Supply chain quality management for subcontracting systems in the construction industry

Lin Lin
University of Wollongong
UNIVERSITY OF WOLLONGONG

COPYRIGHT WARNING

You may print or download ONE copy of this document for the purpose of your own research or study. The University does not authorise you to copy, communicate or otherwise make available electronically to any other person any copyright material contained on this site. You are reminded of the following:

Copyright owners are entitled to take legal action against persons who infringe their copyright. A reproduction of material that is protected by copyright may be a copyright infringement. A court may impose penalties and award damages in relation to offences and infringements relating to copyright material. Higher penalties may apply, and higher damages may be awarded, for offences and infringements involving the conversion of material into digital or electronic form.
Thesis Certification

I, Lin Lin, declare that this thesis, submitted in fulfilment of the requirements for the award of Master of Research, in the Faculty of Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Signed:

Lin Lin

15 November, 2011
ABSTRACT

Achievement of high quality performance can provide a potential competitive edge in the construction industry. Subcontracting is a feature of the construction industry that has been identified as a source of poor quality and overall poor business performance. This thesis aims to determine the root causes of poor quality performance in the subcontracting system. Supply Chain Quality Management (SCQM) by integrating Quality Management into the Construction Supply Chain will be considered for its effectiveness to overcome quality problems. A set of Key Performance Indicators (KPIs) will also be developed as a major contribution to the thesis. KPIs, as a quality management tool, can ensure that SCQM can be effectively implemented in subcontracted projects.

A questionnaire survey was adopted as the research method. It received a total of 53 valid responses from 150 of the larger main contracting companies in Australia. The mean score value analysis and Relative Importance Index was used for data analysis and the data was then processed by Statistical Package for Social Scientists (SPSS). The findings from this research demonstrate that the factors attributed to poor quality performance are mostly soft factors, which could be properly addressed by the concepts of SCQM. From the survey, though the level of awareness of SCQM is not very high in the Australian construction industry, the willingness to accept some approaches related to this concept is high. This provides a possible foundation to implement SCQM in the construction industry. Lastly, a model of KPIs had been developed, based on the result from the previous theoretical studies and this survey, which will encourage the implementation of SCQM in subcontracted projects. It is expected that it will help construction companies achieve a better quality performance, especially in their subcontracted projects. Although the relationship between enhancement of quality and SCQM is not examined directly in this thesis, it does provide a perspective that SCQM could address poor quality performance caused by subcontracting.
ACKNOWLEDGEMENTS

First of all, I would like to express my sincere thanks and deepest gratitude to my supervisor Associate Professor Peter Gibson for his support and inspiration during my research journey. Besides the academic knowledge gained from Peter, ‘stick and carrot’ is what I learned when I worked with Peter.

My grateful thanks also go to Ms Joan Philips. Joan not only clarified my ideas and helped me to present these thoughts in the thesis, but also provided my many editorial and personal advices for this study. Thanks for her helps.

I wish to thank Dr Senevi Kiridena, Dr Lee Styger, and the staff at the Faculty of Engineering and Sydney Business School, University of Wollongong who gave me invaluable advices on this study.

My grateful thanks are going to the individuals and institutions who have participated in the survey and thanks are due to Mr Port Draper for his advice from practical viewpoints.

Last, but not least, I must acknowledge the support and love from my family and friends. Thanks for your understanding, love and supports. I appreciate that.
# TABLE OF CONTENTS

ABSTRACT ................................................................................................................................. i  
ACKNOWLEDGEMENTS ............................................................................................................ ii  
TABLE OF CONTENTS .............................................................................................................. iii  
LIST OF FIGURES ....................................................................................................................... vi  
LIST OF TABLES ......................................................................................................................... vii  
1 INTRODUCTION .................................................................................................................... 1  
1.1 Research background ....................................................................................................... 1  
1.1.1 Quality in the Construction Industry ..................................................................... 2  
1.2 Research Aims and Objectives ..................................................................................... 6  
1.3 Methodology ................................................................................................................... 7  
1.4 Significance of the Research ......................................................................................... 8  
1.5 Thesis Outline .................................................................................................................. 8  
2 THE SUBCONTRACTING ....................................................................................................... 10  
2.1 Subcontracting ............................................................................................................... 10  
2.1.1 Multi-layers of Subcontractors .............................................................................. 12  
2.2 Quality Problems Caused by Subcontracting .............................................................. 13  
2.2.1 Main Contractors and Subcontractors .................................................................. 13  
2.2.2 Subcontractors ..................................................................................................... 15  
2.2.3 Clients and Subcontractors .................................................................................. 16  
2.3 Issues in Subcontracting Systems ................................................................................. 16  
2.4 Improvement Methods .................................................................................................. 20  
2.5 Summary ........................................................................................................................ 21  
3 THE SUBCONTRACTOR SUPPLY CHAIN ......................................................................... 23  
3.1 The Concept of Supply Chain Management ................................................................. 23  
3.2 Supply Chain Management in the Construction Industry ........................................... 24  
3.2.1 The Construction Supply Chain .......................................................................... 24  
3.2.2 Application of the Construction Supply Chain .................................................... 26  
3.2.3 Problems of the Construction Supply Chain ....................................................... 29  
3.3 Quality in the Subcontractor Supply Chain .................................................................. 31  
3.3.1 Application of Cause Studies .............................................................................. 33  
3.3.2 Analysis of Supply Chain Quality Management ................................................ 36
LIST OF FIGURES

Figure 1.1: The structure of thesis development
Figure 2.1: The structure of multi-layer subcontractor
Figure 3.1: A Seamless Supply Chain Management Model
Figure 3.2: The ABC’s business structure
Figure 3.3: The structure of multi-layer subcontractor
Figure 4.1: A Venn diagram
Figure 5.1: The process of survey
Figure 5.2: The structure of questionnaires
Figure 6.1: Distribution of survey respondents by position
Figure 6.2: Distribution of survey by subcontractors’ quality performance
Figure 6.3: The perception of awareness of supply chain quality management
Figure 7.1: The model of KPIs in subcontracted projects
LIST OF TABLES

Table 1.1 : The summary of the factors cause poor quality
Table 2.1 : The list of causes of poor quality in subcontracting systems
Table 3.1 : The possible solutions to achieve the integration construction supply chain
Table 4.1 : The summary of KPIs
Table 4.2 : The indications in the category of quality and stakeholder satisfaction
Table 4.3 : The summary of quality indicators in supply chain
Table 4.4 : KPIs in the Subcontractors Supply Chain
Table 5.1 : The analysis of online survey
Table 5.2 : The methods of data analysis
Table 6.1 : Demographics of survey respondents
Table 6.2 : Distribution of survey respondents by numbers of employees
Table 6.3 : Distribution of survey respondents by percentage of subcontracting
Table 6.4 : Distribution of survey respondents by subcontractors’ quality performance
Table 6.5 : Reliability of data
Table 6.6 : Results of causes for poor quality in subcontracting systems
Table 6.7 : The ranking of causes for poor quality in subcontracting
Table 6.8 : Awareness of Supply Chain Quality Management
Table 6.9 : The result of Supply Chain Quality Management
Table 6.10 : The result of Key Performance Indictors
Table 6.11 : The result of KPIs in the Corporate Level
Table 6.12 : The result of KPIs in the Operational Level
Table 6.13 : The recommendations for responses
Table 7.1 : The ranking of causes for poor quality
Table 7.2 : The ranking of the agendas of Supply Chain Quality Management
Table 7.3 : KPIs in the Corporate Level
Table 7.4 : KPIs in the Operational Level
Table 7.5 : Quality improvement methods through construction process
1. INTRODUCTION

The construction industry is an important economic contributor to any country. However, the construction industry has been criticised worldwide for its unsatisfactory performance, in terms of quality, productivity, reliability and safety (Hoonakker, Carayon & Loushine, 2010). The quality of construction is a core concern of construction managers who have begun to seek new ways to improve the quality of building processes. Further, the business development of this industry also has often been said to be behind other industries. In terms of, ‘state of the art’ business processes, the Subcontracting Supply Chain has been pointed out to be particularly problematical due to adversarial relationships, a blame culture, lack of cooperation between contractors and lack of a joint focus on serving the final customer (Maqsood, Walker & Finegan, 2003; Tam, Shen & Kong, 2011). Quality issues, caused by the Subcontracting Supply Chain have often been overlooked in this industry. Therefore, this study will focus on the relationship between poor quality performance and the Subcontracting Supply Chain in the construction industry. After analysing the reasons causing poor quality in subcontracted projects, a new quality improvement approach – Supply Chain Quality Management (SCQM) will be discussed. Finally, a set of Key Performance Indicators (KPIs) as a tool for implementation of SCQM will be developed.

Firstly, the introduction discusses the definitions of Quality in the construction industry. The aim is to present a clear definition of a high quality construction project and which factors impact on quality performance in buildings. Then, it introduces SCQM and Performance Measurement as effective quality improvement approaches. Finally, the aims, objectives and significance of this study, together with the outline and methodology used will be presented.

1.1 RESEARCH BACKGROUND

Poor quality performance is one of the unsatisfactory consequences of the building process. Ashford (1989) claimed that a quality product is the major premise for a
company to become acceptable in the marketplace. Providing a high quality product is a way to acquire repeat customers and maintain a long-term development for the organisation. Thus, in the construction industry, an effective approach to improve and deliver quality is required.

Subcontracting is a widely accepted approach for many contractors to complete a project. Its benefits are, that it optimises the resource (Parrod et al., 2007), shares the project risks (Yik et al., 2006), and avoids changeable market demands (Ng et al., 2009). However, according to Karim et al. (2006), subcontractors can be the root cause of poor quality buildings. One solution to the quality problem, contributed by subcontracting, is to integrate Quality Management into the Construction Supply Chain, which has been discussed as an effective approach by Egan (1998); Kuei and Madu (2001); and Robinson and Malhotra (2005). This integration has been defined by Kuei and Madu (2001), Robison and Malhotra (2005) as SCQM, which will be discussed here as a quality improvement method. The primary focus will be to examine how SCQM could address quality issues resulting from poor quality work done by subcontractors.

1.1.1 QUALITY IN THE CONSTRUCTION INDUSTRY

Quality, as a term is not new, but many different definitions have been used. Juran defined Quality as ‘fitness for purpose or use’ (1988); Deming (1982) held that quality ‘should be aimed at the needs of the consumer, present and future’; ISO (EN) defined Quality as: the degree to which a set of inherent characteristics fulfil requirements. There are two dimensions to Quality: Quality of Product and Quality of Service. These have been defined by Garvin (1988), Evans and Lindsay (1996). Yasamis, Arditi & Mohammadi (2002) described how quality from the product aspect is connected to the end customers and they described how service quality is associated with the owners. However, mostly, Quality is defined as a simple term that is a way of ‘meeting the customers’ requirements’.

1 The customers means the people who purchase this product
There are various definitions of Quality in the construction industry as well. In 1991, Badn-Hellard demonstrated function, aesthetics, cost and time as the main dimensions of quality measurement for buildings. Further, most researchers developed their definition of Construction Quality from the aspect of ‘meeting expectations of the customer’ (Palaneswaran, Ng & Kumaraswamy, 2006). However, construction companies frequently complain that their clients do not understand what is involved in construction. Hence, only meeting customers’ demands does not mean that the building is of a high quality (Barrett, 2000). Barrett (2000) defined Construction Quality as:

*A broad concept involving the satisfaction of many interacting stakeholders and those delighting customer’s demands externally orientated construction companies working in concert with a strong improvement emphasis (p.379).*

By this definition, Quality not only has to please the customer, but needs to meet the requirements from other interacting stakeholders as well. In the construction industry, these stakeholders will include a large number of specialists with different backgrounds, for example, the subcontractors who take on most of the work in projects. From the building process, a construction project can be described as a result of a combination of a number of events and interactions, planned or unplanned, over the life of a facility (Burati et al., 1992). Walker and Keniger (2002) also stated the importance of projects’ stakeholders in quality improvements from their Australian experience. Therefore, the definition of high quality, in this study, includes the satisfaction of all stakeholders in construction projects.

The construction industry has some significant and unique characteristics, and these inhibit the enhancement of quality performance. For example, Wong and Fung (1999) found that the multitude of stakeholders, excessive changes and non-standardisation were factors that impacted on quality performance improvement in the construction industry. Chan and Chan (2004) argued that the defects in projects are caused by the changing of participants, processes and environment. Dulaimi, Ling and Ofori (2004) demonstrated that the separation of design and construction and the large number of small construction firms, contribute to unsatisfactory performances in Singapore’s
construction industry. Marosszeky (2005) called these characteristics ‘a number of issues that create difficulties’. These include fragmentation of the supply chain; short-term relationships and long time procurement; and unilateral definitions of Quality. Green, Fernier and Weller (2005) shared a similar perspective. They describe the reasons which lead to quality problems as being: fragmentised, highly localised workforces and domination by small firms. Moreover, they claimed that the low barriers to entry, lack of training for workers and an environment of lack of trust were other factors which caused poor quality results. A large number of stakeholders is another factor that can influence quality improvement (Hernandez & Aspinwall, 2008). Hoonakker, Carayon and Loushine (2010) pointed out that there are some barriers which inhibit quality improvement. These include: ‘the nature of the construction process’, ‘many parties involved in the construction process’, ‘non-standardisation’ and ‘the bidding process’.

<table>
<thead>
<tr>
<th>Factors causing poor quality</th>
<th>The researchers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The nature of industry</strong></td>
<td>Wong and Fung (1999); Chan and Chan (2004); Green, Fernier and Weller (2005); Hernandez and Aspinwall(2008); Hoonakker, Carayon and Loushine(2010); Ross (2011)</td>
</tr>
<tr>
<td>e.g., Fragmentation; Culture; Numbers of stakeholders, Changeable, etc.</td>
<td></td>
</tr>
<tr>
<td><strong>Poor Relationship</strong></td>
<td>Dainty, Briscoe and Millett (2001 a); Marosszeky (2005)</td>
</tr>
<tr>
<td><strong>Poor Definition of quality</strong></td>
<td>Wong and Fung (1999); Green, Fernier and Weller (2005); Hoonakker, Carayon and Loushine(2010)</td>
</tr>
<tr>
<td><strong>Numbers of SMEs</strong></td>
<td>Green, Fernier and Weller (2005); Hoonakker, Carayon and Loushine(2010); Dainty, Briscoe and Millett (2001b)</td>
</tr>
<tr>
<td><strong>Lowest bidding</strong></td>
<td>Hoonakker, Carayon and Loushine(2010); Tam et al. (2011)</td>
</tr>
</tbody>
</table>

Table 1.1 The summary of the factors causing poor quality
Note: small and medium-size enterprises (SMEs)

As the analysis above shows, most studies have focused on analysing poor quality caused by the complex nature of the construction industry, the number of stakeholders and unilateral quality definitions, etc. (Hoonakker, Carayon & Loushine,
The negative impact caused by subcontracting has been overlooked. Even though in the construction industry, subcontractors are responsible for most of the work. According to Crowley, Hager and Garrick (2000), in Australia on some certain construction sites as much as 95% of the work was carried out by subcontractors. Poor quality work, done by subcontractors, can degrade the quality of construction projects (Uher, 1991; Chiang, 2009), and better management of the quality of work done by subcontractors would improve the quality performance. The influence of subcontractors in Quality improvement is less noticed and this constitutes a gap between the theoretical research and practical application. Thus, the quality issue, caused by the subcontracting system, is a core theme in this thesis. This will be discussed in details in Chapter 2.

How to achieve quality improvement in the subcontracting system is the second research topic which needs to be discussed. SCQM may be one of the most cutting edge quality management tools. It emphasises the needs to establish a common quality goal and it implements Quality Management within the scope of the supply chain (Wong and Fung, 1999; Kuei & Madu, 2001 Robsin & Malhotra, 2005). Whether SCQM, as a quality management approach, can provide a better quality consequence in subcontracted projects is a core argument and will be discussed in Chapter 3. Before discussing SCQM in subcontracting, the concept of Supply Chain Management (SCM) in the construction industry needs to be studied. An analysis of SCM and SCQM in the construction industry, especially in the quality improvement of subcontracted projects, will be presented in Chapter 3.

Lastly, because Performance Measurement is a traditional tool which can ensure satisfactory quality in the construction industry (Neely, 1999; Beatham, Anumba & Thorpe, 2004), several indicators will be determined to assist construction companies to better manage and control quality in the building process. A number of organisations and companies have already launched their own lists of Key Performance Indicators (KPIs) to ensure they can achieve a high level of performance (Beatham, Anumba & Thorpe, 2004). However, most studies did not consider these indictors from the features of the subcontracting system and SCQM. Therefore, to develop a list of KPIs, related to SCQM and the Subcontractor Supply
Chain is another core issue in this thesis. The aim of this set of KPIs is to better control quality in subcontracted projects and thus act as a guide to assisting the implementation of SCQM. This will be presented in Chapter 4.

1.2 RESEARCH AIMS AND OBJECTIVES

This study examines the theories and findings from the current literature related to quality issues in the Subcontracting Supply Chain within the construction industry. Firstly, because subcontracting has been overlooked by previous researchers, one of the main aims of this study is to analyse the root causes of poor quality in the subcontracting system. Secondly, as Egan (1998), Wong and Fung (1999) suggested, the construction industry needs to learn innovative concepts from the manufacturing industry, therefore, the innovative quality management approach - SCQM should be examined. This will determine whether the implementation of SCQM has a positive influence on quality improvement in the subcontracting system. Finally, Performance Measurement is considered as an effective approach which can ameliorate the construction quality (Yasamis, Arditi & Moammadi, 2002; Karim et al., 2003). A list of suitable key performance indicators (KPIs) could also help construction companies to enhance a projects’ quality.

The first aim of this study, therefore, is to examine the root causes that contribute to poor quality in the subcontracting section. The second aim is to develop a discussion on whether implementing SCQM can improve quality in construction projects, especially in subcontracted projects and finally, determines a set of KPIs to manage SCQM implementation. It is expected that these KPIs can ensure subcontracted projects achieve a high quality result.

- To define the main causes of quality problems in the subcontracting system;
- To examine whether SCQM could improve quality performance in subcontracted projects; and
- To determine a set of KPIs to measure subcontracted projects based on the concept of SCQM.
1.3 METHODOLOGY

The research methodology of this study is divided into four stages (Figure 1.1). The first stage focuses on a literature search that provides a review of the relevant research to date (Chapter 2, 3 and 4). This is used to develop the research questions and objectives. The second stage is to collect data by means of a questionnaire (Chapter 5). After data analysis (Chapter 6), a suitable model of KPIs will be developed (Chapter 7). This is the third main objective. Finally, in conclusion, based on the literature review, data analysis and discussion will be discussed. It also will present recommendations and future research plans in this chapter. The structure of thesis development is presented as followed:

Figure 1.1 The structure of thesis development
1.4 SIGNIFICANCE OF THE RESEARCH

The outcome of this study will provide significant suggestions for the construction industry especially in the subcontracted construction projects. This study extends the current definitions of Quality in the construction industry. The concept of SCM, which has been used by the manufacturing industry, is introduced into the construction industry. It provides a broader view of how to improve Quality in construction projects, especially in subcontracted projects. The contributions of this study include:

- Providing a new view of the relationship between the subcontracting system and poor quality performance in construction projects to overcome the lack of related research.

- Providing more understanding about subcontractors, especially which factors may erode quality performance in subcontracting systems.

- Introducing a state of art quality management approach – SCQM in the construction industry that comes from the concept of SCM. This will be the first time the implementation SCQM has been discussed in the construction industry.

- A set of KPIs provides an achievable tool to adopt SCQM in current construction sites. This can be a practical tool during the project’s building duration.

1.5 THESIS OUTLINE

This study is divided into 8 chapters. In Chapter 1, the definition of Quality in the construction industry are given, plus the overall aim and objectives of this research, followed by the methodology used, significance of the study and the thesis outline. The outline of the other 7 chapters is followed:
Chapter 2 - Presents an introduction to the subcontracting system in the construction industry. Through the literature review, the causes of poor quality and quality improvement methods in subcontracted projects are recommended.

Chapter 3 - Provides a review on SCM in the construction industry, especially in subcontracted projects. In this chapter, it is deduced that there is a possible relationship between SCQM and quality improvement.

Chapter 4 - Presents the analysis of the KPIs in the Subcontractors Supply Chain through a literature review. This chapter also provides a list of two levels of KPIs from Corporate and Operational aspects based on the knowledge of SCQM and the features of the subcontracting system.

Chapter 5 - Provides a review on the research methodology, followed by a discussion of the questionnaire design. The sampling, administration of the questionnaire and method of data analysis are also presented. The Relative Important Index will be the main method in data analysis.

Chapter 6 - Presents the result of the questionnaire and data analysis and it presents the main findings from the survey.

Chapter 7 - Discusses and compares the differences between the results from the survey and literature review.

Chapter 8 - Reviews the achievements of the objectives and concludes with the main findings and provides recommendations for future research.
2. SUBCONTRACTING IN THE CONSTRUCTION INDUSTRY

Subcontracting is a significant feature in the construction industry (Loh & Ofori, 2000). The very nature of the construction industry requires a large number of specialists to work together. Mostly, the subcontractors are specialises in a unique aspect of the construction process, and it is quite rare for them possess multi-skills across the whole project trades (Yik et al., 2006). The result is that various subcontractors, who have special technologies and skills, carry out their work under the supervision of the main contractors. In this chapter, the details of the subcontracting system in the construction industry will be outlined. Secondly, factors that may lead to poor quality performance in the subcontracting system will be analysed. Thirdly, the quality improvement methods, which could enhance the subcontracted projects’ quality performance, will be discussed.

2.1 SUBCONTRACTING

Subcontracting plays an important role in the construction industry. In Singapore, about 60% to 70% of construction work is subcontracted (Loh & Ofori, 2000). Crowley, Hager and Garrick (2000) claimed that as much as 95% of the work was carried by subcontractors on some certain projects in Australia. The cost of subcontractors in Hong Kong also accounts for about half of the total building cost in a project (Chiang, 2009).

Subcontracting is based on a hierarchical multiple-structure between the main contractors and specialist subcontractors (Reeves, 2002). Subcontractors offer specialised equipment, materials, skills and know-how and carry out their work independently. Main contractors are responsible for managing them to ensure that their work will satisfy the clients’ requirements. Master Builders Association NSW (1979) defined subcontracting as:

\[
A \text{ subcontractor is an individual partnership or corporation who, or which, has undertaken, pursuant to contractual obligation, the execution of building work forming part of the obligation of another individual,}
\]
The subcontracting system has been described as the contractual process when a main contractor subcontracts parts of a project to other construction firms (Chiang, 2009). Main contractors are those who directly contract with clients and are responsible for projects completion. Subcontractors are those who are subcontracted to a builder (Department of Industry Science and Tourism, Australia, 1996). To be more specific, when a main contractor wins a tender, some work packages are subcontracted to other building companies in order to complete the project effectively (Reeves, 2002).

Main contractors adopt the subcontracting method because it eases their financial and workload pressures, especially, when several projects are operating simultaneously. Subcontracting allows subcontractors to focus on using their unique skills which leads to the work being accomplished in a highly-effectively managed way (Reeves, 2002). Repetitive work may impact on learning curves in a positive way. The increasing specialisation of tasks provided by subcontractors is a faster and better way to complete a task (Department of Industry Science and Tourism, Australia, 1996). Australian Department of Industry Science and Tourism (1996) also claimed that the benefits to a subcontractor are:

- a subcontractor can enter the industry with little capital outlay;
- the system provides motivation to skilled trades to improve their efficiency;
- the system is administratively simple and supervision costs is low; and
- encourages flexibility and mobility, etc.

The above analysis shows that subcontracting means efficiency and less-cost. Subcontracting is applied worldwide and the same relationship can also be found between subcontractors. According to Tam, Shen and Kong (2011), there are several layers which exist in the subcontracting arrangement. This is called multi-layers of subcontractors. These subcontractors can be divided into different tiers, i.e. first-tier,
second-tier, $N^{th}$-tier subcontractors. The details of the multi-layers of subcontractors are presented in the next section, Section 2.1.1.

2.1.1 MULTI-LAYER SUBCONTRACTORS

Multi-layer subcontracting is efficient because it provides a mobilising of the labour force (Yik & Lai, 2008) and significantly reduces expenses (Tam, Shen & Kong, 2011). Moreover, using multilayer subcontractors avoids changing demands from the main contractors (Ng et al., 2009). The changing requirements of the workers and the equipment needed encourage subcontractors to transmit the workload to the next layer of subcontractors. This will share all the risks among subcontractors.

In order to take various advantages of subcontracting, the first-tier subcontractors sublet some work to other subcontractors which become the second-tier subcontractors. These second-tier subcontractors, in turn, further subcontract the job. Subcontracting may filter down to individual workers (Yik & Lai, 2008). The shape of this multi-layering is that of a pyramid (Figure 2.1). At the bottom are a large number of small firms and self-employed workers. The upper subcontractors may also be small firms.

However, a multi-layered subcontracting system is not free of problems, e.g., inefficient communication, an incomplete contract, insolvency of a subcontractor and substandard work quality. These problems degrade the quality performance of the construction project (Yik & Lai, 2008). Tam, Shen and Kong (2011) criticises multilayer subcontracting in terms of quality issues, time management, cost control, communication, and coordinated performance. Moreover, these small firm
subcontractors, especially the ones on the bottom layer, do not have enough resources to implement formal Quality Management, although, their smaller size does provide them with the flexibility to adopt innovative methods (Karim et al., 2006). In the next section, the causes of poor quality in the subcontracting system will be analysed and then several necessary approaches of quality improvement will be provided.

2.2 QUALITY PROBLEMS CAUSED BY SUBCONTRACTING

When different professionals with various backgrounds work together, they tend to work in isolation with self-interested attitudes and little focus on the quality requirements of the following trade subcontractors or clients. Because of these factors, the goal of high quality is difficult to achieve in a subcontracted project. The research conducted by Tam, Shen and Kong (2011) illustrates that because of ‘the improper work’, ‘limited profit’ and ‘non-compliance to quality specifications’, subcontractors erode quality performance. Karim et al. (2006) shared similar views. They believed that subcontractors need to take more responsibility for quality. An effective management of subcontractors could reduce the incidence of defects in the construction industry (Karim et al., 2006). This could ensure high-quality results across building processes. In the next sections, the factors that cause poor quality will be discussed from the separate view from the main contractors, subcontractors and clients.

2.2.1 MAIN CONTRACTORS AND SUBCONTRACTORS

‘Lowest-bidding’ is one of the factors that leads to a poor quality performance in the construction industry. In general, main contractors are larger and hold ‘power’ positions when compared with subcontractors. To protect their own profitability, main contractors tend to choose subcontractors who offer the lowest price. This cost-orientated approach may foster self-protection, but not customer satisfaction (Eriksson, Dickinson & Khalfan, 2007). Yik et al. (2006) illustrated that main contractors considered subcontracting as a procurement method to acquire different specialists. From this consideration, transaction cost is a dominant factor when selecting subcontractors. Gonzalez, Arrunade and Fernandez (2000) proved this cost-
orientation in the construction industry. During an economic recession, ‘lowest bidding’ seriously affect small subcontractors (Chiang, 2009). This leads subcontractors into a non financial state or even bankruptcy.

The attitude of cost-orientation has many negative influences on quality of work done by subcontractors. For example, it attributes the arms-length contractual relationship in the construction industry and main contractors tend to adopt the lowest bidder when they select subcontractors. This means that to main contractors, quality and technical capabilities are not as significant as price (Reeves, 2002). For survival, ignoring quality is the best choice for some subcontractors. Cost cutting, attributed to the bidding process is a potential factor which leads to poor quality performance in construction projects. In addition, subcontractors are competing with each other and lack bargaining power (Chiang, 2009). To acquire repeat business from the main contractors, an unreasonably low price may be accepted by the subcontractors. However, these limits to profit forces subcontractors to sacrifice quality, in order to maintain their own profits. This problem is often exacerbated by main contractors who are focussed on cost and completion dates rather than their clients’ quality requirements. Low margins, high risk and destructive competition add further fuel to the fire.

Poor communication and lack of common understanding between main contractors and subcontractors is another reason that may contribute to quality problems. As this is often a one-off relationship between the main contractors and subcontractor, the two parties lack a clear understanding of each other. Without any clear and direct control or supervision, subcontractors sometimes cannot complete the work as the clients were required. Moreover, due to the uneven power position between subcontractors and main contractors, subcontractors can be ‘bullied’ and ‘treated with little respect’ by their main contractors who have ‘arrogant attitudes’, ‘short-term focus’ and ‘narrowly win-lose attitudes’ (Packham et al., 2003; Xue et al., 2007). Hence, subcontractors do not have any significant motivation to solve problems innovatively.
2.2.2 SUBCONTRACTORS

The self-restriction of subcontractors, to some degree, leads to potential quality issues. Most subcontracting companies are small. Over 90% of Australian subcontracting firms consist of not more than five employees (Department of Industry, Science and Resource, Australia, 1999), and a large number of these subcontractors are individual operators (Department of Industry, Science and Tourism, Australia, 1996). The majority of subcontractors do not have enough education, knowledge or resources to adopt modern quality management methods. Furthermore, the high level of the mobility of subcontracting firms leads subcontractors to develop a negative attitude to training. In Australia, about 60% of workers do not have formal educational qualifications or formal trade training (Department of Industry, Science and Tourism, Australia, 1996). These untrained workers may increase the possibility of defects. According to Yik et al. (2006), subcontractors are not trained or motivated to work precisely and creatively by adhering to the requirements of clients/main contractors. They may simply complete the required work as a function and do not consider to deliver the clients’ expectations. As a consequence, because of lack of Quality awareness and a less qualified workforce, subcontractors do not consider Quality as an essential factor when they work for main contractors.

The other barrier to quality improvement in subcontracted projects is the traditional working style among different subcontractors. During the construction process, the subcontractors only consider their own interests when they collaborate with others. They do not consider the following trades people as a customer who needs to be satisfied (Egan, 1998), and an inadequate of the fact that their defective work could impact on the following subcontractors (Karim et al., 2006). Mostly, nor do preceding subcontractors consider that a potential defect from their work could incur a serious quality problem in the next process, future operations, or maintenance stage.

Lack of direct communication or information sharing with other subcontractors (that forms the foundation of modern supply chain thinking), may make subcontractors less familiar with other subcontracting trades’ quality codes. Kubal (1994) emphasised that the completely different targets and lack of information sharing,
which can cause the failure of a project. Karim, Marosszeky and Davis (2006) also stated that the different trades’ codes and poor communication among different trades, e.g., tiling, painting, plumbing and carpentry, which were the root reason to cause defects. This lack of understanding can mean that any ill-considered action becomes the root cause of poor quality in the following on subcontracting trades. For example, a poorly laid concrete slab can create numerous problems for the following electricians and plumbers. Quick ‘work-arounds’ are the usual solution to these issues but such strategies usually lead to further quality problems for the next trade subcontractor. The main contractor and client and do not encourage the originator of poor quality work to improve.

2.2.3 CLIENTS AND SUBCONTRACTORS

Lack of direct communication between clients and subcontractors, is another reason that leads to poor quality performance. Main contractors are those who are responsible for fulfilling the client’s requirements and have formal contracts with clients. On the other hand, subcontractors do not normally have any formal contractual relationship with the client, but carry out the work (Tam, Shen & Kong 2011). Mostly, there is no direct communication or supervision from clients. Subcontractors only take responsibility for the specific work task allocated to them from their main contractors. This again is in stark contrast to modern supply chain thinking where, a collective focus on the client’s needs is developed by directly linking and creating an interest in contractors in relation to the effects of their work on the client or main contractor. In current construction supply practices, there is little interest for subcontractors, and/or stick and carrot motivation, to provide an excellent outcome for the client. In many cases, due to inefficient communication between subcontractors and clients, subcontractors are not always fully aware of, or interested in, the client’s requirements. This leads to defective or abortive work (Chiang, 2009).

2.3 ISSUES IN SUBCONTRACTING

From the literature review given in Section 2.2, the main 12 causes of poor quality in the subcontracting system are labelled C1-C10, Table 2.1 below.
The result of a study conducted by Karim et al. (2006) shows that more than half of the defects in construction work are caused by subcontractors’ poor workmanship. Therefore, ‘Subcontractors’ Technical Incompetence in Performing High Quality Work’ (C1), ‘Incompetent Labour Force’ (C2), ‘Unmotivated Subcontractors’ (C3) are the factors that needed to be examined further. Karim et al. (2006) also stated that ‘the defective work by the preceding trade has a cost and time impact on the following trade’, this finding is a basis for the category ‘Unsatisfactory Work Done by Previous Subcontractors’ (C4).

The causes of poor quality

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Subcontractors’ technical incompetence in performing high quality work</td>
</tr>
<tr>
<td>C2</td>
<td>Incompetent labour force</td>
</tr>
<tr>
<td>C3</td>
<td>Unmotivated subcontractors</td>
</tr>
<tr>
<td>C4</td>
<td>Unsatisfactory work done by previous subcontractors</td>
</tr>
<tr>
<td>C5</td>
<td>Too many layers of subcontractors</td>
</tr>
<tr>
<td>C6</td>
<td>Competitive tendering approach (lowest-bidding)</td>
</tr>
<tr>
<td>C7</td>
<td>Time Constraints(project duration)</td>
</tr>
<tr>
<td>C8</td>
<td>Poor communication</td>
</tr>
<tr>
<td>C9</td>
<td>Lack of teamwork</td>
</tr>
<tr>
<td>C10</td>
<td>Inferior materials</td>
</tr>
<tr>
<td>C11</td>
<td>Incomplete contract</td>
</tr>
<tr>
<td>C12</td>
<td>Unsatisfactory quality measurement systems</td>
</tr>
</tbody>
</table>

Table 2.1 Causes of poor quality in subcontracting systems

The statement that increasing number of layers in subcontracting, increases the possibility of quality problem is taken from the study conducted by Tam, Shen and Kong (2011), which means ‘Too Many Layers of Subcontractors’ (C5) could degrade quality. Fewer layers of subcontractors can eliminate the complex relationship between the different subcontracts and the main contractors and ensure there is better coordination between subcontractors. What is more, a linear structure and relationship may help the main contractors to control and monitor the quality of the project more easily. For example, it can define which trade needs to take responsibility for the rework work when defects happen. In addition, multilayer subcontracting can cause problems in time management, cost control and communication, and coordination of performance (Tam, Shen & Kong, 2011). The confusing authority for quality control is another reason for multi-layered subcontractors causing quality problems. Mostly, the main contractors own the total
authority on the construction site, however, when there are more than three layers of subcontractors, the authority of the main contractors may be delegated to subcontractors.

From the project management’s perspective, time, cost and quality can be likened to three sides of a triangle with trade-offs between them. Competitive bidding, as a cost-orientated approach is considered as one of the biggest barriers to quality improvement. This lowest bidding approach may provide the lowest cost for the main contractors but it prevents subcontractors from acquiring a stable profit margin. The hectic work duration of the project can also lead to poor quality performance. Therefore, ‘Competitive Tendering Approach’ (C6) and ‘Time Constraints’ (C7) are needed to be considered as factors that cause poor quality.

Maqsood, Walker & Finegan (2003) stated that poor performance is the result of poor information transfer (C8, Poor Communication) between different subcontractors and main contractors. There are a number of different parties in a project, thus, how to effectively and timely transfer the information through all these parties is extremely important. The details of how Poor Communication can impact on quality in construction projects have been presented in Section 2.2. Poor Communication (C8) can be found between main contractors, subcontractors and clients and it is not only caused by the way to transfer information, ‘arrogant attitudes’ from the main contractors also contributes to a poor communication system between the main contractors and the subcontractors.

On the question of Teamwork (C9), Kubal (1994) stated that different groups may work in the same construction project but lack a sense of team spirit, that is, they only focus on their own interests. This kind of thinking creates mistrust and adversarial relationships between the different parties, which, in turn, can impact on the quality performance on the construction site. From the discussion in Section 2.2, it can be seen that as lack of team spirit, self-oriented attitudes and lack of sense of collaboration in subcontracting processes became the core reasons to cause quality issues.
‘Incomplete Contract’ (C10). Lack of completed contracts between subcontractors and main contractors is a common phenomenon on construction sites. However, in a study conducted by Yik and Lai (2008), the authors stated that undefined and unclear terms and conditions in the contracts often cause disputes in projects and then they escalate to become quality problems. A clearly written contract will assist every member to set a common goal and from this the main contractors can build a partnership and quality management program throughout the project (Kual, 1994). As a consequence, this should contribute to a good quality performance.

‘Inferior Materials’ (C11) also can cause poor quality because poor quality performance of buildings may be attributed to the use of sub-standard material (The Institution of Structural Engineers, Australia, 1983). This is because building materials are firstly processed by different factories and then possibly be delivered by various logistics companies. These materials are then used by specialist subcontractors on the construction site. During these processes, defects could emerge at any phase. Therefore, all suppliers need to be checked and the materials intended for use need be inspected before they are used in the project.

‘Unsatisfactory Quality Measurement Systems’ (C12) was discussed in a study conducted by Hoonakker, Carayon and Loushine (2010). ‘If you cannot measure it, you cannot manage it’. The nature of the project and lack of repeat clients also makes any quality measurement system difficult. Many main contractors or subcontractors have their own measurement system, and when these different measurement approaches are used in the same project, many repeat inspections are created.

As the analysis above shows, poor quality may be caused by some ‘soft issues’, i.e. price orientation, poor communication, unqualified workers, etc. How to address these problems and how to improve quality is a core concern. The details will be discussed in Section 2.4.
2.4 IMPROVEMENT METHODS

From the discussion in Section 2.2 and 2.3, it can be seen that relationships, coordination and communication issues can erode quality performance. From the recommendation offered by Hoonakker, Carayon and Loushine (2010), it was conclude that what is the real need for quality improvement is to establish partnering and standardisation in the subcontracting system. Partnering also features in the study from Ashford (1989) and Kubal (1994) in the studies of quality improvement. All of these can be concluded that the ‘soft issues’ is one of main reasons to attribute poor quality performance and some suitable management tools can address these ‘soft issues’ effectively.

Some experts also stated that to introduce some advanced technologies from the manufacturing industry is a good option to improve quality performance in the construction industry. The reason is that the construction industry, is far behind the manufacturing industry (Levy, 2009; Department of Industry Science and Tourism, Australia, 1996), but, quality improvements in the construction industry are the result of some innovative activities (Fernie, Leiringer & Thorpe, 2006). For example, the use of technology by subcontractors has been seen as a powerful approach leading to quality enhancement (Reeves, 2002; Chiang, 2009), such as adopting mechanisation and automation. Technology development and innovation are possible improvement tools. However, technology development also needs to have a close working relationship between the different participants in the project.

To acquire innovative knowledge from the manufacturing industry, the concept of SCM is one of popular topics in the construction industry. The concept of SCM may have positive impact on quality improvement in subjected projects. The reasons for poor quality in subcontracting systems are mostly related to the poor relationships among the main contractors, subcontractors and clients, especially, the working style between the subcontractors and the main contractors. Appropriate partnering and effective coordination between the main contractor and the subcontractors would encourage a higher quality level. All of these possibilities, point to the concept of SCM, because SCM has the ability to establish a sense of collaboration among
different parties and optimise the process. From the discussions above, it is evident that the root causes of unsatisfactory quality performance in subcontracting systems are ‘soft issues’ and lack of advanced management concepts. As these ‘soft issues’ have been discussed above, the power of SCM in the construction industry needs to be examined further.

Dainty, Briscoe and Millett (2001 a); Cox and Ireland (2002); Love, Irani & Edwards (2004); Briscoe and Dainty (2005); Pryke (2009) and Cheng et al. (2010) are all conducted research on the concept of Construction Supply Chain. Wong and Fung (1999) conducted a case study to discuss the possible adaptation of SCM into the framework of TQM. Karim et al. (2006) developed a decision support tool for better quality performance and from these studies, discussed the possibility of implementing SCM into the construction industry and the benefits of accepting SCM in the construction project management. This will improve effectiveness, maintaining a long-term relationship and share information, etc. However, implementing SCM and Quality Management separately, does not seem powerful or effective enough to address the quality problem caused by the complex subcontracting working relationship. To solve this problem Robinson and Malhotra (2005) demonstrated a new concept called, SCQM. They integrated Quality Management into the scope of the supply chain because they believed that to implement SCQM would ensure the customer would receive high quality products and/or services smoothly and effectively. In Chapter 3, the concept of SCQM will be carefully examined, and some barriers to the implementation of SCQM will be discussed.

2.5 SUMMARY

Subcontracting is an effective approach to complete projects but the quality problems attributed to this unwieldy structure seriously erodes the quality of buildings. Through demonstrating the unwieldy structure seriously erodes the quality of buildings. Through demonstrating the working system of subcontracting, it provides a clear picture of how subcontracting works in construction projects. After analysing this working process, the possible causes of problems attributed to poor quality issues were discussed. It was found that most of these causes are ‘soft issues’, such as poor communication, lack of teamwork attitudes and irresponsibility, etc. In the section of
improved work methods, the concepts of SCM, and SCQM were discussed as a possible approach to help the construction industry improve its quality performance.
3. THE SUBCONTRACTOR SUPPLY CHAIN

Egan (1998) suggested that the advanced concepts used by the manufacturing industry, include Total Quality Management (TQM), SCM and Lean System. They should be introduced and implemented in the construction industry. Of these concepts, SCM, currently, is one of the most popular and has attracted great attentions. O’ Brien and Fischer (1993) suggested that SCM could provide a significant improvement in the construction industry. Hence, the concept of SCM will be introduced in this chapter, followed by examining the possibility of integrating SCM into the construction industry. The final section of this chapter will discuss the implementation of SCQM in subcontracted projects.

3.1 THE CONCEPT OF SUPPLY CHAIN MANAGEMENT

The Institute for Supply Management defined SCM as follows: ‘Supply chain management is the design and management of seamless, value-added processes across organisational boundaries to meet the real needs of the end customer.’ It has also defined a set of principles and practices that aims to manage and coordinate the entire supply chain from raw material suppliers to the end customers, and emphasises the importance of collaboration with every participant across the entire supply chain (Vollman et al., 1997). The goal of SCM is to build efficient and effective processes, in order to add value for the end customer from a supply chain that consists of a series of linked value chains (Fawcett, Ellram & Ogden, 2007). Pryke (2009) considered the SCM strategy as a technique to maintain quality that will encourage innovation and even lead to measurable improvement in the manufacturing industry. He demonstrated that there are key words pertaining to the development of the concept of SCM which include network, integrative, channel, upstream, downstream linkages, ultimate user and value.

Fernie and Thorpe (2007) concluded that SCM was used for developing and understanding relationships within and among different organisations, and it could optimise flow; break down process discontinuities; make decisions for managing competencies; and use power wisely. There are three major benefits of implementing
SCM (Stock, Boyer & Harmon, 2010). They are: add value, create efficiency and increase customer satisfaction. Thus, SCM is not limited to improving efficiency and increasing profits within a company, but aims to achieve a ‘win-win’ result for all organisations within the supply chain.

3.2 SUPPLY CHAIN MANAGEMENT IN THE CONSTRUCTION INDUSTRY

Ngowi (2000) stated that ‘SCM and concurrent engineering principles have been successfully implemented in the manufacturing industry and there is a possibility that they can be used to integrate the various disciplines of the construction at project level’. SCM can provide a broad view of the construction industry, i.e. the importance of total supply chain cost, customer focus, information sharing, partnership, etc., which may address the problems caused by poor collaboration, lack of information sharing or equilibrium power position. It would then enable construction quality to improve. Love, Irani and Edwards (2004) suggested that every participant involved in a project needed to consider the value added from each party across the supply chain.

3.2.1 CONSTRUCTION SUPPLY CHAIN

Previously, the concept of SCM was considered only as a tool to improve the procurement and logistics section in manufacturing companies. The study of SCM in the construction industry was also firstly focused on material delivery and purchasing functions (Ross, 2011). For example, Briscoe et al. (2004) discussed the Construction Supply Chain from the perspective of how to make a procurement decision.

Researchers also focused on modelling the Construction Supply Chain before launching any specific supply chain initiatives, i.e. Barrett (2000); Vrijoef and Koskela (2000); Briscoe, Dainty and Millett (2001 c) and Xue et al. (2007). Dainty, Briscoe and Millett (2001 a) described the main contractors are at the centre and are linked to clients, main suppliers, designers and all the specialist services. Cox and Ireland (2002) presented a simple model of a Construction Supply Chain. They
divided their Supply Chain Model into four parts: construction ‘integration’, professional services, materials, equipment and labour. From these studies, the importance of main contractors has been emphasised in the Construction Supply Chain.

Figure 3.1 A Seamless Supply Chain Management Model  
Source: Adapted from Love, Irani and Edwards (2004)

Later, Love, Irani & Edwards (2004) built a Seamless Construction Supply Chain Model (Figure 3.1). This model integrates the design and production process in projects and links every member in the supply chain to the end customer throughout the design process. Besides discussing the importance to build a cohesive project team, this study also argued how to establish an appropriate relationship between contractors and subcontractors. It stated that poor planning and coordination could directly impact on the performance of subcontractors in the resource planning stage, causing disruption and schedule delays.
Cheng et al. (2010) developed a Construction Supply Chain Model from the framework of Supply Chain Operations Reference (SCOR). To simplify the various buyer-supplier relationships in a construction project, the mechanical, electrical and plumbing (MEP) supply chain has been selected as the research object in this study. Cheng et al. (2010) also focused on the material planning, procurement and delivery management in construction projects and information exchange among main contractors, subcontractors and suppliers. This presents an effective and traceable construction management system. From here, it can be seen that planning and information sharing are the core issues in the Construction Supply Chain.

SCM has been studied from different aspects in the construction industry. For example, Dainty, Briscoe and Millett (2001c) discussed supply chain alliances from subcontractors’ perspective. Other studies are about partnership development in the construction supply chain (Briscoe, Dainty & Millett, 2001 a; Errasti et al., 2007; Parrod et al., 2007). Different roles of the Construction Supply Chain has been researched by Vrijioef and Koskela (2000); readiness assessment of Construction Supply Chain (Khalfan et al., 2001); the progress of the Construction Supply Chain (Saad, Jones & James, 2002); Maqsood, Walker and Finegan (2003) investigated the role of Information Communication Technology in the Construction Supply Chain; coordination mechanisms in the Internet environment (Xue et al., 2007) and the assessment of the framework for Construction Supply Chain relationships (Meng, 2010).

3.2.2 APPLICATION OF THE CONSTRUCTION SUPPLY CHAIN

To better examine the power of SCM in the construction industry, Pryke (2009) used two case studies to demonstrate the huge success that can be achieved by adopting SCM in the construction business.

Case Study 1 - Slough Estates

Slough Estates is a successful property company in the UK. Rimmer (2009) found that because this company implemented the SCM strategy, it reduced its cost by at
least 20%. In this case study, the main scope of SCM at Slough Estates has been estimated by the author as:

- A focus upon the definition and delivery of Value;
- The creation of contractual arrangements in which SCM tools could flourish;
- Investment in Product Development;
- The search for and elimination of waste;
- Performance measurement and benchmarking.

Rimmer emphasised the important role of project managers who ‘establish strong contacts at partnership or CEO/Director level to make sure suppliers understood the new ways of working and would drive the cause from their end’. To address the problems between the main contractor and subcontractors the company would only adopt ‘fixed’ information from the design phase. The resources of design and construction were integrated. A good relationship was built between constructions workers and clients, which lead the contractors to easily satisfy the needs from the end customer. Other experiences of this company included commercial principles and contracts. The author defined this commercial framework encouraged suppliers, main contractors and subcontractors to have positive attitudes when they worked together.

From this study, the author concluded advantages of SCM implementation:

- Consistent strong leadership;
- More open management structures, less command-and-control and less bureaucracy;
- Recognition, respect for and involvement of the workforce;
- Investment in product development, measurement of performance and sharing knowledge with others in industry networking groups;
- Single point responsibility for both main contractors and key specialist contractors;
- Appropriate commercial terms for each relationship with the emphasis on openness collaboration and negotiation.
Case Study 2 - British Airports Authority (BAA)

In this case, Potts (2009) is focused on Heathrow Terminal 5. This project (T5) was extremely complex and costly. To successfully achieve its goals, SCM played a critical role. Potts emphasised on excellence of the project team involved.

*All suppliers working on the projects should operate as a virtual company.*

*Executives were asked to lose their company allegiances and share their information and knowledge with colleagues in other professions. The aim was to create one team, comprising personnel and partner businesses, working to a common set of objectives (p.167).*

From this, it can see that the information sharing, the spirit of teamwork, partnership and ownership are important factors in the success of this project. A special agreement was a contractor for this project. The T5 Agreement was for a 5 year term. This changed short-term thinking by suppliers to long-term and thus, objectives were achieved successfully and cost less. The core values in this project team’s agreement were *teamwork, trust* and *commitment*, which could be defined as the foundation of the collaboration. Establishing this collaborative environment led this project to achieve the best practices in a world-class performance.

It has been demonstrated from previous studies and these two case studies that to integrate every participant into a supply chain would greatly improve effectiveness, productive and quality in the construction industry. The establishment a sense of a Construction Supply Chain could help this industry to address the problem caused by its complex and fragmented nature. What is more, the SCM emphasis is on teamwork, partnership, information sharing, etc. It could solve the dysfunctional working relationships between different trades in the subcontractor section. However, when SCM is introduced into the construction industry, there are some barriers which need to be overcome.
3.2.3 PROBLEMS OF THE CONSTRUCTION SUPPLY CHAIN

Some experts are doubtful about whether the Construction Supply Chain can be integrated without restrictions (Briscoe & Dainty, 2005; Green, Fernie & Weller, 2005; Fernie & Thorpe, 2007). Fernie and Thorpe (2007) concluded that the construction industry is not mature enough to adopt, implement and sustain a SCM. This has also been stated by Bankvall et al. (2010) who claimed that the applications of a SCM model could be problematic in the construction industry. The same concern has been presented from a comparative study between the aerospace and construction industries conducted by Green, Fernie and Weller (2005). From their study, the authors concluded that fewer construction organisations had accepted SCM compared with those of the aerospace industry. Moreover, a change of adversarial culture in the construction industry was considered as a must before implementing SCM in this industry (Green, Fernier & Weller, 2005). Cheng et al. (2010) argued that the planning and management of the Construction Supply Chain could be especially challenging because of the complex structure and large numbers of participants who only consider their own interests in the short term.

Dainty, Briscoe and Millett (2001 b) stated that a large number of small and medium-size enterprises (SMEs) in the construction industry may have serious barriers to implementing SCM in the construction industry. These SMEs had little involvement in the development of supply chain and integration measures within the industry (Dainty, Briscoe & Millett, 2001 b). ‘Financial/cost-related issues’, ‘Programming/time-related issues’, ‘Quality of information and related issues’ and ‘Attitude-related issues’ inhibited the implementation of SCM. Additionally, lack of training in the construction industry had been presented as a negative influence.

Briscoe and Dainty (2005) believed that successful alliances in the Construction Supply Chain could not be achieved without some conditions. The nature of the construction industry may inhibit this industry from taking full advantage from supply chain integration. Inhibiting factors include insufficient trust between the clients and the small contractors as well as the price-drive attitudes and one-off ventures. All of these conditions limit the development of effective systems of
communication and information exchange. Briscoe and Dainty (2005) discussed implementing SCM in the construction industry, and they found that it requires to develop an effective communication system; gain knowledge about others; build a high quality standard; and establish collaboration, etc. Additionally, co-operative working between the client, main contractor and the subcontractors were seen as the most effective approach to accelerate the integration.

From the analysis above, a complex working environment, lack of trust, and no long-term relationship, etc. are considered as the biggest barriers to Construction Supply Chain Integration. The implementation of SCM in the construction industry does not seem to be easily achieved. However, the current study is focused more on quality issues in the subcontracting system, therefore, the discussion of SCM will be more concern with its scope within the subcontracting system.

There are different features between the Construction Supply Chain and the Subcontracting Supply Chain. These are: firstly, there is the simple working relationship between the main contractors and subcontractors. Compared with other construction processes, the relationship between main contractors and subcontractors exist mainly in the construction stage. It is more consistent and involves fewer stakeholders (Hernandez & Aspinwall, 2008). What is more, to some degree, the main contractor and some special subcontractors maintain a working relationship (Wong & Fung, 1999; Yik & Lai, 2008; Chiang, 2009). About 25 % main contractors and subcontractors maintain their business relationships for more than 5 years (Department of Industry Science and Tourism, Australia, 1996). To some degree, this close relationship can simplify the implementation of SCM in the subcontracting system. Although the SCM may not be easy to implement throughout the whole construction industry, the environment of the subcontracting system seems more suitable for its implementation. Karim et al. (2006) and Tam, Shen and Kong (2011) called this process, the Subcontractor Supply Chain.
According to Egan (1998), Wong and Fung (1999), Barrett (2000), Kuei and Madu (2001), implementing Quality Management in only a separate area or by a particular party cannot enhance quality performance significantly. Thus, in order to solve the quality problem in the construction industry, integrating Quality Management into the Construction Supply Chain has been considered as an effective approach (Egan, 1998; Kuei & Madu, 2001; Robinson & Malhotra, 2005). In the construction industry, because the main contractors or subcontractors control quality separately, they cannot achieve the overall goal of quality improvement. To enhance quality, the concept of Quality needs to be integrated throughout the whole supply chain, and involve all employees from top to bottom.

Egan (1998) suggested that building a unified team with clients, designers, main contractors and subcontractors could better deliver value to the client. Wong and Fung (1999) concluded that SCM, by working closely and cooperatively, would help the main contractor to better manage subcontractors and suppliers. Kuei and Madu (2001) concluded that the quality-based paradigm has shifted from the traditional company-centered approach to involvement into supply chain systems. This new approach, by establishing qualified partnering with the main contractor and subcontractors through the supply network, significantly contributed to improved quality (Humphreys et al., 2003). Quality programs should take a view from a supply chain perspective in order to improve quality and satisfy the requirements of the marketplace (Robinson & Malhotra, 2004).

Flynn and Flynn (2005) conducted a world survey to investigate the cumulative capabilities between supply chain performance and quality, and the relationship between Quality Management and supply chain performance. This research shows the importance for organisations to consider implementing SCM and Quality Management together. This can avoid the disadvantages created from the traditional selection of partnership approach and the possible establishment of adversarial relationships with suppliers. The authors also pointed out that to develop a
cumulative capability in SCM and Quality Management could be a powerful competitive advantage.

Foster and Ogden (2008) questioned the term ‘Supply Chain Quality’ and pointed out that the managers need to know how to implement Quality Management in the framework of SCM. Carmignani (2009) discussed the management system related to ISO and the Supply Chain concept and emphasised the importance of collaboration and processes integration of applied quality and SCM. Kuei, Madu and Lin (2011) demonstrate that SCQM could help organisations establish a sense of Supply Chain Quality Community. Some studies now integrated Quality Management and SCM as SCQM. From the aspect of Quality Management, the Construction Supply Chain can be recognised as responsible delivering quality products and services across every organisation in the supply chain. Kuei and Madu (2001) defined SCQM and used three simple equations:

- SC = a production-distribution network;
- Q = meeting market demands correctly, and achieving customer satisfaction rapidly; and profitably; and
- M = enabling conditions and enhancing trust for supply chain quality

Robinson and Malotra (2005) provided a more detailed definition:

\[ \text{SCQM is the formal coordination and integration of business processes involving all partner organization in the supply channel to measure, analyse and continually improve products, services, and processes in order to create value and achieve satisfaction of intermediate and final customers in the marketplace}} \]

SCQM is a new concept of management theory that emphasises the importance of considering Quality Management within a supply chain. Some studies have examined this concept in the manufacturing section, but it is rarely studies in the construction industry. Therefore, the next section will examine this concept in the construction industry by means of two case studies.
3.3.1 APPLICATION OF CASE STUDIES

Two case studies will be examined to determine whether SCQM could improve Quality in the construction industry. The poor quality performance of subcontractors will be the target, based on the research from Wong and Fung (1999), and Tam, Shen and Kong (2011). This will be followed by examining and discussing SCQM in subcontracting systems.

Case Study 3

This case study is the ABC Construction Company that is one of the most successful construction companies in Hong Kong. It has already adopted ISO and TQM as a means of ensuring a high quality construction. Wong and Fung (1999) analysed, from both SCM and TQM perspectives, how main contractors managed subcontractors and enhanced the quality of work performed.

The company was restructured for better cooperation with subcontractors. Teamwork and open discussion became the core factor. They ensured that the company and its own subcontractors were able to collaborate effectively, and assisted other subcontractors to understand what were the requirements from the client. There were different types of meetings between the company and the subcontractors. These involved the majority of the employees from managers to site staff. Through these meetings, the use of TQM was spread to every subcontractor from top to bottom. This ensured better subcontractors performance throughout the work.

In evaluating the relationship between the subcontractors, the ABC Company had its own agendas. Currently, partnership has been labeled as the best way to overcome the problem of quality (Errasti et al., 2007), but, the ABC Company did not specifically pursue partnerships with every subcontractor, but chose the ‘right’ relationships with different subcontracting partners. From the concept of the supply chain, the company carefully analysed the trade-off, when choosing the different levels of partnership it needed to establish. There are several levels of relationships. For example, there are long-term subcontractors of more than 10 years business and personal relationship, but one-off relationships can also be found. By properly evaluating collaborative levels with subcontractors, the company could maintain
flexibility and profitability. Moreover, ‘lowest-bidding’ is not the only way subcontractors are selected in this company. Sometimes they consider ‘soft parameters’ (Eriksson, 2010), which, to some degree, avoids poor quality work by subcontractors, due to limited opportunities for profit and direct cost pressures.

**Case Study 4**

The other case is a survey conducted by Tam, Shen and Kong (2011) aimed to examine the relationship between poor quality performance and multi-layered subcontractors in the Hong Kong construction industry. Six factors were defined as the reasons leading the issue of quality. ‘Limited profit’ and ‘not-compliance to quality specifications’ are the two main ones. As an example, from a building project, a disaster could occur because of a lack focus on ‘big picture’, as well as ignoring the total cost and the cost of defects when subcontractors carry out the work. Additionally, ‘the non-compliance with specifications’ is the result of subcontractors who do not consider that satisfying the end customer is a part of Construction Quality. Other reasons which can be attributed to clients’ dissatisfaction are, for instance, ‘extra cost’, ‘communication errors’, ‘unrealistic contract time’ etc. All of these may be solved by ensuring a high quality standard, establishing long-term quality commitments between the main contractors and subcontractors (Briscoe & Dainty, 2005), developing channels of quality performance measurements and standards (Robinson & Malhotra, 2005), sharing the data of quality inspection, process integration, etc.

![Figure 3.2 The ABC’s business structure](source: Adapted from the Website of ABC Company)
When comparing the structure of the ABC Company (Figure 3.2) with poorly performing construction companies (Figure 3.3), one clearly beneficial feature is indicated: ABC plays the role of supplier, developer and contractor within the scope of the Group Company, which establishes better communication channels and shares common goals among the participants in the supply chain. Therefore, to some degree, ABC integrates quality into its supply chain. By this means, ABC is able to nurture a long-term, closed relationship with its subcontractors, which additionally develops effective quality linkages downstream in the supply chain.

On the other hand, other construction companies rely excessively on their ‘lowest bidding’ subcontractors and suppliers. The same situation also happens to their subcontractors and leads to uncontrolled multi-layer subcontractors (Figure 3.3). Consequently, serious quality problems develop in many projects. This weak linkage, lack of trust, lack of information sharing, and short-term perspectives of various quality goals and measurement systems, combined with price orientation within the subcontracting, can be seen as major limitations in quality performance. The concept of SCQM promises to address these problems by linking all participants within the scope of the supply chain and building a common goal. High quality performance can be achieved, if SCQM is widely accepted, in the construction process.

These two case studies are developing a hypothesis that whilst it seems to be theoretically possible, there may be serious cultural barriers to meet its full potential. The rhetoric provided by companies such as those studied here, may be little more than that and there needs to be a serious attempt to measure the real effectiveness of integrated supply chain principles. In general, the ‘problem’ is now becoming well...
documented but solutions and barriers to them and objective measures of their real effectiveness much less so.

3.3.2 ANALYSIS OF SUPPLY CHAIN QUALITY MANAGEMENT

From the previous studies related to SCQM, it can be seen that the theory of the development of SCQM is still in its infancy and discussion on it is mainly concerned with the manufacturing industry, e.g., the case study conducted by Robinson and Mahotra (2005) was from a technology company, although Kuei, Madu and Lin (2011) examined SCQM in multinational corporations. Other researchers have also studied SCQM in other industries, but the construction business has been excluded. The research, conducted by Wong and Fung (1999), is a rare example that links SCM and Quality Management with the construction industry. This case did not directly examine how SCQM could address the problem of poor quality from subcontracting in the construction industry. They, however, did offer a predictive view about integrating Quality Management into the Subcontractor Supply Chain as a means of improving poor quality performance.

SCQM offers a new point of view of quality improvement, because a separate control of quality by each party involved would not contribute to a quality improvement (Egan, 1998; Wong & Fung, 1999; Barrett, 2000; Kuei & Madu, 2001). There are four main advantages to implementing SCQM in subcontracted projects. Firstly, SCQM can help construction companies build a common ideal of Quality for every participant in the supply chain. Secondly, an effective value-added delivery can be achieved by adopting SCQM through processes of re-engineering and client focus. SCQM offers the scope of the ‘big picture’ and is an effective way to overcome the nature of fragmentation and the weak linkages among supply partners in the construction business. Last, but not least, SCQM is an approach that could help quality decisions be made wisely, by considering whether processes can add value to the end product without sacrificing the interest of other participants, especially subcontractors. From this analysis, it can be assumed that SCQM may positively impact on quality improvement in the Subcontracting Supply Chain, because it can appropriately address the problems caused by the features in the Subcontracting
Supply Chain, e.g., poor relationships between different trades, lack of sense of collaboration, the attitude of ‘work-around’ and cost orientation, etc.

The concepts of SCQM that can assist the construction industry to better implement it in the Subcontracting Supply Chain, include Intimate Knowledge of The Supply Chain (S1); Strategic Supply Chain Management (S2); Due Diligence of Tenders Rather Than Acceptance of Lowest Bidding (S3); Establish Partnerships with Suppliers/ Main Contractors/ Subcontractors/ Clients (S4); Effective Communication (S5); Subcontractors Involved Early (S6); The details can be seen from Table 3.1.

Cox and Ireland (2002), and Fernier and Thorpe (2007) emphasised the importance of launching training actions related to Basic Knowledge of SCM (S1) in the construction industry as the first step to launch SCM initiatives. Briscoe, Dainty and Millett (2001 b); Briscoe and Dainty (2005); and Ross (2011) all stated that without considering the Supply Chain Strategically (S2), the implementation of SCM in the construction industry could not be achieved successfully.

If the relationship between the main contractors and subcontractors is only built on ‘money’, there is no emotional connection, such as a sense of trust or ownership. The subcontractors will most likely consider their work only as a function, which is contrary to the philosophy of SCM. Dainty, Briscoe and Millett (2001 b) stated that with the traditional tender process, the knowledge could not be exchanged between companies and this prevented the formation of a partnership. Wang, Yu and Xue (2007) also pointed out that lowest-price bidding needs to be replaced by a bidding approach based on establishing a long-term relationship. Therefore, the category of Due Diligence of Tenders Rather Than Acceptance of Lowest Bidding (S3) needs to be considered.
Summary of SCQM approach | The research
---|---
S1. Adopting the knowledge of supply chain | Cox and Ireland (2002); Fernier and Thorpe (2007)
S2. Supply chain strategy | Briscoe, Dainty and Millett (2001 b); Briscoe and Dainty (2005); Ross (2011)
S3. Due diligence of tenders rather than acceptance of lowest bidding | Briscoe, Dainty and Millett (2001 b); Cox and Ireland (2002); Briscoe et al. (2004); Love et al. (2004); Briscoe and Dainty (2005); Xue et al. (2007)
S4. Established partnerships | Wong and Fung (1999); Dainty and Millett (2001 b); Cox and Ireland (2002); Love et al. (2004); Saad et al. (2002); Briscoe et al. (2004); Briscoe and Dainty (2005); Green, Fernier and Weller (2005); Ferine and Thorpe (2007)
S5. Effective communication | Briscoe, Dainty and Millett (2001 b); Briscoe et al. (2004); Love et al. (2004); Maqsood, Walker & Finegan (2003)
S5. Early involved | Briscoe, Dainty and Millett (2001 b); Love et al. (2004); Bankvall et al. (2010)

Table 3.1 The possible solutions to achieve the integration Construction Supply Chain

‘Establish Partnerships’ (S4) and ‘Effective Communication’ (S5) have both been emphasised as critical factors to ensure the implementation of SCM. Briscoe, Dainty and Millett (2001 b); Cox and Ireland (2002); Saad et al. (2002); Briscoe et al. (2004); Love et al. (2004); Briscoe and Dainty (2005); Green, Fernier and Weller (2005); and Fernier and Thorpe (2007) all conducted studies to explain the critical position of Partnership in the implementation of SCM in the construction industry. This means that construction companies are already aware of the importance of partnerships. So Establishing Partnerships (S4) is possibly a first step for the construction industry in general, to accept the concept of SCM and provide support to the implementation of SCQM.

Lack of effective communication can impact on establishing partnerships and the implementation of SCM. For example, missing, late or inaccurate information from the main contractors, could confuse subcontractors (Chiang, 2009; Tam, Shen & Kong, 2010). Without Effective Communication (S5) channels between different
subcontractors, the following on trades cannot acquire necessary information. Maqsood, Walker and Finegan (2003) also stated that traditional methods and forms of communication in the Australian construction needed to be replaced by Information Communication Technology (ICT) to provoke collaboration in the Construction Supply Chain.

Briscoe, Dainty and Millett (2001 b); Love et al. (2004) and Bankvall et al.(2010) have all conducted research into the reasons why construction companies need to accept Early Involvement (S6) before they launch an SCM initiative. Their researches concluded that Early Involvement (S6) could assist subcontractors to better integration into the subcontract process and establish better working relationships between different participants of the project. The earlier the subcontractors join the project team, the greater their effort and commitment to the project. This leads to subcontractors establishing a positive attitude to solving problems and improving the quality of their work. Early Involvement (S6) plays a large role in decision-making, reducing cost, product development time and improving new product quality. One other advantage of the implementation of Early Involvement (S6) is that it can encourage main contractors /subcontractors/ suppliers to work together in the pre-building phase (Wong & Fung, 1999; Song, Mohamed & AbourRizk, 2009).

Implementing SCQM into the construction industry, however, calls for some ‘changes’ (Ferine & Thorpe, 2007). This includes, for example, to abandon some traditional images in this industry, such as arms-length relationship, lack of innovation and trust, little understanding of SCM, etc. Change is, undoubtedly, not easy to achieve, but, some changes are necessary. It appears that there are cultural barriers to improving quality by the integrating supply chain philosophy. Many of the practices that are in evidence have evolved over many years and resulted in entrenched negative quality practices amongst contractors and subcontractors. Overcoming these cultural barriers by implementing modern supply chain cooperative practices will be a major challenge for the construction industry, worldwide. Further, there is a scanty of objective measures for improvement and the
evidence presented is largely rhetorical and/or anecdotal. It will be interesting to attempt to objectively measure this aspect and progress made in these companies.

Main contractors have the power to call for change. Hence, to establish a Quality Performance Measurement System from the perspective of the main contractors may be an effective guide. A suitable measurement system using several indicators from SCQM may improve quality significantly. For this to happen, firstly, a set of KPIs could assist each company in the subcontracting system to establish a common goal, which is a vital factor in the concept of SCM. Thus, the implementation of measurement tools can assist all participants in the project to break down their own boundaries and have the same goal as their main contractors. Secondly, to only adopt the concept of SCQM is not enough, it requires a practical tool that is able to make the theory of SCQM clear. The indictors in the Quality Performance Measurement System alert participants in a project to what are the important factors from the view of SCQM. Performance Measurement has the ability to deliver the desired results, based on measuring these special indictors and, it could help a company develop a positive attitude towards quality orientation. Therefore, a proper Quality Measurement System, based on the concept of SCQM, could assist construction firms to achieve a better quality performance and even possibly, slowly change the culture of this industry.

3.4 SUMMARY

In this chapter, the concept of SCM and previous studies related to the construction supply chain have been presented (Section 3.1). The theoretical development of SCM in the construction industry has been demonstrated in the second section of this chapter (Section 3.2). From these two sections, the benefit of managing construction projects, if SCM is implemented, has been discussed. The barriers to implementation were also presented (Section 3.2).

Finally, the concept of SCQM as a new concept in the construction industry was introduced (Section 3.3). Because related research is limited, some deductions have been presented to the whether SCQM has a positive relationship with quality
improvement. Through the theoretical studies and practical case studies, the possibility of adopting this concept in the construction industry is explored and the idea of developing a set of KPIs to realise the concept of SCQM had been given. The next chapter will focus on the discussion of how key performance indicators (KPIs) can be used to measure quality performance based on the awareness of SCQM.
4. PERFORMANCE MEASUREMENTS IN THE SUBCONTRACTOR SUPPLY CHAIN

Performance Measurement is an effective tool which has been widely adopted. Neely et al. (2005) defined Performance Measurement as ‘the process of quantifying effectiveness and efficiency of action’. There are several reasons for measuring performance, i.e., to evaluate business performance, to control employees and to ensure organisations can satisfy the client’s requirements, to motivate people to pursue the same goals as organisations’ and to encourage these organisations to discuss what is the cause of the poor performance, etc. This chapter is divided into two parts. One is the theoretical research of KPIs for the construction performance and the other is the study of the indictors related to SCM. Through these studies, a set of KPIs and a Performance Measurement Model will be developed as a tool to assist the implementation of SCQM in subcontracted projects.

4.1 KEY PERFORMANCE INDICATORS IN THE CONSTRUCTION INDUSTRY

KPIs are groups of key indicators that are used for an organisation’s performance measurement (Salminen, 2005). Collin (2002) claimed that KPIs are the indicators that focus on critical elements of outcomes. It has been widely accepted in many industries including the construction industry. Egan (1998) suggested that the UK construction industry needed to launch Performance Measurement to achieve a satisfactory performance. Walker and Keniger (2002), and Marosszeky (2005) both shared the same view from their Australian experience. Marosszeky (2005) stated that ‘performance measurement is the basis of assessing achievements’ in the construction industry. Beatham, Anumba and Thorpe (2004) examined Performance Measurement as a critical appraisal in construction organisations. Chan and Chan (2004) conducted three case studies to develop a set of KPIs for measuring construction success.

The importance of Performance Measurement and KPIs has been discussed in a study conducted by Fernier, Leiringer and Thorpe (2006). They believe that
Performance Measurement and a suitable set of KPIs can lead the construction industry to achieve excellent performance and improve the level of delivery. There are a number of studies focused on analysing different sets of KPIs in the construction industry and they all believe KPIs can improve performance if construction firms properly measured these indicators. In a report from the Minister for Construction (UK) in 2000, KPIs was defined as a measurement tool that could encourage a project and organisational performance. The seven categories of KPIs in the KPI Working Group (UK) are divided into three levels: Headline Indicators, Operational Indicators and Diagnostic Indicators (The KPI Working Group, UK, 2000). Other organisations have launched their own KPIs. For example, the Mechanical and Electrical Contractors KPIs (M & E), the ACE consultants KPIs, Respect for People (REP) KPIs, the Construction Industry Research and Information Association (CIRIA) KPIs, the MCG Benchmarking Club, Design Quality Indicator (DQI), Satisfaction of service KPIs (SoS KPIs). Beatham, Anumba & Thorpe (2004) categorised these different sets of KPIs as follows:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Indicator</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Client satisfaction</td>
<td>CBPP, M&amp;E, SoS, DQI, CIRIA, ACE</td>
</tr>
<tr>
<td>2</td>
<td>Cost</td>
<td>CBPP, M&amp;E, SoS, MCG, CIRIA</td>
</tr>
<tr>
<td>=2</td>
<td>Time</td>
<td>CBPP, M&amp;E, SoS, CIRIA, MCG</td>
</tr>
<tr>
<td>3</td>
<td>Predictability</td>
<td>CBPP, M&amp;E, SoS, MCG</td>
</tr>
<tr>
<td>4</td>
<td>Defect</td>
<td>CBPP, M&amp;E, MCG</td>
</tr>
</tbody>
</table>

Table 4.1 The summary of KPIs

Source: Adapted from Beatham, Anumba & Thorpe (2004)

Ling and Peh (2005) summarised the KPIs from the USA Construction Institute’s Benchmarking and Metrics Data, the CBPP construction industry KPIs, UK Society of Motor Manufactures and Traders Limited benchmarking toolkit, UK Manufacturing Industry’s KPIs, Australia Centre for Construction Innovation’s Performance Measurement & Benchmarking and European Construction Institute’s Benchmarking Initiative. Beatham, Anumba and Thorpe (2004), and Ling and Peh (2005) included nine heading indicators with similar results. Categories, such as Cost,
Time, Quality and Customer Satisfaction, can be described as the most important indicators in measuring the performance in construction organisations.

### Table 4.2

<table>
<thead>
<tr>
<th>Heading Indicator</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>Rework; Defects; Quality Score; Not Right First Time</td>
</tr>
<tr>
<td>Stakeholder Satisfaction</td>
<td>Client Satisfaction- Product; Client Satisfaction- Service; Customer Satisfaction; Customer Complaints; Employee satisfaction</td>
</tr>
</tbody>
</table>

**Table 4.2** The indicators in the category of Quality and Stakeholder Satisfaction

*Source:* Adapted from Ling and Peh (2005)

As discussed in Chapter 1, the definition of Quality in this thesis includes satisfaction for every stakeholder through the project’s life cycle, thus, client or employee satisfaction will be filed into the quality account. As a result, the indicator of Quality will include Customer Satisfaction, which means the category of Quality now combines both Quality and Customer Satisfaction.


The measurement of quality performance of project/contractors/ subcontractors is another popular KPIs research field. Takim and Akintoye (2002) included KPIs in relation to every stakeholder, such as clients, consultants, contractors, suppliers, the end-user and the community through the project lifetime. Yasanus, Arditi and Mohammadi (2002) divided the Contractors Quality Performance (CQP) indicators into two parts, one indicator at the corporate level and the other at the project level. Takim (2005) examined the criteria for measuring project success, in terms of efficiency and effectiveness measurement. Mbachu (2005) presented the assessment indicators through the project’s lifetime. Salminen (2005) also analysed the quality
measurement on construction sites. Butcher and Sheehan (2010) through the experience in UK analysed how the KPIs could lead to excellent contractor performance. Tam, Shen and Kong (2011) through a survey found six factors lead to poor quality performance in Hong Kong’s multi-layered chain subcontracting, and also provided clues to what would be the key indicators in the subcontracting system. These studies strongly prove the relationship between appropriate quality measurement and quality improvement. However, because all of these studies focused on a separate role in the construction industry, they overlooked the importance of integration that can be defined as supply chain thinking. As a consequence, KPIs will be introduced from the perspective of SCM in the following section.

4.2 KPIs IN SUPPLY CHAIN MANAGEMENT

To better manage Quality Performance, a set of KPIs from the point of view of SCM was developed. Wong and Fung (1999) demonstrated that the integration of Performance Measurement into the supply chain could adjust conflicts caused by different goals by different parties. Additionally, to measure performance through the supply chain would provide positive feedback and motivate improvement (Oakland & Marosszeky, 2006).

From previous research (Chapter 3), it can be assumed that to design a set of KPIs based on the considerations of SCQM through the Subcontractor Supply Chain, will improve quality performance in subcontracted projects. Because there are very few studies about Performance Measurement within the scope of SCQM, the KPIs could not be analysed directly from previous studies. This needs to be a proper cross research from the building’s quality measurement indictors and the indictors for measuring SCM. The KPIs in the construction industry have already been discussed in Section 4.1. Now the indictors related to SCM need to be analysed.

Benita (1999) developed a system to measure supply chain performance. The system includes three separate performance measurement categories: resource measures, output and flexibility measures. A list of KPIs in the supply chain was published by
Shepherd and Gunter (2006). These indications were categorised based on the supply chain operations reference (SCOR) model. Gunasekaran and Kobu (2007) reviewed the literature from 1995 to 2004 on the performance measurement indicators and metrics in SCM. The metrics, such as inventory costs, process cycle time, production flexibility and supply chain response time, had been indicated as the most popular indicators when measuring supply chain performance. The literature review from Akyuz and ErKan (2010) analyses the problem in the current measurement system and then proves the importance of the SCOR model as a foundation in SCM.

<table>
<thead>
<tr>
<th>Stages</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plan</strong></td>
<td>Fill rate (target fill rate achievement &amp; average item fill rate); Order entry methods; Accuracy of forecasting techniques; Autonomy of planning; Perceived effectiveness of departmental relations; Order flexibility; Perfect order fulfilment</td>
</tr>
<tr>
<td><strong>Source</strong></td>
<td>Buyer-supplier partnership level; Level of supplier’s defect-free deliveries; Supplier rejection rate; Mutual trust; Satisfaction with knowledge transfer; Satisfaction with supplier relationship; Supplier assistance in solving technical problems; Extent of mutual assistance leading in problem-solving efforts; Distribution of decision competences between supplier and customer; Quality and frequency of exchange of logistics information between supplier and customer; Quality of perspective taking in supply networks; Information accuracy; Information timeliness; Information availability</td>
</tr>
<tr>
<td><strong>Make</strong></td>
<td>Percentage of wrong products</td>
</tr>
<tr>
<td><strong>Deliver</strong></td>
<td>Delivery performance; Delivery reliability; Number of on-time deliveries; Driver reliability for performance; Effectiveness of distribution planning schedule; Quality of delivered goods; Achievement of defect-free deliveries; Quality of delivery documentation</td>
</tr>
<tr>
<td><strong>Return (customer satisfaction)</strong></td>
<td>Customer satisfaction; Level of customer perceived value of product; Customer complaints; Rate of complaint; Product quality</td>
</tr>
</tbody>
</table>

**Table 4.3** The summary of quality indicators in supply chain

**Source:** Adapted from Shepherd and Gunter (2006)

From the literature review, it can be seen that KPIs in the construction industry and the measurement indicators of the supply chain, focus on different categories, and even the indicators for measuring quality, rarely examine the same area. What is more, the KPIs in SCM do not quite fit the construction industry, e.g., in the building
project, mostly, the make and delivery process are at the same time. Therefore, how to measure the Construction Supply Chain and which indicators can effectively and efficiency measure the construction supply chain is the focus of this study.

Meng (2010) developed a framework for assessing the Construction Supply Chain relationship, focusing on how to build a partnership in the construction industry. Cagnazzo, Taticchi and Brun’s (2010) study highlighted the important role of Performance Measurement in quality improvement initiatives through the Construction Supply Chain. Yeung, Chan and Chan (2010) described the quantitative indicators that measured partnering performance in Hong Kong. Time; Cost; Top management commitment; Quality; Trust and respect; Effective communications; Innovation and improvement had been defined as the KPIs (Yeung, Chan & Chan, 2010).

Robinson and Malhotra (2005) analysed the concepts of SCQM, which included ‘externally focused process integration, management’, ‘strategy’, ‘communication and partnership’, ‘supply chain quality leadership’ and ‘quality and supply chain practices’. Through a structural equation model, Lin et al. (2005) found there are five significant quality practices in the framework of SCQM, there include ‘Top Management and Quality Policy’, ‘Training’, ‘Product/Service Design’, ‘Quality Information Reporting’ and ‘Customer Orientation’. However, these studies were not related to the construction industry, and especially, subcontracting system. There are very few studies which related to KPIs in the Subcontracting Supply Chain, especially from the quality aspect. In the next section the recommendations of KPIs in the Subcontractor Supply Chain will be given.

4.3 KPIs IN SUBCONTRACTOR SUPPLY CHAIN

From the literature review (Chapter 3 & 4), a list of KPIs for quality improvement in the Subcontracting Supply Chain can be assumed. The indicators are summarised in Table 4.4. In this study, these KPIs are divided into two levels: corporate and operational. These two levels of measurement will help the construction industry achieve a high level of quality performance (KPI Working Group, 2000; Yasamis,
Arditi & Mohammadi, 2002; Hernandez & Aspinwall, 2008). The KPIs in the Corporate Level aim to establish a corporate quality culture and through these encourage a quality-conscious environment throughout the firms (Yasamis, Arditi & Mohammadi, 2002). The KPIs in the Operational Level are focused more on the operation and output of the firm and measure more a physical facility or a contracting service (Yasamis, Arditi & Mohammadi, 2002). Collin (2002) stated that only a limited number of KPIs are used regularly and suggested the number of KPIs be no more than 20. From the Figure 4.1, it can be seen that there are several common indictors in this diagram. Therefore, in this study, three indicators from the Corporate Level (CL1-CL3) and nine from Operational Level indicators (OL1-OL9) are suggested. The details are given below.

**Figure 4.1** The Venn diagram
4.3.1 KPIs IN THE CORPORATE LEVEL

From the definition of high quality in this study, every requirement from stakeholder needs to be satisfied. The general community, even though it is usually ignored, is also a stakeholder, therefore, Community Satisfaction¹ (C1) is an indicator in this study. Pitsis et al. (2003) stated it was important to consider Safety, Community and Environment as part of KPIs for building constructions. From the context of ISO 14000 and EFQM, increasing attention is being paid to sustainable development and ‘Green Building’. The consideration of environmentally friendly materials and energy saving would add to Community Satisfaction (C1).

The importance of quality measurement from the Corporate Level has been examined in a number of studies. The measurement of Employee Satisfaction (CL2) is vital for organisations to establish Quality Orientation. Many studies have proved

¹ Community Satisfaction includes the satisfaction of safety, community and environment.
that contented employees provide and deliver high quality work to customers (Yasamis, Arditi & Mohammadi, 2002; Takim & Akintoye, 2002; Ling & Peh, 2005). Employee Satisfaction (CL2) has already been widely adopted in Quality Management in other industries.

The quality of the construction industry is very vulnerable. It can be easily impacted on by small uncertainties and minor changes such as, the weather or changes of design, etc. Huang (2010) stated these changeable environments can impact on the quality performance in a significant way. These uncertainties and changes can seriously impact the working processes in subcontracting systems, because there are a large number of different parties and complex relationships between main contractors and subcontractors. If main contractors cannot appropriately control change, the high quality performance could not be achieved in a subcontracted project. Thus, The Ability of Managing Change (CL3) is another factor which needs to be considered.

At the Corporate Level, three performance measurement indicators have been assumed as KPIs that improve the Quality Performance in the subcontractor supply chain. They are ‘Community Satisfaction’ (CL1), ‘Employee Satisfaction’ (CL2), and ‘The Ability of Managing Change’ (CL3). These KPIs will be examined in Chapter 7.

4.3.2 KPIs IN THE OPERATIONAL LEVEL

KPIs in the Operational Level have been determined in a large number of studies. Customer satisfaction (product & service), defect, rework, etc. are the most widely used indicators in the whole construction industry.

Customer Satisfaction (OL1) is a core category which needs to be measured (Yasamis, Arditi & Mohammadi, 2002; Beatham, Anumba & Thorpe, 2004; Ling & Peh, 2005). It can be divided into two parts: one is Satisfaction with the Product and the other is Service. The construction process involves a number of product and service actions. The construction can be defined by its physical facility, such as durability, features, reliability, etc. Whether the finished product meets the clients’
expectations was the simplest definition of the Customer Satisfaction-Product. The dimensions of Customer Satisfaction-Service relates to accuracy, time, and consistency, etc. (Evans & Lindsay, 1996), all of which need to be met for Customer Satisfaction.

Defect (OL2) is the most common indicator in the quality measurement category. Traditionally, the defect rate is the most direct way to examine the level of quality in construction projects. A large number of companies define their defect rate as an important indicator in their KPIs. For example, the headline indicator in CBPP is Defects; ‘No Defects’ is an assessment for the MCG Benchmarking Club. The number of defects was described as the most consistent ‘output’ measure and the industry aspires to ‘zero defects’ which is a sign of excellence preferment (Butcher & Sheehan, 2010).

Partnership (OL3), Teamwork (OL4), and Effective Communication (OL5) have all been emphasised as vital indicators which can ensure the quality performance (Shepherd & Gunter, 2006; Gunasekaran & Kobu, 2007; Hoonakker, Carayon & Loushine, 2010; Yeung, Chan & Chan, 2010). ‘Poor Communication’ (C8) and ‘Lack of Teamwork’ (C9) also have been discussed as the causes of poor quality in subcontracting systems (Chapter 2). They are also necessary for SCM, from the analysis of KPIs in SCM, e.g., category ‘Establish Partnerships’ (S4) and ‘Effective Communication’ (S5) have been discussed in Chapter 3.

Hoonakker, Carayon and Loushine (2010) defined Partnering (OL3) as a most promising option to overcome conflicts during the whole building process and also found that it positively improved project performance. In the last decade, the Australian Department of Industry, Science and Resources (1999) has produced a document, ‘Partnering: A Strategy for Excellence’ and has fostered the development of cooperative relationships between different participants in a project. The importance of partnerships in the implementation of Quality Management also has been emphasised by Hellard (1994). For example, if the main contractor establishes a partnership with key subcontractors, these subcontractors will be fully involved in the process of the schedule. It can also optimise the process and improve information
sharing. If both main contractors and key subcontractors are able to bring the improvement process to the project in terms of Quality, this will result in unexpected high levels of quality performance during the building process.

*Partnership* (OL3) and *Teamwork* (OL4) were also emphasised by the Department of Housing and Regional Development, Australia, 1995. In this, lack of *Teamwork* (OL4) is considered as a cause which leads to poor quality. The importance of partnerships for quality improvement was also discussed. Mbachu (2005) also pointed out that ‘teamwork/synergetic relationship’ was an assessment of performance, when selecting subcontractors for construction projects.

From the survey conducted by Butcher and Sheehan (2010), poor communication is confirmed as a critical factor in the unsatisfactory performance of contractors. They also described how, through *Effective Communication* (OL5), contractors could quickly understand the requirements of customers. From the analysis in Chapter 2 and 3, it also can be seen that poor communication or lack of cooperation among participants also impacts on quality improvement and the integration of supply chain.

As discussed in Chapter 2, unsuitable planning (*C7: Time Constraints*) could be a factor which causes hectic and inadequate schedules with a serious impact on the quality of the project. Therefore, the category of ‘*Operational/ Predictable Planning*’ (OL6) needs to be considered as an indicator in this set of KPIs.

Poor quality of materials and equipment can seriously erode quality in the subcontractor supply chain, which underlines the necessity of measuring ‘*The Quality of Procurement and Delivery*’ (OL7) (Baden-Hellard, 1991; Yasamis, Arditi & Mohammadi, 2002; Takim, 2005; Shepherd & Gunter, 2006). Because the concept of the supply chain is from raw materials to the end customer, in the Subcontractors Supply Chain, the quality of materials also need to be considered.

*Limited Layer of Subcontractors* (OL8) has already been discussed in Chapter 2 as an effective approach to avoid quality problems (Tam, Shen & Kong, 2011). To limit the number of layers in the Subcontracting Supply Chain may effectively address the
quality issues caused by ‘Unsatisfactory Work Done by Previous Subcontractors’ (C4) and ‘Too Many Layers of Subcontractors’ (C5).

Misunderstandings and confusions, when subcontractors begin their work, were caused by lack of quality standardisation, however, because quality is hard to define, this leaves industry with a lack of standardisation of Quality. Hoonakker, Carayon and Loushine (2010) stated that construction firms need to focus on similarities and use of standardisation in their building process rather than over-emphasising uniqueness. This quality standardisation also needs to be practical and operational for construction projects. Therefore, the category of Operational Quality Standardisation (OL9) should also be measured.

The quality measurement indicators in this chapter are based on the literature review, which highlighted construction quality, the quality problems in the Subcontracting Supply Chain and, the Performance Measurement in SCM, etc. However, the integration of these KPIs has not been examined within the scope of Quality Measurement in the Subcontractors Supply Chain. Therefore, whether these two levels of KPIs can play a useful role in quality improvement in a subcontracted project, still needs to be examined.

4.4. SUMMARY

From the literature review, several main points can be recommended:

- Quality is a broad concept in the construction industry. A high quality standard means satisfaction for every stakeholder through the project’s life cycle (Chapter 1).

- There are many factors that lead to poor quality, such as nature of the industry, not-standardisation and the number of small contracting firms, etc. While, the impact of the subcontracting system is also a vital component that can erode the quality performance (Chapter 1).
The subcontracting system owns a number of special characteristics, which to some degree impacts on quality improvement. For example, the multi-layered subcontracting, the lack of adequate communication and understanding in the subcontracting system, cost-orientation, etc. (Chapter 2).

The quality improvement methods in the subcontracting system focus on developing technology, building partnerships, and adopting SCM, etc. (Chapter 2).

SCM can contribute a positive influence to quality enhancement in the construction industry. This assertion is based on the experience from other industries and some SCM initiatives in several construction organisations. However, the integration of the whole industry could not be easily achieved (Chapter 3).

The integration of the Subcontracting Supply Chain, which includes suppliers, main constructors, subcontractors and clients, into a supply chain - the Subcontractor Supply Chain has been discussed (Chapter 3).

SCQM integrates Quality Management into the supply chain and it provides a new view of quality improvement. Because of the two case studies, it has been assumed that SCQM has a positive influence on enhancing quality performance in the Subcontractors Supply Chain (Chapter 3).

Performance Measurement is one of the best tools to improve the quality performance and KPIs have been widely adopted in the construction industry and SCM, separately. However, there are fewer common indicators between these two sets of KPIs (Chapter 4).

The study of KPIs in the Construction Supply Chain, especially the Subcontractor Supply Chain, is rare and lacks investigation (Chapter 4).

Two levels of KPIs in the Subcontractor Supply Chain have been recommended from the literature review (Chapter 4).
As it can be seen from the studies in the literature review, performance measurement through the Subcontracting Supply Chain may significantly improve quality performance in the construction industry. From previous studies, to improve quality in subcontracting, organisations can adopt SCM. Additionally, the importance of Performance Measurement in improving quality has also been discussed. The studies of KPIs in the construction industry and SCQM are few, and provide insufficient information to develop a set of KPIs fit for the Subcontractor Supply Chain in the construction industry. Therefore, in the next chapter the methodology of how to conduct a research on KPIs in the subcontractor supply chain, in the aspect of Corporate and Operational levels in the framework of Subcontractor Supply Chain will be analysed. The data obtained from the questionnaire is at the ordinal level and that this limits the analysis tools that can be used, thus, Relative Importance Index will be adopted as the method of data analysis in this thesis.
5. Methodology

The main contribution of Chapter 2, 3 and 4 was that they examined previous researches in the fields of the Construction Supply Chain, the subcontracting system and quality problems in the Subcontracting Supply Chain. This has uncovered details about quality issues in subcontracting, giving a preview of the study of the Construction Supply Chain, examined SCQM in subcontracted project and analysed KPIs in the concept of SCQM. However, these topics still need to be tested on the construction site. Therefore, in this chapter, the research methods and process of research will be given. Possible research methods will be discussed followed by the research design and general data analysis.

5.1 AIMS AND OBJECTIVES OF RESEARCH

From the literature review in Chapter 2, a list of the causes of poor quality in the subcontracting phase emerged. The reliability of this list needs to be examined and the factors need be determined further. The possibility of implementing SCQM in subcontracted projects having a positive influence on quality enhancement was presented in Chapter 3. However, because previous studies have not provided adequate information about the implementation of SCQM within the construction industry, an investigation, related to SCQM on the construction site, needs be conducted to examine attitudes to SCQM from the industry’s workers. Lastly, a summary of the set of KPIs presented in Chapter 4 needs to be examined. These include three categories from the Corporate Level and nine from the Operational Level. These need to be examined to determine if a set of KPIs can improve Quality Performance and whether these indictors can be used in this industry.

To protect the welfare and rights of the participants in the research, the details of this survey has been approved by the UOW’s Human Research Ethics Committee before the research conducted. The data of this survey arrived without names or affiliations. The researcher ensured that any such information that arrived in error had been removed and not communicated beyond that point. The researcher examined all data from respondents within 24 hours of receiving it. No conflicts were anticipated as the
respondents remain anonymous and did not comment on any other person or group of people.

The research strategy selected needs to meet the following requirements:

- To further examine the root causes of poor quality performance in subcontracted projects;
- To investigate the level of awareness of SCQM in the construction industry; and
- To identify a set of KPIs, based on the view of SCQM, was the aim to improve the quality level in the Subcontracting Supply Chain.

In order to achieve these aims and objectives, various research methodologies need to be examined. Firstly, the most suitable research approach to conduct this study will be selected.

### 5.2 ALTERNATIVE RESEARCH STRATEGIES

From Bell (1993) and Naoum (1998), there are five acceptable research methods, i.e. grounded theory, ethnographic, experiments, case study and survey, all of which can be used for construction management. Thus, to determine the research methods, all of these five alternative research methods will be analysed.

**Grounded theory**

Most grounded theory researchers, develop a theory before the data is collected (Bell, 2006). This means that this approach does not start from hypotheses, investigation or literature reviews, but, focuses on the available data rather than data collection. In this study, similar sources could not easily be found, therefore, grounded theory was not considered to be a suitable approach.

**Ethnographic**

According to McNeill and Chapman (2005), ethnography aims to describe the culture and lifestyle within a group of people, which could link the theoretical phenomenology and interpretivism. Ethnography is about imitating real life (McNeill
& Chapman, 2005). However, ethnography is a time consuming approach (Bell, 2006), and there is a time constraint for this study and so this matter was not deemed to be suitable.

Case study
Case study researchers aim to identify common or unique features in organisations or individuals. They can also identify the processes of their working and show how they could impact on systems (Bell, 2006). However, according to Bell (2006), the disadvantage of a case study is that it is difficult to cross-check the data or information collected from a single case.

Experimental research
The experimental approach can be described as a tool to solve ‘bounded problems’. The aim of experimental research is to demonstrate the relationship between cause and effect. It is easy to conduct experiments that relates to measurable phenomena (Bell, 2006) but it is mostly used in a laboratory setting. What is more, this study does not relate to the views of sensitive variables, etc., thus, to employ experimental research could not provide achievable results.

Surveys
The survey is a method which collects large amounts of data from a large number of people in a relatively short time (McNeill & Chapman, 2005). It is simply asking respondents to answer the same questions. Robson (1994) suggests there are several advantages of surveys:

- Results allow for generalisation particularly if sample is representative of the population; Personal influences minimised;
- Large amount of standardised data can be easily utilised via statistical techniques for testing the hypotheses and
- The survey design has various methods of systematic data collection.

As analysed above, surveys can be seen as a suitable research method in this study. The reasons for choosing survey as the research method are: firstly, the aim of this research is to collect adequate data, e.g., attitude of quality performance, awareness of SCQM and recommendation of KPIs, etc., from the construction industry. Then,
through data analysis, it aims to demonstrate how to improve quality performance in the subcontracted projects. Secondly, time, costs and ethics issues are other factors needed to be considered to conduct a sound research. Thus, based on time constraints and limited resources, the survey would be the best option for this study. The next section presents the process of the research design and the structure of the questionnaire, etc.

5.3 RESEARCH DESIGN

The process of survey in this research program is divided into two. From Figure 5.1, it can be seen that part one selects participants and the second is the questionnaire design. The details will be discussed in the followed section.

![Figure 5.1 The process of survey](image-url)
5.3.1 QUESTIONNAIRE

In order to examine the results from the literature review, a questionnaire technique was adopted for this study. The questionnaire was designed to collect data about the core arguments in this study, namely, whether implementing the state of the art SCQM could improve construction project’s quality, especially in subcontracted projects. Based on the discussion from the literature review a questionnaire with ten questions was designed (Figure 5.2). Nine closed questions and one open question were decided on as the total questions for this questionnaire. Q1 - Q3 aim to acquire general information from participants and Q4 - Q6 examine the questions that relate to subcontracting systems. Awareness of SCQM is examined by Q7 and Q8, which is designed to test participants’ understanding of SCQM. The fourth part of this questionnaire is Q9. It aims to further examine the list of KPIs that were developed in Chapter 4. The ranking of these indicators will be collected. Finally, Q10 is an open question for general comments on collecting some qualitative data. The reason for an open question is to allow respondents to provide their own special point of view as to how to improve quality in subcontracted projects. This may offer some extremely useful information.

Figure 5.2  The structure of questionnaire
Section 1 General information
The first section collects general information about participants and their organisation, such as the official position of participants, the types of organisations and the number of employees. The reason for collecting general information is to better understand the participants in this survey.

Section 2 Subcontractor
The second part of this questionnaire investigates the general situation of subcontracting in the Australian construction industry, e.g., the percentage of subcontracting in a project (Q4) and the satisfactory rate of subcontractors’ quality performance (Q5). The main aim is to define root causes of poor quality performance in the subcontracting system. Thus, Q6 ranks what causes may contribute to poor quality. These are summarised from the literature review (Chapter 2).

Section 3 Supply Chain Quality Management
The third section is designed to examine awareness of SCQM in the Australian construction industry, e.g., Q7 ‘To what extent has your organisation adopted the concept of Supply Chain Quality Management (SCQM) in business?’ Then, the six indicators in Q8 are indentified based on the review in Chapter 3. By means of ranking, the possibility of the integration of the Construction Supply Chain will be discussed. To help participants understand the term SCQM, an explanation of SCQM is given in this questionnaire.

Section 4 Performance Measurement
The final section is about Performance Measurement in the Subcontracting Supply Chain. Twelve Key Performance Indicators (KPIs) have been summarised in Chapter 4. The aim of the survey here is to establish the ranking of KPIs that could be used to guide the implementation of SCQM and achieve the final goal, that is, to improve the quality performance in the construction industry.

The scaling method was used in this questionnaire. The reason is that according to Moser and Kalton (1971), the scaling method is an appropriate fit to obtain information about opinions and attitudes. The aims of this research are mainly to
investigate attitudes and awareness about SCQM and KPIs. Hence, most questions adopted scaling method with five points, but Q8 and Q9 have a category of N/A, that is, for collecting more reliable data.

The final version of this questionnaire was completed after a pilot study, which tested the effectiveness of the questionnaire posted. The welcome screen with an introduction to this research was designed as the first page of this online survey. The purpose, structure and ethical issues were introduced in this welcome screen which was designed to assist respondents to understand the details of this survey. The final page of the questionnaire is acknowledgement notes. Finally, a six-page online questionnaire was developed with a total of ten questions divided into four sections and an expected completion time is approximately 15 minutes. The questionnaire is provided in Appendix A.

5.3.2 SAMPLE SIZES

Before determining the sample and its size, the target population, as a critical part, needs to be decided. The Commercial and Industrial Building Construction (non-residential building and engineering construction) in Australia was the targeted section in this survey. The reason to choose this industry is that the majority of residential projects are simple and small in size. It means that residential projects provide limited information compared with commercial construction projects. On the other side, the larger commercial construction companies can offer useful information to analyse the attitude and the trend in the Australian construction industry. The Commercial and Industrial Building Construction has a less fragmented structure than other construction sections (IBISWorld, 2011) and thus, the concept of the supply chain may be more easily accepted.

Some studies, such as Nicol and Hooper (1999); Barker and Naim (2008), stated that there is an 80/20 rule in the construction industry, i.e. a minority (20%) of the top construction companies are responsible for 80% of the business. From the data of the Australian Bureau of Statistics, the Australian construction industry follows a similar pattern. In Commercial and Industrial Building Construction (IBISWorld,
2011), about 2/3 of the revenue in this industry is from new building projects operated by the main contractors. Nevertheless, the largest companies in this industry generate approximately three-fourths of the annual industry revenue. Therefore, the top main contractors from the Commercial and Industrial Building Construction Industry with a sample size of 150 were targeted.

From the list of Construction 100, 2003-2009 published by the Housing Industry Association Economics Group and a list of Industry Growth List from SmartCompany, 2006-2007, the companies on this list are the most active and successful construction companies in Australia. Because not all these selected companies have supply chain managers, Site Managers, Quantity Surveyors, Project Managers and Senior Managers were the target participants. After ascertaining appropriate Email addresses from these two lists, a list of 220 construction firms was produced then after the update of contract address, 150 construction firms have been determined.

5.4 ADMINISTRATION OF QUESTIONNAIRE

There are two modes of administrating a questionnaire, one is self-administration by the respondents and the other is administration by interviewer (Settle & Alreck, 1995). There are several methods to conduct questionnaires, e.g., mail, phone and face to face. Because of limited cost and time, the mode of self-administration questionnaire was adopted. Mostly, this type of questionnaire is mailed to the target sample, but there are many limitations to mail surveys. Settle and Alreck (1995) stated that the disadvantages of mail surveys outweigh its advantages. After analysing the pros and cons about an online survey, it was considered as the best approach to conduct this survey. Therefore, an online questionnaire was designed, based on a survey website.
### Table 5.1 The analysis of online survey

**Source** from Smart Survey Design

<table>
<thead>
<tr>
<th>Pros of online survey</th>
<th>Cons of online survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same strengths as a paper version</td>
<td>Spam/Privacy concerns</td>
</tr>
<tr>
<td>Better at addressing sensitive issues</td>
<td>Technical issues</td>
</tr>
<tr>
<td>Cost efficient</td>
<td>Submitting multiple submissions</td>
</tr>
<tr>
<td>Faster delivery</td>
<td>No interviewer present to clarify questions or issues</td>
</tr>
<tr>
<td>Endless design options</td>
<td></td>
</tr>
<tr>
<td>Dynamic</td>
<td></td>
</tr>
<tr>
<td>Ability to track</td>
<td></td>
</tr>
<tr>
<td>Quick response time</td>
<td></td>
</tr>
<tr>
<td>Easier to use of skip logic</td>
<td></td>
</tr>
<tr>
<td>Randomization of answer choices</td>
<td></td>
</tr>
</tbody>
</table>

The UOW’s Human Research Ethics Policy requires the survey to provide adequate information to participants about the objective of the questionnaire to all potential participants before they decide to participate. Thus, an initial email was sent to construction organisations and individuals. This email included the purpose of the survey and assured confidentiality of the respondents. The reasons to send the initial email and assure confidentiality was that the questionnaire included several questions that related to personal information, such as years of experience, roles and employee numbers in the organisation.

The potential respondents included site managers, quantity surveyors and other senior managers, who had adequate experience and knowledge in this special area. After a series of reminders, e.g., telephone calls and emails, a total of 59 people agreed to assist in this research program. There were 53 from major contracting companies, 5 were subcontractors and 1 was a consultant. Because the aim of this survey was to examine the attitude, from the perspective of main contractors, the data from the main contractors were considered as valid. Therefore, 53 are valid responses, with a response rate of approximately 35%, 53 out of 150. In the construction industry, 30% as a response rate is considered good (Black, Akintory & Fitzgerald, 2000), therefore, this respond rate was considered adequate for this
research. The duration of this survey was about 2 months (18\textsuperscript{th} May to 17\textsuperscript{th} July, 2011).

### 5.5 METHODS OF DATA ANALYSIS

There are four common used analysis methods in surveys: descriptive statistics, correlations, comparisons, trends (Fink & Kosecoff, 1985).

- Descriptive statistics(mean, mode, median, number, percentage, range, standard deviations)
- Correlations (spearman rank-order, person product-moment)
- Comparisons (Mann-Whitney U, Chi-square, t-test, analysis of variance)
- Trends (repeated measures analysis of variance, McNeemar test)

In this study, the data do not relate to the issue of correlations, comparisons and trend, thus, the analysis will employ simple statistical methodology. The result can be seen from Table 5.2.

<table>
<thead>
<tr>
<th>Section 1:</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Information</td>
</tr>
<tr>
<td>Descriptive statistics (numbers, percentage)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 2:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Subcontractor</td>
</tr>
<tr>
<td>Descriptive statistics (Mean Score &amp; Ranking)</td>
</tr>
<tr>
<td>Relative Important Index</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Chain Quality Management</td>
</tr>
<tr>
<td>Descriptive statistics (Numbers, Percentage, Mean Score &amp; Ranking)</td>
</tr>
<tr>
<td>Relative Important Index</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 4:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Measurement</td>
</tr>
<tr>
<td>Relative Important Index</td>
</tr>
</tbody>
</table>

**Table 5.2** The methods of data analysis
**Relative Importance Index**

Kometa *et al.* (1994), Tam, Shen & Kong (2011) and Tam *et al.* (2000) adopted the Relative Importance Index (RII) to analyze the data from their questionnaire. Tam, Shen & Kong (2011) employed RII to analyze the relative ranking between the factors contributed to poor performance in multi-layered subcontractors.

\[
RII = \frac{\sum w}{AN}
\]

‘\(W\)’ is the weight given to each factor by the respondent, ranging from 1 to 5, which is similar to the rule in Mean and Ranking. 5 means ‘strongly agree’ while 1 equal to ‘strongly disagree’. The category of N/A is valued as 0 in this study. ‘\(A\)’ is the highest weight, which in this study is 5. ‘\(N\)’ is the total number of samples and the Relative Importance Index varies between 0 and 1.

**Reliability of Scales**

The internal consistency method needs to be employed to ensure the reliability of this survey. Cronbach’s Coefficient alpha is the most common approach to examine reliability. Nunnally (1978) stated the value of Cronbach’s alpha is in the range of 0-1, and higher values mean greater reliability. Generally, when the value of alpha is greater than 0.7 it can be considered that it is a reliable sample (Pallant, 2001). A reliability analysis was conducted and the result is presented in Chapter 6.

\[
\alpha = \frac{N}{N-1} \left( 1 - \frac{\sum \sigma_i^2}{\sigma_x^2} \right)
\]

where \(\sigma_i^2\) is the variance of the observed total test scores
\(\sigma_x^2\) is the variance of component \(i\) for the current sample of persons (Develles, 1911).

**5.6 SUMMARY**

This chapter was focused on introducing the research methodology adopted in this study. After stating its aims and objectives, and a discussion on possible research methods to conduct this study, the questionnaire was employed as the effective
research tool to collect data from the Australian construction industry. The structure and target sample is explained in this chapter. Finally, the approach to process data from questionnaires had been introduced. The questionnaires were delivered to 150 of the large main contracting companies in Australia. A total of 53 questionnaires were received from the target respondents. This was an acceptable result. The data analysis will be introduced in Chapter 6.
6. RESULTS OF QUESTIONNAIRE SURVEY

In this chapter, a statistical analysis of data collected from the questionnaire will be presented. There are three parts to the data analysis in this chapter, firstly, there is the general information about the participants and their organisations. This aims to present a general image of respondents. The second part is the reliability of the analysis which must be tested before any future analysis takes place. Thirdly, the results about the factors which could cause poor quality, the awareness level of SCQM and a possible set of KPIs will be discussed.

6.1 RESULTS OF GENERAL INFORMATION

*Characteristics of the Respondents*

Table 6.1 and Figure 6.1 show the participants’ work experience and position in the company. The results show that the average number years of experience in the construction industry was 25. More than 75% of the respondents had more than 15 years work experience and most are directors or general managers of a company. A high position and a long industry experience in the industry are the common features of these participants. There is, therefore, a high degree of confidence that these respondents accurately represent the attitudes of the sample of construction companies in the Australian construction industry.

![Distribution of survey respondents by position](image)

**Figure 6.1** Distribution of survey respondents by position
<table>
<thead>
<tr>
<th>Demographic</th>
<th>Category</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title of position</strong></td>
<td>Director/ General Manager</td>
<td>22</td>
<td>41.5%</td>
</tr>
<tr>
<td></td>
<td>Manager</td>
<td>18</td>
<td>33.9%</td>
</tr>
<tr>
<td></td>
<td>Estimator</td>
<td>5</td>
<td>9.4%</td>
</tr>
<tr>
<td></td>
<td>Contract Administrator</td>
<td>3</td>
<td>5.8%</td>
</tr>
<tr>
<td></td>
<td>Engineer</td>
<td>5</td>
<td>9.4%</td>
</tr>
<tr>
<td><strong>Experience in industry</strong></td>
<td>0 - 15 years</td>
<td>14</td>
<td>26.4%</td>
</tr>
<tr>
<td></td>
<td>15-25</td>
<td>22</td>
<td>41.5%</td>
</tr>
<tr>
<td></td>
<td>25-35</td>
<td>15</td>
<td>28.3%</td>
</tr>
<tr>
<td></td>
<td>&gt; 35</td>
<td>2</td>
<td>3.8%</td>
</tr>
</tbody>
</table>

**Table 6.1** Demographics of survey respondents

**Characteristics of the Responding Firms**

Table 6.2 gives information about the number of employees in the company, which can be used to define the size of the organisation. From the definition of the Australian Bureau of Statistics, businesses employing 200 or more people are defined as large. In the analysis, almost half of the companies in this survey had employees in the categories 51-200 (43%) and 201-600 (23%). Hence, most respondents are from large companies. This adds confidence in the information provided by the respondents, because it presents a view from the leading Australian construction companies. This result also confirms that the data is from the target sample - the larger main contractors who have the motivation and power to implement SCQM.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Category</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Numbers of employees</strong></td>
<td>1-50</td>
<td>5</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>51-200</td>
<td>23</td>
<td>43%</td>
</tr>
<tr>
<td></td>
<td>201-600</td>
<td>12</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>601-1200</td>
<td>7</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>1201-3000</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>Over 3000</td>
<td>3</td>
<td>6%</td>
</tr>
</tbody>
</table>

**Table 6.2** Distribution of survey respondents by numbers of employees
The Subcontracted Work

Table 6.3 shows the number of percentage of external workers in these companies. From the data, the major organisations subcontracted more than 60% of their work and most companies had many levels of work subcontracted. This means that subcontracting is widely adopted in the Australian construction industry. This is consistent with the results found from the literature review namely, that it is subcontractors who carry out most of the work in projects (Karim et al. 2006). The respondents’ companies have sufficient experience in relation to how to work with their subcontractors and should have a deep understanding of their subcontracting function.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Category</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of subcontracting</td>
<td>None</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Less than 30%</td>
<td>17</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td>30% to 60%</td>
<td>8</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Above 60%</td>
<td>28</td>
<td>53%</td>
</tr>
</tbody>
</table>

Table 6.3 Distribution of survey respondents by percentage of subcontracting

The Results of Subcontractors’ Quality Performance

Table 6.4 and Figure 6.2 show the attitude of the main contractor to the quality performance of subcontractors. The result clearly shows that the majority of main contractors in this survey believed that the quality of work by subcontractors was either ‘Outstanding’ (2%), ‘Very good’ (13%) or ‘Good’ (38%). However, about 11% of main contractors considered the quality was poor. From these data, the attitude of the main contractors in terms of quality performance by subcontractors is positive.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Category</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subcontractors’ quality performance</td>
<td>Poor</td>
<td>6</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>Satisfactory</td>
<td>8</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>20</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>Very good</td>
<td>7</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Outstanding</td>
<td>2</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 6.4 Distribution of survey respondents by subcontractors’ quality performance
6.2 RELIABILITY ANALYSIS

To ensure that the results measured by scale are reliable, Q6, Q8 and Q9 (Appendix A) need to be examined for their reliability before further analysis. Reliability analysis was employed by determining Cronbach Alpha. The results of these three questions are as follows:

<table>
<thead>
<tr>
<th>Attributes of Factors</th>
<th>Cronbach Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causes of poor quality</td>
<td>0.904</td>
</tr>
<tr>
<td>SCQM</td>
<td>0.894</td>
</tr>
<tr>
<td>KPIs</td>
<td>0.931</td>
</tr>
</tbody>
</table>

Table 6.5  Results of reliability of data

According to Pallant (2001), this can determine a reliable sample when the value of alpha is greater than 0.7. Thus, from Table 6.5, the Cronbach Alpha ranges from 0.894 to 0.931, showing the data are interrelated and reliable. It provides adequate confidence in this survey and further analysis can be conducted.
6.3 DATA ANALYSIS

There are three parts to the data analysis in this section. Firstly, the statistical results of the factors, which could cause poor quality, will be presented. The second part is the result of the awareness level of SCQM and finally, a ranking list of KPIs will be presented.

Causes for poor quality in subcontracting

Respondents were asked to answer ‘In your opinion, what are causes of quality problems in subcontracting’. There are 12 possible causes of poor quality in subcontracted project that need to be examined through the questionnaire. The results collected from this survey can be seen as follows (Table 6.6).

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Subcontractors’ technical incompetence in performing high quality work</td>
<td>0</td>
<td>10</td>
<td>7</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>C2 Incompetent labour force</td>
<td>0</td>
<td>15</td>
<td>9</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>C3 Unmotivated subcontractors</td>
<td>0</td>
<td>16</td>
<td>20</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>C4 Unsatisfactory work done by previous subcontractors</td>
<td>1</td>
<td>17</td>
<td>22</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>C5 Too many layers of subcontractors</td>
<td>0</td>
<td>34</td>
<td>10</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>C6 Competitive tendering approach (lowest-bidding)</td>
<td>0</td>
<td>10</td>
<td>2</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>C7 Time constraints(project duration)</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>C8 Poor communication</td>
<td>0</td>
<td>7</td>
<td>5</td>
<td>36</td>
<td>5</td>
</tr>
<tr>
<td>C9 Lack of teamwork</td>
<td>0</td>
<td>2</td>
<td>26</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>C10 Inferior materials</td>
<td>1</td>
<td>30</td>
<td>13</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>C11 Incomplete contract</td>
<td>0</td>
<td>23</td>
<td>21</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>C12 Unsatisfactory quality measurement systems</td>
<td>0</td>
<td>12</td>
<td>18</td>
<td>21</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.6 Results of causes for poor quality in subcontracting systems

1 This question from Q6, Appendix A
After being processed by the relative importance index (RII), the ranking list is acquired.

\[ RII = \frac{\sum w}{AN} \]

As mentioned previously (Chapter 5), in this equation, ‘\( W \)’ is the weight given to each factor by the respondent, ranging from 1 to 5. 1 equals ‘strongly disagree’ while 5 equals ‘strongly agree’. ‘\( A \)’ is the highest weight, in this case was 5 (\( A=5 \)). ‘\( N \)’ is the total number of samples, which is 53 (\( N=53 \)). Therefore, here, taking the category of ‘Competitive Tendering Approach’ as an example,

\[ \sum w = 1*0 + 2*10 + 3*2 + 4*20 + 5*21 = 211 \]

Therefore, \( RII = \frac{211}{5*53} = 0.796 \)

From Table 6.7, results of the RII can be seen: Competitive Tendering Approach (RII=0.796) and Time Constraints (RII=0.796) gained the highest score of RII in this section. Unsatisfactory Work Done by Previous Subcontractors (RII=0.577), Incomplete Contract (RII=0.547), Inferior Materials (RII=0.513) and Too Many Layers of Subcontractors (RII=0.506), these four categories received the lowest ratings as factors causing poor quality in this survey.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Causes of Poor Quality in Subcontracting</th>
<th>RII</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C6. Competitive tendering approach (lowest-bidding)</td>
<td>0.796</td>
</tr>
<tr>
<td>1</td>
<td>C7. Time constraints (project duration)</td>
<td>0.796</td>
</tr>
<tr>
<td>3</td>
<td>C8. Poor communication</td>
<td>0.747</td>
</tr>
<tr>
<td>4</td>
<td>C1. Subcontractors’ technical incompetence in performing high quality work</td>
<td>0.696</td>
</tr>
<tr>
<td>5</td>
<td>C9. Lack of teamwork</td>
<td>0.694</td>
</tr>
<tr>
<td>6</td>
<td>C2. Incompetent labour force</td>
<td>0.653</td>
</tr>
<tr>
<td>7</td>
<td>C12. Unsatisfactory quality measurement systems</td>
<td>0.649</td>
</tr>
<tr>
<td>8</td>
<td>C3. Unmotivated subcontractors</td>
<td>0.611</td>
</tr>
<tr>
<td>9</td>
<td>C4. Unsatisfactory work done by previous subcontractors</td>
<td>0.577</td>
</tr>
<tr>
<td>10</td>
<td>C11. Incomplete contract</td>
<td>0.558</td>
</tr>
<tr>
<td>11</td>
<td>C10. Inferior materials</td>
<td>0.513</td>
</tr>
<tr>
<td>12</td>
<td>C5. Too many layers of subcontractors</td>
<td>0.506</td>
</tr>
</tbody>
</table>

Table 6.7 The ranking of causes for poor quality in subcontracting
Results of Supply Chain Quality Management

This section focuses on examining the awareness of SCQM within the main contractors’ companies. Table 6.8 and Figure 6.3 show the respondents’ perception on the question – ‘To what extent has your organisation adopted the concept of SCQM?’ (Q7, Appendix A). About 38% of respondents’ companies have limited use of the concept in their business. Approximately 50% of companies in this survey did not implement any SCQM activities.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Category</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>The concept of SCQM</td>
<td>Not familiar with</td>
<td>12</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Not used</td>
<td>12</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Limited use</td>
<td>20</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>Extensive use</td>
<td>8</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Unknown level of use</td>
<td>1</td>
<td>2%</td>
</tr>
</tbody>
</table>

Table 6.8 Awareness of supply chain quality management

Figure 6.3 The perception of awareness of Supply Chain Quality Management

The answer to ‘Based on your experience, how useful do you believe following six principles of SCQM can impact on quality in projects?’ will be presented in this part. This question aims to acquire more information about the main contractors’ attitude about SCQM.

---

2 This question from Q8, Appendix A
Table 6.9 The result of Supply Chain Quality Management

<table>
<thead>
<tr>
<th>Supply Chain Quality Management</th>
<th>Not Useful</th>
<th>Somewhat Useful</th>
<th>Useful</th>
<th>Very Useful</th>
<th>Extremely Useful</th>
<th>N/A</th>
<th>RII</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1. Intimate knowledge of the supply chain</td>
<td>3</td>
<td>3</td>
<td>17</td>
<td>20</td>
<td>6</td>
<td>4</td>
<td>0.64</td>
</tr>
<tr>
<td>S2. Strategic supply chain management</td>
<td>3</td>
<td>3</td>
<td>19</td>
<td>15</td>
<td>10</td>
<td>3</td>
<td>0.66</td>
</tr>
<tr>
<td>S3. Due diligence of tenders rather than acceptance of lowest bidding</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>15</td>
<td>20</td>
<td>8</td>
<td>0.70</td>
</tr>
<tr>
<td>S4. Establish partnerships with suppliers/main contractors/subcontractors/clients</td>
<td>3</td>
<td>1</td>
<td>13</td>
<td>7</td>
<td>26</td>
<td>3</td>
<td>0.76</td>
</tr>
<tr>
<td>S5. Effective communication</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>18</td>
<td>23</td>
<td>6</td>
<td>0.75</td>
</tr>
<tr>
<td>S6. Subcontractors involved early</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>18</td>
<td>20</td>
<td>7</td>
<td>0.71</td>
</tr>
</tbody>
</table>

From Table 6.9, it can be seen that main contractors have agreed on that several actions from the concept of SCQM can improve quality performance. *Establish Partnerships* (RII=0.76), *Effective Communication* (RII=0.75), *Subcontractors Involoved Early* (RII=0.71) and *Due Dilligence of Tenders rather than Acceptance of Lowest Bidding* (RII=0.70) all gained a high vaule of RII which means the respondents in this survery considered these all have a postive impact on quality improvement. *Strategic Supply Chain Management* (RII=0.66) and *Intimate Knowledge of the Supply Chain* (RII=0.64) gained the lowest scores in Q8. However, these two categories gained a high aggrement in ‘Useful’(17/19) and ‘Very Useful’(20/15). This means some respondents consider that implementing these two can also impact on the quality improvement in construction projects.

**Results of KPIs**

In this section, the results of KPIs are presented in Table 6.10 below. These represented the evaluating by the main contractors from the perspective of quality improvement. These indicators are used to answer ‘Which indicators do you think can be adopted in your organisation to improve project’s quality when subcontracting?’ (Q9, Appendix A).
‘Employee Satisfaction’, ‘Community Satisfaction’ and ‘The Ability to Manage Change’ are the three indicators in the group at Corporate Level (Table 6.11). These three indicators ensure quality management can be achieved from top to bottom in the organisation. The rest are in the Operational Levels. The most important KPIs in the Corporate Level is Employee Satisfaction (RII=0.71), followed by The Ability to Manage Change (RII=0.65) and Community Satisfaction (RII=0.43), however, the result of Community Satisfaction is negative. The details of these indicators will be discussed in Chapter 7.

<table>
<thead>
<tr>
<th>Key Performance Indicators</th>
<th>No Influence</th>
<th>Somewhat Influence</th>
<th>Influence</th>
<th>Strong Influence</th>
<th>Extremely Strong Influence</th>
<th>N/A</th>
<th>RII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer satisfaction of projects and/or services</td>
<td>0</td>
<td>3</td>
<td>8</td>
<td>26</td>
<td>15</td>
<td>1</td>
<td>0.79</td>
</tr>
<tr>
<td>Defect</td>
<td>0</td>
<td>3</td>
<td>23</td>
<td>16</td>
<td>10</td>
<td>1</td>
<td>0.71</td>
</tr>
<tr>
<td>Operational/Predictable planning</td>
<td>3</td>
<td>3</td>
<td>18</td>
<td>23</td>
<td>3</td>
<td>3</td>
<td>0.64</td>
</tr>
<tr>
<td>Number of layers of subcontractors</td>
<td>10</td>
<td>15</td>
<td>15</td>
<td>11</td>
<td>0</td>
<td>2</td>
<td>0.49</td>
</tr>
<tr>
<td>Community satisfaction</td>
<td>21</td>
<td>10</td>
<td>10</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>0.43</td>
</tr>
<tr>
<td>Employee satisfaction</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>23</td>
<td>13</td>
<td>2</td>
<td>0.71</td>
</tr>
<tr>
<td>The ability to manage change</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>28</td>
<td>5</td>
<td>4</td>
<td>0.65</td>
</tr>
<tr>
<td>Partnership</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>16</td>
<td>13</td>
<td>3</td>
<td>0.60</td>
</tr>
<tr>
<td>Teamwork</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>13</td>
<td>21</td>
<td>3</td>
<td>0.74</td>
</tr>
<tr>
<td>Effective communication</td>
<td>0</td>
<td>2</td>
<td>8</td>
<td>24</td>
<td>16</td>
<td>3</td>
<td>0.77</td>
</tr>
<tr>
<td>The quality of procurement and/or delivery</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>29</td>
<td>10</td>
<td>3</td>
<td>0.72</td>
</tr>
<tr>
<td>Operational quality standardisation</td>
<td>3</td>
<td>5</td>
<td>15</td>
<td>20</td>
<td>8</td>
<td>2</td>
<td>0.67</td>
</tr>
</tbody>
</table>

**Table 6.10** The result of Key Performance Indicators

**Table 6.11** The result of KPIs in the Corporate Level
The results of KPIs in the Operational Level (Table 6.12) show the same trend as in the summary from the previous Chapters 3 and 4. Only the category ‘Number of Layers of Subcontractors’ (OL7) produced a negative result. The details of these indicators will be discussed in the Chapter 7.

<table>
<thead>
<tr>
<th>Rank</th>
<th>KPIs</th>
<th>RII</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OL1.Customer Satisfaction</td>
<td>0.79</td>
</tr>
<tr>
<td>2</td>
<td>OL5.Effective Communication</td>
<td>0.77</td>
</tr>
<tr>
<td>3</td>
<td>OL4.Teamwork</td>
<td>0.74</td>
</tr>
<tr>
<td>4</td>
<td>OL7.The Quality of Procurement &amp; Delivery</td>
<td>0.72</td>
</tr>
<tr>
<td>5</td>
<td>OL2.Defect</td>
<td>0.71</td>
</tr>
<tr>
<td>6</td>
<td>OL9.Operational Quality Standardisation</td>
<td>0.67</td>
</tr>
<tr>
<td>7</td>
<td>OL3.Partnership</td>
<td>0.66</td>
</tr>
<tr>
<td>8</td>
<td>OL6.Operational/ Predictable Planning</td>
<td>0.64</td>
</tr>
<tr>
<td>9</td>
<td>OL8.Number of Layers of Subcontractors</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Table 6.12 The result of KPIs in the Operational Level

Many participants in the survey pointed out that the Culture of Quality in Organisations; Top Management Commitment; Innovation; Mutual Trust and Technology Assistant play powerful roles as performance indicators to measure a project’s quality performance. These are the answers from ‘Please provide any comments on how to improve project quality in subcontracted projects in your organisation?’(Q10, Appendix A). There are 12 via respond, then the results were analysed by SPSS. The details of these indicators are as follows:

<table>
<thead>
<tr>
<th>The recommendations from responses</th>
<th>The number of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture of Quality in Organisations</td>
<td>9</td>
</tr>
<tr>
<td>Top Management Commitment</td>
<td>5</td>
</tr>
<tr>
<td>Innovation</td>
<td>4</td>
</tr>
<tr>
<td>Mutual Trust</td>
<td>4</td>
</tr>
<tr>
<td>Contracts</td>
<td>2</td>
</tr>
<tr>
<td>Technology Assistant</td>
<td>2</td>
</tr>
<tr>
<td>Training</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.13 The recommendations from responses
Other comments include ‘use of early contractor involvement’, ‘tender issues’, ‘motivation’, etc. and the details can be seen in Appendix B.

6.4 SUMMARY

In this chapter, the results from data analysis were presented, such as general information: respondent’s work position in the company, years of experiences, etc. The results, related to the factors attributed to quality problems in the subcontracting section, were examined and the degree of awareness of SCQM and the importance of KPIs were presented. The core questions: the causes of poor quality in the subcontracting system; the awareness of SCQM in the construction industry and the indicators of KPIs for measuring Quality in subcontracted projects, which will be discussed in Chapter 7.
7. DISCUSSION OF THE RESULTS

This chapter is focused on discussing the difference between the findings from the literature review and the results from the survey. Three core arguments are presented in this chapter and after that, a model of a Quality Measurement System will be provided with a set of KPIs.

7.1 SUBCONTRACTORS’ QUALITY PERFORMANCE

From the results of Q5 ‘How do you rate subcontractors’ quality performance in the construction industry?’ (Appendix A), it can see that most main contractors in Australia who responded to the survey (over 80%) stated that the quality of work by subcontractors was satisfactory and only 11% of respondents considered the quality was poor. This is a highly satisfactory rate. However, this highly satisfactory rate may or may not be representative of acceptability on a global scale. Some authors highlighted in the literature survey (Uher, 1991; Walker, 1995; Yeong, 1994) hold that in fact, Australian construction quality may be inferior in terms of rework and on-time performance. Therefore, whilst this is a good result, it may simply reflect the readiness of some respondents to accept the status quo, which may well be below the acceptable standard elsewhere. Further, many of the world’s foremost quality authorities, e.g., Deming (1982), Juran (1988), etc. argue that quality is never acceptable and there is always room for improvement. Therefore, many respondents find quality levels of subcontractors acceptable, this may only imply acceptance of some non-improving quality philosophy that will be increasingly uncompetitive, in terms of cost, on-time delivery and defect rates, against those firms that embrace continuous quality improvement programs.

An interesting result on the question of client satisfaction can also be seen from the study conducted by Hong and Proverbs (2002). In this study, the author compared client satisfaction with quality performance from US, UK and Japan. The result shows that although Japanese contractors provided the best quality performance, the rate of client satisfaction was not the highest. The reason for this may be that satisfaction levels are impacted on by the level of expectation. If the client has a high
expectation of quality performance, then high satisfaction is not easy to achieve. Therefore, in Australia, the high client satisfaction may be also caused by less expectation of quality by the client.

### 7.2 CAUSES FOR POOR QUALITY

From the result of ‘In your opinion, what are causes of quality problems in subcontracting’ (Q6, Appendix A), it can be seen that most categories gained high agreement from the participants, but the category ‘Too Many Layers of Subcontractors’ does not show significant agreement (Table 7.1). To better understand this response, a list of what are the causes of poor quality in the subcontracting system will be discussed as follows.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Causes of Poor Quality in Subcontracting</th>
<th>RII</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C6.Competitive tendering approach (lowest-bidding)</td>
<td>0.796</td>
</tr>
<tr>
<td>1</td>
<td>C7.Time constraints(project duration)</td>
<td>0.796</td>
</tr>
<tr>
<td>3</td>
<td>C8.Poor communication</td>
<td>0.747</td>
</tr>
<tr>
<td>4</td>
<td>C1.Subcontractors’ technical incompetence in performing high quality work</td>
<td>0.696</td>
</tr>
<tr>
<td>5</td>
<td>C9.Lack of teamwork</td>
<td>0.694</td>
</tr>
<tr>
<td>6</td>
<td>C2.Incompetent labour force</td>
<td>0.653</td>
</tr>
<tr>
<td>7</td>
<td>C12.Unsatisfactory quality measurement systems</td>
<td>0.649</td>
</tr>
<tr>
<td>8</td>
<td>C3.Unmotivated subcontractors</td>
<td>0.611</td>
</tr>
<tr>
<td>9</td>
<td>C4.Unsatisfactory work done by previous subcontractors</td>
<td>0.577</td>
</tr>
<tr>
<td>10</td>
<td>C11.Incomplete contract</td>
<td>0.558</td>
</tr>
<tr>
<td>11</td>
<td>C10.Inferior materials</td>
<td>0.513</td>
</tr>
<tr>
<td>12</td>
<td>C5.Too many layers of subcontractors</td>
<td>0.506</td>
</tr>
</tbody>
</table>

*Table 7.1* The ranking of causes for poor quality in subcontracting systems

#### 7.2.1 FEATURES OF CAUSES FOR POOR QUALITY

*Cost & Time*

‘Competitive Tendering Approach’ (C6) and ‘Time Constraints’ (C7) gained the same value of RII (0.796), which is the highest of agreement in these 12 factors. This means that these two factors have been considered as the most influential to quality issues in the subcontracted project in this survey. The discussion and suggestion of abandoning ‘lowest-bidding’ has been discussed in Chapter 2. The high agreement of
these two factors also confirms the findings from the literature review that cost and time are the biggest barriers to quality improvement (Tam, Shen and Kong, 2011; Hoonakker, Carayon and Loushine, 2010). However, how to address the poor quality performance caused by ‘Competitive Tendering Approach’ (C6) and ‘Time Constraints’ (C7) still needs to be discussed. Some possible solutions will be presented as followed.

Pre-qualification will be a good option to address the issues attributed to competitive tendering. Hoonakker, Carayon and Loushine (2010) provided some alternative methods including pre-qualification to replace lowest-bidding as the only approach to select the main contractors/subcontractors. If pre-qualification is used, bidders will not be selected only by cost, but also by abilities to provide commitment to quality, safety and performance. Value and technical performance are more important than cost when making a hiring decision. Tam, Shen and Kong (2011) discussed the new approaches of bidding launched by the Hong Kong Government. These new approaches also emphasised evaluating technical resources, past performance and experience, etc. Hoxley (2000) also stated that if there was a proper pre-selection during the bidding process, there would not be a direct connection between competitive bidding and poor quality performance. Here, the total supply chain cost would be a good option to consider during the phase of pre-selection.

In Australia, from the result provided by the Australian Industry Group Construction Update Survey, 49% of construction firms are dissatisfied with current tendering process (Australian Industry Group, 2008). The lowest bidding has been replaced by ‘best value for money’ in the project of Nation Museum of Australia (Walker & Keniger, 2002), however, it seems that this selection approach has not been accepted widely yet. Hence, Australian/State governments and some industry organisations, such as the Master Builders Association, Australian Building Codes Board, etc., could play an important role, by launching an approach for guiding construction companies to award better approaches to conduct their business.

To address the problem caused by hectic and inadequate schedules with poor planning, some experts suggest that subcontractors and other participants of projects
should be involved early in the planning process. The reason is that inadequate schedules are often caused by poor planning, because neither client nor main contractors understand the working process of their subcontractors (Briscoe, Dainty & Millett, 2001 b; Love et al., 2004; Song, Mohamed & AbourRizk, 2009; Bankvall et al., 2010). This is one reason why the main contractors need to consider early involvement of the subcontractors. Early involvement also comes from the principles of SCM, which emphasises the positive influence in quality improvement which can be contributed by SCQM.

**Communication & Teamwork**

‘Poor Communication’ (C8) and ‘Lack of Teamwork’ (C9) are considered the main reasons that lead to unsatisfactory quality of work. These ranked third (RII=0.747) and fifth (RII=0.694) in this survey, respectively. These results are consistent with the finding from the literature review. The study conducted by Kubal (1994), Tam, Shen and Kong (2011), etc. emphasised the importance of communication and teamwork in quality improvement (Chapter 2). To discuss communication and teamwork together emphasises that there is a special relationship between them. Poor communication can become a barrier for teamwork, and a lack of a sense of team spirit also can degrade the level of information sharing. Therefore, these two factors need to be considered together when the main contractors attempt to address quality problems caused these issues.

**Subcontractors**

‘Subcontractors’ Technical Incompetence in Performing High Quality Work’(C1), ‘Incompetent Labour Force’ (C2), ‘Unmotivated Subcontractors’ (C3) and ‘Unsatisfactory Work Done by Previous Subcontractors’ (C4), can be summarised as a category – i.e., a problem of subcontractors which includes poor workmanship, unsatisfactory technical level, etc. In this survey, ‘Subcontractors’ Technical Incompetence in Performing High Quality Work’ (C1) (RII=0.698), and ‘Incompetent Labour Force’ (RII=0.653) have been considered as critical factors which impact on quality performance. These results can prove the statement provided by Karim et al. (2006) that is more than half of the defects are caused by poor workmanship by subcontractors. The result of high agreement of
\[
\begin{align*}
\text{Subcontractors’ Technical Incompetence in Performing High Quality Work’ (C1)}
\end{align*}
\]
and ‘Incompelement Labour Force’ (C2) also further emphasised the importance of considering subcontractors’ technical and workmanship levels of competence rather than only consider the cost as the selection criteria.

\textit{Quality Measurement Systems}

The category \textit{Unsatisfactory Quality Measurement Systems} (C12) has been considered as a barrier which impacts on quality performance in the construction industry. The term \textit{Unsatisfactory Quality Measurement Systems} (C12), means that during building processes, the work done by main contractors and subcontractors could not be controlled or measured by suitable measurement tools. \textit{Unsatisfactory Quality Measurement Systems} (C12) received a high value of RII, 0.649, which is consistent with the result from the literature reviews. In Australia, quality measurement systems have been noticed as a quality improvement tool. National Museum of Australia as a project used a suitable quality measurement system and it achieved a great success in quality management (Walker & Keniger, 2002). The high agreement of Quality Management systems also emphasise the significance of this study, because one of its aims of this study is to develop a practical Quality Measurement System. The details of this system will be discussed later in this chapter.

\textit{Unmotivated Subcontractors}

The category ‘Unmotivated Subcontractors’ (RII=0.611) also acquired a high level of agreement. ‘Unmotivated Subcontractors’ (C3) means that subcontractors lack a sense of responsibility or ownership when they carry out their work. Most of them only consider the scope of their job in a narrow way. Hence, this attitude is a quick ‘work-around’ and they do not consider themselves as team members with the main contractors or other subcontractors. This, of course, is diametrically opposed to the relationships that the SCM ideology attempts to develop. A culture of lack of motivation makes it difficult for main contractors to require subcontractors to take more responsibility to ‘see in detail’, become ‘innovative’ and ‘work towards the prevention of quality issues’ when subcontractors take on their work. Therefore, it
can be seen that some causes for poor quality in subcontracting can also be barriers to the implementation of SCQM.

From the analysis above, it can be assumed that some factors for poor quality also can be barriers to development of SCQM in subcontracted projects. Obviously, ‘Unmotivated Subcontractors’ (C3) is one of them, and the ‘Poor Communication’ (C8) and ‘Lack of Teamwork’ (C9) also can be included as factors which can influence quality improvement and the development of SCM in the construction industry. It may also be assumed the factors which cause poor quality, sometimes, can be those which contrary to the concept of SCQM. Therefore, if these factors can be addressed, the quality improvement and implementation of SCQM can be achieved simultaneously.

**Unsatisfactory Work Done by Previous Subcontractors**

The meaning of *Unsatisfactory Work Done by Previous Subcontractors* (C4, RII=0.577) is that quality issues may not be caused by the current trade workers, but caused by poor work done by previous subcontractors (Karim et al., 2006), however, this category did not gain a high agreement. Nevertheless, poor quality works provided by previous subcontractors can have a negative impact on the following trade (Chapter 2). For example, a poorly laid concrete slab can create numerous problems for the following on frame workers, electricians and plumbers. The concrete may have achieved the quality required, but then creates potential quality problems to the following trades. The low agreement acquired by this category also emphasised, in the Australian construction industry, how the subcontracting system still lacks examination on construction sites. Main contractors only notice some obvious factors that can be attributed the quality issues but have not conducted any deeper study with the subcontracting systems.

**Incomplete Contract**

‘Incomplete Contract’ (C11) did not score highly (RII=0.547) in this survey. This means that principal contractors do not see a need for more complete contracts in the subcontracting system, but this does not mean a detailed and completed contract is unimportant. Contracts are used to define and transfer responsibility to every
member involved in a project. The ‘Incomplete Contract’ (C11) means contracts do not include a full description of work, timing, quality standard and the price (Kual, 1994). The low agreement of ‘Incomplete Contract’ (C11), however, is a consistent feature in the Australian construction industry. Completed contracts and/or agreements are rarely found in the Australian construction industry, especially in the subcontracting system related to small construction projects (Department of Industry Science and Tourism, Australia, 1996). This may be the reason why the category of ‘Incomplete Contract’ (C11) gained a low agreement in this survey. From the finding of this survey and the feature of Australian construction industry, the relationship between completed contracts and quality improvement has not been enquired into yet.

**Inferior Materials**
Most respondents considered that the category ‘Inferior Materials’ (C10) did not have any significant impact on quality in construction projects. The result of this category is 0.513. It makes no sense that a high quality project can be achieved by using inferior materials. However, this result provides a possible statement that in Australia, the unsatisfactory poor quality performance is not mainly caused by raw materials. This may further support the fact that most quality problems are attributed to ‘soft issues’ in subcontracting systems, e.g., Incompetent Labour Force (C2), Poor Communication (C8) or Lack of Teamwork (C9), etc.

**Multi-layers subcontractors**
In this survey, most participants disagreed that the category ‘Too Many Layers of Subcontractors’ (C5) is the main cause of quality issues. It only gained 0.506 in the value of RII and this is the lowest score received here. However, this result is not consistent with the studies of Karim et al. (2006), Yik and Lai (2008), Tam, Shen and Kong (2011). The discrepancy for this factor is the largest and most difficult to explain. The reason for this difference on multi-layer subcontractors will be discussed in the following Section 7.2.2.
7.2.2 DISCUSSION OF CAUSES FOR POOR QUALITY

The low RII for one factor is the most marked difference from what is expected from the literature review and that is, whether *Too Many Layers of Subcontractors (RII=0.506)* can impact on quality performance. In the studies, conducted by Chiang (2009), Yik and Lain (2008), Ng, Tang and Palanesswaran (2009), Tam, Shen and Kong (2011) all agreed that there was a significant relationship between a multi-layered subcontracting system and poor quality performance. Tam, Shen and Kong (2011) even conducted a research that compared the work done by a one tier subcontractor to multi-layered subcontractors. The result shows that even though the main contractors understood the workmanship standard required, the bottom-layers subcontractor could not really follow the clients’ wishes. However, subcontractors, who did not further subcontract their work to others, achieved a high level of quality performance.

Reeves (2002) stated that this inefficiency of the multiple contracting systems can cause poor performance throughout the duration of the build. Yik and Lai (2008) stated that multi-layer subcontractors formed a structure like a pyramid and this is the major reason for poor construction quality. Chiang (2009) pointed out that the ‘slack operational structure’ attributed to multi-layer subcontracting is one reason which contributes to a number of challenges in the construction industry. These studies present a clear statement that the multi-layer subcontracting system has a negative impact on construction quality. The more layers of subcontractors there are, the greater the possibility of a poor quality project.

These researches, however, are all based on Asian construction companies, i.e. Hong Kong and Japan. Some deductions can be made why there are different attitudes on the multi-layers subcontractors between Hong Kong and Australian construction companies. Firstly, this difference may be a feature of the market. The Australian construction industry lacks competition (Karim et al., 2000). This is also mentioned by several participants in the current survey. The main contractors in the current industry have dominated the market for several years. Similar situations could also be found in its subcontractors market. The market for subcontractors is more
competitive than for main constructors, but not compared with other countries, such as Hong Kong, Singapore and Japan. It means that the level of competition is still lower in Australia (Karim et al., 2000). As this is a demand-led business system, it means that the Australian construction industry may be less motivated to examine their subcontracting systems and not eager to improve its quality performance. From the result of the survey in this study, it can be seen that over 80% of the main contractors considered subcontractors provided satisfactory work (The result from Q5). In this ‘less motivation’, the relationship between multi-layered subcontracting and poor quality lacks notice by this industry.

The culture issue in Australia can be another reason for different attitudes on the Quality result in subcontracting. The philosophy of ‘she’ll be right’ is an example. Pitsis et al. (2003) explained that the culture ‘she’ll be right’ could contribute to a negative attitude. When problems emerge, the construction worker still believes the result will be fine. The thinking of ‘everything will be fine’ can inhibit subcontractors from delivering high quality performance. Moreover, as the client and the main contractors have the same attitude, neither may have very high expectations towards quality. This may also explain why poor quality produced by subcontractors does not attract much attention in Australia.

Karim et al. (2000) conducted a research comparing the Quality Management System in Australia, Hong Kong and Singapore. The result shows that Quality Management is considered as the fundamental factor for construction organisations in Singapore, but, in Australia, Quality Management is only seen as a marketing tool. This means that in Australia, the culture of Quality still not widely spread compared to Japan, Hong Kong and Singapore. A similar result can be found in a survey conducted by Hong and Proverbs (2002). This research compared quality performance in the US, UK and Japanese construction industries. Japan gained the highest Quality Performance and the reason for this is that in Japan, Quality is the most critical element for the construction industry. Ahmed et al. (2005) stated the differences of Quality Management System between Hong Kong and the USA. It was found that in the USA most construction companies are satisfied with their quality performance. Clients and governments in the USA also lack interest in
obtaining high quality results. However, construction companies in Hong Kong obtained a higher percentage of ISO 9000 certification compared with USA. The culture in Australia may have a feature similar to one in the USA whereby clients and governments may have a less high expectation of quality than Hong Kong or Japan. Therefore, because of this lack of culture of quality in the Australian construction industry, the relationship between poor quality and multi-layered subcontractors is unnoticed by these main contractors in this survey.

Another deduction that can be made is that research participants in this survey (Q1), who are from the managerial level (about 75% of respondents are directors or general managers), may not be really involved in the actual construction site and may not have direct communication with the third or fourth tiers subcontractors. These participants may lack experience, and direct involvement in multi-layer subcontracting. This, therefore, may be a reason for differences in the answer of the question about whether the multi-layer subcontractors can have a negative impact on quality. Therefore, the difference attitude between the Australian and Hong Kong’ construction workers on the question of multi-layers subcontractors may be caused by different markets, cultural issues and the authority level of participants in this survey.

The results of the other causes in this survey are generally consistent with the findings from the literature review, i.e. that quality issues are attributed more to the ‘soft issues’ than physical factors. Barrett (2000) described how communication and relationships were crucial for the success of projects. Huang (2010) claimed that poor quality performance was caused by insufficient coordination. Karim et al. (2006) stated that the workmanship of subcontractors was the reason for poor quality. A similar result can be found from the survey conducted by Hoonakker, Carayon and Loushine (2010), ‘lack of skilled workers’, ‘low bid mindset’ and ‘lack of effective teams and/or team building skills’ were the barriers to improve quality. Wong and Fund (1999); Packham et al. (2003); Tam, Shen and Kong (2011), etc. all came to a similar conclusion that to better manage these ‘soft issues’ can contribute a better quality performance in construction projects. The results of the survey also confirmed the importance of better management of these soft elements. For example,
Lowest-Bidding \((RII=0.796)\), Poor Communication \((RII=0.747)\), Lack of Teamwork \((RII=0.694)\) and Unmotivated Subcontractors \((RII=0.611)\) all acquired high ranking in this survey. Time Constraints \((RII=0.796)\), which gained the highest mark in the survey, may also be caused by lack of cooperation and communication during the schedule phase and poor coordination in the construction phase of a project. On the other hand the ‘hard factors’, such as Inferior Materials only gained a value of 0.513 in RII. From the literature review, it can be seen that SCQM can better manage relationships and working cooperatively with all the different subcontractors in the Subcontracting Supply Chain. This can shift the traditional working style into a supply chain system (Kuei & Madu, 2001). Therefore, it can be assumed that to implement SCQM in the subcontracting system can address the poor quality performance caused by these ‘soft issues’.

7.3 SUPPLY CHAIN QUALITY MANAGEMENT

The results to the previous survey questions (Q6) on the causes of poor quality in the subcontracting system gives encouragement to believe that now is the time to launch SCQM initiatives in the construction industry. Poor teamwork and ineffective communication, unmotivated subcontractors etc. have all been defined as causes of poor quality performance. This provides ammunition to launch a SCQM initiative, especially when related to subcontracted projects. SCQM will provide a better understanding about how to deliver high quality performance through all the different parties in a project. SCQM integrates Quality Management into the whole supply chain, which, in turn affects sections within it and will establish the common goal of quality as a top priority. SCQM is also an effective approach to eliminate poor relationships between the main contractors and subcontractors. The attitude of respondents toward the concept of SCQM is given as follow.

From the results of Q7 (Appendix A) ‘To what extent has your organisation adopted the concept of Supply Chain Quality Management (SCQM) in business?’, it can be seen that the awareness of SCQM (23\% Not familiar with; 23\% Not used; 38\% Limited use; 15\% Extensive use; 2\% Unknown level of use) has not been widely accepted by the main contractors in Australia. This is no surprise, as the result of
other surveys conducted by Barker and Naim (2008) showed only a few respondents in the UK construction industry acknowledged supply chain strategy. It seems that even though Egan who in 1998 claimed to have launched SCM in the UK, the concept of SCM has still not been widely accepted.

7.3.1 FEATURES OF SUPPLY CHAIN QUALITY MANAGEMENT

The results from this survey (Q7 and Q8) show that SCQM may have not been widely accepted in the Australian construction industry. However, main contractors in this survey have a positive expectation about some approaches that come from the concept of SCQM and they believe these approaches could contribute to a high quality project. They highly agree to some approaches, such as partnerships, if they are pressured to improve their quality performance. Though most of participants, believe partnership, effective communication, early involvement, etc. can achieve a high level of quality performance, they still lack any deep understanding of why using these approaches will gain better results.

From the analysis above, the six approaches from the concept of SCQM did acquire a high value of RII (Q8), especially in the categories ‘Establish Partnerships’ (RII=0.76), ‘Effective Communication’ (RII=0.75), ‘Subcontractors Involved Early (RII=0.71)’, and ‘Due Diligence of Tenders Rather than Acceptance of Lowest Bidding’ (RII=0.70). All of these factors received a value of RII above 0.7. To acquire ‘Intimate Knowledge of the Supply Chain’ (RII=0.64) and implement ‘Strategic Supply Management’ (RII=0.66), were ignored by most organisations in this survey. However, 35% those respondents ranked Intimate Knowledge of the Supply Chain as ‘Useful’ while 41% ranked it as ‘Very Useful’ or ‘Extremely Useful’. Also, 38% of those respondents who assigned a rand to Strategic Supply Management ranked it as ‘Useful’ while 50% ranked it as ‘very Useful’ or ‘Extremely Useful’. This means that most respondents in this survey may have aware the important of SCQM, but they still have insufficient knowledge about the concept of SCQM.
The ranking of the agendas of SCQM (Q8) can be seen from the Table 7.2. It seems as if the concepts of *Partnerships, Effective Communication, Early Involvement* and ‘Due Diligence of Tenders Rather than Acceptance of Lowest Bidding’ are popular in those respondents’ firms.

<table>
<thead>
<tr>
<th>Rank</th>
<th>The factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S4. Establish partnerships with suppliers/main contractors/subcontractors/clients (RII = 0.76)</td>
</tr>
<tr>
<td>2</td>
<td>S5. Effective communication (RII = 0.75)</td>
</tr>
<tr>
<td>3</td>
<td>S6. Early involvement of subcontractors (RII = 0.71)</td>
</tr>
<tr>
<td>4</td>
<td>S3. Due diligence of tenders rather than acceptance of lowest bidding (RII = 0.70)</td>
</tr>
<tr>
<td>5</td>
<td>S2. Strategic Supply Chain Management (RII = 0.66)</td>
</tr>
<tr>
<td>6</td>
<td>S1. Intimate knowledge of the supply chain (RII = 0.64)</td>
</tr>
</tbody>
</table>

**Table 7.2** The ranking of the agendas of Supply Chain Quality Management

*Partnership*

*Partnership* (S4), in Chapter 3, as a core principle in SCM has been discussed by Wong and Fung (1999); Dainty and Millett (2001b); Cox and Ireland (2002); Love *et al.* (2004); Saad *et al.* (2002); Briscoe *et al.* (2004); Briscoe and Dainty (2005); Green, Fernier and Weller (2005); Ferine and Thorpe (2007). Most participants in this study also considered that establishing a partnership was a good approach to achieve a high level of quality performance with clients, subcontractors and suppliers. This gained the highest value of RII - 0.76 in this section of the questionnaire. From the result of the category ‘*Partnership*’ (S4), it may be assumed that the main contractors have enough knowledge of partnerships and a high motivation to establish them with others connected with the construction’s progress. From the discussion in Case Study 3 (Chapter 3), it can be seen that to establish a partnership is a good approach to improve the overall performance. To establish a ‘right’ partnership also can address the quality problems caused by ‘Unmotivated Subcontractors’ (C3) and ‘Lack of Teamwork’ (C9). In the current survey, these two factors have been identified as the main reasons for poor quality (Q6).
**Effective communication**

The category of ‘Effective Communication’ (S5) has been ranked as the second most valuable factor (RII=0.75) which may influence the projects’ quality performance. The importance of communication was also highlighted by Briscoe, Dainty and Millett (2001 b); Briscoe et al., (2004) and Love et al., (2004). From the results in this survey, (Q6), Poor Communication (C8) is also considered as a root cause of poor quality. The survey further examines how the implementation of SCQM can improve the quality performance in subcontracting systems. However, improving the effectiveness of communication is a challenge, i.e. the ability to share information. In the manufacturing industry, companies establish ERP or ICT systems to share their information between the different parties in the supply chain for better communication. In the future, to establish communication mechanisms through several tiers and staff training will be critical. Without such a mechanism or ‘soft skills’ effective communication cannot be achieved.

**Early Involvement of subcontractors**

The category, Early Involvement (S6), was generally agreed to by the main contractors with the result that RII scored 0.71. This is the third highest results in this section. Early Involvement (S6) is now gaining great interest in the manufacturing industry and has been considered an important sign of the implementation of SCM (Briscoe, Dainty and Millett, 2001 b; Love et al., 2004; Bankvall et al., 2010). In early involvement, key subcontractors meet main contractors before the building process begin, therefore, subcontractors can slot in their knowledge more effectively. This will uncover fields, such as determining resources, workflows and schedules etc. In the discussion of Time Constraints (C7), the Early Involvement (S6) is considered as an effective approach to avoid poor planning. Early Involvement (S6) may address the unsatisfactory quality performance caused by poor planning. This further emphases the importance of implementing SCQM in the Subcontractors Supply Chain.

**Lowest bidding**

‘Due Diligence of Tenders rather Than Acceptance of Lowest Bidding’ (S3) has been marked as the 4th favoured approach (RII=0.70) to improve quality in the
construction supply chain. In the traditional lump-sum bidding, the main contractor is selected solely by price. This competitive bidding could also be viewed as the root cause which prevents the integration of the Construction Supply Chain. It also has a negative impact on the establishment of partnerships, which, has been considered as one of best approaches to improve quality. Although, the category ‘lowest bidding’ (C2: Competitive Tendering Approach) was mentioned in Q6, the category Due Diligence of Tenders rather Than Acceptance of Lowest Bidding (S3) in here is considered from the view of SCQM, that is, selecting subcontractors from the total cost of supply chain.

Knowledge of SCM
The category ‘Intimate Knowledge of the Supply Chain’ (S1) and ‘Strategic Supply Chain Management’ (S2) recorded the lowest score with values of 0.66 and 0.64, respectively. Compared with other categories, these two are basic to SCM. From the concept of the supply chain, every party in the project needs to work together as a team, rather than play separate roles. The common aim is to deliver values to the end customer and to best satisfy that customer. This includes a high quality performance of the project. To establish the awareness of the supply chain with employees and partners could be considered as an operational approach by construction companies. The difficulty is, how to encourage employees to accept the concept of SCM? The other questions that need to be considered are: How to select partners and what kind of partnership needs to be established with different organisations? How to build a communication channel with other organisations? These questions need to be tackled strategically. Knowledge of the strategic supply chain would be the best solution.

The results from this survey (Q7 and Q8) show that SCQM has not been widely accepted in the Australian construction industry. However, the main contractors in this survey have a positive expectation about some approaches that come from the concept of SCQM and they believe these approaches could contribute to a high quality project. They highly agree to some approaches, such as partnerships, believe partnership, effective communication, early involvement, etc. can achieve a high
level of quality performance, they still lack any deep understanding of why these approaches will gain better results.

It also means that the construction industry may still has inadequate awareness of the power of the supply chain or deep understandings about SCM and Strategic Supply Chain Management. Main contractors in this survey agree that partnerships, early involvement and effective communication can improve quality, however, they do not know why these approaches work. Without the knowledge of SCM and integrating the concept of supply chain into strategic planning, partnerships, and early involvement etc. cannot be achieved. Therefore, the main contractors in Australia are aware of the importance of better managed relationships, but, more training and education about SCQM is required before implementing throughout the Australian construction industry.

7.3.2 IMPLEMENTATION OF SUPPLY CHAIN QUALITY MANAGEMENT

SCQM can provide a most effective way to address the ‘soft issues’, such as poor communication, lack of mutual understanding and irresponsible attitudes to quality. SCQM would help participants in the project to establish a broader view of their work that would lead them to not only consider their own interests, but think about the ‘big picture’. Main contractors and subcontractors need to have a common goal, that is, to deliver high quality performance products/services to the end customers. This customer focus is what is missing in the construction industry and a change in this attitude could help construction companies to balance the trade-offs among Quality, Cost and Time. Finally, SCQM may not only be considered as a general approach, but could also address quality problems. It has the power to launch a revaluation within the construction industry by reshaping the working structure, changing ineffective working relationships and reducing on site complexity. However, there are several problems which need to be overcome to successfully implement SCQM in the Australian construction industry.
Lack of Motivation to Call for Change

The construction industry in Australia may lack motivation to improve quality performance. From the results of rating subcontractors’ quality performance (Q5), it can be seen that more than 80% of main contractors considered subcontractors provided satisfactory work. If only a few stakeholders who are motivated to improve quality performance, it is difficult to launch SCQM initiatives which need the support from the majority of companies within the total supply chain. Government support to the initiatives of SCQM is a critical factor in its implementation in the construction industry.

Cultural Issues

The cultural issues have been discussed in Section 7.2.2. The cultural issue of ‘everything will be fine’ has been assumed to be the cause of different attitudes on the question about multi-layered subcontractors between Australia and other countries. In here, there are also many serious cultural barriers to the implementation of SCQM in the construction industry. For example, the arms-length relationship between subcontractors and main contractors, cost-orientation and separate construction processes, etc. How to breakdown traditional cultural barriers to implement SCQM between the main contractors and subcontractors needs to be carefully considered. A resonant and robust agenda firstly needs to be developed (Fernier & Thorpe, 2007).

Lack of Awareness of SCQM

Results of the questionnaire (Q7 and Q8) related to SCQM show that main contractors in this survey still lack awareness of SCQM. The absence of education or training about the content of a supply chain is notable (Fernier & Thorpe, 2007) and the lack of successful implementation and lack of information stops this industry from fully understanding this concept.

In order to ensure SCQM can be implemented in the Australian construction industry the government’s support is needed. Thomas et al. (2002) stated that there are two sources of motivation for quality improvement: one from the client and the other from the government. As mentioned before, there are few repeat clients in the
construction industry and most of these may not have adequate knowledge or motivation for change. Thus, to improve building quality in Australia, the government needs to take more responsibility than it does at present.

The reason to emphasise the importance of governments is that they have power to influence culture (Dibdin & Boveri, 1992). For example, the ISO9000/AS3900 System Standard has been required by Federal and State Government Policy in Australia. As the input of Australian Government, the culture of this industry has slowly changed (Dibdin & Boveri, 1992).

The influence of the government is significant. For example, the Construction Industry Institute - Hong Kong, launched a project called ‘Best Practices in Managing Specialist Sub-contracting Performance’ in Hong Kong. Because of the government’s support, a larger amount of research has been focused on the performance of subcontractors, e.g., Yik and Lai (2008), Chiang (2009) and Tam, Shen and Kong (2011), etc. These researchers have provided a large number of recommendations about how to improve performances in the subcontracting system. The research conducted by Egan (1998) was also supported by government in the UK. The Australian government needs to take responsibility to push this industry to improve its quality performance, with the aim to improve its international competitiveness (Thomas et al., 2002). The construction industry, which relies heavily on past experience, and if the government can successfully launch SCQM initiatives in complex projects, the main contractors may have greater motivation to adopt SCQM in their own small projects to improve that quality.

### 7.4 ANALYSIS OF KPIs

Performance Measurement is a widely accepted tool to evaluate effectiveness and efficiency. Wong and Fung (1999), and Oakland and Marosszeky (2006) demonstrated that the integration of Performance Measurement into the supply chain could reduce conflicts, provide positive feedback and motivation for improvement. To accomplish this, a tool of Performance Measurement should be adopted. The purpose of developing a set of KPIs in this study is providing a guide to what is
needed to be measured. There are two groups of indicators in this set of KPIs. One is indicators from the Corporate Level and the other from the Operational Level.

### 7.4.1 FEATURES OF KPIs IN THE CORPORATE LEVEL

The categories *Employee Satisfaction* (*RII*=0.71), *The Ability to Manage Change* (*RII*=0.65), *Community Satisfaction* (*RII*=0.43) were included in Question 9 of the survey questionnaire. The categories *Culture of Quality in Organisations, Top Management Commitment, Innovation & Technology Assistance, Mutual Trust* are from the recommendations from responses in this survey. The result of KPIs in the Corporate Level can be seen from Table 7.3.

<table>
<thead>
<tr>
<th>Key Performance Indictors</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL3.Employee Satisfaction(<em>RII</em>=0.71)</td>
</tr>
<tr>
<td>CL2.The Ability to Manage Change (<em>RII</em>=0.65)</td>
</tr>
<tr>
<td>CL1.Community Satisfaction (<em>RII</em>=0.43)</td>
</tr>
<tr>
<td>CL4.Culture of Quality in Organisations</td>
</tr>
<tr>
<td>CL5.Top Management Commitment</td>
</tr>
<tr>
<td>CL6.Innovation and Technology Assistant</td>
</tr>
<tr>
<td>CL7.Mutual Trust</td>
</tr>
</tbody>
</table>

**Table 7.3 KPIs in the Corporate Level**

*Employee Satisfaction*

The category ‘*Employee Satisfaction*’ (CL3) gained the highest score (0.71) of the three categories, followed by ‘*The Ability to Manage Change*’ (CL2). Many studies (Yasamis, Arditi & Mohammadi, 2002; Takim & Akintoye, 2002; Ling & Peh, 2005) have proved that satisfied employees provide and deliver high quality work to customers. The highest score gained by this indicator also proves the importance of *Employee Satisfaction* (CL3) in the Australian construction industry. The employee satisfaction survey, focus group meetings and interviews, etc., are good options for construction companies to measure their employee’s satisfaction.
The result of the category is 0.65 which is the second highest score in this survey. The quality of a construction can be seriously impacted by uncertainties and changes during the project’s building phase (Huang, 2010), such as change of design, rescheduling, owner changes requests, a change of environment, etc. These uncertainties cannot be avoided during the project’s building process. The ability to cope quickly with these changes and offering proper solutions would not only ensure the quality of the project, it could also eliminate the possibility of delays and disputes. The indicator of *The Ability of Managing Change* can be evaluated by an equation (Huang, 2010):

\[ I = \int_{t_1}^{t_2} F \, dt = \int_{t_1}^{t_2} \left( \frac{\Delta v}{\Delta t} \right) \, dt = \Delta p \]

where \( I \) is the impulse of change; \( F \) is the force; \( t \) is time; \( \Delta p \) is the change in momentum.

Community Satisfaction

‘Community Satisfaction’ (CL1) gained the lowest value (RII=0.43) in this survey. From this, it can be assumed that most main contractors do not consider Community Satisfaction (CL1) as a component of construction quality. However, satisfying the community is a future trend of quality improvement. For example, during the building process, the construction team needs to eliminate noise and reduce construction waste to a minimum because these can have negative impacts on the community and environment. Sustainable constructions and ‘green buildings’ are an example of community satisfaction (Levy, 2009). According to Yasamis, Arditi and Mohammadi (2002), the construction company needs to consider its social responsiveness and that obviously includes the satisfaction of the community. The government needs to provide more supports for these ‘green buildings’. The categories ‘Environment’ and ‘Public and Industry Recognition’ have been used as the quality score for the National Museum of Australia (Walker & Keniger, 2002). However, the concept of ‘Community Satisfaction’ (CL1) is still not widely accepted on Australian construction sites. Main contractors and subcontractors in Australia need to take more responsibility to Community Satisfaction (CL1), even, sustainable constructions mean great cost.
Many participants in the survey pointed out that the items *Culture of Quality in Organisations* (CL4); *Top Management Commitment* (CL5); *Innovation & Technology Assistant* (CL6); *Mutual Trust* (CL7) all play powerful roles as performance indicators to measure a projects’ quality performance. The details of these indicators are as follows:

_The Culture of Quality_

_The Culture of Quality_ (CL4) may help organisations to establish a strong belief on the integrity of high quality and a strong desire to satisfy customers. Hong and David (2002) conducted a survey, aimed at comparing quality performance in Japan, the UK and the USA. In this study, Japanese contractors gained the highest quality performance, because most Japanese organisations have a deep-rooted culture of Quality and they regard Quality as the top propriety. A similar result has been obtained in other studies, which confirms the importance of the culture of Quality in the Japanese organisations (Thomas et al., 2002; Zuo, 2008). The discussions on the causes for poor quality and the implementation of SCQM both emphasise the importance of _The Culture of Quality_ (CL4). Establishing a culture of quality throughout the workplaces can greatly improve quality performance. To set the concepts of Quality into every employee’s mind may ultimately improve quality performance and prevent poor quality work from the beginning reduce cost and improve on-time completion. From the analysis above, it can see _The Culture of Quality_ (CL4) may have a positive impact on establishing a quality conscious environment in organisations, which means this category is fit for the requirement of indictors in the Corporate Level (Yasamis, Arditi & Mohammadi, 2002). The cultural issues also have been determined as the barriers to quality improvement and the implementation of SCQM in Section 7.2.2 & 7.3.2. Therefore, _The Culture of Quality_ (CL4) can be seen as an indicator at the Corporate Level.

_Top Management Commitment_

Commitment from top management is extremely important to Quality Improvement. _Top Management Commitment_ (CL5) is an indispensable indicator for measuring performance in construction projects (Yeung, Chan & Chan, 2010). This view was shared by Butcher and Sheehan (2010) who emphasised commitment and ownership
of the project by every shareholder. This was a key point that the contractor can adopt to achieve an outstanding performance. Oakland and Marosszeky (2006), from the operational view, demonstrated that commitments from the project management would lead to a successful project. Moreover, the integration of Quality Management into the supply chain definitely needs the support and commitment from these leaders from top management. This is the first step which needs to be taken into account to achieve the integration of the supply chain in the construction projects. Ownership is the other essential factor which can assist the company to obtain a high standard of quality. It requires motivation to seek improvement in performance without considering the financial cost. The sense of ownership among employees will establish the attitude of constant questioning, eventually achieving excellent performance. Hence, the category Top Management Commitment (CL5) becomes an indicator at the Corporate Level.

Innovation & Technology

Innovation and Technology (CL6) were highlighted by several participants. In the current construction industry, experience is more important than innovation and the implementation of advanced technology. This is an obvious reason why the construction industry has lagged behind others. The concept of innovation, no matter which aspects of technology or management skills are used, has the potential to push this industry up to a higher level (Egan, 1998; Pitsis et al., 2003). In Chapter 2, the importance of Innovation and Technology (CL6) in quality improvement has been discussed. The category Innovation and Technology (CL6) can also be considered as an indicator in this set of KPIs.

Trust

Lack of Trust is another factor which prevents quality improvement in the construction industry (Hoonakker, Carayon & Loushine, 2010; Oakland & Marossezky, 2006). The Australian National Construction Industry Conference (1982) emphasised the importance of trust in the construction business. The integration of the supply chain requires adjustment in their overall plans and resources. Without trust the goal of the supply chain integration cannot be achieved (Shepherd & Gunter, 2006). The establishment of Mutual Trust (CL7) between the
main contractors and the subcontractors would encourage quality improvement and supply chain integration. Hence, Mutual Trust (CL7) as an indicator in the Corporate Level should be considered in this Performance Measurement system.

### 7.4.2 FEATURES OF KPIs IN THE OPERATIONAL LEVEL

The result of KPIs in the Operational Level (Table 7.4) shows the same trend as in the summary from previous chapters, 3 and 4. Only the category ‘Number of Layers of Subcontractors’ (OL8) produced a negative result. The details are presented as follows:

<table>
<thead>
<tr>
<th>Rank</th>
<th>KPIs</th>
<th>RII</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OL1.Customer Satisfaction</td>
<td>0.79</td>
</tr>
<tr>
<td>2</td>
<td>OL5.Effective Communication</td>
<td>0.77</td>
</tr>
<tr>
<td>3</td>
<td>OL4.Teamwork</td>
<td>0.74</td>
</tr>
<tr>
<td>4</td>
<td>OL7.The Quality of Procurement &amp; Delivery</td>
<td>0.72</td>
</tr>
<tr>
<td>5</td>
<td>OL2.Defect</td>
<td>0.71</td>
</tr>
<tr>
<td>6</td>
<td>OL9.Operational Quality Standardisation</td>
<td>0.67</td>
</tr>
<tr>
<td>7</td>
<td>OL3.Partnership</td>
<td>0.66</td>
</tr>
<tr>
<td>8</td>
<td>OL6.Operational/ Predictable Planning</td>
<td>0.64</td>
</tr>
<tr>
<td>9</td>
<td>OL8.Number of Layers of Subcontractors</td>
<td>0.49</td>
</tr>
</tbody>
</table>

**Table 7.4** KPIs in the Operational Level

*Customer Satisfaction & Defect*

In Table 7.4, the indicators of the Operational Level, *Customer Satisfaction* (OL1) and *Defect* (OL2) were ranked 1st and 5th with value of 0.79 and 0.77, respectively. These indicators had an extremely strong influence on quality improvement in the Operational Level.

Traditionally, indicators of KPIs measure customer satisfaction and defect rate in the construction industry (Beatham *et al.*, 2004; Ling & Peh, 2005; Yasamis, Arditi & Mohammadi, 2002). The principle behind *Customer Satisfaction* (OL1) is to examine whether the project satisfies the customer’s expectations. There are several ways to
measure customer satisfaction, these are: surveys, focus groups, client advisory groups, etc.

Compared with the subjective indicators of client satisfaction, the measurement of *Defects* (OL2) is easier because there are some traditional tools to measure defect rate. Karim *et al.* (2006) illustrated how to use the Pareto Principle, Isoquant lines and Defect Incident Record to examine construction defects. These measurement approaches, in this study, are considered as tools to measure *Customer Satisfaction* (OL1) and *Defects* (OL2).

**Effective Communication**

The category *Effective Communication* (OL5) gained 0.77 which is the second highest score in the result of indictors in the operational level. In a construction project, excellent communication means ‘two-way communication’ (Butcher & Sheehan, 2010). It also means that the subcontractor cannot play a ‘yes man’ game but needs to provide useful feedback to the main contractors. The indictors of measuring effective communication should include timeliness/accuracy of information, a number of open meeting, etc. Most importantly, without the help of *Effective Communication* (OL5), teamwork and partnership cannot be successfully implemented.

**Partnership & Teamwork**

*Partnership* (OL3) *Teamwork* (OL4) and have now become necessities in the construction industry, especially, if the organisation aims for a high quality performance and long-term development. The category *Teamwork* (OL4) gained 0.74 and *Partnership* (OL3) gained a value of 0.66. From the result of survey, it can be seen that main contractors are already aware of the importance of these two factors. By measuring the level of information sharing, cross training, subcontractors’ involvement, etc. (Yasamis, Arditi and Mohammadi, 2002) were able to attribute better teamwork and partnership to these indictors.
**Quality of Procurement and/or Delivery**

The category ‘The Quality of Procurement and/or Delivery’ (OL7) was ranked as 4th indicator with a value of 0.72. This means that the quality of raw material needs to be better controlled. Its importance has been emphasised in Chapter 4. Here, being able to measure Quality of Procurement and/or Delivery (OL7) is to assure quality of materials in the construction project. To improve the quality of supply, main contractors need to audit and evaluate the suppliers, and select suppliers based on who can deliver defect-free products rather than only considering the costs (Hernandez & Aspinwall, 2008). Compared with the low agreement gained by ‘Inferior Materials’ (C10) in this survey, it may be assumed that through measuring The Quality of Procurement and/or Delivery, it ensures the Inferior Materials not be used in Australian construction projects.

**Quality Standardisation**

‘Operational Quality Standardisation’ (OL9) has been considered as a significant influence on the quality of the project with a value of 0.64. The reason for this is that different organisations have different definitions of Quality and most organisations consider Quality to be subjective. Hence, the standardisation of quality is quite difficult and unclear across a construction site. For example, when concrete is laid in different construction sites, there may be different standards used as the requirement of the quality of the work. Without clear and detailed explanation of quality requirement, the work done by subcontractors cannot be guaranteed to achieve a high level of quality.

**Planning**

The category of ‘Operational/Predictable Planning’ (OL6) was not valued highly. It only gained the value of 0.64. However, from the literature review in Chapter 4, it can be seen that time and cost constraints are the biggest barriers for the main contractor to improve quality. In this situation, an operational and predictable plan could help construction organisations to minimise this negative influence caused by poor scheduling and workload plan. Black and Porter (1996) decided to separate this operational planning into two indicators ‘Development/implementation of short-term..."
plans/strategies focused on quality’ and ‘Consideration of performance requirements in developing short term goals’.

The high agreement of *Time Constraints* (C7) in this present survey (Q6) also highlights the importance of appropriate planning. However, ‘*Operational/Predictable Planning*’ (OL6) gained a low agreement. It seems that main contractors, in the Australian construction industry, may have a clear idea which factors can impact on the quality improvement, but do not know what they needed to do to address this problem.

**Numbers of Layers of Subcontractors**

*The Number of Layers of Subcontractors* (OL8) acquired the lowest score, only 0.49, which assumes most participants do not consider that limiting the layers of subcontractors would improve quality. This result is quite different from the studies of Tam, Shen and Kong (2011), and Yik and Lai (2008) related to the Hong Kong construction industry. From the result of these studies, multilayer subcontracting has a negative impact on quality. This difference may be caused by the different industry behaviour between Australia and Hong Kong.

From the discussion in Section 7.2.2, one can see the relationship between multi-layered subcontractors and poor quality work still needs to be examined further. In the Australian construction industry, ‘*Too Many Layers of Subcontractors*’ (C5) may be not considered as a factor contributing to quality issues. The exact reason for this need further study and a comparison of the subcontracting system between the Australian and Hong Kong construction industries would be useful. Therefore, the indicator of ‘*The Number of Layers of Subcontractors*’ (OL8) may also need to be examined in any future study.

7.4.3 THE MODEL OF KPIs

Previous studies have not really considered the topics of SCQM and Performance Measurement together. There is almost no research in how to consider the KPIs from the perspective of SCQM in the construction industry. To solve this, this study,
combined the indicators from the field of SCM and Quality Management together. Then, after analysing the features of the Subcontractor Supply Chain, a list of quality performance measurement indicators, aimed at evaluating quality performance in the Subcontractor Supply Chain, was determined. From the result of the survey, a better understanding of KPIs for quality improvement was provided, from the viewpoint of the main contractors in Australia.

A proper Performance Measurement may contribute to an excellent construction project (Egan, 1998; Fernier, Leiringer & Thorpe 2006; Butcher & Sheehan, 2010). All these researchers emphasise the importance of performance measurement in the construction industry. Takim and Akintoye (2002); Chan and Chan (2004); Beatham et al. (2004); Ling and Peh (2005); and Takim (2005) discussed the relationship between successful construction projects and performance measurement. However, these studies are more concerned with how to measure the overall project performance, not its quality.

Currently, most of construction firms in Australia adopt various types of Quality Management Systems to ensure to achieve high levels of customer satisfactory. Most of these systems are coherent documentations of local government activities with policies and clearly defined objects (Auff, 1993). Most of Quality Management Systems are in the form of quality assurance and the form of accreditation to the ISO9000 (Saha & Hardie, 2005). Furneaux et al. (2010) mentioned that the Australian Construction Industry Forum and the Australian Procurement and Construction Council have now joined together to determine a set of KPIs that fit for the Australian construction industry. However, the final result has not yet been published. Walker and Keniger (2002) are among the few researchers to discuss quality measurement systems from the Australian construction industry experience. Therefore, this is why this thesis aims to conduct a deep research in the study about the KPIs in the Australian construction industry.

Shepherd and Gunter (2006); Gunasekaran and Kobu (2007); Akyuz and ErKan (2010) were more concerned to study how to measure KPIs on SCM. Yasamis, Arditi and Mohammadi (2002); Cagnazzo, Taticchi and Brun (2010) illustrated that the
Implementation of Performance Measurement has a positive influence on construction quality improvement or SCM performance. However, research related KPIs with SCQM in the construction industry is rare. In Chapter 4, a cross study related to KPIs in the construction industry and SCM was conducted.

The results of the survey provide a better understanding of the importance of these indicators from the viewpoint of the main contractors. However, to only present a list of KPIs is inadequate. According to Yasamis, Arditi and Mohammadi (2002), Quality Performance Measurement Models can help construction organisations develop a customised measurement tool which can lead building teams to better understand their tasks. Hence, after the analysis from this survey, a model of KPIs in the construction industry through the concept of SCQM, especially to measure the quality performance in subcontracting system has been built, Figure 6.3 below.

The model in this study has been divided into two parts, one is the indicator in the Corporate Level and the other is in the Operational Level. Combining the results of the survey and the previous analysis, except for the category ‘Number of Layers of Subcontractors’ (OL8), other 11 indicators have been used and categorised into Corporate Level and Operational Level. The reason to exclude the category ‘Number of Layers of Subcontractors’ is that the relationship between multi-layer subcontractors and poor quality in the Australian construction industry is not yet clear. It still needs to be examined further. The results can be seen as follows:
Figure 7.1 The model of KPIs in subcontracted projects

- Corporate Level: Employee Satisfaction; The Ability to Manage Change; Community Satisfaction
- Operational Level: Customer Satisfaction; Effective Communication; Teamwork; The Quality of Procurement and/or Delivery; Defect; Operational Quality Standardisation; Operational/Predictable Planning

Four indicators, raised by the participants, are considered to be vital factors to ensure quality performance. Therefore, after analysis, the category ‘The Commitment from Top Management’, ‘Culture of Quality’, ‘Innovation and Technical Improvement’ and ‘Mutual Trust’ have been placed into the corporate level indicators. A list of fifteen indicators, which includes two measurement levels, has been produced. There are seven factors in the Corporate Level and another eight indicators in Operational Level.
The other feature of this model is in the Operational Level. The project’s life-cycle, has been separated into three phases. The first, is Pre-Project phase, which is followed by the Project Implementation phases and finally, Project Completion phase. The reason to determine this indicator in the project’s life-cycle is that during different phases there are different factors which could influence quality performance. Hernandez and Aspinwall (2008) divided the project’s life-cycle into five phases and found that during the different phases there are different quality improvement methods which can be adopted, Table 7.5 below.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Brief description</th>
<th>Quality improvement methods (groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Briefing (schematic design)</td>
<td>Customer needs are collected and a blueprint elaborated</td>
<td>Gathering customer needs, organising customer needs and technology</td>
</tr>
<tr>
<td>Designing (detailed design and construction documentation)</td>
<td>The facility that will satisfy the customer needs is designed. The specification documents that will help to assemble the final product are developed</td>
<td>Formal methods and technology</td>
</tr>
<tr>
<td>Bidding</td>
<td>A contractor is chosen to carry out the site construction work</td>
<td>Planning and programming tools and technology</td>
</tr>
<tr>
<td>Construction</td>
<td>The facility is built in accordance with drawings and specifications. Construction materials are selected</td>
<td>Quality control and technology</td>
</tr>
<tr>
<td>Commissioning</td>
<td>Users take over the facility</td>
<td>Performance measures and technology</td>
</tr>
</tbody>
</table>

**Table 7.5** Quality improvement methods through construction process

*Source* Hernandez and Aspinwall (2008)

The model of the KPIs also has many different indicators during the duration of its life-cycle. For example, in the Pre-Project phase, the main contractors focus on communicating with clients to ensure they have understood the clients’ wishes. This Pre-Building phase will also include a statement of the project’s objectives and scope, preliminary designs and plans, and the selection of the main contractors, etc. In this phase, *Communication* is extremely critical for each party. *Customer Satisfaction* also needs to be measured from the beginning of the project. Teamwork, predictable planning and clearly defining standard of quality required are critical factors that cannot be ignored in this Pre-Project phase. Traditionally, subcontractors and suppliers do not join the project team in the Pre-Project phase, but, as the previous analysis has shown, key subcontractors and suppliers could play a greater role in the function of planning and resource allocation, if they are willing and able
to exchange their knowledge and experience of these functions. This would avoid quality issues caused by poor planning and lack of coordination, inaccurate cost estimates and the lowest bidding syndrome. Hence, partnerships need to be emphasised at this phase.

The indictors in the phase of Project’s Implementation and Completion are identical to the Pre-Project stage, but this does not mean that the weight of measurement is the same. In practical terms, the indicators need to have different weights of different phases and in different projects. The same indicators used in the Pre-Project are valued and weighed differently. For example, the indicators of Communication can be found in three phases (Pre-Project; Project Implementation and Project Completion phase), but the weight in the stage of Pre-Project may be higher than the other two, because, to understand the client’s requirements is heavily dependent on effective two-way communication with the client and the main purpose of the communication is to acquire feedback from the client. Communication may not as vital (/?202) to the main contractors as examining the defect rate in the Project Completion stage.

There are some problems within this model. Firstly, measurement requires financial supports and human resources. This could be a problem for small and medium size construction companies, but, the more important problem is, how to measure it? Traditionally, the level of the project quality is through measuring the customer’s satisfaction. However, Barrett (2000) claimed that most of the time clients do not understand construction methods, if the project’s quality is only measured through the indicators of Customer Satisfaction, this would not ensure that the construction project achieves a high quality level. ‘Looks good, feels good’ is the attitude of contractors to measure quality (Hoonakker, Carayon & Loushine, 2010). This attitude leads to quality measurement impossibility or difficulty. This is another core issue that needs future study. One other future study is which indicators can be adopted to evaluate quality and how to measure them. Some indicators, in this model, may not be able to be measured quantitatively, such as Commitment from Top Management, Level of Partnership and Effective Communication. How to properly measure these indicators needs future study. Different companies may have different
priorities about aspects of quality. All in all, each organisation needs to consider, from its own point of view, how to effectively and flexibly adopt this model.

7.5 SUMMARY

In this chapter, the results from data analysis were presented. The findings from the survey were discussed, especially in the context related to factors that can cause poor quality in the subcontracting section (Section 7.1 and 7.2). In the second part (Section 7.3) of this thesis the benefits and barriers to implementing SCQM in construction projects have been highlighted. Finally, a model of KPIs was established (Section 7.4).

The results provide details of the core questions in this study: the causes of poor quality in the subcontracting system; the awareness of SCQM in the construction industry and the indictors of KPIs for measuring Quality in subcontracted projects. The findings from the literature review and the results from the survey have been compared. The aim is to develop a deeper understanding for the themes of this study. After analysis, most results were found to be consistent with the findings from the literature review. In summary, the findings of this study provide a new point of view to the quality issues in the subcontracting systems and introduces the concept of SCQM and provides a model of KPIs based on SCQM. Further research needs to be conducted to gain a better understanding in these fields.
Quality is a critical factor in assessing the value of construction projects. There are a number of factors during the project life-cycle which may impact on the quality of construction. In this study, the influence from the Subcontracting Supply Chain has been determined as the factor which can cause poor quality performance. Subcontractors, as effective project implementers, need to contribute more to enhance quality performance. In the first part of this study, the relationship between the Subcontracting Supply Chain and poor quality performance was examined. Second, it investigated whether the new concept of SCQM can have a positive influence on improving Quality in a subcontracted project after highlighting the relationship between subcontractors and poor quality performance. It was then determined that a set of KPIs can ensure SCQM can be implemented effectively and efficiently. This study effectively closed the gap between existing theoretical research and work practices on the site, especially the field of subcontractors and SCQM in the construction industry.

This study offers a different point of view about the quality issues in the construction industry. It filled the gap in the study of quality problems in the subcontracting system that had not been carefully examined previously. It also introduces SCQM as a means of solving poor quality performance caused by the ‘soft factors’ in the subcontracted projects. Lastly, a set of KPIs provides unusual indicators which are needed to be measured in subcontracted projects. In the construction industry, because there is lack of repeat clients, the main contractors are considered as the most powerful stakeholders who need to take most of the responsibility to ensure the quality performance in subcontracted projects. Therefore, the analysis in this study is from the perspective of the main contractors.

Chapter 1 provided an introduction to the research and its theoretical development. Chapter 2 presented the structure of subcontracting and then discussed the factors which cause quality issues in the subcontracting system. Chapter 3 introduced the concept of SCM and Construction Supply Chain. Following this, the concept of SCQM was demonstrated and a discussion of why SCQM can offer a positive impact
on quality enhancement was presented. In Chapter 4, it was argued that performance measurement can be a useful tool to improve quality. Then, a set of KPIs, based on the consideration of SCQM and the features of a subcontracting system, was determined. Chapter 5 explained the methodology used in this study. A questionnaire survey was the method used to collect data from the large main contractors in the Australian Commercial and Industrial Building Construction Industry. A total of 53 of 150 questionnaires distributed (53%) were collected and analysed. The results of the survey were presented in Chapter 6. The discussion of the core agreements between the questionnaire and the literature survey results was also presents in Chapter 7 and then a model of a quality performance measurement system was provided.

8.1 FINDINGS IN TERMS OF THE OBJECTIVE OF THE RESEARCH

Overall, all the objectives of this research were achieved. Based on the findings from of the literature review, a ten question questionnaire was developed. After analysis, the data collected from this questionnaire, the findings, related to the objective, were presented as followed.

8.1.1 ROOT CAUSES OF POOR QUALITY IN SUBCONTRACTED PROJECTS

As quality problems caused by subcontracting have been overlooked in the construction industry, this study firstly focused on studying which factors caused the poor quality performance in subcontracting system.

From the literature review (Chapter 2), it was shown that there were several factors that can contribute to the quality problems in subcontracted projects. Through analysing the process and relationships among the main contractors, subcontractors and clients, it seems as if some ‘soft issues’ between different participants in a subcontracted project are the core factors that erode Construction Quality rather than some technique issues. These ‘soft issues’ can be demonstrated as attitudes towards cost, lack of motivation and poor communication between the main contractors and
subcontractors, etc. From the result of this survey, it can be seen that excepting the relationship between multi-layered subcontractors and poor quality performance is still not clear in the Australian construction industry. Other results, to some degree, are consistent with the finding from the literature review, which is, that many soft issues are the main causes of poor quality performance. For example, the category that relates to poor communication, lack of teamwork and the approach to select subcontractors is not directly related to the qualifications of the main contractors or subcontractors. Poor coordination and planning also seriously impact on the project’s duration and this indirectly influences the quality enhancement. The root cause of poor quality was linked to the lack of partnership, the lack of information sharing, and more specially, the lack of awareness of SCQM.

8.1.2 SCQM IN THE SUBCONTRACTING SYSTEM

SCQM, as a modern theory in the construction industry needs to be fully examined. In Chapter 3, drawing on the earlier study related to SCM and the Construction Supply Chain, the discussion emphasised the power of implementation of SCM in the construction industry. Then, from the definition of SCQM, it can be seen that SCQM emphases the implementing of Quality Management through the whole supply chain and then achieves a high quality performance.

In the literature review, the implementation of SCQM in a subcontracting system was firstly discussed. Then from analysis of a case study, it appeared that spreading the concept of SCQM across the construction supply chain, especially between the main contractors and the subcontractors, would offer a positive impact on quality improvement. Chapter 3 provided an acceptable prediction that SCQM could be an effective approach to address the issue of quality incurred by subcontractors. SCQM emphasises the importance of communication, building common quality goals, maintaining the proper relationships and most critically, assisting the construction industry to build a ‘big picture’ image. The consequences of implementation of SCQM perfectly match some solutions to the problem of improving quality in subcontracted projects. The high level of agreement in the results of this survey, with the importance of factors such as Partnership(S4), Effective Communication (S5) and
Early Involvement (S6), all of which come from SCQM, proves that SCQM can appropriately address the poor quality performance caused by these ‘soft issues’. This result also stated that the main contractors in the Australian construction industry have noticed some approaches that from the concept of SCQM can improve quality in buildings.

However, the results from the questionnaire (Q7 & Q8) also proved that SCQM will not be successfully implemented in a short time. Firstly, from the result of the survey, the concept of SCQM has not been widely accepted by the main contractors in Australia. Further, there are still many barriers to implement SCQM, including the issues of lack of motivation and awareness of SCQM, and cultural issues.

8.1.3 KPIs IN SUBCONTRACTED PROJECTS

Performance measurement has been defined as a process to measure effectiveness and efficiency of a special action. In this thesis, a performance measurement system has been considered as a tool to better implement SCQM and then achieve a high level of quality performance in subcontracted projects.

A list of KPIs, based on the consideration of the feature of subcontracted construction projects and SCQM have been developed. After examination by the main contractors, this raking of KPIs has been presented. Because the result of the ‘Number of Layers of Subcontractors’ (OL8) shows as negative, this indicator was not included in the further Quality Performance Measurement System. This system has been divided into two levels, one is the Corporation Level designed to encourage organisations to establish a culture of quality, and the other level, is the Operational Level, where the focus is on better control of the quality in the building process. Then, with four more indicators provided by respondents, a total of 15 indicators was determined.

Finally, based on the consideration of the project life-cycle, a model of quality performance measurement has been established. The reason for separating the development of these indictors into three phases is that during different building
processes different factors influence quality. This separation provides the clues that different projects, different processes and different clients may have various factors which can restrict the quality performance. This means that all models or approaches need to be flexible.

8.2 LIMITATIONS OF THIS RESEARCH

There are some limitations to this study and the details are presented as followed:

- The concept of SCQM is new in the construction industry and its related publication is small. The information related to quality performance measurement is also small, especially, about the Australian construction industry. For these reasons, the analysis in this thesis based on limited information may have restricted the scope of this study.

- The questions in the questionnaire were from a conceptual framework which was based on the analysis from the literature review. Therefore, these questions may have limited the participants’ explanations. Furthermore, the target population in this survey is from the larger main construction firms in the non-residential section of the construction industries. The result may not therefore represent the whole of the Australian construction industry. In addition, the sample size and response rate in this survey, may impact on the results of implementing the statistical techniques. Nevertheless, as most of the participants in this survey are from executive positions and have wide work experience in the construction industry, this adds more confidence to the results.

- The reason for the differences between literature reviews and the findings in this thesis on the question of multi-layer subcontractors lacks evidence. This may cause this study to miss some important features of the subcontracting system in the Australian construction industry. However, the possible causes of this difference have been discussed in Chapter 7 and it also provides a direction of future study.
• The larger limitation of this research is that only a quantitative method was employed to collect and analyse data. Without the support from the results collected from a qualitative analysis, it limits the development of the theory of KPIs in the subcontracted projects. Nevertheless, the open question in this questionnaire offers the possible qualitative answer.

8.3 FURTHER RESEARCH

Considering the limitations and the findings from this research, there are some opportunities for further study.

• Investigate the main reasons for causing the differences between the findings from the literature review and the data from the Australian construction industry, especially on the question of multi-layered subcontractors. Future studies may be needed to collect the data from other countries. To compare the data from Australian and other countries, it will be a development of this research.

• Additional work needs to be done to investigate the relationship between SCQM and quality improvement in subcontracted projects on a construction site. A semi-structured interview is needed to be conducted in the future to discuss the issues related to SCQM and the questions related to the Quality Performance Measurement Model developed in this research. The target participants could be selected from the respondents from the survey in this research program.

• The triangulation of the model will be conducted in the further research. It is expected that this model would be examined in a working construction project. The details of every indicator need to be determined, such as, the way to measure and the weight for every indicator. Finally, a set of KPIs should be developed that could be used in the practical work environment.
REFERENCES


Fawcett, SE, Ellram, LM & Ogden, JA 2007, *Supply Chain Management: from vision to implementation*, Prentice Hall, USA.


Humphreys, P, Mathews, J & Kumaraswamy, M 2003, ‘Pre-construction project partnering: from adversarial to collaborative relationships’, *Supply Chain Management*, vol. 8 no. 2, pp166-78.


423.
Master Builders Association NSW 1979, ‘MBA submission to the commission of inquiry into the nature and terms of employment in the NSW building industry’, *Builder NSW*, pp550-574.
Ngowi, AB 2000, ‘Construction procurement based on concurrent engineering Principles’, *Logistics Information Management*, vol.13, no.6, pp361-368


APPENDIX A: SURVEY QUESTIONNAIRE

Dear Sir/Madam,

I am writing to inform you of a research program that is being currently undertaken in the University of Wollongong on *Key Performance Indicators in the Construction Industry*. The purpose of this study is to examine whether implementing state of the art Supply Chain Quality Management could improve construction project quality, especially in subcontracted projects. Your response would be an immense benefit for our research – particularly from *Site Managers*, *Quantity Surveyors* and *Senior Managers*. We would be very grateful if you could provide email addresses of potential respondents from your organisation who might be like to help us. Your cooperation is crucial to the success of this research.

There are a total of ten questions in the questionnaire, which should take no longer than 10 minutes to complete. We assure that any information will be treated confidentially. All results from this study will be reported as statistical summaries only.

If you have any enquiries about the research, you can contact me, Lin Lin on ll575@uowmail.edu.au (4239 2327 and/or Peter Gibson 42215968). If you have any concerns, you can also contact the Ethics Office, University of Wollongong on 42214457. Many thank for your cooperation.

Your sincerely,

Lin Lin

Master of Research (Engineering)
Faculty of Engineering
University of Wollongong
1. Welcome screen

Dear Sir/Madam,

Welcome to the survey – Key Performance Indicators in the Construction Industry. This is a study being conducted by the University of Wollongong. The purpose of this study is to examine whether implementing Supply Chain Quality Management could improve construction project quality, especially in subcontracted projects. There are a total of ten questions in this questionnaire, which should take no longer than 10 minutes to complete.

Thank you so much to share your ideas and opinions with us and any information from you will be treated confidentially.

If you have any enquiries about the research, you can contact Lin Lin (0242392377 and/or Peter Gibson 42215968). If you have any concerns, you can contact the Ethics Offices, University of Wollongong on 42214457.

Thank you for your participation. Your response is crucial to this research!
2. General information

*1. General information

Title of your current position

Years of experience in the construction industry

*2. Select the classification of your organisation

☐ Public Client (Central & Regional Authority, Ministry, State-Owned Enterprise)

☐ Private Client (Estate & Commercial Developer, Private Company & Individual)

☐ Consultant (Architectural Designer, Engineering, Quantity Surveyor, etc)

☐ Main Contractor

☐ Subcontractor or Trade Contractor

☐ Self-Employed

☐ Academic Staff

☐ Other (please specify)  

*3. State the number of permanent employees in your current organisation

☐ 1–50

☐ 51–200

☐ 201–600

☐ 601–1200

☐ 1201–3000

☐ Over 3000
3. Subcontracting

*4. State the percentage (%) of external workers (including subsidiary contractors and subcontractors) in your current projects

- None
- Less than 30% of your works
- 30% to 60% of your works
- Above 60% of your works

*5. How do you rate subcontractors’ quality performance in the construction industry?

<table>
<thead>
<tr>
<th>Performance</th>
<th>Poor</th>
<th>Satisfactory</th>
<th>Good</th>
<th>Very good</th>
<th>Outstanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>The subcontractors' quality performance in Australian construction industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*6. In your opinion, what are causes of quality problems in subcontracting?

<table>
<thead>
<tr>
<th>Cause of Quality Problems</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unmotivated subcontractors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too many layers of subcontractors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsatisfactory quality measurement systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competitive tendering approach (lowest-bidding)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcontractors’ technical incompetence in performing high quality work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsatisfactory work done by previous subcontractors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incompetent labour force</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incomplete contract</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of teamwork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time constraints/project duration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. Supply Chain Management

* 7. To what extent has your organisation adopted the concept of Supply Chain Quality Management (SCQM) in business?

**Definition:** SCQM is the formal coordination and integration of business processes involving all partner organisation to measure, analyse and continually improve products, services, and processes in order to create value and achieve satisfaction of intermediate and final customers.

- Not familiar with
- Not used
- Limited use
- Extensive use
- Unknown level of use

* 8. Based on your experience, how useful do you believe the following principles of Supply Chain Quality Management (SCQM) can impact quality in projects?

<table>
<thead>
<tr>
<th>Principle</th>
<th>Not Useful</th>
<th>Somewhat Useful</th>
<th>Useful</th>
<th>Very Extremely Useful</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intimate knowledge of the supply chain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategic supply chain management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Establish partnerships with suppliers/main contractors/subcontractors/clients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Due diligence of tenders rather than acceptance of lowest bidding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcontractors involved early</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Performance Measurement

*9. Which indicators do you think can be adopted in your organisation to improve projects' quality when subcontracting?

<table>
<thead>
<tr>
<th>Indicator</th>
<th>No Influence</th>
<th>Somewhat Influence</th>
<th>Strong Influence</th>
<th>Extremely Strong Influence</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer satisfaction of projects and/or services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational Predictable planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of layers of subcontractors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community satisfaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee satisfaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The ability to manage change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partnership</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The quality of procurement and/or delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational quality standardisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. Please provide any comments on how to improve project quality in subcontracted projects in your organisation?
APPENDIX B: THE REPORT OF OPEN-ENDED QUESTION

The General Comments from respondents in this survey:

1. Use of early contractor involvement contracts

2. Instead of Lumpsum tendering.

3. Clear understanding of specification and appropriate resources (technically competent and quantity) to manage quality

4. Customer service business mind: internal and external CS

5. Technical classes/educational programs via intranet; Company Uni

6. Company culture development and functions/events involvement

7. Within the construction industry the term normally used is sub-contract packages - ie insulation package, chiller package, commissioning package, etc rather than project which is normally referred to as the head contract.

8. We need to train our Tradesmen better and have more apprentices. We need to teach them the art of quality work and the excitement you can get in doing the job right the first time

9. The introduction of training and competency assessment in Quality Management for all those who hold position of authority

10. Culture - you need to build a culture about getting it right. You need to start from the beginning - do it all the way along the job, as you go. Not at the end. Set expectations early though use of sample panels etc. Measure and report regularly.

11. Motivation of the employees to achieve high quality

12. Adequate pre-planning Sample panels or sections to establish the required standard for the project prior to work commencing