but, at the same time, took away time from project manager duties. The project manager had good communication skills providing easy access to project personnel.

When asked whether he could recommend any other category, the interviewee was of the opinion that measuring the progress under each category needs to be done.

This completes the last interview conducted. The results from the interviews are discussed next.

9.3 Discussion of results

Table 9.1 provides a summary of projects used in the interviews.

Table 9.1 Summary of projects used in the interviews

Interview no.	Industry	Project
1	IT	Setting up of a new operational centre for the police to control activities for an international sporting event.
2	Oil and gas	Designing and installing a new mechanism to improve a seal of a gas pipeline to minimise the

		release of gas from a joint.
3	Mining	Providing solutions to constant breakdowns of moving machinery in an underground mine which were subjected to dynamic situation of moving material.
4	Oil and gas	Designing and installing impact-proof gas pipelines in a liquid gas extraction and purification facility, 250 Km offshore.
5	Electrical power generation	Designing the turbine upgrade to improve the efficiency and to reduce greenhouse gas emissions in an electricity power generation facility.
6	Steel manufacturing	Planning and undertaking the replacement of a 30m. section of a 70m. high chimney of a blast furnace stove of a steel manufacturing plant.
7	Mining	Undertaking a major repair to a mill in a copper mine.
8	Mineral processing	Improving a drive chain mechanism of a grinding mill used for mineral processing.
9	IT	Providing IT infrastructure to a new office building of a leading bank.
10	Electricity generation industry	Measuring greenhouse gas emissions from a coal power station.
11	IT	Establishing a cloud-based correspondence management system for a city council.

It was noticed that unlike in construction projects, the role of the contractor is diluted in IT projects, the tasks of which is generally performed by the project manager with the help of service providers. In mechanical engineering projects, innovative activities were mostly depended on the motivation of trade level people.

In these interviews, the participants were requested to select one of their most successful projects to comment on. One of the first few questions was to comment on the applicability of the project level innovation definition to the selected project.

The interviewees agreed that the definition was acceptable to their projects, except for one interviewee, who said that risk mitigation needs to be included in the definition.

The inclusion of risk in the project level innovation definition has been discussed under *Section 2.9.2* - Discussion on the proposed definition. It was decided to exclude the mention of risk in the definition due to a number of reasons which have been given in the above section. Another participant said that the definition was too long, but did not offer suggestions to shorten it. The proposed definition has been arrived at through a careful study with inputs from a number of experts. The length of the definition has not been a concern to all except one. As there was no suggestion how to shorten it, the definition was kept unchanged.

The innovation enablers of projects as mentioned by interviewees are discussed below, separately under each model construct.

Idea harnessing

Brainstorming seems to be the most popular idea generation technique used as revealed in interviews. Use of service providers early during the planning stage as an idea source, was also practiced by many. There was one special case where the challenge of finding solutions to a problem forced the interviewee to look ‘outside the box’. In this case, the interviewee was able to find the solution to a mining plant breakdown in a mechanism used in a motorcycle. There was another case where one power station owner has gone to the extra distance by sending the turbine design engineer to study abroad in order to incorporate up-to-date techniques in the design to upgrade the plant. All this point out that idea harnessing is a major category when considering innovation enablers in projects.

Relationship enhancement

None of the projects mentioned by interviewees had poor relationships between parties, suggesting that relationship enhancement is an essential ingredient for successful projects. Most projects in the area of mechanical engineering had a strong innovation input from operational level staff. The strong relationships the project manager had with the operational level staff seem to have created opportunities for innovative outcomes.

Incentivisation

As was the case with previous projects considered during the validation process, none of the interviewees mentioned about providing personal incentives or rewards for innovation except in one occasion. This supports the previous conclusion that it is not the general practice in Australia to provide personal incentives or rewards to encourage innovative outcomes. However, there were cases where the parent company recognised and encouraged innovation through actions such as annual awards.

Project team fitness

In all the projects mentioned, there has been good support from the parent organisation. The team members involved in these projects seemed to be well-experienced and extra training was not mentioned. There were cases where the project team consisted of diverse persons, sometimes drawn from different parts of the world. Two case studies showed that young members of the project team played a significant role in identifying and perfecting new ideas, and implementing them.

Although the project managers were interviewed, it could be seen that the project manager attributes have contributed to innovative outcomes. These included encouraging innovative activities, building strong relationships with project personnel, respect to and listening to project personnel, and good communication and planning skills.

After completing the interviews on innovation enablers, the interviewees were then asked to suggest any other major categories that they could identify which were not considered during the interview. Only one interviewee identified risk mitigation to be a category. Risk mitigation is accommodated in two constructs of the model: one in idea harnessing and the other in project team fitness. Risk analysis and risk mitigation should be essential tasks when implementing new ideas. In project team fitness, it is an essential task of the parent organisation to establish advanced risk management procedures in the organisation for innovation to thrive. Therefore, it is not necessary to include risk mitigation as another category.

With the above findings, it can be concluded that:

- The innovation definition developed in the study can be applied to any project, irrespective of the project area; and
- The model developed in the study to describe client-led innovation enablers for construction projects may be applied to any project, irrespective of the project area.

The following evidence also suggested the general applicability of the model:

- None of the model constructs are specific to the construction industry and can be applied to projects in general;
- One of the cross-checks used when testing the conceptual model was to investigate the innovation process at workplace situations, identify the drivers that contribute to workplace situation and translate the findings to construction project situations. It was noticed during this process that none of the drivers were specific to construction projects, suggesting that they could be applied to any project; and
- The definition of project level innovation does not depend on the type of project and is generic in nature.

Although it can be argued that it is not possible to come to the conclusion that the conceptual model can be applicable to any project just by going through a few projects. However, the fact that the model was developed using the fundamental research findings on workplace creativity and innovation, which has no bearing on the type of project and tested with construction projects and projects outside the construction industry is strong enough to assume that it can be applied to projects in general.

There is current thinking among some scholars that contemporary project management practices lead only to achieving limited outcomes and therefore, fresh approaches need to be found to enhance project outcomes. The simple model and the resulting simple framework to enhance project outcomes found in the research could be the perfect answer to this dilemma which will be discussed next.

9.4 Achievement of project success

In order to discuss whether current project management approaches are capable of achieving project success, it is necessary to look into what factors contribute to project success.

9.4.1 Project success

Project success (or failure) is a comparative term which can be interpreted by different parties in different ways. For example, citing other researchers, Mir and Pinnington (2014) have identified the following different ways of measuring project success:

- Measuring the success in the implementation process, the perceived value of the project and client satisfaction with the result.
- Measuring project success across the four dimensions of meeting planning and design goals, customer benefits, benefit to the developing organisation.
- Dividing project success into three categories: doing the process right, getting the system right and getting the benefits right.
- Assessing project success according to short-term and long-term project objectives including efficiency (meeting schedule and budget goals), impact on customers (customer benefits in performance of end products and meeting customer needs), business success (project benefits in commercial value and market share) and preparing for the future (creating new technological and operational infrastructure and market opportunities). (Mir & Pinnington 2014).

Many researchers such as Baccarini (1999), Dulaimi et al. (2003), Dulaimi et al. (2005), Eaton et al. (2006), Gambatese and Hallowell (2011), Lu and Sexton (2006), Ozorhon (2012), Panuwatwanich (2008), and Shenhar et al. (2001) have identified general factors that contribute to project success. Combining the findings of the above researchers, Fernando et al. (2015) compiled the following list:

1. User and stakeholder considerations: solving a customer’s problem, fitness for use, satisfying stakeholders and user needs, creating user happiness and loyalty, providing positive economic impact to surrounding community.
2. Firm level considerations: increased revenues, profits and market share, competitive advantage and market impact, enhanced reputation, higher diversification, increased capabilities, creation of new opportunities for new products and markets.
3. Project execution level considerations: meeting owner’s needs, decreased time and cost, higher quality, higher project efficiency and productivity, meeting functional performance, meeting technical specifications, reduced waste and sustainable outcomes.
4. Organisational level considerations: content project team, job satisfaction and personal development of team members, positive organisational and professional learning, increased organisational effectiveness and

commitment, higher organisational motivation.

The above list can be improved further by replacing the word ‘firm’ by ‘business’, taking ‘reduced waste and sustainable outcomes’ to the category of user and stakeholder considerations, adding a new item ‘reduced greenhouse gas emissions’ to the user and stakeholder considerations group and making some changes to the wording. The new project success consideration list is given below.

1. Project execution level considerations: meet owner’s needs; decrease time and cost; achieve higher quality, higher project efficiency and productivity; meet functional performance; meet technical specifications.
2. User and stakeholder considerations: solve customer’s problem; achieve fitness for use; satisfy stakeholders and user needs; create user happiness and loyalty; provide positive economic impact to surrounding community; reduce waste; improve sustainable outcomes; reduce greenhouse gas emissions.
3. Business level considerations: increase revenues, profits and market share; increase competitive advantage and market impact; enhance reputation; achieve higher diversification and increased capabilities; achieve creation of new opportunities for new products and markets.
4. Organisational level considerations: achieve content project team, job satisfaction and personal development of team members; achieve positive organisational and professional learning; increase organisational effectiveness and commitment; achieve higher organisational motivation.

This clearly shows that the factors that are currently being considered as project success are not confined only to those related to scope, time, cost, quality, and risk. Supporting this view, Shenhar et al. (2001) noted that the project management success criteria of time, cost and performance are subordinate to the higher product success of goal and purpose. As noted by Egemen and Mohamed (2006), the traditional assumption that clients only need projects which are completed within budget, on schedule and with a reasonable quality should start to change. The question arises whether the current project management practices are capable of achieving these successes.

9.4.2 Project success and contemporary project management approaches

It is apparent that the project success is still looked from achieving limited outcomes by some popular project management approaches used in managing construction projects such as the approach of the Project Management Institute of USA. In its 6th edition, PMBOK covers the knowledge areas of time, cost, quality, procurement, human resources, communications, risk management and stakeholder management (PMI 2017). Referring views from the 1950's, Atkinson (1999) noted that after 50 years it appears that the definitions for project management continue to include a limited set of success criteria, namely the Iron Triangle of cost, time and quality. He argued that this emphasis and the rhetoric which has followed over the last 50 years supporting those ideas may have resulted in a biased measurement of project management success and could be the problem to realising more successful projects. Supporting this view, Shenhar et al. (2001) noted that one of the most common approaches to project success has been to consider a project successful when it has met its time and budget goals. Although this may seem true in some cases—and appropriate in the short run when time to market is critical—there are many examples where this approach is simply not enough. Quite often, what seemed to be a troubled project, with extensive delays and overruns, turned out later to be a great business success (Shenhar et al. 2001). Mir and Pinnington (2014) added further stating that projects differ in size, uniqueness and complexity, thus the criteria for measuring success vary from project to project making it unlikely that a universal set of project success criteria will be agreed. Traditional project management systems which exclusively pursue the success criteria of cost, time, quality and meeting technical requirements have become considered ineffective (Mir & Pinnington 2014).

9.4.3 The need for incorporating innovation

Many scholars have recommended the use of innovation to achieve enhanced benefits in projects. Commenting on adopting innovation into construction projects, Murphy et al. (2011) noted that the current strategy of relying on project management activities has been found faulty by many due to the over-reliance on strict project control and evaluation methods, around which construction operates which often serves to stifle innovation. They recommended that projects attempting to deliver innovation must be innovation driven rather than project driven; therefore, project management and innovation management must be mapped and delivered as a single strategy (Murphy et al. 2011).

Commenting on the importance of innovation in construction projects, Tawiah and Russel (2008) noted that the delivery of infrastructure projects as long-term capital investments is impacted in most cases by critical issues of budget constraints, program delays, quality and safety concerns, and an increasingly complex stakeholder environment. Innovation, as it relates to the physical, process, organisational/ contractual, and financial/ revenue dimensions of a project, has a central role to play in not only contributing to the requirements set for a wide variety of project performance metrics but also improving upon them (Tawiah & Russel 2008). Newton (1999) went even further stating that innovation has been advanced as the fourth dimension of competition in construction, along with cost, quality and time.

Innovation benefits all types of projects. However, some types of projects receive more benefits than others from innovation management. Shenhar et al. (2001) has categorised projects into the following:

1. Low-technology projects, which rely on existing and well-established technologies, such as construction, road building and “build to print” projects, where a contractor rebuilds an existing product;
2. Medium-technology projects, which rest mainly on existing, base technologies but incorporate some new technology or feature. Examples include industrial projects of incremental innovation, as well as improvements and modifications of existing products;
3. High-technology projects, which are defined as projects in which most of the technologies employed are new, but existent, having been developed prior to project initiation, such as developments of new computer facilities, or many defence developments;
4. Super-technology projects, which are based primarily on new, not yet existent technologies, which must be developed during project execution. This type of project is relatively rare and is usually carried out by only a few (and probably large) organisations or government agencies.

All these categories can benefit from innovation. However, as the hierarchy goes up, more benefits can be achieved through innovation as the requirement for new knowledge is increased. Most of the construction projects falls into the lowest category of low-technology projects due to the reliance of existing and well-established technologies. Many researchers have identified potential benefits to construction projects from innovation as shown previously in *Section 1.2.1*. If low-technology projects such as construction projects benefit from innovation, the benefits to higher order projects can be even higher.

It is also interesting to explore how innovation brings in benefits to projects. For this, it is necessary to look at the fundamental characteristics of innovation. Innovation is closely related to creativity. Creativity, in general, means the ability to combine ideas in a unique way to make unusual associations between ideas. Innovation is the process of taking a creative idea and turning it into a useful product, service, or method of operations (Robbins 1994). In other words, facilitation of innovation means providing opportunities to generate beneficial ideas and implementing them. As there is no limit to the scope of ideas, they could include the ideas contributing to achieve the 'iron triangle' considerations of time, cost and quality and all the other success considerations discussed above.

Therefore, it can be concluded based on the evidence presented, that the contemporary project management approaches are incapable of meeting the expectations of current project owners and the solution to this is the use of innovation management. It is suggested to integrate innovation management in contemporary project management approaches for enhanced project outcomes.

9.5 Chapter summary

Having observed strong evidence that the model and the framework developed for the client-led innovation enablers for construction projects could be applied in general, it was investigated in this chapter whether or not that the findings could be applied for all projects, irrespective of the project area.

By adopting the research strategy of examining projects in areas other than the construction industry, eleven project managers in areas such as mining, oil and gas, IT, and power generation were interviewed to assess the applicability of the study results to other project management areas. The same interviews were also used to assess the applicability of the innovation definition developed in this research, on other projects. The research method used here was a single case study using a single information source through interviews of project managers.

Having examined the interview results, the following conclusions were made:

1. The project level definition holds true for any project, irrespective of the project area; and
2. The conceptual model and the framework developed can be applicable to any project, irrespective of the project area.

The attention was then focussed on how these findings can be utilised to enhance outcomes in projects in view of claims by some scholars that contemporary project management approaches only concentrate on selected project outcomes. This was examined first by looking at the meaning of project success and then on the achievement of project success through contemporary project management approaches. It was concluded that the contemporary project management approaches are unable to achieve most of the project successes required by clients nowadays and new approach based on innovation using the developed model and the framework is required.

9.5.1 Way forward

Nowadays, clients are not satisfied with the short-term benefits associated with conventional project management approaches such as achieving time, cost and quality objectives. They look for more such as long-term successes that benefit users, stakeholders and their own organisations. As pointed out by many scholars, the answer is to use innovation management. This research has simplified the approach to innovation management in projects enabling the integration of project management and innovation management.

CHAPTER 10
CONCLUSIONS & RECOMMENDATIONS

10.1 Chapter overview

This is the last chapter of the thesis. It provides a summary of how the research was conducted, gives major findings and recommendations, and makes conclusions. It starts with an overview of the research conducted, which includes the research objectives and scope, methodology and design. It also discusses the processes adopted to enhance research credibility.

This is followed by a discussion on major findings, systematically from the comparative analysis, literature review, statistical analysis, case studies and generalisation. The development of a definition for project level innovation is mentioned together with the recommendations for both clients and policy makers.

It also focuses on research contributions; especially to the body of knowledge, to industry practitioners and to the sustainability and prosperity of the world. The chapter and the thesis conclude with a section on study limitations and future research directions.

An overview of the research direction is discussed first.

10.2 Research overview

The research was undertaken to study the actions that clients can take to enhance innovative outcomes in construction projects. Clients are increasingly conscious of achieving additional benefits from their construction projects and do not restrict their thinking to traditional time, cost and quality outcomes. The new role of the construction client is that of innovation co-creator in which the client plays the pivotal role of diminishing the barriers which exist under the traditional procurement method's hierarchy and inducing the construction project stakeholders to work closely and collaboratively to co-create innovation (Al-Tayeh 2017). In this context, it is vital for clients to have a simple tool to identify the actions that they can take to promote innovation, and the research fulfilled this necessity.

10.2.1 Research objectives and scope

The following were the research objectives examined in this study:

1. To explore clients' influence in promoting innovation in their construction projects;
2. To explore actions that construction clients can take to promote innovation in their projects;
3. To group these actions (also called innovation enablers) into major categories for easy identification and deliberation;
4. To develop a model that encapsulates the above identified constructs and uncovered relationships which can be used to depict the mechanisms of enhancing innovation promotion in construction projects;
5. To empirically-test the model using the data from Australia;
6. To validate the developed model through case studies of selected construction projects; and
7. To contribute knowledge to the research area of project level innovation in the context of construction industry, and to provide practical recommendations for clients and policy makers to use in promoting innovation in construction projects.

At the commencement of the study, it was decided that these objectives were to be explored within the following boundaries:

1. Only the data from Australia to be used to test the conceptual model;
2. The research to cover all the phases in a construction project except the maintenance phase. However, major rehabilitation work which may require innovative solutions were to be included.
3. Residential construction activities were not to be considered in the study.

The objectives of the research were translated to the following research questions at the commencement of the study:

RQ1: Is it possible for clients of construction projects to influence promoting innovation in their projects?

RQ2: If this is possible, what actions can construction clients take to promote innovation in their projects?

RQ3: Is it possible to group these actions (also called innovation enablers) into major categories?

RQ4: If possible, what are the enabler categories?

RQ5: What are the relationships of these categories with innovative performance?

RQ6: Do these categories have relationships among themselves?

However, after completing the study, there was evidence to suggest that the model developed could be applied to any project, irrespective of the project area. With this observation, an additional research question was added, i.e. whether the model developed can be applied to projects in general and the boundary was expanded to test the model for projects of any discipline or industry area.

10.2.2 Research methodology and design

This research is in the social science area under the sociology group. A mixed method research approach was used, combining quantitative and qualitative research techniques, methods and approaches. The research focussed on client-led innovations in construction projects. It searched for explanations of human action by understanding the way in which the world is understood by individuals, thus situating in the research paradigm of interpretivism. With regard to epistemology, the research used the anti-positivism position. The use of the knowledge and experience of industry practitioners within the context of construction innovation gave a value-laden aspect to the research in respect of axiology.

The research design adopted at the commencement of the study included the following:

1. Compilation of knowledge using a literature review to ascertain the knowledge gap and identify research questions;
2. Development of the conceptual model based on the knowledge gathered;
3. Development of a questionnaire for the survey (primary data collection);
4. Conduct of the questionnaire survey in Australia;
5. Conduct of a descriptive data analysis to describe the characteristics of the survey sample;

6. Conduct of further statistical analysis to refine the conceptual model for the Australian-specific data;
7. Use of the case study approach to validate (or not) research findings;
8. Comparison of the conceptual model and the refined model (i.e. Australian-specific model) and reaching conclusions; and
9. Provision of recommendations.

After undertaking this procedure, it was realised that the model developed can be used for any project and the research was extended to test the model using case studies from practitioners in disciplines outside the construction industry. The final research design, which includes this generalisation of the model that was adopted, is given in *Fig. 10.1*.

Undertaking a study of this nature requires credibility which in turn requires considerable effort using cross-checks. The actions taken to improve the credibility are discussed next.

10.2.3 Enhancing research credibility

As Macal (2005) pointed out, unlike physical systems, for which there are well established procedures for model validation, no such guidelines exist for social modelling. In the case of models that contain elements of human decision making, validation becomes a matter of establishing credibility in the model. Some of the efforts taken in this study to improve its credibility are discussed below.

Conceptual model formulation

The conceptual model was developed based on a comprehensive literature review, which involved studying over 300 publications, most of which were journal papers. Notwithstanding the comprehensive literature review, the model constructs were tested through an insight into fundamental research on how innovation occurs in workplace situations. This was done by examining fundamental motivations contributing to workplace innovation and interpreting them in the context of construction projects. Executing construction projects is yet another workplace situation and the findings were in total agreement with the model developed using the comprehensive literature review. In addition to testing with this approach, input from highly experienced industry experts was also sought to enhance the credibility. This testing supported the validity of the conceptual model.

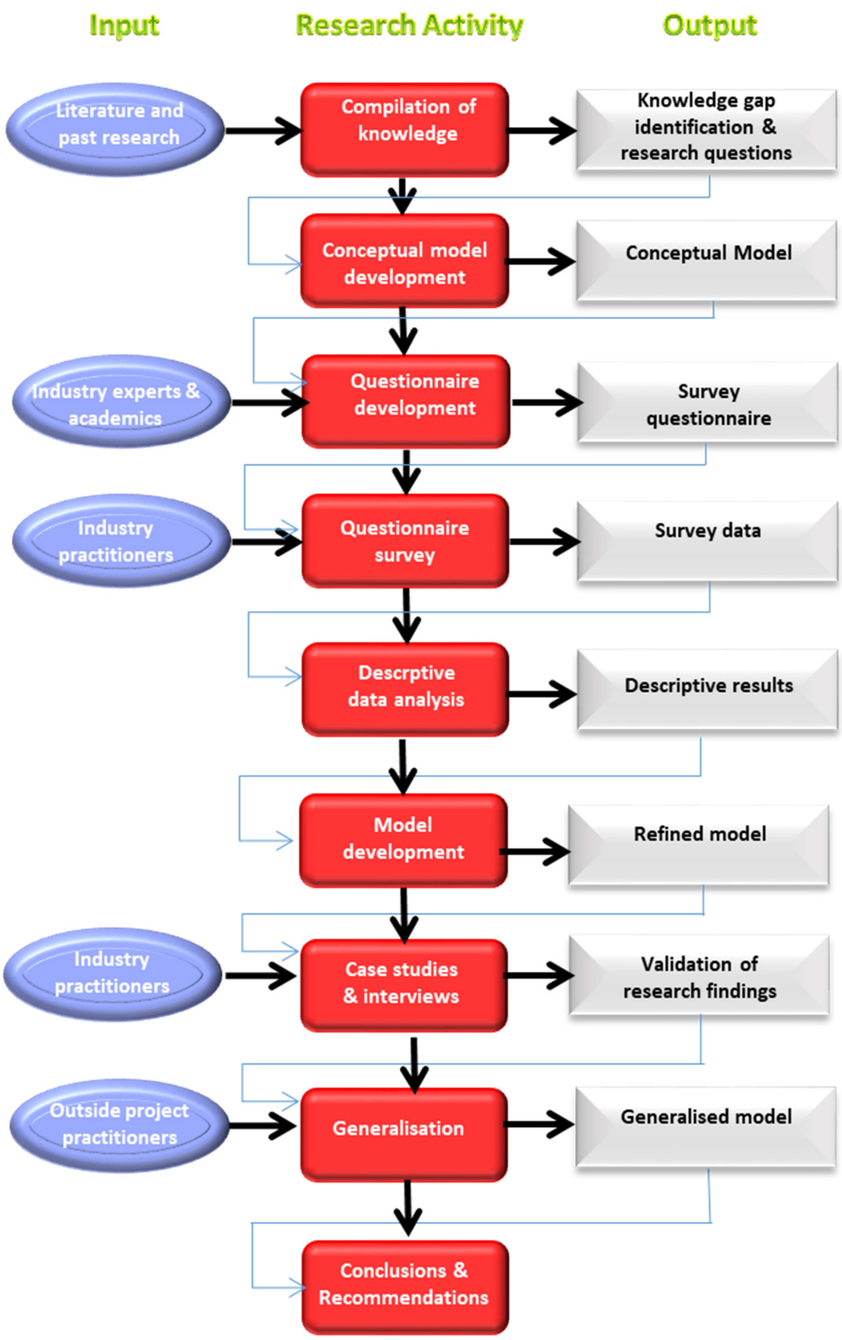


Figure 10.1 Adopted research design

With a large number of references reviewed and many practitioners interviewed, not a single action of a client or client's project team was identified that can be categorised outside the conceptual model constructs which provided further proof to the validity of the conceptual model. During the generalisation phase, the interviewees were specifically asked whether they could identify any group outside the categories represented by conceptual model constructs. Although some identified different areas, they could be grouped under model constructs, also validating the conceptual model constructs.

Statistical model formulation

The statistical model was developed by subjecting the survey data to a rigorous statistical analysis, ensuring a high degree of statistical certainty of variables used in the analysis.

The general model (i.e. the conceptual model) and the refined Australian-specific model were both validated using real world conditions through case studies. A further validation was achieved when the general model was tested with the input of project managers from areas outside the construction industry.

Development of a definition for project level innovation

The development of the definition for project level innovation was done after carefully examining a large number of innovation definitions and the factors considered by other scholars when defining innovation. The definition developed was tested with a number of experts in the construction industry. It was further tested later with a number of project managers outside the construction industry. All these actions validated the accuracy of the definition.

The above facts show that the research is robust with multiple testing and verification points.

10.3 Major research findings

The literature review, statistical analysis, case studies and generalisation helped discover several findings beneficial to the academic community, industry practitioners and policy makers. The major findings are given below.

10.3.1 Findings from comparative analysis

The statistical analysis undertaken on the Australian survey data revealed the following regarding construction projects:

- The level of innovation in Australian construction projects is considered moderate.
- Most clients resort to traditional form of contracts.
- Clients are less inclined to provide personal rewards/incentives to improve

the innovative performance of contracts.

The following findings resulted from comparing subgroups in the data set.

Comparison between public and private sector organisations:

- Private sector performance is better in all innovation enabler categories except for the relationship enhancement.
- Public sector clients perform better in relationship enhancement.

Comparison between delivery types:

- Design, Bid and Build (the design and construction by one party) delivery types perform better in idea harnessing, closely followed by collaborative contracts (the delivery using collaborative contracts such as alliance and Early Contractor Involvement Contracts).
- Design and Build (the design is done by one party and the construction is carried out by another party after completing the design)delivery types perform poorly in relationship enhancement.
- Collaborative contracts provide greater incentivisation.

Project cost comparison:

- As the project is costing more, the performance under each innovation enabler category gets better.
- Most remarkable improvement is seen in idea harnessing.
- However, the improvement of relationship enhancement is marginal.

10.3.2 Development of a definition for project level innovation

The research enabled the development of a definition for project level innovation, for the first time. This definition can be used for any project, irrespective of the discipline or the project area. The following is the definition for project level innovation:

> *"With respect to projects, innovation can be regarded as the application of ideas for new or improved products (including materials, plant and equipment) and software, technologies, methods, practices and systems designed to benefit the project".*

10.3.3 Findings from the literature review

The literature review clearly provided evidence that clients have a strong influence in promoting innovation in their construction projects. It was possible to identify several actions that clients can use to promote innovation. They are included in the list given under *Section 10.4*. It was possible to group these actions under the following categories:

1. Idea harnessing (strategies for the generation of new and beneficial ideas and their implementation);
2. Relationship enhancement (employing actions to improve relationships between parties to a project);
3. Incentivisation (providing incentives/rewards to promote innovative activities); and
4. Project team fitness (deliberate actions taken to strengthen the project team and improve its ability to focus on innovative activities).

In addition, the literature review provided evidence of relationships between these categories and innovative performance, and of relationships between the categories, thus enabling the development of a model that depicts client-led enablers that promote innovation in construction projects. This model, named the conceptual model, is reproduced as *Fig 10.2*. It was revealed that this model could be used by any party such as the client, project manager, designer or the contractor.

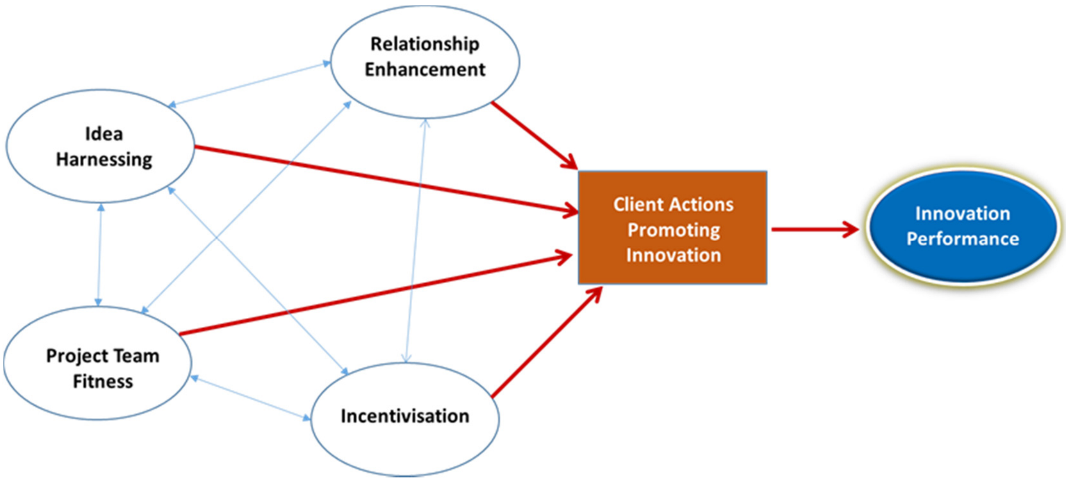


Figure 10.2 Conceptual model

10.3.4 Findings from the statistical analysis

The analysis revealed that the importance given to incentivisation in Australian construction projects is low. It is not known at this stage, whether this particular characteristic, i.e. less attention paid to incentivisation, is specific to Australia or not. However, there is some evidence to suggest that Australia is not a leader in innovation, especially in the construction industry. For example, Na et al. (2006) found that countries such as Australia, Canada, Japan, and the United States experience lower than expected rates of construction innovation. In fact, Australia is not considered to be a leading innovative nation. In 2018, the Global Innovation Index (produced by the World Intellectual Property Organisation and partner organisations) ranked Australia 20 of 126 countries (Dutta et al. 2018).

The statistical analysis using the factor analysis and the correlation analysis enabled the development of a model for Australian construction projects (as the data used were exclusively from Australia) which was named the Australian-specific model (reproduced in *Fig. 10.3*). Although they looked different to each other, the Australian-specific model contained all the constructs identified in the conceptual model.

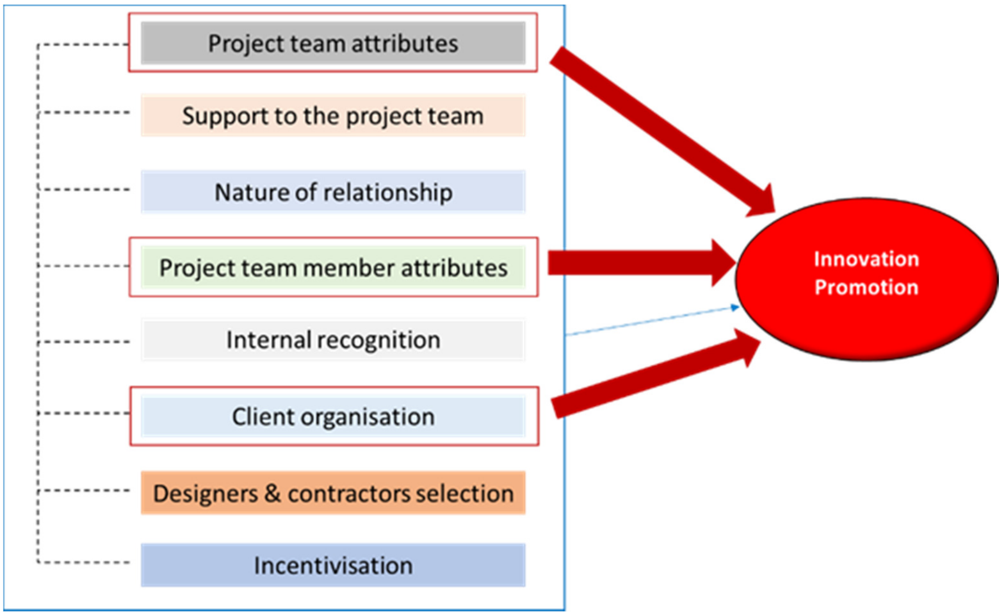


Figure 10.3 Australian-specific model

10.3.5 Findings from validation

The case study approach was used for validation purposes. These case studies validated that clients have a strong influence on the promotion of innovation in their construction projects. They identified a number of additional actions that construction clients can use to promote innovation in their projects. These actions are given in *Section 10.4* together with the actions identified during the literature review stage.

The four case studies validated both models and highlighted the deficiency that Australian clients do not pay much attention to incentivisation. It would have been more appropriate if a few projects were selected from outside Australia to check whether this deficiency is a characteristic only prevailing in Australia or not. However, due to practical limitations, it was not possible to do this. Even if a few projects outside Australia had been selected, the deficiency would not have been investigated properly, as it would require the consideration of a large number of projects from different countries.

In general, the case studies showed that a major driver for innovation in construction projects in Australia is the challenge due to constraints.

Case studies consisted of the following contract types: Design and Build; Cost Plus; Double ECI (this was defined under *Section 8.4.4* Case Study 4.); and Public Private Partnership (PPP). Out of these contract types, PPP seems to generate more innovative solutions due its collaborative relationship between parties. Double ECI contract types contribute to more design innovations due to the competitive nature of the delivery type as the motivation of bidders is to win the contract. Buying the design of the unaccepted tenderer also contributed in innovative ideas.

10.3.6 Findings from generalisation

As there was evidence that the conceptual model can be applied to any project irrespective of the project area, eleven project managers were interviewed outside the construction area to verify this possibility. Findings from the generalisation supported the notion that the conceptual model can be applied to projects in general, irrespective of the project area. The only change necessary is a name change from 'owner organisation' to 'parent organisation' when considering activities related to project team fitness. This leads to a major finding that the simple groupings found in the study, namely idea harnessing, relationship enhancement, incentivisation and project team fitness, could be used by project managers to seek ways of enhancing outcomes from projects, previously limited mainly to a few goals such as time, cost, quality, scope, risk and sustainability due to the reliance of established project management approaches. It is now possible to integrate project management and innovation management to derive much greater outcomes from projects.

10.3.7 Model comparison

While the conceptual model is universally applicable, the Australian-specific model shows Australian specific characteristics. Although they looked different to each other, the Australian-specific model contained all the constructs identified in the conceptual model. *Figure 10.4* shows the relationships between the constructs of the conceptual model and the Australian-specific model. These were explained in Section 7.4.

The conceptual model was recommended to use for the identification of actions that clients (or any other party) to promote innovation in projects due to the following reasons:

- It was derived using the findings of fundamental research, which has no bearing on the geographic locations, type of industry or the enabling body of the project.

- The model was tested through literature review, case studies and expert interviews with industry practitioners, both in the construction industry and out of the construction industry.
- It is a simple and easy to use model.
- On the other hand, the Australian-specific model contained characteristics believed to be specific to the Australian construction industry and was somewhat complex and not easy to interpret and use. In addition, the model was developed using the factor analysis, and the selection of factors in factor analysis is subject to individual interpretation. It is also to be noted that this model was based on a questionnaire which was founded on the constructs of the conceptual model and therefore, was a derivation of the conceptual model.

The two findings, i.e. that the model can be used for any project and by any party, make the conceptual model universally applicable, broadening its sphere of usage.

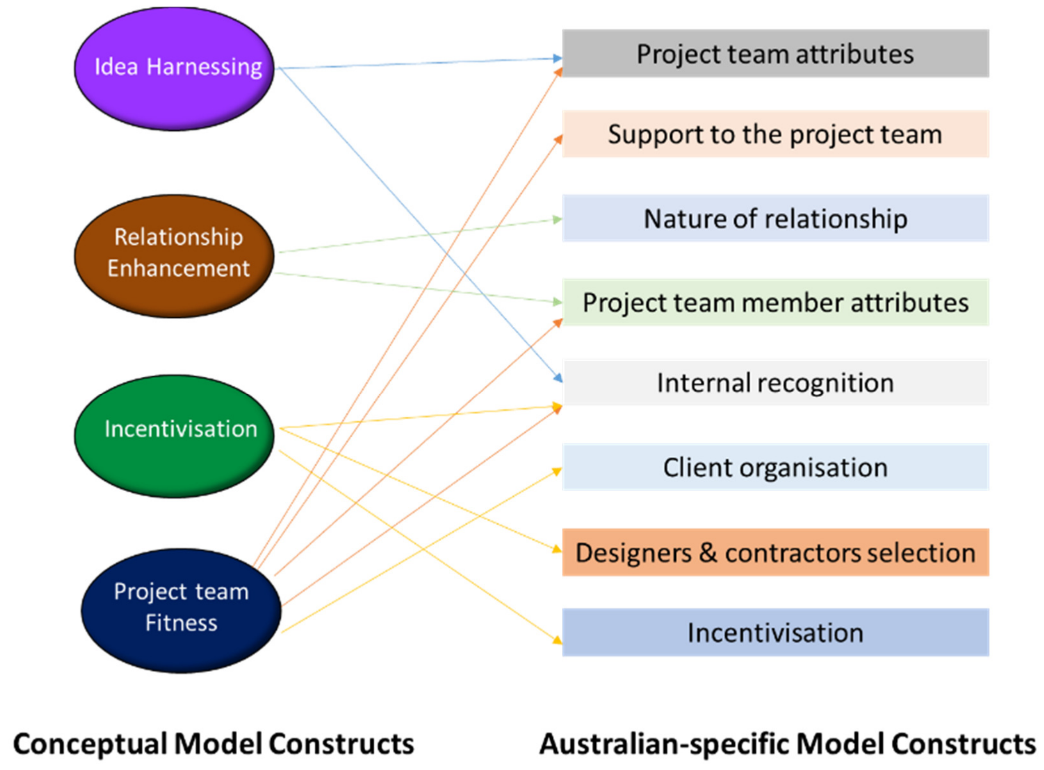


Figure 10.4 Relationships between constructs of Conceptual and Australian-specific models

10.3.8 Revisiting research questions

Both the literature review and the statistical analysis involving the factor analysis and the correlation analysis with subsequent validation and generalisation, provided answers to the research questions identified at the commencement of the study. The response to research questions are as follows:

1. In construction projects, clients have a strong influence in promoting innovation in their projects.
2. The literature review and the case studies were able to identify a large number of actions that construction clients can take to promote innovation in their projects. They are included in the list given under *Section 10.4* and *Appendix 1*.
3. It was possible to group these actions into the following major categories: idea harnessing (strategies for the generation of new and beneficial ideas and their implementation); relationship enhancement (employing actions to improve relationships between parties to a project); incentivisation (providing incentives/rewards to promote innovative activities); and project team fitness (deliberate actions taken to strengthen the project team and improve its ability to focus on innovative activities).
4. The literature review, correlation analysis and the case studies showed the strong relationships of these categories with innovation performance. Although the literature review and the correlation analysis showed the relationships of these categories within themselves, the case study did not identify the levels of relationships due to limitations of the technique. Validation of relationships of model constructs within themselves requires a major research effort such as another survey.

10.3.9 Recommendations for clients and policy makers

Research identified a number of considerations both for clients and for policy makers interested in promoting innovation in construction projects. The considerations beneficial to clients are given first.

10.4 Recommendations for clients

Many actions can be taken by clients (or project managers) who are interested in achieving enhanced outcomes through innovation promotion in their construction projects. However, each construction project is different to another and there are many complexities depending on factors such as the type of project (i.e. traditional, Design and Build, PPP etc.), type of client (public, private), stage of project execution (planning, designing, tendering, construction etc.) and capabilities and characteristics of the project team. Therefore, no universal actions suitable to all projects can be given. It is up to the client or the project manager to select the actions suitable for their respective projects.

A list of possible actions for the client or the project manager is given below under the following headings:

1. Idea harnessing;
2. Relationship enhancement;
3. Incentivisation; and
4. Project team fitness.

These actions were identified through the literature review (See *Sections 3.4 to 3.7* and the list in *Appendix 1*), case studies (*Sections 8.3.1 to 8.3.4*) and interviews with project personnel for generalising the model (*Sections 9.2.2 to 9.2.12*). Some of the recommendations are repeated in other places, depending on the context.

Although this is a long list, it was not curtailed considering its benefit to the practicing world.

10.4.1 Idea harnessing

Idea harnessing concerns the generation, development and the use of new and beneficial ideas for the project. The following are the actions identified under idea harnessing:

1. Undertake idea generation techniques relevant to the project from the following before making important decisions: brainstorming, scenario planning, risk assessment planning, life cycle costing, sustainable design, constructability review, value management and value engineering. In brainstorming, techniques such as the 'thinking hats' tool introduced by Edward de Bono can be used to generate new ideas. Another technique, as used in a case study, is to write to the attendees after brainstorming meeting, requesting them to add further to what was said in the meeting. It was revealed in the case study that at least three times more good ideas could be received using this technique, because some people do not like to talk openly

with only a few people dominating in meeting situations.

2. Conduct frequent cordial meetings with stakeholders. Not only could they provide beneficial new ideas, they also can identify potential risks to the project. In addition, a close cooperation between stakeholders is vital for the implementation of innovative ideas.
3. Expose project team members to outsiders who have considerable knowledge in the area of the project. Interacting with those who have different backgrounds and experience and build on others' knowledge also provides opportunities for new ideas. Those who are not directly involved with the project can also provide different perspectives, especially in the planning and design phases of the project.
4. Encourage and prompt project personnel to submit beneficial ideas. Operational level staff, followed by middle management, are a rich source of innovative ideas. When working on a major rehabilitation project to service joints and bearings of a bridge (one of the case studies), the novel idea of vacuuming instead of costly cleaning with water, came from the operational level staff.
5. Encourage project personnel to look 'outside the box'. As a case study revealed, a simple mechanism used in motorcycles was used to solve a major technical issue in plants used in underground mining, improving productivity substantially.
6. Engage suppliers earlier on in the process to gain from their expertise, experience, understanding of the construction process and the consideration of buildability issues.
7. Use best practices and learn from others by visits to other buildings and/or construction sites.
8. Obtain fresh ideas from: captured project learnings from completed projects; reading trade or professional magazines; studying work of competitors; accessing on-line databases and in-house libraries; working with new equipment/ software; attending fairs and exhibitions; and following up on new research in the field of work.
9. If possible, use the competitive tendering to prepare the detailed design and buy the designs of unsuccessful bidders. The use of the Double ECI (Early Contractor Involvement) delivery type, i.e. two proponents work on the

detailed design independently to select one, is an example which can create opportunities for generating new ideas. The desire to win the contract creates motivations for proponents to innovate. Client can buy the design from the unsuccessful tenderer and then incorporate its beneficial components into the final design. Encouraging alternative designs in the tender procedure also provides a rich source of novel ideas.

10. Provide opportunities for idea generators/ implementors to work in external organisations for shorter periods of time to obtain further training and collect new ideas.
11. When ideas are selected for implementation, undertake a careful risk analysis and take actions to manage potential risks. As innovation often requires wading into unchartered waters, pilot testing may be needed.

10.4.2 Relationship enhancement

Relationship enhancement refers to employing actions to improve relationships between parties.

1. Look for contractors, designers and other service providers for their track record on forming good relationships in previous projects. Checking previous claim history may help.
2. Consider the co-location of all parties in the same or adjacent buildings enabling constant professional interactions and socialising.
3. Celebrate successes of the project jointly with all the parties and convey the message that the credit to success belongs to all.
4. Give recognition to good ideas from anybody from any party.
5. Encourage contractors, designers and other service providers to take project collaboration seriously, and remind parties that this type of relationship will be considered when awarding future contracts.
6. Going one step further, encourage service providers to enter into partnering agreements in projects. In partnering, parties voluntarily agree to co-operate in a partnering relationship without any legal effect.
7. Going yet another step further, encourage service providers to enter into extended partnering agreements. This is a formal process. Although not legally binding, the partnering process may be included in the tender

documents as an option. Usually, this includes a series of meetings, workshops and reviews.

8. If possible, enter into contract types that promote improved relationships between parties. Such contract types include Early Contractor Involvement contracts and Alliance contracts. Public Private Partnership (PPP) contracts also have characteristics similar to project alliances with respect to relationships between parties.
9. Enhanced relationships with stakeholders is also vital. Hold regular meetings with stakeholders. Use layperson language where necessary to explain technical matters.

10.4.3 Incentivisation

This is on providing incentives/rewards to promote innovative activities.

1. Identify, recognise and offer incentives and rewards to the best performers, beneficial idea generators and implementors in the project (incentives are given to motivate or encourage people to do better, and a reward is what people receive for doing better). These may not necessarily be financial, and can be in the form of recognition at corporate events, head of the organisation or top management personally thanking, taking them to dinner and similar recognition.
2. Where possible, select designers and contractors based on innovative proposals in their tender submissions.
3. When selecting designers and contractors, give priority to those who have a good innovation history as a form of incentive for past innovations.
4. Make contractors and designers understand that innovation performance will help them obtain future jobs.
5. When drafting contract conditions for projects, include clauses in contract documents to share savings from innovations with the respective service provider. In addition, include KPIs (Key Performance Indicators) based on innovation.
6. Where possible, select contract types which have gain-share clauses to provide financial incentives for innovative work.
7. Inculcate a team environment where team members with innovative ideas are

recognised along with those who help to implement them.

8. Where possible, celebrate small successes with other parties and recognise the contributions of individuals irrespective of the party to which they belong.
9. Especially focus attention to operational staff. Show them respect, value their ideas, spend more time with them and give the message that they are equal partners whose ideas are valued. This attitude needs to be extended to all in the project teams.

10.4.4 Project team fitness

Project team fitness refers to the deliberate actions taken to strengthen the project team and improve its capacity to focus on innovative activities.

1. Appoint a high-performing project manager who recognises the importance of innovation and has necessary knowledge, skills and experience to lead the innovation facilitation process.

To encourage and lead innovation, the project manager needs to demonstrate a high level of the following:

- Achievement orientation - showing improvement in performance, more entrepreneurial behaviour and provide more innovative ideas;
- Initiative - proactive actions to avert problems in order to enhance results;
- Information seeking - proactive exploration of issues and solutions outside the immediate environment;
- Focus on client's needs - effort to meet the client's requirements;
- Impact and influence - proficiency in coordinating, inspiring and directing the team;
- Directiveness - effort to ensure that individual subordinates comply with project manager's wishes in the way that was intended;
- Teamwork and cooperation - influencing the team to perform in a desirable manner;
- Team leadership - recognising when and when not to act authoritatively to get the best out of the team;
- Analytical thinking - conception, analysis and reasoning in order to make appropriate management decisions;

- Conceptual thinking - being able to see the bigger picture;
- Self-control - staying calm and maintaining performance under stressful conditions;
- Flexibility - remaining adaptable and flexible to solve the problems in hand;
- Commitment to innovation - demonstrating commitment for innovation; and
- Stimulating innovation - stimulating project team members for innovation.

When recruiting the project manager, look for the above characteristics. In addition, the project manager should be technically knowledgeable and experienced.

2. Appoint a capable project team by recruiting technically knowledgeable, highly skilled and experienced project team members from diverse backgrounds. The case studies have highlighted that young people play significant roles in suggesting novel ideas, and perfecting and implementing them. Therefore, although they may lack knowledge and experience, recruiting young people into project teams makes them able to make significant contributions through their creativity and motivation.
3. Assemble people with different organisational roles, who possess a broad array of skills, knowledge, and expertise which helps the team solve complex tasks.
4. Develop the project team by inculcating team innovative culture and developing it as a high-performing team.
5. Include a standing item in team meetings and meetings between the client and the project manager to go through the actions under the headings of idea harnessing, relationship enhancement, incentivisation and project team fitness to find out whether any new actions can be found to promote innovation.
6. Provide a supportive environment for the project team. Recruit sufficient staff to avoid time pressure that prevents project personnel from engaging in innovative activities.
7. Take actions to make the parent organisation more innovative.

For innovation to happen, it is necessary to create a conducive team environment with the following characteristics:

- A psychologically safe environment to expresses ideas freely - a psychologically safe environment created by a more inclusive, socially cohesive group dynamic is more likely to promote creativity;

- A cohesive environment where sharing of values exists - the cohesiveness of a work group determines the degree to which individuals believe that they can introduce ideas without personal censure, collaborative effort among peers is crucial to idea generation.
- An innovative environment where looking for and accepting novel ideas and experimentation constantly occur with calculated risk-taking.

When the appointed project manager and/or team members do not have necessary skills and abilities, the parent organisation needs to provide the training required to acquire such skills and abilities. For example, a power station in Australia sent its turbine engineer to a foreign country to learn new turbine design techniques before embarking on a major upgrading of the plant. The same power station recruited another engineer to assist the designer to do the mandatory work, in order to provide more time for the designer to concentrate on the upgrading work.

When providing support to the team for innovation, consideration needs to be given to the following:

- Establishment of policies and procedures that encourage project level innovation.
- Provision of adequate supplies of resources such as money, equipment, facilities, and time.
- Provision of support to be both articulated by personnel documents, policy statements, or word of mouth, and enacted, by active promotion of innovative behaviour such as sufficient time for producing novel work in the domain or the availability of training.
- Support should be provided without too much control or disturbing the project on a daily basis.

Policies and procedures that can encourage project level innovation include:

- Instituting value-based selection of tenders;
- Encouraging the use of alternative bids in the bidding process;
- Using prequalification systems that assess innovation history;
- Employing performance-based standards and regulations;
- Encouraging financial incentives within contracts;
- Incorporating Key Performance Indicators relevant to innovation in contracts;

- Establishing high-level risk management policies and procedures; and
- Encouraging taking calculated risks.

The parent organisation may take the following actions to be more innovative:

- Trusting employees and providing them with a degree of freedom of thought and action with no blame culture, especially with regard to mistakes made in the process of innovation.
- Providing recognition, encouragement, support and robust incentives for innovative activities.
- Providing opportunities for networking facilities within and outside the organisation.
- Top management showing commitment to promoting innovation through their actions.
- Establishing separate units dedicated to promoting innovation in the organisation and a strong focus on knowledge management.
- Allocating funds for research and development.
- Introducing processes to recognise and reward innovators. These may include senior management messages, broadcasting names in organisational publications, recognition at organisational gatherings and presenting awards at special events of the organisation.
- Introducing management systems to capture good ideas and monitor the progress of their implementation such as running idea generation challenges and computerised idea capturing systems or paper-based systems.
- Encouraging employees to have strong relationships with customers and other stakeholders.
- Holding frequent knowledge sharing sessions, especially project learning sessions often referred to as 'post-mortem analysis' which discuss both successful and unsuccessful learnings in a blame-free environment that captures learnings.
- Encouraging the monitoring of new ideas and practices. The careful evaluation of innovations creates an atmosphere in which further innovations are likely to occur.
- Providing space for creative thinking and reflective practice, e.g., away-days, brainstorming sessions, peer assists, after-action reviews and retrospects,

problem-solving groups, and discussion groups and forums.

- Providing an enriched physical workplace that enhances creativity by providing accessible and casual meeting spots, physical stimuli, space for quiet reflection, a variety of communication tools such as white boards, and bulletin boards, contact space for clients, audiences, and partners, and room for individual expression, among others.
- Creating an organisational culture that values innovation, where there is encouragement for personnel to think differently, take calculated risks, and challenge the status quo. Major forces such as leadership, attitudes to risk, budgeting, audit, performance measurement, recruitment, and open innovation should be aligned in support of innovation.
- Creating a high level of decentralisation and functional differentiation and a range of specialised areas within the organisation.
- Creating knowledge management systems and processes that constantly bring new ideas, concepts, data, information, and knowledge into the organisation.
- Creating a performance measurement system that measures the innovative pulse of the organisation, ensures the monitoring and evaluation of inputs, activities, outputs, outcomes, and impacts, and feeds lessons back to the system.
- Documenting innovation relevant information for future use.

The above are recommendations for practitioners. Practitioners can include not only the clients, but any party contributing to projects. The following section provides recommendations for policy makers.

10.5 Recommendations for policy makers

As the survey was conducted with Australian respondents, the recommendations given below are applicable to policy makers in Australia. However, policy makers elsewhere may also use them with appropriate changes.

This research found evidence that Australia is not performing well in the innovation arena compared to many other developed nations. For example, Australia ranked 20 among 126 countries in 2018 in the Global Innovation Index produced by the World Intellectual Property Organisation and partner organisations. In addition, the research showed that the innovation performance of construction projects is not high in Australia and the public sector clients are less innovative compared to private sector clients. Therefore, there is a clear role for policy makers in promoting innovation in general and construction innovation in particular. The policy makers referred to here are governments at all levels, i.e. federal, state and local governments. The policy maker's role is twofold: providing a general direction and encouragement for innovation, and directing public sector organisations to promote innovations. These two roles are discussed below.

10.5.1 Providing direction

The governments, especially the federal government, need to play a dominant role in encouraging and promoting innovation in the country. Some of the actions for the Federal government to promote innovations in Australia were highlighted by Engineers Australia, in its 'Innovation in Engineering Report' (2012). Given below are selected actions suggested in this report:

- Focusing on providing quality education in science, maths and technology to produce the new generation of innovators and technology-literate citizenry. The report specifically pointed out that the conventional education systems do not provide adequate incentives and encouragement for students to develop their creative skills. Some attributes of creative children often frustrate those teachers who do not know how to recognise them. Therefore, it recommended introducing deliberate programmes for students to develop creative skills from a young age. The need to train the teachers to develop creative skills of students at all levels of education (from primary schools to universities) was also emphasised.
- Strengthening the legal and regulatory systems relevant to innovation. While strengthening the legal system contributes to protecting intellectual property rights, strengthening the regulatory system encourages businesses to invest in innovation and provides a means of protecting rights resulting from innovation related activities.
- Rationalising and simplifying the large number of incentive programs currently available and making them known to businesses, especially to small and medium level enterprises.
- Providing more funding for research and development for state owned

enterprises and to universities and provide more tax incentives for businesses to spend money on research and development activities.

- Encouraging more collaboration between academic and research organisations with businesses.

In addition, the top level of the government needs to convey the importance of promoting innovation.

This research also found that the number of women in construction project management is low. Policy makers need to work to raise the level of female participation in this industry.

10.5.2 Role of governments as owners of public sector organisations

Public sector organisations belong to federal, state and local governments that can have a direct influence on innovation promotion. Particular attention may be given to state authorities providing services such as roads, water, drainage and electricity. Local councils are another area where particular attention is needed.

As the owners of public sector organisations, governments can promote innovation in these organisations in many ways including the following:

- Conveying a strong message that innovation is a prerequisite of public sector organisation activity.
- Amending procurement policies to encourage them to be more performance based rather than prescription based when purchasing goods or services.
- Encouraging more calculated risk taking to find better ways of serving the public.
- Encouraging the establishment of units to promote innovation and focus on research and development.

In addition, as suggested in Engineers Australia's Innovation in Engineering Report (2012), allocating a percentage of project value to embedding an innovation framework in large infrastructure projects. This will enable the development of specific innovations, which can become a part of the legacy of the project, and available for adoption by the rest of the industry and the world.

Furthermore, being responsible corporate citizens, public sector organisations should aim at objectives such as to minimise waste, reduce carbon emissions, enhance corporate image and recognition, future collaboration along the supply chain, knowledge transfer to inform future projects, client and end user satisfaction, and improved quality of life for local people through their projects.

10.5.3 Role of other entities

Professional bodies such as Engineers Australia also have a role to play in encouraging, recognising, and promoting innovations. This can be done by rewarding innovation excellence through competitions and organising events to encourage, recognise and promote innovations. In addition, Engineers Australia can work with governments at all levels, highlighting the areas that require focus. Already, Engineers Australia is playing a significant role in this direction through the Innovation in Engineering Committee, attached to its Queensland Division (EA 2019). However, this role should be played at the national level.

The above sections provide recommendations for clients, policy makers and other relevant entities to promote innovation in Australian construction projects using the learnings of this study. Having discussed how this research was conducted and summarised major findings and recommendations, the purpose of the next section is to highlight the research contributions from the study.

10.6 Research contributions

This research bridges a significant knowledge gap in the area of construction innovation. After undertaking a comprehensive literature review, it was found that no comprehensive research has been conducted to study actions that can be implemented by clients to enhance innovation performance in construction projects. The research addressed this knowledge gap.

The research made valuable contributions to the following areas:

- to the existing body of knowledge on client enablers to promote innovation in construction projects;
- to Australian industry practitioners and policy-makers of the actions they can take to promote innovation;
- to all key players of projects such as clients, designers, contractors and project managers to achieve enhanced project outcomes; and

- to make a better world.

The above contributions are elaborated below starting with the contribution to the body of knowledge.

10.6.1 Contribution to the body of knowledge

Using the inputs from past researchers world-wide and industry practitioners in Australia, the research was able to develop a simple model that can be used by clients interested in promoting innovation in construction projects. The research that led to this simple model paves the way to make valuable contributions for the betterment of the construction industry in both theoretical and practical aspects. First, the theoretical contribution to the body of knowledge is discussed.

To the best of knowledge of the author, this is the first time that client-led innovation enablers have been studied in a comprehensive manner to derive a model. The study provided empirical evidence that helped to unravel the complex relationships of factors that contribute to promote innovation in construction projects which has been a barrier to extend research into the project execution area. As Ozorhon (2012) pointed out, project level innovation has largely been ignored due to the difficulties in monitoring the different activities conducted by different parties in each stage of a construction project. In this research, it was possible to categorise the enabling factors into four major areas, i.e. idea harnessing, relationship enhancement, incentivisation and project team fitness.

This finding is of importance to researchers providing an accessible channel to target some of the categories in detail to assess their impact on the broader context. In addition, researchers can contribute to identifying techniques and actions to enhance innovation performance under each category, thus expanding the body of knowledge. The specific contributions to the current research body of knowledge are elaborated below.

One of the main findings of the study is that idea harnessing influences innovative outcomes. Although this finding is not new in the broader context of innovation, the author is of the opinion that this is the first time its applicability in the construction project level has been proven with empirical evidence.

Although not proven in the construction project level context, industry practitioners have been using contract processes such as partnering and contract types such as alliances to enhance relationships between parties to projects. With this proven validity of the strong association between enhanced relationships between parties to a construction project resulting in higher innovative outcomes, more focus can now be given to finding better practices that enhance relationships in the construction world.

The influence of incentivisation on innovative outcomes is another crucial finding with significant ramifications. Although not proven empirically, the significance of incentivisation on innovative outcomes in construction projects has been recognised for many years. However, as revealed in the research, many in the construction industry have failed to utilise this valuable approach to promote innovation in construction projects. Findings in relation to this category of innovation enablers has placed a spotlight on the need to focus more on utilising incentivisation for enhanced innovative outcomes.

The other finding that project team fitness influences innovation in construction projects is also accepted in the construction industry although not proven previously in the project level context. Many factors contribute to building a capable project team driving innovation in construction projects. The appointment of a technically competent, highly skilled project manager and the parent organisation taking actions to be more innovative are two outstanding factors that prominently revealed by the research which future researchers may concentrate their efforts on to expand the knowledge further.

The lack of a definition for construction innovation at the project level also imposed a research barrier. Providing a definition for project level innovation, for the first time, has been another contribution to the body of knowledge from this research. This new definition is:

> *"With respect to projects, innovation can be regarded as the application of ideas for new or improved products (including materials, plant and equipment) and software, technologies, methods, practices and systems designed to benefit the project".*

The model developed in this research has the following beneficial characteristics:

- Simple, easy to understand by clients; and
- The innovation enablers identified can be implemented by clients without seeking external assistance from policy makers such as federal, state and

local level governments or industry players such as professional organisations.

Having discussed the contribution to the body of knowledge, the next section will explain the contribution of this study to industry practitioners and policy makers.

10.6.2 Contribution to industry practitioners and policy makers

If the research findings are used by clients and other parties to promote innovation in construction projects, they can achieve significant benefits. As an example, the following benefits due to innovation have been identified by researchers for the construction industry:

- Decreased cost;
- Quicker construction times;
- Higher quality;
- Increased productivity;
- Profit maximisation;
- Competitive advantage;
- Developing solutions to problems encountered on site;
- Responding to conflicting expectations from clients;
- Improved client satisfaction;
- Better value for clients;
- Improved working conditions;
- Aspirations towards improved performance and organisational effectiveness;
- Increased organisational commitment; and
- Higher organisational motivation.

The research also highlighted areas where actions are needed by Australian policy makers such as the need to improve the innovation level in the country in general, and in the construction industry in particular. The specific actions that policy makers can take have been identified.

10.6.3 Contribution to key players of a project

The most valuable contribution of this research, although not anticipated when commencing the study, is the identification of a simple model which can be used by key players of projects such as clients, designers, contractors and project managers, on any project to enhance project outcomes. This translates into the identification of a simple framework that can be used in projects to enhance benefits, hitherto has been difficult. As commented by many researches (see *Section 9.4.2*), contemporary project management approaches mainly concentrate on aspects such as time, cost, quality and scope. However, present-day project owners and project managers expect more benefits from their projects such as the following:

1. Project execution level considerations: meet owner's needs; decrease time and cost; achieve higher quality, higher project efficiency and productivity; meet functional performance; meet technical specifications.
2. User and stakeholder considerations: solve customer's problem; achieve fitness for use; satisfy stakeholders and user needs; create user happiness and loyalty; provide positive economic impact to surrounding community; reduce waste; improve sustainable outcomes; reduce greenhouse gas emissions.
3. Business level considerations: increase revenues, profits and market share; increase competitive advantage and market impact; enhance reputation; achieve higher diversification and increased capabilities; achieve creation of new opportunities for new products and markets.
4. Organisational level considerations: achieve content project team, job satisfaction and personal development of team members; achieve positive organisational and professional learning; increase organisational effectiveness and commitment; achieve higher organisational motivation.

Only a few of the above expected benefits can be achieved by following contemporary project management approaches. On the other hand, innovation has the potential to achieve all these benefits. Therefore, the research has paved a way to integrate innovation management and project management to achieve enhanced benefits to project owners and project managers.

10.6.4 Contribution to the world

Innovation has helped the world immensely to make it better in many spheres of life. In this research, attention was to use this beneficial tool for the betterment in the area of project management. As Ozorhon (2013) pointed out, health and safety improvements, minimised waste, reduced carbon emissions, enhanced corporate image and recognition, future collaboration along the supply chain, knowledge transfer to inform future projects, client and end user satisfaction, and improved quality of life for local people are some of the benefits of innovation. In addition, innovation has the potential to drive productivity and to improve sustainable outcomes in projectsWhen added together, a small contribution from each project towards these important areas can result in an enormous social and economic contribution. Therefore, these factors contribute significantly to a better world.

10.7 General conclusions

In the quest to identify the actions clients and project managers can take to promote innovation in construction projects, two models were produced. The first model was the conceptual model, using findings of researchers world-wide through a comprehensive literature review. The other model was a refinement of the previous, developed using the data collected through a questionnaire survey of Australian construction projects. This was named the Australian-specific model. Using the case studies as a validation technique, these models were validated.

The research suggested that Australian clients are hesitating to provide personal and financial incentives for innovation. Most innovations seem to be motivated by project personnel's sense of professionalism, problem-solving skills and the desire to be creative. Therefore, one of the major findings of the research is that Australian clients can achieve further benefits from innovation by focussing more on providing incentives to project personnel and parties.

The conceptual model was recommended to use for the identification of actions that clients (or any other party) to promote innovation in projects due to the following reasons:

- It was derived using the findings of fundamental research, which has no bearing on the geographic locations, type of industry or the enabling body of the project.
- The model was tested through literature review, case studies and expert interviews with industry practitioners, both in the construction industry and out of the construction industry.
- It is a simple and easy to use model.

- It can be applied to any project irrespective of the industry by any party such as the client, project manager, contractor and the designer.
- On the other hand, the Australian-specific model contained characteristics believed to be specific to the Australian construction industry and was somewhat complex and not easy to interpret and use. In addition, the model was developed using the factor analysis, and the selection of factors in factor analysis is subject to individual interpretation.

This research has unlocked a barrier to the enhancement of project success. Innovation promotion within the project execution area was considered so complicated that no researcher seems to have attempted to find a simplified way of analysing the dynamics relevant to innovation. For the first time, a discovery was made to categorise innovation enablers into four major groups, i.e. idea harnessing, relationship enhancement, incentivisation and project team fitness. This simple grouping opens up endless opportunities for key players of projects such as clients, designers, contractors or project managers to look for ways of enhancing outcomes from projects.

The study identified a number of short and long term benefits expected by present-day project owners and project managers. Only a few of the expected benefits can be achieved by following contemporary project management approaches. On the other hand, facilitation of innovation means providing opportunities to generate beneficial ideas and implementing them. Ideas come from the human brain, which has no limit to idea generation, and therefore, no limit to harnessing ideas beneficial to key players of projects such as clients, designers, contractors and project managers.

Innovation can result in ideas to improve productivity and sustainability in addition to finding ways to reduce greenhouse gas emissions. All these factors significantly contribute to a better world. Therefore, it is not an exaggeration to state that this research has the potential to integrate project management and innovation management for project delivery which would bring immense benefits to the world.

10.8 Study limitations and future research directions

To investigate this topic further, future research may attempt to increase the sample size of the survey. Similarly, the validity of the model can also be strengthened by undertaking a larger number of case studies, with a greater number of interviewees, in a variety of firms of different sizes.

It was revealed in the study that 62% survey participants had experience ranging from 26 years to 45 years. The percentage of participants under 15 years of experience was only 20%. It is not known whether this reflects the type of personnel engaged in construction project management in Australia or whether personnel with less experience were reluctant to participate in the survey. However, if this reflects the type of personnel engaged in construction project management in Australia, it can create a problem with a shortage of personnel in the future and the policy makers need to act fast to face this potential problem. This aspect needs further research.

The four case studies highlighted the deficiency that Australian clients do not pay much attention to incentivisation. It would have been more appropriate if a few projects were selected from outside Australia to check whether this deficiency is a characteristic only prevailing in Australia or not.

This research used the data from Australian construction projects. Similar research may be conducted using the data from different countries to further validate the findings and compare the innovative characteristics of the construction industry elsewhere. In addition, research may be conducted using the data from projects other than construction to further validate the general applicability of the model.

10.9 The closure

Innovation is about changing the way we do things. It is about pushing the frontier of what we know in the hope of generating new and useful ideas, and then putting them into practice. Successful innovation raises productivity and living standards, expanding the range of goods and services available for individuals and society as a whole, and allowing us to live longer, healthier lives (UK Government 2014).

It is a great pleasure for the researcher to have conducted this study which has the potential to make significant benefits not only to key players of projects such as clients, designers, contractors and project managers, but to the whole world in terms of improving sustainability and prosperity and reducing greenhouse gas emissions. Innovation has been one of the most effective tools that humankind has ever used to achieve greater material comfort, wealth and prosperity. However, it appears that the use of this valuable tool has been limited in the area of project management.

Having explored the innovation performance of Australian construction projects, the researcher found little evidence of any client or project manager deliberately promoting innovation in construction projects. There have been many innovative projects, but it appears that these innovations have occurred at random and sprung only due to ad hoc efforts rather than concerted efforts. This suggests that Australian clients and project managers are yet to recognise the importance of innovation and the considerable monetary savings and other benefits that can be made through innovation. A concerted effort by policy makers to promote innovation in projects as recommended, and the clients realising benefits from using innovation to enhance project outcomes, may change this situation in the future.

Those clients who would like to use this valuable tool of innovation to reap benefits can use the recommendations given in here. It is the wish of the researcher that this study contributes to save billions of dollars each year from projects, particularly from construction projects, in addition to achieving unlimited benefits and contributing to world prosperity and sustainability.

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Appendix 1

Details of Literature Review

No	Author	Title	Construction innovation?	What is covered	What is not covered
1	Ahmed, Pervaiz K	Culture and climate for innovation	General	Idea generation, development, commercialisation organisational culture and climate.	This is on organisational innovation and does not cover client's enabler categories except for the part of project team fitness.
2	Amabile, Teresa M	The motivation for creativity in organisations	General	Creativity, motivation, workplace	This is on organisational innovation and does not cover client's enabler categories except for the part of project team fitness.
3	Amabile, Teresa M	Motivating creativity in organisations: on doing what you love and loving what you do	General	Creativity, motivation, workplace	This is on organisational innovation and does not cover client's enabler categories except for the part of project team fitness.
4	Asad, S. et al	Learning to innovate in construction: a case study	Yes	What is construction innovation, why construction organisations should innovate, importance of clients, procurement methods, attitudes and processes, organisational climate. Check - Slaughter's definition is used for innovation. No	The study does not comprehensively cover innovation facilitation enabler categories. It is on identification of some actions clients can implement and not on enabler categories.

				project innovation mentioned.	
5	Barrett, Jennifer et al	The social life of the novel idea: what did social psychologists ever do for us?	Yes	This is on using innovation in building designs. Covered behavioural aspects.	The study does not comprehensively cover innovation facilitation enabler categories.
6	Blayse, A.M. & another	Influences on construction innovation: a brief overview of recent literature	Yes	Covered: client leadership, relationship with manufacturers, knowledge management, innovative procurement systems, regulations and standards, organisational resources. Slaughter's definition is used for innovation. No project innovation mentioned.	The study does not comprehensively cover innovation facilitation enabler categories. It is on identification of some actions clients can implement and not on enabler categories.
7	Blayse, A.M. & another	Key influences on construction innovation	Yes	Same as above – almost repeating	
8	Bossink, B.A.G.	Managing drivers of innovation in construction networks	Yes	Innovation drivers such as environmental pressure, technological capability, knowledge exchange, boundary spanning.	This does not deal with client enabler categories in a comprehensive way.
9	Bossink, B.A.G	Effectiveness of innovation leadership styles: a	Yes	Paper is on construction innovation. Four basic	This does not deal with client enabler categories in a comprehensive way.

		manager's influence on ecological innovation in construction projects		innovation leadership styles: charismatic, instrumental, strategic and interactive innovation leadership Used case studies	
10	Briscoe, Geoffrey H et al	Client-led strategies for construction supply chain improvement	Yes	Identified early supplier involvement has the potential for innovation.	This does not deal with client enabler categories in a comprehensive way.
11	Claver, Enrique et al	Organisational culture for innovation and new technological behavior		This is a general reference covering technological innovation. Covers organisational innovation especially culture.	This does not deal with client enabler categories.
12	Chen, Hong Long	Innovation stimulants, innovation capacity, and the performance of capital projects	Yes	This paper discusses project leadership and team behaviour and mainly on organisational innovation.	This does not deal with client enabler categories in a comprehensive way.
13	Davidson, Colin	Innovation in construction– before the curtain goes up	Yes	Pitfalls and difficulties in construction innovations.	This does not deal with client enabler categories.
14	Dulaimi, M. & other	Procuring for innovation: the integrating role of innovation in construction procurement	Yes	Deals with procurement. Barriers to innovation such as risk averse, adversarial attitude	This does not deal with client enabler categories.
15	Dulaimi, M.F. et al	Organisational motivation and inter-organisational	Yes	organisational motivation and inter-organisational	This does not deal with client enabler categories.

		interaction in construction innovation in Singapore		relationships.	
16	Dulaimi, M.F. et al	A hierarchical structural model of assessing innovation and project performance	Yes	Organisational innovation and role of the PM	This does not deal with client enabler categories in a comprehensive way.
17	EA	Innovation in Engineering Report	Yes	Technological innovation, organisational innovation	This does not deal with client enabler categories.
18	Eaton, D. et al	An evaluation of the stimulants and impediments to innovation within PFI/PPP projects	Yes	This is on Private Finance Initiative/Public Private Partnership projects. Covers innovation stimulants and impediments, organisational culture and climate	This does not deal with client enabler categories.
19	Egan, John	Rethinking construction: The report of the construction task force	Yes	Covers importance of innovation in the construction industry, and organisational innovation.	This does not deal with client enabler categories.
20	Ejohwom u, O.A. & other	Incentivization and innovation in construction supply chains	Yes	Slaughter's definition is used for innovation. No project innovation mentioned. Covered the importance of incentivisation and how the supply chain can contribute.	This does not deal with client enabler categories.

21	Engström, S	Sustaining inertia?: Construction clients' decision-making and information-processing approach to industrialized building innovations	Yes	Barriers to overcoming inertia in client decision making. Slaughter's definition is used for innovation. No project innovation mentioned.	This does not deal with client enabler categories.
22	Eriksson, Per Erik et al	The influence of partnering and procurement on subcontractor involvement and innovation	Yes	incentives and rewards, contract conditions	This does not deal with client enabler categories.
23	Fairclough, John	Rethinking construction innovation and research – a review of the Government's R&D policies and practices.	Yes	Covers importance of innovation in the construction industry, and organisational innovation.	This does not deal with client enabler categories.
24	Gambatese, J.A. and another	Factors that influence the development and diffusion of technical innovations in the construction industry	Yes	Innovation generating organisations, barriers and enabler categories, owner/client support, organisation culture	This does not deal with client enabler categories.
25	Gann, D.M. & Salter, A.J.	Innovation in project-based, service-enhanced firms: the construction of complex products and systems	Yes	Supply chain, knowledge management, supply chain	This does not deal with client enabler categories.

26	Hardie, Mary and other	Factors influencing technical innovation in construction SMEs: an Australian perspective	Yes	ON SMEs. Client and end-user influences, Client and end-user influences, supply chains, Industry networks	This does not deal with client enabler categories in a comprehensive way.
27	Hardie, Mary and other	Experience with the management of technological innovations within the Australian construction industry	Yes	On innovation in the construction industry based on an Australian survey. Discussed Characteristics of High Innovators, organisational and technological innovations	This does not deal with client enabler categories in a comprehensive way.
28	Hartmann, A.	The context of innovation management in construction firms	Yes	This is on innovation management in construction firms. Discussed client and location, procurement form, innovation acceptance of the client and regulation degree.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
29	Hartmann, A.	The role of organisational culture in motivating innovative behaviour in construction firms	Yes	Based on a Swiss case study, this paper deals with organisational culture with respective to construction innovation. The paper is on organisational innovation.	This does not deal with project level innovation.
30	Harty, Chris	Innovation in construction: a sociology of	Yes	Based on a UK case study, this paper discusses	This does not deal with project level innovation.

		technology approach		insights from a sociology of technology approach of unbounded innovation	
31	Holt, G.	Contractor selection innovation: examination of two decades' published research	Yes	This literature review discusses contractor selection in construction projects, especially the use of modelling	This does not deal with project level innovation.
32	Ivory, C.	The cult of customer responsiveness: is design innovation the price of a client-focused construction industry?	Yes	Drawing on three construction case studies, this paper argues that strong client leadership may have negative consequences for innovation, including the suppression of innovation and an overly narrow focus on particular types of innovation	This does not deal with project level innovation.
33	Kadefors, A. et al	Procuring service innovations: contractor selection for partnering projects	Yes	Based on Swedish partnering projects, this paper is on procurement and collaboration for construction innovation.	This covers only a part of enabler categories, i.e. project team fitness and does not deal with project level innovation comprehensively.
34	Keegan, A. and other	The management of innovation in project-based firms	Yes	This is on organisational innovation and covers What managers of project based	This covers only a part of enabler categories, i.e. project team fitness and does not deal with project level innovation comprehensively.

				firms are saying about innovation? · How are they managing innovation? · What are the really important debates for them?	
35	Khalfan, M.M.A. & other	Innovating for supply chain integration within construction	Yes	This is on relationship contracting, especially partnering and supply chain integration based on case studies. Ling's definition of innovation highlighted.	This covers only a part of enabler categories, i.e. project team fitness and does not deal with project level innovation comprehensively.
36	Kilinc, Nida et al	The Changing Role of the Client in Driving Innovation for Design-build Projects: Stakeholders' Perspective	Yes	This paper looks at Turkish real estate sector initiatives of the clients to promote innovation.	Some parts of enabler categories such as incentivisation and project team fitness discussed.
37	Kissi J, Dainty A, Liu A	Examining middle managers' influence on innovation in construction professional services firms: A tale of three innovations	Yes	Leadership and organisational innovation covered.	This covers only a part of enabler categories, i.e. project team fitness and does not deal with project level innovation comprehensively.
38	Koskela, L. Vrijhoef, R.	Is the current theory of construction a hindrance to innovation?	Yes	Covers organisational innovation.	This does not deal with project level innovation.
39	Kulatunga	Researching	Yes	This paper is on	This does not deal with client

	, KJ Amaratunga, RDG Haigh, RP	construction client and innovation: methodological perspective		research philosophy.	enabler categories, which is innovation facilitation, in a comprehensive way.
40	Kulatunga, KJ Amaratunga, RDG Haigh, RP	"Construction client and innovation": Pilot study and analysis	Yes	This paper is based on a case study on what ways the client can promote innovation in the construction industry including the role of client as a manager, interpersonal role and informational role.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
41	Kulatunga, K. Kulatunga, U. Amaratunga, D. Haigh, R.	Client's championing characteristics that promote construction innovation	Yes	Using case studies, aspects such as team dynamics, and team action, competence, value judgement, flexibility, and self-motivation are discussed.	This covers only a part of enabler categories, i.e. project team fitness and does not deal with project level innovation comprehensively.
42	Kulatunga, U. Amaratunga, RDG Haigh, RP	Construction innovation: a literature review on current research	Yes	This is a literature review on current research. Innovation is defined in an organisational perspective.	This does not focus on project level innovation.
43	Kumaraswamy, M. Dulaimi, M.	Empowering innovative improvements through creative construction procurement	Yes	Construction and manufacturing compared to identify improvements to construction procurement.	This covers only parts of enabler categories, i.e. project team fitness, incentivisation and does not deal with project level innovation comprehensively.
44	Kumaraswamy, M.	Integrating procurement	Yes	This is on procurement and	This covers only parts of enabler categories, i.e. project

	Love, P.E.D. Dulaimi, M. Rahman, M.	and operational innovations for construction industry development		covers relationship contracting Slaugher's definition used.	team fitness, incentivisation and does not deal with project level innovation comprehensively.
45	Lampel, Joseph Miller, Roger Floricel, Serghei	Information asymmetries and technological innovation in large engineering construction projects	Yes	This covered the factors that contributed to project level innovativeness including design, construction, project management.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
46	Lenfle, Sylvain, 2007	Projects and innovation: the ambiguity of the literature and its implications	Yes	This paper discusses projects and innovation from the managerial perspective. The paper is not confined to construction projects. No attempt to define innovation with respect to projects. However, this is the second paper which linked innovation and projects.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
47	Lim, J.N. Ofori, G.	Classification of innovation for strategic decision making in construction businesses	Yes	This paper is on Singapore construction industry focussing on contractors, especially covering innovation behaviour of contractors	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.

48	Ling, Florence YY Hartmann, Andreas Kumaraswamy, Mohan Dulaimi, Mohammed	Influences on innovation benefits during implementation: client's perspective	Yes	Based on a survey in Hong Kong this paper covers client's perspective of innovation including benefits.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
49	Ling, F.Y.Y.	Managing the implementation of construction innovations	Yes	This is based on a study on innovation in Singapore's construction industry covers benefits of an innovation to project team members and the project as a whole. New definition for construction innovation given.	This covers organisational innovation. Client enabler categories not comprehensively covered except for the parts of project team fitness.
50	Liu, Hui Skibniewski, Miroslaw J Wang, Mengjun	Identification and hierarchical structure of critical success factors for innovation in construction projects: Chinese perspective	Yes	Based on a literature review, a case study and expert interviews, this paper discusses inter-relationships, involvement and leadership, top management commitment.	This covers organisational innovation. Client enabler categories not comprehensively covered except for the parts of project team fitness.
51	Lu, S.L. Sexton, M.	Innovation in small construction knowledge-intensive professional service firms: a	Yes	Based on a case study, this paper looks at knowledge-based innovation and covers organisational	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.

		case study of an architectural practice		innovation.	
52	Manley, K.	The innovation competence of repeat public sector clients in the Australian construction industry	Yes	Based on a large scale Australian construction industry survey, this study looks at innovation competence of public sector clients. This covers innovation competence of clients.	This covers organisational innovation. Client enabler categories not comprehensively covered except for the parts of project team fitness.
53	Manley, K.	Implementation of innovation by manufacturers subcontracting to construction projects	Yes	Based on four case studies this looks at manufacturers focussing on innovation.	This does not deal with client enabler categories.
54	Manley, K. Mcfallan, S.	Exploring the drivers of firm-level innovation in the construction industry	Yes	This is on organisational innovation based on an Australian survey.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
55	Manley, K. McFallan, S. Kajewski, S.	Relationship between construction firm strategies and innovation outcomes	Yes	This is on organisational innovation based on an Australian survey and cover business strategies to innovation performance by firms.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
56	Manley, K. McFallan, S. Swainston, M. Kajewski, S.	Assessing the value of different business strategies to innovation by firms in the construction	Yes	This is on organisational innovation based on an Australian survey and cover business strategies to innovation performance by	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.

		industry		firms.	
57	Miller, C. Carr, R. Cheung, W.	Construction Innovation–An Annotated Bibliography	Yes	This is a collection of papers on construction innovation, most of which mentioned here.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
58	Murphy, Martina Heaney, George Perera, Srinath	A methodology for evaluating construction innovation constraints through project stakeholder competencies and FMEA	Yes	Based on case studies this research covers stakeholder competency. Construction innovation defined using Slaughet's definition.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
59	Na, L.J. Ofori, G. Park, M.	Stimulating construction innovation in Singapore through the national system of innovation	Yes	This is mainly on government actions.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
60	Nam, CH Tatum, CB	Strategies for technology push: Lessons from construction innovations	Yes	This is mainly on leadership and technical push to promote innovation.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
61	Nam, CH Tatum, CB	Leaders and champions for construction innovation	Yes	Based on empirical studies the role of key individuals on innovations in the US construction industry explored.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
62	Nepal, M.P.	The role of the project manager as a champion of construction innovation	Yes	This thesis examines the role of the project manager as a champion of construction	This covers organisational innovation. Client enabler categories not comprehensively covered except for the parts of project team fitness.

				innovation.	
63	Newton, PW	Modelling innovation in AEC: understanding the fourth dimension of competition	Yes	This is on organisational innovation. He proposes innovation to be the fourth dimension of completion in project management.	This does not deal with client enabler categories, which is innovation facilitation, in a comprehensive way.
64	Nifa, Faizatul A Abdul Ahmed, Vian	The role of organisational culture in construction partnering to produced innovation	Yes	partnering, the role of organisational culture	This covers organisational innovation. Client enabler categories not comprehensively covered except for the parts of relationship harnessing.
65	Ozorhon, Beliz, 2012	Analysis of construction innovation process at project level	Yes	Based on a case study, this research investigates the innovation process in construction projects. It proposes a framework including the drivers, inputs, enabler categories, barriers, innovative activities, benefits, and impacts.	This is the third research dealing with project level innovation. However, it has not discussed client enabler categories in a detailed manner. This is more on project team fitness.
66	Panuwatwanich, Kriengsak	Modelling the Innovation Diffusion Process in Australian Architectural and Engineering	Yes	This thesis is more on organisational innovation.	This covers organisational innovation. Client enabler categories not comprehensively covered except for the parts of project team fitness.

		Design Organisations			
67	Panuwatwanich, Kriengsak Stewart, Rodney A Mohamed, Sherif	The role of climate for innovation in enhancing business performance: the case of design firms	Yes	This covers organisational innovation.	Client enabler categories not comprehensively covered except for the parts of project team fitness
68	Park, M. Nepal, M.P. Dulaimi, M.F. 2004	Dynamic modeling for construction innovation	Yes	This paper looks at the role of participants at the project level and addresses the dynamics of construction innovation.	This is the first paper directly discussing innovation at the project level. Client enabler categories not comprehensively covered except for the parts of project team fitness
69	Pellicer, Eugenio Yepes, Víctor Correa, Christian L Alarcón, Luis F	Model for Systematic Innovation in Construction Companies	Yes	Based on case studies, a model for innovation management discussed. The paper is on organisational innovation.	Client enabler categories not comprehensively covered except for the parts of project team fitness
70	Pries, F. Janszen, F.	Innovation in the construction industry: the dominant role of the environment	Yes	This paper discusses innovation with respect to the environment such as the market and technology.	This does not deal with client enabler categories.
71	Russell, AD Tawiah, P Zoysa, S De	Project innovation-a function of procurement mode?	Yes	This paper is on a theory related to procurement in a construction project. Included in the discussion are Project complexity/uniqueness Number of	Client enabler categories not comprehensively covered

				competitors	
72	Salter, Ammon Gann, David	Sources of ideas for innovation in engineering design	Yes	Based on a case study and survey, this paper examines the role of different enabler categories for learning about new designs, the motivations of designers, problem-solving and limits to designers' ability to innovate.	This covers idea harnessing only.
73	Seaden, G. Guolla, M. Doutriaux, J. Nash, J.	Strategic decisions and innovation in construction firms	Yes	This discusses a model on decision making.	Client enabler categories not discussed.
74	Sexton, M. Barrett, P.	Performance-based building and innovation: balancing client and industry needs	Yes	This discusses how performance-based building industry relate to innovation. It is related to project level innovation.	This is an action and doesn't cover enabler categories.
75	Slaughter, E.S.	Models of construction innovation	Yes	This paper presents five models of construction innovation, which companies can select and implement innovations. Models are based on types of innovations.	The paper is on organisational innovation and does not discuss client enabler categories.
76	Slaughter,	Implementation	Yes	This discusses	The paper is on organisational

	E.S.	of construction innovations		organisational strategies to implement innovation.	innovation and does not discuss client enabler categories.
77	Tatum, CB	Organising to increase innovation in construction firms	Yes	This is on organisational structure and culture.	Client enabler categories not comprehensively covered except for the parts of project team fitness
78	Tatum, CB	What prompts construction innovation?	Yes	Innovation challenges are discussed including technological challenges, organisational challenges.	Client enabler categories not comprehensively covered.
79	Tatum, CB	Potential enabler categories for construction innovation	Yes	Advantages and disadvantages which the construction industry presents for innovation are discussed including project organisation, necessity and challenge, engineering and construction integration, low capital investment, capability and experience of key personnel, process emphasis, and variation in methods.	Client enabler categories not comprehensively covered.
80	Tatum, CB	Process of innovation in construction firm	Yes	This is more towards organisational innovation.	Client enabler categories not comprehensively covered.
81	Thomson,	Managing the	Yes	Based on case	Client enabler categories not

	Craig S Munns, Andrew K 2010	implementation of component innovation within construction projects.		studies, this paper focusses on management support for innovation. This is on project innovation.	comprehensively covered except for the parts of project team fitness
82	Toole, T.M. Hallowell, M. Chinowsky, P. 2012	A tool for enhancing innovation in construction organisations	Yes	In this study drivers and barriers to innovation, organisational and management characteristics that promote innovation discussed.	This is mostly on organisational innovation and client enabler categories not comprehensively covered.
83	Widén, K. 2002	Innovation in the construction process	Yes	In this thesis, construction process and the innovation process are compared. The research is based on a literature review and included in the discussion are: communication, relationship and co-operation with other parties. .	This is mostly on communication and client enabler categories not comprehensively covered.
84	Winch, G.	Zephyrs of creative destruction: understanding the management of innovation in construction	Yes	This is a paper on a framework for the management of innovation in construction, addressing the construction innovation problem in two distinctive ways at the institutional	This is mostly on organisational innovation and client enabler categories not comprehensively covered.

				and firm levels.	

Appendix 2

Expert Panel Briefing Sheet

Research Title: Analysis of mechanisms that enhance innovation potential of infrastructure projects.

Purpose: The aim of the research is to gather information on factors that augment innovative performance of infrastructure projects at the execution level. Using literature review and other means, the researcher has already identified these factors (hereafter called mechanisms or model constructs). Researcher also has identified their interrelationships and their relationship on the innovative performance in the form of a model. In order to verify the model, a draft questionnaire was developed.

This expert review process is conducted to assess the adequacy of the draft questionnaire, by seeking comments from independent experts who have experience both in the execution of major infrastructure projects as well as those knowledgeable on research design.

This briefing sheet contains two parts:

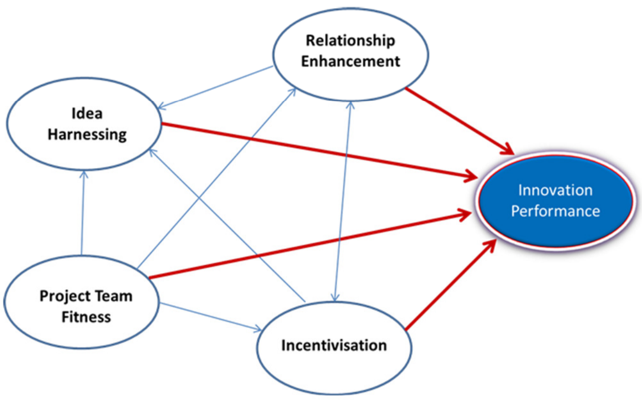
1. Part 1 – brief description of the research and the questionnaire
2. Part 2 – detailing the assessment process for panel members

Part 1

Model description: The proposed model uses the following mechanisms as its constructs. They are:

1. Idea Harnessing - the use of new and beneficial ideas
2. Relationship enhancement - employing actions to improve the relationship between the client's project team and external parties such as the contractor, consultant and stakeholders
3. Incentivisation - providing incentives or rewards to promote innovative activities
4. Project team fitness - deliberate actions taken by the client to strengthen its project team and improving its capability to focus on innovative activities.

A graphical representation of the proposed model showing inter-relationships between constructs is given below.



Appendix 3
Questionnaire

Confidential When Completed

Questionnaire Survey

Analysis of mechanisms that enhance innovation potential of construction projects

Information for respondents

This Questionnaire is available on line at http://usqsurvey.usq.edu.au/~H14REA181

Purpose of the survey: The aim of the survey is to gather information on factors that augment innovative performance of construction projects at the execution level. This is a pioneering area of innovation research, the completion of which will benefit practitioners like you to enhance project outcomes through the use of innovation.

Confidentiality: The information that you provide will be kept completely confidential and used only for academic purposes. Individual information will not be identified. Once the research is completed all the data will be deleted from computers and all written information destroyed.

Questionnaire structure: The questionnaire consists of three parts: Part 1 details of the project you are using to answer the questionnaire; Part 2 innovation related information about the project; and Part 3 background information about you and your organisation. Innovation related questions are grouped under idea harnessing, relationship enhancing, incentivisation, project team fitness and innovative performance.

Notes on responding to questions

1. Based on your experience in construction projects, you are kindly requested to provide insight into the factors that contribute to augment innovation. The research looks at construction projects from the perspective of a project team member working for the client (or owner) of the project. The member may be from a team representing the owner such as the consultant, design, superintendent team. If you **have not been a member representing the client (or owner) please refrain from participating in this survey**.
2. Please answer questions based on an innovative construction project you were involved with as a member representing the client (or owner) during the last five years. It could be a project which used new or significantly improved technologies, methods, services, practices, materials, products, plant and equipment, advanced computer software/ hardware and models etc. that generated noteworthy benefits. The ideas for these may have either been generated within or adopted from elsewhere.
3. The research covers all phases of a construction project except the maintenance phase. In addition, residential construction is excluded. However, the construction of large public, commercial and industrial buildings (such as museums, shopping complexes) are included.
4. Project team means Client's project team (or the team representing client's interests) and parent organisation means Client's (or owner's) organisation.
5. The terms with superscripts are explained under notes.

PART 1 - Project Information: Please give the following details of the project you are using to answer the questionnaire.

What is the main engineering area of your project?

	Roads and bridges		Mining, oil and gas
	Water resources		Construction of large buildings
	Railways		Marine structures
	Airports		Public utilities
	Sanitation		Other (please specify below)
	Power and electrical		

What is the delivery type of your project?

	Design, bid and build		Alliance or other collaborative contract
	Design and build		Other (please specify below)
	Early Contractor Involvement		

What is the cost of your project?

	Less than $100, 000		Over $100 Million to $200 Million
	$100, 000 to $1 Million		Over $200 Million
	Over $1 Million to $100 Million		

How do you describe the *complexity*[1] of your project?

Not complex	Somewhat complex	Fairly complex	Very complex	Extremely complex

Note:

*[1]**Complexity:** In your opinion, if it was a simple project that used established systems and processes and there were no external circumstances complicating the procedures, you may identify it as 'not complex'. On the other hand, if the project, in your opinion, had multiple interfaces, difficult technical challenges, difficult stakeholders to satisfy, unanticipated problems constantly happening, and other considerations making it difficult to manage, you may identify it as 'extremely complex'.*

PART 2: This part consists of questions related to the project under idea harnessing, relationship enhancing, incentivisation, project team fitness and innovative performance.

Section A: Idea Harnessing

This section deals with the use of new and beneficial ideas and covers idea generation and implementation aspects in the project.

Use of idea generation techniques: What are the techniques you used to generate new ideas in your project? (Can be more than one).

	Online idea database/ Suggestion Box		**Constructability review**[2]
	Brainstorming/ innovation workshops		**Sustainable design**[3]
	Scenario planning		**Value Management**[4] **or Value Engineering**[5]
	Risk assessment planning		Other (please give below)
	Life cycle costing		

Notes:

*[2]**Constructability review:** This is the review exploring the extent to which a design is facilitating the efficient use of construction resources and enhancing the ease and safety of construction on site whilst meeting the client's requirements.*

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Notes Contd..

[3]***Sustainable design:*** *The consideration of issues related to sustainability such as energy efficiency, water efficiency, the indoor environment, site locations, material usage and atmospheric consideration in the design.*

[4]***Value Management:*** *A strategy of examining every aspect of the whole project to ensure that all of the expectations can be delivered in a most economical way.*

[5]***Value Engineering:*** *A systematic approach for enhancing value by eliminating unnecessary costs while maintaining function.*

Idea generation & implementation strategies: Please rate your opinion on the following statements:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
We extensively used inputs from experienced personnel, key stakeholders, contractors and suppliers and fellow staff and workers.					
We looked for practices of external organisations (local and overseas) to generate new ideas for projects.					
We constantly followed new research and best practices.					
We captured project learnings for ongoing reference. When the projects were completed, we frequently had **post-mortems**[6] that generated new ideas for subsequent projects.					
In our team meetings, if we found an idea that had merit, we pursued the idea and followed up until the idea was completely dealt with.					
In our team, we had implementers to help idea generators to develop and implement ideas.					

Note: [6]***Post-mortems***: *Lesson learning sessions which discuss what went right and what went wrong in a no-blame culture situation.*

Section B: Relationship enhancement

This section deals with employing actions to improve the relationship between the client's project team and external parties such as the contractor, consultant and stakeholders.

Form of relationship with the contractor: What is the formal or informal relationship you had with the contractor's team? (Can be more than one).

	Traditional[7], but collaboration taken seriously into the behaviour between parties during the execution of the contract.		Part of the contract involved characteristics similar to alliance - example, **Early Contractor Involvement Contract**[10]
	Partnering[8] included in the traditional contract.		**Alliance**[11]—If none of the above, please give below.
	Extended Partnering[9] included in the traditional contract.		

Notes:

[7]***Traditional***: *The traditional or the conventional approach to projects involves discrete design development, tender and contract award and construction delivery phases. Example: design, bid and build.*

[8]***Partnering***: *Parties voluntarily agree to co-operate in a partnering relationship without any legal effect.*

[9]***Extended Partnering***: *This is a formal process. Although not legally binding, the partnering process may be included in the tender documents as an option. Usually, this includes a series of meetings, workshops and reviews.*

[10]***Early Contractor Involvement Contract***: *This is a single contract with two distinct stages. The first is a services agreement to develop the design to a point where it can be confidently estimated. Here the input from the proposed constructor is sought whilst the design is still at a point where it can be efficiently influenced. This stage has characteristics of an alliance. The second stage is to complete the design through to final construction, which could be done by the party involved with stage 1 process or any other provider.*

[11]***Alliance***: *A Project Alliance is an agreement between two or more entities that undertake to work co-operatively, on the basis of sharing project risk and reward, for the purpose of achieving agreed outcomes based on principles of good faith and trust and an open book approach towards costs.*

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Nature of the relationship - Please rate your opinion on the following statements:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
We in client's team and the other (such as contractor's/ and or designer's) teams respected each other and worked to get better outcomes for the project.					
There was a culture of trust, free and open communication, cooperation and collaboration and joint problem resolution between our teams.					
We had extremely good relationships with the key stakeholders of the project.					
All worked in the project including contractors, consultants and other stakeholders had excellent relationships and open communications with each other.					

Section C: Incentivisation

This section is on providing incentives or rewards to promote innovative activities. It deals with recognising and rewarding innovators (i.e. idea generators and implementers) in general and rewarding designers and contractors in particular.

Incentivisation strategies - Please rate your opinion on the following statements:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Within our team and in the parent organisation, we always recognised idea generators.					
Within our team and in the parent organisation, we always recognised idea implementers in addition to idea generators.					
Within our team and in the parent organisation, we always rewarded idea generators and implementers by offering more **financial incentives**[12].					
Within our team and in the parent organisation, we always rewarded idea generators and implementers by offering more **personal incentives**[13].					
When selecting designers and contractors, we gave priority to those who had innovative proposals in their submissions.					
When selecting designers and contractors, we gave priority to those who had good innovation history.					
Contractors and designers were made to understand that innovation performance would help them in getting future jobs.					
When drafting contract conditions for projects, we included clauses in contract documents to share savings from innovations with the contractor.					
For our projects, we deliberately selected contract types such as alliance which had gain-share clauses to provide financial incentives for innovative work.					

Notes:

[12]***Financial incentives****: Provision of incentives to individuals related to financial gains such as salary increase, payment of a bonus and payment by company shares.*

[13]***Personal incentives****: Provision of incentives to individuals related to non-financial gains such as personally thanked by the head of the organisation, recognised by the peer group, given an award or trophy, names published in organisational communication channels and dinner with the head of the organisation.*

Section D: Project team fitness

This section deals with deliberate actions taken by the client to strengthen its project team and improving its capability to focus on innovative activities. It relates to the project team and to the Client's organisation.

Project Manager: Please think about your immediate project manager and rate your opinion on the following statements. If there was no other project manager above you, please rate yourself.

The Project Manager:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
sought out, encouraged and promoted new ideas/ technology/ processes.					
was experienced and technologically competent.					
earned respect from the team due to his/her **innovative leadership skills**[14]**.**					
made quick decisions in regards to new ideas/ technology/ processes.					
protected the team from external criticism and acted as a wall absorbing all external pressures.					

Note:

[14]***Innovative leadership skills:*** *These skills enable the project manager to harness the best ideas of the team and significantly enhance project outcomes through innovation. They include skills such as: the ability to encourage team members to try new ways of doing their jobs; constantly looking for opportunities to improve; seeking out and promote new technologies, processes, techniques, ideas to solve problems; and convincing and selling innovative ideas to potential allies and getting their support and approval.*

Project team facilities: Please think about the facilities provided to your project team and rate your opinion on the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Our project team was provided with ongoing training and other activities to improve our team skills and to improve knowledge on subject areas that we were dealing with.					
Our project team was provided with training to improve our knowledge on the processes that could promote innovation in our activities.					
Our team members had ample opportunities to be exposed to others who did not belong to our cohesive group such as meeting in tea breaks, attending conferences, seminars, professional meetings.					
Our team members had ample opportunities to be exposed to best national and international practices through activities such as presentations by experts, attending conferences, newsletter articles and the circulation of identified articles/websites.					
Those interested to act as 'implementers' were given special training to develop and implement ideas.					

Project team environment: Please think about your project team environment and rate your opinion on the following statements.

Our project team members:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
were helpful to each other and were excellent partners in team work.					
were motivated individuals interested in project success and implementing new ideas.					
were diverse persons with regard to their fields of work.					
had considerable knowledge and experience in the type of work they did.					
had exposure to innovation previously in their work.					
had strong relationships with customers and other stakeholders.					
considered innovation as a day-to-day duty in their work.					

Project team culture: Please think about your project team culture and rate your opinion on the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Irrespective of relevant positions in the organisation, all were treated equally in the team.					
Members felt free to talk on any idea, even though they may have felt silly.					
When ideas were accepted, they became team ideas, not individual ideas and the team was prepared to accept risks associated with their decisions.					
When ideas were accepted, there was no difficulty in forming teams to develop ideas.					
When things went wrong there was no blame game.					

Client organisation perception: Please think about the client organisation and rate your opinion on the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
We believed that the client organisation supported our innovative activities by providing material support and decision making.					
We believed that the client organisation's relaxation of technical regulations/ specifications supported our innovative activities.					
We believed that the client organisation had **characteristics of an innovative organisation**[15]**.**					

Notes:

[15]An innovative organisation would have all or some of the characteristics given below:

- Trusting employees and providing them with a degree of freedom of thought and action with no blame culture, especially with regard to mistakes done in the process of innovation.
- Providing recognition, encouragement, support and robust incentives towards innovative activities.
- Providing opportunities for networking facilities within and outside the organisation.
- Top management showing its commitment to promoting innovation through their actions.
- Having a separate unit dedicated to promoting innovation in the organisation and a strong focus on knowledge management.
- Allocating funds for research and development.
- Organisation having **processes**[16] (see below) to recognise and reward innovators.
- Organisation having **management systems**[17] (see below) to capture good ideas and monitor the progress of their implementation.
- Employees encouraged to have strong relationships with customers and other stakeholders.

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Notes Contd:

*[16]**Processes**: Processes used by organisations to recognise and reward innovators include senior management messages, broadcasting names in organisational publications, recognising at organisational gatherings and presenting awards in special events of the organisation.*

*[17]**Management systems**: Management systems to capture good ideas and monitor the progress of their implementation include those such as running idea generation challenges and computerised idea capturing systems or paper-based systems.*

Section E: Project innovative performance

This section deals with the innovative performance of the project that you considered earlier in answering questions.

Project usage: Please rate your opinion on the project usage on the following statements:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
We used improved/ advanced technologies, methods and practices in the project.					
We used improved/ advanced materials, products, plant, and equipment in the project.					
We used improved/ advanced computer software/ hardware, models and communication systems in the project.					
We used improved/ advanced business or procurement techniques, processes and systems in the project.					
We used construction resources efficiently.					
We used sustainable practices during the project execution.					

Project outcomes: Please rate your opinion on project outcomes on the following statements.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
operational goals of time, cost and quality.					
satisfied customers.					
sustainable outcomes and reduced waste.					
satisfied project team and personal development of our project team members.					
increased productivity and competitive advantage for the client organisation.					
positive organisational and professional learning for the client organisation.					
positive economic impact to the surrounding community.					

Project Recognition: Please rate your opinion on recognition for the project on the following statements:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Some of our project personnel received internal (within the organisation) recognition for their outstanding service to the project.					
Our project received internal recognition from our organisation.					
Our project was highly commended in the media such as in radio and newspapers.					
The project received external recognition in professional bodies such as the Institution of Engineers Australia.					
Industry has started using the practices we introduced in the project.					

The space below is for you if you like to contribute additional information regarding the areas covered in the questionnaire. Please use an additional paper, if you need more space.

Appendix 4

Questionnaire for case studies for the Client

The Project

Please comment on the following aspects of the project:

- Project usage;
- Project outcomes; and
- Project Recognition.

Project usage

Please comment on whether the project had the usage of:

- improved/ advanced technologies, methods and practices.
- improved/ advanced materials, products, plant, and equipment.
- improved/ advanced business or procurement techniques, processes and systems.
- Any other usage.

Project outcomes

Please comment on whether the project had the achievement of:

- operational goals of time, cost and quality.
- satisfied customers.
- sustainable outcomes and reduced waste.
- satisfied project team and personal development of our project team members.
- increased productivity and competitive advantage for the client organisation.
- positive organisational and professional learning for the client organisation.
- positive economic impact to the surrounding community.
- Any other achievement.

Project Recognition

Please comment on whether:

- some of the project personnel received internal (within the organisation) recognition for their outstanding service to the project.
- the project received internal recognition from your organisation.
- the project was highly commended in the media such as in radio and newspapers.
- the project received external recognition in professional bodies such as the Institution of Engineers Australia.
- The industry has started using the practices introduced in the project.

Now, please comment on the innovation enablers that contributed to the innovative outcomes.

Section A: Idea Harnessing

(a). Idea generation techniques

1. Did you use one or more of the following idea generation techniques in planning and execution of the project?
   - Online idea database/ Suggestion Box
   - Brainstorming/ innovation workshops
   - Scenario planning
   - Risk assessment planning
   - Life cycle costing
   - Constructability review
   - Sustainable design
   - Value Management or Value Engineering
2. How did you use them?
3. Any indication how effective they were?

Comment on

(b). Idea generation & implementation strategies

Idea inputs to do better

1. Comment on the inputs you got from team members.
2. Comment on the inputs you got from experienced personnel.
3. Comment on the inputs you got from contractors and suppliers.
4. Comment on the inputs you got from fellow staff and workers.
5. Comment on the inputs you got from other key stakeholders.

Looking for best practices

1. Comment on looking for best practices of external organisations (local and overseas) to generate new ideas for the project.
2. Comment on following new research in this area.

Capturing project learnings

1. Comment on capturing project learnings from previous projects.
2. Do you practice post-mortems?

Idea follow up

1. How did you follow up ideas?
2. Did you have implementers to put ideas into practice?

Section B: Relationship enhancement

(a). Form of relationship with the contractor

1. Among the following forms of relationship, what did you have in your contract?
    - Traditional, where collaboration was not taken seriously into the behaviour between parties during the execution of the contract.
    - Traditional, but collaboration was taken seriously into the behaviour between parties during the execution of the contract.
    - Partnering practiced with the traditional contract.
    - Extended Partnering (formal partnering process) included in the traditional contract.
    - Part of the contract involved characteristics similar to alliance - example, Early Contractor Involvement Contract.
    - Alliance.
    - Any other.
2. Did they contribute to outcomes in your opinion?

(b). Nature of the relationship

1. Comment on the respect of teams to each other to get better outcomes for the project.
2. Comment on the culture of trust, free and open communication, cooperation and collaboration and joint problem resolution between teams.
3. Who were your key stakeholders and what type of relationships your team had with them?

Section C: Incentivisation

(a). Incentivisation strategies

1. Comment on recognising idea generators and implementors within your team and in the parent organisation and offering personal and financial incentives.
2. Comment on giving priority to those who had innovative proposals in their submissions when selecting designers and contractors.
3. Comment on giving priority to those who had good innovation history when selecting designers and contractors.
4. Did you make contractors and designers understand that innovation performance would help them in getting future jobs?
5. When drafting contract conditions for projects, did you include clauses in contract documents to share savings from innovations with the contractor or any other clauses that provide incentives?

Section D: Project team fitness

(a). Project Manager

1. Comment on the Project Manager on encouraging and promoting new ideas/ technology/ processes?
2. In your opinion, was the Project Manager experienced and technologically competent?

(b). Project team facilities

1. Comment on your project team's ongoing training and other activities to improve team skills and knowledge on subject areas that you were dealing with?
2. Comment on your project team's training to improve knowledge on the processes that can promote innovation in your activities?
3. Comment on the opportunities your team members had exposing to others who did not belong to your cohesive group such as meeting in tea breaks, professional meetings.
4. Comment on the opportunities your team members had exposing to best national and international practices through activities such as presentations by experts, attending conferences, newsletter articles and the circulation of identified articles/ websites.

(c). Project team environment

Comment on your project team members as to whether they:

- were helpful to each other and were excellent partners in team work.
- were motivated individuals interested in project success and implementing new ideas.
- were diverse persons with regard to their fields of work.
- had considerable knowledge and experience in the type of work they did.
- had exposure to innovation previously in their work.
- had strong relationships with customers and other stakeholders.
- considered innovation as a day-to-day duty in their work.

(d). Project team culture

Comment on whether in your team:

- all were treated equally irrespective of relevant positions in the organisation.
- team members felt free to talk on any idea, even though they may have felt silly.
- when ideas were accepted, they became team ideas, not individual ideas and the team was prepared to accept risks associated with their decisions.
- when things went wrong there was no blame game.

(e). Client organisation perception

Comment on whether:

- you believed that the client organisation supported your innovative activities by providing material support and decision making.
- you believed that the client organisation's relaxation of technical regulations/ specifications supported your innovative activities.
- you believed that the client organisation had characteristics of an innovative organisation.

Please comment on any other innovation enablers that contributed to innovative outcomes.

Characteristics of an innovative organisation

An innovative organisation would have all or some of the characteristics given below:

- Trusting employees and providing them with a degree of freedom of thought and action with no blame culture, especially with regard to mistakes done in the process of innovation.
- Providing recognition, encouragement, support and robust incentives towards innovative activities.
- Providing opportunities for networking facilities within and outside the organisation.
- Top management showing its commitment to promoting innovation through their actions.
- Having a separate unit dedicated to promoting innovation in the organisation and a strong focus on knowledge management.
- Allocating funds for research and development.
- Organisation having processes (see below) to recognise and reward innovators.
- Organisation having management systems (see below) to capture good ideas and monitor the progress of their implementation.
- Employees encouraged to have strong relationships with customers and other stakeholders.

Processes: Processes used by organisations to recognise and reward innovators include senior management messages, broadcasting names in organisational publications, recognising at organisational gatherings and presenting awards in special events of the organisation.

Management systems: Management systems to capture good ideas and monitor the progress of their implementation such as running idea generation challenges and computerised idea capturing systems or paper-based systems.

Appendix 5

Table Showing outlier detection using Mahalanobis distances

ID No of the variable	P value	Outlier no.
1	0.99	
2	0.27	
3	0.36	
4	0.51	
5	0.06	
6	0.04	1
7	0.38	
8	0.68	
9	0.91	
10	0.77	
11	0.89	
12	1	
13	0	2
14	1	
15	0.99	
16	0.75	
17	1	
18	0.45	
19	0.01	3
20	0.91	
21	1	
22	0.01	4
23	0.94	
24	0.71	
25	0.45	
26	0.11	
27	0.52	
28	0.35	
29	0.76	
30	0.86	
31	1	
32	0.87	
33	0.45	
34	0.96	

35	0.44	
36	1	
37	0.58	
38	0.14	
39	0.85	
40	0.33	
41	0.81	
42	0.01	5
43	0.36	
44	0.16	
45	1	
46	0.02	6
47	0.02	7
48	0.02	8
49	0.93	
50	0.1	
51	0.82	
52	0.99	
53	0.69	
54	0.61	
55	0.2	
56	0.57	
57	0.12	
58	0.53	
59	0.71	
60	0.15	
61	0.63	
62	0.78	
63	0.9	
64	0.83	
65	0.45	
66	0.07	
67	0.65	
68	0.07	
69	0.96	
70	0.17	
71	0.16	
72	0.14	
73	0.71	
74	1	
75	0.75	
76	0.54	
77	0.67	
78	0.89	
79	0.11	
80	0.01	9
81	1	
82	0.12	

83	0.71	
84	0.98	
85	0.83	
86	0.96	
87	0.02	10
88	0.01	11
89	0.14	
90	0.2	
91	0.98	
92	0.57	
93	0.06	
94	0.37	
95	0.63	
96	0	12
97	0.22	
98	0.1	
99	0.84	
100	0.29	
101	0.96	
102	0.13	
103	0.16	
104	0.18	
105	0.98	
106	0.03	13
107	0.15	
108	0.26	
109	0.95	
110	0.94	
111	0.07	
112	1	
113	0.11	
114	0.88	
115	0.77	
116	0.74	
117	0.42	
118	0.07	
119	0.26	
120	0.29	
121	0.06	
122	0.84	
123	0.14	
124	0.13	
125	0.97	
126	0.03	14
127	0.08	
128	0.59	
129	0.07	

Appendix 6

Table showing variables used for factor analysis with their grouping and identification numbers

Section A: Idea Harnessing: Idea generation & implementation strategies
2A2.1 We extensively used inputs from experienced personnel, key stakeholders, contractors and suppliers and fellow staff and workers.
2A2.2 We looked for practices of external organisations (local and overseas) to generate new ideas for projects.
2A2.3 We constantly followed new research and best practices.
2A2.4 We captured project learnings for ongoing reference. When the projects were completed, we frequently had post-mortems that generated new ideas for subsequent projects.
2A2.5 In our team meetings, if we found an idea that had merit, we pursued the idea and followed up until the idea was completely dealt with.
2A2.6 In our team, we had implementers to help idea generators to develop and implement ideas.
Section B: Relationship enhancement: Nature of the relationship
2B2.1 We in client's team and the other (such as contractor's/ and or designer's) teams respected each other and worked to get better outcomes for the project.
2B2.2 There was a culture of trust, free and open communication, cooperation and collaboration and joint problem resolution between our teams.
2B2.3 We had extremely good relationships with the key stakeholders of the project.
2B2.4 All worked in the project including contractors, consultants and other stakeholders had excellent relationships and open communications with each other.
Section C: Incentivisation: Incentivisation strategies
2C1.1 Within our team and in the parent organisation, we always recognised idea generators.
2C1.2 Within our team and in the parent organisation, we always recognised idea implementers in addition to idea generators.
2C1.3 Within our team and in the parent organisation, we always rewarded idea generators and implementers by offering more financial incentives.

2C1.4 Within our team and in the parent organisation, we always rewarded idea generators and implementers by offering more personal incentives.
2C1.5 When selecting designers and contractors, we gave priority to those who had innovative proposals in their submissions.
2C1.6 When selecting designers and contractors, we gave priority to those who had good innovation history.
2C1.7 Contractors and designers were made to understand that innovation performance would help them in getting future jobs.
2C1.8 When drafting contract conditions for projects, we included clauses in contract documents to share savings from innovations with the contractor.
2C1.9 For our projects, we deliberately selected contract types such as alliance which had gain-share clauses to provide financial incentives for innovative work.
Section D: Project team fitness: Project Manager
2D1.1 sought out, encouraged and promoted new ideas/ technology/ processes.
2D1.2 was experienced and technologically competent.
2D1.3 earned respect from the team due to his/her innovative leadership skills.
2D1.4 made quick decisions in regard to new ideas/ technology/ processes.
2D1.5 protected the team from external criticism and acted as a wall absorbing all external pressures.
Section D: Project team fitness: Project team facilities
2D2.1 Our project team was provided with ongoing training and other activities to improve our team skills and to improve knowledge on subject areas that we were dealing with.
2D2.2 Our project team was provided with training to improve our knowledge on the processes that could promote innovation in our activities.
2D2.3 Our team members had ample opportunities to be exposed to others who did not belong to our cohesive group such as meeting in tea breaks, attending conferences, seminars, professional meetings.
2D2.4 Our team members had ample opportunities to be exposed to best national and international practices through activities such as presentations by experts, attending conferences, newsletter articles and the circulation of identified articles/ websites.
2D2.5 Those interested to act as ‘implementers’ were given special training to develop and implement ideas.
Section D: Project team fitness: Project team environment
2D3.1 were helpful to each other and were excellent partners in team work.
2D3.2 were motivated individuals interested in project success and implementing new ideas.
2D3.3 were diverse persons with regard to their fields of work.

2D3.4 had considerable knowledge and experience in the type of work they did.
2D3.5 had exposure to innovation previously in their work.
2D3.6 had strong relationships with customers and other stakeholders.
2D3.7 considered innovation as a day-to-day duty in their work.
Section D: Project team fitness: Project team culture
2D4.1 Irrespective of relevant positions in the organisation, all were treated equally in the team.
2D4.2 Members felt free to talk on any idea, even though they may have felt silly.
2D4.3 When ideas were accepted, they became team ideas, not individual ideas and the team was prepared to accept risks associated with their decisions.
2D4.4 When ideas were accepted, there was no difficulty in forming teams to develop ideas.
2D4.5 When things went wrong there was no blame game.
Section D: Project team fitness: Client organisation perception
2D5.1 We believed that the client organisation supported our innovative activities by providing material support and decision making.
2D5.2 We believed that the client organisation's relaxation of technical regulations/ specifications supported our innovative activities.
2D5.3 We believed that the client organisation had characteristics of an innovative organisation.
Section E: Project innovative performance: Project usage
2E1.1 We used improved/ advanced technologies, methods and practices in the project.
2E1.2 We used improved/ advanced materials, products, plant, and equipment in the project
2E1.3 We used improved/ advanced computer software/ hardware, models and communication systems in the project.
2E1.4 We used improved/ advanced business or procurement techniques, processes and systems in the project.
2E1.5 We used construction resources efficiently.
2E1.6 We used sustainable practices during the project execution.
Section E: Project innovative performance: Project outcomes
2E2.1 operational goals of time, cost and quality.
2E2.2 satisfied customers.
2E2.3 sustainable outcomes and reduced waste.
2E2.4 satisfied project team and personal development of our project team members.
2E2.5 increased productivity and competitive advantage for the client organisation.
2E2.6 positive organisational and professional learning for the client organisation.
2E2.7 positive economic impact to the surrounding community.

Section E: Project innovative performance: Project Recognition
2E3.1 Some of our project personnel received internal (within the organisation) recognition for their outstanding service to the project.
2E3.2 Our project received internal recognition from our organisation.
2E3.3 Our project was highly commended in the media such as in radio and newspapers.
2E3.4 The project received external recognition in professional bodies such as the Institution of Engineers Australia.
2E3.5 Industry has started using the practices we introduced in the project.

Appendix 7

Table showing Results from normality tests

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
2A2.1 We used inputs from experienced personnel	0.321	115	0	0.735	115	0
2A2.2 We looked for practices	0.359	115	0	0.785	115	0
2A2.3 We followed new research	0.245	115	0	0.857	115	0
2A2.4 We captured project learnings	0.293	115	0	0.824	115	0
2A2.5 We followed up team ideas which had merit until completion	0.361	115	0	0.743	115	0
2A2.6 We had implementers to help idea generators	0.256	115	0	0.870	115	0
2B2.1 Respected each other teams	0.333	115	0	0.749	115	0
2B2.2 Had conducive culture within teams	0.333	115	0	0.807	115	0
2B2.3 Had good relationships with key stakeholders	0.334	115	0	0.773	115	0
2B2.4 Had excellent relationships with other teams	0.371	115	0	0.761	115	0
2C1.1 We recognised idea generators	0.328	115	0	0.816	115	0
2C1.2 We recognised idea implementers	0.307	115	0	0.822	115	0
2C1.3 Rewarded with financial incentives	0.263	115	0	0.879	115	0
2C1.4 Rewarded with personal incentives	0.262	115	0	0.873	115	0
2C1.5 Selecting designers and contractors - used innovative proposals	0.253	115	0	0.862	115	0
2C1.6 Selecting designers and contractors - used innovation history	0.238	115	0	0.855	115	0
2C1.7 Selecting designers and contractors - used innovation performance	0.225	115	0	0.874	115	0
2C1.8 Included contract clauses to share savings	0.198	115	0	0.896	115	0
2C1.9 Selected contract types such as	0.228	115	0	0.885	115	0

alliances						
2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes	0.370	115	0	0.750	115	0
2D1.2 PM experienced and technologically competent	0.367	115	0	0.747	115	0
2D1.3 PM earned respect	0.312	115	0	0.824	115	0
2D1.4 PM made quick decisions	0.356	115	0	0.789	115	0
2D1.5 PM protected the team	0.334	115	0	0.816	115	0
2D2.1 Project team was provided with training to improve team skills	0.307	115	0	0.848	115	0
2D2.2 Project team was provided with training to improve knowledge	0.229	115	0	0.878	115	0
2D2.3 Project team had opportunities to be exposed to others	0.306	115	0	0.837	115	0
2D2.4 Project team had opportunities to be exposed to best national and international practices	0.252	115	0	0.868	115	0
2D2.5 Project team was provided with training to implementers	0.242	115	0	0.877	115	0
2D3.1 Project team members helpful	0.364	115	0	0.723	115	0
2D3.2 Project team members motivated	0.372	115	0	0.699	115	0
2D3.3 Project team members diverse persons	0.376	115	0	0.719	115	0
2D3.4 Project team members had considerable knowledge and experience	0.371	115	0	0.722	115	0
2D3.5 Project team members had exposure to innovation	0.341	115	0	0.795	115	0
2D3.6 Project team members had strong relationships with customers	0.355	115	0	0.742	115	0
2D3.7 Project team members considered innovation as a day-to-day duty	0.244	115	0	0.873	115	0
2D4.1 All were treated equally	0.370	115	0	0.752	115	0
2D4.2 Felt free to talk	0.376	115	0	0.708	115	0
2D4.3 Ideas became team ideas	0.395	115	0	0.702	115	0
2D4.4 No difficulty in forming teams	0.374	115	0	0.753	115	0
2D4.5 No blame game	0.346	115	0	0.797	115	0
2D5.1 Client organisation supported innovative activities	0.302	115	0	0.840	115	0
2D5.2 Client organisation relaxed technical regulations/ specifications	0.247	115	0	0.854	115	0

2D5.3 Client organisation had characteristics of an innovative organisation	0.267	115	0	0.865	115	0
2E1.1 We used improved technologies, methods and practices	0.332	115	0	0.800	115	0
2E1.2 We used improved materials, products, plant, and equipment	0.337	115	0	0.801	115	0
2E1.3 We used improved computer software/ hardware, models and communication systems	0.250	115	0	0.876	115	0
2E1.4 We used improved advanced business or procurement techniques, processes and systems	0.243	115	0	0.869	115	0
2E1.5 We used construction resources efficiently	0.360	115	0	0.782	115	0
2E1.6 We used sustainable practices	0.342	115	0	0.797	115	0
2E2.1 Project outcome: Operational goals	0.348	115	0	0.765	115	0
2E2.2 Project outcome: Satisfied customers	0.368	115	0	0.719	115	0
2E2.3 Project outcome: Sustainable outcomes and reduced waste	0.355	115	0	0.761	115	0
2E2.4 Project outcome: Satisfied project team	0.371	115	0	0.743	115	0
2E2.5 Project outcome: Increased productivity and competitive advantage	0.313	115	0	0.820	115	0
2E2.6 Project outcome: Positive organisational and professional learning	0.357	115	0	0.780	115	0
2E2.7 Project outcome: Positive economic impact	0.314	115	0	0.808	115	0
2E3.1 Project personnel received internal recognition	0.339	115	0	0.811	115	0
2E3.2 Project received internal recognition	0.325	115	0	0.827	115	0
2E3.3 Highly commended in the media	0.236	115	0	0.892	115	0
2E3.4 External recognition in professional bodies	0.219	115	0	0.899	115	0
2E3.5 Industry has started using the practices	0.277	115	0	0.867	115	0

Appendix 8

Table showing Item-total correlations test result

Item-Total Statistics				
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
2A2.1 We used inputs from experienced personnel	219.040	545.937	0.380	0.952
2A2.2 We looked for practices	219.770	545.159	0.273	0.952
2A2.3 We followed new research	219.970	537.420	0.515	0.951
2A2.4 We captured project learnings	219.520	542.427	0.433	0.952
2A2.5 We followed up team ideas which had merit until completion	219.390	542.293	0.513	0.951
2A2.6 We had implementers to help idea generators	220.030	538.517	0.404	0.952
2B2.1 Respected each other teams	219.220	540.698	0.546	0.951
2B2.2 Had conducive culture within teams	219.480	540.164	0.460	0.951
2B2.3 Had good relationships with key stakeholders	219.390	545.328	0.393	0.952
2B2.4 Had excellent relationships with other teams	219.510	540.568	0.515	0.951
2C1.1 We recognised idea generators	219.710	537.961	0.548	0.951
2C1.2 We recognised idea implementers	219.790	541.430	0.452	0.951
2C1.3 Rewarded with financial incentives	220.960	531.516	0.582	0.951
2C1.4 Rewarded with personal incentives	220.770	531.234	0.553	0.951
2C1.5 Selecting designers and contractors - used innovative proposals	219.910	538.870	0.458	0.951

2C1.6 Selecting designers and contractors - used innovation history	220.070	537.346	0.523	0.951
2C1.7 Selecting designers and contractors - used innovation performance	220.230	534.562	0.561	0.951
2C1.8 Included contract clauses to share savings	220.440	536.775	0.435	0.952
2C1.9 Selected contract types such as alliances	220.690	539.392	0.419	0.952
2D1.1 PM sought out, encouraged and promoted new ideas/ technology/ processes	219.460	538.251	0.636	0.951
2D1.2 PM experienced and technologically competent	219.420	540.754	0.525	0.951
2D1.3 PM earned respect	219.700	535.473	0.615	0.951
2D1.4 PM made quick decisions	219.650	538.369	0.529	0.951
2D1.5 PM protected the team	219.610	537.381	0.517	0.951
2D2.1 Project team was provided with training to improve team skills	219.790	537.658	0.466	0.951
2D2.2 Project team was provided with training to improve knowledge	220.070	538.837	0.436	0.952
2D2.3 Project team had opportunities to be exposed to others	219.920	537.494	0.469	0.951
2D2.4 Project team had opportunities to be exposed to best national and international practices	220.190	536.524	0.445	0.952
2D2.5 Project team was provided with training to implementers	220.570	541.598	0.378	0.952
2D3.1 Project team members helpful	219.290	543.926	0.483	0.951
2D3.2 Project team members motivated	219.360	544.705	0.476	0.951
2D3.3 Project team members diverse persons	219.400	547.382	0.343	0.952
2D3.4 Project team members had considerable knowledge and experience	219.220	545.996	0.415	0.952
2D3.5 Project team members had exposure to innovation	219.680	538.957	0.567	0.951
2D3.6 Project team members had strong relationships with customers	219.380	543.449	0.490	0.951
2D3.7 Project team members	219.960	531.709	0.628	0.951

considered innovation as a day-to-day duty				
2D4.1 All were treated equally	219.430	536.722	0.534	0.951
2D4.2 Felt free to talk	219.370	545.429	0.421	0.952
2D4.3 Ideas became team ideas	219.470	546.093	0.422	0.952
2D4.4 No difficulty in forming teams	219.650	541.510	0.524	0.951
2D4.5 No blame game	219.630	530.269	0.662	0.951
2D5.1 Client organisation supported innovative activities	219.740	533.177	0.645	0.951
2D5.2 Client organisation relaxed technical regulations/ specifications	220.190	534.349	0.523	0.951
2D5.3 Client organisation had characteristics of an innovative organisation	220.030	531.517	0.602	0.951
2E1.1 We used improved technologies, methods and practices	219.610	541.486	0.492	0.951
2E1.2 We used improved materials, products, plant, and equipment	219.610	542.451	0.450	0.952
2E1.3 We used improved computer software/ hardware, models and communication systems	219.900	539.122	0.433	0.952
2E1.4 We used improved advanced business or procurement techniques, processes and systems	219.970	539.508	0.437	0.952
2E1.5 We used construction resources efficiently	219.640	542.530	0.430	0.952
2E1.6 We used sustainable practices	219.600	543.663	0.413	0.952
2E2.1 Project outcome: Operational goals	219.400	541.698	0.515	0.951
2E2.2 Project outcome: Satisfied customers	219.270	543.444	0.504	0.951
2E2.3 Project outcome: Sustainable outcomes and reduced waste	219.490	543.480	0.473	0.951
2E2.4 Project outcome: Satisfied project team	219.430	538.703	0.576	0.951
2E2.5 Project outcome: Increased productivity and competitive advantage	219.690	538.831	0.547	0.951
2E2.6 Project outcome: Positive organisational and professional learning	219.550	540.531	0.524	0.951

2E2.7 Project outcome: Positive economic impact	219.370	544.131	0.367	0.952
2E3.1 Project personnel received internal recognition	219.680	538.483	0.481	0.951
2E3.2 Project received internal recognition	219.640	537.547	0.478	0.951
2E3.3 Highly commended in the media	220.450	535.425	0.495	0.951
2E3.4 External recognition in professional bodies	220.500	539.357	0.378	0.952
2E3.5 Industry has started using the practices	220.410	536.893	0.503	0.951