Evaluation of the Impact of Quality Risk Management on Quality Performance in the UAE Construction Projects

Naveen Ratnam Didla

Submitted for the degree of Doctor of Philosophy

Heriot-Watt University, United Kingdom
School of Energy, Geoscience, Infrastructure and Society

May 2018

ABSTRACT

Purpose: Despite the implementation of Quality Management Systems(QMS) in construction projects, the repetition of quality failures and their negative impact clearly exposes the deficiencies in the current Quality Management practices with regards to lack of implementing proactive approaches in preventing quality failures. In spite of the wide appeal to adopt 'Risk-based methodologies' in quality management, most of the previous quality management studies have ignored it and hence 'Risk' is identified as the missing gap, which needs more attention, both in theory and practice. In seeking to overcome these deficiencies/gaps, this study has developed an innovative Project Quality Risk Management (PQRM) model including QRM, QR & QP measurement scales, which are expected to help academicians and practitioners to gain a better understanding of QRM, QR and QP along with their causal relationships, thus enabling them to make more informed decisions in dealing with quality risks.

Design/Methodology: In this study, Interview method is used for data collection related to research objective#1, while Literature Review method is used for objective#2. For objectives 3 & 4, Survey method is used for data collection, while data analysis is done through statistical techniques namely Exploratory Factor Analysis (EFA) using IBM SPSS 24.0 and Confirmatory Factor Analysis (CFA) using IBM AMOS 24.0 which are carried out for scale development and statistically analyzing & validating the Measurement models. Structural Equation Modeling (SEM) technique using IBM AMOS 24.0 software package is applied to test the hypotheses for examining and evaluating the relationships among QRM, QR and QP.

Research Findings: The investigation through interviews, highlights the deficiencies in the existing QM system and concludes with strong suggestions of adopting risk-based approaches for achieving continual improvement. On the other hand, the testing of PQRM model validates the hypotheses, indicating that an increase in the effectiveness of QRM actions can enable in reducing Quality Risks, while enhancing the Quality Performance.

Originality/Value: The research study makes three significant contributions to knowledge in advancing the literature of QRM along with good benefits to the industry. Firstly, the deficiencies in the current QM practices have been identified while stressing the importance of reinforcing the traditional QM practices with risk-based approaches. Secondly, three reliable and valid measurement scales viz., QRM, QR & QP are developed through a robust 7-stage scale development process, which can be used to measure the respective processes. Thirdly, an innovative PQRM model is developed and validated. This PQRM model can be used as a causal relationship tool capable of enabling the project teams to make informed decisions in a more holistic manner, for dealing with quality related risks. All the above contributions can be regarded to be very helpful to academicians and practitioners for effective application in both theory and practice.

Research Limitations: This study has been done from the Main Contractor perspective only, while it can also be done from the other stakeholders' perspective, like Client, Consultant etc.

DEDICATION

This Thesis is dedicated to

GOD

Parents

Wife - Esther

Children - Johnny & Jimmy

ACKNOWLEDGEMENTS

I would like to express my deepest thanks to my respected PhD supervisor Dr Taha Elhag for his dedication in providing valuable guidance, encouragement and continuous support throughout this study. I am grateful to my MSc Supervisor Dr Assem Al-Hajj, for motivating me to initiate this study. My appreciation to all the academic and administrative staff of Heriot-watt University, for providing wonderful assistance and support throughout my PhD study period.

I am greatly indebted to Engr Daniel Steyn (Chairperson of American Society of Quality, UAE) and Engr Seema Singh (Dubai Quality Group) for being instrumental in providing good professional contacts/references needed for professional reviews related to this research. I would like to express my sincere gratitude to all the construction professionals who participated in this research by providing their honest input/information to data collection. I am hugely grateful to all the professional reviewers for their constructive feedback and suggestions.

I am immensely thankful to all my colleagues and friends, especially Engr Ajimshad (Head of Quality), Engr Mahmoud (Project Director) and Engr Yahya (Construction Manager) for their continued support at the workplace in terms of being liberal with my workload, while generously granting permission for carrying out data collection.

My whole-hearted gratitude goes to the unsung heroes of my PhD journey…., my dear wife Esther and children Johnny & Jimmy, for their strong support and encouragement to pursue my passion of continued studies, especially for patiently tolerating my extended study hours!

I am indeed grateful to **God for His Grace and Mercy** upon me and the immense blessings that He has been constantly showering upon me.

DECLARATION STATEMENT

ACADEMIC REGISTRY
Research Thesis Submission

Name:	NAVEEN RATNAM DIDLA		
School:	School of Energy, Geoscience, Infrastructure and Society		
Version: *(i.e. First, Resubmission, Final)*	Final	Degree Sought:	Doctor of Philosophy (PhD)

Declaration
In accordance with the appropriate regulations I hereby submit my thesis and I declare that:

1) the thesis embodies the results of my own work and has been composed by myself
2) where appropriate, I have made acknowledgement of the work of others and have made reference to work carried out in collaboration with other persons
3) the thesis is the correct version of the thesis for submission and is the same version as any electronic versions submitted*.
4) my thesis for the award referred to, deposited in the Heriot-Watt University Library, should be made available for loan or photocopying and be available via the Institutional Repository, subject to such conditions as the Librarian may require
5) I understand that as a student of the University I am required to abide by the Regulations of the University and to conform to its discipline.
6) I confirm that the thesis has been verified against plagiarism via an approved plagiarism detection application e.g. Turnitin.

* *Please note that it is the responsibility of the candidate to ensure that the correct version of the thesis is submitted.*

Signature of Candidate:		Date:	

Submission

Submitted By *(name in capitals):*	NAVEEN RATNAM DIDLA
Signature of Individual Submitting:	
Date Submitted:	

For Completion in the Student Service Centre (SSC)

Received in the SSC by *(name in capitals):*			
Method of Submission *(Handed in to SSC; posted through internal/external mail):*			
E-thesis Submitted (**mandatory for final theses)**			
Signature:		Date:	

Please note this form should be bound into the submitted thesis.
Academic Registry/Version (1) August 2016

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AED	:	Arab Emirates Dirham
AHP	:	Analytic Hierarchy Process
AMOS	:	Analysis of Moment Structures
ASTM	:	American Society for Testing Materials
ASQ	:	American Society for Quality
AVE	:	Average Variance Extracted
BSI	:	British Standards Institution
CAPA	:	Corrective and Preventive Actions
CFA	:	Confirmatory Factor Analysis
CFI	:	Comparative Fit Index
CMQ/OE	:	Certified Manager of Quality / Organizational Excellence
CONQUAS	:	Construction Quality Assessment System
COPQ	:	Cost of Poor Quality
COQ	:	Cost of Quality
CR	:	Composite Reliability
CVI	:	Content Validity Index
CVR	:	Content Validity Ratio
DM	:	Dubai Municipality
EFA	:	Exploratory Factor Analysis
EFQM	:	European Foundation for Quality Management
EU	:	European Union
FMEA	:	Failure Mode and Effects Analysis
GFI	:	Goodness of Fitness Index
ISO	:	International Organization for Standardization

ITP	:	Inspection and Test Plan
MIR	:	Material Inspection Request
KMO	:	Kaiser-Meyer-Olkin Measure of Sampling Adequacy
KPI	:	Key Performance Indicator
MIR	:	Material Inspection Request
MS	:	Method Statement
MSA	:	Material Submittal for Approval
NCR	:	Non-Conformance Report
OM	:	Operations Management
PAF	:	Prevention, Appraisal and Failure Model
PCFC	:	Ports, Customs and Freezone Corporation, Dubai
PDCA	:	Plan-Do-Check-Act
PhD	:	Doctor of Philosophy
PM	:	Project Management
PMI	:	Project Management Institute
PMP	:	Project Management Professional
PQ	:	Pre-Qualification
PQP	:	Project Quality Plan
PQRM	:	Project Quality Risk Management
QA/QC	:	Quality Assurance and Quality Control
QM	:	Quality Management
QMS	:	Quality Management System
QP	:	Quality Performance
QR	:	Quality Risks
QRM	:	Quality Risk Management
RAC	:	Risk Accept

RAV	:	Risk Avoidance
RBV	:	Resource Based View theory
RM	:	Risk Management
RMI	:	Risk Mitigation
RMSEA	:	Root Mean Square Error Analysis
RTR	:	Risk Transfer
SEM	:	Structural Equation Modelling
SME	:	Subject Matter Expert
SPSS	:	Statistical Package for the Social Sciences
SQRM	:	Supply chain Quality Risk Management
SQM	:	Supply chain Quality Management
TR	:	Test Report
UAE	:	United Arab Emirates
UK	:	United Kingdom
WIR	:	Work Inspection Request

LIST OF PUBLICATIONS AND PRESENTATIONS

International conferences: The following have been presented to peers in two international conferences and published in conference proceedings.

- Didla, N. R., Al-Hajj, A. (2014). Towards Quality Risk Management Application in the UAE Construction Projects. *At: 2nd Annual International Conference on Architecture & Civil Engineering 24-25 March 2014, Singapore*

- Didla, N. R., Al-Hajj, A. (2014). The need for a Quality Risk Management Methodology in the UAE Construction Projects. *At: 1st International Conference of the CIB Middle East & North Africa Research Network, 14-16 December 2014, United Arab Emirates*

International Journals: The following manuscript has been submitted to international journal and is under review by the Editorial board.

- Didla, N. R. (2017) A study on the causes and effects of quality failures in the UAE construction projects. International Journal of Quality & Reliability Management. (Submitted and under review).

Research Student Seminars: The progressive outcome of the PhD research study at various stages has been presented to the research students and faculty on the following dates, which enabled to gain constructive feed-back.

- Major review stage: 9th & 10th June 2015 at Heriot-watt University, Dubai campus.
- Minor review stage: 17th October 2016 at Heriot-watt University, Dubai campus.
- Draft thesis stage: 3rd October 2017 at Heriot-watt University, Dubai campus.
- Final thesis stage: 23rd April 2018 at Heriot-watt University, Dubai campus.

Chapter 1: INTRODUCTION

1.1 Chapter Introduction

This chapter provides an overview of the research study undertaken, from the context in which the study is being initiated along with the significant features of the study. First, the research context is set by presenting the study background and the problem at hand through a review of relevant past studies, wherein the identified gaps naturally lead to the rationale for all parts of the study. These form the basis for the theoretical background of the research study, upon which the research questions, aim and objectives of the study are established. Subsequently, an outline research methodology employed for the study is provided along with the scope and boundaries of the study. Successively, a brief description of the significance and contribution of this study is provided. Finally, the chapter concludes by providing the way the chapters of the thesis are organized along with a brief explanation of their contents.

1.2 Research Background

The United Arab Emirates construction market is the second largest in the Middle East & North Africa region and the construction sector's contribution to the country's overall GDP has jumped from 10.3% in 2011 to 11.1% in 2015. Dubai is expecting a total investment of Dhs 25 billion ($ 6.8 billion) into the infrastructure-related projects in run-up to Expo 2020 (Deulgaonkar, 2014). In this backdrop of massive economic growth and stiff competition, it is highly difficult for any construction company to secure a stable business in the UAE, if unable to demonstrate high scale of quality. PMI (2013, p.227) warns that failure to meet the quality requirements can have serious, negative consequences for any or all of the project's stakeholders.

Hence, the need to enhance the effectiveness of quality management practices in the UAE is evident, requiring more research in this area. In this regard, a thorough review of the previous studies related to the Quality Management, Quality failures & impact, Quality Risks, Quality Risk Management, effects of Quality Management practices on Quality Performance etc., is done and elaborated, which forms the background for this research study.

- ***Quality Management in construction projects:***

The construction industry tends to define quality as the ability of the products, processes or services to conform to the established requirements as specified in the contractual agreement (Idrus and Sodangi 2010; Leong et al. 2014). There has been a plethora of quality management studies wherein the definitions and measurement of 'Quality' have been viewed in a wide variety of ways, as it is subjective based on viewpoints of various stakeholders. In order to reach a better understanding about quality, it must be examined from different perspectives and usage, wherein 'Quality of production' focuses on satisfaction of the internal needs, while 'Quality of product' focuses on client satisfaction and 'Quality of process' which aims at getting it right the first time (Rad and Khosrowshahi 1998). In the project context, Takim et al. (2003) says the quality-driven agenda means that the total package needs to deliver zero defects, be right the first time, deliver on time and to budget and exceed customer expectations. But mostly they are classified into Quality of Service, Quality of Product, Quality of Process (Leong et al. 2014; Idrus and Sodangi 2010, Yasamis et al. 2002; Rad and Khosrowshahi 1998). According to Idrus and Sodangi(2010), a mix of product and service quality dimensions would therefore be very instrumental to the achievement of site-level quality performance.

As the perceptions of quality vary, so do the measurement indicators of quality, according to the revelations of the previous quality management studies done in various countries across the globe. The study carried out by Cheung et al. (2004) identified the key quality related indicators used are related to 'Inspections, 'Non-compliance records', 'Work rejections' and 'Survey(sample) rejections'. Few studies (Maloney et al., 2002) reported that communication between customers and construction companies was fundamental to ensure both customer satisfaction and repeat business. Yasamis et al. (2002) study in USA indicated contractor quality performance (CQP) indicators which focused on Inspection and testing and Conformance. Cheung et al. (2004) study in Hongkong used Non-Conformances, Work Rejection and sample rejection as KPIs for Quality performance. Kagioglou et al. (2001) study in UK used Time for remedial action of NCR, Outstanding defects at construction handing over, Supplier & Sub-contractor performance review, Staff performance review appraisal, Customer satisfaction feedback questionnaire to measure QP. Leong et al. (2014) study in Malaysia indicates that Quality performance can be measured by considering the non-conformance report (NCR) along with taking

Clients' satisfaction into consideration. However, the client's satisfaction in not explicitly mentioned. Takim et al. (2003) study in UK identifies 'Zero defects', 'Be right the first time', 'Exceed customer expectations' etc., as indicators of quality performance. However, the customer expectations are not explicitly mentioned. Ali et al. (2013) study in Saudi Arabia identifies Quality of work and service, Training and development, Quality control and rework, Defects as quality performance indicators.

Considering the previous studies, it is evident that there is a very wide range of perception in measuring quality depending on the variations in interpretation and context, clearly indicating that a standardized measurement of quality is missing. Despite lot of studies being done on measuring quality performance in construction projects, however there is a lack of 'off-the shelf' measurement scale for measuring quality and hence this implies the need to develop a standard measurement scale for measuring quality performance in the construction projects.

- ***Quality failures and impact:***

Construction projects usually start out with great enthusiasm and excitement of turning two-dimensional plans into three-dimensional objects, but it is when problems arise that each quality deviation becomes a moment of truth. Following are some of the excerpts from the local media related to poor quality in the UAE, to name a few – "Poor quality materials caused building collapse" Boley (2009); "Villas show their age" Naylor (2009); "Build quality seen as looming threat to Dubai property market" Jeff (2012). While 'Cost', 'Time' and 'Quality' are widely deliberated to be the three primary objectives of any project's success, failing to meet quality objectives or poor quality/defects leads to reworks resulting in claims of delays (Ren et al., 2008) and increased costs (Zaneldin, 2006). PMI (2013, p. 227) warns that failure to meet the quality requirements can have serious, negative consequences for any or all of the project's stakeholders. PMI (2013, p. 235) cautions about the high failure costs due to poor quality wherein failing to meet quality objectives or poor quality/defects leads to reworks resulting in claims of delays (Ren et al., 2008) and increased costs (Zaneldin, 2006).

References	Country	Studied Projects	Sample size	Percentage	Failure costs
Burati et al (1992)	United States	Industrial	9	12.4	Direct costs
Abdul-Rahman et al (1996)	U. K	Industrial	1	6	Cost of resources+time-related costs
Josephson and Hammarlund (1999)	Sweden	Building	7	16-23	Direct costs
Barbar et al (2000)	U. K	Roadway	2	2.4	Direct costs
Love and Li (2000)	Australia	Industrial	1	3.15	Direct costs
Hall and Tomkins (2001)	UK	Building	1	5.8	Direct costs+delay costs
Love (2001)	Australia	Building	161	12.0	Direct costs+indirectcosts
Kazaz et al (2010)	Turkey	Building	3.100	11.59	Internal and External failure costs
Abdel Salam and Gad (2009)	UAE	Building	291	0.7	Internal failure costs
Mills er al (2009)	Australia	Building	800,000	4	Direct costs+Examine the claim costs
Love et al (2010)	Australia	Infrastructure	115	10.29	Direct costs+indirectcosts
Oyewobi et al (2011)	Nigeria	Building	25	3.47	Direct costs
Jafari and Love (2013)	Iran	Monorail	1	0.05	On-site costs

Table 1.1: Percentage of Failure costs in proportion to total project cost in previous studies (Source: Heravi and Jafari(2014))

It is mostly suggested that preventive actions over detection/inspection aid to reduce quality costs (PMI, 2013, Basu, 2004). PMI (2013, p. 235) cautions about the high failure costs due to poor quality. Quality management /excellence models (EFQM, Malcom Baldridge, quality awards etc.) only provide guidelines for measuring quality performance. One of the most important concerns of any construction company is how to achieve a right balance between the desired level of quality and the expenses associated with it. Previous studies (Heravi and Jafari 2014; Jafari and Love, 2013; Abdelsalam and Gad, 2009; Kazaz et al., 2005) have used PAF model for estimating the optimum level of COQ, however the means of how to prioritize addressing of various quality issues to achieve the optimum level of COQ remains to be unclear. It is mostly suggested that preventive actions over detection/inspection aids to reduce quality costs (PMI, 2013, Basu, 2004).

Current QM practices put more focus on 'Reactive approaches' while neglecting 'Proactive approaches' in dealing with quality failures. In the construction projects, quality control usually relies upon checklist-based inspections, during which once a quality problem is encountered, a solution is sought mostly based on experience in an ad-hoc manner. The sole use of checklist based conformance has been widely criticized (Chin-keng and Abdul-Rahman, 2011, p 548; Goh and Abdul-Rahman, 2013) that it cannot match the effectiveness of a systematic risk management application. Apparently, quality decisions are often divorced from risk evaluation while more prominence is given to checklist based conformance, mostly tilted towards adherence to filing commitments.

- ***Quality Risks in construction projects***

In the construction industry, the inherent dynamic nature of projects and over-dependence on multiple specialist parties toward achieving the project objectives attracts a lot of risks. PMI (2013, p.309) stresses the need to identify potential risks for taking appropriate preventive actions while ISO (2005) calls for optimizing the use of resources in meeting quality objectives to minimize the risk of not meeting quality requirements. Realizing these gaps in the previous QM standard, the term 'risk' has been injected into the new version of ISO 9001:2015 which has been released recently. ASQ (2015) states that ISO 9001:2015 emphasizes Risk-based Thinking to prevent poor quality. Table 1.2 indicates the stressing of 'Risk' and 'Risk-based thinking', wherein these terms were used 2 times in 2008 version while they are being used 49 times in the new 2015 version!

Keywords in ISO 9001:	2008	2015
"Customer"	50 Times	63 Times
"Customer Satisfaction"	8 Times	27 Times
"Top Management", "Leadership"	10 Times	16 Times
"Context"	0 Times	10 Times
"Interested Party(ies)"	0 Times	14 Times
"Plan", "Planned", "Planning"	36 Times	50 Times
"Quality Objective", "Objective"	15 Times	17 Times
"Improve", "Improvement"	24 Times	41 Times
"Process", "Processes"	78 Times	114 Times
"Risk", "Risk-Based Thinking"	**2 Times**	**49 Times**

Table 1.2 Emphasis of 'Risk' in ISO 9001:2015 vs ISO 9001:2008(Source ASQ, 2015)

Despite the wide appeal of adopting 'Risk' in quality management, quality risks are evidently neglected both in theory and practice. Researchers have developed a number of risk management decision models to manage project risks with relatively less focus on quality risks. Tables 2 & 6 of El-Sayegh (2008) depict only 2 quality related risks out of total 42 risks identified, while tables 3 & 4 of (Goh and Abdul-Rahman, 2013) shows risk responses related to time and cost only, ignoring the third objective Quality!

Knowing how to handle quality risks through proper risk management practices is important for firms who wish to sustain themselves or compete in the market. The research related to project quality risks (PQR) provides an opportunity for many researchers to investigate and extend the existing risk management and quality management theories and frameworks.

ISO 9001(2015) defines risk as an effect of uncertainty on an expected result. Sir Michael Latham says, “No construction project is risk free. Risk can be managed, minimized, shared, transferred or accepted. It cannot be ignored”. Risks which have not been identified and managed are undoubtedly unchecked threats to a project's objectives, which in turn may lead to unnecessary cost overruns and time extensions. Hence it is imperative that a systematic approach must be taken to manage risks throughout the project lifecycle. Recognizing the need for RM in construction industry, in the last decade, many researchers developed models stressing on risk identification and classification. Lot of studies have been carried out in various countries Eg.: Malaysia (Goh and Abdul-Rahman, 2013), United Arab Emirates (El-Sayegh, 2008), Chile (Serpella et al., 2014), Italy (Cagno et al., 2007), Iran (Khazaeni et al, 2012), India (Dey, 2001) etc.

Despite the obvious benefits of applying RM, still many organizations are lagging behind in practicing RM. The findings of (Goh and Abdul-Rahman, 2013) show that risk management is not widely implemented in the local construction industry. Approximately 26.67% of the respondents indicate that a lack of knowledge about risk management is the major factor leading to local contractors lagging their foreign counterparts with respect to risk management. This result is followed by cost (24.4%), lack of awareness (15.56%) and lack of exposure (8.89%). (Serpella et al., 2014) also points out similar fact that risk management in construction projects is still very ineffective and that the main cause of this situation is the lack of knowledge. As risk is interpreted differently by various stakeholders in a different manner, there is a need to identify the risks related to Main contractor perspective, who are primarily made responsible for ensuring that the project is successfully delivered in terms of Cost, Time and Quality.

- ***Quality Risk Management***

Previously some attempts have been made to integrate Risk Management and Quality Management. Maria and Adina (2011) attempted to highlight the links between risk management and quality management and brought up the considerations on Integrating Risk and Quality Management. As the QRM concept is relatively new, there is a need to put in more efforts to explore deeper to understand the related/underlying concepts and the associations among them. Some studies on Quality Risk Management have been done in relation to some industries viz., Healthcare (ICH Q9), Pharmaceuticals et., of which ICH9 has been taken seriously to the extent of getting recognition as part of regulatory requirements. ICH Q9 - Quality Risk Management provides an excellent high-level framework for the use of risk management in pharmaceutical product development and manufacturing quality decision making applications. (Frank et al, 2009) prepared a database of case studies representing a range of quality-specific applications and risk management tools in a structured format, which demonstrate that there is a wide range of applications for the use of structured risk management analysis to facilitate effective quality decision activities.

In the last decade, attempts have been made to apply QRM predominantly in the healthcare industry (Samardelis and Cappucci, 2009; Agoston et al., 2011), pharmaceutical manufacturing (Liebowitz, 2011; Lopez et al., 2010) while relatively little efforts have been noticed in other industries like dairy (Noordhuizen & Cannas, 2008, Noordhuizen & Cannas, 2009) and construction (Ghezavati et al., 2013). (Samardelis and Cappucci, 2009) conducted a case study which demonstrates the application of QRM strategy to maintain compliance in laboratory computer systems. The outcome of the case study of applying QRM in supplier selection, evaluation and control in blood supply chain (Agoston et al., 2011) strongly suggests that QRM can be a valuable component of an effective quality management system by providing a proactive approach for identifying and controlling potential quality and safety issues throughout the blood supply chain. It concludes with a strong recommendation, to monitor the effects of quality risk management, it is key to have adequate tools (preferably a database ⁄ integrated quality management system) in place. The case study of (Liebowitz, 2011) illustrates how QRM was applied in the development of a new drug product and used in Production. The study conveys a strong message that Knowledge Management and QRM begin in Product Development and continues through a product’s life cycle and concludes that QRM is integral to executing an effective control strategy and maintaining the product. (Lopez et al., 2010) used the QRM approach in cell therapy manufacturing wherein a QRM model is developed using FMEA, AHP, Pareto chart etc. (Noordhuizen & Cannas, 2008, Noordhuizen & Cannas, 2009) applies QRM in dairy farms drawing the attention of farmers to all relevant areas and highlighting prevention through risk identification and management. The study recognizes that the Quality risk management programs follows the principles of hazard analysis critical control points, HACCP, are highly structured, strictly formalized and well-planned, because they have to stick to preset international rules of quality control.

Although the concept of QRM is still at a dormant stage by large, in the recent years QRM implementation has been widely promoted, especially in the healthcare industry (Samardelis and Cappucci, 2009; Mire-Sluis et al, 2010; Lopez et al., 2010; Liebowitz, 2011; Agoston et al., 2011) and other industries like mining (Ionica et al., 2007), Dairy (Noordhuizen & Cannas, 2008 & Cannas, 2009), and disappointingly the Construction industry seems to be too slow to ignite despite the great necessity. (Ghezavati et al., 2013) applies QRM in a real-world case study of a road construction project wherein the prioritization of quality risks. While most of them are prescriptive, aimed at encouraging practicing managers to promote the use of QRM in organizations, and citing the expected benefits in managing risks and reducing their impact, little empirical effort has been made to scrutinize the concepts of quality risk management.

- ***Effect of Quality Management practices on Quality Performance***

The effect of QM practices has been widely studied before. Zin et al. (2009) study indicates that the QMS implementation has the following impacts

- Improved storage and traceability of project quality records
- More organized inspections
- Better control over QA/QC works of Sub-contractors
- Improved testing and commissioning
- Less defects
- Facilitate the preparation of handing over project

Parvadavardini et al. (2016) conducted a study to explore the relationship between quality management (QM) practices, quality performance and financial performance using SEM. The study of Shanmugapriya and Subramanian (2015) used Structural equation model to investigate the factors influencing quality performance in Indian construction projects. However, there is a lack of a comprehensive framework that would enable to examine/assess the effect/impact of QRM practices on QR and overall QP.

1.3 Problem Statement and Rationale

Considering the background question for this study – "Despite the implementation of Project Quality Systems, why do quality failures continue to occur and re-occur?", the preliminary investigation reveals that the current QM practices put more focus on 'Reactive approach' and neglecting 'Proactive approach' in dealing with quality failures. In other words, project teams tend to act on solving quality failures through corrective actions like rework, resubmission, retesting etc., instead of putting efforts in preventing them from happening in the first place through techniques like risk assessment/analysis, so that potential risks/causes leading quality failures could be detected ahead for applying preventive actions could potentially avoid quality failures from occurring/re-occuring. Hence the very basic principle of quality "Do it right the first time" is diluted. The reactive actions rework, resubmission, retesting etc., result in leaving negative impact on other project objectives – Cost, Time, Customer satisfaction etc., in terms of additional costs, delays, reliability/credibility loss. Although proactive approaches like internal review of documentation, internal checking/inspection of works using checklists, tool-box talk/training, audits etc., are done, they are mostly done in a random/adhoc manner/case-by-case manner mainly focusing on conformance and rarely consider/take into account the level of risks associated, for enhancing the efficiency/effectiveness of the QM actions taken. Hence the traditional QM practices need to be reinforced with Risk Management methodology which could fill up the gaps related to deficiency in proactive approach in a holistic manner, to reduce quality failures so as ensure achievement of quality objectives or enhance quality performance. Although risk management is done, the identification of quality risks is neglected and moreover, the risk assessment scoring is provided absolute value which is very subjective wherein the past trends or data base is seldom referred to. This potentially leads to a very baseless or unreliable risk assessment/evaluation.

Specifically considering the context of UAE construction projects, risk-based approaches are applied in the disciplines of Safety & Environment through 'Risk Assessments' and 'Aspect & Impact Assessments' respectively, just because they are demanded by the Federal law/regulatory requirements. Whereas, a similar obligation lacks in the discipline of 'Quality', obviously overlooking the need for a risk-based framework of quality management. This calls for the need to develop and implement a Quality Risk Management model that can ensure the risks hindering the achievement of project quality objectives are identified, assessed and appropriate corrective actions taken to mitigate them.

In seeking to help address the above deficiencies, this research study proposes an innovative approach called PQRM Model to examine the relationship between QRM, QR and QP in the UAE construction projects. The goal of this study is to design and implement a Project Quality Risk Management (PQRM) model which can help the Quality team to identify/predict/assess the potential quality risks to apply preventive actions so as to mitigate the risks to achieving Quality objectives. The purpose of this study is to understand what quality risk management (QRM) is and how QRM can help in reducing QR and enhance QP. This dissertation attempts to reveal the QRM practices to provide new insights in dealing with project quality risks, for academicians and practitioners to gain a better understanding of the causal relationships among them.

1.4 Research Gaps and Questions

Considering the deficiencies as discussed in sections 1.2 and 1.3, the research gaps are consolidated and presented as follows:

Gap#1: Even though the construction companies have been developing and implementing good Quality Management Systems, conforming to the requirements of International standards viz., ISO 9001, PMI (2013), BSI (2000), ISO 10005, ISO 10006(2003) etc., the implementation of QMS continues to be facing an array of challenges, posturing risks to quality. Literature review reveals that the current QM practices put more focus on 'Reactive approach' while neglecting 'Proactive approaches' like quality risk assessment in preventing quality failures. The need to consider risk in the quality management has been reinforced through the recent version of ISO 9001:2015. Hence the missing element risk is an obvious gap in the ongoing quality management practices, which needs more attention both in theory and practice.

Gap#2: Although the previous studies have used measures for Quality Management practices, Quality Risks and Quality Performance, they are all scattered and do not represent a comprehensive scale of measurement. As a result, a formal definition which captures its dimensional characteristics, in the form of a measurement construct has not been adequately done and there has been no any systematic attempt to develop a valid measure that reflects the multi-dimensionality of QRM and other scales QR & QP. Hence there is a need to develop comprehensive measurement scales for QP, QR & QRM.

Gap#3: Previous Quality Management studies have mostly examined the quality issues/failures, their causes and impact on project objectives in general, in the light of quality management principles and practices. Some studies extended this by studying the causal relationship between quality management practices and quality performance, financial performance, organizational performance etc., wherein the risk factors have been ignored. However, the causal relationship between the various quality risk factors and quality performance has not been studied adequately. Thus, a comprehensive framework of PQRM which reflects the multi-dimensional content of QRM and Quality risks (QR) and Quality performance(QP) is needed for academics and practitioners to gain a better understanding of the measurement and association/relationships among them.

From the above gaps, the following research questions are set

RQ#1 How effective are the current Quality Management practices in construction projects and what are the suggestions for continual improvement?

RQ#2 What would be valid measurement scales of QRM, QR & QP entail?

RQ#3 What is the impact/effect of QRM practices on QR and QP?

This study strives to answer these three research questions for contributing to the knowledge area of QRM and hence the below research aim and objectives are established.

1.5 Research Aim and Objectives

The aim of this research study is to evaluate the impact of Quality Risk Management on Quality Risks and Quality Performance, in the UAE construction projects.

In order to answer the above research questions and achieve the research aim, the following objectives are pursued

Objective#1: To investigate and assess the effectiveness of the current Quality Management(QM) practices in the UAE construction projects and seek suggestions for continual improvement.

Objective#2: To review the concepts of Quality Risk Management, Quality Risk and Quality Performance so as to conceptualize and operationalize their respective measurement scales.

Objective#3: To develop and validate Quality Risk Management, Quality Risk and Quality Performance Measurement Models.

Objective#4: To develop and validate Project Quality Risk Management(PQRM) Model and evaluate the effect of Quality Risk Management practices on Quality Risks and Quality Performance.

In objective#4, the effect of QRM on QR and QP is studied through two competing models wherein the following hypotheses are established and tested.

Hypothesis Code	Hypothesis description
Standalone Model: Effect of Individual QRM practices on QR and QP	
H1	Each individual QRM practice has a significant negative association/relationship with Quality Risks
H2	Each individual QRM practice has a significant positive association/relationship with Quality Performance
Complementarity Model: Effect of combined QRM practices on QR and QP	
H3	Combined Quality Risk Management practices has a significant negative association/relationship with Quality Risks
H4	Combined Quality Risk Management practices has a significant positive association/relationship with Quality Performance

Table 1.3 Hypotheses for examining the effect of QRM on QR and QP

1.6 Outline of Research Methodology

Considering the research questions and research objectives, it is vital to adopt most appropriate/suitable methods for data collection, analysis and interpretation of the findings to provide effective/reliable outcome to benefit researchers and industry practitioners. An extensive literature review is done to gain a thorough understanding of prospective methodologies relevant to addressing the research questions/objectives similar to this study in the construction management discipline. The aim of literature review is to provide good exposure to the author to gain adequate understanding of the related subjects of Quality and Risk management in the construction projects and to identify most appropriate methods for the study. Detailed discussions related to the research methodology including the rationale for choosing specific methods from a range of prospective methods, population sampling and other criteria are presented in chapter 3.

Following the literature review and considering the research aim & key objectives of this research study, a deductive theory/approach along with positivism which is an empirical, quantitative approach are followed, wherein hypotheses deducted from theory are tested statistically to arrive at logical conclusion/inference through validation of the models. To this effect mixed methods (a combination of Qualitative and Quantitative approaches) have been adopted for data collection, analysis and interpretation. While, Qualitative and Quantitative approaches have been combinedly used for interview, a Quantitative methodology is used to analyze the primary data collected from Questionnaire Survey. Moreover, Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) are the major tools used to analyze the primary data obtained from the questionnaire survey. Hence, this research study attempts to develop a ‘Project Quality Risk Management Model' so as to examine the effect of QRM on QR and QP in the UAE construction projects. An empirical study is being conducted using a structured questionnaire survey with five-point Likert scale for data collection and CFA, & SEM are used for analyzing the causal relationship among them, while evaluating the hypotheses regarding the impact of QRM on QR and QP.

Research objective	Research Methods/Techniques		(CHAPTER) Results/Outcome
	Data collection	Data Analysis	
Objective#1: To investigate and assess the effectiveness of the current Quality Management(QM) practices in the UAE construction projects and seek suggestions for continual improvement.	• Semi-structured Interview	• Descriptive statistics using MS Excel	(CHAPTER 4) • Effectiveness of QM practices • Deficiencies in current QM practices and suggestions for improvement
Objective#2: To review the concepts of Quality Risk Management, Quality Risk and Quality Performance so as to conceptualize and operationalize their respective measurement scales.	• Literature review	• Descriptive statistics using MS Excel	(CHAPTER 5) • PQRM Conceptual framework
Objective#3: To develop and validate Quality Risk Management, Quality Risk and Quality Performance Measurement Models.	• Content Adequacy Assessment • Questionnaire Survey	• Inter-judge's agreement based on Fleiss Kappa coefficient. • Content validity • Pearson's correlation coefficient • EFA using SPSS 24.0 • Item parceling • CFA using AMOS 24.0	(CHAPTER 6) • QRM, QR and QP Measurement models
Objective#4: To develop and validate Project Quality Risk Management(PQRM) Model and evaluate the effect of Quality Risk Management practices on Quality Risks and Quality Performance.	• Questionnaire Survey	• Structural Equation Modeling using IBM AMOS 24.0	(CHAPTER 7) • Hypothesized PQRM model • Impact of QRM on QR and QP

Table 1.4 Outline of Research Methodology

1.7 Scope and Boundaries of Research Study

The goal of this research study is to develop a Project Quality Risk Management (PQRM) model consisting of Quality Risk Management (QRM), Quality Risks (QR) & Quality Performance (QP) and evaluate the effect of QRM on QR and QP in the UAE construction projects. As there are no off-the shelf measurement scales for QRM, QR and QP, this study focuses on the development of measurement instruments, followed by examining the effect of QRM on QR and QP, which involves the following steps:

- To conceptualize and operationalize the three measurement scales - QRM, QR, QP
- To develop and validate the three measurement scales - QRM, QR, QP
- To evaluate the effect of QRM practices on QR and QP

The research study takes the following scope and boundaries into account

- ***Project life-cycle:*** From contract award to project handover
- ***Categories of risks:*** Negative operational risks affecting quality are mainly focused
- ***Stakeholder perspective:*** The study is done from Main contractor perspective
- ***Population:*** Quality professionals working for Main Contractor in the UAE
- ***Geographical:*** Construction projects located in the seven emirates of UAE

1.8 Significance of the Research Study

This research study is undertaken in an attempt to overcome the gaps/deficiencies in the past Quality and Risk Management studies, as elaborated in the previous sections of this chapter. The main goal/intention of the study is to enhance the existing knowledge domain of Quality and Risk Management while on the practical side the proposed PQRM model is expected to help the Quality team & other project team to identify/predict/assess the potential quality risks to apply preventive actions in order to mitigate the risks to achieving Quality objectives. This dissertation attempts to reveal and understand the QRM practices to provide new insights in dealing with project quality risks. This would enable the project team in becoming more knowledgeable in the key performance indicators related to QRM, QR and QP so as to focus on the respective KPI’s in terms of measuring and monitoring the trends. Especially, as the proposed PQRM model enables the users to understand the causal relationships among QRM, QR and QP, the approach will be useful to project teams to initiate proactive measures in assessing quality risks effectively/efficiently during project lifecycles and take appropriate timely corrective actions to avoid project delays and cost overruns. Eventually, the efficient use of this PQRM model is expected to benefit the project team in preventing/avoiding additional costs, construction delays, loss of credibility etc., by addressing quality risks resulting in re-submissions, re-works, re-tests etc.

Considering the above, the proposed PQRM model is expected to be a useful tool to assist the project quality Engineers and Managers to be more efficient and effective in their decision-making about managing quality risks in construction projects. Thus, the proposed comprehensive framework of PQRM which reflects the multi-dimensional content of QRM and Quality risks (QR) and Quality performance(QP) could be helpful for academicians and practitioners to gain a better understanding of the association/relationships among them.

1.9 Thesis Structure

The thesis consists of nine chapters and is organized as below:

***Chapter 1: Introduction* -** Provides an overview of the research study including the background issues related to the chosen topic, justification for the study, research aim & objectives, research outline methodology, research scope, significance & contribution of the study and thesis structure.

***Chapter 2: Literature Review* -** Provides a critical review of the literature related to the overall Quality Management, Risk Management in the construction projects which forms the basis for the theoretical background for the research study, including showing the way for adopting appropriate research methodology along with the scope and boundaries of the study.

***Chapter 3: Research Methodology* –** Addresses the research methodology/strategy adopted for the study including justification for selection of the chosen research methods/techniques. It provides an overview of various data collection, analysis and interpretation methodologies followed to achieve the research aim & objectives of the research study.

***Chapter 4: Study on the Current QM practices in the UAE* -** This chapter provides the results of the investigation of the current QM practices in the UAE construction projects, while suggesting opportunities for improvement.

***Chapter 5: Development of Conceptual Framework* –** This chapter focuses on identification/generation of potential measurement items from literature review that can represent each of the construct/scale namely QRM, QR & QP and proposed so as to conceptualize and operationalize each scale.

***Chapter 6: Development of Measurement Models* –**This chapter covers the application of well-proven scale development procedures conducted for assessing the validity and reliability of the scales which are conceptualized and operationalized in the chapter 5. The resultant well-defined, valid and reliable measurement scales obtained are used as Measurement models/components of SEM model in the chapter 7.

***Chapter 7: Effect of QRM on Quality Risks and Quality Performance* –** This chapter explains the development of hypothesized PQRM model along with establishing hypotheses. The SEM methodology is applied on the hypothesized models using the statistical software AMOS, to scrutinize the effect of QRM on QP. The chapter concludes by providing a statistical analysis of the collected data along with discussion of the results.

***Chapter 8: Conclusion and Recommendations* -** The chapter provides a summary of discussions about the key findings/results of the study while providing implications of how the research results contribute to the existing theory or enhance current professional practices. The chapter concludes with acknowledging the key limitation and providing some suggestions for future research.

Appendix A: Contains Interview Questionnaire format and data details.

Appendix B: Contains Content adequacy assessment format and data details.

Appendix C: Contains Survey Questionnaire format and data details.

1.10 Chapter Summary

The background of the study including the context of the study and the problem statement have been elaborated, based on which the research aim and objectives have been established. The research scope and outline methodology have been presented along with the ethical considerations for conducting the research study. The significance of the study along with the potential contribution to knowledge has been illuminated. An outline of the Thesis structure is provided for quick understanding of the readers. The next chapter critically reviews the literature related to the key research areas associated with QM, QR and QP, which forms the basis to the theoretical framework established for this research study.

Chapter 2: LITERATURE REVIEW

2.1 Chapter Introduction

This chapter describes the key areas focused in the study namely QM, RM and QRM. The purpose of the literature review is to establish a theoretical framework for this study, including definitions and terminology of key terms, critical evaluation of relevant previous studies which forms the basis for the theoretical and empirical background for the research study, including showing the way for adopting appropriate research methodology. Figure 2.1 illustrates the way in which the literature review is undertaken in a structured manner, ensuring to keep focus on the relevant areas and concepts, associated with this topic of study.

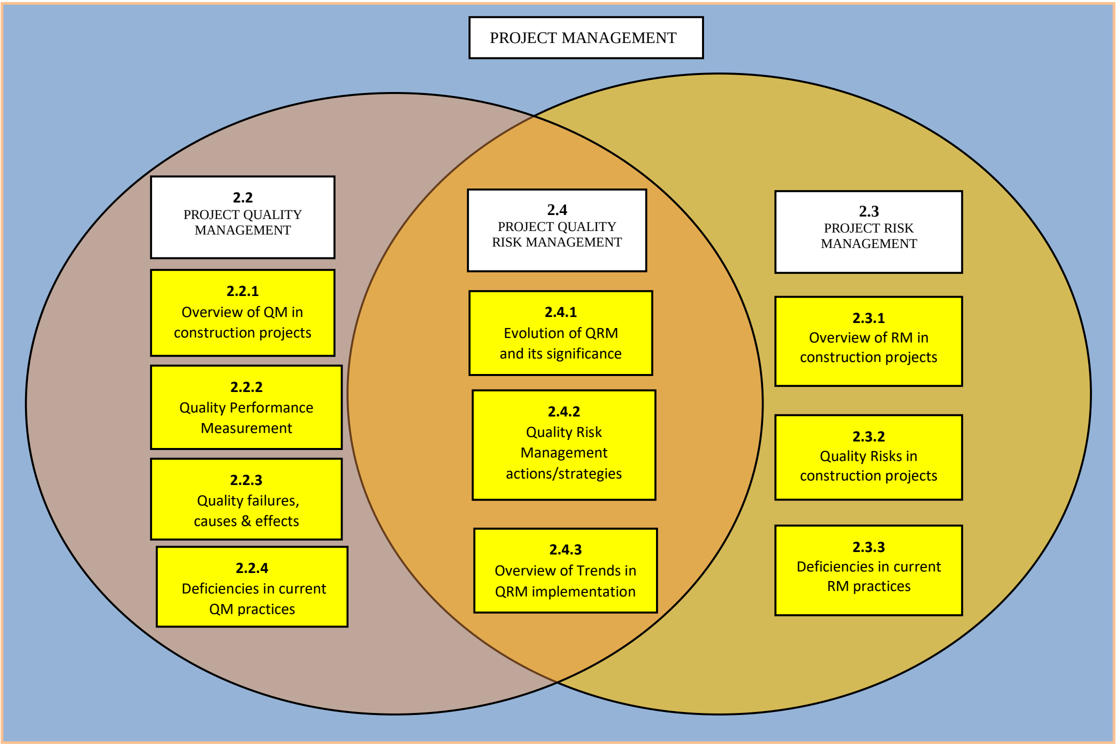

Figure 2.1: Illustration of structure of literature review

Firstly, an overview of the current QM practices including the measurement of quality performance are elaborated, along with the deficiencies in the QM with respect to failure to control quality failures are presented. Secondly, an overview of the current RM practices along with the deficiencies in the RM with respect to failure to control quality risks are explained. Thirdly, the evolution of QRM along with its significance and ongoing trends in implementation are presented. Subsequently, the gaps in the theory and current practices are discussed along with pointing out the way forward with QRM methodology, aimed at enhanced quality performance. The chapter concludes by providing a summary of various sections of this chapter.

2.2 Project Quality Management

2.2.1 Overview of Quality Management in Construction Projects

In the last two decades numerous publications like Jain (2001), Basu (2004) have focused on the appraisal of works done by quality gurus and the emerging concepts like TQM, Six Sigma, and ISO. Some empirical studies were done on quality aspects – cost of quality (Abdelsalam and Gad, 2009), measuring quality (Conca et al., 2004), importance of tools and techniques for quality management improvement (Tari and Sabater, 2004). Meanwhile, few International standards viz., PMI (2013), BSI (2000), ISO 10005, ISO 10006 (2003), have emerged which provide overall guidance on establishing and implementing project quality systems. Based on these guidelines and as per the requirements of the contract documents, the Project Quality Plan (PQP) is developed consisting of the processes and procedures related to Quality Assurance and Quality Control which provide an assurance to the Client and other stakeholders as to how quality would be achieved in line with the contractual requirements. The need for establishing and implementing a Quality Management System in construction projects is mostly Client-driven and included as a contractual obligation, while in a few cases it is the voluntary initiative of the Contractor. As per the contract requirements, the Project Quality Plan is developed consisting of the processes and procedures related to Quality Assurance and Quality Control which provide an assurance to the Client and other stakeholders as to how quality of works/services would be achieved to meet or excel the customer requirements, within the contractual framework. ISO 10006 (2003) stipulates that the PQP should identify activities and resources necessary for achieving the quality objectives of the project, while BSI (2000, p.33) statues that “the project management objective is to deliver on time, to cost and to specification; this can be made easier and more efficient if the organization implements a sound quality policy”.

As illustrated in Figure 2.2, the project quality system is developed considering the project contract documents along with complying with UAE Legal and regulatory requirements like Emirate-wise Municipalities (Sharjah/Abu Dhabi/Fujairah) and Construction Regulatory bodies (Trakhees/TECOM/JAFZA). Project KPIs are established generally revolving around the Client’s requirements, project contract requirements, especially the Quality Assurance and quality control activities/requirements. As the project is a sub-set of the construction company, the PQP makes many cross-references to the quality processes, procedures, forms etc., of the corporate quality manual, for standardization across the company, which are audited as per the ISO requirements for ISO certification purposes.

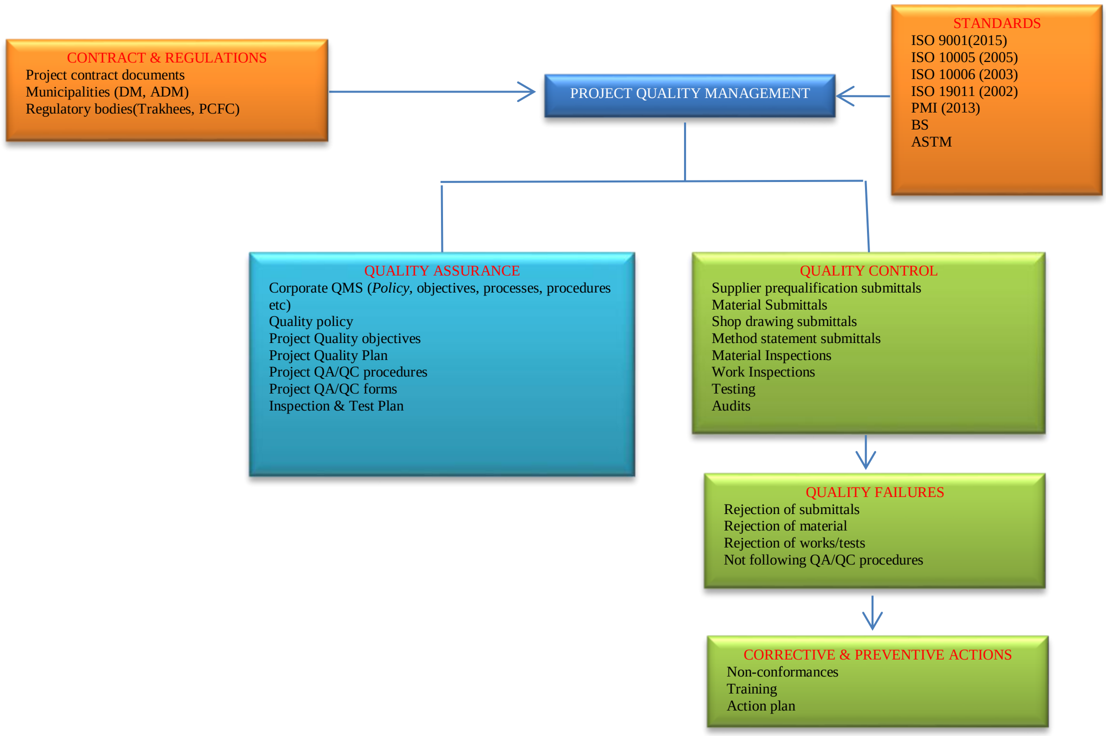

Figure 2.2 Illustration of project quality management

Figure 2.3 shows a typical PDCA cycle followed through the development and implementation of project quality system, aiming at continual improvement.

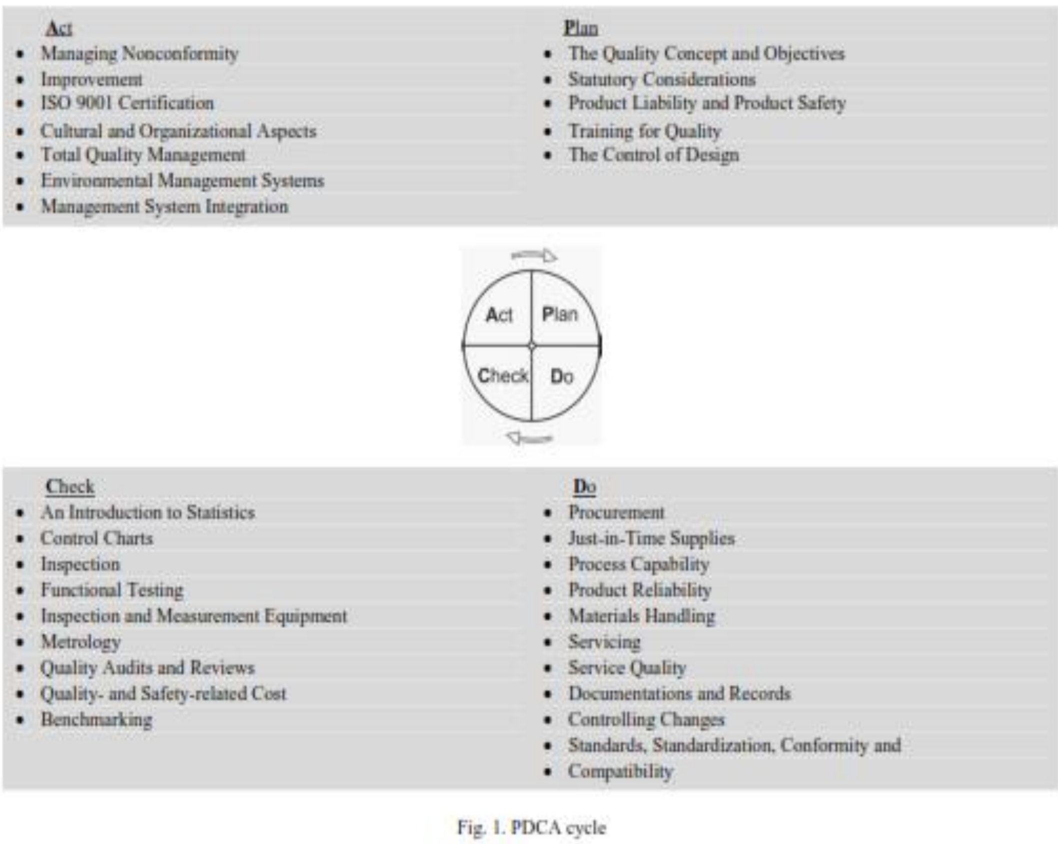

Figure 2.3: Typical PDCA cycle (Source: Sokovik, 2010)

According to Song (2000) Quality management process of the main contractors in a construction project is composed of four sub-processes, and they are quality planning, quality check, quality action, and quality analysis.

‘PLAN’ includes establishing the PQP including project specific quality objectives, QA/QC processes and procedures to be followed included along with the forms/formats to be used. Other preparatory works before proceeding with implementation include inspection and test plan(ITP), Method Statements, Shop drawings, calibrations etc. This also includes other significant issues like communication protocol, task responsibility matrix etc. related to quality implementation.

‘DO’ involves carrying out internal review of Document submittals before submitting to the Consultant for approval viz., Material Submittals, Shop Drawings, Method Statements etc. The main QC functions include inspection and testing of material and works. Quality inspections are classified into the factory inspection, material inspection on delivery, work-in-process inspection(surveillance), and final inspection. Quality action includes the measures to handle non-conforming materials or works. The tests and inspections for materials and finished works are executed according to the approved ITP.

‘CHECK’ involves the quality analysis stage, the inspection results are periodically analyzed and used to evaluate the level of project quality. Non-conformance items are classified along with building types, project types, or trades and managers assess the performance by comparing actual values to the original objectives.

‘ACT’ involves CAPA actions taken for rectifying the identified deficiencies while taking necessary preventive actions to prevent failures from re-occurring. The application of the PDCA cycle has been found more effective than adopting “the right first time” approach. Using of the PDCA cycle means continuously looking for better methods of improvement. The PDCA cycle is effective in both doing a job and managing a programme. The PDCA cycle enables two types of corrective action – temporary and permanent. The temporary action is aimed at results by practically tackling and fixing the problem. The permanent corrective action, on the other hand, consists of investigation and eliminating the root causes, while targeting the sustainability of the improved processes.

2.2.2 Quality Performance Measurement

The construction industry tends to define quality as the ability of the products, processes or services to conform to the established requirements as specified in the contractual agreement (Idrus and Sodangi 2010, Leong et al. 2014). In order to reach a better understanding about quality, it must be examined from different perspectives and usage wherein ‘Quality of production’ focuses on satisfaction of the internal needs, while Quality of product’ focuses on client satisfaction and Quality of process’ which aims at getting it right the first time (Rad and Khosrowshahi 1998). In the project context, Takim (2003) says the quality-driven agenda means that the total package needs to deliver zero defects, be right the first time, deliver on time and to budget and exceed customer expectations.

Considering various definitions/perceptions of quality from various school of thoughts, multiple quality performance measurement models have been evolved. Chan (2001) developed a project quality performance model based on some empirical study of project critical variables involving Hong Kong construction projects. These variables are regarded as independent variables where the impact and interaction of these variables will determine the dependent variable i.e. quality performance. According to Idrus and Sodangi (2010), a mix of product and service quality dimensions would therefore be very instrumental to the achievement of site-level quality performance. The study carried out by Leong et al. (2014) indicates that Quality performance can be measured by considering the non-conformance report (NCR) along with taking clients’ satisfaction into consideration. Usually, clients of construction sector experience dissatisfaction in many aspects including overspend in project cost, delay of completion, poor quality, and incompetent project teams like subcontractors and consultants. Eagan (1998) divided client satisfaction into product and service. Cheung et al. (2004) identified the key quality related indicators used are related to ‘Inspections, ’Non-compliance records’, ‘Work rejections’ and ’Survey(sample) rejections’. Moreover, Flynn et al., (1994) stated that quality management can be conceptualized into two major elements, i.e. quality management practices (input) and quality performance (output). Juran (1992) reported that a systematic and structured approach could help to develop quality products. Maloney et al. (2002) reported that communication between customers and construction companies was fundamental to ensure both customer satisfaction and repeat business. Considering the above, it is evident that measuring quality performance is very subjective and very much dependent on the context/requirements of the project or organization.

Reference/ Study	Location	Quality Measurement model	Description/Purpose
Chan (2001)	Hongkong	Project quality performance model	The variables are groups under the headings of client, project, project environment, project team leader, project management action and project procedure. These variables are regarded as independent variables where the impact and interaction of these variables will determine the dependent variable (i.e. quality performance).
Construction Industry Development Board of Malaysia-CIDB(2001b).	Malaysia	Quality Assessment System in Construction (QLASSIC) model	Assesses the contractor's performance in terms of quality of the finished product
Low and Ong (2014)	Singapore	Construction Quality Assessment System(CONQUAS)	CONQUAS is used to measure the level of quality achieved in a completed building project using numerical scores. As part of the overall QMS, it provides a trusted and comprehensive assessment system to validate the contractor's workmanship excellence.
Quality Performance Measurement Task Force (QPMTF) of the Construction Industry Institute (CII)	United States	Blueprint	For measuring quality performance on engineer-procure construct (EPC) projects
Construction Industry Institute (CII),	United States	Quality performance management system (QPMS)	The primary objective of CII is to improve the cost-effectiveness of the Construction industry. Two key issues of total quality management addressed by QPMS are: (1) the cost of quality; and (2) Quality performance.
Housing Department (1996), PASS Manual	Hong Kong	Performance Assessment Scoring Scheme (PASS)	As an objective quality-measuring yardstick, the Performance Assessment Scoring Scheme (PASS) is used to monitor the performance quality of contractors.
Toni et al. (1995)	Italy	Quality Performance Scale	Used to measure • Inbound quality (of Suppliers) • Perceived Quality (Customer satisfaction) • Quality costs • Internal quality (process performance)

Table 2.1: Quality Performance Measurement models

S. No	Study/ Author	Country	Study significance	Measurement of Quality performance in construction projects
1	Cha and Kim (2011)	South Korea	The research study identified 18 key Performance Indicators (KPIs) to define a project performance measurement system, focusing on residential building projects. The research findings are expected to encourage the project stakeholders to develop a performance-based project control system, thereby enhancing their level of satisfaction.	• Defect Frequency • Rework • Non-Conformances
2	Cheung et al. (2004)	Hong Kong	This paper describes the development of a Web-based construction Project Performance Monitoring System (PPMS) with Key performance indicators(KPIs), that aims to assist project managers in exercising construction project control.	• Non-Conformances • Work Rejection • Survey (Samples) Rejection
3	Idrus and Sodangi (2010)	Nigeria	The study identified quality attributes relevant to the construction process and proposed a quality performance evaluation model that covers both the corporate and operational levels of a construction project.	• Non-conformances • Conformance • Competency • Completeness • Accuracy • Communication • Understanding Client needs
4	Kagioglou et al. (2001)	United Kingdom	The study presented a performance management process framework (PMPF) to suit construction industry needs.	• Time for remedial action of NCR • Outstanding defects at construction handing over • Supplier & Sub-contractor performance review • Staff performance review appraisal • Customer satisfaction feedback questionnaire
5	Leong et al. (2014)	Malaysia	This paper proposed seven existing and new performance indicators to measure the effectiveness of quality management system (QMS) maintenance and practices in construction industry.	• Non-Conformances • Client satisfaction
6	Low and Ong (2014)	Singapore	Construction Quality Assessment System(CONQUAS)	• Workmanship • Doing right the first time
7	Construction Industry Institute (CII),	United States of America	Quality performance management system (QPMS)	• Cost of quality
8	Yasamis et al. (2002)	United States of America	A framework for the assessment of a contractor's quality performance is established.	• Inspection and testing • Conformance • Inspections • Audits • Training • Quality Systems • Reviews

9	Ali (2012)	Saudi Arabia	Customer Internal Business	• Quality of work and service • Training and development • Quality control and rework • Defects
10	Rad and Khosrowshahi(1998)	United States of America	Quality of Production Quality of Product Quality of Process	• Satisfaction of internal needs • Client satisfaction, • Value for money, • Fit for purpose • Quality of materials • Get right the first time

Table 2.2: Quality performance measures from previous studies

2.2.3 Quality Failures, Causes and Effects

Abdul-rehman (2000) consolidates various terms for quality failure from previous literature on construction management as re-work (Love and Edwards 2004; Love et al. 2004), non-conformance (Abdul-Rahman et al. 1995), defects (Josephson and Hammarlund 1999; Sommerville 2007), quality lapses (Sommerville 2007), snags (Sommerville and McCosh 2006) and quality failures (Barber et al. 2000) that are often used but tend to vary. Regardless of the term used, quality failures lead to re-works and additional time for the correction process. The above literature clearly reveals that most causes can be attributed to the poor implementation of QM activities/practices. Several researchers (Love and Edwards 2004; Love et al. 2004; Yates and Lockley 2002; Love and Li 2000) claimed that the implementation of COC activities, such as design reviews, inspection and training is the first step to minimize the potential impact of quality failures. In addition, the proper implementation of a quality management system assures the logical and progressive sequence of work, which prevents or mitigates delays during construction (Abdul-Rahman et al. 2006).

Love et al. (2004) defines rework as ‘the unnecessary effort of re-doing a process or activity that was incorrectly implemented at the first time’. Within the construction industry, rework has been identified as a significant factor that contributes to cost increases and schedule delays on projects (Love and Edwards, 2004). Previous research has generally focused on quantifying rework costs and identifying ‘apparent’ rather than ‘root’ causes. Abdelsalam and Gad (2009) defined failure costs as the losses associated with the production of a non-conforming product. Impacts of quality failures can result in cost impact (Abdelsalam and Gad 2009, Love et al. (2004), Kazaz et al. (2005), Heravi and Jafari(2014) Jafari and Love(2013)), time impact(Ren et al. 2008, Megha and Rajiv 2013). Some of the common causes for the quality failures are incompetent project staff or unskilled workers (Ren et al. 2008, Megha and Rajiv 2013), Mistakes during construction(Ren et al. 2008 ,), Poor quality control(Ren et al. 2008), problems with neighbors(Megha and Rajiv 2013), Rework due to errors in construction (Megha and Rajiv 2013), lack of understanding for end-user requirements(Love and Edwards 2004),poor standard of workmanship(Love and Edwards 2004),lack of a quality focus(Love et al. 2004),Poor supervision(Love et al. 2004),Poor inspection(Love et al. 2004).

The delays due to quality failures is because of additional time consumed by re-submission of Submittals/documents, Re-review of documents, Factory visits/re-visits for evaluation/assessment, Re-inspection, Rework/Repair, Re-testing etc. Poor quality managements may have a negative effect both internally and externally. In internal context it may result in additional costs, delays, decrease in the effectiveness/efficiency of decision making, Non-conformances, overall ineffective continual improvement etc. While in the external context it may lead to customer dissatisfaction resulting in increased rejections, penalties, termination etc., and even potential loss of repeat business or referenced business. Table 2.3 provides an approximate percentage of failure cost in total project cost, from the previous studies.

Author	Country	%	Project type
Abdul-Rahman [19]	UK	2.5	Plant
Abdul-Rahman [20]	UK	5	Highway
Barber et al. [21]	UK	16–23	Road
Burati et al. [22]	USA	12.4	Industrial
BRE [23]	UK	15	Building
CIDB [24]	Singapore	5–10	General
Dale and Plunkett [25]	USA	12<	General
Hall and Tomkins [26]	UK	5.84	Building
Hammarlund et al. [27]	Sweden	2–6	Building
Josephson and Hammarlund [28]	Sweden	2.3–9.4	Building
Love et al. [29]	Australia	3.15	Building
		2.4	Industrial
Love et al. [30]	Australia	10>	Building
Nylen [31]	Sweden	10	Railway
Patterson and Ledbetter [32]	USA	25	Industrial

Table 2.3: The percentage of failure cost in total project cost (Source: Kazaz et al. (2005)

Abdelsalam and Gad (2009) research study in Dubai concluded that the average failure cost in the construction industry in Dubai is .7% of the project total cost. The contractors need to realize that this cost of poor quality is due to not doing the things right from the first time and try to minimize the defects and reworks in their projects. He continues to advise that they should consider the optimum value for cost of quality calculated in this research (refer to Figure 2.4), above which it will be more economical for the contractors to rectify the defected items rather than increasing the preventive and appraisal costs to try to do them right from the first.

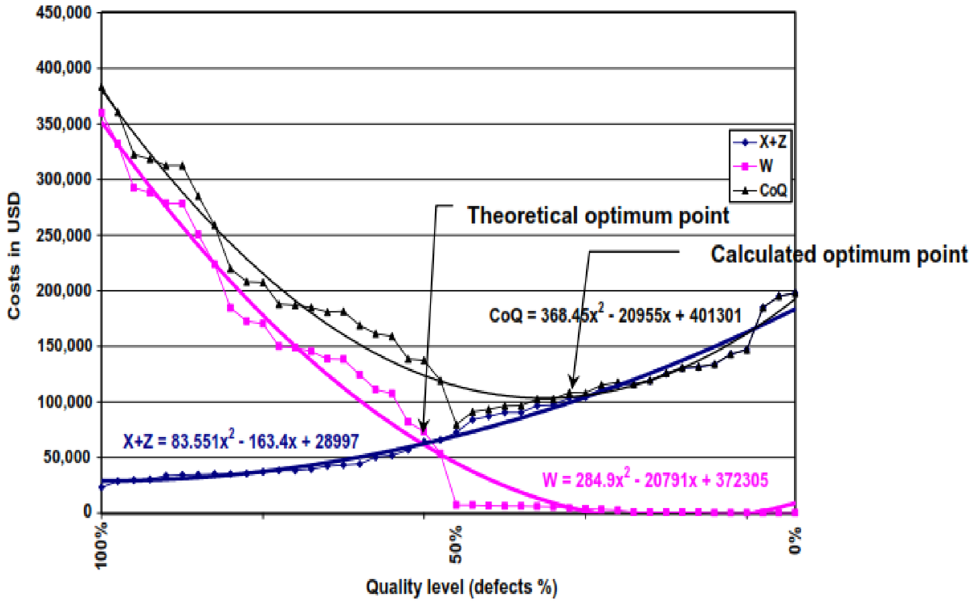

Figure 2.4: Optimum value of COQ (Source: Abdelsalam and Gad (2009))

Jafari and Love (2013) study on cost of quality revealed that its onsite quality program was 2.78% of the total project costs, of which 2.32% was attributable to supervisory costs. The quality failures during construction were revealed to be 0.05% of the total project costs. The overall prevention costs are 16%, while the appraisal costs are 49% and 35 % respectively for material and execution. The study points out that a major factor leading to a reduction in quality failures was the implementation of a dedicated quality team and the repetitive nature of the tasks undertaken.

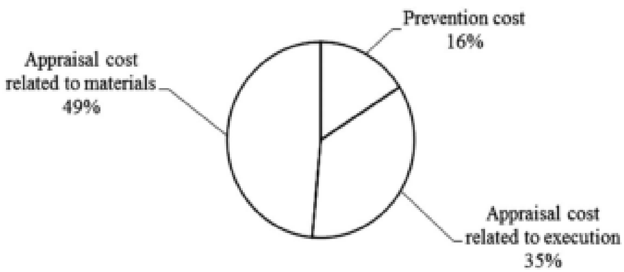

Figure 2.5: Percentage of onsite quality program cost elements (Source: Jafari and Love, 2013)

Root causes of quality failures may be categorized as below

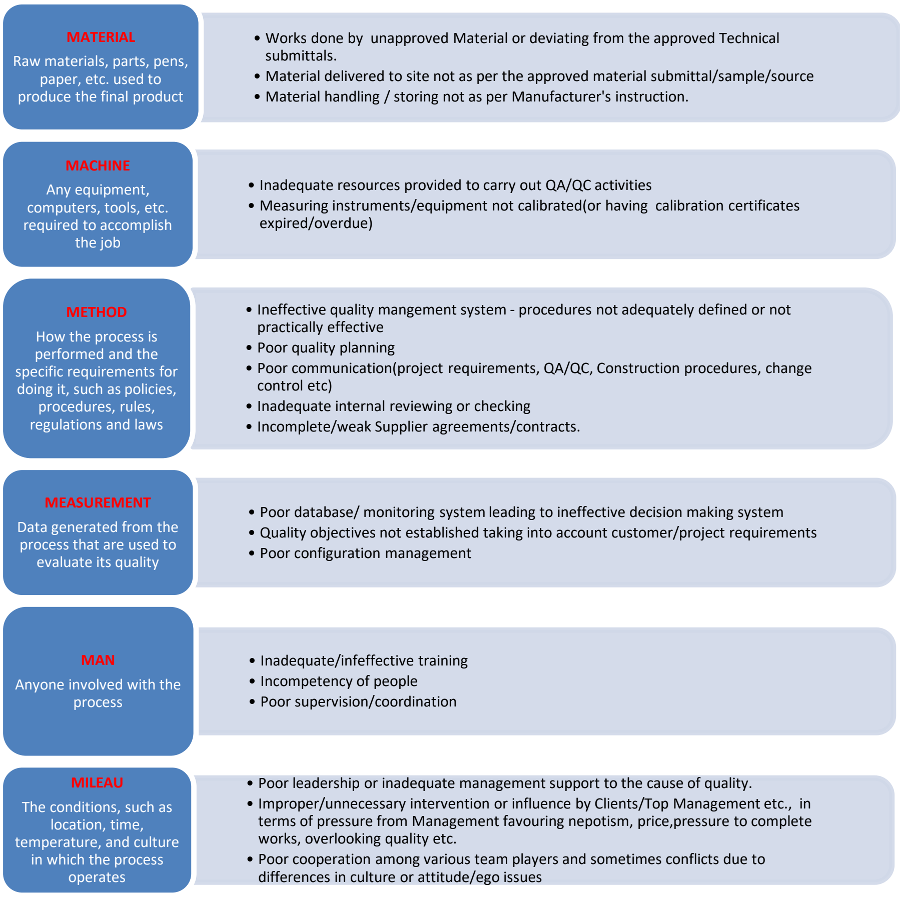

Figure 2.6: Categorization of root causes of quality failures

Abdul-rehman (2010) explains the importance of understanding the underlying causes of these failures and developing strategies to eliminate or to mitigate their occurrence are important to increase the probability of achieving the project objectives. The first step in reducing the occurrences of quality failure is to study its causes and to develop subsequent effective prevention strategies (Love et al. 2004; Yates and Lockley 2002). Abdelgawad and Fayek(2010) expounds that a root cause analysis is conducted to identify the root causes of different risk events. Understanding the root causes can help the risk analysts to estimate the probability of occurrence of each risk event based on its root causes and to suggest appropriate risk response strategies to minimize these root causes. One of the key reasons for repetition of failures is that the corrective actions initiated are not effective, wherein the reactive approach is given more prominence over the proactive approach. Love and Edwards (2004) carried out two longitudinal case studies to determine the antecedents of rework. Based on the findings presented, strategies for reducing the incidence of rework were identified and discussed. This paper contributes to study of quality in construction by identifying the underlying factors that influence rework in projects. The study explains that although the reasons for rework appeared to be relatively straightforward, however a closer examination the rework events presented revealed that an intricately ‘complex’ interwoven array of factors contributed to its occurrence. In fact, it was impossible to identify a specific cause and effect relationship in the case studies undertaken because of the interdependency of work arrangements, dynamic social interactions between project participants, and the socio-economic and political structure that existed between the client and their occupiers.

2.2.4 Deficiencies in Current Quality Management Practices

Low and Ong (2014) highlights the barriers to Quality Management in Construction. Even with the obvious benefits of quality improvement, quality performance in construction is lagging in many industries, including manufacturing (Gould and Joyce 2003). This suggests that one of the contributory factors is due to the numerous obstacles that contractors faced in trying to execute quality management practices to attain quality performance. As profit-driven contractors want to minimize cost, they hire insufficient and incompetent staffs to deal with the workload as well as select subcontractor based on the lowest price with no regard to their workmanship quality (Ashford 1989). Further, there is no training and proper directions given to staffs (Kanji and Wong 1998), which means that Contractors are unwilling to support the QMS and adopt the tactic to ensure better workmanship quality to achieve good quality. Abdul-rehman (2010) states that almost all instances of nonconformity can be avoided either by timely inspections or using more experienced and skilled employees (Abdul-Rahman et al., 1996). Jianxun (2009) explains some key deficiencies in the current Engineering quality management model where in the current management models focus on supervision afterwards, but not pre-control and hence they cannot prevent the occurrence of some engineering quality risks. He points out that due to lack of Engineering quality supervision and risk management awareness, risk prevention has not become the core of supervision. Although some of the engineering firms have bought engineering insurance, but the insurance company does not get involved into the pre-control of the engineering risks, hence the quality self-control of the construction party also does not work as it is expected.

2.3 Project Risk Management

2.3.1 Overview of Risk Management in Construction Projects

From a project risk management perspective, “risk” is referred to as a “failure mode,” which is “an uncertain event or condition that, if it occurs, has a positive or a negative effect on at least one project objective, such as time, cost, scope or quality” (PMI, 2004; PMI, 2013). On similar lines, ISO 31000(2009) defines risk as an effect of uncertainty on objectives while ISO 9001(2015) defines risk as an effect of uncertainty on an expected result. From a measurement point of view BSI (2000) defines risk as a combination of the probability or frequency of occurrence of a defined threat or opportunity and the magnitude of the consequences of the occurrence.

Chandra (2015) states that Risk is a measure of the probability and consequence of not achieving a defined project goal that can be managed, minimized, shared, transferred or accepted, and it cannot be ignored. In a construction project, risk cannot be eliminated, but it can be minimized or transferred from one party to another. Risk and uncertainty are present in all aspects of construction work irrespective of the size, complexity, location, resources, or speed of construction of the project. Uncertainty exists where there is no information about future information, conditions or values. Uncertainty commonly gives rise to risk because of ignorance of the identify of variables that explicitly define a system, or a lack of knowledge of the variables which describe a system.

The inherent dynamic nature of construction projects and over-dependence on multiple specialist parties toward achieving the project objectives attracts a lot of risks. PMI (2008, p.309) expounds “The objectives of project risk management are to increase the likelihood and impact of positive events, and decrease the likelihood and impact of negative events in the project.” and hence stresses the need to identify potential problems for taking appropriate preventive actions. ISO 31000 (2009) is an international standard which serves as a guideline related to Risk Management. ISO 31000 (2009) highlights that organizations of all types and sizes face internal and external factors and influences that make it uncertain whether and when they will achieve their objectives. The effect this uncertainty has on an organization's objectives is “risk”.

Extracted from ISO 31000 (2009), Fig.2.7 and Table 2.4 illustrate the Risk Management framework/ methodology used to manage risks. The basis of ISO 31000 is to provide a best practice structure and guidance to all operations concerned with risk management. Strategies used to manage risk include: 'Transferring risk to another party', 'Avoiding the risk altogether', 'Taking action to reduce the negative impact of the risk' or 'Accept all or some of the consequences of the risk'. Deciding on what strategy is best for a particular risk determines the prioritization process that follows. Those risks with the greatest probability of occurrence and that have the highest impact to the business/process are first priorities followed in descending order to the least likely to occur with the lowest impact. ISO 31000 assures that when implemented and maintained in accordance with this International Standard, the management of risk enables an organization to(for example):

- increase the likelihood of achieving objectives;
- encourage proactive management;
- be aware of the need to identify and treat risk throughout the organization;
- improve the identification of opportunities and threats

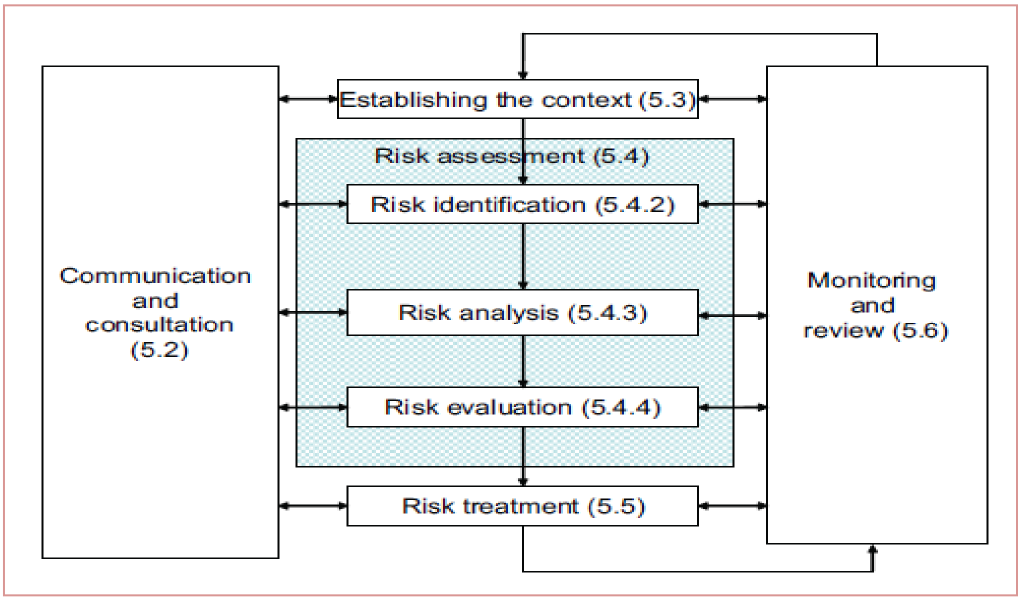

Figure 2.7: Risk management process (source: ISO 31000:2009)

ISO 31000 clauses & brief details (to be read in conjunction with Figure 2.7)
5.2 Communication and consultation: Communication and consultation with external and internal stakeholders should take place during all stages of the risk management process. Effective external and internal communication and consultation should take place to ensure that those accountable for implementing the risk management process and stakeholders understand the basis on which decisions are made, and the reasons why particular actions are required.
5.3 Establishing the context: By establishing the context, the organization articulates its objectives, defines the external and internal parameters to be taken into account when managing risk, and sets the scope and risk criteria for the remaining process.
5.4 Risk assessment: Risk assessment is the overall process of risk identification, risk analysis and risk evaluation.
5.4.2 Risk identification: The organization should identify sources of risk, areas of impacts, events (including changes in circumstances) and their causes and their potential consequences. The aim of this step is to generate a comprehensive list of risks based on those events that might create, enhance, prevent, degrade, accelerate or delay the achievement of objectives.
5.4.3 Risk analysis: Risk analysis involves developing an understanding of the risk. Risk analysis provides an input to risk evaluation and to decisions on whether risks need to be treated, and on the most appropriate risk treatment strategies and methods. Risk analysis can also provide an input into making decisions where choices must be made and the options involve different types and levels of risk.
5.4.4 Risk Evaluation: The purpose of risk evaluation is to assist in making decisions, based on the outcomes of risk analysis, about which risks need treatment and the priority for treatment implementation. Risk evaluation involves comparing the level of risk found during the analysis process with risk criteria established when the context was considered. Based on this comparison, the need for treatment can be considered.
5.5 Risk treatment: Risk treatment involves selecting one or more options for modifying risks, and implementing those options. Risk treatment involves a cyclical process of: assessing a risk treatment; deciding whether residual risk levels are tolerable; if not tolerable, generating a new risk treatment; and assessing the effectiveness of that treatment.
5.6 Monitoring and review: The organization's monitoring and review processes should encompass all aspects of the risk management process for the purposes of: ensuring that controls are effective and efficient in both design and operation; obtaining further information to improve risk assessment; analyzing and learning lessons from events (including near-misses), changes, trends, successes and failures; detecting changes in the external and internal context, including changes to risk criteria and the risk itself which can require revision of risk treatments and priorities; and identifying emerging risks.

Table 2.4: Risk management clauses & brief details (adopted from ISO 31000:2009)

Mahendra et al. (2013) states that “Risk Control is the final step of the process. After we have implemented response actions, we must track and record their effectiveness and any changes to the project risk profile. Did the response actions have a positive or negative effect on achieving project objectives?” Responses taken in risks should also be documented for future reference and project plans. Abdul-Rehman (2015) states that the risks that occur in construction projects will usually lead to inability to achieve the desired project objectives. Delays, cost overruns, and reduction of quality of projects are the common negative effects of risk inherent to construction projects. Failure to manage such risks might further result in financial loss, damage of reputation, and loss of future business. El-Karim et al. (2017) states that the strategies for negative risks or threats are Avoid, Transfer, Mitigate or Accept. On the other hand, strategies for positive risks or opportunities are Exploit, Enhance or Accept. ISO (10006) mentions risk response strategies as solutions to eliminate, mitigate, transfer, share or accept risks, and plans to take advantage of opportunities should preferably be based on known technologies or data from past experiences.

PMI (2013) states the following definitions for risk response strategies

- Risk avoid is a risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact.
- Risk mitigate is a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk
- Risk transfer is a risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response.
- Risk accept is a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs.

The methods of risk management strategy take anyone or a combination of risk retention, risk transfer, risk reduction, and risk avoidance. From the above literature, it seems that there are various RM approaches developed in different disciplines, but all these approaches have a common goal, i.e. to reduce the uncertainty and threat to achieve objectives and improve performance.

2.3.2 Quality Risks in Construction Projects

Ghezavati et al. (2013) states that according to the concept of quality and strive to meet customer expectations, every risk at any stage of work that can affect quality of performance and cause negative customer satisfaction would be considered as a quality risk and adds that Quality risks affect the customer's satisfaction and somehow on the product's quality negatively, if occured.

Reference/Study	Quality risks
Ghezavati et al. (2013)	• Not enough reviews and choosing wrong contractor • Incompetent managers • Purchasing a counterfeit substance (intentional / inadvertent) • The shortage of resources especially the main ones • Unavailable technical expertise • Inappropriate and unrealistic scheduling • Incomplete and inaccurate cost estimate • Mistake during performance • Non- standard details • Inappropriate equipment
El-Sayegh(2008)	• Sub-contractor's poor performance & management • Contractor's incompetence • Poor quality of work • Quality problems of Supplier material • Deficiencies in drawings and specifications
Iqbal et al. (2015)	• Risk of bad quality material/equipment • Risk of defective material from supplier • Lack of qualified staff • Poor competence and productivity of labor • Poor coordination with subcontractor • Inaccurate execution plan/schedule • Risk of labor, materials and equipment availability • Poor performance of subcontractor • Shortage of plant and equipment
Khodeir and Mohamed (2015)	• Poor documentations • Defective work • Defective material • Material storage • Quality control & testing methods • Improper construction methods • Lack of experience • Bad communication between stakeholders • Poor material management • Poor equipment management
Yildiz et al. (2014)	• Contractor's Lack of Managerial Skills • Contractor's Lack of Experience • Contractor's Lack of Resources • Decrease in Quality of Work

Love and Edwards (2004)	• poor management and employee training; • low skill level of subcontractors; • lack of supervision and on-site inspection; • damage due to carelessness; • poor planning and coordination of on-site resources; and • poor workmanship and use of materials. • lack of understanding for end-user requirements; • poor standard of workmanship
Low and Ong (2014)	• As profit-driven contractors want to minimize cost • insufficient staffs • incompetent staffs • no training and proper directions given to staffs
Chin-keng and Abdul-Rahman (2011)	• Inadequate management support • Unwillingness of project staff to accept the quality system • Problem with documentation • Difficulties in measuring results • Ineffective communication • Inadequate technical expertise/skills • Problems with subcontractors' works

Table 2.5: Quality risks

2.3.3 Deficiencies in Current Risk Management practices

Sir Michael Latham says, "No construction project is risk free. Risk can be managed, minimized, shared, transferred or accepted. It cannot be ignored". Risks which have not been identified and managed are undoubtedly unchecked threats to a project's objectives, which in turn may lead to unnecessary cost overruns and time extensions. Hence it is imperative that a systematic approach must be taken to manage risks throughout the project lifecycle. Recognizing the need for RM in construction industry, lot of studies have carried out in various countries - Malaysia (Goh and Abdul-Rahman, 2013), United Arab Emirates (El-Sayegh, 2008), Chile (Serpella et al., 2014), Italy (Cagno et al., 2007), Iran (Khazaeni et al, 2012), India (Dey, 2001), China (Zou et al., 2005) etc. Typically, the risk management process involves Risk identification, Risk analysis, Risk evaluation and Risk treatment. Based on these steps of RM process, a plethora of Risk Management Models have been developed by researchers which are mainly categorized on the approach of qualitative, quantitative or a combination of the two methods. The Integrated Project Funded by the European Commission case studies (Technuea, 2010) provides a comparison on the various methods of risk assessment and concludes that the selection of method should be based on what results are needed and what resources are available.

- Qualitative methods require a medium level of expertise, time and level of data details.
- Quantitative methods required a medium or high level of expertise, time and data details.

In the last decade, many researchers developed models stressing on risk identification and classification. (Mahendra et al., 2013) presents the risk identification methods – Brainstorming, Delphi technique, Interview/ expert opinion, Past experience, Checklists etc., while (Taroun et al., 2011) provided a better risk rating alternative to the widely used approach of qualitative risk rating, which can actually quantify risk and concludes that the use of 'risk cost' as a common scale within a belief-based decision making framework would be an ideal solution. The model proposed by (Cagno et al., 2007) stressed on risk classification making it possible to identify and classify project major risks, creating a project risk map considering all organizational and operational coordinates. On the other hand, some other researches were focused on risk allocation; (Khazaeni et al, 2012) aims at providing a quantitative model for the risk allocation process while it provides a definite and structured framework for risk allocation, rather than a prejudiced and invisible approach based on an individual's expert judgment. Accordingly, the model provides a reasonable decision tool to select the optimal allocation of risks. Similarly, (Hanna et al., 2013) provides a risk allocation model consisting of 'single party risk assessment worksheets' to allow the participants to perform internal risk alignment and a 'two-party risk assessment worksheet' to perform external risk alignment. On similar lines, (El-Sayegh, 2008) identifies and assesses the significant risks in the UAE construction industry and addresses their proper allocation.

Despite the obvious benefits of applying RM, still many organizations are lagging behind in practicing RM. The findings of (Goh and Abdul-Rahman, 2013) show that risk management is not widely implemented in the local construction industry. Approximately 26.67% of the respondents indicate that a lack of knowledge about risk management is the major factor leading to local contractors lagging behind their foreign counterparts with respect to risk management. This result is followed by cost (24.4%), lack of awareness (15.56%) and lack of exposure (8.89%). (Serpella et al., 2014) also points out similar fact that risk management in construction projects is still very ineffective and that the main cause of this situation is the lack of knowledge.

2.4 Project Quality Risk Management

2.4.1 Evolution of Quality Risk Management and its significance

The term/concept of Quality Risk Management(QRM) is mainly brought to light from the healthcare and pharmaceutical industry, through the introduction of ICH Q9 document related to Quality Risk Management. This is a guideline that applies to the regulatory authorities in the fields of pharmaceutical assessment of the quality part of the marketing authorization dossier, GMP inspections and the handling of suspected quality defects. As part of the EU implementation of ICH Q9, the GMP Guide (Quality Management) was published in February 2008 which came into force in July 2008.

ICH9 explains the following definitions implying how QRM has evolved in principle: -

- *QUALITY: Degree to which a set of inherent properties of a product, system or process fulfills requirements.*
- *RISK: combination of the probability of occurrence of harm and the severity of that harm*
- *QUALITY RISK MANAGEMENT: Systematic process for the assessment, control, communication and review of risks to quality.*

It states two primary principles of quality risk management are:

- *The evaluation of the risk to quality should be based on scientific knowledge and ultimately link to the achievement of quality objectives/project requirements*
- *The level of effort, formality and documentation of the quality risk management process should be commensurate with the level of risk.*

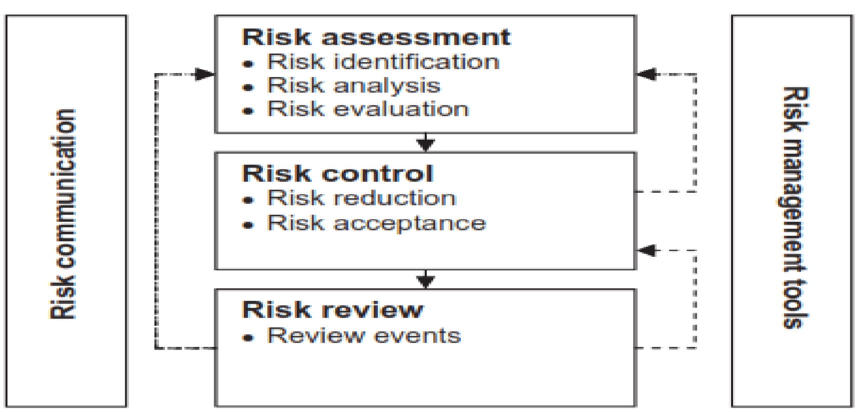

Figure 2.8: QRM process (source: Agoston, 2011)

The study of Agoston (2011) stresses that Quality risk management can be a valuable component of an effective quality management system by providing a proactive approach for identifying and controlling potential quality and safety issues throughout the blood supply chain. Quality risk management consists of three main elements namely, risk assessment, risk control and risk review. A typical quality risk management process is outlined in Figure 2.8.

Previously some attempts have been made to integrate Risk Management and Quality Management. Maria and Adina (2011) attempted to highlight the links between risk management and quality management and brought up the considerations on Integrating Risk and Quality Management. This paper points out that the implementation of Integrated quality-risk systems approach may shift from the reactive management to a new attitude, foresight and proactive. Some studies on Quality Risk Management have been done in relation to various industries viz., Healthcare (ICH Q9), Mining, Pharmaceuticals, Construction, and others, of which ICH9 has been taken seriously to the extent of getting recognition as part of regulatory requirements.

2.4.2 Quality Risk Management Actions

(Ghezavati et al., 2013) states that according to the concept of quality and strive to meet customer expectations, every risk at any stage of work that can affect the quality of performance and cause negative customer satisfaction would be considered as a quality risk. Table 2.6 provides some of the QM/corrective actions taken to control quality risks.

Reference/ Study	CAPA	Description
Willis (1996) - (CII)	Quality System	Developing quality improvement programmes, standards and goals. Indoctrination and training. Data collection, analysis, and reporting.
Willis (1996) - (CII)	Personnel qualification, testing and training	Testing personnel's ability to perform work according to specified standards. Craft certification and training for quality assurance/control activities.
Willis (1996) - (CII)	Supplier Qualification	Evaluating the ability of suppliers, vendors, contractors and subcontractors to perform capably.
Willis (1996) - (CII)	Supplier performance evaluation	Developing a certification system and compiling rating scores to measure supplier performance.
Willis (1996) - (CII)	Examinations, Internal	Reviewing, checking, inspecting, testing and observing services/products produced internally in the organization. Reviewing designs, drafting and documentation.

Willis (1996) - (CII)	Examinations, External	Reviewing, checking, inspecting, testing and observing services/products produced externally by others. Inspection of material/equipment received, vendor document reviews, etc.
Ghezavati et al. (2013)	Equipment	Purchasing and using modern and updated equipment could be a solution to avoid inappropriate equipment cost as much as possible.
Ghezavati et al. (2013)	Material	Sampling, test and verifying purchased product before entrance to the workshop could be a solution to prevent purchasing a counterfeit substance (intentional / inadvertent).
Ghezavati et al. (2013)	Contractor selection	Review tender documents at the time of contractor selection and not considering too much to price criterion as the only factor, could be a solution to reduce or eliminate the risk of choosing wrong contractor.
Chin-keng and Abdul-Rahman (2011)	Quality Audits	Quality Audits
Chin-keng and Abdul-Rahman (2011)	Inspection	Inspection
Chin-keng and Abdul-Rahman (2011)	Cost of Quality	Cost of Quality
Chin-keng and Abdul-Rahman (2011)	Leadership commitment	Leadership commitment
Chin-keng and Abdul-Rahman (2011)	Allocation of resources	Allocation of resources
Chin-keng and Abdul-Rahman (2011)	Trend analysis	Trend analysis
Love and Edwards (2004)	Training	Implementation of training programmes to enhance skills and knowledge, to avoid/reduce rework
Love and Edwards (2004)	Client requirements	understanding and identifying client and end-user requirements and implementing techniques for mitigating change to avoid/reduce rework
Love and Edwards (2004)	Auditing	Conducting audits, to avoid/reduce rework
Love and Edwards (2004)	Quality Management practices	Implementation of Quality Management practices to avoid/reduce rework
Low and Ong (2014)	Supplier/Sub-contractor evaluation	Having a Rigorous Prequalification Process to Select Subcontractors and Suppliers
Low and Ong (2014)	Competency/ skills	Ensuring the Skill Level of Labourers
Low and Ong (2014)	Cooperation	Collaborative Efforts Between Subcontractors and Main Contractor
Low and Ong (2014)	Communication	Giving Clear Instructions to Subcontractors on How to Adhere to the CONQUAS Requirements
Low and Ong (2014)	Penalty	Imposing a Penalty to Subcontractors

Low and Ong (2014)	Material	Inspect Materials Upon Delivery
Low and Ong (2014)	Material	Proper Materials Handling and Storage
Low and Ong (2014)	Material	Protection of Materials After Completion of that Portion of Works
Low and Ong (2014)	Testing	Sample Testing of Materials Through an Independent Testing Agency (ITA) to Check for Proper Usage of Materials
Low and Ong (2014)	Review	Ensuring that Shop Drawings are Checked Thoroughly Before Actual Construction
Low and Ong (2014)	Mock-ups	Constructing Mock-Ups to Check for Implications with Other Trades of Works
Low and Ong (2014)	Training	Field Demonstration by Labourers to Showcase their understanding of the Workmanship Quality Required
Low and Ong(2014)	Inspection	Conducting Preparatory Inspection Using Template Checklist at Every Stage of Work Activity
Low and Ong (2014)	Internal review/inspection	Adherence to Reporting and Follow-Up Procedure of Defects Before CONQUAS Assessment
AlMaian et al. (2016)	practices for SQM	supplier's work observation
AlMaian et al. (2016)	practices for SQM	supplier performance rating,
AlMaian et al. (2016)	practices for SQM	inspection and testing plans
Yasamis et al. (2002)	Quality systems	Activities of managing and performing the quality management system on the project
Yasamis et al. (2002)	Quality training	Training of personnel to perform quality activities
Yasamis et al. (2002)	Internal review checks	Activities to ascertain whether design enables the most efficient construction methods to be used, and the planned construction activities are the most effective
Yasamis et al. (2002)	Audits	Activities of inspecting, testing and checking of products/services already produced internally and externally to see if they meet requirements
Yasamis et al. (2002)	Inspection & testing	Activities such as measuring, examining and testing undertaken to determine whether results conform to requirements
Yasamis et al. (2002)	Checklists	Providing structured tools to verify that a set of required steps has been performed
Yasamis et al. (2002)	Sampling	Choosing a part of a population of interest for inspection
Yasamis et al. (2002)	Cause and effect analysis	Providing illustrations of how various causes and sub-causes relate to create potential problems or diagramming effects
Yasamis et al. (2002)	Control charts	Producing graphic displays of the results, over time, of a process. They can be used in monitoring batch activities, as well as cost and schedule variances, volume of scope changes . . . etc.

Table 2.6: Quality management actions

The following are the eight types of prevention and appraisal activities defined and popularly used to reduce and prevent quality failures (CII, Abdul-rehman 2010).

(1) Quality systems.

(2) Supplier qualification.

(3) Personnel qualification, testing and training.

(4) Expediting

(5) Constructability review.

(6) Operability, safety, and value review.

(7) Examinations, internal.

(8) Examinations, external.

2.4.3 Overview of trends in QRM implementation

Although the concept of QRM is still at a dormant stage by large, in the recent years QRM implementation has been widely promoted, especially in the healthcare industry (Samardelis and Cappucci, 2009; Mire-Sluis et al, 2010; Lopez et al., 2010; Liebowitz, 2011; Agoston et al., 2011). However, it has received very little attention in other industries like mining (Ionica et al., 2007), Dairy (Noordhuizen & Cannas, 2008, Noordhuizen & Cannas, 2009), and disappointingly the Construction industry seems to be too slow to ignite despite the great necessity. However, most of them are prescriptive, aimed at encouraging practicing managers to promote the use of QRM in organizations, and citing the expected benefits in managing risks and reducing their impact. Little empirical effort has been made to scrutinize the concepts of quality risk management.

ICH Q9 - Quality Risk Management provides an excellent high-level framework for the use of risk management in pharmaceutical product development/manufacturing for quality decision making applications. It is a landmark document in acknowledging risk management as a standard and acceptable quality system practice to facilitate good decision-making about risk identification, resource prioritization, and risk mitigation / elimination, as appropriate. Recognizing the need to propagate and expedite holistic adoption of Quality Risk Management across the pharmaceutical industry, the Pharmaceutical Quality Research Institute Manufacturing Technology Committee (PQRI-MTC) commissioned a small working group of industry and FDA representatives to seek out good case studies of actual risk management practices used by large Pharma and Bio-Pharmaceutical firms for sharing with the industry at large. (Frank et al, 2009) prepared a database of case studies representing a range of quality-specific applications and risk management tools in a structured format, for easy review and subsequent training applications, as appropriate. The collected case studies demonstrate that there is a wide range of applications for the use of structured risk management analysis to facilitate effective quality decision activities.

In the last decade, attempts have been made to apply QRM predominantly in the healthcare industry (Samardelis and Cappucci, 2009; Agoston et al., 2011), pharmaceutical manufacturing (Liebowitz, 2011; Lopez et al., 2010) while relatively little efforts have been noticed in other industries like dairy (Noordhuizen & Cannas, 2008, Noordhuizen & Cannas, 2009) and construction (Ghezavati et al., 2013). (Agoston et al., 2011) strongly suggests that QRM can be a valuable component of an effective quality management system by providing a proactive approach for identifying and controlling potential quality and safety issues throughout the blood supply chain. It concludes with a strong recommendation that, to monitor the effects of quality risk management, it's key to have in place adequate tools (preferably a database ⁄ integrated quality management system). The case study of (Liebowitz, 2011) illustrates how QRM was applied in the development of a new drug product and used in Production. The study conveys a strong message that Knowledge Management and QRM begin in Product Development and continues through a product's life cycle and concludes that QRM is integral to executing an effective control strategy and maintaining the product. (Lopez et al., 2010) uses the QRM approach in cell therapy manufacturing wherein a QRM model is developed using FMEA, AHP, Pareto chart etc. (Noordhuizen & Cannas, 2008, Noordhuizen & Cannas, 2009) applies QRM in dairy farms drawing the attention of farmers to all relevant areas and highlighting prevention through risk identification and management. The study recognizes that the Quality risk management programs follows the principles of hazard analysis critical control points, HACCP, are highly structured, strictly formalized and well-planned. (Ghezavati et al., 2013) applies QRM in a real-world case study of a road construction project wherein the prioritization of quality risks was done in three different phases viz., FMEA, quality criteria, COQ approach.

2.5 Quality Management relationship/impact studies

Literature review reveals that the previous Quality Management studies have mostly examined the quality issues/failures, their causes and impact on project objectives in general, in the light of quality management principles and practices. However, few studies extended this by studying the causal relationship between quality management practices and quality performance, financial performance, organizational performance etc. Parvadavardini et al. (2016) study explored the relationship between quality management (QM) practices, quality performance and financial performance using SEM. Shanmugapriya and Subramanian (2015) study used Structural equation model to investigate the factors influencing quality performance in Indian construction projects. Interestingly, Leong et al. (2014) research was set out to examine and verify the relationship between project performance indicators and QMS variables.

Reference/ Study	Description
Parvadavardini et al. (2016)	This study aims to explore the relationship between quality management (QM) practices, quality performance and financial performance using SEM.
Zin et al. (2009)	The primary aim of this study is to explore the areas of benefits that are experienced by our contractors after having certified to ISO 9001:2000. It concludes that QMS implementation has the following impacts • Improved storage and traceability of project quality records • More organized of inspections • Better control over QA/QC works of Sub-contractors • Improved testing and commissioning • Less defects • Facilitate the preparation of handing over project
Chan (2001)	A causal relationship between the factors affecting quality performance were established, which shows that an increase in client satisfaction with quality is achievable through better project management actions, effectiveness of the team leader, viability and feasibility of procedures and stability of the project environment.
Shanmugapriya and Subramanian (2015)	Used Structural equation model to investigate the factors influencing quality performance in Indian construction projects.
Leong et al. (2014)	This research was set out to examine and verify the relationship between project performance indicators and QMS variables.

Table 2.7: Previous studies on relationship between QM practices and Quality Performance

2.6 Research gaps

The critical literature review of Williams (1995) concludes that limited research had been undertaken on ‘quality risk’ and likewise, there was a lack of adequate research into the impact of risk on different project objectives. The seven case studies in UK (Delgado-Hernandez and Aspinwall, 2008) conveys the message that the ‘ineffective decision-making processes’ is one of the key shortcomings in the current practices in the industry. (Abdelgawad and Fayek, 2010) suggest that, to address several drawbacks of the traditional FMEA application, future work is required to address this limitation by developing a database of recommended corrective actions that are suitable for each specific risk, partially based on historical data and lessons learned.

In summary, the research gaps are consolidated and presented as follows:

(i) Firstly, literature review reveals that most of the quality management studies have ignored the element of risk. The need to consider risk in the quality management has been reinforced through the recent version of ISO 9001:2015. Hence the missing element risk is an obvious gap in the ongoing quality management practices, which needs more attention both in theory and practice. As the QRM concept is relatively new, there is a need to put in more efforts to explore deeper to understand the related/underlying concepts and the association among them. In the field of RM in construction projects, majority of the investigations focused on only on selective types of risks related to finance, design, safety etc., while there are still areas for exploring quality risks in projects. Since there has been a significant claim due to COPQ in recent years, that means there is a considerable amount of quality risks prevalent in construction projects. It is essential for the project teams to understand how to manage QR with the aim of reducing the probability of risk occurrence and minimize the negative impact on quality objectives/performance, to gain customer satisfaction and internal achievement of quality.

(ii) Secondly, although the measures of Quality Management practices, Quality Risks and Quality Performance have been identified in multiple research studies, they are all scattered and do not represent a comprehensive scale of measurement. Moreover, the said measures have not been examined empirically with large scale data. As a result, a formal definition which captures its multi-dimensional characteristics, in the form of a measurement construct has not been adequately done and there has been no any systematic attempt to develop a valid measure that reflects the multi-dimensionality of QRM and other scales QR & QP. Thus, the third research gap in PQRM is the lack of validated measurement instruments. Hence there is a need to develop comprehensive measurement scales for QP, QR & QRM.

(iii) Thirdly, most of the literature examines the quality issues/failures, their causes and impact on project objectives in general, in the light of quality management principles and practices. Some studies extended this by studying the causal relationship between quality management practices and quality performance, financial performance, organizational performance etc., wherein the risk factors have been ignored. However, the causal relationship between the various quality risk factors and quality performance has not been studied. In order to reduce the quality risks, a key challenge faced by a manager is to know how well the QRM performs in dealing with the uncertainties in the quality management. Therefore, examining the relationships among QRM practices, quality risks and quality performance is another important research gap that needs to be bridged. Hence, a comprehensive framework of PQRM which reflects the multi-dimensional content of QRM and Quality risks (QR) and Quality performance(QP) is needed for academics and practitioners to gain a better understanding of the causal relationships among them.

In the UAE construction projects, risk-based approaches are applied in the disciplines of Safety & Environment through ‘Risk Assessments’ and ‘Aspect & Impact Assessments’ respectively, just because they are demanded by the Federal law/regulatory requirements. Whereas, a similar obligation lacks in the discipline of ‘Quality’, obviously overlooking the need for a risk-based framework of quality management. This calls for the need to develop and implement a Project Quality Risk Management model that can ensure the risks hindering the achievement of project quality objectives are identified, assessed and appropriate corrective actions taken to mitigate them.

2.7 Way forward with Quality Risk Management

(Ghezavati et al., 2013) states that according to the concept of quality and strive to meet customer expectations, every risk at any stage of work that can affect the quality of performance and cause negative customer satisfaction would be considered as a quality risk. Previously some attempts have been made to integrate Risk Management and Quality Management. Maria and Adina (2011) attempted to highlight the links between risk management and quality management and brought up the considerations on Integrating Risk and Quality Management. This paper points out that the implementation of Integrated quality-risk systems approach may shift from the reactive management to a new attitude, foresight and proactive. Some studies on Quality Risk Management have been done in relation to various industries viz., Healthcare (ICH Q9), Mining, Pharmaceuticals, Construction, and others, of which ICH9 has been taken seriously to the extent of getting recognition as part of regulatory requirements.

The following are the benefits Quality Risk Management can bring to overcome the deficiencies in existing project QM system

- Can help in establishing a more robust/realistic Project Quality Plan reflecting a more proactive approach in managing quality.
- Can increase the chances of first time approvals of Technical Submittals.
- Can decrease the rejection rate of MIR, WIR and test failures.
- Can make the Supplier/Sub-contractor management more effective/efficient.
- Can improve the proactive approach of identifying and potential quality failures/risks, so that appropriate corrective actions can be taken to prevent failures.
- Cost of Quality can be better monitored and controlled.
- Can increase the efficiency/effectiveness of the Audits wherein more focus can be put upon risk areas.
- Identification and delivery of training needs is more specific and easy.
- Decision making is relatively easier, leading quicker way for remedial actions
- Overall continual improvement (PDCA cycle) can be enhanced through the dynamic risk based approach.

2.8 Chapter summary

This chapter analyses the existing literature and reveals research gaps and explains how QRM can enable in improving the existing QM systems. The critical review of the literature has revealed 3 research gaps and 3 research questions, based on which the research objectives and research design has been established for further study. Fristly, a preliminary review has been done on the overall quality management in construction projects including what are the various definitions and interpretations in the construction projects context, followed by how quality performance is measured in the construction projects. Furthermore, a critical review of the previous studies has been done to identify the quality failures and understand their causes and impact including identifying the deficiencies in the current QM practices(CAPA) in failing to prevent/control quality failures have been studied. Secondly, review has been done on the overall risk management in construction projects including identifying the risks related to quality in the construction projects. Furthermore, a critical review of the previous studies has been done to identify the quality risks including identifying the deficiencies in the current RM practices in failing to prevent/control quality risks have been studied. Thirdly, the Quality risk management concept has been reviewed, including its evolution, significance and ongoing trends. Furthermore, literature has been explored to extract the quality management practices which are aimed at preventing/controlling quality risks. The definition of QRM is further refined as the actions taken to manage/mitigate the risks hindering the achievement of quality objectives or affecting quality performance. Additionally, a search for the previous studies which used SEM techniques to study the relationships between QM practices and Quality/Organizational performance has been done. The critical review of the literature related to the Quality Management and Risk Management in the construction projects has provided the basis for the theoretical background for the research study, including showing the way for adopting appropriate research methodology along with the scope and boundaries of the study, which are explained in the next chapter.

Chapter 3: RESEARCH METHODOLOGY

3.1 Chapter Introduction

This chapter describes the methodology adopted for achieving the aim and objectives of the research study undertaken.

Firstly, the key research questions and the research aims & objectives are briefly discussed which form the basis for the development of research strategy & design which are elaborated separately in the next section. The research strategy & design section includes discussion on the research paradigm, the strategy for achieving each research question/objective followed by a review of various potential research methods applicable for this study, forming a rational for the chosen research methods specifically suitable for this study. Subsequently, the research instruments design & pilot study along with the strategies related to data collection, sampling, data analysis including and the ethical considerations for conducting the research study are explained. The data collection procedure is also described in this chapter. Subsequently, the relevant information on the respondents, the sampling frame and sample size are also presented.

The chapter concludes on how data shall be collected and analyzed, while providing a summary of the highlights of the aspects covered in research methodology applicable to this study.

3.2 Research Questions and Objectives

From the research background and rationale discussed in chapter 1, the following three research questions are set

RQ#1 How effective are the current Quality Management practices in construction projects and what are the suggestions for continual improvement?
RQ#2 What would be valid measurement scales of QRM, QR & QP entail?
RQ#3 What is the impact/effect of QRM practices on QR and QP?

The goal of this research study is to develop a Project Quality Risk Management (PQRM) model consisting of Quality Risk Management (QRM), Quality Risks (QR) & Quality Performance (QP) and evaluate the effect of QRM on QR and QP in the UAE construction projects. In order to answer the above research questions and achieve the above goal, the following objectives are pursued

Objective#1: To investigate and assess the effectiveness of the current Quality Management(QM) practices in the UAE construction projects and seek suggestions for continual improvement.

Objective#2: To review the concepts of Quality Risk Management (QRM), Quality Risk (QR) and Quality Performance (QP) so as to conceptualize and operationalize respective measurement scales.

Objective#3: To develop and validate Quality Risk Management, Quality Risk and Quality Performance Measurement models.

Objective#4: To develop and validate Project Quality Risk Management(PQRM) Model and evaluate the effect of Quality Risk Management practices on Quality Risks and Quality Performance.

Related to objective # 4, hypotheses are established as stated in 1.5 of chapter 1.

3.3 Research Strategy and Design

The goal of this research study is to develop a Project Quality Risk Management (PQRM) model consisting of Quality Risk Management (QRM), Quality Risks (QR) & Quality Performance (QP) and evaluate the effect of QRM on QR and QP in the UAE construction projects. Considering the research goal, this section explains the research design. Research design is the logical sequence that connects the generated empirical data to the initial research objectives of the study and ultimately to its conclusions (Yin, 1994). The research strategy is chosen based on the research questions/objectives so as to ensure that the appropriate strategy is chosen so as to provide a framework to answer each question. The main intention is to choose the most appropriate research type (qualitative or quantitative or mixed), methods (interview, survey, case-study etc.), while the philosophical underpinnings of each research strategy are reviewed and considered including issues such as objectivity, bias, subjectivity, reliability, validity etc.

3.3.1 Research paradigm

According to Walliman and Baiche(2001), Paradigms are a system of thinking, a basic orientation to theory and research. A paradigm is a shared world view that represents the beliefs and values in a discipline and that guides how problems are solved (Schwandt, 2001). Epistemology is a theory of knowledge and refers to a stance on what should pass as acceptable knowledge (Bogdan & Biklen, 2003). Epistemology refers to ways of knowing and how to understand the world through three main paradigms which are positivism, interpretivism and realism. In this study positivism is the applicable paradigm. According to Eichelberger (1989), Positivism is an empirical, quantitative approach in which hypothesis testing (deducted from theory) is used to discover relationships and facts that are generalizable to the population which includes logical empiricism, covering law model, behaviorism, psychodynamic, developmental. Johnson-Laird & Byrne (1991) explains that Deductive reasoning is a basic form of valid reasoning which starts with out with a general statement, or hypothesis, and examines the possibilities to reach a specific, logical conclusion. We go from the general (the theory) to the specific (the observations). The scientific method uses deduction to test hypotheses and theories. In deductive inference, we hold a theory and based on it we make a prediction of its consequences. That is, we predict what the observations should be if the theory were correct. For deductive reasoning to be sound, the hypothesis must be correct so that the conclusion is logical and true.

3.3.2 Research strategy

3.3.2.1 Review of research types and strategies

- ***Qualitative research:*** According to Atedunji (2005), Qualitative research consists of detailed descriptions of events, people, interactions and observed behaviors (Patton, 1992) and general opinion. It seeks to describe and explain both perspectives and behavior of the people studied (Brannen, 1992). Information gathered in qualitative research can be classified under two categories, namely exploratory and attitudinal research (Naoum, 1998). Exploratory research is used when the researcher has a limited amount of knowledge about the research topic. The purpose is closely linked with the need for a clear and precise statement of the recognized problem. Attitudinal research, on the other hand, is used to subjectively evaluate the opinion of a person or a group of people towards a particular attribute, variable, factor or a question. According to Hancock (1998), the main examples of methods of collecting qualitative data are individual interviews, focus groups, direct observation and case studies. There are several advantages as well as disadvantages involved in using a qualitative research method. Some of the advantages are that it facilitates in-depth study, produces overwhelming detailed information with a smaller number of people and provides a great understanding of the topic under study. A few examples of weakness are, that it takes a great deal of time to collect data and the analysis requires some degree of interpretation, which may be subjected to bias and subjectivity. The comparison of both qualitative and quantitative research is tabulated in Table 3.1.

- ***Quantitative research:*** Adetunji(2005) explains that Quantitative research is objective in nature. It is defined as "an inquiry into a social or human problem, based on testing a hypothesis or theory composed of variables, measured with numbers, and analyzed with statistical procedure to determine whether the hypothesis or theory hold true" (Creswell, 1994). According to Brannen (1992), quantitative research is concerned with attitudes and large-scale surveys rather than simply with behavior and small-scale surveys. The three types of quantitative research are experiments, quasi-experiments and surveys (SJI, 1999). The effectiveness of the selected types depends mainly on the nature of the research. Some of the key contrasts between the

- ***Qualitative vs Quantitative research:***

The comparison between Qualitative and Quantitative research can be based on key points as explained below.

From the 'Objective/purpose of research' point of view, qualitative method is generally used to gain understanding of underlying reasons and motivations or to uncover prevalent trends in thought and opinion, while on the other hand the quantitative method is used to quantify data and generalize results from a sample to the population of interest. Taking into account the data classification, Qualitative follows a 'subjective' type, while Quantitative usually follows an 'objective' type. Considering the data collection point of view, mostly methods like un-structured or semi-structured interviews are followed for Qualitative, while structured survey questionnaires are used for Quantitative. From data analysis point of view, non-statistical data analysis is adopted for Qualitative while statistical data analysis is for Quantitative.

The key points of comparison of Qualitative research and Quantitative research is detailed in Table 3.1.

Point of Comparisons	Qualitative Research	Quantitative Research
Alternative Labels	Constructivist, naturalistic-ethnographic or interpretative.	Positivist, rationalistic or functionalist.
Scientific Explanation	Inductive in nature	Deductive
Data classification	Subjective	Objective
Objective/Purpose	To gain understanding of underlying reasons and motivations. To provide insight into the settings of a problem, generating ideas and /or hypothesis for later quantitative research. To uncover prevalent trends in thought and opinion.	To quantify data and generalize results from a sample to the population of interest. To measure the incidence of various views and options in a chosen sample.
Sample	Usually a small number of non-representative cases. Respondents selected to fulfil a given quota or requirement.	Usually a large number of cases representing the population of interest. Randomly selected respondents
Data collection	Participation Observation, semi-and unstructured interview, focus groups, conversation and discourse analysis.	Structured interview, self-administered questionnaires, experiments, structured observation, content analysis/statistical analysis
Data analysis	Non-statistical	Statistical usually in the form of tabulations. Findings are conclusive and usually descriptive in nature
Outcome	Exploratory and/or investigative. Findings are not conclusive and cannot be used to make generalizations.	Used to recommend a final course of action.

Table 3.1: Comparison between qualitative and quantitative research (source: Walliman and Baiche (2001)

3.3.2.2 Research strategy for each question and objective

The different types of research strategies are broadly categorized as: experimental, survey, archival analysis, historical, case study, interview etc. Each provides an alternative way, with its own logic, of collecting and analyzing Empirical evidence. Although each has its own advantages and disadvantages, they can all be used for three customary purposes of research: exploration, description and explanation.

Strategy	**Form of research question**	**Requires control over behavior of events?**	**Focuses on contemporary events?**
Experimental	How, why, what if?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival analysis	Who, what, where, how many, how much?	No	Yes/No
Historical	How, why?	No	No
Case study	How, why?	No	Yes

Table 3.2: Research strategies (source: Yin, 1994, p. 6)

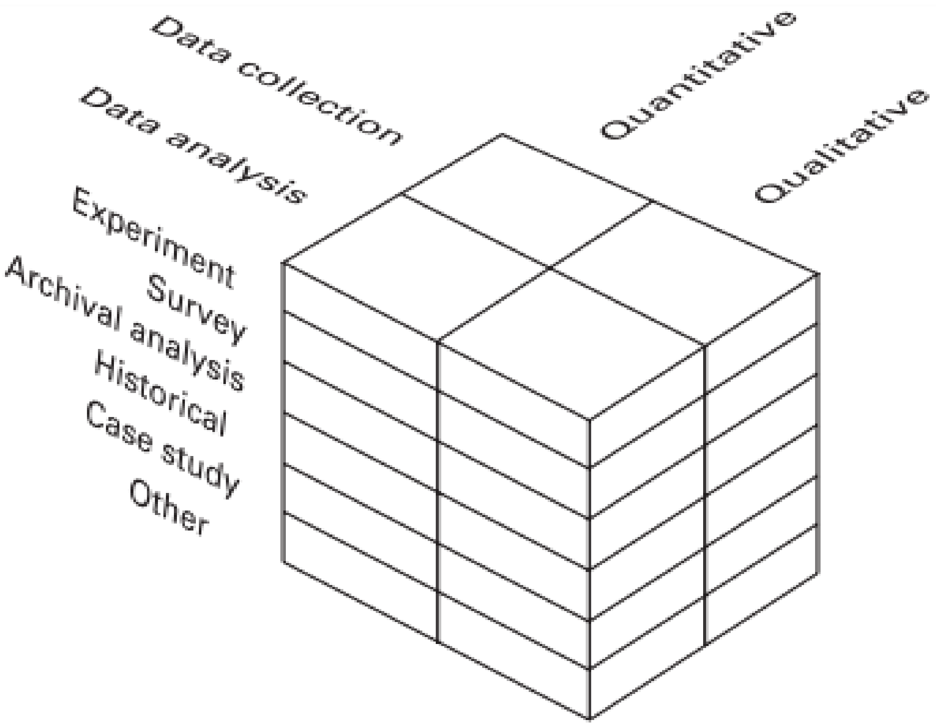

Figure 3.1: Links between research perspectives (source: Walliman and Baiche, 2001)

- ***Research strategy for objective#1:*** The first research objective is to investigate/evaluate the current QM practices of QM in the UAE construction projects along with their deficiencies in controlling quality failures and seek suggestions for improvement. As required by research objective#1, Interview research method is adopted for collecting primary data. Based on the data types to be collected mixed methods (combination of both qualitative and quantitative strategies) are used.

- ***Research strategy for objective#2:*** The second research objective is to review the concepts of Quality Risk Management (QRM), Quality Risks (QR) and Quality Performance (QP) to conceptualize and operationalize the QRM, QR and QP constructs. As required by research objective#2, Literature review research method is adopted for collecting secondary data. Based on the data types to be collected qualitative research strategy is used.

- ***Research strategy for objective#3:*** The third research objective is to develop, test and validate the QRM, QR & QP measurement scales. As required by research objective#3, Survey research method is adopted for collecting primary data. Based on the data types to be collected quantitative research strategy is used.

- ***Research strategy for objective#4:*** The fourth objective is to develop & empirically validate PQRM model, so as to assess/evaluate the effect of QRM on QR and QP. As required by research objective#4, Survey research method is adopted for collecting primary data. Based on the data types to be collected quantitative research strategy is used. As the data analysis involves examining the association or relationship between variables the quantitative strategy falls under the 'Correlation research' category. This form of quantitative research can be broadly classified into two types of studies:

  (i) Relational studies (ii) Prediction studies.

  In this study the first one is applicable, which is an investigation of possible relationships between phenomena to establish if a correlation exists and, if so, its extent. In order to find meaning in the numerical data, the statistical techniques (EFA/CFA/SEM) are used.

3.3.2.3 Research road map

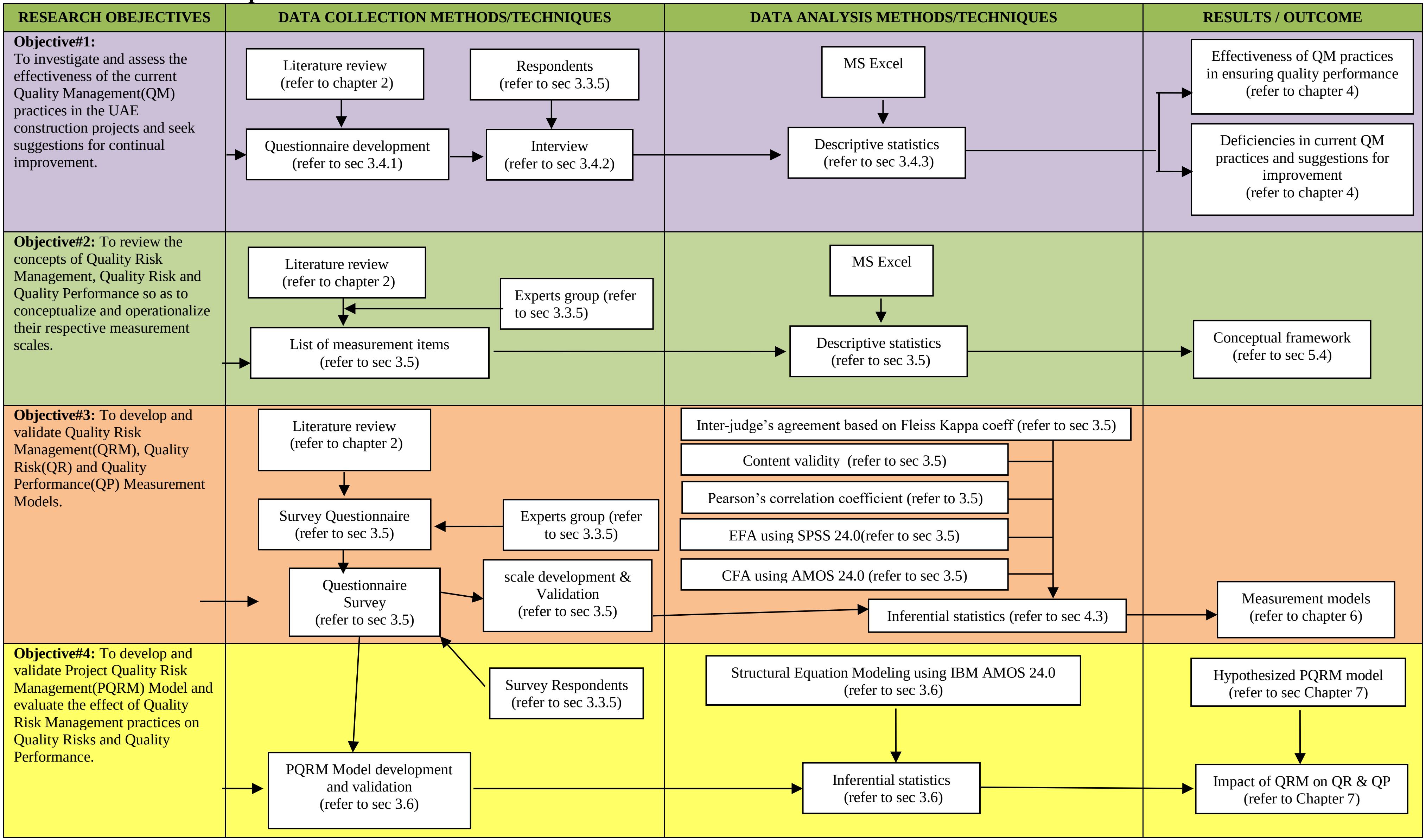

Figure 3.2: Research roadmap

3.3.3 Research Methods

3.3.3.1 Interview

Adetunji (2005) explains that interview can be conducted face-to-face, telephone or group interview using structured, semi-structured and/or unstructured questions to elicit answers pertinent to research hypothesis from the respondents. According to Patton, (1980) there are four types of interviews, namely informal conversation, interview guide approach, standardized open-ended and closed quantitative interviews. These can be grouped into three types as shown in Table 3.3.

Type	Characteristics
Structured	Wording of the questions and the order in which they are asked in the same from one interview to another. Respondents are expected to choose an answer from a series of alternatives given by the interviewer.
Semi-structured	Interviewer asks certain major questions the same each time, but is free to alter their sequence and probe for more information.
Unstructured	Interviewer prepares a list of topics that they want the respondent to talk about, but is free to phrase the questions as they wish, ask them in any order that seems sensible and even join in conversation by discussing what they think of the topic themselves.

Table 3.3: Types of interview (adopted from Coomb, 1999 cited in Sherif, 2002)

Face-to-face interview is the most commonly used method for collecting primary data, because it is most suitable for collecting comprehensive and detailed information from a small number of people or organizations. Also, it allows free flow of information and maximum participation of the interviewees. An interview questionnaire is usually used which is of three types namely, Structured, Semi-structured and Un-structured. In a Structured questionnaire interview, wording of the questions and the order in which they are asked in the same from one interview to another, wherein respondents are expected to choose an answer from a series of alternatives given by the interviewer. In a Semi-structured questionnaire interview, the interviewer asks certain major questions the same each time, but is free to alter their sequence and probe for more information. In an un-structured questionnaire interview, the interviewer prepares a list of topics that they want the respondent to talk about, but is free to phrase the questions as they wish, ask them in any order that seems sensible and even join in conversation by discussing what they think of the topic themselves.

Rationale for choosing Interview method: Considering research objective**#1**, which involves investigation of the current QM practices the UAE construction projects along with their deficiencies in controlling quality failures and seek suggestions for improvement, an exploratory study has been initiated by adopting the interview method using structured questionnaire for collection of primary data. Cooper and Schindler (1998) proposed that in the early stage of an exploratory research, where the researcher is seeking guidance, to test ideas, or even to gain ideas about a subject of interest, such approach might be applicable. In this early stage of the research study wherein more insights are needed to further move to the next stage of research, the exploratory research (Observation type - Open-ended questions – qualitative analysis of results) approach is chosen, wherein focus is on the discovery of ideas and insights as opposed to collecting statistically accurate data. The objective of the face-to-face interviews is to probe specific but dynamic questions that the quantitative survey is unable to address, to allow an understanding professionals' opinions/ perception via open ended questions (Low and Ong, 2014). Moreover, as stated in Abdelsalam and Gad (2009), most of the professionals working in Dubai will not be keen to fill up surveys. The industry professionals prefer to sit and discuss the matter rather than filling up paper or talking about it over the phone. Keeping in mind the nature and significance of the data to be collected to achieve objective#1, interview method is chosen over survey in the best interest of the research study.

3.3.3.2 Survey

The survey technique is the most widely use method in social science and also very relevant to this study. It typically involves cross-sectional and longitudinal studies using questionnaires or interviews to collect large amount of data. The most common of this technique are mail, personal and telephone survey (OWBC, 2001). Abdul-rehman (2010) says that a survey is conducted to obtain maximum information at minimal cost (Ader et al. 2008). Table 3.4 collates the advantages and disadvantages of the three survey methods.

Types of Survey	Advantages	Disadvantages
Mail Survey	• Cost is low compared to other methods • High degree of respondent's anonymity • Wide geographical reach • Relatively low cost of processing	• Low rates of response • Requires easily understood questions and instructions • Lack of chance to probe for further or clarity of answers • Greater respondents bias • High uncompleted questions
Personal Survey	• Allows high flexibility in the questioning process • Interviewers have control of the interviewing situation • High response rate • Possibility of collecting supplementary information	• Higher cost than mail questionnaire • Potential interviewers bias due to high flexibility • Lack of anonymity; hesitant to disclose personal data • Time consuming
Telephone Survey	• Moderate cost • Increase speed and time of data collection • High response rate • Increase quality of data	• Hesitancy to discuss sensitive data on phone • High chance of respondents terminating interview earlier • Less chance for supplement information

Table 3.4: Advantages and disadvantages of Survey methods

Rational for choosing Survey method: The aim of this research study is to investigate/examine the relationships among quality risks, quality risk management actions and project quality performance in the UAE construction projects. In order to address the 3rd & 4th objectives of the research study along with testing the hypotheses (H1, H2 & H3), a survey method using a structured survey questionnaire is used for data collection.

3.3.4 Pilot study

Abdul-rehman (2010) cautions that the success of the survey depends on the cooperation of the respondents (Adams and Brace 2006). To achieve a high success rate of the survey, prior meetings are held with a group of experts to evaluate and to enhance the quality of the survey items and contents of the survey. Pilot study is important in evaluating the questionnaire in terms of its clarity and its comprehensibility as well as its suitability for the chosen sector. According to Ader et al. (2008), a pilot survey provides feedback on errors, identifies problems that may arise, and measures the, willingness of the respondents to participate in the survey. In addition, a pilot questionnaire is a commonly used and successful approach in situations when the subject of the survey is not widely known (Wong and Aspinwall 2005).

Also, feedback on the questionnaire design can be obtained from the pilot test. The major purpose is to ensure the practitioners have a clear understanding of respondents of the measurement items. This pilot study is expected to provide a proxy data with a reasonably good understanding about the adequacy of the questionnaire contents, including forming an idea regarding aspects like target research sample, potential respondents, timeframe etc. thereby providing a chance to make practical revisions before proceeding with the full-fledged research study successfully. The feedback from the pilot survey is important in improving the quality, finding gaps and determining the time required to complete the exercise (Fellow and Liu, 2003).

After the completion of the design of the questionnaire, the questionnaire is given to the practitioners to have a pilot test for fine-tuning the wording. The initial copy of the questionnaire was used in a pilot study prior to the main conduct of the survey. According to Ader et al. (2008), four to five experts can adequately assess the survey items. The questionnaire in the present study is vetted by experts having good academic background and practical experience in the building construction industry. The results of the pilot survey provided information that enhanced the final version of the questionnaire; hence some questions were revised or rephrased based on the feedback. Specific issues that were raised prompted some changes to the sentence structure and word usage for more clarity on the intended purpose of the questions being asked. With lessons from the pilot study, final list of measurement items is upgraded and incorporated to establish the final survey questionnaire ready to proceed with data collection.

3.3.5 Sampling strategy

"There are basically two types of sampling procedure – random and non-random. Random sampling techniques give the most reliable representation of the whole population, while non-random techniques, relying on the judgement of the researcher or on accident, cannot generally be used to make generalizations about the whole population" (Walliman and Baiche, 2001). Hence, in this study, sampling is given due importance and carefully chosen as below.

- *Sampling strategy for Interview study*: The population considered for the interview is illustrative of experienced Project/Construction Management professionals and Quality professionals working for a Main Contractor/Sub-Contractor in the UAE. The requirement for this study falls under the 'Non-random sampling'. According to Walliman and Baiche (2001), 'Purposive sampling' is used where the researcher selects what he/she thinks is a 'typical' sample. "A useful method of getting information from a sample of the population that you think knows most about a subject is theoretical sampling." (Walliman and Baiche, 2001). This approach is common in qualitative research where statistical inference is not required. "snowball techniques, where you contact a small number of members of the target population and get them to introduce you to others" (Walliman and Baiche, 2001). Here the snowball technique is applied. Nevertheless, to increase the validity of the study, the potential interviewees with a targeted sample size of around 10 have been carefully chosen after doing a background check fulfilling certain criteria like who are graduates in Civil Engineering, working in the Project/Quality management role with a of minimum local experience of 10 years in the UAE construction projects.

- *Sampling strategy for Survey study*: The population considered for the survey study is illustrative of Quality professionals working for a Main Contractor in the UAE. The requirement for this study falls under the 'Random sampling' under the sub-category of simple random sampling, which is considered generally for homogeneous population. The selection of sample is based on convenience sampling approach where the author obtained the sampling units that were convenience available (Frankfort-Nachmias et al., 2000, Chin-keng and Abdul-Rahman, 2011) from the personal contacts of the authors or contacts through recommendation from friends of authors. Hinkin et al. (1997) The data must be collected from an adequate sample size to appropriately conduct subsequent analyses. There has been substantial debate over the sample size needed to appropriately conduct tests of statistical significance. Recent studies have found that in most cases, a sample size of 150 observations should be sufficient to obtain an accurate solution in exploratory factor analysis, as long as item intercorrelations are reasonably strong (Guadagnoli and Velicer, 1988). For confirmatory factor analysis, we recommend a minimum sample size of 100 (cf., Bollen, 1989). However, for this study a conservative approach is adopted and a final target sample of around 400 has been set.

3.3.6 Ethical considerations

The Oxford dictionary defines ‘Ethics’ as “Moral principles that govern a person's behavior or the conducting of an activity” or “The moral correctness of specified conduct”. According to Walliman and Baiche(2001), there are two perspectives from which you can view the ethical issues in research. One is concerned with the values of honesty, frankness and personal integrity, while the other with those of responsibilities to the subjects of research, such as privacy, confidentiality and courtesy.

From the first perspective point of view, the ethical guidelines of ‘Heriot-Watt University PGR Code of Practice, V20 August 2014’ have been followed (eg.: ethical requirements as mentioned in cl 6.1.6, 6.2.9, 6.4.3, 14 etc.). Especially cl. 14 which stresses upon ‘Plagiarism’ has been dealt with utmost care, wherein any ideas or works of other authors or publications have been diligently acknowledged through the ‘Harvard referencing system’. Additionally, the researcher has taken all due care to be ethical in carrying out the research activities related to data collection, data analysis and presentation. The research instruments used for this study including the cover letters, methods employed etc., ‘Ethics approval form’ were submitted and explained to the PhD study Supervisor and the ethics to be taken care of were explained/justified and data collection proceeded only upon his consent. According to Bryman and Bell (2008), objectivity measures the extent to which the researcher’s own values affect the conducted study. Hence, to the best of the researcher’s ability, focus has been put to maintain a neutral point of view, and to pronounce facts, including facts about opinion but without asserting the opinion.

From the second perspective point of view, ethics related to privacy, confidentiality, courtesy etc., have been regarded with due care in terms of providing assurance and accountability to the participants and/or their organizations. The main concern as expressed by the participants in the study is the risk/threat of their identity being as stake arising from the disclosure of any information or adverse comments/statements made by participants. However, the participants were assured of privacy through a statement of confidentiality mentioned on the questionnaire cover letter, wherein assurance has been provided that all information from this survey will be used for purely academic purposes and shall remain strictly anonymous.

3.4 Evaluation of current QM practices in the UAE

Considering research objective**#1**, which involves investigation of the current QM practices the UAE construction projects along with their deficiencies in controlling quality failures and seek suggestions for improvement, an exploratory study has been initiated. Data collection is done through a semi-structured questionnaire survey method targeting 10 Subject Matter Experts (SMEs) with good academic and industry experience. Based on the type of data to be collected and/or purpose of the study and the type of data analysis, mixed method (combination of qualitative & quantitative) is chosen. Figure 3.3 shows the various stages followed for conducting interview method.

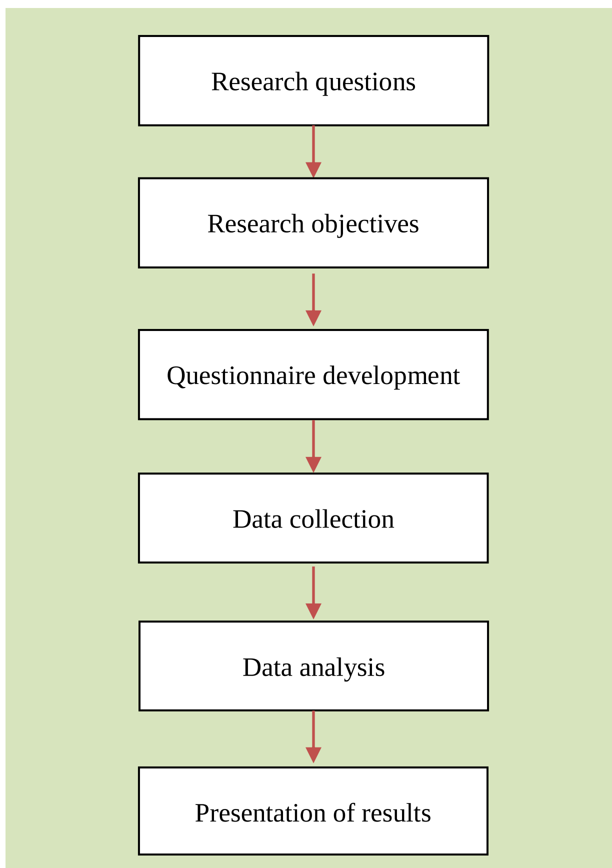

Figure 3.3: Flowchart for interview method

3.4.1 Development of Interview Questionnaire

Considering the objective#1 of this research study, an interview survey has been initiated wherein the interview questionnaire format consists of the below 4 sections

Section 1 - The purpose of this section is to gather the general information about the Interviewee & company/project. As section 1 tries to obtain demographic information related to the respondent viz., identification, education, experience and additionally some basic information about their company and projects, the aim is to ensure that data is obtained from well qualified, highly competent construction professionals working for Main Contractor/Sub-contractor in the UAE construction projects, with good experience in project quality management. As it involves only information with a specific range or preferences, a combination of multiple-choice check boxes and blanks are used to structure the questions.

Section 2 – As it tries to identify the quality performance indicators most commonly used in UAE construction projects, a Boolean type answer(YES/NO) scale is used.

Section 3 - The purpose of this section is to assess the effectiveness of the current Quality Management(QM) practices. As section 3 involves assessment/evaluation of the effectiveness of the current Quality Management (QM) practices, questions involving relative scoring with a 5-point Likert scale are used.

Section 4 - As the purpose of this section is to explore/investigate the deficiencies in the current QM practices along with suggestions for improvement, open-ended questions are formed which are asked at two levels viz., first one is to provide the deficiencies in the current QM practices and the second question to seek their suggestions for improvement.

After the completion of the design of the questionnaire, the questionnaire is given to the practitioners to have a pilot test for fine-tuning the wording. The major purpose is to ensure the practitioners have a clear understanding of respondents of the measurement items. The complete details related to development of interview questionnaire are explained in section 4.2.1 of Chapter 4.

3.4.2 Data Collection through Interviews

Data collection is done through a semi-structured questionnaire survey method targeting Subject Matter Experts(SMEs). The SMEs/Respondents were personally visited (Field visits) Interviews with practicing professionals (Quality Managers, Project Managers, Construction Managers) representing Main Contractor and Sub-contractors were carried out. Each interview session was taking one to one-and-a-half hour. Respondents were personally visited (field visits) to investigate the quality failures along with their causes and controls in place to manage quality in projects. The complete details related to data collection are explained in section 4.2 of Chapter 4.

3.4.3 Data analysis of interview results/information

Qualitative data analysis for research objective#1, which involves investigation/evaluation of the current QM practices of QM in the UAE construction projects along with their deficiencies in controlling quality failures and seek suggestions for improvement, data collection is done through a semi-structured questionnaire survey method targeting Subject Matter Experts(SMEs). Based on the type of data collected and/or purpose of the study and the type of analysis, mixed method (qualitative & quantitative) is chosen. The results are presented using descriptive statistics which are explained in sections 4.3 & 4.4 of Chapter 4.

3.5 Development of Measurement Models

In this section, the process for developing reliable and valid measurement instruments is explained. As mentioned in chapter 1 and chapter 2, there is a lack of "off-the-shelf' measurement items for QRM, QR and QP in the literature. Many instances exist in which the researcher cannot find an adequate or appropriate existing scale to measure an important construct. In these situations, it is necessary to create a new scale. Failure to carefully develop a measurement instrument can result in invalid and unreliable data/results. Hence, a systematic seven-step process is outlined here to assist researcher in devising usable scales.

A well-established framework to guide researchers through the various stages of survey scale development is lacking. This article builds on the work of Churchill (1979) and Hinkin et al. (1995) and presents a seven-step process for scale development and analysis, appropriate methods for designing reliable and valid scales. The focus will be on the development of multiple measures each of which consists of multiple items. However, the process would be the same, although less complex, for developing a single scale with multiple items. As such, this paper will describe the process of the development of multi-item, multi-subscale, interval-level scales. Figure 3.4 lists the seven steps necessary to produce reliable and valid scales.

The following sections cover each of the steps of scale development in greater detail. In multi-item measurement and scale development, there are two major challenges: (i) to reduce measurement error by providing a more robust representation of complex variables (Menor and Roth 2007, Drolet and Morrison 2001); (ii) to select the appropriate measurement items (Little et al. 1999, Menor and Roth 2007), that cover the construct domain with the desired reliability and validity. For dealing with these challenges, this research adopts the scale development approach by Menor and Roth (2007) as the skeleton, and combines this with steps suggested in the literature (Churchill 1979, DeVellis 2003, Hinkin et al. 1995, Janz and Prasarnphanich 2003, Kaynak and Hartley 2006, Netemeyer et al. 2003, Rungtusanatham et al. 1999, Schwab 1980), and forms systematic procedures to develop and validate the measurement of the new measurement scales. Hinkin et al. (1997) says good research begins with good measurement. Poor scale construction brings into question the reliability and validity of the research results, no matter how careful the design of the study. In contrast, carefully constructed measures help to advance our understanding and ensure that the study will provide accurate and usable data. By using the seven steps suggested, a researcher more likely can create scales that will provide critical information and enhance the future of research.

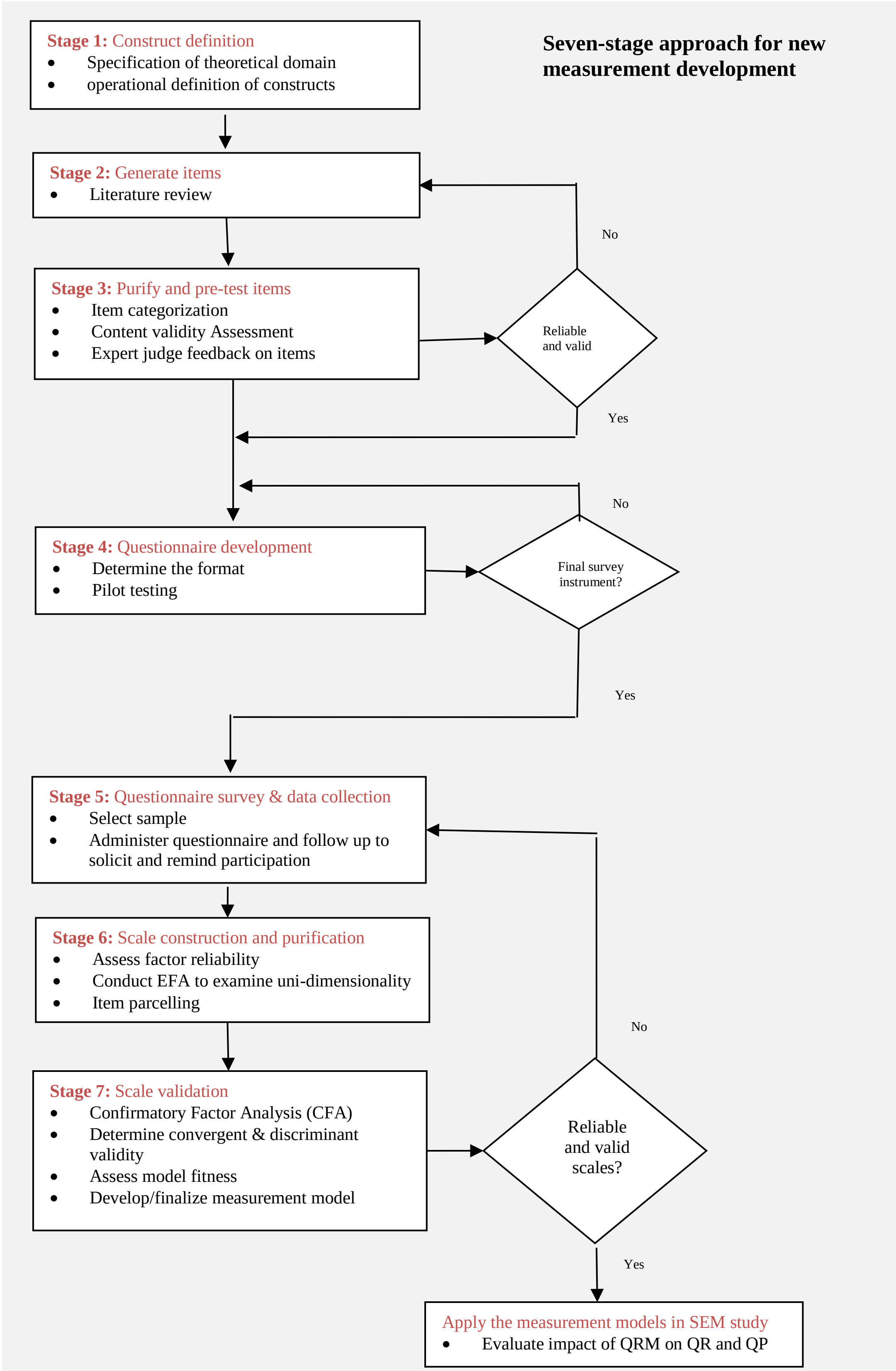

Figure 3.4: Seven stage approach for new measurement scale development

3.5.1 Theoretical/operational definitions of constructs(Stage-1)

Literature review method is used to gather secondary information, which serves the basis for establishing the theoretical framework and operational definitions of the measurement constructs. The conceptualizations should be based on a thorough literature review (Netemeyer et al. 2003). The researcher needs to clarify the characteristics which are included in the definition. This conceptualization step provides the conceptual model in which item measurement and scale development take place.

After a thorough literature review done in Chapter 2, operational definitions of the three constructs viz., QRM, QR and QP are defined based on which the potential measurement items are identified and grouped under the respective constructs and epitomized in the form of a conceptual model as explained in Chapter 5. The measurement items are generated from literature as explained in the next section 3.5.2.

3.5.2 Generation of measurement items(Stage-2)

While the purpose of developing a scale has been clearly articulated, the measurement developer should start to generate an item pool (DeVellis 2003). The new multi-item measurement scales are supposed to reflect that of QRM, QR and QP respectively. Moreover, the measurement instruments are derived from measurement items either cited in, or motivated by existing literature (Churchill 1979). Additionally, the literature suggests that the items generated must not be either too narrow nor too broad (Netemeyer et al. 2003). At this stage, the conceptual domain as specified will be captured (Churchill 1979), and scale items will be generated to tap into the conceptual domain (Hinkin et al. 1995, Netemeyer et al. 2003). Hinkin et al. (1997) explains the scale development process which begins with the creation of items to assess a construct under examination. This process can be conducted inductively, by generating items first, from which scales are then derived, or deductively, beginning with a theoretical definition from which items are then generated. Deductive scale development uses a theoretical definition of a-construct which is then used as a guide for the creation of items (Schwab, 1980). This approach requires an understanding of the relevant literature and of the phenomenon to be investigated and helps to ensure content adequacy in the final scales. In most situations where some theory exists, the deductive approach would be most appropriate.

There are no specific rules about the number of items to be retained but some helpful heuristics exist. A measure needs to be internally consistent and be parsimonious, comprised of the minimum number of items that adequately assess the domain of interest (Thurstone, 1947). Adequate internal consistency reliability can be obtained with four or five items per scale (Harvey, Billings and Nilan, 1985; Hinkin and Schriesheim, 1989). Keeping a measure short is an effective means of minimizing response biases caused by boredom or fatigue (Schmitt and Stults, 1985). Additional items also demand more time in both the development and administration of a measure (Carmines and Zeller, 1979). These issues would suggest that a quality scale comprised of four to six items could be developed for most constructs or conceptual dimensions. It should be anticipated that approximately one-half of the new items will be retained for use in the final scales, so at least twice as many items should be generated than will be needed for the final scales. Once the scale has been developed it is time to pretest the scale for the content adequacy of the items. Reflective measures are used for the scale as they suit better for data analysis using AMOS.

3.5.3 Purification of measurement items(Stage-3)

Even though it is a common practice to generate measurement items through a comprehensive review of relative literature and through interviews with practitioners and academics (Li et al. 2005, Cha and Kim, 2011), Hinkin et al. (1997) warns an often overlooked yet necessary step in the scale development process is pretesting items for content adequacy.

The most basic requirement of good item measures is content validity (Li et al. 2005). This means the measurement items in an instrument cover the major content of the construct (Li et al. 2005, Churchill 1979). In other words, the good content items should represent the intended domain of the concept that is going to be measured. Rungtusanatham (1998) mentioned that "content validity can be achieved, while the generated items can constitute a randomly chosen subset of the universe of items that represent the entire domain of the construct". Assuring content adequacy prior to final questionnaire development provides support for construct validity as it allows the deletion of items that may be conceptually inconsistent.

Considering the importance of content validity, in this study, the review of literature is complemented by in-depth discussions with practitioners who are familiar with QRM practices in construction projects followed by a more recently developed method for conducting content assessments utilizes both sorting and factor analytical techniques to quantitatively assess the content adequacy of a set of newly developed items (Schriesheim, Powers, Scandura, Gardiner and Lankau, 1993). This test is done to ensure that the empirical scrutiny is sufficiently rigorous and adequate for the measurement items and construct definition.

At first a panel of expert/judges possessing the appropriate knowledge, skills and experience in QRM are selected for the test. As the QRM construct is defined as a multi-dimensional taking into account the underlying theoretical concepts, item purification takes a three-step process, while step1 is common for all constructs, for the other two constructs (QP & QR), step1 is skipped and directly jumped to step 2.

Item categorization(Task-A)

The purpose of item categorization is to group the list of items generated from literature into the fixed number of dimensions. One common method requires respondents to categorize or sort items based on their similarity to construct definitions. This can be conducted using experts in a content domain. In either case, respondents are presented with construct definitions without titles and are asked to match items with a corresponding definition. The instrument used for item sorting consists of a definition of each of the four QRM dimensions, and a randomized list of all measurement items (Menor and Roth 2007, Hinkin et al. 1997). This is an item-sorting exercise which includes assigning the correct dimension by judges and the measurement items are filtered through the inter-judge agreement considering two criteria as below

- *Inter-judge agreement percentage:* The inter-judge agreement percentage is the percentage of judges assigning the item to the desired category (Hardesty and Bearden 2004). According to the study of Hardesty and Bearden (2004), the cut-off ranging from 60% to 75% is treated as a minimum extent of agreement among judges for item retention. The inter-judge agreement cut off for this study is taken as 60%.

- *Fleiss' kappa (k) test:* Fleiss' kappa is a statistical measure for assessing the reliability of agreement between a fixed number of raters when assigning categorical ratings to a number of items or classify them. It is used for binary or nominal-scale ratings. The following are the notations and equations to be followed for calculation of Fleiss' Kappa coefficient.

N = Total number of items;
n = Number of ratings per item (items are indexed by i=1…N)
k = Number of categories into which assignments are made (categories are indexed by j=1…k)
nij represent the number of raters who assigned the i-th item to j-th category

Fleiss' kappa coefficient $K = \frac{(P-Pe)}{(1-Pe)}$
P = 1/N $\sum_{i=1}^{N} Pi$
Pi $= 1/n(n-1)\ \sum_{j=1}^{k} nij(nij-1)$
Pe $= \sum_{j=1}^{k}$(pj)2
Pj = 1/Nn $\sum_{i=1}^{N} nij$

If raters are in complete agreement then k=1, while on the other hand if there is no agreement among the raters (other than what would be expected by chance) then k$\leq$ 0.

Content validity test(Task-B)

The aim of task B is to test how adequately each measurement item measures the dimension. Respondents were asked to rate the extent to which items corresponded with construct definitions. Those items that are retained from this analysis can then be used with some confidence for further data collection. If enough items are not retained then more may be generated at this stage. The measurement items of each construct mentioned above are purified using Content validity process wherein the items are filtered through the inter-rater agreement through Content validity ratio(CVR) and validated through Content validity index(CVI).

- *Content validity ratio(CVR)*

The CVR is an item statistic that is useful in the rejection or retention of specific items. As per Rangthunsanatham (1998), CVR is used to operationalize a theoretical construct. This is used for quantifying the extent of consensus among judges on a particular item(item-wise)

Ne=No. of panelists who put ‘ESSENTIAL’ for that particular item
N=Total no. of panelists
CVR=Content Validity Ratio
CVR=(Ne-N/2)/N/2

The cut off for inter-judge agreement is taken as Content validity ratio(CVR) of 0.62 as per the study of Lawshe (1975) and anything above that is an indication of good inter-judge agreement.

- *Content validity index(CVI)*

After items have been identified for inclusion in the final form, the content validity index (CVI) is computed for the whole test. The CVI is simply the mean of the CVR values of the retained items.

CVI=Average of all CVRs

Content validity index(CVI) is operationally the average percentage of overlap between the test items and the construct domain.

3.5.4 Development of Survey questionnaire(Stage-4)

Survey questionnaire design

The questionnaire has a range of structured questions and can be self-administered. Moreover, the questionnaire can be sent to a large number of respondents at a relatively lower cost. The success of any questionnaire survey and the accuracy of data collected largely depend on the careful design of the questionnaire's contents, structure and form of response. Hinkin et al. (1995) suggested that the researchers need to consider the following issues while designing a questionnaire: (i) the number of items in the construct (ii) the selection of a Likert scale, (iii) negative wordings. Ordinal and nominal scales were used to transform the respondent's views and opinions into a scale to facilitate statistical analysis. An ordinal scale was used for the measurement of each variable, each respondent being asked to assign a score from 1 to 5. Nominal scales were used, for certain variables without numerical values, to generate data that fit into categories (e.g. 0 = no; 1 = yes). An introduction letter explaining the purpose of this study is sent prior to start of survey. A statement of confidentiality has been issued wherein assurance has been provided that all information from this survey will be used for purely academic purposes, while maintaining anonymity.

The survey instrument in the form of a questionnaire consists of the following four sections

Section 1 - Respondent, company & project details: In this section the respondents are expected to provide some general respondent's demographics characteristics (e.g. educational level, age, experience, and occupation) of the participants. The second section captured the basic profile of respondents including their education, experiences, company, and characteristic of the building.

Section 2 - Quality Risk Management: This section of the questionnaire has items which represent the reflective indicators of the QRM construct/scale which are designed to indicate/measure the extent to which quality actions are taken with an aim to avoid/control quality risks in construction projects, with a goal of enhancing quality performance. The rating of each reflective indicator of the scale/construct is taken on a five-point Likert scale *(1= Never; 2=Rarely;3=Sometimes; 4=Frequently; 5=Always)* has been adopted to assign the score against each item.

Section 3 - Quality Risks: This section of the questionnaire has items which represent the reflective indicators of the QR construct/scale which are designed to indicate/measure the level of changes in quality risks in construction projects. The rating of each reflective indicator of the scale/construct is taken on a five-point Likert scale *(1=Decreased significantly; 2=Decreased; 3=No change; 4=Increased; 5=Increased significantly)* has been adopted to assign the score against each item.

Section 4 - Quality Performance: This section of the questionnaire has items which represent the reflective indicators of the QP construct/scale which are designed to indicate/measure the quality performance in construction projects. For questions QP1 to QP4, a five-point Likert scale *(1=Decreased significantly; 2=Decreased; 3=No change; 4=Increased; 5=Increased significantly)* has been adopted to assign the score against each item. For questions QP5 to QP9, a five-point Likert scale *(1= Strongly disagree; 2=Disagree;3=Neutral;4=Agree;5=Strongly Agree)* has been adopted to assign the score against each item. For questions QP10 to QP15, a five-point Likert scale *(1=Significantly worsened; 2=Worsened; 3=No change; 4=Improved; 5=Significantly improved)* has been adopted to assign the score against each item.

3.5.5 Data collection through Survey(Stage-5)

Sample size

Selection of sample was based on convenience sampling approach where the authors obtained the sampling units that were convenience available (Frankfort-Nachmias et al., 2000) from the personal contacts of the authors or contacts through recommendation from friends of authors. Nevertheless, to increase the validity of the study, certain criterion had been set. Firstly, the sample must be practicing quality professionals (Quality Managers, Quality Engineers etc.) working for the Main Contractor, as the research study is done from the Main Contractor perspective. Along with personal contacts from construction companies, contacts were also taken from professional’s bodies viz., ASQ, DQG, Training centers etc.

Survey questionnaire distribution

As the scope of the research is focused / oriented towards the Main Contractor perspective, mainly the Quality professionals working for Main Contractor in the UAE construction projects were expected/required to answer this questionnaire. Survey Questionnaires were administered directly to 415 potential participants. A total of 264 survey questionnaire responses were received representing 63.61 % response rate. In this study, a complete case approach as advised by Hair et al. (2009) is adopted to deal with the missing data (i.e. the respondent is eliminated if missing data on any variable). Hence after deleting 6 incomplete cases, finally sample of 258 valid cases were used of conducting data analyses. All participants responded on a voluntary basis and were assured that their individual responses would remain confidential.

3.5.6 Scale construction & purification(Stage-6)

Assessment of correlation using Pearson's correlation coefficient method

Before starting EFA, the correlations among the item measures in the respective constructs are assessed *using Pearson's correlation coefficient method*. Hinkin et al. (1997) says prior to conducting the factor analysis, the researcher may find it useful to examine the inter-item correlations among the variables and any variable that correlates at less than .4 with all other variables may be deleted from the analysis (Kim and Mueller, 1978). Low correlations indicate items that are not drawn from the appropriate domain and that are producing error and unreliability (Churchill, 1979). In statistics, the Pearson correlation coefficient is a measure of the linear correlation between two variables X and Y. The Pearson correlation coefficient is a very helpful statistical formula that measures the strength between variables and relationships. It has a value between +1 and −1, where 1 is total positive linear correlation, 0 is no linear correlation, and −1 is total negative linear correlation. If the value is in the positive range, then that means the relationship between the variables is positively correlated, or both values increase or decrease together and vice-versa. The items which "correlated negatively" or "weakly correlate with other items" in the same construct are removed. In addition, Devellis (2003) suggests that items which are correlated negatively or weakly with other items in the same construct be removed. The rule of thumb of removal is 0.20 (Netemeyer et al. 2003, Robinson 1991).

Assessment of unidimensionality using Exploratory Factor Analysis(EFA)

EFA always is the first undertaken before estimating the measurement model. The aim of EFA is to reveal whether the variables are grouped under the same factor as that proposed in the conceptualized model. In this stage, EFA is used for purifying the scale. Narasimham and Jayaram (1998)'s two-step approach is employed: conducting EFA is to assess the unidimensionality, then Cronbach's alpha to assess the reliability and to purify the scales (Zhao et al. 2008, O'Leary-Kelly and Vokurka 1998). Cronbach's alpha is a reliability statistic which is used as the indicator of the strength of the item, and the adequacy of the reliability of the subscale. The objective is to identify those items that most clearly represent the content domain of the underlying construct. Again, there are no hard and fast rules for this, but the .40 criterion level appears most commonly used in judging factor loadings as meaningful (Ford et al., 1986). It may also be useful to examine the communality statistics to determine the proportion of variance in the variable explained by each of the items, retaining the items with higher communalities. The percentage of the total item variance that is explained is also important; the larger the percentage the better. Once again there are no strict guidelines, but 60% may serve as a minimum acceptable target.

The major indications that need to be confirmed during EFA are:

(i) All the factor loadings are > min value of 0.30 (Chen and Paulraj 2004a)

(ii) Convergent validity of the construct is acceptable if the Eigen value exceeds 1.0 (Hair et al. 2009, Chen and Paulraj 2004a)

(iii) The percentage of variance of the measurement items extracted by the construct should be larger than 0.50 (Hair et al. 2009). This indicates that more than half of the variance of the items are accounted for by the construct.

(iv) The cut-off point of Cronbach's alpha is greater than 0.70 (Nunnally 1978).

Cronbach's alpha	**Internal consistency**
$\alpha > 0.9$	Excellent
$0.9 > \alpha > 0.8$	Good
$0.8 > \alpha > 0.7$	Acceptable
$0.7 > \alpha > 0.6$	Questionable
$0.6 > \alpha > 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Table 3.5: Cronbach's alpha acceptance criteria

Item parceling

To measure the sub-criteria in the enabler domain, items sharing the same sub-criterion were averaged to form composite measures (Landis et al., 2000), also referred to as testlets (Wainer and Kiely, 1987) or item parcels (Bandalos and Finney, 2001). Composite measures are combination of items to create score aggregates that are then subjected to confirmatory factor analyses (CFA) as indicator variables in the scale validation process. In CFA, the use of composite measures is useful by two reasons. Firstly, it enables to better meet the normal-distribution assumption of maximum likelihood estimation. Secondly, it results in more parsimonious models because it reduces the number of variances and covariances to estimate, thus increasing the stability of the parameter estimates, improving the variable-to-sample-size ratio and reducing the impact for sampling error on the estimation process (Bagozzi and Edwards, 1998; Bandalos and Finney, 2001; McCallum et al., 1999; Little et al., 2002). Thus, a composite measure for each sub-criterion was introduced as an indicator variable in the analyses conducted to assess the dimensionality, reliability and validity of the construct.

Zulu (2007) emphasizes that the use of item parceling is recommended in literature as a way of reducing the number of indicator variables (Schumacher and Lomax 2004 and Hau and Marsh 2004). Item parceling involves forming composite items from a number of items, thereby reducing the number of items while still accounting for all. Rocha (2012) considers that in social and behavioral sciences is not quite easy to have access to large-enough samples, item parceling has been proposed as a remedy for this kind of situation. Matsunaga (2008) recommended 3 parcels per factor.

Five major parcel formation algorithms viz., Random, Factorial, Correlational, Radial and Content-based. Landis et al. (2000) noted that parcels may be created based on item content. In this content-based method, items are assigned to parcels so that each parcel forms a theoretically meaningful cluster. The appropriateness of parceling is a function of the purpose of a given study and the nature of the scales being used. When the focus of the study is to examine the relationship among latent constructs, rather than to validate new measures, and the scales used have well-established unidimensional structure, undertaking parcel based analyses would be not only appropriate but also likely to reveal structural patterns with enhanced accuracy and to ameliorate many problems.

3.5.7 Scale validation(Stage-7)

Confirmatory Factor Analysis(CFA)

Tse(2012) in his study says that if the researcher has a preconceived idea of what the structure of the data base of his proposed framework should be, whether based on theoretical considerations or on empirical support described in the literature, factor analysis is needed that can take a confirmatory approach to evaluate the degree to which the data fits the expected structure. i.e. CFA. CFA is conducted for assessing the "fit" of the indicators representing the latent variables. Hinkin et al. (1997) says Confirmatory factor analysis is used to assess the quality of the factor structure by statistically testing the significance of the overall model (e.g., distinction among scales), as well as the relationships among items and scales. For deductive studies confirmatory analysis may be most useful. As such, it is recommended that new scales be subjected to confirmatory factor analysis, if exploratory analyses have been conducted. In scale development, confirmatory factor analysis should be just that a confirmation that the prior analyses have been conducted thoroughly and appropriately. It is recommended that confirmatory factor analysis be conducted by using the item variance-covariance matrix (Harvey et al., 1985).

The purpose of confirmatory factor analysis is to test hypothesis about a factor structure.

- The theories come first.
- The model is derived from the theory.
- The model is tested for consistency with observed data.

The relationship between the factor and its indicator is represented by a factor loading. If the squared multiple correlations of an observed variable are 0.71 then it can be interpreted that 71% of its variance is accounted for by latent variable and the remaining 29% of its variance is accounted for by the unique factor(error). In stage 7 of Tse (2012) study, the validation of the model is tested by using CFA. The results of the CFA test enable us to compare the theory developed against the reality that is presented in the data (Hair et al. 2009). Construct validity is defined as "a set of measured items that actually reflects the theoretical latent construct those items are designed to measure"(Hair et al. 2009). Thus, construct validity deals with the accuracy of the measurement and provides the evidence that the items measured, taken from the sample, represent the actual score in the population. In this research, the validity of the scale is assessed in three ways, by: (i) the model fit, (ii) convergent validity and (iii) discriminant validity.

Assess model fitness

In the study of Tse(2012), the model fitness is assessed by using absolute, incremental and parsimonious measures to provide different aspects in showing "how well the estimated relationships in the model match the observed data" (Shah and Ward 2007). Three types of measures are usually reported to show the overall model, and the recommended values of these indices for the acceptable model fit are shown in Table 3.6. The absolute measures indicate how well the specified model reproduces the observed data; incremental fit measures show how well the proposed model fit the baseline model, such as null model (assuming that all the observed variables are uncorrelated); parsimony fit measures assess the parsimony of the proposed model and provide information about the fit of the model versus the estimated coefficient needed to achieve the level of fit. Also, the parsimony fit is related to the model complexity (Shah and Ward 2007, Hair et al. 2009, Shah and Goldstein 2006).

Measures of fit	Statistics measures	Recommended values for acceptable model fit
Absolute	χ^2-Test statistic (d.f.)	NA
	Root mean square error of approximation (RMSEA)	≤0.08
	RMSEA, 90% confidence interval	(0.00;0.08)
	Standardized root mean square residual (SRMR)	≤0.10
Incremental	Non-normed fit index (NNFI)	≥0.90
	Normed Fit Index (NFI)	≥0.90
	Comparative fit index (CFI)	≥0.90
Parsimonious	Normed χ^2 (χ^2/d.f.)	≤3.0
	Parsimony normed fit index (PNFI)	≥0.70

Table 3.6: Model fit indices recommended values (adopted from Shah and Goldstein, 2006; Shah and Ward, 2007)

(Hinkin et al. (1997) says that there are several statistics that can be used to assess goodness-of-fit. The chi- square statistic permits the assessment of fit of a specific model, as well as the comparison between two models. The smaller the chi-square, the better the fit of the model. It has been suggested that a chi-square two or three times as large as the degrees of freedom is acceptable (Carmines and Mclver, 1981), but the fit is considered better the closer the chi-square value is to the degrees of freedom for a model (Thacker, Fields, and Tetrick, 1989). As indicated in Table 3.6, Goodness of Fit Index, Normalized Fit Index, and Tucker-Lewis Index are used to assess the correspondence between the proposed model and the data. In addition, the use of relative fit indices, such as the Comparative Fit Index, has been suggested to control for the effects of sample size. Each of these indices measures the amount of variance and covariance accounted for in the model, and values range from 0 to 1. Unlike chi-square, there is no statistical test of fit. As such, the interpretation of these indices is somewhat subjective.

Convergent validity

Tse (2012) says that the recommended values for acceptable model fit Convergent validity is the "extent to which indicators of a specific construct converge or share a high proportion of variance in common" (Hair et al. 2009). In other words, if the construct has a good convergent validity, the item measurement should correlate closely with other measures designed to measure the same construct (Churchill 1979). In this research, three approaches are adopted to assess the convergent validity among item measures: (i) factor loading; (ii) average variance extracted (AVE) and (iii) convergent reliability. Hair et al. (2009) suggested that the rule of thumb is that standard loading should be 0.5 or higher. Another indication of convergent validity is AVE. AVE is treated as a summary indicator of convergence in that it is calculated as the mean variance extracted for the measurement items loading on a construct. An AVE value of 0.5 or higher is at the threshold of suggesting adequate convergence. Finally, the composite reliability is taken as the measure of convergent validity in which the rule of thumb is that, for good reliability, it should be higher than 0.7.

Discriminant validity

According to Hair et al. (2009), discriminant validity is "the extent to which a construct is truly distinct from other constructs". For achieving a high discriminant validity, both "how much the construct correlates with other constructs in the model" and "how distinctly the measurement items only represent this single construct" need to be indicated. There are several approaches to assess discriminant validity. In this research, the rigorous approach suggested by Hair et al. (2009) is adopted. The AVE values of any two constructs are compared with the square of the correlation estimated by two constructs. In order to prove a high discriminant validity in the model, the estimated AVE should be greater than the squared correlation estimated. This indicates that the latent construct explains more of the variance in its item measures than the variance shared with any other construct.

3.6 Testing and Validation of Structural Equation Models

For research objective#4, which involves examining the effect of QRM on QP, hypotheses are derived from theory and the SEM models are established which are tested & validated through SEM technique which is a confirmatory approach, using IBM AMOS 24.0.

3.6.1 Development/Formulation of Hypotheses

Based on theory, firstly the hypothesized SEM models are proposed and the corresponding hypotheses are established. These hypotheses are tested using SEM technique.

3.6.2 Testing of hypotheses using Structural Equation Modeling

Structural equation modeling is a multivariate statistical analysis technique that is used to analyze structural relationships. This technique is the combination of factor analysis and multiple regression analysis, and it is used to analyze the structural relationship between measured variables and latent constructs. Structural Equation Modeling (SEM) is a methodology which is a confirmatory approach to the multivariate analysis of a structural theory (Byrne 1998). Moreover, Hair et al. (2009) provided a clear description of three characteristics of the SEM model. “The SEM model's characteristics include (i) the estimation of multiple and interrelated dependence relationships, (ii) an ability to represent unobserved concepts in these relationship and account for errors in the estimation, and (iii) defining the model to explain the entire set of relationships" (Hair et al., 2009). In short, SEM is a statistical methodology that can enable the researchers to propose their hypotheses to construct the model and statistically test all hypotheses simultaneously in order to determine the consistency between the model and the data. Also, it is a superior multivariate technique that can improve statistical estimation by not overlooking measurement error. In this way, a desirable outcome in SEM analysis implies that the hypothesized model has provided a good approximation of real world phenomena by data sampling (Shah and Goldstein 2006).

In this research, the classic two-step testing SEM approach is adopted in which CFA can be viewed as the pre-step of the path analysis. CFA can provide evidence for the validity of individual measures based on the model fit and other evidence of construct validity (Hair et al. 2009). However, CFA is only limited to analyzing the nature of relationships between constructs. A structural model should be examined after the validation of CFA is completed. The portion of the model that specifies how the observed variables depend on the unobserved, or latent, variables is sometimes called the measurement model. The portion of the model that specifies how the latent variables are related to each other is sometimes called the structural model. The intent of a SEM which is a correlation method is to assess the relationship between the dependent variable and the independent variables. (Tabachnick & Fidell, 2001, p. 111).

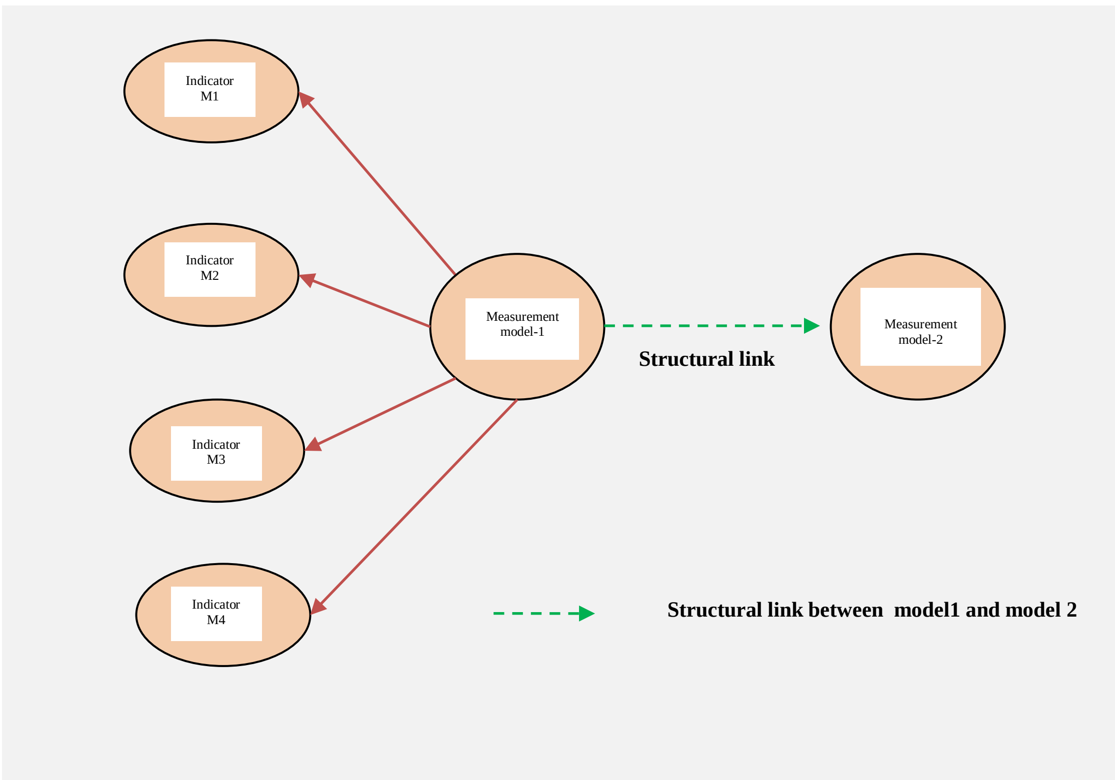

Figure 3.5: Illustration of SEM

Chandra (2015) in his study says data were analyzed by using an SEM (Structural Equation Modeling) software package. The SEM is a statistical technique that combines a measurement model (confirmatory factor analysis) and a structural model in a single statistical test. These equations depict all the relationships among construct involved in the analysis. In the SEM process, the measurement model must be validated due to capture the structure relationship between latent variables. Structural Equation Modeling examines a series of dependence relationships simultaneously. The structural equation model has two components, a measurement model and a structural model.

When a CFA model fits and displays construct validity, the measurement theory is supported. A feasible model should be selected based on the recommended Goodness of Fit (GOF) that measure indicating how well a specified model reproduces the covariance matrix among the indicator variables. Hair. Scale reliability is the internal consistency of a latent variable and is measured most commonly with a coefficient called Cronbach. Cronbach's alpha is a reliability statistic. A higher Cronbach's coefficient indicates higher reliability of the scale used to measure the latent variable and the minimum value is 0.70.

In this decade, SEM methodology is one of the most popular empirical research approaches, especially in OM and SCM areas. Shah and Goldstein (2006) stated that it is one of the preferred data analysis methods among empirical operation management researchers and this is also reflected in the publication trend in the top-grade operations management journals (such as Management Science, Journal of Operations Management, Decision Sciences, and Journal of Production and Operations Management Society). Many empirical researchers advocate employing SEM as a more appropriate path analysis methodology to examine the links among OM practice and performance (Prahinski and Benton 2004, Yeung et al. 2005, Yeung 2008, Narayanan et al. 2011). Structural equation modeling (SEM) has been applied to a variety of research problems.

Author	Description/purpose of using SEM in study	Software used for SEM
Hemsworth (2016)	To explore the relationship between quality management (QM) practices, quality performance	IBM Amos
Parvadavardini et al. (2016)	To explore the relationship between quality management (QM) practices, quality performance and financial performance of the manufacturing firm.	LISREL
Ahire and Dreyfus (2000)	To show the impact of design management and process management on internal and external quality performance	IBM Amos
Yeung (2008)	To provide a better understanding of relationships among strategic supply management, quality initiatives and firm performance	IBM Amos
Chandra (2015)	To examine the relationship beteenQM practices and project performance	LISREL

Table 3.7: Previous studies related to SEM techniques and relevant software

One of the relevant previous studies, Tse (2012) has proposed a comprehensive SCQRM framework and used Structural model building technique to examine the relationships between SCQRM and quality performance and firm performance. He adopted quantitative analysis techniques, exploratory factor analysis (EFA), confirmatory factor analysis (CFA) and structural equation modelling (SEM), were adopted to analyze survey data from questionnaire. Validation of structural model, data collection is done through Questionnaire-based Survey research method. The hypothesized model is validated empirically/statistically through CFA method using IBM Amos 22.0.

In this study, SEM is employed to examine the linkages among QRM practices and Quality performance. SEM is usually not recommended for exploratory research when the measurement structure is not yet defined, or the theory that underlies patterns of relationships among latent variables is not yet well established (Shah and Goldstein 2006). Thus, a scale development process is conducted, so the measurement structure and the underlying pattern of the QRM construct is investigated before the performance of QRM is studied. Data analysis is done using IBM SPSS for factor analysis while IBM AMOS is used for conducting the Structural Equation Modeling techniques. Both descriptive and inferential statistics are used for analysis/presentation of results. In the study of Hemsworth (2016), the model and hypotheses were tested using structural equation modeling (SEM) as depicted in Figure 3. SEM is an appropriate statistical technique when assessing the relationships among latent constructs that are measured by multiple scale items, where at least one construct is both a dependent and an independent variable (Hair, Anderson, Tatham, & Black, 1995). SEM techniques are used to test the hypothesized causal relationships (i.e. structural links between constructs). For this reason, we tested the study's hypotheses using structural equation modeling. IBM SPSS Amos lets you easily use structural equation modeling (SEM) to test hypotheses on complex variable relationships and gain new insights from data. IBM SPSS Amos is powerful structural equation modeling software that enables you to support your research and theories by extending standard multivariate analysis methods, including regression, factor analysis, correlation, and analysis of variance. With SPSS Amos you can build attitudinal and behavioral models that reflect complex relationships more accurately than with standard multivariate statistics techniques using either an intuitive graphical, or programmatic user interface.

3.7 Chapter summary

This chapter described the methodology adopted for achieving the aim and objectives of the research study as mentioned in Chapter 1, wherein the study's main goal is to develop a holistic framework of PQRM, and investigate the impact of QRM on the Quality Performance. The research design/strategy which includes steps followed to achieve each research question/objective is separately explained and represented in the form of a road map which forms the basis for carrying out the entire research. Considering research objective**#1**, which involves investigation of the current QM practices the UAE construction projects along with their deficiencies in controlling quality failures and seek suggestions for improvement, an exploratory study has been initiated. Interview method has been adopted to collect data through a semi-structured questionnaire survey method targeting the population consisting of Construction/Quality Managers working in the UAE construction projects. Based on the type of data collected and/or purpose of the study and the type of analysis (qualitative/quantitative), the interview type of method was chosen.

The key data collection methods used in this study are Interview for achieving research objective#1; Literature review for achieving objective#2 and Survey for achieving objectives 3 & 4. The main data analysis methods/techniques applied MS Excel for descriptive statistics/analysis related to objectives 1, 2 & 3, IBM SPSS 24.0 for data purification and EFA related to objective#3; validation of inter-judge agreement using Fleiss' Kappa coefficient, Content Validity assessment using Content Validity Ratio(CVR) & Content Validity Index(CVI). EFA is carried out using IBM SPSS 24.0 for scale development process, while CFA is carried out using IBM AMOS 24.0 for validating the Measurement models and Structural equation model. The significance of these have been explained in the previous sections of this chapter, including the context/purpose of their usage, the basis/reason for choosing them, how they are used to facilitate the delivery/achievement of the respective research objectives etc.

Chapter 4: STUDY ON THE CURRENT QM PRACTICES IN THE UAE CONSTRUCTION PROJECTS

4.1 Chapter Introduction

This chapter provides details of the study done in response to research objective#1 which is to investigate and assess the effectiveness of current Quality Management(QM) practices in the UAE construction projects and explore how risk-based approaches can facilitate continual improvement. The research objective#1 is established to answer the research question #1 which tries to investigate, "How effective are the current Quality Management practices in construction projects and what are the suggestions for continual improvement?

This part of the research is a preliminary study of the doctorate research, so as to explore and evaluate the current practices of implementation of quality management in construction projects in the UAE and investigates issues related to the below:

(1) Which indicators are used to measure quality performance in construction projects?

(2) How effective are the current quality management practices in ensuring the achievement of project quality objectives/quality performance?

(3) What are the deficiencies in the current quality management practices and what are the suggestions for improvement?

Taking into account the nature/significance of the data to be collected, an exploratory study has been initiated through the interview method was chosen, which has been explained in Chapter 3. Firstly, the design & development of the semi-structured interview questionnaire including a detailed explanation of the purpose and contents of each section of the questionnaire are explained. Secondly, how the data is collected through the administration of the questionnaire, including the population and sampling adopted is explained. Thirdly, data analysis and presentation of results are explained section-wise. The chapter concludes by providing a brief discussion of the findings and their implications on the construction projects in the UAE, covering the quality performance indicators used the effectiveness of current QM practices along with their deficiencies and suggestions for improvement from practicing professionals. It is an exploratory study in nature aimed at ascertaining perceptions and experiences of practitioners in the UAE construction projects.

4.2 Data Collection through Interviews

4.2.1 Interview questionnaire design & development

The interview questionnaire has been designed and developed taking into account the objective#1 of the study which is to investigate the quality management practices in the UAE construction projects along with their deficiencies, while seeking suggestions for improvement. Accordingly, the survey questionnaire has been designed to consist 4 sections such that the information required as per the requirements of objective#1 of this study is obtained in a structured and systematic manner. The questions/items of the questionnaire have been obtained from a thorough review of the literature and after a series of discussion with focus group for design, development and finalization of the survey questionnaire. To enhance the validity of the quantitative results, qualitative research through interviews with twelve Subject Matter Experts in the construction industry. The objective of the three face-to-face interviews is to probe specific but dynamic questions that the quantitative survey is unable to address, to allow an understanding of how professionals perceived the, especially the suggestion for improvement. The final survey instrument in the form of a semi-structured interview questionnaire (attached in Appendix-A) consists of the following four sections:

Section 1: Demographic information: In this section the respondents are required to provide some of individual details related to their identification, education, experience and additionally some basic information about their company and projects.

Section 2: Quality Performance Measurement: This section of the questionnaire has 10 items which measure the indicators used to measure quality performance in construction projects. The respondents are required to indicate/assign a score (1=Yes; 0=No) against each item.

Section 3: Effectiveness of Quality Management Practices: This section of the questionnaire has 18 items which measure the effectiveness of QM practices in construction projects. A five-point Likert scale (1=Very ineffective; 5= Very effective) has been adopted to assign the score against each item.

Section 4: Deficiencies in the current QM practices and suggestions for improvement : This section of the questionnaire has 6 questions which are open-ended questions of exploratory type. The first five questions try to get the views of the respondent regarding the deficiencies in the quality management practices viz., quality planning, Internal review of Technical/Engineering Submittals, Inspection & Testing, Control of Non-conformances, Supplier/Sub-contractor management etc., while seeking suggestions how it can be enhanced to provide greater assurance of achieving quality objectives. The last question tries to identify/investigate the gaps in the continual improvement aspects focusing on Management commitment & employee motivation, Auditing, Training, Communication, Lessons learned database, while seeking key recommendations for addressing the above deficiencies to ensure continual improvement in construction projects.

4.2.2 Sampling

As the research study is done from the Main Contractor/Sub-contractor perspective, the targeted sample population consists of Quality Managers and Project Managers working for Main Contractor/Sub-contractor in the UAE. Sampling was based on convenience sampling approach where the authors obtained the sampling units that were convenience available (Frankfort-Nachmias et al., 2000) from the personal contacts of the authors or contacts through recommendation from professional friends of authors. Along with personal contacts from construction companies, contacts were also taken from professional bodies viz., ASQ, DQG, Training centers etc. However, certain criteria have been set to increase the validity of the study as below, wherein a preliminary enquiry has been carried out both verbally from contacts and their profiles have been cross-checked through electronic media (Linkedin etc.), so as to verify/authenticate the credentials of the interviewees, before proceeding with the interview

- He should be at least a graduate in Civil Engineering
- He should be working for a Main Contractor/Sub-contractor in the UAE
- He should have at least 5 years of experience in the UAE construction projects
- He should have hands-on experience in Quality Management and Risk Management.

After following the above sampling approach, a preliminary list of potential participants was prepared. To improve the response rate, all the potential respondents were previously contacted by telephone to explain the aim and objectives of the research and specifically the purpose of this interview, and to ask them if they wanted to participate in the survey. Interestingly, almost all the people contacted expressed their willingness to participate in the interview survey and a finalized list of interviewees has been done.

4.2.3 Conducting interview

Cover letter has been sent to the interviewees after their acceptance through telephone call. Respondents were personally visited (Field visits) and interviews with practicing professionals (Quality Managers, Project Managers, Construction Managers) representing Main Contractor and Sub-contractors were carried out. The purpose of the interview was clearly explained to the interviewees, including the significance of the study wherein the findings helped in identifying the gaps in the existing QM system while provided useful insights into the areas of improvement which could be focused on. Although problems had been encountered in getting consent from construction companies to be interviewed, the authors managed to obtain 12 respondents. A semi-structured interview questionnaire with 4 sections was used to gather information needed to achieve objective#1 of the research study. In the 1st section the respondents were asked to provide the demographic details wherein assurance has been provided that all information from this survey will be used for purely academic purposes and shall remain strictly anonymous. In the 2nd section the respondents were asked to indicate which indicators are used to measure quality in their projects while in the 3rd section, they are required to indicate rating regarding the effectiveness of the following quality management practices in ensuring the achievement of quality objectives/quality performance in your project. The last section gathers the opinions of the interviewees regarding the deficiencies in the current QM practices along with their recommendations for improvement. The information gathered from this interview shall be helpful to evaluate the current QM practices along with their deficiencies, while the suggestions from experts would enable to seek alternative solutions to overcome the obstacles and work towards continual improvement. The findings helped in identifying the gaps in the existing QM system while provided useful insights into the areas of improvement which could be focused on. Hence the respondents were strongly advised to answer all the questions, which would enhance the data analysis resulting in a more robust outcome of the research study.

4.3 Data analysis and Discussion on Results

Qualitative data analysis is done for research objective#1, which involves investigation/evaluation of the current QM practices of QM in the UAE construction projects along with their deficiencies in controlling quality failures and seek suggestions for improvement. Data collection is done through a semi-structured questionnaire survey method targeting the Subject Matter Experts(SMEs). Based on the type of data collected and/or purpose of the study, mixed methods (qualitative/quantitative) of analysis is chosen. The interview results are attached in Appendix A.

4.3.1 Demographic information

The data is from the section 1 of the questionnaire, wherein the respondents are required to provide some of individual details related to their identification, education, experience and additionally some basic information about their company and projects. The interview participants were assured that all information gathered from the interview shall be used solely for academic purposes only and the names of the individuals/companies shall be kept confidential. A descriptive statistic of the results of section-1 of the questionnaire are provided for analyzing and getting an understanding of the profile of the respondents and the role they play in the case study project.

The sample is 12 respondents which is equally distributed with half representing Main contractor and the other half from Sub-contractor.

Designation	Nos.	%
Quality Manager	6	50%
Project Manager	4	33%
Others	2	17%
Total	12	

Table 4.1: Interview results – Participants' Designation details

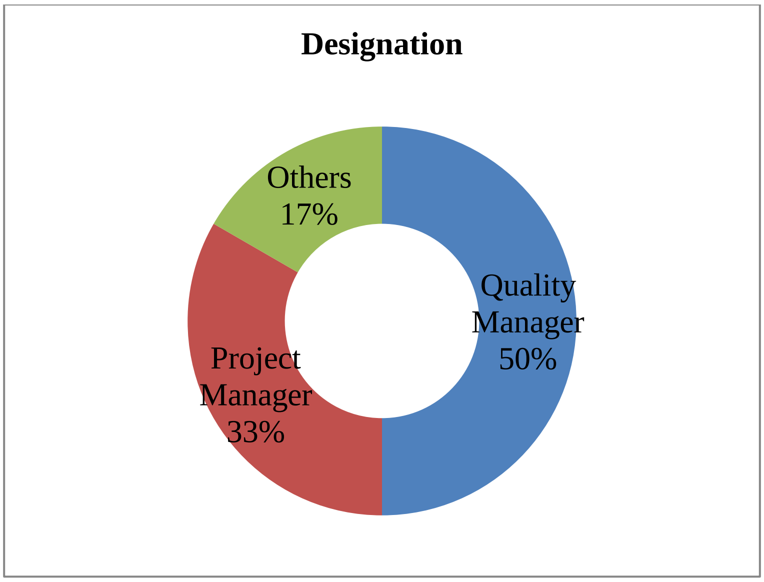

Figure 4.1: Interview results - Participants' Designation-wise distribution

As depicted in Table 4.1 and Figure 4.1 Of the sample size of 12, 6 are Quality Managers, 4 are Project Managers while the other 2 are Construction Manager and Operations Manager.

Highest Academic Qualification	Nos.	%
Doctorate	0	0%
Master's degree	2	17%
Bachelor's degree	9	75%
Others	1	8%
Total	12	

Table 4.2: Interview results - Participants' Qualification details

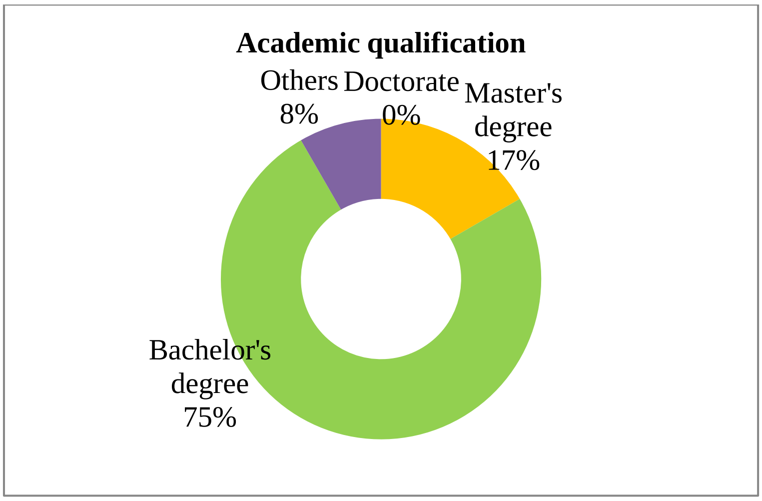

Figure 4.2: Interview results - Participants' Qualification-wise distribution

It can be seen from Figure 4.1 that there are four main classifications with respect to the education level in construction: Doctorate degree (0%), Master's Degrees (17%), Bachelor's Degrees (75%) and Others (8%). Employees with PhD degrees are very rare in the construction industry and especially very rarely assigned to construction projects. They only visit the projects for specific assignments like audits, training, client meetings etc. This explains why only 0% employees hold PhD degrees.

Professional certification	Nos.	%
ISO 9001 Auditor	5	42%
Certified Manager of Quality	4	33%
Project Management Professional	2	17%
Others	1	8%
Total	12	

Table 4.3: Interview results - Professional certification

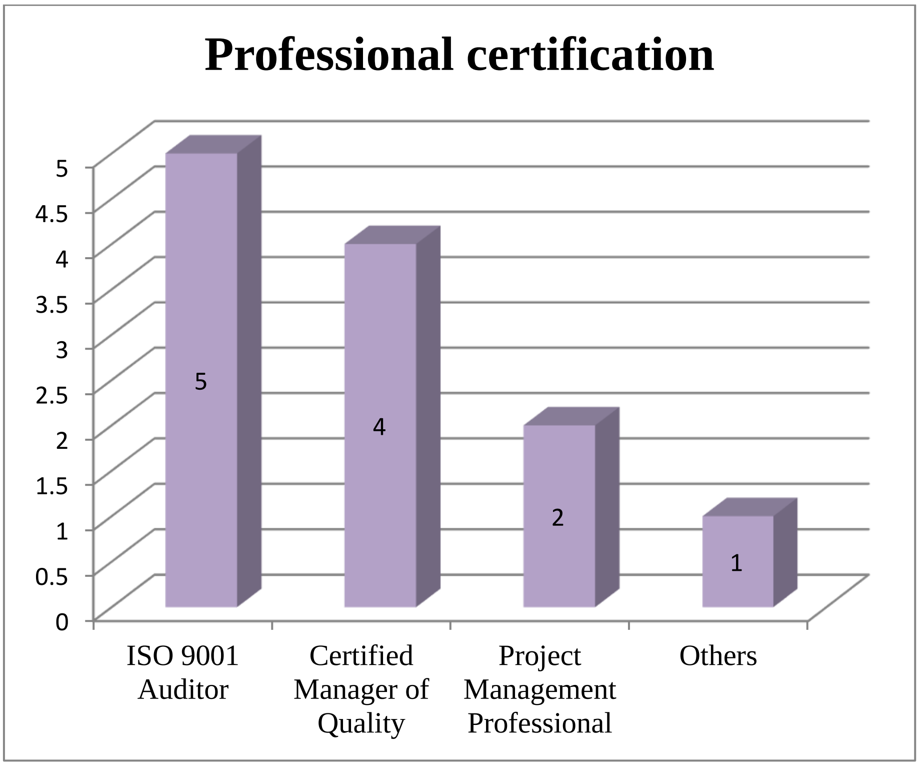

Figure 4.3: Interview results - Participants' Professional certification

Almost all the 12 Experts have professional qualifications like CMQ/OE/ PMP etc. demonstrating dedication and commitment in continued professional development. Especially, out of 12 interviewees 5 are ISO 9001 certified auditors while 4 are certified Quality Managers which are representative of professional passion for quality.

Total experience in Construction industry	Nos.	%
Less than 10 years	2	17%
10 years - 20 years	7	58%
More than 20 years	3	25%
Total	12	

Table 4.4: Interview results - Participants' Experience in construction

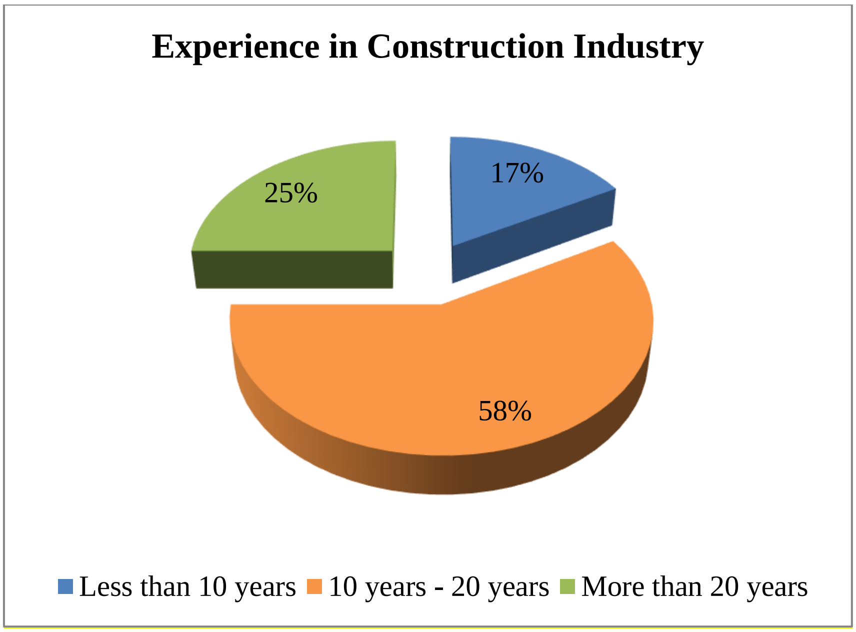

Figure 4.4: Interview results - Participants' Distribution by Experience in Construction

The sample used for this content adequacy assessment consisted of 12 experts of which 25 % have more than 20 years of experience in the construction industry while 17% have more than 20 years of experience in project quality management. Majority (around 50-60%) of professionals have experience between 10-20 years of experience.

Total experience in project quality management	Nos.	%
Less than 10 years	4	33%
10 years - 20 years	6	50%
More than 20 years	2	17%
Total	12	

Table 4.5: Interview results - Participants' Experience in Project Quality Management

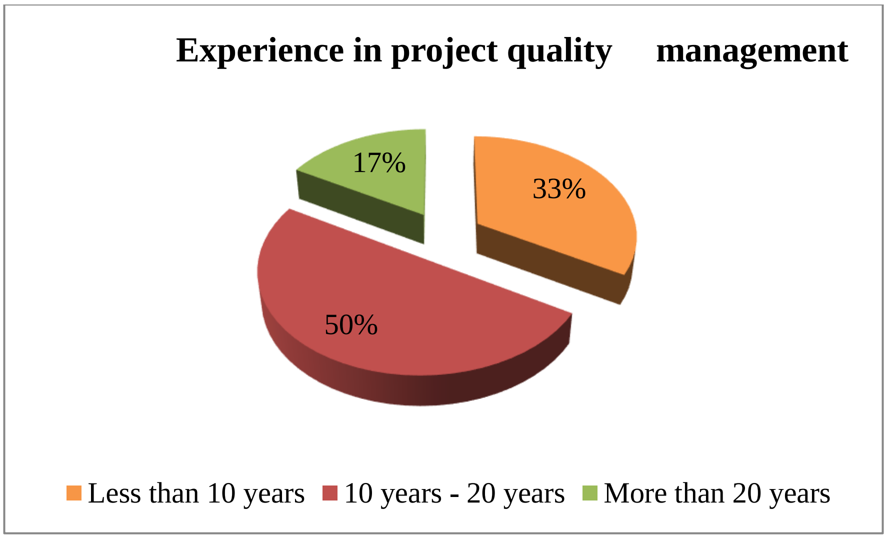

Figure 4.5: Interview results - Distribution by Experience in project quality management

50% of the interviewees work in construction projects whose contract values are over AED 500 Million while 33% are 100-500 Million and the other 16.66 % are less than AED 100 Million which are all relatively smaller Sub-contract works.

All the Main contractors and Sub-contractors are ISO:9001 certified companies.

4.3.2 Quality Performance Measurement

The data is from the section 2 of the questionnaire, the purpose of which is to understand which indicators are used to measure quality in the views of Main contractor and sub-contractor. This section of the questionnaire has 10 items which measure the indicators used to measure quality performance in construction projects. The respondents are required to indicate/assign a score (1=Yes; 0=No) against each item.

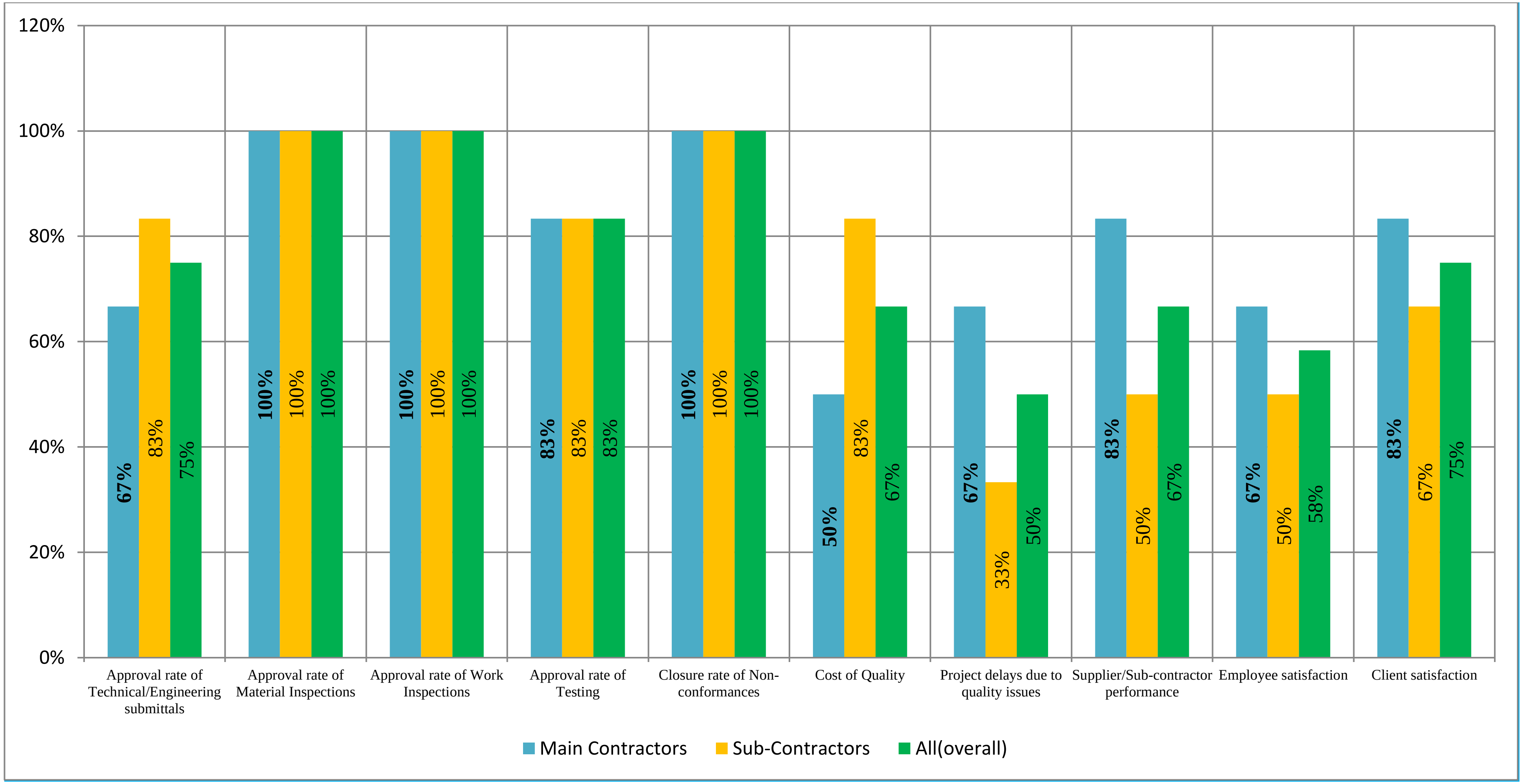

Figure 4.6: Interview results - Indicators used to measure quality performance

From Figure 4.6 the following is a brief discussion on the results related to quality performance indicators used in the UAE construction projects:

- Approval rate of Material Inspections & Work inspections along with closure rate of NCRs are top of the list with 100% from both Main and Sub-contractors. These have been highlighted in previous researches, Cheung et al. (2004) which identified the key quality related indicators used are related to 'Inspections, 'Non-compliance records', 'Work rejections' and 'Survey(sample) rejections'.

- The next most significant indicator for quality is Approval rate of testing with overall 83% of both Main contractor and sub-contractor agreeing. The previous studies also stressed the significance of using testing as KPIs for quality (Rad and Khosrowshahi (1998), Takim et al. (2003), Idrus and Sodangi (2010), Yasamis et al. (2002).

- Using Cost of Poor Quality as a KPI for quality has overall score of 67% wherein the Sub-contractor put a score of 83% while the Main contractor put only 50%. The previous studies also stressed the significance of using COPQ as KPIs for quality (CII, Shanmughapriya (2015),Chin-keng and Abdul-Rahman(2011)). 'Project delays due to quality failures' is rated as 50%. The previous studies clearly establish that the impacts of quality failures can result in cost impact (Abdelsalam and Gad 2009, Love et al. (2004), Kazaz et al. (2005), Heravi and Jafari(2014) Jafari and Love(2013)), time impact(Ren et al. 2008, Megha and Rajiv 2013). The delays due to quality failures is because of additional time consumed by re-submission of Submittals/documents, Re-review of documents, Factory visits/re-visits for evaluation/assessment, Re-inspection, Rework/Repair, Re-testing etc.

- It is evident that the soft measures like Client satisfaction, Employee satisfaction, and Supplier performance are neglected as against other tangible measures. However, the impact of poor quality or quality failures viz., cost and time impact are neglected as its measurement is tedious practically, while in some cases the project management tries to ignore it as their inefficiency gets exposed. The study carried out by Leong et al. (2014) indicates that Quality performance can be measured by looking into the non-conformance report (NCR) along with taking clients' satisfaction into consideration. Usually, clients of construction sector experienced dissatisfaction in many aspects including overspend in project cost, delay of completion, poor quality, and incompetent project teams like subcontractors and consultants.

Taking into account the above, Approval rate of Supplier Pre-qualification, Material submittals, Shop drawings, Method Statements, Material inspections, Work inspections, Tests, closure rate of NCR's are considered to be the most commonly used KPIs to measure the quality performance in the UAE construction projects.

4.3.3 Effectiveness of Quality Management Practices in the UAE construction projects

The data is from the section 3 of the questionnaire the purpose of which is to understand the effectiveness of the current management practices in the views of Main contractor and sub-contractor. The success of quality management in construction project depends on the joint efforts of both the Main contractor and Sub-contractor. However, the above graph in Figure 4.7 indicates that Sub-contractor is lagging behind mainly because of support from their top management, scarcity of funds/resources, incompetency, poor quality culture etc.

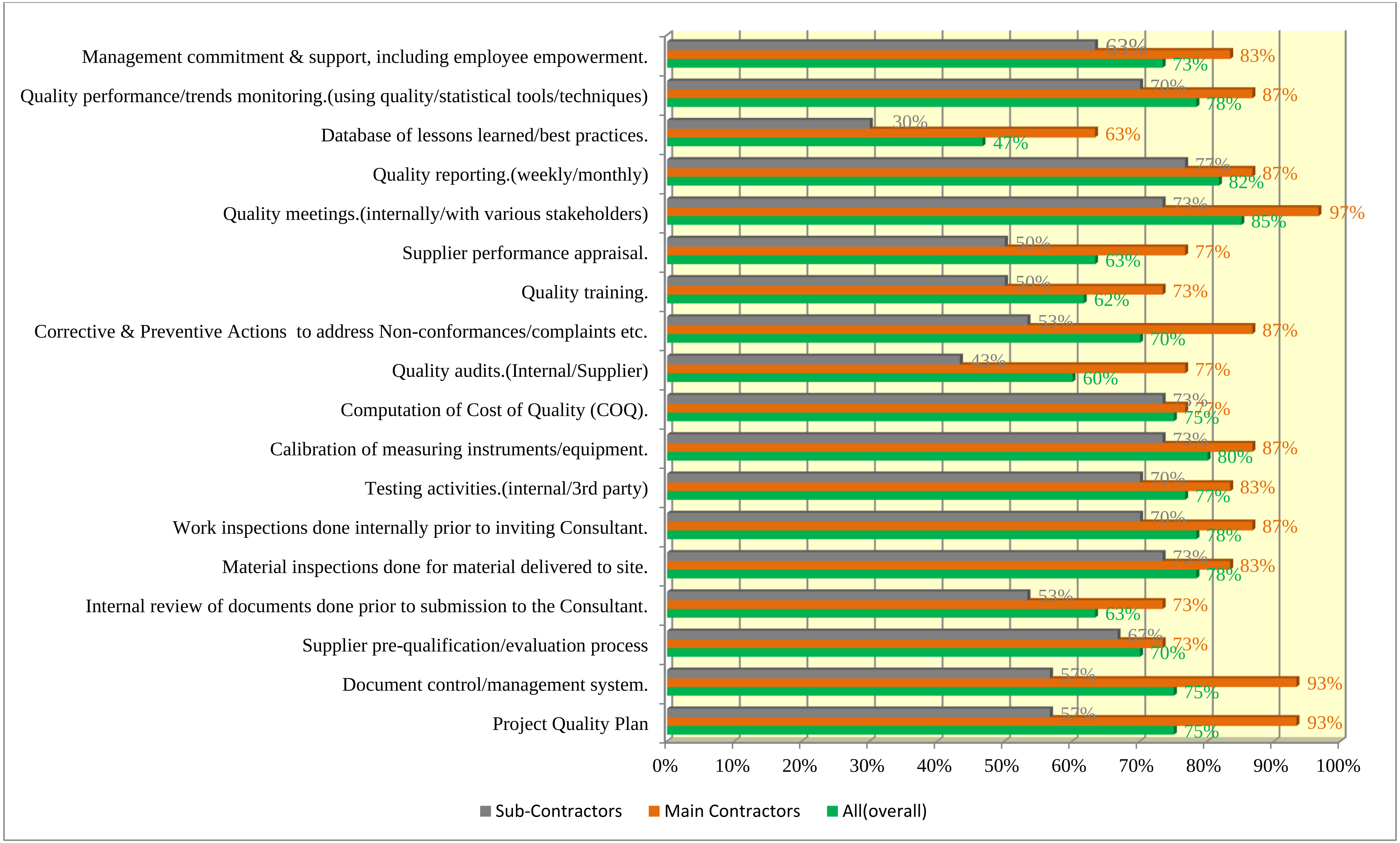

Figure 4.7: Interview results - Effectiveness of QM practices in ensuring quality performance

- The overall mean score for PQP is 3.75 which mean that the PQP is 75% effective in ensuring the achievement of quality objectives/performance. It can be noted that while the main contractor has rated as 93% effective, the sub-contractor has provided a rating of only 57% effective. The main reasons of the gaps are that the sub-contractors usually operate on a very low profit margin and hence find it difficult to provide resources necessary to establish and implement PQP and especially avoid the costly process of being certified to ISO 9001. This is quite evident in the inadequate management support wherein on 63% Management support is provided in the case of Sub-contractors, while 83% support is the case with Main contractor. This is also highlighted in similar studies like Chin-keng and Abdul-Rahman (2011) which suggests that "Leadership and participation of top management of construction companies in quality management need to be strengthened" and "Allocation of financial and human resources for the purpose of problems of the implementation of quality management should be further increased". The Project Quality Plan (PQP) is a quality document which usually consists of the processes and procedures related to Quality Assurance and Quality Control which provide an assurance to the Client and other stakeholders as to how quality would be achieved in line with the contractual requirements. The need for establishing and implementing a Quality Management System in construction projects is mostly Client driven and included as a contractual obligation, while in a few cases it is the voluntary initiative of the Contractor. Project KPIs are established generally revolving around the Client's requirements and project contract requirements. Hence more importance should be given to establishing and effective implementation of PQP.

- Effectiveness of internal review of documents prior to submission to the consultant is only 63% while the effectiveness of the inspections and testing activities is between 77 % and 80%. These are also attributed to the effectiveness of the Document control/Management system which is rated as 75%. Submission of Submittals and obtaining approval is an important QPI which is driven by internal review prior to submission to the consultant. Technical/Engineering submittals usually consist of Supplier pre-qualifications, Material Submittals, Shop Drawings, Method Statements etc., while QC submittals include Work Inspection Requests (WIR), Material Inspection Requests (MIR), Test Requests (TR) etc. The rejections of these result in additional costs and additional time. The delays due to quality failures is because of additional time consumed by re-submission of Submittals/documents, Re-review of documents, Factory visits/re-visits for evaluation/assessment, Re-inspection, Rework/Repair, Re-testing etc. Poor quality management may have a negative effect both internally and externally. In internal context it may result in additional costs, delays, decrease in the effectiveness/efficiency of decision making, Non-conformances, overall ineffective continual improvement etc. While in the external context it may lead to customer dissatisfaction resulting in increased rejections, penalties, termination etc. Hence, more importance need to be given to ensure getting approval on the very first-time submissions.

- The effectiveness of computation of Cost of Quality is 75%. It is mostly suggested that preventive actions over detection/inspection aids to reduce quality costs (PMI, 2013, Basu, 2004). PMI (2013, p. 235) cautions about the high failure costs due to poor quality. One of the most important concerns of any construction company is how to achieve a right balance between the desired level of quality and the expenses associated with it. Previous studies (Heravi and Jafari, 2014; Jafari and Love, 2013; Abdelsalam and Gad, 2009; Kazaz et al., 2005) have used PAF model for estimating the optimum level of COQ, however the means of how to prioritize addressing of various quality issues to achieve the optimum level of COQ remains to be unclear. It is mostly suggested that preventive actions over detection/inspection aids to reduce quality costs (PMI, 2013, Basu, 2004). Hence the methods for computation COQ should be established and more importance should be given to follow the process to reduce cost of poor quality.

- The effectiveness of CAPA is rated as 70%. While the CAPA has two basic components namely corrective actions aimed at rectification (reactive approach) and preventive actions aimed at preventing quality failures from happening in the first place. The main reason for the ineffectiveness of CAPA is that the current QM practices put more focus on ‘Reactive approach’ and neglecting ‘Proactive approach’ in dealing with quality failures. In other words, project teams tend to act on solving quality failures through corrective actions like rework, resubmission, retesting etc., instead of putting efforts in preventing them from happening in the first place through identification of risk assessment/analysis, so that potential risks/causes leading quality failures could be detected ahead so that preventive actions could be applied to avoid quality failures from occurring/happening.

- Effectiveness of quality training and Quality audits are very low with 62 % and 60% respectively. Although proactive approaches like training, audits etc., are done, they are mostly done in a random/case-by-case manner mainly focusing on conformance and rarely consider/take into account the level of risks associated. Poor employee training is commonly highlighted in previous researches (Love and Edwards (2004), Yasamis et al. (2002), Love et al. 2004; Yates and Lockley 2002; Love and Li 2000). Low and Ong (2014) brings forth an interesting point that as profit-driven contractors want to minimize cost, insufficient staffs, incompetent staffs, no training and proper directions given to staffs. As per ISO 19011(5.2.1,6.5.2), one of the objectives of conducting audits is to identify risks to the organization and communicate the same for necessary actions. Moreover, as the project is a sub-set of the construction company, which is audited as per the ISO requirements for ISO certification purposes. Hence the audits are focused on ISO certification purpose while losing focus on the continual improvement of the project.
- The effectiveness of maintaining Database of lessons learned/best practices is rated as 47% which is very low. Some studies like Agoston et al., 2011) strongly suggests that in order to monitor the effects of quality risk management, it's key to have in place adequate tools like a database ⁄ integrated quality management system). (Abdelgawad and Fayek, 2010) suggest that, in order to address several drawbacks of the traditional FMEA application, future work is required to address this limitation by developing a database of recommended corrective actions that are suitable for each specific risk, partially based on historical data and lessons learned. The important QM practices namely, quality meetings, quality reporting KPIs performance monitoring are rated as 85%, 82% and 78% respectively. This is an important requirement of ISO.
- Lastly, the effectiveness of the Supplier prequalification/evaluation process and Supplier performance appraisal processes are rated as 70% and 63% respectively. Low and Ong (2014) emphasizes having a Rigorous Prequalification Process to Select Subcontractors and Suppliers. Kagioglou et al. (2001) study in Supplier & Sub-contractor performance review, to measure QP. AlMaian et al. (2016) streses upon supplier performance rating. Taking into account the EFQM requirements and other excellence model requirements, the relationship with other key stakeholders viz., Sub-contractors/Suppliers, Society etc is vital in measuring quality of services which are in line with the studies of (Takim et al. (2003); Rad and Khosrowshahi (1998); Ali (2012); Leong et al. (2014); Kagioglou et al.(2001); Llusar(2008); Idrus and Sodangi(2010)

4.3.4 Deficiencies in the current QM practices and suggestions for improvement

The below data is from the section 4 of the questionnaire, the purpose of which is to understand the deficiencies in the current QM practices along with the suggestions for improvement in the opinion of Main contractor and sub-contractor.

Deficiencies in the current QM practices	Suggestions/Recommendations for improvement
4.1 Quality Planning	
• PQP once approved by the consultant, is rarely updated during the project. • Quality objectives are mostly established without proper understanding of project/customer requirements.	• PQP needs to be periodically reviewed and updated to incorporate the new progressive changes. Frequency should be fixed either quarterly or as mutually agreed by Client/Consultant and Contractor as per the need of the project. • Establishing of Quality objectives needs to consider from risk point of view so as support proactive approach in preventing quality failures. Additionally, they need to be SMART to be achieved. •
4.2 Internal review of documentation for Submittals	
• Adequate information/input (technical & operational requirements/procedures etc.) not provided to the Suppliers to prepare their proposals • Short notice given to prepare & submit which dampens the quality of the submittal, often increasing the chances of rejection by the consultant. • Poor Submittal documentation due to incorrect compilation related to no. of copies/formats, forms, numbering, details, invalid/expired documents, Delivery notes, Third party test certificates etc. •	• Adequate information should be provided to the Supplier needed for preparation of submittals. • Suppliers/Sub-contractors need to be provided adequate time for preparation of their submittals. • Contractor QA/QC Engineer should be given adequate time for internal review/verification • A checklist can be prepared for each Submittal along with the list of documents which need to be attached including the required no. of copies.
4.3 Inspection & Testing	
Material Inspections • The major reasons for the MIR rejections are the delivered material is not as per the approved material submittal from the approved source (manufacturer/Supplier) or brand/type as that mentioned in the approved Material Submittal. • In some cases, the delivered material has been found to be in a damaged / unacceptable condition.	• Verification sampling to be done based on the risk • Advanced notice needs to be given to QA/QC and Stores personnel to make necessary arrangements for receiving, checking and storing to avoid hasty checking.
Work Inspections • Not adequately using proactive control measures like checklists etc. • In some cases, the rejection is repeating due to the same/similar failure cause. Testing frequency crossing more than required in the specification due to lack of proactive checking measures in place • In many cases some works/activities are carried out without the Consultant’s approval	• More focus should be put based on the trends in the previous inspections and based on the risk assessment. • Communication with the consultant needs to be improved. • Internal review needs to be increased. Not adequately using proactive control measures like checklists etc. • Checklists to be revised based on the root cause analysis.

of the previous/preceding activity/works or the testing requirements. • The other key reasons for rejections are if the works are carried out by unapproved Drawings or Method statements or Sub-contractors or usage of unapproved material. • Reasons related to Poor/Incorrect Submittal Documentation /compilation are, wherein the attachments like MEP clearance, NOC, approval of previous work/activity, signed-up checklist etc are not attached.	• Root cause analysis needs to be fed back into the system for continual improvement.
Testing • In some cases, the test results are not fulfilling the requirements of the specification. • Testing done at unapproved laboratory. The above failures have resulted in repetition of tests or remove the completed works and reworks.	• Resting frequencies should be done as per the contract specification or as per the approved ITP. • Calibration log needs to be maintained for all testing instruments/equipment along with archiving valid calibration certificates.
4.4 Non-conformances	
• Root cause analysis in some cases shows lack of proactive control measures in place. • Poor effectiveness of corrective actions taken before, leading to repetition. • The basis of corrective actions is Root cause analysis in some cases shows lack of proactive control measures in place.	• Proactive approaches like Checklists, risk management techniques etc., need to be followed to avoid/prevent potential quality failures from occurring in the first place. • The repletion of failure indicates that there is no mechanism in place to enable lessons from previous failures being recorded and efforts put in to prevent them from repeating. • Decision making & prioritization to be based on database for historical information or Cost of quality.
4.5 Supplier/Sub-contractor management	
• Supplier prequalification process is done in a weak manner with no adequate review or verification and sometimes with no ground checks (factory visits etc.). • The most common influencing factors for the contractor deviation from the vendor list are lowest price and in many cases, the pressure from the top management. • Sub-contractors express their concern that due to the mis-coordination with sub-contractors of multiple disciplines viz., MEP, Architectural, Structural, specialized works etc., sometimes key details are not taken into account in the development of various shop drawings.	• During Sub-contractors/Supplier’s selection, adequate weight must be given to Quality, similar to price. Potential risks from quality point of view should be considered. Field visits should be prioritized based on the potential risks they carry. • Supplier performance database must be maintained indicating history of issues/complaints/delivery performance etc. which can be a helpful reference for decision making. • Quality requirements need to be clearly mentioned in the sub-contract agreements/LPOs so as to avoid surprises later. • Supplier performance appraisals • Compliance statement should be used. • RFI needs to be raised to clarify in case of any ambiguity of details. • Communication/interaction needs to be improved through workshops, meetings etc.

4.6 Continual improvement	
Management support • Management unnecessarily interferes and put negative pressure compromising quality (favoring nepotism, pressure to complete works, price overshadowing quality etc.? • Poor leadership or inadequate management support to the cause of quality, in terms of not providing adequate resources (People/Machines/Material etc.). • Employees not adequately empowered to make decisions	• Top management needs to support employees. • Rewarding system to be implemented to motivate/encourage employees
Auditing • The audit schedule reflects elements/processes more focused on the corporate level procedures seemingly targeting the ISO certification. • The scope seems to be less focused on the project quality performance and more on financial aspects (resources/assets etc.).	• Audits to put more focus on risk-based approach.
Quality Training • Failure in delivery of planned training sessions indicates that the opportunities to prevent potential quality failures are being repeatedly foregone. • Basis for quality training is random and not clear.	• Training plan must take into account both system/procedures and also be dynamic/prioritize from the outcome of NCRs and other rejections from Consultant. • Should take into account the high-risk areas. • Skill based training needs to be planned and implemented. •
Quality Database • Poor database/ monitoring system leading to ineffective decision-making system	• Database of lessons learned must be used.

Table 4.6: Interview results - Deficiencies in the current QM practices in the UAE construction projects and suggestions for improvement

Low and Ong (2014) explains some key deficiencies in the current Engineering quality management model wherein the current management model focus on supervision afterwards, but not pre-control, and hence cannot prevent the occurrence of some engineering quality risks, wherein risk prevention has not become the core of supervision.

The preliminary interview findings during the site visits indicate that the Project Quality Management in the United Arab Emirates (UAE) construction projects usually follows a reactive approach, wherein once the quality defects/issues are encountered, the necessary corrective actions are taken in a random/ ad hoc manner and regrettably not prioritized such that quality issues with more risk could be focused on. thereby enabling the various key personnel/stakeholders to be in a better position to make more informed decisions in controlling quality and maintaining continual improvement.

The repetition of quality failures and increasing Cost of Poor Quality clearly exposes the deficiencies in the current Project Quality System and the inadequate awareness of the project team with regards to understanding the causes and effects of quality failures. Literature stresses the importance of understanding the underlying causes of these failures and developing strategies to eliminate or to mitigate their occurrence are important to increase the probability of achieving the project objectives. On the other hand, the impact of the quality failures needs to be assessed so that prioritization of the corrective actions can be effectively carried out.

The interview findings unearthed the quality failures in the UAE construction projects along with their causes and effects. Additionally, the study provides some suggestions for continual improvement which could be helpful to the project teams to follow a more proactive approach in preventing quality failures from happening in the first place, thus aiming at the core principle of quality – “DO IT RIGHT THE FIRST TIME!” Didla and Al-Hajj (2017)

Deficiencies in the current QM practices

1) Quality control usually relies upon checklist-based inspections, wherein quality decisions are often divorced from risk evaluation while more prominence is given to checklist based conformance which focus on fulfilling documentation requirements only.

2) The basis of setting quality objectives or KPIs or quality budget/resources is not so clear.

3) Basis for quality training is random and not clear. Failure in delivery of planned training sessions indicates that the opportunities to prevent potential quality failures are being repeatedly foregone. Poor guidance to the project teams in managing quality could possibly result in overall poor quality of products and service, thus ending up with customer dissatisfaction.

4) Audit schedule is tilted toward compliance oriented auditing and not upon risk-based approach. The schedule shows fixed dates, wherein the tendency of static overshadows dynamic aspects of sprouting problems/issues. The audit schedule reflects elements/processes more focused on the corporate level procedures seemingly targeting the ISO certification. More focused on ISO system audits than process/product based. The scope seems to be less focused on the project quality performance and more on financial aspects (resources/assets etc.). Focus on compliance oriented auditing and not upon risk-based approach.

5) In the UAE construction projects, risk-based approaches are applied in HSE through 'Risk Assessments' and 'Aspect & Impact Assessments' respectively, just because they are demanded by the Federal law/regulatory requirements. Whereas, a similar obligation lacks in the discipline of 'Quality

Suggestions for improvement

The suggestions for improvement in the opinion of the project professionals are emphasizing that more focus should be put on a proactive approach, especially risk-based thinking and actions should be followed, as summarized below

a) PQP needs to be periodically reviewed and updated to incorporate the new progressive changes and frequency should be as per the dynamic need of the project.
b) Top management should extend adequate support for effective implementation of PQP.
c) RFI needs to be raised to clarify in case of any ambiguity of details.
d) Communication/interaction needs to be improved through workshops, meetings etc.
e) During Sub-contractors/Supplier's selection, adequate weight must be given to Quality, similar to price. Field visits should be prioritized based on the potential risks they carry.
f) Supplier performance database must be maintained indicating history of issues/complaints/delivery performance etc. which can be helpful for decision making.
g) Required information and adequate time needed for preparation of submittals should be provided to the Contractor/Supplier/Sub-contractors
h) Contractor QA/QC Engineer should be given adequate time for internal review/verification
i) Proactive approaches like Checklists, risk management techniques etc., need to be followed to avoid/prevent potential quality failures from occurring in the first place.
j) Calibration log needs to be maintained for all testing instruments/equipment along with archiving valid calibration certificates.
k) Audits need to be more focused and prioritized based on high risk areas.
l) Training plan must take into account high-risk areas and also be dynamic/prioritize from the outcome of NCRs and other rejections from Consultant.
m) Database of lessons learned must be used and decision making & prioritization should be based on database for historical information.

4.4 Chapter summary

To address the research objective#1, which highlights the need to explore/investigate the current quality management practices in the UAE along with their deficiencies and seeking suggestions for improvement, an exploratory study has been initiated by adopting the survey method. Data collection was done using a semi-structured interview questionnaire which is distributed to experienced practicing professionals (Project/Construction Management professionals, Quality professionals etc.) working for Main Contractors/Sub-Contractors have been chosen based on references from reliable sources. The data from the section 2 of the questionnaire, indicates that the soft measures like Client satisfaction, Employee satisfaction, and Supplier performance are neglected as against other tangible measures. However, the impact of poor quality or quality failures viz., cost and time impact are neglected as its measurement is tedious practically, while in some cases the project management tries to ignore it as their inefficiency gets exposed. The data from section 3 of the questionnaire suggests that the success of quality management in construction project depends on the joint efforts of both the Main contractor and Sub-contractor. However, the results indicate that the Sub-contractors are lagging behind mainly because of poor support from their top management, scarcity of funds/resources, incompetency, poor quality culture etc. Additionally, the last section gathers the opinions of the interviewees regarding the deficiencies in the current QM practices along with their recommendations for improvement. The findings helped in identifying the gaps in the existing QM system while provided useful insights into the areas of improvement which could be focused on.

The interview findings indicate that the Project Quality Management in the United Arab Emirates (UAE) construction projects usually follows a reactive approach, wherein once the quality defects/issues are encountered, the necessary corrective actions are taken in a random/ ad-hoc manner and regrettably not prioritized such that quality issues with more risk could be focused on. thereby enabling the various key personnel/stakeholders to be in a better position to make more informed decisions in controlling quality and maintaining continual improvement. The findings helped in identifying the gaps in the existing QM system while provided useful insights into the areas of improvement which could be focused on. The results are presented using descriptive statistics and the comparison of the opinions of Main Contractor and Sub-contractor brings to light some interesting differences.

Chapter 5: DEVELOPMENT OF CONCEPTUAL FRAMEWORK

5.1 Chapter introduction

This chapter focuses on addressing research objective#2 whose purpose is to review the concepts of Quality Risk Management (QRM), Quality Risks (QR) and Quality Performance (QP) to conceptualize and operationalize the QRM, QR and QP constructs.

Firstly, the QRM process is explained based on which a theoretical framework of PQRM along with the QRM, QR and QP constructs are described. This forms the background for addressing objectives 3 & 4. Secondly, the proposed measurement items that represent these constructs are presented, wherein the multi-item measurement and scale development for QRM, QR and QP constructs are discussed. As mentioned in chapter 1 and chapter 2, there is a lack of "off-the-shelf' measurement items for QRM, QR and QP in the literature. Hence, this chapter focuses on identification/generation of potential measurement items from literature review and proposed to represent each of the construct/scale namely QRM, QR & QP to conceptualize and operationalize each scale. This is part of the multi-item measurement done as per the stages 1 & 2 of the seven-stage approach of scale development procedure which is explained in chapter 3. Finally, a detailed discussion of the proposed QRM, QR & QP measurement scales along with the conceptual PQRM framework are provided, followed by summarizing the conclusions.

5.2 Theoretical Framework of Project Quality Risk Management

Based on the literature review done in chapter 2, a theoretical framework among QP, QR and QRM is represented in Figure 5.1. Considering the scope and boundaries of the study as stated in 1.7 of chapter 1, this chapter focuses conceptualizing and operationalizing the three measurement scales namely QRM, QR, QP. From the stakeholder’s perspective, the research study considers the actions taken to address risks arising from the Main contractor and his supply chain, while the quality performance measures include all the internal and external stakeholders. Figure 5.1 shows the theoretical framework in the context of construction project environment wherein Stakeholder-1 represents the Main contractor and his supply-chain, while Stakeholder cluster-2 represents Consultant, Client, Authorities and Society.

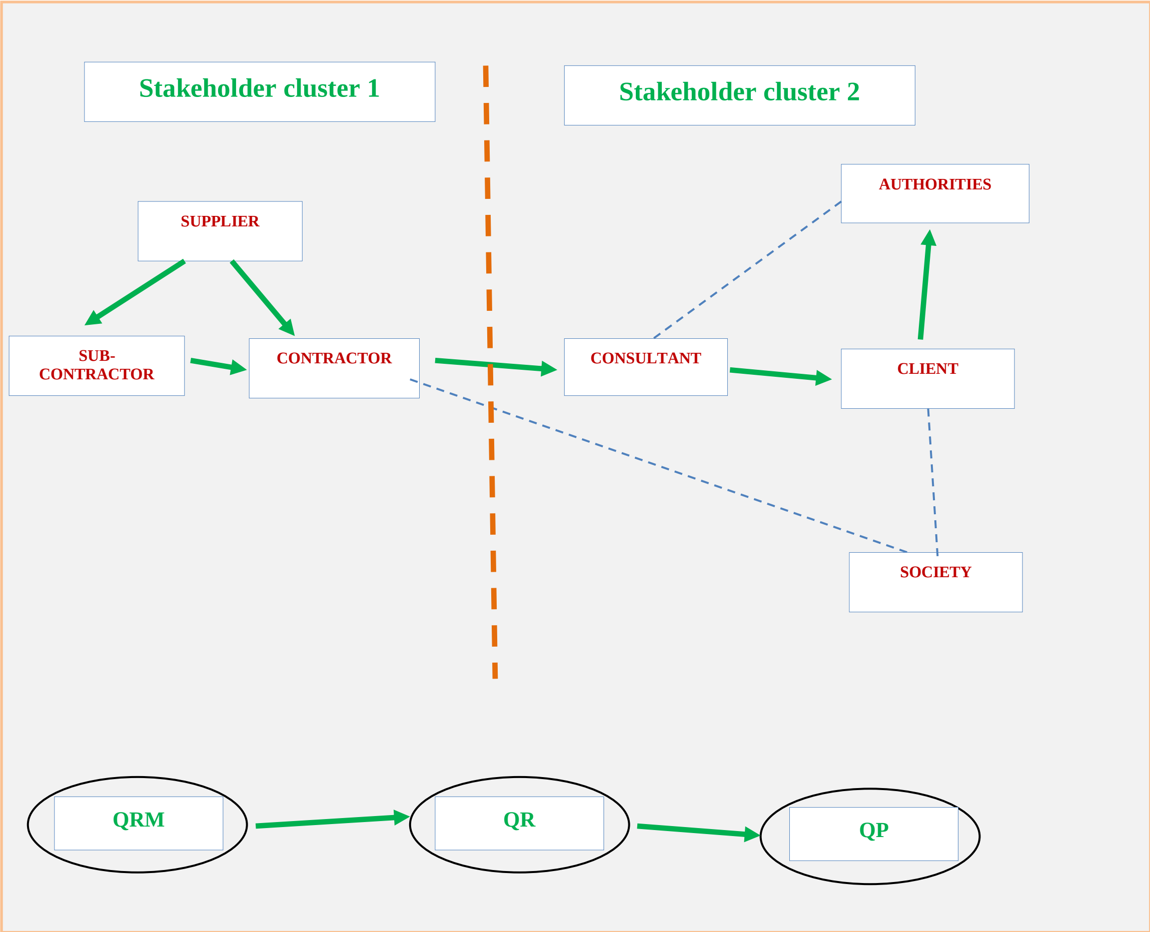

Figure 5.1 Theoretical framework – QRM, QR and QP

Achievement of the required quality is one of the primary objectives of any construction project. However, the achievement of the quality objectives is often obstructed by quality risks. Hence quality actions should be designed in a manner such that a risk-based approach should be applied to ensure that the quality risks are addressed in a systematic manner in line with the general principles/processes of QM and RM. However, the research gap#2 which explains that although the measures of Quality Management practices, Quality Risks and Quality Performance have identified in multiple research studies, they are all scattered and do not represent a comprehensive scale of measurement. There is a lack of "off-the-shelf' measurement items for QRM, QR, QP in the literature. Hence the generation of potential measurement items of respective constructs are explained in the next sections.

5.3 Conceptualization and Operationalization of Measurement Scales

5.3.1 Quality Performance Measurement Scale

According to PMI (2003) project success is measured by product and project quality, timeliness, budget compliance, and degree of customer satisfaction. In the context of construction projects, Quality is defined as the conformance to the established requirements and the requirements are regarded as the characteristics of product, process, or services specified by the contracts. (Ledbetter1994, Idrus and Sodangi 2010). Idrus and Sodangi(2010) says that the quality performance of a construction project at the site- level includes the quality of the constructed facility as well as the quality of services. A mix of product and service quality dimensions would therefore be very instrumental to the achievement of site-level quality performance.

Leong et al. (2014) states that quality in construction industry emphasizes the capability to establish requirements with conformance to the quality standard. Requirements are generally redefined by client in the contract agreements and the requirements consist of the established characteristics of products, processes, and services. All the parties involved in the project must fully understand those requirements and expectation to achieve a complete project that meets clients' quality expectation. Moreover, quality performance can be determined by taking clients' satisfaction into consideration. Usually, clients of construction sector experienced dissatisfaction in many aspects including overspend in project cost, delay of completion, poor quality, and incompetent project teams like subcontractors and consultants. The main aim of quality management is to prevent/reduce failures such that the quality objectives are achieved.

Idrus and Sodangi (2010) says that the quality performance of a construction project at the site-level includes the quality of the constructed facility as well as the quality of services. Leong et al. (2014) defined Quality Performance wherein Quality is described as the totality of features required by a product or service to satisfy a given need; fitness for purpose. In other words, quality in construction industry emphasizes the capability to establish requirements with conformance to the quality standard. The study indicates that Quality performance can be measured by considering the nonconformance report (NCR) in the ISO 9000 certified companies.

Moreover, quality performance can be determined by taking clients' satisfaction into consideration. Usually, clients of construction sector experienced dissatisfaction in many aspects including overspend in project cost, delay of completion, poor quality, and incompetent project teams like subcontractors and consultants. Many theories or studies (Rad and Khosrowshahi 1998, Idrus and Sodangi 2010) stress upon 'Get right the first time' which is commonly viewed as an indicator of quality performance. In the context of construction projects, these are measured in the processes of the following submissions made to the Consultant for approval before proceeding with construction activities viz., technical submittals viz., Supplier pre-qualification submittals, Material Submittals, Shop Drawings, Method Statements etc. Some studies measured quality performance through the rate of failures or defects. Takim et al. (2003) insists on zero defects, which in the projects are indicated through the rejections of Material, Works, Testing, rate of reworks/retesting, defects rate, non-conformances etc.

Apart from products, quality performance in construction projects is also measured in the form of services wherein the most common one is the 'Timely response in addressing customer complaints/queries'. Additionally, the final soft measures/perspective measures used to measure quality customer satisfaction which are can be further classified into internal customers who are the staff members, while the external customers are Clients, society and other stakeholders. Employee satisfaction is a key driver to achieve quality, which can be reflected through motivation, involvement, engagement etc. In fact, most of the quality failures which are attributed to human errors or competencies can be addressed through this issue. The client satisfaction which is a central indicator of any project success and mainly quality performance, is obtained through the feed-back results in addition through its reflection in other forms like NCR's, complaint letters, rejections etc. Considering the EFQM requirements and other excellence model requirements, the relationship with other key stakeholders viz., Sub-contractors/Suppliers, Society etc. is vital in measuring quality of services.

Item code	Proposed measurement items for Quality Performance scale	Sample references (from literature)
A1	Approval rate of Technical/Engineering submittals. (eg.: Material Submittals, Shop Drawings, Method Statements etc.)	Rad and Khosrowshahi (1998), Takim et al. (2003), Idrus and Sodangi (2010), Yasamis et al. (2002)
A2	Approval rate of Material Inspections.	Rad and Khosrowshahi (1998), Takim et al. (2003), Idrus and Sodangi(2010), Yasamis et al.(2002)
A3	Approval rate of Work Inspections.	Rad and Khosrowshahi(1998), Idrus and Sodangi(2010), Takim et al.(2003), Yasamis et al.(2002), Low and Ong(2014)
A4	Statutory and Regulatory compliance	BSI (2005); Chin-keng(2011); Banuchandar(2014)
A5	Approval rate of Testing.	Rad and Khosrowshahi(1998), Takim et al.(2003), Idrus and Sodangi(2010), Yasamis et al.(2002)
A6	Defects.	Cha and Kim (2011), Ali (2012)
A7	Rate of completion & effectiveness of training.	Yasamis et al. (2002); Ali et al. (2013)
A8	Rate of completion & effectiveness of auditing.	Yasamis et al. (2002); Kagioglou et al. (2001),
A9	Reworks.	Cha and Kim (2011), Cheung et al. (2004), Ali (2012)
A10	Non-conformances.	Cha and Kim (2011), Leong et al. (2014), Cheung et al. (2004), Idrus and Sodangi (2010), Yasamis et al. (2002)
A11	Cost of Poor Quality.	CII, Shanmughapriya(2015) Chin-keng and Abdul-Rahman (2011)
A12	Project delays due to quality issues.	Idrus and Sodangi(2010), Aibinu and Odeyinka (2006)
A13	Project handing-over items	Chan and Chan (2004); Low and Ong (2014); Nudurupati et al. (2007); Takim et al. (2003)
A14	Timely response in addressing customer complaints/queries. (eg.: closing of NCRs, action items in minutes of meetings etc.)	Kagioglou et al. (2001), Idrus and Sodangi (2010)
A15	Client satisfaction. (eg.: through results of customer satisfaction feedback survey etc.)	Takim et al. (2003), Rad and Khosrowshahi (1998), Ali (2012), Leong et al. (2014), Kagioglou et al. (2001)
A16	Supplier/Sub-contractor performance. (eg.: through results of performance appraisal etc.)	Kagioglou et al. (2001), Llusar (2008)
A17	Employee satisfaction. (eg.: in terms of motivation, involvement, engagement etc.)	Kagioglou et al. (2001); Nudurupati et al. (2007); Cha and Kim (2011)
A18	Relationship with project stakeholders. (eg.: in terms of communication, coordination, cooperation etc.)	Idrus and Sodangi (2010); Ali et al. (2013); Bassioni et al. (2004); Cheung et al. (2004)
A19	Employee turnover	Low and Ong (2014), Chin-keng and Abdul-Rahman (2010); Cha and Kim (2011)
A20	Relationship with society/neighbors. (eg.:in terms of effective communication, less disturbance/pollution etc.)	Idrus and Sodangi(2010), Llusar(2008); Bassioni et al. (2004); Cheung et al.(2004)

Table 5.1: Quality Performance measurement items

5.3.2 Quality Risks Measurement Scale

Ghezavati et al. (2013) states that according to the concept of quality and strive to meet customer expectations, every risk at any stage of work that can affect quality of performance and cause negative customer satisfaction would be considered as quality risks. ISO 31000(2009) states that the aim of risk identification is to generate a comprehensive list of risks based on those events that might create, enhance, prevent, degrade, accelerate or delay the achievement of objectives. Broadly speaking from PDCA cycle of QM, some risks arise at the planning stage which includes deficiencies in the development/establishment of the QM system and the Management's support to implement the system which includes providing resources. The quality risks arising from system related risks include failures during the development/implementation of the system, failure of the system itself, inadequate resources etc. These are the risks related to deficiencies/mistakes in the execution / implementation of the QA/QC processes which affect the quality performance. Apart from these, the human related ones include inadequate supervision, coordination, communication, training, lack of skills, unauthorized activity etc., These are the risks related to the people which affect the quality performance. and the external factors like Regulatory, political, outsourcing etc., are also considered. These are the risks related to the suppliers/sub-contractors, Clients, Consultant, Society, Regulatory authorities etc., which affect the quality performance.

In this study the operational risks related to quality are considered wherein the quality risks are viewed as risk of loss resulting from inadequate or failed internal processes, systems, people and to an extent external events are considered. In this research focus is put mostly on negative risks which lead to negative impact on the quality performance.

Item code	Proposed measurement items for Quality Risks scale	Sample references (from literature)
B1	Poor understanding of the Client needs/project quality requirements.	Love and Edwards (2004), Low and Ong (2014)
B2	Inadequate training provided.	Ghezavati et al. (2013), Love and Edwards (2004); Hanna et al. (2013)
B3	Inadequate management support towards effective implementation of quality system. (in terms of providing resources, motivating, quality culture, management review etc)	Chin-keng and Abdul-Rahman (2011), ISO 9001(2015), Loosemore et al. (2006)
B4	Poor/unrealistic planning.	Loosemore et al. (2006); Khodeir and Mohamed (2015, p 133)
B5	Poor information management systems/controls affecting decision making.	Loosemore et al. (2006)

B6	Careless attitude of workers.	Boateng (2014); Goh (2013)
B7	Shortage of resources (eg.: people, plant & equipment, material etc.)	Ghezavati et al. (2013), Low and Ong (2014), Yildiz et al. (2014), Iqbal et al. (2015)
B8	Inadequate internal reviewing/checking.	Love and Edwards (2004), Ghezavati et al. (2013)
B9	Poor documentation.	Khodeir and Mohamed (2015), Chin-keng and Abdul-Rahman (2011)
B10	Improper construction methods (eg.: using wrong methodology, equipment, measurement etc.)	Khodeir and Mohamed (2015), Ghezavati et al. (2013)
B11	Poor material handling/storing, not done as per Manufacturer's instructions.	Khodeir and Mohamed (2015), El-Karim (2015), Love and Edwards (2004)
B12	Defective material usage at site.	Khodeir and Mohamed (2015), Iqbal et al. (2015), Love and Edwards (2004) El-Sayegh (2008), Loosemore et al. (2006)
B13	Difficulties in measuring results.	Low and Ong (2014)
B14	Defective works resulting in rework/delays. (eg.: due to poor workmanship, errors/mistakes during execution etc.)	El-Sayegh (2008), Love and Edwards (2004), Yildiz et al. (2014), Khodeir and Mohamed (2015), Ghezavati et al.(2013), Chin-keng and Abdul-Rahman(2011), Loosemore et al.(2006)
B15	Execution of works without prior approval of Consultant (eg.: using unapproved Material, Drawing, Method Statement, Sub-contractor etc.)	Loosemore et al. (2006), Low and Ong (2014)
B16	Inspections & Testing methods/frequency deviating from the approved Inspection & Test Plan (ITP).	Loosemore et al. (2006), Khodeir and Mohamed (2015), Low and Ong (2014)
B17	Using bad equipment in poor working condition or not calibrated.	Khodeir and Mohamed (2015), Ghezavati et al. (2013), Iqbal et al. (2015), Loosemore et al. (2006)
B18	Incompetent project staff/unskilled workers	Ghezavati et al. (2013), El-Sayegh(2008), Iqbal et al.(2015), Khodeir and Mohamed(2015), Yildiz et al.(2014), Low and Ong(2014)
B19	Resistance/unwillingness of project members to follow quality procedures.	Loosemore et al. (2006); Low and Ong (2014)
B20	Poor supervision/coordination on site.	Love and Edwards (2004), Iqbal et al. (2015), Loosemore et al. (2006)
B21	Inadequate/incomplete information related to drawings, specifications etc.	Loosemore et al. (2006), El-Sayegh(2008), Ghezavati et al.(2013)
B22	Poor communication/coordination among various project stakeholders.	Khodeir and Mohamed (2015), Iqbal et al. (2015), Chin-keng and Abdul-Rahman (2011), Megha and Rajiv (2013), Loosemore et al. (2006)
B23	Unnecessary interference by Client.	Boateng (2014);
B24	Weak Supplier agreements/contracts leading to creation of potential quality issues/disputes.	Ghezavati et al. (2013); Low and Ong (2014)
B25	Pressure to complete works affecting quality.	Boateng (2014); Low and Ong (2014)
B26	Incompetency & poor performance of Sub-contractor/Suppliers. (eg.: poor quality of submittals/products/services)	Love and Edwards (2004), El-Sayegh(2008), Iqbal et al.(2015), Chin-keng and Abdul-Rahman(2011)

Table 5.2: Quality Risk measurement items

5.3.3 Quality Risk Management Measurement Scale

QRM in this research is defined as actions undertaken by the project team to address (prevent/reduce) quality risks, aiming at enhancing project quality performance. The aim of these practices is to manage quality risks/issues to enhance the quality performance on the project. After reviewing and consolidating the literature related to RM & PM (PMI 2004), the QRM practices are captured into four distinctive dimensions/strategies and following dimensions are proposed: Risk Avoidance, Risk Mitigation, Risk Transference and Risk Acceptance. Table 5.3 shows the literature from which the four QRM practices/strategies are consolidated for managing/reducing quality risks. Zou (2005) states that risk response has been further divided into four actions, i.e. retention, reduction, transfer and avoidance (Berkeley *et al.*, 1991; Flanagan and Norman, 1993). Loosemore et al. (2006) states that in dealing with residual risks which cannot be reduced or eliminated, the choices are to retain them, transfer them to some other party or share them. However, in transferring risks there is a premium charged and opportunity cost associated with the loss of benefit from potential opportunities. (Eg.: outsourcing specialized works while you have your own teams inside). In transferring there is a premium. Risk appetite is an important factor which decides which ones to transfer or which ones to retain, again depending on the cost impact or loss of opportunities. Two options in transferring a risk are to transfer to an external party that specialized in buying risks (Insurance company) or transfer to a business partner/project stakeholder (Sub-contractor/Supplier etc). In both the cases, the conditions are clearly mentioned and agreed by both the parties.

Several researchers claimed that the implementation of preventive activities, such as design reviews, inspection and training is the first step to minimize the potential impact of quality failures (Love et al. 2004; Yates and Lockley 2002; Love and Li 2000). In addition, the proper implementation of a quality management system assures the logical and progressive sequence of work, which prevents or mitigates delays during construction (Abdul-Rahman et al. 2006). The aim of preventive action is to avoid the risk and reduce the probability of QR happening. Reactive action focuses on the response action after QR has happened and attempts to mitigate its impact (Thun and Hoenig 2011). PMI (2013) Expert judgment is input from knowledgeable parties pertaining to the actions to be taken on a specific and defined risk. Expertise may be provided by any group or person with specialized education, knowledge, skill, experience, or training in establishing risk responses. WHO (2012) Specific corrective actions should be developed to prevent recurrence of instances where there have been deviations from established risk control measures, especially for high risks. These actions should ensure that the risk is brought under control as soon as possible in compliance with the established deviation handling procedures. Specific corrective actions should be developed in advance for each identified risk including what is to be done when a deviation occurs, who is responsible for implementing the corrective actions, and that a record will be kept and maintained of the actions taken.

Abdul-rehman (2010) states that understanding the underlying causes of these failures and developing strategies to eliminate or to mitigate their occurrence are important to increase the probability of achieving the project objectives. The first step in reducing the occurrences of quality failure is to study its causes and to develop subsequent effective prevention strategies (Love et al. 2004; Yates and Lockley 2002). Abdelgawad and Fayek (2010) insists that root cause analysis is conducted to identify the root causes of different risk events. Understanding the root causes can help the risk analysts to estimate the probability of occurrence of each risk event based on its root causes and to suggest appropriate risk response strategies to minimize these root causes.

Adopting the definition of a multi-dimensional model from Edwards (2001), QRM can be viewed as a "superordinate construct" wherein QRM represents a general concept that is manifested by multiple dimensions. The study of Edwards (2001) specified that a multi-dimensional construct can allow researchers to match the broad predictors with broad outcomes while claiming that "the relationship between the multi-dimensional construct and its dimensions are not causal forces linking separate conceptual entities, but instead represent associations between a general concept and the dimensions that represent or constitute the construct". In this study, QRM is conceptualized as a multi-dimensional concept which consists of four dimensions: risk avoidance, risk mitigation, risk transfer and risk acceptance. Hence QRM is a multidimensional construct which is conceptualized in terms of its dimensions, wherein the four dimensions RAV, RMI, RTR and RAC are treated as the indicators of the QRM model. These individual dimensions are operationalized with potential measurement items generated from the relevant literature, which are termed as the observed variables measuring or representing the respective dimension. Thus, the observed variables of the dimensions are the indicators of the dimensions, and the dimensions themselves represent as the indicators of the QRM construct (see figure 5.2).

Risk Avoidance	Risk avoidance is a risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact. The aim of this risk treatment strategy is to ensure that potential risks/negative effects hindering the achievement of quality objectives are avoided/prevented, to provide greater assurance that the customer/project requirements would be met. They are a set of proactive measures undertaken by the project team, which focus on establishing and implementing a robust project quality management system, to address/deal with the common root causes leading to potential quality failures/customer dissatisfaction.	PMI (2013), ISO 31000(2009), ISO 10006(2003), ISO 9001(2015), Loosemore et al. (2006), Flanagan (1993), Smith(1999), Mahendra et al.(2013), El-Karim(2015), Goh and Abdul-Rahman(2013)
Risk Mitigation	Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk. It implies a reduction in the probability and/or impact of an adverse risk to be within acceptable threshold limits. The aim of this risk treatment strategy is to reduce/mitigate the occurrence or impact of adverse risks hindering the achievement of quality objectives, whereby it is imperative that taking early action to reduce the probability and/or impact of a risk occurring is often more effective than trying to repair the damage after the risk has occurred. They are a set of quality control actions taken by the project team which focus on verifying whether or not the delivery of products, works, processes, services etc., conform to the customer/project requirements, whereby any deviations or potential non-conformances are detected and acted upon early, before they reach the Consultant/Customer.	PMI (2013), ISO 31000(2009), ISO 10006(2003), ISO 9001(2015), Smith(1999), Mahendra et al.(2013), Loosemore et al.(2006), Flanagan(1993), El-Karim(2015), Goh and Abdul-Rahman(2013)

Risk Transference	Risk transference is a risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response. The aim of this risk treatment strategy is to enable the Contractor to safeguard himself from the negative consequences/impact through shifting/allocating the risk impact to other stakeholders in the Supply chain (Sub-contractors/Suppliers/Manufacturers/3rd party testing etc.), based on the risk source or who is better able to handle/manage those risks. They are a set of risk shifting actions/practices undertaken by the Contractor to shift/allocate the impact of the risk together with ownership of the response onto another stakeholder.	PMI (2013), ISO 31000(2009), ISO 10006(2003), ISO 9001(2015), Smith(1999), Mahendra et al.(2013), Loosemore et al.(2006), Flanagan(1993), El-Karim(2015), Goh and Abdul-Rahman(2013)
Risk Acceptance	Risk acceptance is a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs. The aim of risk treatment strategy is to take appropriate remedial/reactive actions focused on addressing/dealing with the quality failures/defects/non-conformances which have already occurred and resulted in customer dissatisfaction/complaints. They are a set of corrective actions taken by the project team such that the detected quality failures/defects/non-conformances are adequately rectified and addressed, while ensuring that their recurrence is prevented.	PMI (2013), ISO 31000(2009), ISO 10006(2003), ISO 9001(2015), Smith(1999), Mahendra et al.(2013), Loosemore et al.(2006), Flanagan(1993), El-Karim(2015), Goh and Abdul-Rahman(2013)

Table 5.3: Risk Management /Response Strategies

Risk avoidance (RAV - measurement items)

Risk avoidance is a risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact (PMI 2003). PMI (2013) suggests that some risks that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise. The aim of this risk treatment strategy is to ensure that potential risks/negative effects hindering the achievement of quality objectives are avoided/prevented, to provide greater assurance that the customer/project requirements would be met. They are a set of proactive measures undertaken by the project team, which focus on establishing and implementing a robust project quality management system, to address/deal with the common root causes leading to potential quality failures/customer dissatisfaction.

Item code	Proposed Measurement items for Risk Avoidance scale	Sample references (from literature)
C1	We establish and implement Project Quality Plan to provide assurance that the client/project quality requirements are met.	Low and Ong (2014), Willis (1996), Love et al. (2004), Yasamis et al. (2002)
C2	Our Management demonstrates leadership and commitment to quality by providing adequate support (resources, employee motivation/empowerment etc.) needed for effective implementation of quality system.	Low and Ong (2014), Chin-keng and Abdul-Rahman (2011)
C3	We carryout activities to ascertain whether design enables the most efficient construction methods to be used and the planned construction activities are the most effective.	Low and Ong (2014); Idrus and Sodangi (2010); Yasamis et al. (2002)
C4	We ensure to deploy competent staff appropriately as needed for the project, considering relevant education/training, skills, experience etc.	Willis (1996), Low and Ong (2014)
C5	We follow a collaborative approach to solve quality problems/issues with various stakeholders in an amicable way to avoid any potential disputes that may affect quality performance.	Low and Ong (2014), Love et al. (2004)
C6	We establish and implement good controls & monitoring systems for observing trends in quality performance and take appropriate actions to avoid any obstacles hindering the achievement of quality objectives.	Low and Ong (2014); Yasamis et al. (2002)
C7	We establish and follow good communication protocols with all project stakeholders to ensure improved information sharing, coordination, decision making etc., thus avoiding any misunderstanding or ambiguity.	Low and Ong (2014); Idrus and Sodangi (2010)
C8	We believe that purchasing and using modern and updated equipment could be a solution to avoid inappropriate equipment cost as much as possible.	Rad and Khosrowshahi(1998); Low and Ong (2014)
C9	We provide training to communicate various project requirements aimed at enhancing peoples' knowledge, awareness and capabilities.	Love et al. (2004), Low and Ong (2014), Yasamis et al. (2002), Willis (1996)
C10	We obtain clarification/confirmation through RFI (Request for Information), in case any details are not clear.	Low and Ong (2014); Yasamis et al. (2002), Idrus and Sodangi (2010)
C11	We organize/attend meetings with various stakeholders (Client/Consultant/Supplier etc), to discuss and prevent/avoid any potential obstacles which may affect quality performance.	Low and Ong (2014); Idrus and Sodangi (2010)

C12	We avoid using defective material.	Ghezavati et al. (2013), El-Karim (2015); Idrus and Sodangi (2010)
C13	We avoid using any defective equipment/instrument which is not calibrated.	Ghezavati et al. (2013), El-Karim (2015); Idrus and Sodangi (2010)
C14	We avoid selection of Suppliers or material purely based on price/cost, wherein quality is compromised.	Low and Ong (2014); Toni et al. (1995); Kagioglou et al. (2001)
C15	We avoid using unapproved Sub-contractors, Suppliers, Material, Shop drawings, Method statements etc., for executing works.	Low and Ong (2014); Kagioglou et al. (2001)
C16	We follow a rigorous Pre-qualification process to ensure that only competent & reliable Sub-contractors/Suppliers are selected/chosen.	Willis (1996), Low and Ong (2014), Ghezavati et al. (2013)

Table 5.4: Risk Avoidance measurement items

Risk mitigation (RMI - measurement items)

Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk. It implies a reduction in the probability and/or impact of an adverse risk to be within acceptable threshold limits. The aim of this risk treatment strategy is to reduce/mitigate the occurrence or impact of adverse risks hindering the achievement of quality objectives, whereby it is imperative that taking early action to reduce the probability and/or impact of a risk occurring is often more effective than trying to repair the damage after the risk has occurred. They are a set of quality control actions taken by the project team which focus on verifying if the delivery of products, works, processes, services etc., conform to the customer/project requirements, whereby any deviations or potential non-conformances are detected and acted upon early, before they reach the Consultant/Customer.

Item code	Proposed measurement items for Risk Mitigation scale	Sample references (from literature)
C17	We carryout adequate rounds/levels of internal reviews of Submittal documentation to reduce the chances of rejection.	Willis (1996), Yasamis et al. (2002), Low and Ong (2014)
C18	We provide illustrations of how various causes and sub-causes relate to creation of potential quality issues/problems to take appropriate precautionary/control measures.	Rad and Khosrowshahi(1998)
C19	We inspect material delivered to site, to ensure that only approved materials which are free from defects are received.	Low and Ong (2014), Chin-keng and Abdul-Rahman (2011), Willis (1996), Ghezavati et al. (2013), Yasamis et al. (2002)
C20	We ensure that the manufacturer's instructions are strictly followed for material handling, storing/protection, application etc.	Low and Ong (2014); Rad and Khosrowshahi(1998)
C21	We conduct field demonstration by laborers to showcase their understanding of the workmanship quality required.	Rad and Khosrowshahi(1998)
C22	We conduct Tool-box talks to communicate the quality requirements to the project execution teams & workers.	Low and Ong (2014), Yasamis et al. (2002); Ali (2012)

C23	We build mock-ups and ensure the successive works are effectively done in line with these benchmarks, to enhance approval rate.	Low and Ong (2014); Yasamis et al. (2002)
C24	We ensure that all the measuring instruments/equipment used are calibrated and valid certificates and logs are maintained and monitored effectively.	Rad and Khosrowshahi(1998); Low and Ong (2014)
C25	We carryout internal inspection of our works and if we detect any non-compliance, we proactively address them before inviting the Consultant.	Chin-keng and Abdul-Rahman (2011), Willis (1996), Low and Ong (2014), AlMaian et al. (2016), Yasamis et al.(2002)
C26	We conduct internal tests and 3rd party testing as per approved ITP.	Willis (1996), Low and Ong (2014)
C27	We take adequate input from relevant Engineers to prepare Method statements, to make it more realistic/practical during implementation.	Yasamis et al. (2002); Rad and Khosrowshahi(1998)
C28	We use controls like Checklists etc., during our process of internal review/inspection, to crosscheck conformance to quality requirements.	Yasamis et al. (2002); Rad and Khosrowshahi(1998)
C29	We perform audits to check compliance with the project requirements and seeking any areas of improvement.	Chin-keng and Abdul-Rahman (2011), Yasamis et al. (2002)
C30	We carry out Supplier performance evaluation, to take appropriate action against any detected deficiencies, aiming at improved performance.	Chin-keng and Abdul-Rahman (2011), Yasamis et al. (2002), Willis (1996), AlMaian et al. (2016)

Table 5.5: Risk Mitigation measurement items

Risk transference (RTR - measurement items)

Risk transference is a risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response (PMI, 2013). Transferring does not mean disowning the risk by transferring it to a later project or another person without his or her knowledge or agreement. Transference tools can be quite diverse and include, but are not limited to, the use of insurance, performance bonds, warranties, guarantees, etc. Contracts or agreements may be used to transfer liability for specified risks to another party. The aim of this risk treatment strategy is to enable the Contractor to safeguard himself from the negative consequences/impact through shifting/allocating the risk impact to other stakeholders in the Supply chain (Sub-contractors/Suppliers/Manufacturers/3rd party testing etc.), based on the risk source or who is better able to handle/manage those risks. They are a set of risk shifting actions/practices undertaken by the Contractor to shift/allocate the impact of the risk together with ownership of the response onto another stakeholder. Rule is that it is wise to transfer the risk to the party who is best able to manage it.

Item code	Proposed measurement items for Risk Transference scale	Sample references (from literature)
C31	We make the Suppliers/Sub-contractors responsible for their goods & services, covered through Undertaking letter, Warranty/Guarantee, Performance bonds, Insurance etc..	Flanagan (1993), Loosemore et al. (2006)
C32	We transfer some risks to the Insurance companies, which are generally beyond the control of the project stakeholders. (eg.: Natural disasters etc)	Low and Ong (2014); Cheung et al. (2004)
C33	In case of rejection of any Supplier/Sub-contractor’s submittals, we make them responsible to revise & resubmit after addressing the Consultant's comments.	Cheung et al. (2004); Low and Ong (2014)
C34	We require our key Suppliers/Sub-contractors to provide us their process control data for us to keep track of the production quality.	Kagioglou et al. (2001); Idrus and Sodangi (2010)
C35	We make the Suppliers/Sub-contractors responsible for unconditionally replacing any defective material delivered to site by them, at their own expense.	Low and Ong (2014); Kagioglou et al. (2001)
C36	We make the Sub-contractors responsible for rectifying any defective works under their scope, with no liability (cost/time impact) to the Main Contractor.	Low and Ong (2014)
C37	We make the Suppliers/Sub-contractors responsible to provide the necessary training to their staff and Suppliers such that they completely understand the project quality requirements.	Idrus and Sodangi (2010)
C38	In case of any penalties imposed by the Client/Authority due to the quality issues arising from Supplier's goods/services, the same shall be recovered from them.	Low and Ong (2014)
C39	We make the Suppliers/Sub-contractors responsible for ensuring all the statutory/regulatory requirements related to their men, machines/equipment etc., are complied with.	Low and Ong (2014); Kagioglou et al. (2001)
C40	We make our Suppliers/Sub-contractors responsible to ensure that all applicable tests related to their material/products/works are conducted and test reports submitted for approval.	Low and Ong (2014)
C41	We make the Suppliers/Sub-contractors responsible to inspect/audit their Suppliers products/services.	Kagioglou et al. (2001); Idrus and Sodangi (2010)
C42	We make it clear in the Sub-contract agreement/LPO, regarding the Sub-contractor’s/Supplier’s responsibilities/liabilities towards fulfilling the project quality requirements.	Flanagan (1993), Loosemore et al. (2006)

Table 5.6: Risk Transference measurement items

Risk Acceptance (RAC - measurement items)

Risk acceptance is a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs (PMI, 2003). The aim of risk treatment strategy is to be prepared to take appropriate remedial/reactive actions focused on addressing/dealing with the quality failures/defects/non-conformances in case they occur or which have already occurred and resulted in customer dissatisfaction/complaints. They are a set of corrective actions taken by the project team such that the detected quality failures/defects/non-conformances are adequately rectified and addressed, while ensuring that their recurrence is prevented. This strategy requires establishing a contingency reserve, including amounts of time, money, or resources to handle the risks as they come along. This covers the quality failures/risks which pass undetected or could not be controlled through the proactive strategies namely Risk Avoidance and Risk Mitigation. The nature of this PQRM practice is different from the other three, which look at a more proactive approach in preventing risks while this one focuses on how to solve the quality problems if they could not be avoided and if happens. PMI (2013) classifies this strategy to be either passive or active wherein passive acceptance requires no action except to document the strategy, leaving the project team to deal with the risks as they occur, and to periodically review the threat to ensure that it does not change significantly. While on the other hand, active acceptance strategy generally establishes a contingency reserve, including amounts of time, money, or resources to handle the risks. The construct of risk acceptance includes the following items which includes the extent of preparation in the event quality failures/risks occur.

Item code	Proposed measurement items for Risk Acceptance scale	Sample references (from literature)
C43	We have set up a procedure related to control of nonconforming outputs, including carrying out root cause analysis and corrective & preventive actions.	Toni et al. (1995); Kagioglou et al. (2001); Leong et al. (2014)
C44	We establish a contingency reserve, including amounts of time, money, or resources to handle the risks as they come along.	Flanagan (1993); Low and Ong (2014)
C45	In case of rejection of our Submittals, we revise and resubmit after taking the appropriate corrective actions.	Kagioglou et al. (2001); Cha and Kim (2011)
C46	We audit the supply chain of our Suppliers/Sub-contractors based on the quality failures recorded.	Kagioglou et al. (2001); Idrus and Sodangi (2010)
C47	In case of rejection of our material/products, we unconditionally replace them.	Kagioglou et al. (2001)
C48	We ensure that our Suppliers/Sub-contractors are adequately trained to prevent recurrence of failures noticed.	Ali (2012); Yasamis et al. (2002)
C49	In case of rejection of our works or testing, we allocate additional resources and contingency amount to unconditionally repair/Rework/Retest.	Kagioglou et al. (2001)
C50	During project handing over, we deploy additional resources to complete the punch list items for smooth handover to the satisfaction of the Client.	Kagioglou et al. (2001)
C51	In case of any problems with the Suppliers/Sub-contractors (eg.: poor performance, acting opportunistically/taking undue advantage etc) we keep reserved approvals for stand-by Suppliers/Sub-contractors.	Low and Ong (2014); Ali (2012)
C52	In case of any quality violations (regulatory etc), we pay penalties to the Authorities/Client from the contingency amount reserve.	Flanagan (1993); Cha and Kim (2011)
C53	In case of any Customer complaints on the performance of any individual, we investigate the cause and take appropriate actions (eg warning, replacement etc.)	Kagioglou et al. (2001); Yasamis et al. (2002)
C54	We resolve/address quality problems/issues with various stakeholders in an amicable way, through discussion, meetings etc.	Kagioglou et al. (2001)

Table 5.7: Risk Acceptance measurement items

5.4 Discussion on Measurement Scales and proposed Conceptual Framework for Project Quality Risk Management

In chapter 5, the conceptualization and operationalization of QRM practices along with QR and QP have been described. The major contribution of this chapter is to advance the current QM practices by integrating the risk-based thinking/perspective and proposing a comprehensive framework so as to enable the examination the relationship between QRM practices, QR and QP. Considering the deficiencies in the current QM in mitigating which are mentioned in chapter 2 and the research gap#2 mentioned in chapter 1, the need to study more to identify the measurement scales of QRM, QR and QP has been initiated. The citations and the justifications of the measurement items for each construct are mentioned in previous sections of chapter 5. A brief discussion on each of the construct is as below.

QP construct: QP is conceptualized and operationalized with 20 potential items, which covers the general definition of quality performance measurement in the context of construction projects, in terms of conformance to the established requirements and the requirements are regarded as the characteristics of product, process, or services specified by the contracts. These are in line with the previous studies - Idrus and Sodangi 2010). Idrus and Sodangi(2010) which says that the quality performance of a construction project at the site- level includes the quality of the constructed facility as well as the quality of services. From a more practical point of view as per many theories or studies (Rad and Khosrowshahi 1998, Idrus and Sodangi(2010)) stress upon 'Get right the first time' which is commonly viewed as an indicator of quality performance, measured in the processes of the following submissions made to the Consultant for approval before proceeding with construction activities viz., technical submittals viz., Supplier pre-qualification submittals, Material Submittals, Shop Drawings, Method Statements etc. which are used to measure quality performance in many studies(Rad and Khosrowshahi, 1998; Takim et al., 2003; Idrus and Sodangi, 2010; Yasamis et al., 2002; Low and Ong, 2014). Some studies measured quality performance through the rate of failures or defects, which in the projects are indicated through the rejections of Material, Works, Testing, rate of reworks/retesting, defects rate, non-conformances, Cost of Poor quality etc., used as indicators of quality performance in many studies (Cha 2011; Leong et al. 2014; Cheung et al. 2004; Idrus and Sodangi 2010; Yasamis et al. 2002. CII, Shanmughapriya 2015; Chin-keng 2011).

Additionally, the final soft measures/perspective measures used to measure quality customer satisfaction which are can be further classified into internal customers who are the staff members, while the external customers are Clients, society and other stakeholders. The client satisfaction which is a central indicator of any project success and mainly quality performance, is obtained through the feed-back results in addition through its reflection in other forms like NCR's, complaint letters, rejections etc. Moreover, quality performance can be determined by taking clients' satisfaction into consideration. Usually, clients of construction sector experienced dissatisfaction in many aspects including overspend in project cost, delay of completion, poor quality, and incompetent project teams like subcontractors and consultants, including 'Timely response in addressing customer complaints/queries'. Taking into account the EFQM requirements and other excellence model requirements, the relationship with other key stakeholders viz., Sub-contractors/Suppliers, Society etc., is vital in measuring quality of services which are in line with the studies of Takim et al. (2003); Rad and Khosrowshahi(1998) Ali(2012)Leong et al.(2014)Kagioglou et al.(2001)Llusar(2008) Idrus and Sodangi(2010).

QR construct:

QR is conceptualized and operationalized with 26 potential items which are derived from the literature. These are closely related to Ghezavati et al. (2013) which states that the concept of quality and strive to meet customer expectations, every risk at any stage of work that can affect quality of performance and cause negative customer satisfaction would be considered as quality risks. The quality risks arising from system related risks include failures during the development/implementation of the system, failure of the system itself, inadequate resources etc., These are the risks related to deficiencies/mistakes in the execution / implementation of the QA/QC processes which affect the quality performance. Apart from these, the human related ones include inadequate supervision, coordination, communication, training, lack of skills, unauthorized activity etc. The risks related to the suppliers/sub-contractors, Clients, Consultant, Society, Regulatory authorities etc., which affect the quality performance are also covered. In this research focus is put mostly on negative risks which lead to negative impact on the quality performance.

QRM construct:

Based on the operational definitions of QRM 54 list of items have been extracted from the literature to operationalize the QRM construct and grouped under four dimensions namely RAV, RMI, RTR and RAC. QRM is conceptualized as a multi-dimensional concept which consists of four dimensions viz., RAV, RMI, RTR & RAC following the definition and suggestions by Edwards (2001), wherein QRM can be viewed as a "superordinate construct" since it represents a general concept that is manifested by specific dimensions, which has been used by many research studies (Lewis 2003, Jtittner et al. 2003, Tang 2008). Moreover, the four dimensions have been operationalized into sets of potential measurement items which represent their respective constructs.

Risk avoidance (RAV) is conceptualized as the first dimension of the QRM construct, which is considered as a risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact (PMI 2003). They are a set of proactive measures undertaken by the project team, which focus on establishing and implementing a robust project quality management system, to address/deal with the common root causes leading to potential quality failures/customer dissatisfaction. The aim of RAV risk treatment strategy is to ensure that potential risks/negative effects hindering the achievement of quality objectives are avoided/prevented, to provide greater assurance that the customer/project requirements would be met.

Risk mitigation (RMI) is conceptualized as the second dimension of the QRM construct, which is considered as a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk. They are a set of quality control actions taken by the project team which focus on verifying whether or not, the delivery of products, works, processes, services etc., conform to the customer/project requirements, whereby any deviations or potential non-conformances are detected and acted upon early, before they reach the Consultant/Customer. The aim of this risk treatment strategy is to reduce/mitigate the occurrence or impact of adverse risks hindering the achievement of quality objectives, whereby it is imperative that taking early action to reduce the probability and/or impact of a risk occurring is often more effective than trying to repair the damage after the risk has occurred.

Risk transference (RTR) is conceptualized as the third dimension of the QRM construct, which is considered as a risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response (PMI, 2013). Transferring does not mean disowning the risk by transferring it to a later project or another person without his or her knowledge or agreement. Transference tools can be quite diverse and include, but are not limited to, the use of insurance, performance bonds, warranties, guarantees, etc. Contracts or agreements may be used to transfer liability for specified risks to another party. They are a set of risk shifting actions/practices undertaken by the Contractor to shift/allocate the impact of the risk together with ownership of the response onto another stakeholder. Rule is that, it is wise to transfer the risk to the party who is best able to manage it. The aim of this risk treatment strategy is to enable the Contractor to safeguard himself from the negative consequences/impact through shifting/allocating the risk impact to other stakeholders in the Supply chain (Sub-contractors/Suppliers/Manufacturers/3rd party testing etc.), based on the risk source or who is better able to handle/manage those risks.

Risk acceptance (RAC) is conceptualized as the fourth dimension of the QRM construct, which is considered as a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs (PMI, 2003). They are a set of corrective actions taken by the project team such that the detected quality failures/defects/non-conformances are adequately rectified and addressed, while ensuring that their recurrence is prevented. The aim of risk treatment strategy is to be prepared to take appropriate remedial/reactive actions focused on addressing/dealing with the quality failures/defects/non-conformances in case they occur or which have already occurred and resulted in customer dissatisfaction/complaints. This strategy requires establishing a contingency reserve, including amounts of time, money, or resources to handle the risks as they come along. This covers the quality failures/risks which pass undetected or could not be controlled through the proactive strategies namely Risk Avoidance and Risk Mitigation. The nature of this QRM practice is different from the other three, which look at a more proactive approach in preventing risks while this one focuses on how to solve the quality problems if they could not be avoided and if happens. While on the other hand, active acceptance strategy generally establishes a contingency reserve, including amounts of time, money, or resources to handle the risks.

Hence the conceptualization of QRM as a multidimensional construct integrating the risk-based thinking perspective, adds a better combination of a synergic proactive and reactive components to the current QM, thus enabling to overcome the deficiencies of the current QM practices of a more reactive inclined approach in addressing quality failures in ensuring achievement of quality objectives. Figure 5.2 shows the proposed conceptual framework for PQRM model consisting the three measurement scales/constructs namely QRM, QR and QP along with their indicators.

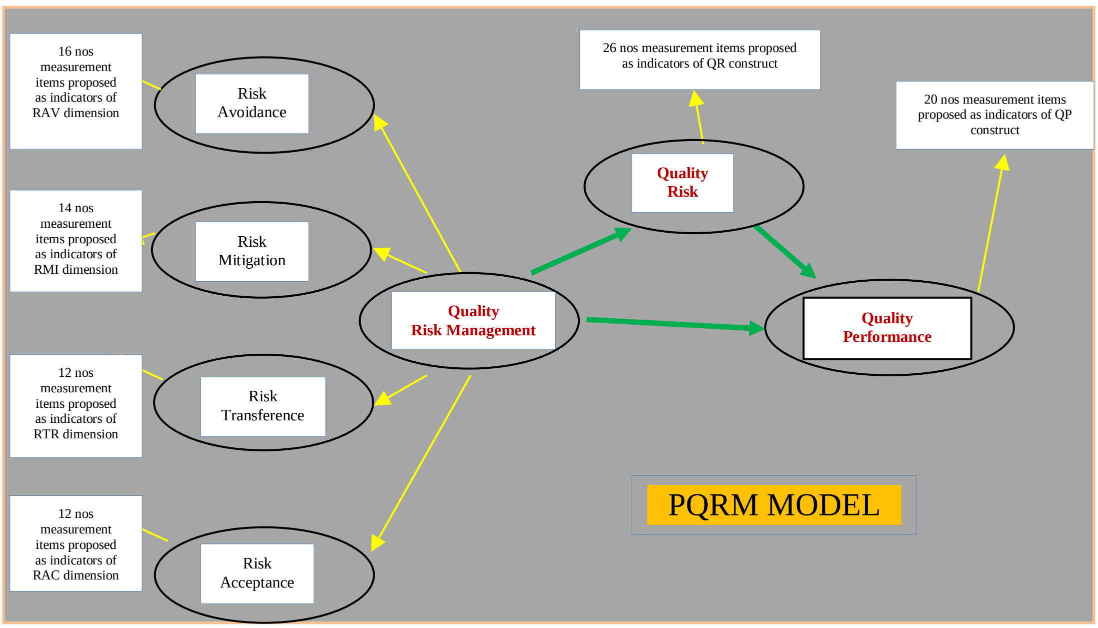

Figure 5.2: Proposed conceptual framework for PQRM model

5.5 Chapter summary

This chapter focuses on addressing research objective#2 whose purpose is to review the concepts of Quality Risk Management (QRM), Quality Risks (QR) and Quality Performance (QP) so as to conceptualize and operationalize the QRM, QR and QP constructs. Firstly, the QRM process is explained based on which a theoretical framework of PQRM is developed in separate sections, wherein the theoretical development of the PQRM framework and the constructs are described. This forms the background for addressing objectives 3 & 4. Secondly, the conceptualization and operationalization has been done for the three constructs. In this study QRM is proposed as a multi-dimensional construct with four distinctive dimensions: risk avoidance (RAV), risk mitigation (RMI), risk transference (RTR) and risk acceptance (RAC). On the other hand, QR and QP are proposed as unidimensional scales. Comprehensive potential measurement items of each QRM, QR and QP practice are proposed which are originated from the literature related to Quality and risk management in construction projects. In general, these items have been modified and adjusted mainly in terms of re-wording to suit the context of QRM undertaken in this study. Moreover, the operationalization of QRM, QR and QP has contributed to project quality and risk management empirical research. This study makes valuable theoretical contributions to the advancement of knowledge about QRM. In order to further enhance the theoretical and conceptual understanding of the measurement scales, the reliability and validity of generated multi- dimensional measurement items are assessed by a rigorous 7-stage scale development process which is described in the next chapter.

Chapter 6: DEVELOPMENT OF MEASUREMENT MODELS

6.1 Chapter Introduction

In this chapter, multi-item measurement and scale development for Quality Risk Management (QRM), Quality Risks (QR) and Quality Performance (QP) are discussed. The purpose of developing these measurement scales is to address the identified gap#2 in chapter 2 which expresses the concern that although the measures of Quality Management practices, Quality Risks and Quality Performance have identified in multiple research studies, they are all scattered and do not represent a comprehensive scale of measurement. It is obvious that there is a lack of "off-the-shelf' measurement scale related to QRM, QR and QP in the literature. Hence, a seven-stage approach of scale development procedure which is explained in chapter 3, is followed in order to develop and validate the measurement scales of QRM, QR and QP. In the previous chapter, the generation of potential measurement items for the three scales was clearly described. In this chapter, the proposed measurement items are purified through the 'Content Adequacy Test, so as to validate the filtered items which in turn are included as final questionnaire items in the Survey Questionnaire. The data from the survey is used to statistically test and validate the three measurement models viz., Quality Risk Management (QRM), Quality Risks (QR) and Quality Performance (QP). Hence the outcome of this chapter addresses research objective#3, which is to develop and validate Quality Risk Management, Quality Risk and Quality Performance Measurement models.

6.2 Measurement Items Purification

Content adequacy assessment is done to ensure that the measurement items which are obtained from the literature are purified and pre-tested prior to development of the Survey questionnaire. The Content adequacy assessment is done using the format which is attached in Appendix B. The content adequacy assessment has been done in two steps as shown in the next sections 6.2.1 & 6.2.2, as per the procedure explained in 3.5.3 of Chapter 3.

The sample used for this content adequacy assessment test consists of 10 Subject Matter Experts (SMEs) who are all practicing Quality Professionals with good qualification and having over a decade experience in the construction industry and good track records were invited to be the Judges.

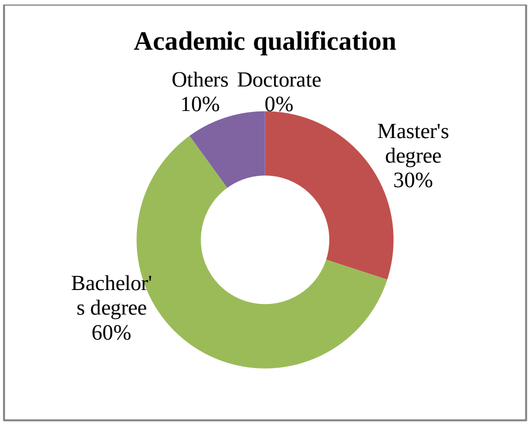

Figure 6.1: Judges' Qualification-wise distribution

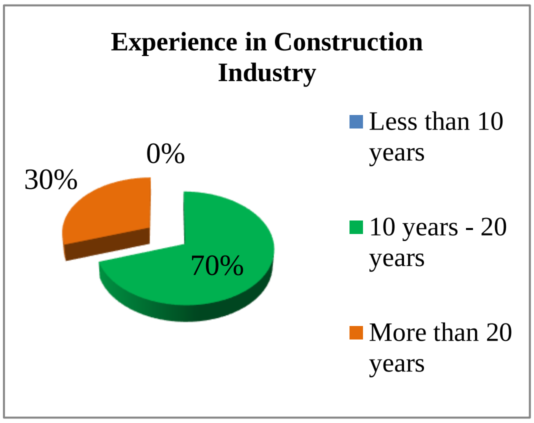

Figure 6.2: Judges' Experience-wise distribution

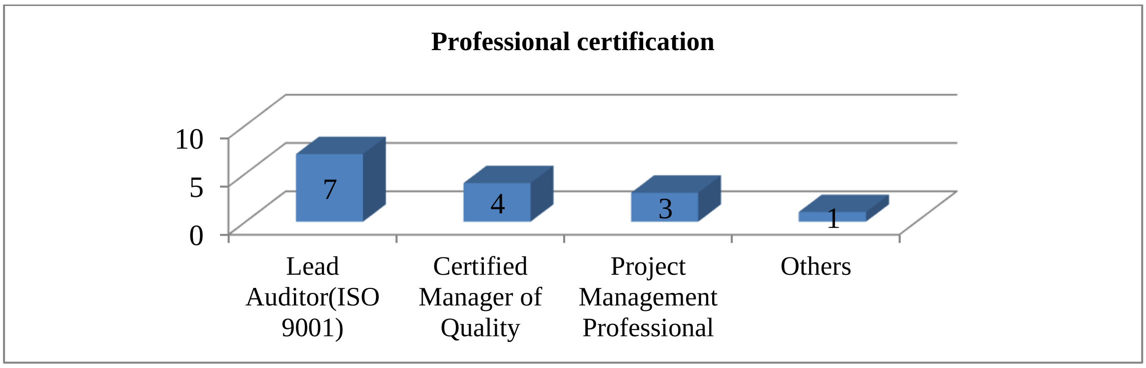

Figure 6.3: Judges' Professional certification-wise distribution

30 % of the Judges have Master's degree while 60 % have Bachelor's degree and the rest 10% are others like Diploma holders. The average overall experience in the construction industry is 18.2 years, while the average experience in Quality Management and Risk Management is 14.2 years and 6.8 years respectively. 30% of the respondents have more than 20 years of experience in the construction industry, while 70% have experience between 10 to 20 years. Almost all the 10 Experts have professional qualifications like CMQ/OE/ PMP etc. demonstrating dedication and commitment in continued professional development. Especially, out of 10 respondents, 7 are ISO 9001 certified auditors while 4 are certified Quality Managers which are representative of professional passion for quality. Most of the respondents have professional qualifications like CMQ/OE/ PMP etc. demonstrating dedication and commitment in continued professional development.

6.2.1 Item categorization (Task-A)

In Task-A, the content adequacy form attached in Appendix B which contains 54 items that are purported to measure four distinct dimensions of QRM namely RAV, RMI, RTR & RAC, was given to each Judge. Each Judge was requested to use the operational definitions of four QRM dimensions provided to them as a guidance to categorize the items into no more than one dimension. Two versions of the content assessment forms were administered randomly, each with the items presented in a different order. This was done to control for response bias that may be due to order effects. The Judges rated each of the 54 QRM items on the extent to which they believed the items were consistent with each of the four dimensions of QRM. After completion of the item-sorting exercise, the measurement items are filtered through the inter-judge agreement considering two criteria namely

(i) Inter-judge agreement percentage

(ii) Fleiss' kappa coefficient(k) test.

The cut off for inter-judge agreement is taken as 60%, by which out of the total 54 items, 7 items have been discarded. Fleiss' Kappa coefficient before discarding of the items is (k) =0.631 and the Fleiss' Kappa coefficient after discarding the items is (k)=0.709. Considering the improvement in the Fleiss' Kappa coefficient, the 7 items have been removed for the items list before proceeding with the next step of content validity assessment. The worksheets are attached in Appendix B.

6.2.2 Content validity(Task-B)

In Task B, the judges were asked to rate the adequacy of the item based on a 2-point scale wherein '0' stands for 'NOT ESSENTIAL' while '1'stands for 'ESSENTIAL'. The aim of task B is to test how adequately each measurement item measures the dimension. The measurement items of each construct viz., QRM, QR and QP are purified using Content validity process wherein the inter-judge agreement has been validated through Content validity ratio(CVR) and Content validity index(CVI). The worksheets are attached in Appendix B.

The cut off for inter-judge agreement is taken as Content validity ratio(CVR) of 0.62 as per the study of Lawshe (1975) and the item purification results are as below

- *Quality performance construct:* Out of total 20 items, 5 items have been discarded and the retained 15 items have been finalized as the final measurement items for the questionnaire with item code having a prefix of 'QP'. Hence the 15 items are coded from QP1 to QP15. The content validity index (CVI) is 0.85, which is good indication of inter-judge agreement.
- *Quality risks construct:* Out of total 26 items, 5 items have been discarded and the retained 21 items have been finalized as the final measurement items for the questionnaire with item code having a prefix of 'QR'. Hence the 21 items are coded from QR1 to QR21. The content validity index(CVI) is 0.88, which is good indication of inter-judge agreement.
- *Quality risk management construct:* Out of total 47 items, 8 items have been discarded and the retained 39 items have been finalized as the final measurement items for the questionnaire with item code having a prefix of 'RAV' for Risk Avoidance items, 'RMI' for Risk mitigation items, 'RTR' for Risk transference items and 'RAC' for Risk acceptance items. Hence the 12 RAV items are coded from RAV1 to RAV12 and the 9 RMI items are coded from RMI1 to RMI9. Similarly, the 9 RTR items are coded from RTR1 to RTR9 while the 9 RAC items coded from RAC1 to RAC9. The content validity index (CVI) is 0.91, which is good indication of inter-judge agreement.

The worksheets, indicating both the items discarded and retained are attached in Appendix B.

6.3 Data collection through Survey

6.3.1 Survey questionnaire design & development

Considering the aim of the research study which is to evaluate the impact of Quality Risk Management on Quality Risks and Quality Performance, in the UAE construction projects and to address research objectives 3 & 4 along with testing the hypotheses (H1, H2 & H3), a survey method using a structured survey questionnaire was used for data collection. The data collected from this survey is used to examine the relationship among quality risks, quality risk management practices and quality performance.

The survey instrument in the form of a questionnaire which is included in Appendix C, consists of the following four sections

- *Section 1 - Respondent, company & project details:* In this section the respondents are expected to provide some of individual details related to their identification, education, experience and additionally some basic information about their company and projects. A statement of confidentiality has been issued wherein assurance has been provided that all information from this survey will be used for purely academic purposes and shall remain strictly anonymous.
- *Section 2 - Quality Risk Management:* This section of the questionnaire has 39 items which indicate/measure the extent to which quality actions are taken with an aim to avoid/control quality risks and enhancing quality performance in construction projects. In this section, the respondent was asked to indicate (√ tick) the extent/frequency of the following actions which are taken in your project to reduce/control quality risks, aimed at enhancing quality performance. A five-point Likert scale (1= Never; 2=Rarely; 3=Sometimes; 4=Frequently; 5=Always) has been adopted to assign the score against each item.
- *Section 3 - Quality Risks:* This section of the questionnaire has 21 items which indicate/measure the level of risks in construction projects. In this section, the respondent is required to provide score (√ tick) indicating the overall changes in the risk levels for the mentioned quality risks in his project. A five-point Likert scale *(1=Decreased significantly; 2=Decreased; 3=No change; 4=Increased; 5=Increased significantly)* has been adopted to assign the score against each item.
- *Section 4 - Quality Performance:* This section of the questionnaire has 15 items which indicate/measure the quality performance in construction projects. In this section, the respondent was asked to indicate (√ tick) indicating the overall changes related quality performance in his project. For items QP1 to QP4, a five-point Likert scale *(1=Decreased significantly; 2=Decreased; 3=No change; 4=Increased; 5=Increased significantly)* has been adopted to assign the score against each item. For items QP5 to QP9, a five-point Likert scale *(1= Strongly disagree; 2=Disagree;3=Neutral;4=Agree;5=Strongly Agree)* has been adopted to assign the score against each item. For items QP10 to QP15, a five-point Likert scale *(1=Significantly worsened; 2=Worsened; 3=No change; 4=Improved; 5=Significantly improved)* has been adopted to assign the score against each item.

6.3.2 Pilot study

The questionnaire has been sent to 10 Quality professionals for a preliminary study prior to formal sending to the sample population. The intention of conducting this pilot study is

(i) to detect if there is any confusion/ambiguity in understanding the questions,

(ii) to get any feed-back from the respondents which could be used to enhance the quality of questionnaire

(iii) to see how much time is taken to answer the full questionnaire

The purpose was to identify any language ambiguities or perceived clarity of items included in the survey, while getting a rough estimation of the approximate time needed to complete the survey. There were no significant ambiguities noted in the pilot study questionnaire but only minor wording discrepancies and comments which were then used to further refine the survey instrument. The recorded time in minutes taken to complete the trial Survey questionnaire by the 10 individuals is 47, 49, 34, 43, 35, 48, 50, 32, 42 and 46. Based on the pilot study, as per the obtained 'median' value of 44.5 minutes and average of 42.6 minutes, it has been concluded that answering all the items in the questionnaire may take approximately 45 minutes and respondents were advised accordingly.

6.3.3 Sampling

After a thorough review of sampling strategies as explained in Chapter 3, the selection of sample was based on convenience sampling approach where the author obtained the sampling units from the personal contacts of the author or contacts through recommendation of his friends. Based on a set of criteria- practicing quality professionals (Quality Managers, Quality Engineers etc.) working for the Main Contractor, as the research study is done from the Main Contractor perspective. As the scope of the research is focused / oriented towards the Main Contractor perspective, mainly the Quality professionals working for Main Contractor in the UAE construction projects were expected/required to answer this questionnaire. According to recommendations of Hinkin et al. (1995), the item-to-response ratios should range from 1:4 (Rummel 1970) to 1: 10 (Schwab 1980) for the factor analysis of the scale. However, for this study a conservative approach is adopted and a final target sample of around 400 has been set. There were altogether 258 usable questionnaires, so the adequacy of item-to-response ratio is far beyond the recommended minimum ratio.

6.3.4 Questionnaire administration and Data collection

A structured survey questionnaire consisting of 5 sections was sent to around 415 practicing quality professionals (Quality Managers, Quality Engineers etc.) working for the Main Contractor, as the research study is done from the Main Contractor perspective. The purpose of the survey is to rate the extent of implementation of QRM practices and to evaluate its effect/impact on Quality risks and Quality performance.

Data was collected through a survey mostly which was distributed at construction projects through know sources. Initially, the interest/willingness of the potential respondents was enquired through telephone calls or face-to-face meeting, prior to proceeding with data collection. Further to getting their willingness, survey questionnaire was distributed enclosed with an invitation letter (see Appendix C) and then there was a follow up call to remind the key informants to respond. A total of 264 survey questionnaire responses were received representing 63.61 % response rate. In this study, a complete case approach was adopted to deal with the missing data i.e. the respondent is eliminated if missing data found on any variable (Hair et al. 2009). Therefore, only 258 copies of the questionnaire were valid, as 6 responses were deleted. Below tables shows the demographic information of the respondents along with other details

Designation of respondents	No of respondents	Proportion (%)
Quality Manager	43	17%
Quality Engineer	215	83%
Others	0	0%
Total	258	100%

Table 6.1: Survey results - Respondents' Designation details

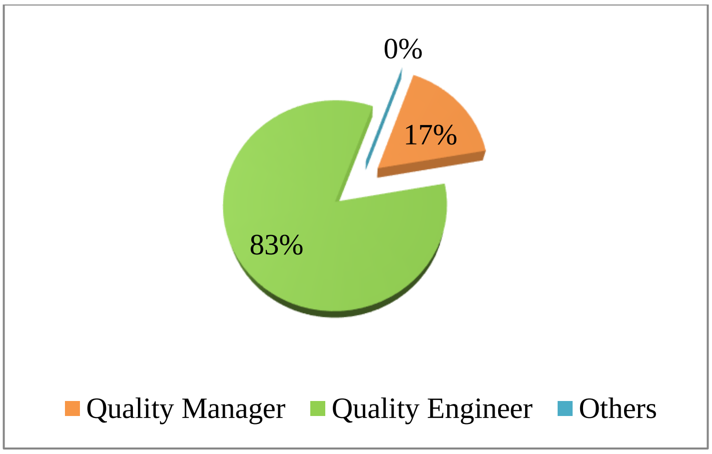

Figure 6.4: Survey respondents' Designation-wise distribution

The sample used for the survey consists of 258 QA/QC professionals working in the UAE construction projects, who are Quality Managers (17%) and Quality Engineers (83%). This is reflecting the general practice in the UAE construction projects which has an average quality team of around 5 QA/QC Engineers or Inspectors headed by a Project Quality Manager.

Academic Qualification	**No of respondents**	**Proportion (%)**
Master's degree	14	5%
Bachelor's degree	208	81%
Others	36	14%
Total	258	100%

Table 6.2: Survey results - Respondents' Academic qualification details

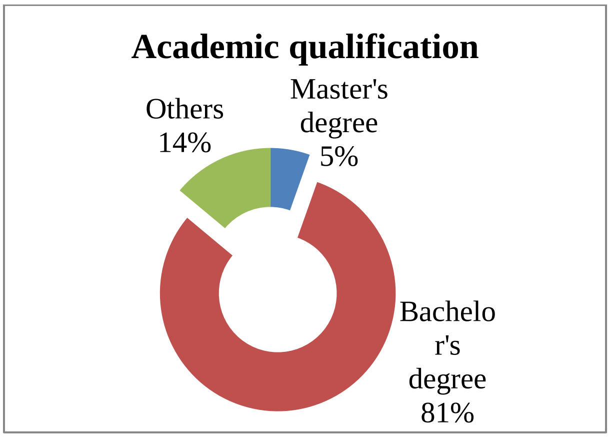

Figure 6.5: Survey respondents' Qualification-wise distribution

The sample represents 5 % have Master's degree while 81 % have Bachelor's degree and the remaining 14 % consists of mostly Diploma degrees and secondary/school education. It is evident that the quality professionals working in the projects are mostly with a Bachelor's degree as the nature of the job concentrates mostly on Quality control aspects involving direct field inspections, testing etc. and less of QA. QA aspects like preparation of PQP, quality procedures, Audits, Training etc. are centralized and operated from HO wherein more qualified people with Master's degrees are preferred as it needs more writing/academic skills with soft skills like English language writing etc., which obviously are regarded as high-income bracket and hence centralized operations to make more economic from budget point of view, especially considering the post-global economic recession in the last decade. From the data, it can be observed that almost 90% of the QA/QC Engineers holding Master's degree are only put on the projects with high value segment of contract value > 500 Million Dirhams.

Total experience in Construction industry	No of respondents	%
Less than 5 years	28	11%
5 years - 10 years	134	52%
More than 10 years	96	37%
Total	258	100%

Table 6.3: Survey results - Respondents' Experience details

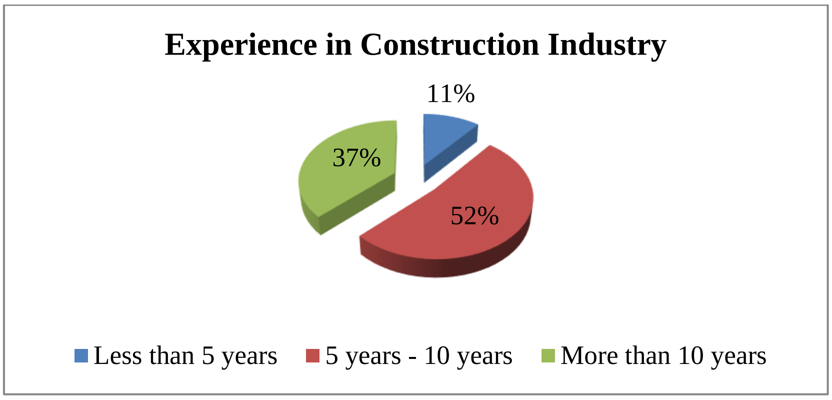

Figure 6.6: Survey Respondents' Experience-wise distribution

Among the 258 respondents, 11% are have construction field experience less than 5 years, while 52% have experience between 5 years to 10 years, and 37% have field experience more than 10 years. Additionally, some details pertaining to their company and projects have been gathered for getting an overall comparison of the background or context of operations. As per the scope of the survey and targeted population, all the respondents are working for Main Contractors in the UAE and most of them (91%) are ISO 9001 certified companies.

Figure 6.7: Map of United Arab Emirates (UAE)

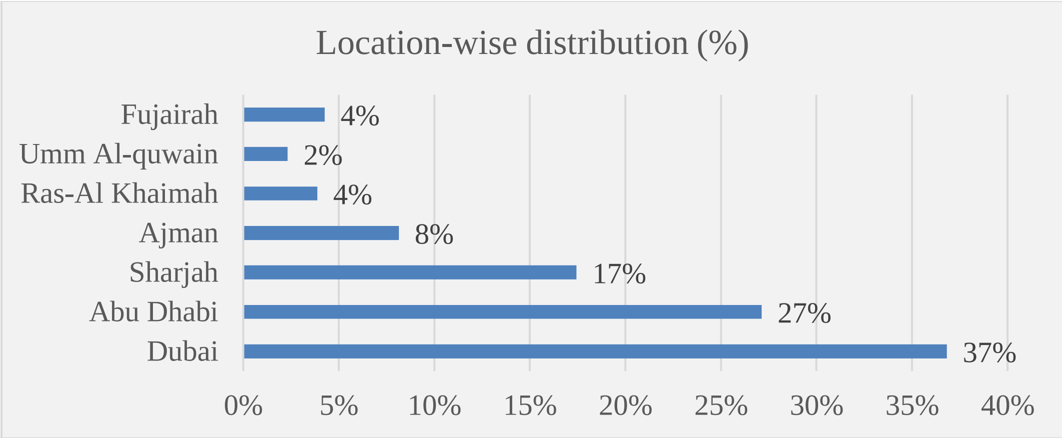

Figure 6.8: Location-wise distribution

Regarding the project geographical location details, 37 % of projects are located in the emirate of Dubai, 27% are from Abu Dhabi, 17% from Sharjah while the balance 18% are from the other 4 emirates namely Fujairah, Ajman, Ras-Al-Khaimah and Umm Al-Quwain.

Project value (AED in millions)	No of cases	%
< 100	29	11%
100 to 500	146	57%
> 500	83	32%
Total	258	100%

Table 6.4: Survey results - Project contract value details

The project contract values of 32% of the cases are more than 500 Million Dirhams while majority of the cases constituting 57% are between the range of 100 to 500 Million and a small part of 11% are less than 100 million.

Project duration(years)	No of cases	%
< 1	23	9%
1 to 2	147	57%
> 2	88	34%
Total	258	100%

Table 6.5: Survey results - Project duration details

The project duration of 9% of the cases are less than 1 year while majority of the cases constituting 57% are between the range of 1 to 2 years and 34% are above 2 years.

6.4 Quality Risk Management Measurement Model

6.4.1 Scale construction and purification

Assessment of correlation using Pearson's correlation coefficient method

Before starting EFA, the inter-item correlations in the respective constructs are assessed *using Pearson's correlation coefficient method*. The items which "correlated negatively" or "weakly correlate with other items" in the same construct are removed. The inter-item correlation results for the 4 proposed QRM dimensions (RAV, RMI, RTR, RAC) are detailed in separate tables as below.

Inter-Item Correlation Matrix (SPSS output)

	RAV1	RAV2	RAV3	RAV4	RAV5	RAV6	RAV7	RAV8	RAV9	RAV10	RAV11	RAV12
RAV1	1.000	.867	.883	.851	.777	.782	.828	.797	.872	.755	.841	.900
RAV2	.867	1.000	.764	.774	.693	.705	.714	.727	.753	.641	.706	.704
RAV3	.883	.764	1.000	.744	.696	.679	.728	.717	.768	.672	.736	.765
RAV4	.851	.774	.744	1.000	.905	.923	.914	.923	.819	.696	.780	.762
RAV5	.777	.693	.696	.905	1.000	.837	.823	.835	.781	.657	.769	.689
RAV6	.782	.705	.679	.923	.837	1.000	.846	.851	.765	.661	.724	.686
RAV7	.828	.714	.728	.914	.823	.846	1.000	.854	.783	.675	.753	.771
RAV8	.797	.727	.717	.923	.835	.851	.854	1.000	.767	.650	.720	.710
RAV9	.872	.753	.768	.819	.781	.765	.783	.767	1.000	.886	.914	.777
RAV10	.755	.641	.672	.696	.657	.661	.675	.650	.886	1.000	.789	.667
RAV11	.841	.706	.736	.780	.769	.724	.753	.720	.914	.789	1.000	.762
RAV12	.900	.704	.765	.762	.689	.686	.771	.710	.777	.667	.762	1.000

Table 6.6: Pearson's correlation coefficient between items of Risk Avoidance (RAV)

The Pearson's correlation coefficient values in table 6.6 suggests that all the 12 RAV items demonstrate good correlation values between each other with all of them above .50, thus suggesting that all the items adequately represent the measurement scale RAV. Hence it is decided to proceed forward without dropping any item.

Inter-Item Correlation Matrix (SPSS output)

	RMI1	RMI2	RMI3	RMI4	RMI5	RMI6	RMI7	RMI8	RMI9
RMI1	1.000	.914	.848	.778	.749	.898	.921	.826	.697
RMI2	.914	1.000	.777	.713	.690	.818	.830	.786	.653
RMI3	.848	.777	1.000	.886	.881	.770	.789	.761	.635
RMI4	.778	.713	.886	1.000	.746	.713	.724	.668	.578
RMI5	.749	.690	.881	.746	1.000	.681	.685	.675	.539
RMI6	.898	.818	.770	.713	.681	1.000	.815	.777	.629
RMI7	.921	.830	.789	.724	.685	.815	1.000	.753	.640
RMI8	.826	.786	.761	.668	.675	.777	.753	1.000	.822
RMI9	.697	.653	.635	.578	.539	.629	.640	.822	1.000

Table 6.7: Pearson's correlation coefficient between items of Risk Mitigation (RMI)

The Pearson's correlation coefficient values in table 6.7 suggests that almost all the 9 RMI items demonstrate good correlation values between each other by majority of them above .50, with very few exceptions like RMI 4 & 5. On an overall, it is decided to proceed with all the items without any dropping, as they look that all the items adequately represent the measurement scale RMI.

Inter-Item Correlation Matrix (SPSS output)

	RTR1	RTR2	RTR3	RTR4	RTR5	RTR6	RTR7	RTR8	RTR9
RTR1	1.000	.874	.824	.764	.799	.771	.892	.771	.904
RTR2	.874	1.000	.718	.666	.693	.694	.811	.700	.768
RTR3	.824	.718	1.000	.929	.944	.934	.765	.653	.752
RTR4	.764	.666	.929	1.000	.872	.863	.708	.613	.702
RTR5	.799	.693	.944	.872	1.000	.884	.736	.635	.730
RTR6	.771	.694	.934	.863	.884	1.000	.743	.642	.709
RTR7	.892	.811	.765	.708	.736	.743	1.000	.846	.795
RTR8	.771	.700	.653	.613	.635	.642	.846	1.000	.708
RTR9	.904	.768	.752	.702	.730	.709	.795	.708	1.000

Table 6.8: Pearson's correlation coefficient between items of Risk Transference (RTR)

The Pearson's correlation coefficient values in table 6.8 suggest that all the 9 RTR items demonstrate good correlation values between each other with all of them above .50, thus suggesting that all the items adequately represent the measurement scale RTR. Hence it is decided to proceed forward without dropping any item.

Inter-Item Correlation Matrix (SPSS output)

	RAC1	RAC2	RAC3	RAC4	RAC5	RAC6	RAC7	RAC8	RAC9
RAC1	1.000	.831	.704	.609	.614	.748	.620	.659	.634
RAC2	.831	1.000	.552	.492	.470	.587	.491	.490	.497
RAC3	.704	.552	1.000	.893	.875	.669	.611	.623	.528
RAC4	.609	.492	.893	1.000	.770	.559	.503	.513	.405
RAC5	.614	.470	.875	.770	1.000	.610	.561	.610	.484
RAC6	.748	.587	.669	.559	.610	1.000	.872	.888	.871
RAC7	.620	.491	.611	.503	.561	.872	1.000	.777	.752
RAC8	.659	.490	.623	.513	.610	.888	.777	1.000	.749
RAC9	.634	.497	.528	.405	.484	.871	.752	.749	1.000

Table 6.9: Pearson's correlation coefficient between items of Risk Acceptance(RAC)

The Pearson's correlation coefficient values in table 6.9 suggests that majority of the 9 RMI items demonstrate good correlation values between each other by majority of them above .50, with very few exceptions like RAC 2 & 9. However, in the case of RAC 2 & 9 less than half of the cases are below .50, but on the borderline. Hence it is decided to proceed with all the items without any dropping, with an assumption that they would be filtered during the factor analysis stage of construct validity testing. Hence the final RAC construct can be proceeded without the eliminated items.

Assessment of unidimensionality using EFA method

The unidimensionality of the QRM components is addressed by carrying out EFA using SPSS software and the results are presented in table 6.10. Firstly, the Kaiser-Meyer-Olkin test (KMO) is run for testing the sampling adequacy for running EFA, which is compared against the suggested criteria 0.60 (Worthington and Whittaker 2006). The KMO values for all the four individual constructs is greater than 0.80 which fulfills the sampling adequacy requirements of min 0.60. The Eigenvalues for the four constructs are greater than 1.0. The Cronbach's alpha test was adopted to assess the consistency of the entire scale wherein Cronbach's alpha is a reliability statistic. The Cronbach's alpha values for all the four individual constructs is greater than 0.90 which fulfills the criteria of reliability required by Cronbach's alpha > 0.70 (Hair et al. 2009). Hence it can be concluded that the unidimensionality of each dimension is supported, and altogether 39 items are retained as items for the QRM construct, wherein there are 12 items in RAV and 9 items each in RMI, RTR and RAC dimensions respectively, as shown in table 6.10.

QRM measurement items	Dimension 1: RISK AVOIDANCE		Dimension 2: RISK MITIGATION		Dimension 3: RISK TRANSFERENCE		Dimension 4: RISK ACCEPTANCE	
	Factor loadings	**Communalities**	**Factor loadings**	**Communalities**	**Factor loadings**	**Communalities**	**Factor loadings**	**Communalities**
RAV1	0.951	0.904						
RAV2	0.847	0.717						
RAV3	0.856	0.733						
RAV4	0.947	0.896						
RAV5	0.887	0.788						
RAV6	0.887	0.787						
RAV7	0.909	0.826						
RAV8	0.896	0.803						
RAV9	0.926	0.857						
RAV10	0.817	0.668						
RAV11	0.889	0.790						
RAV12	0.861	0.741						
RMI-1			0.963	0.927				
RMI-2			0.906	0.821				
RMI-3			0.925	0.855				
RMI-4			0.856	0.733				
RMI-5			0.835	0.698				
RMI-6			0.896	0.802				
RMI-7			0.903	0.816				
RMI-8			0.887	0.788				
RMI-9			0.773	0.597				
RTR-1					0.945	0.894		
RTR-2					0.860	0.739		
RTR-3					0.937	0.879		
RTR-4					0.887	0.787		

RTR-5					0.909	0.827		
RTR-6					0.902	0.814		
RTR-7					0.906	0.821		
RTR-8					0.813	0.660		
RTR-9					0.879	0.772		
RAC-1							0.861	0.741
RAC-2							0.720	0.518
RAC-3							0.867	0.751
RAC-4							0.769	0.591
RAC-5							0.805	0.647
RAC-6							0.920	0.847
RAC-7							0.837	0.701
RAC-8							0.854	0.730
RAC-9							0.800	0.640
Average	**0.889**	**0.793**	**0.883**	**0.782**	**0.893**	**0.799**	**0.826**	**0.685**
Kaiser-Meyer-Olkin test(KMO)	**0.932**		**0.905**		**0.912**		**0.864**	
% Variance of scale	**79.30**		**78.200**		**80.00**		**68.50**	
Eigen value of construct	**9.50**		**7.000**		**7.20**		**6.165**	
Cronbach's alpha of scale	**0.976**		**0.965**		**0.968**		**0.942**	

Table 6.10: Assessment of unidimensionality using EFA method

Item parceling

In this study item parceling is done as each scale has demonstrated unidimensionality, which is a pre-requisite for proceeding with obtaining composite measures through the item parceling method. The purpose of adopting item parceling is take the advantage of increased model fitness due to reduced number of items, wherein the main objectives of this research is to examine the relationship between constructs. The significance of item parceling and the basis or procedure are explained in Chapter 3. The parcels for each construct have been formed by grouping theoretically meaningful parcels which is one of the popularly used item parceling method. The below table shows the parcels formed for each construct along with the corresponding explanation provided in the remarks column.

Assessment of un-dimensionality using EFA method

After item parceling as shown in table 6.11, the unidimensionality of the QRM components is addressed by carrying out EFA using SPSS software and the results are presented in table 6.12. Firstly, the Kaiser-Meyer-Olkin test (KMO) is run for testing the sampling adequacy for running EFA, which is compared against the suggested criteria 0.60 (Worthington and Whittaker 2006). The KMO values for all the four individual constructs is greater than 0.700 which fulfills the sampling adequacy requirements of min 0.60. The Eigenvalues for the four constructs are greater than 1.0. The Cronbach's alpha test was adopted to assess the consistency of the entire scale wherein Cronbach's alpha is a reliability statistic. The Cronbach’s alpha values for all the four individual constructs is greater than 0.800 which fulfills the criteria of reliability required by Cronbach's alpha >0.70 (Hair et al. 2009). Hence it can be concluded that the undimensionality of each dimension is supported, and altogether 12 item parcels are retained as indicators for the QRM construct, wherein there are 3 item parcels each in RAV, RMI, RTR and RAC dimensions respectively, as shown in table 6.12.

Constructs	Parcels	Measurement Items	Remarks *(justification for item parceling grouped under theoretically meaningful clusters)*
Risk Avoidance (RAV)	RAV_P1	RAV1, RAV2, RAV3, RAV12	These are considered to be generally reflecting the quality planning activities related to establishing procedures, Management supports through providing appropriate resources etc.
	RAV_P2	RAV4, RAV5, RAV6, RAV7 RAV8	These are considered to be generally reflecting the QA/QC actions related to the soft skills implementation of procedures and people viz., communication, training/awareness, problem solving skills, people management skills, monitoring/controls etc.
	RAV_P3	RAV9, RAV10, RAV11	These are considered to be generally reflecting the QA/QC actions related to avoiding some bad practices directly affecting quality and which are more specific viz., avoiding using defective material, defective equipment, unapproved material/suppliers/sub-contractors/method statements etc.
Risk Mitigation (RMI)	RMI_P1	RMI1, RMI2, RMI6, RMI7	These are considered to be generally reflecting the in-process QA/QC actions focusing on compliance viz., internal review of documentation, inspection and internal & external testing.
	RMI_P2	RMI3, RMI4, RMI5	These are considered to be generally reflecting the QA/QC actions focusing on ensuring the project requirements viz., Manufacturer's instructions and other project quality requirements are properly made understood to the relevant personnel through tool-box talks, mock-ups etc.
	RMI_P3	RMI8, RMI9	These are considered to be generally reflecting the post-process QA/QC actions focusing on general performance/process compliance viz., audits and Supplier performance evaluation.
Risk Transference (RTR)	RTR_P1	RTR1, RTR2, RTR9	These are considered to be generally reflecting the Main contractor safeguarding himself contractually/legally through Sub-contractor agreement/Purchase Order, 3rd party insurance etc.
	RTR_P2	RTR3, RTR4, RTR5, RTR6	These are considered to be generally reflecting the Suppliers/sub-contractors' fulfilment of responsibilities related to corrective actions including resubmissions/reworks related to rejections of submittals, works, material etc.
	RTR_P3	RTR7, RTR8	These are considered to be generally reflecting the Suppliers/sub-contractors' fulfilment of responsibilities related to men, machines/equipment, testing etc.
Risk Acceptance (RAC)	RAV_P1	RAC1, RAC2	These are considered to be generally reflecting the being of preparedness to handle risks as they come along by being ready with contingency amounts and conducting root-cause analysis with an aim of preventing recurrence of quality failures/risks.
	RAV_P2	RAC3, RAC4, RAC5	These are considered to be generally reflecting the Main Contractors' fulfilment of responsibilities related to corrective actions including resubmissions/reworks related to rejections of submittals, works, material etc.
	RAV_P3	RAC6, RAC7, RAC8, RAC9	These are considered to be generally reflecting the Main Contractors' fulfilment of responsibilities related to responding to failures which have already occurred, so as to reduce the effect and take actions to target completion or closing of issues viz., de-snagging, penalties for regulatory violations, solving issues amicably with other stakeholders etc.

Table 6.11: Item parceling of QRM construct

Constructs	Parcels	Factor loadings	Communalities	Determinant	Kaiser-Meyer-Olkin Measure (KMO)	Bartlett's Test of Sphericity	Degrees of freedom (df)	Chi-square (r)	% Variance of scale	Eigen value of construct	Cronbach's alpha of scale
Risk Avoidance (RAV)	RAV_P1	0.951	0.904	0.072	.767	0.00	3	670	89	2.7	0.938
	RAV_P2	0.939	0.882								
	RAV_P3	0.939	0.882								
Risk Mitigation (RMI)	RMI_P1	0.949	0.901	0.11	0.730	0.00	3	563	85.4	2.6	0.915
	RMI_P2	0.918	0.843								
	RMI_P3	0.905	0.818								
Risk Transference (RTR)	RTR_P1	0.954	0.910	0.09	0.736	0.00	3	608	87.0	2.6	0.924
	RTR_P2	0.910	0.828								
	RTR_P3	0.931	0.866								
Risk Acceptance (RAC)	RAC_P1	0.878	0.771	0.290	0.728	0.00	3	316	76.2	2.3	0.844
	RAC_P2	0.863	0.745								
	RAC_P3	0.877	0.770								

Table 6.12: Assessment of unidimensionality of QRM sub-scales

6.4.2 Scale validation using CFA method

This section covers the scale validation process to establish/confirm the dimensional structure of the model using CFA approach in AMOS, wherein the Convergent validity and Discriminant validity of the scales are tested to validate the scales. The competing models are compared and evaluated to propose the final measurement model which emerges out with the best fit among the competing models.

Convergent validity:

As shown in the below table 6.13, all factor loadings (λ) are greater than 0.50, while and all the composite reliabilities are greater than 0.70 and all the AVE values that are higher than 0.50. Based on these results, it can be confirmed that the scales show acceptable convergent validity.

Constructs	**Parcels**	**Standardized regression weights** (w)	**Squared Multiple Correlation or Variance explained** (S)	**Error Variance** (e)	**Composite Reliability** (CR)	**Average Variance Extracted** (AVE)
Risk Avoidance (RAV)	RAV_P1	0.936	0.876	0.124	0.94	0.83
	RAV_P2	0.902	0.814	0.186		
	RAV_P3	0.902	0.814	0.186		
Risk Mitigation (RMI)	RMI_P1	0.962	0.925	0.075	0.92	0.79
	RMI_P2	0.863	0.745	0.255		
	RMI_P3	0.829	0.687	0.313		
Risk Transference (RTR)	RTR_P1	0.964	0.929	0.071	0.93	0.81
	RTR_P2	0.836	0.699	0.301		
	RTR_P3	0.889	0.790	0.210		
Risk Acceptance (RAC)	RAC_P1	0.816	0.666	0.334	0.84	0.64
	RAC_P2	0.776	0.602	0.398		
	RAC_P3	0.814	0.663	0.337		

e = 1 - Squared Multiple Correlation
t = Standardized regression weights / Error Variance
CR = Square of Sum of all factor loadings /(Square of Sum of all standardized regression weights + Sum of all error variances
AVE = Sum of square of standardized regression weights / total no. of indicators

Table 6.13: Convergent validity of QRM sub-scales

Discriminant validity:

Moreover, another more robust discriminant validity test suggested by Hair (2009), Lawson et al. (2008), and Swink and Nair, (2007) was used in this study, which states that if the AVE values for both the constructs that make up the pair are higher than the square of the inter-correlation between any two constructs in the model, then the latent construct explains its assigned item that it shares with other constructs.

Inter-correlation	Φ	Φ2	Is discriminant validity supported (AVE > Φ2)
RAV and RMI	0.55	0.302	Yes
RAV and RTR	0.73	0.533	Yes
RAV and RAC	0.59	0.348	Yes
RMI and RTR	0.68	0.462	Yes
RMI and RAC	0.64	0.409	Yes
RTR and RAC	0.75	0.562	Yes

Table 6.14: Discriminant validity of QRM dimensions

As shown in table 6.14, the square of inter-correlation value of all six pairs is smaller than the AVE values of each construct, so this provides good evidence of discriminant validity (Fornell and Larcker 1981a). If AVE > Φ2, then discriminant validity is supported which proves existence of 2nd order model. (Super-ordinate construct). Figure 6.12 shows a CFA model where a second-order factor model is introduced as the cause of the four first-order factors (RAV, RMI, RTR, and RAC). It matches the Hair et al. (2009) suggestion of constructing a second-order model: a minimum of three first-order factors is needed in order to access a second-order construct. Moreover, a second-order QRM factor model is proposed to determine the extent of the four first-order factors' implementation (Byrne 1998).

Assessment of model fitness (by comparing with competing models):

At this stage, four measurement models are compared and analyzed to establish the dimensional structure of QRM practice by adopting CFA approach using AMOS. The fit statistics are shown in the below table, the model fitness is assessed according to the values of the fit indices, including X2, degree of freedom (df), RMSEA, CFI, NNFI, NFl, Normed X2, SRMR and PNFI. The one-factor model conceptualizes all 39 items into one unidimentional factor whereby all variances of 39 items are accounted for in one single construct.

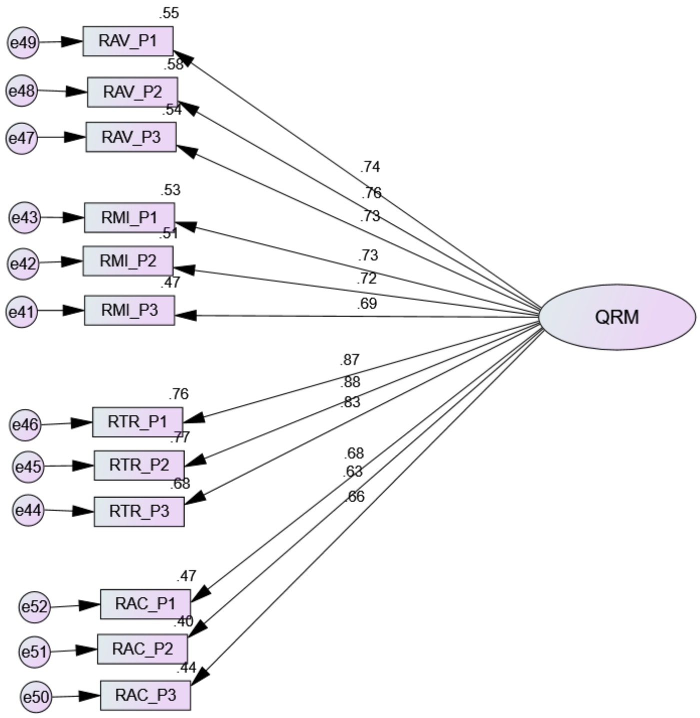

Figure 6.9: QRM Model 1: Single factor (1st order)

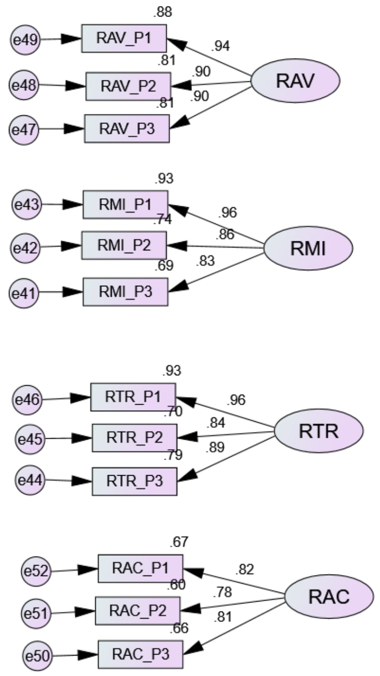

Figure 6.10: QRM Model 2-Four uncorrelated factors

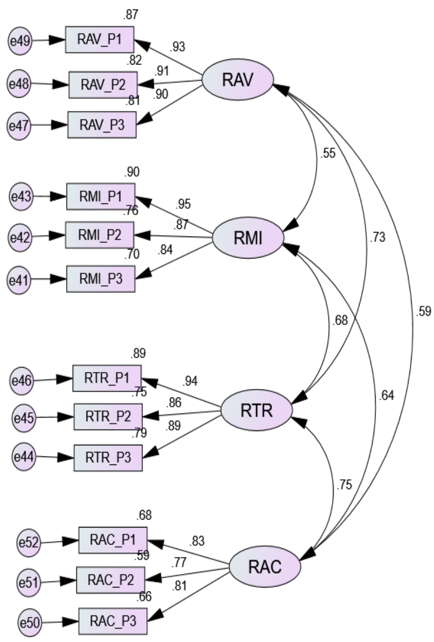

Figure 6.11: QRM Model 3-Four correlated factors

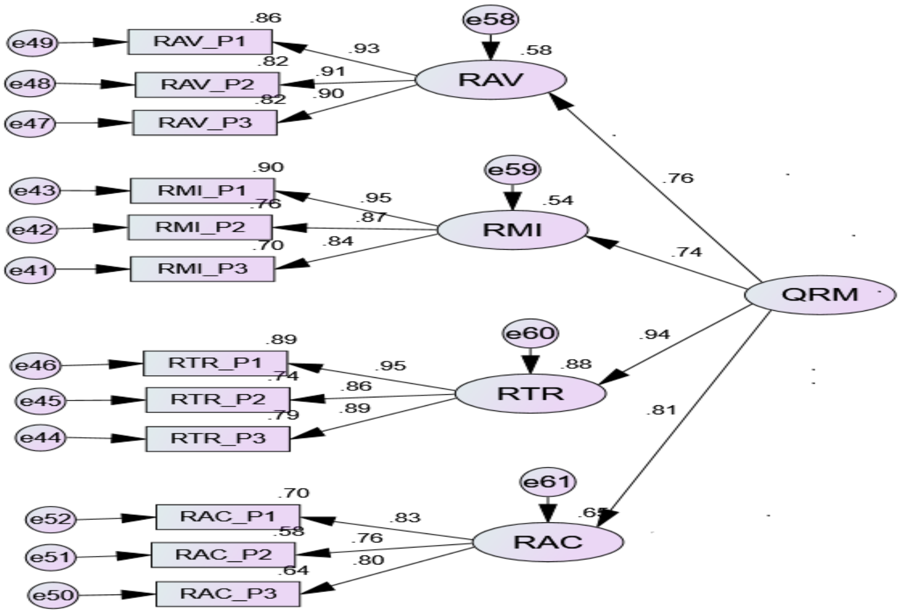

Figure 6.12: QRM Model 4-QRM Measurement model (2nd order)

Model	*Chisquare (x2)*	Degree of freedom (df)	Normed x2 (x2/df)	CFI	GFI	NFI	RMSEA
Model 1: Single factor (1st order)	994.966	54	18.425	0.667	0.605	0.656	0.260
Model 2: Four uncorrelated factors (1st order)	716.33	54	13.265	0.766	0.658	0.752	0.218
Model 3: Four correlated factors (1st order)	248.448	48	5.176	0.929	0.850	0.914	0.127
Model 4: Four factors (2nd order)	252.446	50	5.049	0.928	0.847	0.913	0.126

Table 6.15: Comparison of QRM models in terms of model fitness

It is shown that Model 1 has a poor fit and Model 2 has a relatively better fit than Model 1 which proves that a multidimensional model composed of four uncorrelated first order factors is superior to a unidimensional first order model 1. Model 3 conceptualizes that the four factors are freely correlated with each other. The fit indices of model 3 match the acceptable model fit suggested by Shah and Goldstein (2006). The model fit of model 3 is much better than model 2 which indicates that model 3 represents data better than model 2. In other words, the model with QRM's four dimensions significantly and positively correlating with each other's practices has a stronger fit to sample data than the other two models. As shown in the above table, the establishment of a second-order factor model is considered as the best among all the alternate models, although the four-correlated factor models (model 3) and second-order factor model (model 4) have nearly the same fit measures.

Construct	Structural link loading (ɤ)
RAV	0.76
RMI	0.74
RTR	0.94
RAC	0.81

Table 6.16: Gamma values of 2nd order QRM model

From the above table 6.16 it is evident that QRM positively influences RAV (ɤ=0.76), RMI (ɤ =0.74), RTR (ɤ =0.94) and RAC (ɤ =0.81) and from the figure 6.11 all factor loadings are significant (p-value <0.001) which indicate that the implementation of four practices is really driven by the latent QRM. Moreover, the monological validity is provided in the second-order factor model, since the structure links (ɤ) from QRM to the four dimensions is highly significant.

6.5 Quality Risks Measurement Model

6.5.1 Scale construction & purification

Assessment of correlation using Pearson's correlation coefficient method

Before starting EFA, the correlations among the item measures in the respective constructs are assessed *using Pearson's correlation coefficient method*. The items which "correlated negatively" or "weakly correlate with other items" in the same construct are removed. R value is 'Negative' if < 0.0; 'Week' if 0.0 to 0.3; 'Low positive' if 0.3 to 0.5; 'Medium positive' if 0.5 to 0.7; 'High positive' if 0.7 to 0.9; 'Very High positive' if 0.9 to 1.0. In table 6.17, it can be observed that majority of the Pearson's correlation coefficient values are between 0.5 to 0.7 while some values are between 0.3 to 0.5, suggesting an overall medium positive correlation. Hence it is decided to proceed with all the items without any dropping, with an assumption that they would be filtered during the factor analysis stage of construct validity testing. Hence the final QR construct can be proceeded without the eliminated items.

Indicator	QR1	QR2	QR3	QR4	QR5	QR6	QR7	QR8	QR9	QR10	QR11	QR12	QR13	QR14	QR15	QR16	QR17	QR18	QR19	QR20	QR21
QR1	1.000	0.861	0.856	0.883	0.878	0.644	0.582	0.553	0.553	0.592	0.547	0.533	0.552	0.563	0.602	0.487	0.512	0.489	0.542	0.561	0.495
QR2	0.861	1.000	0.727	0.786	0.771	0.557	0.506	0.476	0.486	0.506	0.472	0.456	0.476	0.497	0.516	0.411	0.486	0.425	0.467	0.456	0.399
QR3	0.856	0.727	1.000	0.750	0.725	0.552	0.522	0.481	0.471	0.511	0.497	0.461	0.461	0.471	0.532	0.436	0.452	0.459	0.492	0.501	0.433
QR4	0.883	0.786	0.750	1.000	0.753	0.542	0.491	0.482	0.452	0.501	0.467	0.462	0.462	0.482	0.521	0.407	0.452	0.459	0.472	0.490	0.445
QR5	0.878	0.771	0.725	0.753	1.000	0.607	0.537	0.518	0.518	0.556	0.522	0.498	0.527	0.518	0.567	0.462	0.487	0.436	0.507	0.516	0.470
QR6	0.644	0.557	0.552	0.542	0.607	1.000	0.877	0.881	0.881	0.896	0.904	0.885	0.897	0.881	0.561	0.447	0.472	0.490	0.531	0.490	0.351
QR7	0.582	0.506	0.522	0.491	0.537	0.877	1.000	0.778	0.788	0.784	0.823	0.782	0.795	0.788	0.501	0.388	0.413	0.432	0.463	0.460	0.361
QR8	0.553	0.476	0.481	0.482	0.518	0.881	0.778	1.000	0.761	0.788	0.787	0.825	0.818	0.791	0.483	0.369	0.423	0.413	0.464	0.422	0.321
QR9	0.553	0.486	0.471	0.452	0.518	0.881	0.788	0.761	1.000	0.797	0.787	0.764	0.798	0.771	0.453	0.378	0.374	0.375	0.415	0.363	0.253
QR10	0.592	0.506	0.511	0.501	0.556	0.896	0.784	0.788	0.797	1.000	0.812	0.791	0.794	0.797	0.520	0.416	0.431	0.459	0.500	0.459	0.340
QR11	0.547	0.472	0.497	0.467	0.522	0.904	0.823	0.787	0.787	0.812	1.000	0.810	0.813	0.797	0.486	0.394	0.400	0.419	0.458	0.465	0.358
QR12	0.533	0.456	0.461	0.462	0.498	0.885	0.782	0.825	0.764	0.791	0.810	1.000	0.801	0.774	0.483	0.378	0.414	0.423	0.464	0.412	0.330
QR13	0.552	0.476	0.461	0.462	0.527	0.897	0.795	0.818	0.798	0.794	0.813	0.801	1.000	0.778	0.482	0.388	0.423	0.432	0.454	0.431	0.293
QR14	0.563	0.497	0.471	0.482	0.518	0.881	0.788	0.791	0.771	0.797	0.797	0.774	0.778	1.000	0.483	0.369	0.414	0.413	0.464	0.412	0.272
QR15	0.602	0.516	0.532	0.521	0.567	0.561	0.501	0.483	0.453	0.520	0.486	0.483	0.482	0.483	1.000	0.884	0.898	0.783	0.895	0.888	0.700
QR16	0.487	0.411	0.436	0.407	0.462	0.447	0.388	0.369	0.378	0.416	0.394	0.378	0.388	0.369	0.884	1.000	0.783	0.662	0.791	0.773	0.597
QR17	0.512	0.486	0.452	0.452	0.487	0.472	0.413	0.423	0.374	0.431	0.400	0.414	0.423	0.414	0.898	0.783	1.000	0.686	0.796	0.788	0.621
QR18	0.489	0.425	0.459	0.459	0.436	0.490	0.432	0.413	0.375	0.459	0.419	0.423	0.432	0.413	0.783	0.662	0.686	1.000	0.898	0.676	0.540
QR19	0.542	0.467	0.492	0.472	0.507	0.531	0.463	0.464	0.415	0.500	0.458	0.464	0.454	0.464	0.895	0.791	0.796	0.898	1.000	0.786	0.630
QR20	0.561	0.456	0.501	0.490	0.516	0.490	0.460	0.422	0.363	0.459	0.465	0.412	0.431	0.412	0.888	0.773	0.788	0.676	0.786	1.000	0.794
QR21	0.495	0.399	0.433	0.445	0.470	0.351	0.361	0.321	0.253	0.340	0.358	0.330	0.293	0.272	0.700	0.597	0.621	0.540	0.630	0.794	1.000

Table 6.17: Pearson's correlation coefficient between items of Quality Risks(QR)

<u>Assessment of unidimensionality using EFA method</u>

The uni-dimensionality of the QR component is addressed by using EFA wherein all the measurement items in each construct are aggregated to run EFA using SPSS software and the results are presented in table 6.18. Firstly, the Kaiser-Meyer-Olkin test (KMO) is run for testing the sampling adequacy for running EFA, which is compared against the suggested criteria 0.60 (Worthington and Whittaker 2006). The KMO values for all the four individual constructs is greater than 0.800 which fulfills the sampling adequacy requirements of min 0.60. The Eigenvalues for the four constructs are greater than 1.0. The % variance of the entire scale is 59% which is higher than the accepted value of minimum 50%. The Cronbach's alpha test was adopted to assess the consistency of the entire scale and the Cronbach's alpha reliability statistic value for the construct is greater than 0.900 which fulfills the criteria of reliability required by Cronbach's alpha >0.70 (Hair et al. 2009). Hence it can be concluded that the undimensionality of the QR construct is supported, and altogether 21 items are retained as items for the QR construct, as shown in table 6.18.

Assessment of unidimensionality	Factor loadings	Communalities
QR1	0.820	0.672
QR2	0.723	0.523
QR3	0.726	0.527
QR4	0.723	0.523
QR5	0.764	0.583
QR6	0.902	0.813
QR7	0.821	0.674
QR8	0.807	0.652
QR9	0.784	0.615
QR10	0.833	0.693
QR11	0.819	0.670
QR12	0.802	0.643
QR13	0.810	0.657
QR14	0.802	0.643
QR15	0.807	0.651
QR16	0.681	0.464
QR17	0.713	0.509
QR18	0.693	0.480
QR19	0.761	0.580
QR20	0.738	0.545
QR21	0.602	0.362
Average	0.768	0.594
Kaiser-Meyer-Olkin test(KMO)	**0.948**	
% Variance of scale	**59.00**	
Eigen value of construct	**12.50**	
Cronbach’s alpha of scale	**0.965**	

Table 6.18: Assessment of unidimensionality of QR scale

Item parceling

In this study item parceling is done as each scale has demonstrated unidimensionality, which is a pre-requisite for proceeding with obtaining composite measures through the item parceling method. The purpose of adopting item parceling is take the advantage of increased model fitness due to reduced number of items, wherein the main objectives of this research is to examine the relationship between constructs. The parcels for each construct have been formed by grouping theoretically meaningful parcels which is one of the popularly used item parceling method. The below table shows the parcels formed for each construct along with the corresponding explanation provided in the remarks column.

Assessment of unidimensionality using EFA method

After item parceling as shown in table 6.19, the unidimensionality of the QR construct is addressed by carrying out EFA using SPSS software and the results are presented in table 6.20. Firstly, the Kaiser-Meyer-Olkin test (KMO) is run for testing the sampling adequacy for running EFA, which is compared against the suggested criteria 0.60 (Worthington and Whittaker 2006). The KMO value for the QR construct is greater than 0.700 which fulfills the sampling adequacy requirements of min 0.60. The Eigenvalue of the QR construct are greater than 1.0. The Cronbach's alpha test was adopted to assess the consistency of the entire scale wherein Cronbach's alpha is a reliability statistic. The Cronbach’s alpha values for the QR construct is greater than 0.800 which fulfills the criteria of reliability required by Cronbach's alpha >0.70 (Hair et al. 2009). Hence it can be concluded that the undimensionality of each dimension is supported, and altogether 4 item parcels are retained as indicators for the QR construct, as shown in table 6.20.

Construct	Parcels	Items	Remarks *(justification for item parceling grouped under theoretically meaningful clusters)*
Quality Risks (QR)	QR_P1	QR1, QR2, QR3, QR4, QR5	These are considered to be generally reflecting poor quality planning and poor management support viz., poor quality planning, poor understanding of client/project requirements, inadequate Management support/resources etc.
	QR_P2	QR6, QR7, QR8, QR9, QR10, QR11, QR12, QR13, QR14	These are considered to be generally reflecting poor quality practices including inadequate internal reviewing, Poor documentation, improper construction methods, poor material handling/storing, defective material usage, defective works, Using bad equipment in poor working condition or not calibrated, execution of works without prior approval of Consultant, inspections & Testing methods/frequency deviating from the approved Inspection & Test Plan (ITP) etc.
	QR_P3	QR15, QR16, QR17, QR18, QR19	These are risks related to incompetency of project staff/unskilled workers, resistance/unwillingness of project members to follow quality procedures. They also include poor supervision/coordination on site and poor communication/coordination among various project stakeholders.
	QR_P4	QR20, QR21	These are risks related to Suppliers/Sub-contractors arising Weak Supplier agreements/contracts, incompetency & poor performance of Sub-contractor/Suppliers. (eg.: poor quality of submittals/products/services)

Table 6.19: Item parceling of QR items

Constructs	Parcels	Factor loadings	Communalities	Determinant	Kaiser-Meyer-Olkin Measure (KMO)	Bartlett's Test of Sphericity	Degrees of freedom (df)	Chi-square (r)	% Variance of scale	Eigen value of construct	Cronbach's alpha of scale
Quality Risks (QR)	QR_P1	0.821	0.673	0.133	0.723	0.000	6	513.84	69	2.8	.848
	QR_P2	0.762	0.580								
	QR_P3	0.884	0.781								
	QR_P4	0.850	0.722								

Table 6.20: Assessment of unidimensionality of QR scale

6.5.2 Scale validation using CFA method

This section covers the scale validation process to establish/confirm the dimensional structure of the model using CFA approach in AMOS, wherein the Convergent validity and Discriminant validity of the scales are tested so as to validate the scales.

<u>*Convergent validity:*</u>

As shown in the below table 6.21 and figure 6.13, all factor loadings (λ) are greater than 0.50, while and all the composite reliabilities are greater than 0.70 and all the AVE values that are higher than 0.50. Based on these results, it can be confirmed that the scales show acceptable convergent validity.

Constructs	**Parcels**	**Standardized regression weights** (w)	**Squared Multiple Correlation or Variance explained** (S)	**Error variance**	**Composite Reliability** (CR)	**Average Variance Extracted** (AVE)
Quality Risks (QR)	QR_P1	0.654	0.428	0.572	0.85	0.59
	QR_P2	0.581	0.338	0.662		
	QR_P3	0.919	0.845	0.155		
	QR_P4	0.861	0.741	0.259		

Table 6.21: Convergent validity of QR scale

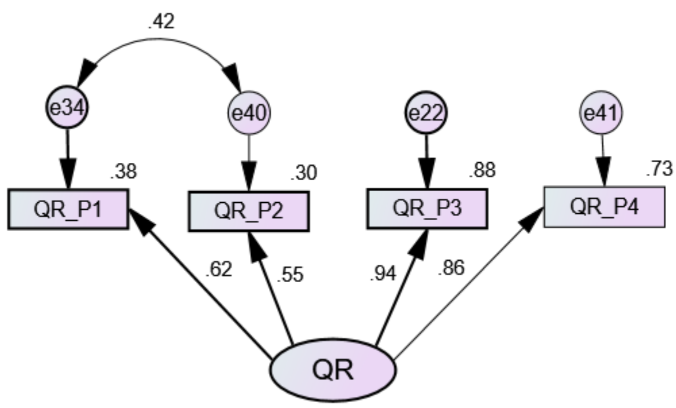

Figure 6.13: QR Measurement model (output from AMOS)

Assessment of model fitness:

The QR measurement model is analyzed to establish the dimensional structure of QR practice by adopting CFA approach using AMOS. The fit statistics are shown in the below table 6.22, the model fitness is assessed according to the values of the fit indices. The one-factor model conceptualizes all 4 parcel items into one unidimentional factor whereby all variances of parcel items are accounted for in one single construct.

Model	***Chisquare (x2)***	**Degree of freedom (df)**	**Normed x2** (x2/df)	**CFI**	**GFI**	**NFI**	**RMSEA** (90% confidence interval)
QR Model:	49.84	2	24.74	0.907	0.917	0.905	0.304

Table 6.22: QR Measurement Model fitness

6.6 Quality Performance Measurement Model

6.6.1 Scale construction & purification

Assessment of correlation using Pearson's correlation coefficient method

Before starting EFA, the correlations among the item measures in the QP construct is assessed *using Pearson's correlation coefficient method*. The items which "correlated negatively" or "weakly correlate with other items" in the same construct are removed. R value is 'Negative' if < 0.0; 'Week' if 0.0 to 0.3; 'Low positive' if 0.3 to 0.5; 'Medium positive' if 0.5 to 0.7; 'High positive' if 0.7 to 0.9; 'Very High positive' if 0.9 to 1.0. In table 6.23, it can be observed that majority of the Pearson's correlation coefficient values are between 0.5 to 0.7 while some values are between 0.3 to 0.5 and the others in 0.7 to 0.9, suggesting an overall medium positive correlation. Hence it is decided to proceed with all the items without any dropping, with an assumption that they would be filtered during the factor analysis stage of construct validity testing. Hence the final QR construct can be proceeded without the eliminated items.

Indicator	QP1	QP2	QP3	QP4	QP5	QP6	QP7	QP8	QP9	QP10	QP11	QP12	QP13	QP14	QP15
QP1	1.000	0.862	0.858	0.861	0.601	0.548	0.530	0.581	0.489	0.592	0.533	0.516	0.569	0.506	0.512
QP2	0.862	1.000	0.731	0.777	0.527	0.485	0.489	0.529	0.428	0.499	0.442	0.426	0.477	0.415	0.432
QP3	0.858	0.731	1.000	0.707	0.504	0.472	0.442	0.485	0.402	0.507	0.447	0.473	0.506	0.462	0.459
QP4	0.861	0.777	0.707	1.000	0.557	0.525	0.475	0.528	0.488	0.580	0.510	0.504	0.537	0.473	0.470
QP5	0.601	0.527	0.504	0.557	1.000	0.868	0.863	0.865	0.848	0.596	0.505	0.530	0.616	0.520	0.567
QP6	0.548	0.485	0.472	0.525	0.868	1.000	0.730	0.778	0.729	0.521	0.441	0.466	0.552	0.477	0.493
QP7	0.530	0.489	0.442	0.475	0.863	0.730	1.000	0.729	0.723	0.503	0.412	0.426	0.523	0.437	0.476
QP8	0.581	0.529	0.485	0.528	0.865	0.778	0.729	1.000	0.727	0.565	0.476	0.500	0.552	0.469	0.495
QP9	0.489	0.428	0.402	0.488	0.848	0.729	0.723	0.727	1.000	0.494	0.415	0.451	0.535	0.451	0.477
QP10	0.592	0.499	0.507	0.580	0.596	0.521	0.503	0.565	0.494	1.000	0.885	0.890	0.848	0.753	0.725
QP11	0.533	0.442	0.447	0.510	0.505	0.441	0.412	0.476	0.415	0.885	1.000	0.766	0.735	0.672	0.656
QP12	0.516	0.426	0.473	0.504	0.530	0.466	0.426	0.500	0.451	0.890	0.766	1.000	0.771	0.687	0.650
QP13	0.569	0.477	0.506	0.537	0.616	0.552	0.523	0.552	0.535	0.848	0.735	0.771	1.000	0.854	0.856
QP14	0.506	0.415	0.462	0.473	0.520	0.477	0.437	0.469	0.451	0.753	0.672	0.687	0.854	1.000	0.691
QP15	0.512	0.432	0.459	0.470	0.567	0.493	0.476	0.495	0.477	0.725	0.656	0.650	0.856	0.691	1.000

Table 6.23: Pearson’s correlation coefficient between items of Quality Performance(QP)

Assessment of unidimensionality using EFA method

The uni-dimensionality of the QP component is addressed by using EFA wherein all the measurement items in each construct are aggregated to run EFA using SPSS software and the results are presented in table 6.24. The Kaiser-Meyer-Olkin test (KMO value for the QP construct is 0.912 which fulfills the sampling adequacy requirements of minimum 0.60. The Eigenvalues for the four constructs are greater than 1.0. The % variance of the entire scale is 61% which is higher than the accepted value of minimum 50%. The Cronbach's alpha test was adopted to assess the consistency of the entire scale and the Cronbach's alpha reliability statistic value for the construct is greater than 0.954 which fulfills the criteria of reliability required by Cronbach's alpha >0.70 (Hair et al. 2009). Hence it can be concluded that the undimensionality of the QP construct is supported, and altogether 15 items are retained as items for the QP construct, as shown in table 6.24.

Assessment of unidimensionality using EFA	Factor loadings	Communalities
QP1	0.813	0.661
QP2	0.723	0.522
QP3	0.717	0.515
QP4	0.765	0.585
QP5	0.852	0.726
QP6	0.776	0.603
QP7	0.748	0.559
QP8	0.793	0.630
QP9	0.739	0.546
QP10	0.854	0.730
QP11	0.763	0.582
QP12	0.777	0.604
QP13	0.852	0.726
QP14	0.760	0.578
QP15	0.768	0.590
Average	0.780	0.610
Kaiser-Meyer-Olkin test(KMO)	0.912	
% Variance of scale	61.00	
Eigen value of construct	9.200	
Cronbach’s alpha of scale	.954	

Table 6.24: Assessment of unidimensionality of QP scale

Item parceling

In this study item parceling is done as each scale has demonstrated unidimensionality, which is a pre-requisite for proceeding with obtaining composite measures through the item parceling method. The purpose of adopting item parceling is take the advantage of increased model fitness due to reduced number of items, wherein the main objectives of this research is to examine the relationship between constructs. The parcels for each construct have been formed by grouping theoretically meaningful parcels which is one of the popularly used item parceling method. The below table 6.25 shows the parcels formed for each construct along with the corresponding explanation provided in the remarks column.

Construct	Parcels	Items	Remarks *(justification for item parceling grouped under theoretically meaningful clusters)*
Quality Performance (QP)	QP_P1	QP1, QP2, QP3, QP4	These are the quality performance indicators mainly related to approval rates of Technical/Engineering submittals. *(eg.: Material Submittals, Shop Drawings, Method Statements etc.),* Material Inspections, Work Inspections and Testing.
	QP_P2	QP5, QP6, QP7, QP8, QP9	These are the quality performance indicators mainly related to quality defects, reworks, Non-conformances, Cost of Poor Quality, and project delays due to quality issues.
	QP_P3	QP10, QP11, QP12, QP13	These are the quality performance indicators mainly related to customer satisfaction which includes both internal and external customers with special focus on Client. These include timely response in addressing customer complaints/queries. *(eg.: closing of NCRs, action items in minutes of meetings etc.),* Client satisfaction. *(eg.: through results of customer satisfaction feedback survey etc.,* Supplier/Sub-contractor performance. *(eg.: through results of performance appraisal etc.) and* Employee satisfaction *(eg: in terms of motivation/empowerment, involvement, engagement, etc)*
	QP_P4	QP14, QP15	These are the quality performance indicators mainly related to relationship with project stakeholders *(eg.: in terms of communication, coordination, cooperation etc.) and r*elationship with other stakeholders associated with the project society/neighbors *(eg.:in terms of effective communication, less disturbance/pollution etc.)*

Table 6.25: Item parceling of QP items

Constructs	Parcels	Factor loadings	Communalities	Determinant	Kaiser-Meyer-Olkin Measure (KMO)	Bartlett's Test of Sphericity	Degrees of freedom (df)	Chi-square (r)	% Variance of scale	Eigen value of construct	Cronbach's alpha of scale
Quality Performance (QP)	QP_P1	0.797	0.635	0.092	0.755	0	6	608.60	72	2.9	0.872
	QP_P2	0.809	0.655								
	QP_P3	0.905	0.819								
	QP_P4	0.888	0.788								

Table 6.26: Assessment of unidimensionality of QP scale

6.6.2 Scale validation using CFA method

This section covers the scale validation process to establish/confirm the dimensional structure of the model using CFA approach in AMOS, wherein the Convergent validity and Discriminant validity of the scales are tested so as to validate the scales.

<u>*Convergent validity:*</u>

As shown in the below table 6.27 and figure 6.14, all factor loadings (λ) are greater than 0.50, while the composite reliability is greater than 0.70 and the AVE values that are higher than 0.50. Based on these results, it can be confirmed that the scales show acceptable convergent validity.

Constructs	**Parcels**	**Standardized regression weights** (w)	**Squared Multiple Correlation or Variance explained** (S)	**Error Variance** (e)	**Composite Reliability** (CR)	**Average Variance Extracted** (AVE)
Quality Performance (QP)	QP_P1	0.639	0.408	0.592	0.87	0.63
	QP_P2	0.653	0.427	0.573		
	QP_P3	0.94	0.883	0.117		
	QP_P4	0.906	0.821	0.179		

e = 1 - Squared Multiple Correlation
t = Standardized regression weights / Error Variance
CR = Square of Sum of all factor loadings /(Square of Sum of all standardized regression weights + Sum of all error variances
AVE = Sum of square of standardized regression weights / total no. of indicators

Table 6.27: Convergent validity of QP scale

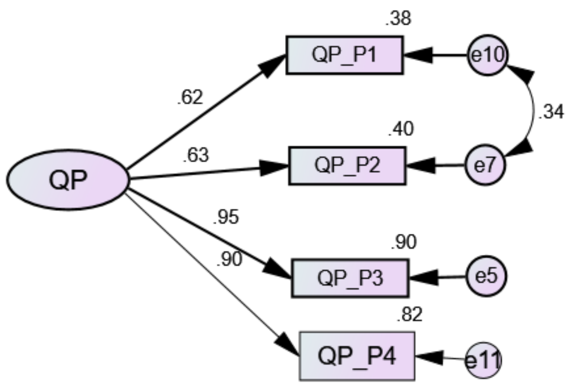

Figure 6.14: QP Measurement model (output from AMOS)

Assessment of model fitness

The QR measurement model is analysed to establish the dimensional structure of QR practice by adopting CFA approach using AMOS. The fit statistics are shown in the below table 6.28, the model fitness is assessed according to the values of the fit indices. The one-factor model conceptualizes all 4 parcel items into one unidimentional factor whereby all variances of parcel items are accounted for in one single construct.

Model	***Chi-square (x2)***	**Degree of freedom (df)**	**Normed x2** (x2/df)	**CFI**	**GFI**	**NFI**	**RMSEA**
QP Measurement Model	30.5	2	15.28	0.953	0.945	0.950	0.236

Table 6.28: Model fitness of QP model

6.7 Discussion of PQRM Measurement Models Development and Validation

In this chapter, multi-item measurement and scale development for Quality Risk Management (QRM), Quality Risks(QR) and Quality Performance(QP) are discussed. The major contribution of this chapter is it provides a reliable and valid scales for QRM, QR and QP wherein, a 7-stage scale development procedure has been conducted to ensure the proposed scale is valid and reliable. In such, quantitative statistical analysis techniques, exploratory factor analysis (EFA), confirmatory factor analysis (CFA) are carried out using software tools IBM SPSS and IBM Amos respectively, for validating the measurement models. As per the identified gap#2 in chapter 2 which explains that although the measures of Quality Management practices, Quality Risks and Quality Performance have identified in multiple research studies, they are all scattered and do not represent a comprehensive scale of measurement. There is a lack of "off-the-shelf' measurement items for QRM, QR, QP in the literature. This gave rise to the need to develop comprehensive measurement scales for QP, QR & QRM. Based on this the RQ#3 What would be valid measurement scales of QRM, QR & QP entail research objective # 2 has been established which calls for identify/generate individual sets of measurement items to operationalize QRM, QR & QP scales followed by empirically validate the QR, QRR & QP measurement scales.

Survey method is chosen for data collection using a structured survey questionnaire. The survey data has been used to statistically test and validate the three measurement models. The proposed measurement models form a foundation for empirical research in PQRM, especially for reducing quality risk in the construction projects. The validated measurement instruments are expected to be useful for the researchers who are interested in conducting survey research related to PQRM. The researchers and practitioners can make use of the instruments to assess the state of risk management practice implementation, as well as for setting up hypotheses to test how these practices impact on the quality performance in construction projects. One of the major contributions of this study is to identify and validate key constructs underlying QRM, QR and QP. The constructs were identified following a thorough review of the relevant literature across diverse disciplines. The result of the iterative instrument development and purification process is a set of reliable, valid, and unidimensional constructs.

A multi-dimensional measure of the QRM construct is developed and validated, and the four dimensions derived during the empirical analysis are positively and significantly correlated with each other ($p<0.01$). Thus, it provides support for the fact that the dimensions are significantly correlated with each other and for the fact that each dimension is truly distinct from the other dimensions. The statistical and empirical results also suggest that QRM can be represented with four factors where each factor represents a unique facet, and shows that QRM is actually a multidimensional construct. Moreover, the second-order factor test further confirms QRM as a second-order reflective factor, and proves that QRM is a multi-dimensional construct. Moreover, as QRM is conceptualized in terms of its dimensions, it does not exist separately from its dimensions. In other words, the relationships between a multidimensional QRM construct and its dimension are not causal forces linking separate conceptual entities. Instead, the "superordinate" model represents associations between a general concept and the dimensions that constitute the concept (Edwards 2001). The measures scale developed in this study provides a self-evaluated checklist for firms to evaluate the level or their progress in protecting the projects from Quality Risks. By interpreting the result of the second-order factor model, it is inferred that the project teams should try to employ these four dimensions simultaneously.

6.8 Chapter summary

This chapter has addressed the research gap#2 which expresses the concern that although the measures of Quality Management practices, Quality Risks and Quality Performance have identified in multiple research studies, they are all scattered and do not represent a comprehensive scale of measurement. In this chapter, multi-item measurement and scale development for Quality Risk Management (QRM), Quality Risks (QR) and Quality Performance (QP) are developed and validated through a robust 7-stage scale development process. Hence the outcome of this chapter has achieved research objective#3, which is to develop and validate Quality Risk Management, Quality Risk and Quality Performance Measurement models.

The proposed QRM, QR and QP measurement models form a foundation for empirical research in PQRM, especially for reducing quality risk in the construction projects. The validated measurement instruments are expected to be useful for the researchers who are interested in conducting survey research related to PQRM. The researchers and practitioners can make use of the instruments to assess the state of risk management practice implementation, as well as for setting up hypotheses to test how these practices impact on the quality performance in construction projects. On the other hand, from the practice point of view, these measurement scales can be used as a self-evaluated checklist to evaluate the level or their progress in protecting the projects from Quality Risks. By interpreting the result of the second-order factor model, it is inferred that the project teams should try to employ these four dimensions simultaneously to maximize the benefits of quality risk management in addressing quality risks in construction projects.

Chapter 7: EFFECT OF QUALITY RISK MANAGEMENT ON QUALITY RISKS AND QUALITY PERFORMANCE

7. 1 Chapter Introduction

This chapter tries to address research objective#4 which is to develop and test PQRM model in order to evaluate the effect of QRM on QR and QP. The PQRM model is built by structurally linking the QRM, QR and QP measurement models, wherein the measurement models have already been developed, tested and validated in Chapter 6. The hypotheses to check the structural links are established by deduction from the theory and are statistically tested using the primary data collected through survey. In this study, two competing PQRM models namely (i) Standalone model and (ii) Complementarity model are proposed for studying the effect of QRM on QR and QP.

The first model termed as Standalone model analyzes the effect of individual QRM practices on QR and QP separately, wherein the individual effect of each of the four QRM practices on the QR and QP is examined and evaluated in isolation. On the other hand, the second model termed as Complementarity model analyzes the combined effect of QRM practices on QR and QP. The two models are further appraised by comparing their results. Hypotheses related to both the approaches are established and tested through the above mentioned two competing models respectively. SEM techniques are used to test the hypothesized causal relationships, i.e. the structural links between constructs. The aim of examining two models is to compare the effect on the performance of individual QRM practices with the effect on performance of the full QRM system. This comparison is widely adopted in the literature for testing whether the effect of the full system outweighs the effect of individual components or not (Ichniowski et al. 1997, Whittington et al. 1999, Tanriverdi and Venkatraman 2005, Mishra and Shah 2009).

7.2 Standalone Model Effect

In this section, the theoretical development of the Standalone model including development of hypotheses is based on the discussion in literature review of chapter 2 and Conceptual framework of chapter 5. In this Standalone model, each QRM practice, referred to as Risk Avoidance (RAV), Risk Mitigation (RMI), Risk Transference (RTR), and Risk Acceptance (RAC) are hypothesized to have an individual effect on Quality Risks (QR) and Quality Performance (QP) wherein the theoretical settings of structural links from each QRM practices to quality risks and quality performance are established separately. Hence the hypotheses developed in this section are deduced from theory which means that when a project applies the four QRM practices separately, each of them can reduce quality risks and can have a positive impact on the project's quality performance.

7.2.1 Hypothesis development for Standalone model

Risk avoidance is a risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact (PMI 2003). PMI (2013) suggests that some risks that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise. They are a set of proactive measures undertaken by the project team, which focus on establishing and implementing a robust project quality management system, to address/deal with the common root causes leading to potential quality failures or customer dissatisfaction. The aim of this risk treatment strategy is to ensure that potential risks or negative effects hindering the achievement of quality objectives are avoided/prevented, to provide greater assurance that the customer and project requirements would be met. Hence, the application of Risk Avoidance tends to decrease the risks while it increases the Quality performance. From the above discussion the following two hypotheses are established.

- Sub-hypothesis H1a: Risk Avoidance has a negative association/relationship with Quality Risks
- Sub-hypothesis H2a: Risk Avoidance has a positive association/relationship with Quality Performance

Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk. They are a set of quality control actions taken by the project team which focus on verifying if the delivery of products, works, processes, services etc., conform to the customer/project requirements, whereby any deviations or potential non-conformances are detected and acted upon early, before they reach the Consultant/Customer. The aim of this risk treatment strategy is to reduce/mitigate the occurrence or impact of adverse risks hindering the achievement of quality objectives, whereby it is imperative that taking early action to reduce the probability and/or impact of a risk occurring is often more effective than trying to repair the damage after the risk has occurred. Hence, the application of Risk Mitigation practices tends to decrease the risks while increases the Quality performance. From the above discussion the following two hypotheses are derived/established.

- Sub-hypothesis H1b: Risk Mitigation has a negative association/relationship with Quality Risks
- Sub-hypothesis H2b: Risk Mitigation has a positive association/relationship with Quality Performance

Risk transference is a risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response (PMI, 2013). Transference tools can be quite diverse and include, but are not limited to, the use of insurance, performance bonds, warranties, guarantees, etc. Contracts or agreements may be used to transfer liability for specified risks to another party. They are a set of risk shifting actions/practices undertaken by the Contractor to shift/allocate the impact of the risk together with ownership of the response onto another stakeholder. The aim of this risk treatment strategy is to enable the Main Contractor to safeguard himself from the negative consequences/impact through shifting/allocating the risk impact to other stakeholders in the Supply chain (Sub-contractors/Suppliers/Manufacturers/3rd party testing etc.), based on the risk source or who is better able to handle/manage those risks. Hence, the application of Risk Transference practices tends to decrease the risks while increases the Quality performance. From the above discussion the following two hypotheses are established.

- Sub-hypothesis H1c: Risk Transference has a negative association/relationship with Quality Risks
- Sub-hypothesis H2c: Risk Transference has a positive association/relationship with Quality Performance

Risk acceptance is a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs (PMI, 2003). The aim of risk treatment strategy is to be prepared to take appropriate remedial/reactive actions focused on addressing/dealing with the quality failures/defects/non-conformances in case they occur or which have already occurred and resulted in customer dissatisfaction/complaints. They are a set of corrective actions taken by the project team such that the detected quality failures/defects/non-conformances are adequately rectified and addressed, while ensuring that their recurrence is prevented. This strategy requires establishing a contingency reserve, including amounts of time, money, or resources to handle the risks as they come along. This covers the quality failures/risks which pass undetected or could not be controlled through the proactive strategies namely Risk Avoidance and Risk Mitigation. The nature of this QRM practice is different from the other three, which look at a more proactive approach in preventing risks while this one focuses on how to solve the quality problems if they could not be avoided and if happens. PMI (2013) classifies this strategy to be either passive or active wherein passive acceptance requires no action except to document the strategy, leaving the project team to deal with the risks as they occur, and to periodically review the threat to ensure that it does not change significantly. While on the other hand, active acceptance strategy generally establishes a contingency reserve, including amounts of time, money, or resources to handle the risks. The construct of risk acceptance includes the following items which includes the extent of preparation in the event quality failures/risks occur. From the above discussion the following two hypotheses are established.

- Sub-hypothesis H1d: Risk Acceptance has a negative association/relationship with Quality Risks
- Sub-hypothesis H2d: Risk Acceptance has a positive association/relationship with Quality Performance

From the above theoretical arguments, all QRM practices (RAV, RMI, RTR, and RAC) have an Standalone on the quality risk and quality performance. When evaluating each type of QRM practice, there will be an individual effect on quality risk(QR) and Quality Performance (QP), thus the following integrated hypotheses are developed:

- Hypothesis H1: Each individual QRM practice has a negative association/relationship with QR
- Hypothesis H2: Each individual QRM practice has a positive association/relationship with QP

From the above discussions, the following are the hypotheses and sub-hypotheses developed to test the individual effect of each of the QRM practice on QR and QP.

Hypothesis code	Hypothesis statement	Structural link
H1	**Each individual QRM practice has a negative relationship/association with QR**	
H1a	Risk Avoidance has a negative association/relationship with Quality Risks	RAV --> QR
H1b	Risk Mitigation has a negative association/relationship with Quality Risks	RMI --> QR
H1c	Risk Transference has a negative association/relationship with Quality Risks	RTR --> QR
H1d	Risk Acceptance has a negative association/relationship with Quality Risks	RAC --> QR
H2	**Each individual QRM practice has a positive relationship/association with QP**	
H2a	Risk Avoidance has a positive association/relationship with Quality Performance	RAV --> QP
H2b	Risk Mitigation has a positive association/relationship with Quality Performance	RMI --> QP
H2c	Risk Transference has a positive association/relationship with Quality Performance	RTR --> QP
H2d	Risk Acceptance has a positive association/relationship with Quality Performance	RAC --> QP

Table 7.1: Hypotheses for Standalone Model

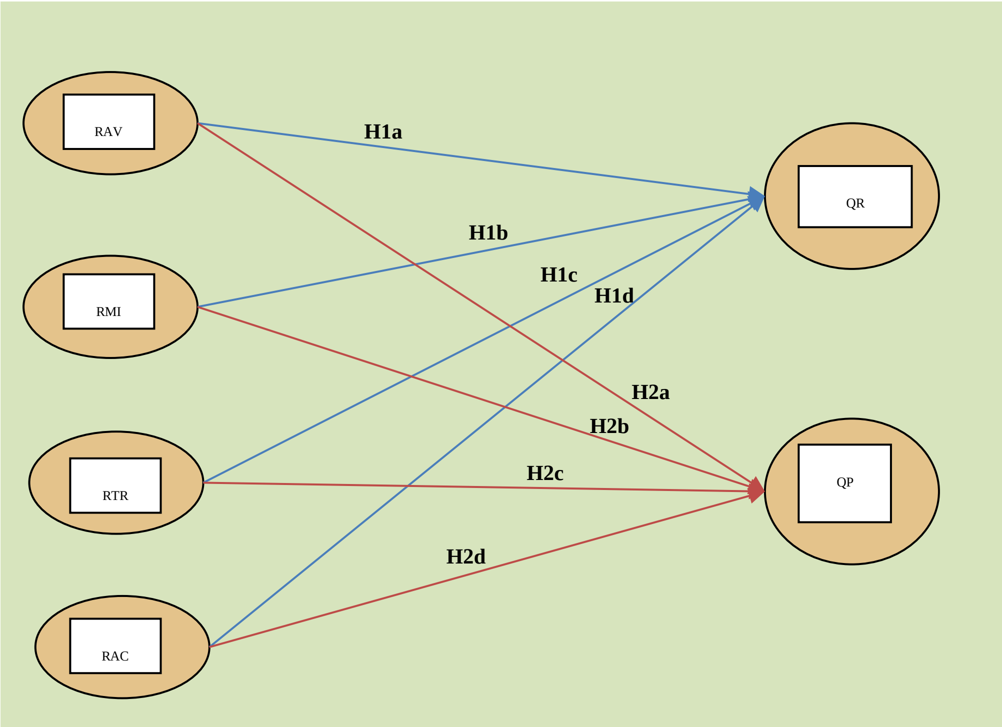

Figure 7.1: Hypothesized Structure of Standalone Model (PQRM Model-1)

7.2.2 Data analysis and results of Standalone model

In this section, SEM techniques are used to test the hypothesized causal relationships (i.e. structural links) between constructs which are depicted in Figure 7.1. Figure 7.2 shows the AMOS output after running the Standalone model and Table 7.2 summarizes the results of the Standalone model (PQRM Model-1).

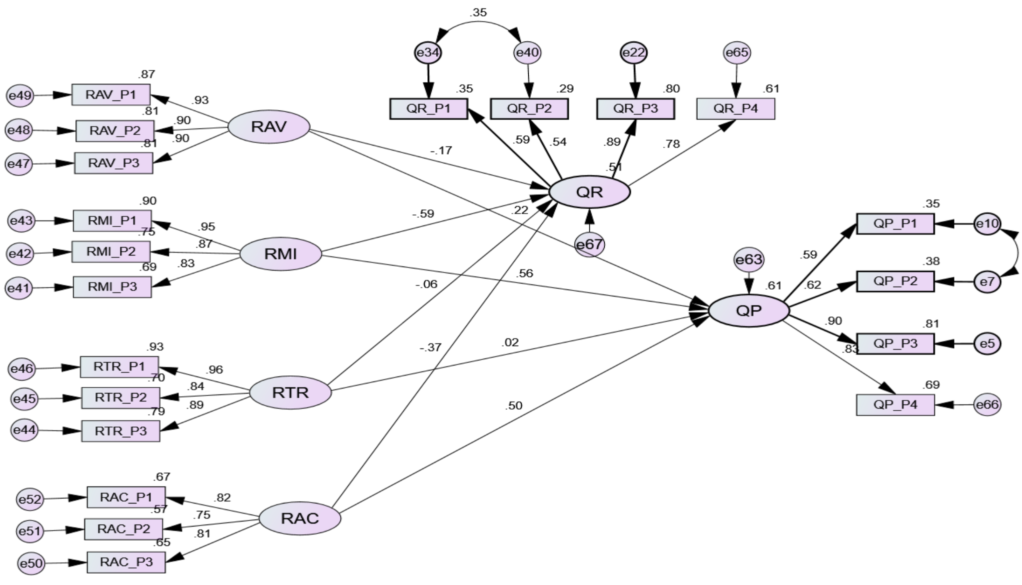

Figure 7.2: Results of Standalone model (source: AMOS output of PQRM Model-1)

Hypothesis	Structural link	Standardized Path Coefficient	Remarks
Hypothesis H1: Each individual QRM practice has a negative relationship/association with QR			
H1a: Risk Avoidance has a negative relationship with Quality Risks	RAV --> QR	- 0.17	Weakly supported
H1b: Risk Mitigation has a negative relationship with Quality Risks	RMI --> QR	- 0.59	Medium supported
H1c: Risk Transference has a negative relationship with Quality Risks	RTR --> QR	- 0.06	Weakly supported
H1d: Risk Acceptance has a negative relationship with Quality Risks	RAC --> QR	- 0.37	Weakly supported
Hypothesis H2: Each individual QRM practice has a positive relationship/association with QP			
H2a: Risk Avoidance has a positive relationship with Quality Performance	**RAV** --> **QP**	+0.22	Weakly supported
H2b: Risk Mitigation has a positive relationship with Quality Performance	**RMI** --> **QP**	+ 0.56	Medium supported
H2c: Risk Transference has a positive relationship with Quality Performance	**RTR** --> **QP**	+0.02	Weakly supported
H2d: Risk Acceptance has a positive relationship with Quality Performance	**RAC** --> **QP**	+0.50	Weakly supported

Table 7.2: Hypothesis test results of Standalone model (source: AMOS output of PQRM Model-1)

The standardized path coefficients of the structural links in PQRM model-1 are not so satisfactory as illustrated in Figure 7.2 and Table 7.2, wherein only three of the eight structural links from the four practices to quality risks & performance constructs are significant. Although, the structural links shows a negative association/relationship between individual QRM practices and QR, the strength of the relationship/association seems to be relatively poor. Among the four individual QRM practices, RMI shows the highest value of -0.59 followed by -0.37 for RAC and -0.17 for RAV. The lowest is RTR -0.06. This means that as the impact of individual QRM practices shows a low effect on quality risks. Similarly, although, the structural link shows a positive association/relationship between individual QRM practices and QP, the strength of the relationship/association seems to be relatively poor. Among the four individual QRM practices, RMI shows the highest value of +0.56 followed by +0.50 for RAC and +0.22 for RAV. The lowest is RTR +0.02. This means that as the impact of individual QRM practices shows a low impact on quality performance.

Model	***Chi-square (x2)***	**Degree of freedom (df)**	**Normed x2** (x2/df)	**CFI**	**GFI**	**NFI**	**RMSEA**
PQRM Model-1: Standalone Model	1570	*160*	9.813	0.725	0.593	0.705	0.185

Table 7.3: Model fitness of Standalone model (source: AMOS output)

The model fit indices in Table 7.3 show that the model is poorly fit for the given data set, especially the GFI is 0.593 while the normed chi-square is high 9.8(which should be approximately less than 5). The works of Tanriverdi and Venkatraman (2005), Mishra and Shah (2009), Menor and Roth (2008), Zhu (2004), and Wu et al., (2006), provide hints on how to turn the Standalone model into a more meaningful model with better fit indices. Their research stated that the second-order factor model captures the nature of complementarity of first-order factors. In chapter 5, the test result of the second-order factor model (model 4) has proved the existence of a higher-order nature in QRM. Therefore, a second- order structure model is proposed for further study in the relationship between QRM and Quality risks, and between QRM and quality performance, as explained in the next section.

7.3 Complementarity Model Effect

It is suggested that the unsatisfactory results in the Standalone model (PQRM model-1) can be explained by the complementarity theory. A synergy effect exists when the four QRM practices are adopted in the project simultaneously, wherein each of the four QRM practice tend to complement each other. Although the insignificance of these relationships can be justified by the above arguments, the author has further investigated the limitations of PQRM model-1 i.e. the concept of complementarity of four QRM practices is not captured in the model. PQRM model-1 can only represent the individual effect of each of the QRM practices wherein only the Individual effect of the practice on QR and QP was tested. Thus, the complementarity model (PQRM model-2) is developed to test the relationship between QRM practices, QR and QP. The model's re-specification does not compromise the theory used in the original model. It offers a more systematic set of relationships providing a consistent and comprehensive explanation of phenomena.

The way to compare two structural models can be viewed as "competing model strategy". A competing model strategy is based on comparing the established model with an alternative model through overall model comparisons. It requires two models with the same number of indicators but with different relationships portrayed for comparison. By adopting this competing model approach, the researcher attempts to test competing theories. This provides a much stronger support than testing a single model (Hair et al. 2009). Thus, the competition between Standalone model (PQRM model-1) and the Complementarity model (PQRM model-2) is used to justify the existence of a complementarity effect of QRM impact on QP performance.

For proving the synergy effect of the complementariness, two opposing hypotheses are usually proposed. This method is proposed by Tabriverdi and Venkatraman (2005), and further applied by Mishra and Shah (2009). Tabriverdi and Venkatraman (2005) stated "In assessing performance effects of a complementary system, it is imperative to compare performance effects of the full system to define the conditionality of individual effects on the effects of other system components and to ensure that the full system effects outweigh the individual effects ". Therefore, the complementarity of the QRM system can be proven if hypotheses H4 and H5 show a superior result to that of hypotheses H1(sub-hypotheses H1a to H1d) and H2 (sub-hypotheses H2a to H2d).

7.3.1 Hypothesis development for Complementarity model

The theory of a resource-based view (RBV) and the complementarity theory are adopted to develop PQRM Model-2 (see Figure 7.3). In this decade, RBV has been adopted in several OM research studies as it can provide interesting insights to clarify the strength and capability that can lead the firm to obtain sustainable competitiveness (Lewis 2000, Priem and Bultler 2001). The meaning of the term "resource" is quite broad seen from an RBV perspective, in that it can be a bundle of unique materials, human, organizational resources, and skills in which the resource enables the creating of unique values.

According to the theory of complementarity, a set of resources can be viewed as complementary when employing more than one of them can bring in a greater return than when they are employed individually (Milgrom and Roberts 1995, Tanriverdi and Venkatraman 2005). Mishra and Shah (2009) further claims that complementarity exists when a resource becomes more valuable in the presence of another resource, than when the resource is considered by itself. Thus, in the context of QRM, the process of each QRM practice is treated as a complementary resource that is interdependent and mutually supportive. Synergies tend to arise internally when the four QRM are adopted in dealing with QR wherein the four QRM practices complement each other. Their co-existence can create super-additive value Competitiveness is not only gained from performing numbers of individual activities, but also from the integration of these activities. This argument also can be applied to the integration of QRM activities in four dimensions. The bundle of QRM processes acts as the resources that form unique values to a firm. Thus, the project can coordinate the QRM activities more closely. In QRM, the four practices share some common resources: i.e., there are joint resources when the firm operates these QRM activities together, so the joint operations costs are less than the sum of the Individual operation cost of each practice. Owing to the interdependence of the four QRM practices, the operations costs of each practice are reduced. In this study, the first level of the latent construct captures the sub-additive operations cost synergy in four QRM practices. On the other hand, the super-additive value synergies arising from complementarity are captured in the second level construct. Thus, for the evaluating the effect of the complementarity of QRM synergies on quality risks and quality performance, the PQRM Model-2 is established along with hypotheses for testing.

In Chapters 2 and 5, the definition of QRM is further refined as the actions taken to manage/mitigate the risks hindering the achievement of quality objectives or affecting quality performance. QRM in this research is defined as actions undertaken by the project team to address (prevent/reduce) quality risks, aiming at enhancing project quality performance. The aim of these practices is to manage quality risks/issues to enhance the quality performance on the project. Hence it can be acknowledged that the more effectively Quality risk management activities are taken/applied, it leads to decrease in quality risks aiming at enhancing quality performance. From the above the following hypotheses can be deduced:

- Hypothesis H4: QRM has a negative association/relationship with QR
- Hypothesis H5: QRM has a positive association/relationship with QP

Ghezavati et al. (2013) states that according to the concept of quality and strive to meet customer expectations, every risk at any stage of work that can affect quality of performance and cause negative customer satisfaction would be considered as quality risks. ISO 31000(2009) states that the aim of risk identification is to generate a comprehensive list of risks based on those events that might create, enhance, prevent, degrade, accelerate or delay the achievement of objectives. These are the risks related to deficiencies/mistakes in the execution / implementation of the QA/QC processes which affect the quality performance. Apart from these, the human related ones include inadequate supervision, coordination, communication, training, lack of skills, unauthorized activity etc., These are the risks related to the people which affect the quality performance. and the external factors like Regulatory, political, outsourcing etc., are also considered. These are the risks related to the suppliers/sub-contractors, Clients, Consultant, Society, Regulatory authorities etc., which affect the quality performance. In this study the operational risks related to quality are considered wherein the quality risks are viewed as risk of loss resulting from inadequate or failed internal processes, systems, people and to an extent external events are considered. In this research focus is put mostly on negative risks which lead to negative impact on the quality performance. Hence it can be acknowledged that as the increase in Quality risks leads to poor performance. From the above the following hypothesis can be deduced

- Hypothesis H6: QR has a negative association/relationship with QP

From the above discussions, the following hypotheses are developed to test the Complementarity effect of QRM practices on QR and QP, along with the effect of QR on QP. Table 7.4 and Figure 7.3 illustrate the Hypothesized Structure of Complementarity Model with QR as mediator (PQRM Model-2) along with representation of the hypotheses.

Hypothesis type	Hypothesis code	Hypothesis statement	Structural link
Hypothesis	H4	QRM has a negative association/relationship with QR	QRM --> QR
Hypothesis	H5	QRM has a positive association/relationship with QP	QRM --> QP
Hypothesis	H6	QR has a negative association/relationship with QP	QR --> QP

Table 7.4: Hypotheses for Complementarity Model (PQRM Model-2)

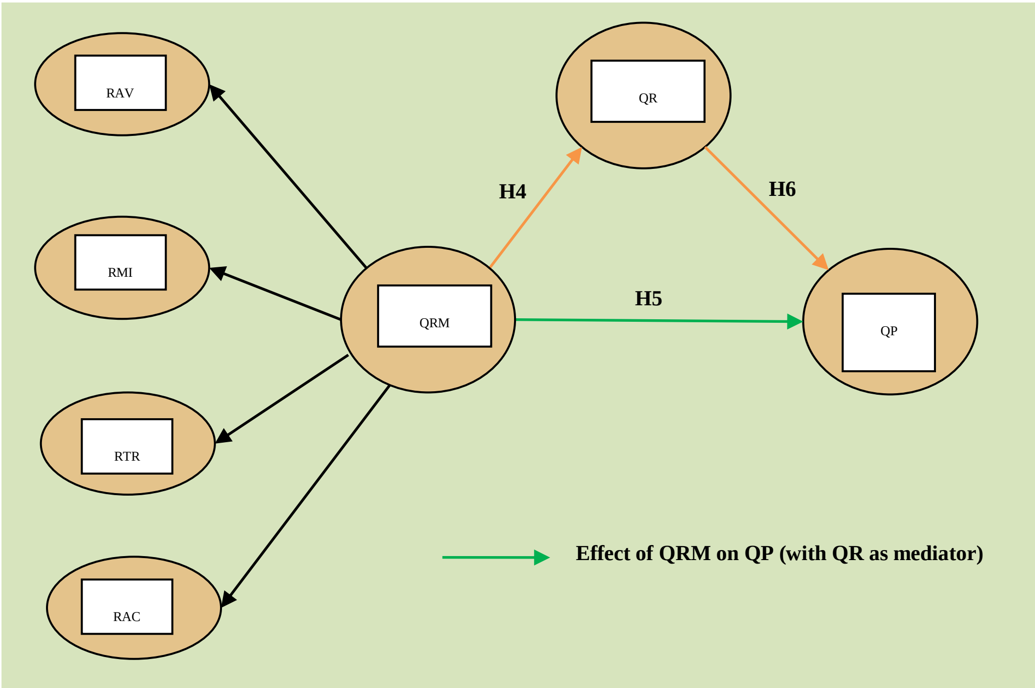

Figure 7.3: Hypothesized Structure of Complementarity Model with QR as mediator (PQRM Model-2)

7.3.2 Data analysis and results of Complementarity model

In this section, SEM techniques are used to test the hypothesized causal relationships (i.e. structural links) between constructs. Figure 7.4 and Table 7.5 summarize the structural links of the Complementarity model (PQRM Model-2).

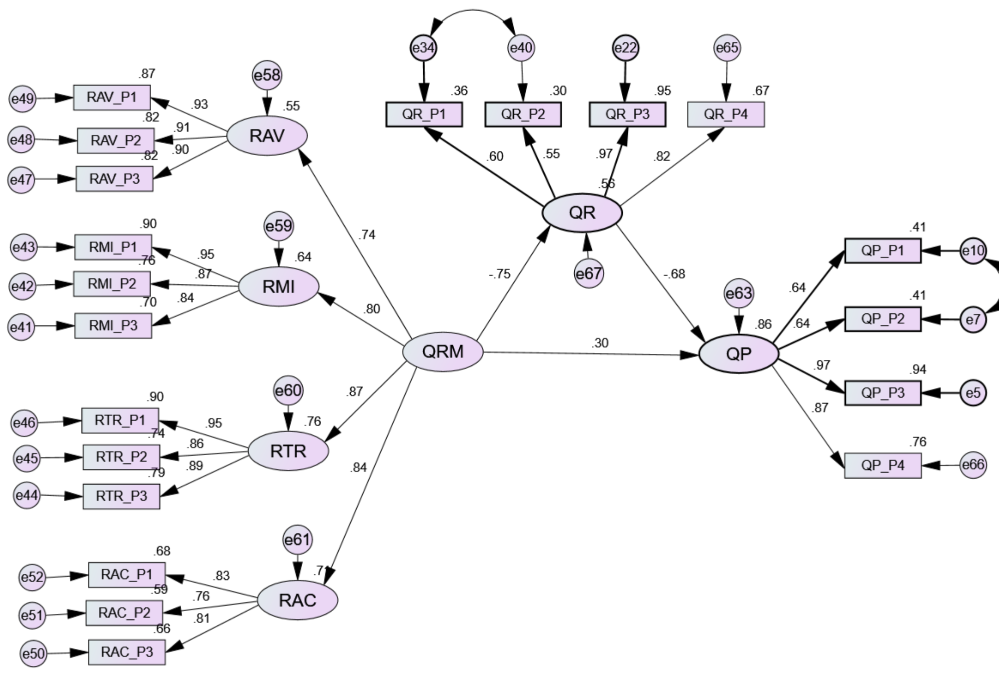

Figure 7.4: Results of Complementarity effect model with QR as mediator (source: AMOS output for PQRM Model-2)

Hypothesis	Structural link	Standardized Path Coefficient	Supported Or Not supported
H4: Quality Risk Management has a negative association/relationship with Quality Risks	QRM --> QR	-0.75	Supported
H5: Quality Risk Management has a positive association/relationship with Quality Performance	QRM --> QP	+0.30	Supported
H6: Quality Risk has a negative association/relationship with Quality Performance	QR --> QP	-0.68	Supported

Table 7.5: *Hypothesis test results of Complementarity effect model with QR as mediator (source: AMOS output for PQRM Model-2)*

Model	Chi-square (x2)	Degree of freedom (df)	Normed x2 (x2/df)	CFI	GFI	NFI	RMSEA
PQRM Model-2: Complementarity effect model with QR as mediator	1000.760	161	6.216	.836	.735	.812	.142

Table 7.6: *Model fitness of Complementarity effect model with QR as mediator (source: AMOS output for PQRM Model-2)*

Comparison of Table 7.6 and Table 7.3 shows that the fit indices of two models have very similar results in model fit with the data sample. Most importantly, as described in section 7.2.2, only three of the eight structural links from the four practices to the performance constructs are significant in the Standalone model. The insignificance in the structural links of the Standalone model provides indirect support to the complementarity model (Tanriverdi and Venkatraman 2005, Mishra and Shah 2009). Thus, hypotheses H1 and H2 are not supported. In contrast, the structural links in the Complementarity model are strong and highly significant as shown in Table 7.5. The structural link between QRM and QP is positive and significant (structure link=0.30) which fulfills the requirement of Hypothesis H5. Moreover, the structural link from QRM to QR is negative and significant (structural link= - 0.75) which fulfills the requirement of Hypothesis H4 while the structural link from QR to QP is also negative and significant (structural link= - 0.68) which fulfills the requirement of Hypothesis H6. These findings indicate a second-order factor interpretation that the complementarity of four types of QRM practices has a significant effect on quality performance and QR. Table 7.5 shows the results of structural links in the complementarity model. The above section has shown the evidence of the presence of the complementarity effect of QRM on QR and QP. Hence, from the above comparison and discussion, it can be concluded that the Complementarity model is superior to the Standalone model as it indicates stronger standardized path coefficients while demonstrating better model fitness.

7.4 Mediation effect of Quality Risks

7.4.1 Hypothesis development for Mediation effect of QR

In order to examine the mediating effect of QR between QRM and QP, we need to evaluate the strength of the relationship between QRM and QP within two models as i.e. Figure 7.4 and Figure 7.6. Hypothesis H5 is already set and tested in sections 7.3.1 and 7.3.2. As the ultimate goal of QRM practices is to enhance the quality performance on the project, it can be acknowledged that the more effectively Quality risk management activities are taken/applied, it leads to enhanced QP. From the above the following hypothesis can be deduced as represented in Figure 7.5.

Hypothesis H7: *QRM has a positive association/relationship with QP*

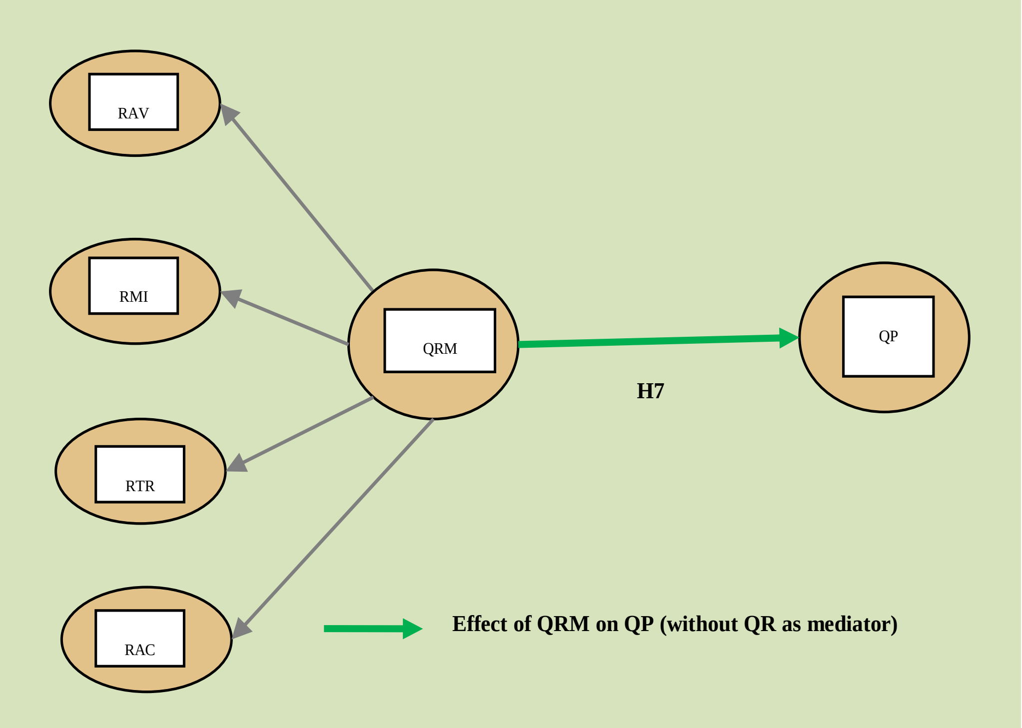

Figure 7.5: Hypothesized Structure of Complementarity Effect Model without QR as mediator (PQRM Model-3)

There are two possibilities of QR mediation effect between QRM and QP

(i) No mediating effect
(ii) Partial mediating effect

The mediator, QR is already included in PQRM Model-2 as shown in Figure 7.4 and was tested in the previous section, thus the only thing that we need to evaluate is to test the model without the mediator. If the relationship between QRM and QP in PQRM Model-3 as show in Figure 7.6 does not have any difference to PQRM Model-2, it means there is no mediation effect of QR. On the other hand, if the relationship between QRM and QP in PQRM Model-3(H7) has a stronger structural link than PQRM Model-2(H5), it indicates that there is a partial mediating effect of QP. In other words, the presence of mediator QR has decreased the strength of the relationship between QRM and QP of PQRM Model-3. Hence from the above discussion, the mediating effect of QR is set as below:

Hypothesis H8: *QR has a mediating effect between QRM and QP*

In other works, H8 is valid if H7 > H5

7.4.2 Data analysis and results of mediation effect of Quality Risks

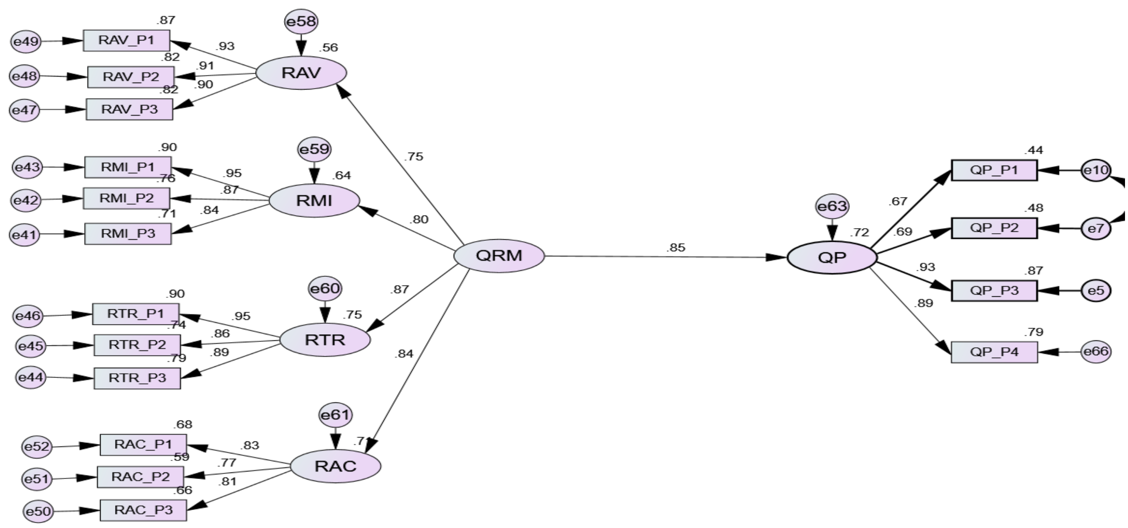

Figure 7.6: Results of Complementarity effect model without QR as mediator (source: AMOS output for PQRM Model-3)

Model	*Chi-square (x2)*	Degree of freedom (df)	Normed x2 (x2/df)	CFI	GFI	NFI	RMSEA
PQRM Model-3: Direct effect of QRM on QP	474.17	98	4.839	0.901	0.813	0.879	0.122

Table 7.7: Model fitness of Complementarity effect model without QR as mediator

PQRM Model	Hypothesis	Structural link	Standardized Path Coefficient
PQRM Model-2: Complementarity effect model with QR as mediator	**H5:** Quality Risk Management has a positive association/relationship with Quality Performance	**QRM --> QP**	**+0.30**
PQRM Model-3: Complementarity effect model without QR as mediator	**H7:** Quality Risk Management has a direct positive association/relationship with Quality Performance	**QRM --> QP**	**+0.85**

Table 7.8: Comparison of strength of structural links of Complementarity effect model with QR as mediator vs without QR as mediator (source: AMOS output)

In Figure 7.6, the result of the PQRM Model-3 is illustrated (without mediator) shows that the structural link value between QRM and QP is + 0.85 and it is highly significant. However, the effect of QRM on QP has diminished after controlling for the effects of mediator - QR (as shown in PQRM Model-2, Figure 7.4), and the relationship between QRM and QP still remains significant. Thus, it can be concluded that the effects of the QRM to QP are said to be "partially" mediated by QR.

7.5 Discussion on the effect of QRM on Quality Risks and Quality Performance

Apart from developing valid scales for QRM, QR and QP, another major contribution of this study is the investigation of the performance effect of QRM on QR and QP. Two critical structural models are developed and tested in this study. These two models are based on a "competing model strategy" which compares the established model with an alternative model through overall model comparisons, including overall fitness, and structural links. It also requires the two models to have the same number of indicators but with different relationships portrayed for comparison. Edward's (2001) work of distinguished different multi-dimensional construct is relevant to the structure of the complementarity model in this study which is classified as a "superordinate cause model" in which the QRM is a "superordinate construct" that has an impact on the performance.

In this chapter, the first model is the Standalone model which examines/assesses the effect of individual QRM practices on quality risks and quality performance. The second model is Complementarity model which examines/assesses the effect of combined QRM practices on quality risks and quality performance. The next sections provide a discussion on the two said competing models.

7.5.1 Discussion on Standalone model

The standardized path coefficients of the structure links in PQRM model-1 are not so satisfactory. As illustrated in Figure 7.2 and Table 7.2, only three of the eight structural links from the four practices to quality risks & performance constructs are significant. Although, the structural link shows a negative association/relationship between individual QRM practices and QR, the strength of the relationship/association seems to be relatively poor. Among the four individual QRM practices, RMI shows the highest value of -0.59 followed by -0.37 for RAC and -0.17 for RAV. The lowest is RTR -0.06. This means that as the impact of individual QRM practices shows a low effect on quality risks. Similarly, although, the structural link shows a positive association/relationship between individual QRM practices and QP, the strength of the relationship/association seems to be relatively poor. Among the four individual QRM practices, RMI shows the highest value of +0.56 followed by +0.50 for RAC and +0.22 for RAV. The lowest is RTR +0.02. This means that as the impact of individual QRM practices shows a low impact on quality performance.

Although the insignificance of these relationships can be justified by the above arguments, the author has further investigated the limitations of model 6 - i.e. the concept of complementarity of four QRM practices is not captured in the model. Model 6 can only represent the Standalone of each QRM practice, and only the Standalone of the practice on firm performance was tested. The testing of the Standalone model shows a result which is not consistent with what is reported in the literature. Only three out of eight of the structural links are supported in the data analysis. The works of Tanriverdi and Venkatraman (2005), Mishra and Shah (2009), Menor and Roth (2008), Zhu (2004), and Wu et al., (2006), provide hints on how to tum the direct-effect model into a more meaningful model. Their research stated that the second-order factor model captured the nature of complementarity of first-order factors. In other words, the presence of a second-order factor structure has an implication that the dimensions can provide a synergy effect to the outcome performance. In chapter 6, the test result of the second-order factor model (model 4) has proved the existence of a higher-order nature in QRM.

Therefore, a second- order structure model is proposed for further study in the relationship between QRM and QR, and between QRM and quality performance. It is suggested that the unsatisfactory result in the Standalone model can be explained by the complementarity theory. A synergy effect exists when the four QRM practices are adopted in the firm simultaneously. Each of the four QRM practice are complementary to each other. Thus, the complementarity model is developed to test the relationship between QRM practices and the QP. The model's re-specification does not compromise the theory used in the original model. It offers a more systematic set of relationships providing a consistent and comprehensive explanation of phenomena. The way to compare two structural models can be viewed as "competing model strategy". A competing model strategy is based on comparing the established model with an alternative model through overall model comparisons. It requires two models with the same number of indicators but with different relationships portrayed for comparison. By adopting this competing model approach, the researcher attempts to test competing theories. This provides a much stronger support than testing a single model (Hair et al. 2009). Thus, the competition between Standalone model and the complementarity model is used to justify the existence of a complementarity effect of QRM impact on QP.

7.5.2 Discussion on Complementarity model

Taking into account the unsatisfactory result in the Standalone model (PQRM model-1) as explained in 7.2.2, the complementarity model (PQRM model-2) is developed to test the relationship between QRM practices, QR and QP. The model's re-specification does not compromise the theory used in the original model. It offers a more systematic set of relationships providing a consistent and comprehensive explanation of phenomena. The way to compare two structural models can be viewed as "competing model strategy". A competing model strategy is based on comparing the established model with an alternative model through overall model comparisons. It requires two models with the same number of indicators but with different relationships portrayed for comparison. By adopting this competing model approach, the researcher attempts to test competing theories. This provides a much stronger support than testing a single model (Hair et al. 2009). Thus, the competition between Standalone model (PQRM model-1) and the complementarity model (PQRM model-2) is used to justify the existence of a complementarity effect of QRM impact on QP performance.

7.5.3 Discussion on Mediating effect of QR

In order to examine the mediating effect of QR between QRM and QP, we need to evaluate the strength of the relationship between QRM and QP within two models as i.e. Figure 7.4 and Figure 7.6. As the ultimate goal of QRM practices is to enhance the quality performance on the project, it can be acknowledged that the more effectively Quality risk management activities are taken/applied, it leads to enhanced QP. From the above the following hypothesis can be deduced as represented in Figure 7.5. In Figure 7.6, the result of the PQRM Model-3 is illustrated (without mediator) shows that the structural link value between QRM and QP is 0.85. However, the effect of QRM on QP has diminished after controlling for the effects of mediator - QR (as shown in PQRM Model-2, Figure 7.4), and the relationship between QRM and QP still remains significant. Thus, it can be concluded that the effects of the QRM to QP are said to be "partially" mediated by QR.

7.6 Chapter summary

This chapter has addressed the research objective#4 which seeks the impact/effect of QRM practices on QR and QP. A PQRM model has been developed by structurally linking the QRM, QR and QP measurement models and the hypotheses to check the structural links are established by deduction from the theory and are statistically tested using the primary data collected through survey. In this study, two competing PQRM models namely (i) Standalone model and (ii) Complementarity model are proposed for studying the effect of QRM on QR and QP. Data collection was done using a structured survey and SEM technique is used to test the hypothesized causal relationships (i.e. structural links between constructs) while validating the PQRM model. The comparison of the SEM results of these two models, indicate that the full QRM system effect outweighs the individual component effect. Therefore, on the evidence of the test results, we can conclude that the complementarity model is superior to the Standalone model and that it confirms that the multiple manifestations of risk shifting, risk sharing, risk avoidance, and risk remedy are all driven by a cohesive synergy. Moreover, the test results of the mediating effect of quality risks between QRM and quality performance shows that quality risk has a partial mediation effect on quality performance. The presence of this partial effect of 'Quality Risk' gives indirect support to the existence of the complementarity effect of QRM on Quality performance.

The theoretical and managerial contributions of this research study are discussed below. Theoretically, this study overcomes two main weaknesses in previous studies which have mostly ignored 'quality risks' in studying the causal relationship between quality management practices and quality performance, financial performance, organizational performance etc. However, the causal relationship between the various quality risk factors and quality performance has not been studied. Therefore, a comprehensive framework of PQRM which reflects the multi-dimensional content of QRM and Quality risks (QR) and Quality performance(QP) has been developed, tested and validated which can be helpful for academics and practitioners to gain a better understanding of the causal relationships among them. In the construction projects, the PQRM model can help the project teams to make informed decisions while taking actions to mitigate quality risks aimed at continual improvement. Hence the outcome of this chapter addresses research objective#4.

Chapter 8: CONCLUSIONS AND RECOMMENDATIONS

8.1 Chapter Introduction

In this chapter, the research study is concluded by summarizing the issues throughout the study as represented in last seven chapters which have so far have elucidated the literary, conceptual, methodological and substantive approaches adopted in addressing the research agenda. To start with, the research questions and objectives are revisited to review the extent to which they have been addressed by this study. Thereafter, a summary of the key findings of this study are presented along with stating the main conclusions of the research study. The study provides some recommendations for the application of the newly developed innovative PQRM model which can help the construction practitioners/professionals to control quality risks, aimed at improving quality performance in construction projects. The key contributions to knowledge are provided, while on the other hand, the limitations of the research are highlighted along with providing some suggestions for future research.

8.2 Review of Research Aim, Questions and Objectives

As explained in chapter 1, the following 3 research questions have evolved based on the gaps in literature

RQ#1 How effective are the current Quality Management practices in construction projects and what are the suggestions for continual improvement?

RQ#2 What would be valid measurement scales of QRM, QR & QP entail?

RQ#3 What is the impact/effect of QRM practices on QR and QP?

To address the above three research questions, the following aim and objectives are set:

Aim: The aim of this research study is to evaluate the impact of Quality Risk Management on Quality Risks and Quality Performance, in the UAE construction projects.

Objective#1: To investigate and assess the effectiveness of the current Quality Management(QM) practices in the UAE construction projects and seek suggestions for continual improvement.

A thorough review of literature regarding quality failures, their causes & effects along with a review of current QM practices, has exposed the gaps in quality management practices. Additionally, literature also indicates limited research on QM practices in the UAE, which suggests that more investigation needs to be done to understand the effectiveness of the current QM practices in the UAE construction projects. Hence, a semi-structured interview questionnaire was used for interviewing experienced practicing professionals working for Main Contractors/Sub-Contractors, who have been chosen based on references from reliable sources. The findings helped in identifying the gaps/deficiencies in the existing QM system while provided useful insights into the areas of improvement which could be focused on, as explained in chapter 4.

Objective#2: To review the concepts of Quality Risk Management (QRM), Quality Risk (QR) and Quality Performance (QP) so as to conceptualize and operationalize the QRM, QR and QP measurement scales.

In chapter 5, the conceptualization and operationalization of QRM practices along with QR and QP have been described. Considering the research gap#2 mentioned in chapter 1, the need to study more to identify the measurement scales of QRM, QR and QP has been initiated. Based on the operational definitions of QRM 54 list of items have been extracted from the literature to operationalize the QRM construct and grouped under four dimensions namely RAV, RMI, RTR and RAC. QR is conceptualized and operationalized with 26 potential items which are derived from the literature. QP is conceptualized and operationalized with 20 potential items. Hence in response to objective#2 separate Constructs have been conceptualized and operationalized.

Objective#3: To develop and validate Quality Risk Management, Quality Risk and Quality Performance Measurement models.

As per the identified gap#3 in chapter 1 the need to develop comprehensive measurement scales for QP, QR & QRM has been established. Accordingly, in chapter 5, a 7-stage scale development procedure has been proposed and conducted to conceptualize and operationalize multi-item measurement scales QRM, QR & QP and tested to ensure the proposed scales are valid and reliable. To test and validate the scales, survey data collected from 258 respondents has been used. In such, quantitative statistical analysis techniques, exploratory factor analysis (EFA), confirmatory factor analysis (CFA) are carried out using software tools IBM SPSS and IBM Amos respectively, for validating the measurement models.

Objective#4: To develop and validate Project Quality Risk Management(PQRM) Model and evaluate the effect of Quality Risk Management practices on Quality Risks and Quality Performance.

In chapter 5 the three constructs QRM, QR and QP have been conceptualized and operationalized, followed by validation of the same in chapters 6 resulting in the final three measurement models of QRM, QR and QP. Considering the gaps in the literature review, research question #3 and research objective#4 have sprouted which require examining the effect of QRM on QP. In this study, the effect of QRM on QP is studied and evaluated through two approaches namely standalone/individual effect of QRM on QP and complementarity effect of QRM on QP. Hypotheses related to both the approaches are established and tested through two competing models respectively, wherein the effect on the performance of individual QRM practices against the combined effect of QRM practices have been compared and evaluated.

Chapter	Significant contribution and link to research objectives
Chapter 2: LITERATURE REVIEW	A systematic literature review is done to gain in-depth understanding of the concepts of QM, QP, RM, QRM etc., which enabled to identity the research gaps and enabling the establishment of theoretical framework for the study. The gaps identified through literature review gave rise to four research questions, based on which the **four research objectives** have been established for further study and validation.
Chapter 3: RESEARCH METHODOLOGY	Research methodology employed in this research is thoroughly discussed including sampling, data collection & data analysis methods, results presentation etc. The research design and how the quantitative/qualitative techniques are employed to address the **four research objectives** is described.
Chapter 4: STUDY ON THE CURRENT QM PRACTICES IN THE UAE	Addressed **research objective#1**, wherein the information gathered from interview enabled to evaluate the current QM practices along with their deficiencies, while obtained suggestions from experts which provide alternative solutions to overcome the obstacles and work towards continual improvement.
Chapter 5: THEORETICAL FRAMEWORK & CONCEPTUAL MODEL	Addressed **research objective#2,** wherein the concepts of QRM, QR and QP are reviewed which enabled to conceptualize and operationalize the respective constructs/scales.
Chapter 6: MEASUREMENT MODELS/SCALESDEVELOPMENT (EFA & CFA)	Addressed **research objective#3,** wherein QRM, QR and QP measurement models are developed and validated through a seven-stage robust scale development process.
Chapter 7: THE EFFECT OF QUALITY RISK MANAGEMENT ON QUALITY PERFORMANCE	Addressed **research objective#4,** wherein the PQRM model is developed through which the effect of QRM on QR and QP is evaluated and reported. Additionally, the mediating effect of QR is also analyzed.

Table 8.1 Chapter-wise significance and value added

8.3 Conclusion

The rapid rise of the number of quality failures resulting in delays, additional costs and credibility loss has become the wake-up call to the project teams and Management, warning them that they need to develop a systematic approach to deal with the quality risks in construction projects. Although QM and RM are implemented independently, several voices have been raised for the need of integrating QM and RM. Literature review reveals that most of the quality management studies have ignored the element of risk. Hence, as per research objective#1, data collection was done through interviewing practicing professionals and the key findings indicate that the Project Quality Management in the United Arab Emirates (UAE) construction projects usually follows a reactive approach, wherein once the quality defects/issues are encountered, the necessary corrective actions are taken in a random/ ad hoc manner and regrettably not prioritized such that quality issues with more risk could be focused on. During the interview, the Subject Matter Experts/Practicing Quality Professionals expressed and stressed upon the need to put more focus on proactive approaches like risk-based thinking and actions to enhance the effectiveness of quality management in construction projects.

On the other hand, the causal relationship between the various quality risk factors and quality performance has not been adequately studied in previous research studies. Thus, a comprehensive framework of PQRM consisting of QRM, QR and QP is developed, with an intent to enable academicians and practitioners to gain a better understanding of the causal relationships among them. In seeking to help address the above gaps, this research put forward an innovative PQRM model to examine the relationship between QRM, QR and QP in the UAE construction projects. In this study, the effect of QRM on QP is studied and evaluated through two approaches namely direct effect of QRM on QP and complementarity effect of QRM on QP. Hypotheses related to both the approaches are established and tested through two competing models respectively, wherein the effect on the performance of individual QRM practices with the effect on performance of the full QRM system. By comparing the SEM results of these two models, it can be claimed that the full system effect outweighs the individual component effect. Therefore, on the evidence of the test results, we can conclude that the Complementarity model is superior to the Standalone effect model and that it confirms that the multiple manifestations of risk shifting, risk sharing, risk avoidance, and risk remedy are all driven by a cohesive synergy. Moreover, the test results of the mediating effect of quality risks between QRM and quality performance shows that QR has a partial mediation effect between QRM and

QP. The presence of this partial effect on quality performance gives indirect support to the existence of the complementarity effect of QRM on quality performance. This implies that part of the QP can be improved through the reduction of QR, and part of quality risks is influenced by the complementarity of QRM. On the other hand, the testing of PQRM model validates the hypotheses, which indicate that the increase in the effectiveness of QRM actions results in reduction of QR, while enhancing the Quality performance. QRM is one of the most discussed and popular topics recently especially in the backdrop of the new ISO 9001:2015 which clearly stresses the need for a risk-based approach. However, as it is still in its embryonic stage wherein it is gaining steam in industries like Pharmaceutical, Healthcare, dairy etc., construction industry is still yet to taste the advantage of QRM methodology.

Considering the above and as explained in 8.2, this study has effectively answered the research questions, while the research aim and objectives have been fulfilled.

8.4 Recommendations

- ***Based on Interview results***

During the interview, the Subject Matter Experts/Practicing Quality Professionals expressed and stressed upon the need to put more focus on proactive approaches like risk-based thinking & actions to enhance the effectiveness of quality management in construction projects and following are the key recommendations

- Proactive approaches like Risk-based thinking and actions need to be implemented.
- Prioritization of CAPA needs to be based on database of historical information/lessons learned.
- Audits need to be prioritized with more focus on high risk areas.
- Training plan must take into account high risk areas.

Additionally, following are the suggestions made by them for continual improvement

a) PQP needs to be periodically reviewed and updated to incorporate the new progressive changes and frequency should be as per the dynamic need of the project.
b) Top management should extend adequate support for effective implementation of PQP.
c) Communication/interaction needs to be improved through workshops, meetings etc.

d) During Sub-contractors/Supplier's selection, adequate weight must be given to quality, similar to price. Field visits should be prioritized based on the potential risks they carry.
e) Required information and adequate time needed for preparation of submittals should be provided to the Contractor/Supplier/Sub-contractors
f) Proactive approaches like Checklists, risk management techniques etc., need to be followed to avoid/prevent potential quality failures from occurring in the first place.
g) All testing instruments/equipment shall be having valid calibration certificates.
h) Audits need to be more focused and prioritized based on high risk areas.
i) Training plan must prioritize based on the outcome of NCRs and other rejections from Consultant.
j) Database of lessons learned must be used and decision making & prioritization should be based on database for historical information

- ***Based on Survey results***

The PQRM model could be used by project quality professionals and other project personnel project managers to act in a proactive approach to identify the risks related to quality and take preventive actions to avoid quality failures and subsequently save time and money due to preventing quality failures. It is suggested that the PQRM model has the potential of reducing the quality risks thus improving the quality performance in construction projects, when used as part of a wider sphere of quality and risk management practices and procedures. Based on the survey results and test results of PQRM model, it is suggested that PQRM implementation offers the following advantages in ensuring continual improvement

- Can help in establishing a more robust/realistic Project Quality Plan reflecting a more proactive approach in managing quality.
- Can decrease the rejection rate of Submittals, Inspections, Testing etc.
- Can make the Supplier/Sub-contractor management more effective/efficient.
- Can improve the proactive approach of identifying and potential quality failures/risks, so that appropriate corrective actions can be taken to prevent failures.
- Cost of Quality can be better monitored and controlled based on risk-priorities.
- Can increase the efficiency/effectiveness of the Audits and Training wherein more focus can be put upon high risk areas.
- Decision making is relatively easier, leading quicker way for remedial actions
- Overall continual improvement (PDCA cycle) can be enhanced through risk based approach.

8.5 Research Contributions and Value Added

The main goal/intention of the study is to enhance the existing knowledge domain of Quality and Risk Management along with contribution to industry practices. This dissertation attempts to reveal and understand the QRM practices to provide new insights in dealing with project quality risks. The contributions and value added are put under Academic and Industry perspectives as below

- ***Academic Perspective***

Theoretically, this study overcomes the three main gaps in the previous studies related to Project Quality Management and Risk Management Studies, wherein, firstly 'Quality Risks' were ignored, secondly no 'Off-the-shelf measurement scales' for measuring Quality and Risks; and thirdly very few previous studies examined the 'Causal relationships' between Quality practices and risks in construction projects. Moreover, literature review reveals that there are hardly any quality management research studies done on the UAE construction projects. By addressing these deficiencies/gaps, this study has made the following three contributions to knowledge, aiding in advancing the literature of Quality and Risk Management in the Construction industry.

(i) The need to adopt risk-based approaches/methodologies to enhance the effectiveness of current QM practices in construction projects has been established.

(ii) Three measurement scales namely Quality Risk Management(QRM), Quality Risk(QR) and Quality Performance (QP) are developed and validated using a robust 7-stage procedure, which can be used by researchers for future Quality and Risk Management studies. Especially, the validated measurement instruments can be useful for the researchers who are interested in conducting survey research.

(iii) Project Quality Risk Management(PQRM) model is developed and validated, which can be used to study the causal relationships among Quality Risk Management(QRM), Quality Risk(QR) and Quality Performance (QP).

Based on the preliminary presentation of the PQRM model to key members of American Society of Quality(ASQ) in Dubai, an invite has been extended to make a presentation to international audience during the upcoming global ASQ conference, thus demonstrating wider acceptance of the innovative PQRM model by the professional fraternity.

- ***Industry Perspective***

This study highlights the deficiencies in the current Quality Management practices in terms of lack of proactive approach in preventing quality failures wherein, more focus is put on ‘Reactive approach’ while neglecting ‘Proactive approaches’ like quality risk assessment. Hence the missing element risk is an obvious gap in the ongoing quality management practices, which needs more attention so as to ensure good quality performance in construction projects. With an intent to overcome the above gaps/deficiencies in practice, this study has made the following contributions to enhance the effectives of QM practices in construction projects,

a) The three valid and reliable measurement scales developed in this study - QRM, QR and QP can be used as self-evaluated checklists, by the project team members, thus enabling them to be pro-active in controlling quality risks in construction projects.

b) The Project Quality Risk Management(PQRM) model developed in this study, which can be used to study the causal relationships among Quality Risk Management(QRM), Quality Risk(QR) and Quality Performance (QP), which would enable the project teams to make informed decisions while taking actions to mitigate quality risks aimed at continual improvement.

Based on the theoretical and managerial contributions of this research study as discussed above, comprehensive framework of PQRM which reflects the multi-dimensional content of QRM and Quality risks (QR) and Quality performance (QP) can be very helpful for the academicians and practitioners to gain a better understanding of the causal relationships among them, to better manage Quality and Risks. Moreover, the researchers and practitioners can make use of the instruments to assess the state of risk management implementation, as well as for setting up hypotheses to test how these practices impact on the quality performance in construction projects.

8.6 Limitation of Study and Suggestions for Future Research

While this study has made significant contributions to academics and industry, there are limitations of the study that need to be considered and acknowledged as detailed below

- As risk is viewed as a perspective and how each stakeholder views it, risk varies depending upon individual stakeholder's perspective or vested interests. In some cases, a risk from the contractor point of view may not be treated the same from the view of another stakeholder like Contractor or Client. As the old saying "Beauty lies in the eyes of the beholder", 'Risk' depends upon how each stakeholder views it individually. This study has been done only from the Main Contractor perspective. However, it also can be studied from the other stakeholders' perspective, like Client and Consultant.

- While the study is done considering the UAE projects only, it can also be extended to other countries. In this regard, it should be noted that the PQRM model specifically developed for UAE projects can be modified and tailor-made to suit the local conditions or context of those countries, wherein factors like local culture, weather/climatic conditions, legal and regulatory requirements should be taken into account, so as to ensure effective implementation of the model.

- While QRM has been conceptualized/developed as a multi-dimensional construct, QR and QP have been considered as unidimensional constructs/scales. In fact, QR and QP can also be conceptualized/developed as a multi-dimensional construct depending upon the need of the project/organization and the relationship can be examined between the latent variables of QRM, QR and QP more precisely rather than between the three constructs as done in this study. Hence this extension can be done depending upon the need and operational context of the project/organization.

- Though the QRM, QR and QP measurement instruments developed in chapter 5 has gone through a robust 7-stage procedure, a re-validation is suggested for further enhancing the generalization of the concept domain. One of the alternate methods is the case-study method which can be conducted on various construction projects to re-validate the empirical findings in this study. Case study based research can be very useful for generating deeper insights of the through investigating the implementation problems by interview responses, objective evidences, observation etc., which could be used to cross-check against the primary data collection.

Table 8.2 provides a summary of the study limitations and suggestions for future research

Area/Aspect	Limitations of this study	Recommendations for future studies
Stakeholder	Studied from a Main Contractor perspective.	Can be studied from the other stakeholders' perspective, like Client and Consultant.
Sample	Covered UAE construction projects.	Can be extended to other countries or geographical locations.
Construct	Constructs developed QRM - multi-dimensional construct QR - unidimensional construct QP - unidimensional construct	QR and QP can also be developed as multi-dimensional constructs depending upon the need of the project/organization.
Revalidation	QRM, QR and QP measurement instruments have been developed through a robust 7-stage scale development procedure.	Re-validation can be done through Case-studies; multi-grouping etc., for further enhancing the generalization of the concept domain.

Table 8.2: Summary of the study limitations and suggestions for future research

8.7 Chapter Summary

This chapter has provided a review of the original research objectives and the extent to which they were achieved. The main conclusions have been presented with a brief discussion of the key findings along with their interpretations/implications. To summarize, the research has developed a PQRM model consisting of three distinct QRM, QR & QP measurement scales which could be used to measure the quality risk management practices, Quality Risks and Quality performance and monitor the effect of QRM on QR and QP. This PQRM model could be used by project quality professionals and other project personnel project managers to act in a proactive approach to identify the risks related to quality and take preventive actions to avoid quality failures and subsequently save time and money due to preventing quality failures. It is contended that the PQRM model has the potential of reducing the quality risks thus improving the quality performance in construction projects, when used as part of a wider sphere of quality and risk management practices and procedures. Additionally, the recommendations have been provided in the large interest of the construction practitioners/professionals. The key contributions to knowledge have been provided while the limitations of the research have been acknowledged and suggestions for future research have been stated.

REFERENCES

Abdelgawad, M. and Fayek, A. R. (2010). Risk Management in the Construction Industry Using Combined Fuzzy FMEA and Fuzzy AHP. *Journal of Construction Engineering and Management*. 136(9), 1028-1036.

Abdelsalam, H. M. E. and Gad, M. M. (2009). Cost of quality in Dubai: An analytical case study of residential construction projects. *International Journal of Project Management*, 27, 501-511.

Abdul-Rahman, H., Wang, C., and Mohamad, F. S. (2015). Implementation of Risk Management in Malaysian Construction Industry: Case Studies. *Journal of Construction Engineering*, 2015(1), 1-6.

Agoston, S. M. I., VanMourik, P. C. and Strengers, P. F. W. (2011). Quality risk management: a valuable tool in implementing, maintaining and improving a quality management system. *ISBT Science Series*, 6(1), 52-55.

Aibinu, A.A. and Odeyinka, H.A. (2006). Construction delays and their causative factors in Nigeria. Journal of Construction Engineering and Management. 132 (7), 667–677.

Alemayehu, D., Alvir, J., Levenstein, M. and Nickerson, D. (2013). A data-driven approach to quality risk management. *Perspectives in Clinical Research*, 4(4), 221-226

Ali, H. A. E. M., Al-Sulaihi, I. A. and Al-Gahtani, K. S. (2013). Indicators for measuring performance of building construction companies in Kingdom of Saudi Arabia. *Journal of King Saud University - Engineering Sciences*, 25(2), 125-134.

AlMaian, R. Y., Needy, K. L., Walsh, K. D., Alves, T. C. L., and Scala, N. M. (2016). Analyzing supplier quality management practices in the construction industry. *Quality Engineering*, 28(2), 175-183.

BanuChandar, N. and Saravannan, M. M. (2014). Development of Risk Management Model for the Underground Corridor Construction for Metro. *International Journal of Advanced Research in Civil, Structural, Environmental and Infrastructure Engineering and Developing*, 1(2), 13-18

Barber P., Graves A., Hall M., Sheath D. and Tomkins C. (2000). Quality failure costs in civil engineering projects. *International Journal of Quality and Reliability Management*, 17(4/5):479-492.

Bassioni, H. A., Price, A. D. F. and Hassan, T. M. (2004). Performance Measurement in Construction. *Journal of Management in Engineering*. 20(2), 42-50.

Basu, R. (2004). *Implementing Quality: A Practical Guide to Tools and Techniques*. London: Thomson Learning, London

Bhattacharya, J. (2015). Quality Risk Management –Understanding and Control the Risk in Pharmaceutical Manufacturing Industry. *International Journal of Pharmaceutical Science Invention.* 4(1), 29-41

Boateng, P. (2014). *A Dynamic Systems Approach to Risk Assessment in Megaproject*s. Unpublished PhD thesis, Department of School of Energy, Geoscience, Infrastructure and Society, Heriot-watt university.

Bogdan, R.C., & Biklen, S.K. (2003). Qualitative research for education: An introduction to theory and methods (4th ed.). Boston: Allyn & Bacon.

Boley, J. (2009). *Poor quality materials caused building collapse*, http://www.constructionweekonline.com/article-6312-poor-quality-materials-caused-building-collapse/ (10.03.2015)

Borodin, V., Bourtembourg, J., Hnaien, F and Labadie, N. (2014). A quality risk management problem: case of annual crop harvest scheduling, *International Journal of Production Research*, 52(9), 2682-2695.

Bou-Llusar, J. C. and Zornoza, C. C. (2000). Validity and reliability in perceived quality measurement models. *International Journal of Quality and Reliability Management*, 17(8), 899–918.

Bou-Llusar, J C., Escrig-Tena, A. B., Roca-Puig, V. and Beltran-Martin, I. (2009). An empirical assessment of the EFQM Excellence Model: Evaluation as a TQM framework relative to the MBNQA Model. *Journal of Operations Management*, 27(2), 1–22

BSI (2003). *British Standard BS ISO 10006:2003. QMS - Guidelines for quality management in projects*. 2nd ed. UK: British Standards Institution.

BSI (2005). *British Standard ISO 10005:2005 Quality management systems — Guidelines for quality plans*. 2nd ed. UK: British Standards Institution.

Busch, T. A. and Girmscheid, G. (2005). Quantitative Risk Management Model for General Contractors. *In: The Third International Conference on Construction in the 21st Century, 15-17 September 2005, Athens, Greece*. Advancing Engineering Management and Technology. 240-245

Cagno, E., Caron, F., and Mancini, M. (2007).A Multi-dimensional Analysis of Major Risks in Complex Projects. *Risk Management*, 9, 1–18

CEN (2015). *European Standard EN ISO 9001: Quality management systems — Requirements (ISO 9001:2015)*, 2nd ed. Brussels: European Committee for Standardization.

Chan, A. P.C. and Chan, A. P.L. (2004). Key performance indicators for measuring construction success. Benchmarking: *An International Jo*urnal, 11(2), 203-221.

Cha, H. S. and Kim, C. K. (2011). Quantitative Approach for Project Performance Measurement on Building Construction in South Korea. *KSCE Journal of Civil Engineering*, 15(8), 1319-1328

Chandra, H. P. (2015). Structural equation model for investigating risk factors affecting project success in Surabaya. *In: The 5th International Conference of Euro Asia Civil Engineering Forum (EACEF-5)*, 15th to 18th September 2015 Surabaya, East Java, Indonesia. Procedia Engineering, 125(1), 53 – 59

Cheung, S. O., Suen, H. C. H. and Cheung, K. C. W. (2004). PPMS: a Web-based construction Project Performance Monitoring System. *Automation in Construction*, 13(1), 361-376.

Chin-Keng, T. and Abdul-Rahman, H. (2011). Study of Quality Management in Construction Projects. *Chinese Business Review,* 10(7), 542-552

Chua, D.K.H., Kog, Y.C., and Loh, P.K. (1999). Critical Success Factors for Different Project Objectives. *Journal of Construction Engineering and Management*, 125(3), 142-150

Delgado-Hernandez, D. J. and Aspinwall, E. (2008). Quality management case studies in the UK construction industry. *Total Quality Management*, 19(9), 919–938

Dey, P. K. (2001). Decision support system for Risk Management: a case study. Management decision, 39(8), 634-649.

Didla, N. R., Al-Hajj, A. (2014). Towards Quality Risk Management Application in the UAE Construction Projects. *In: 2nd Annual International Conference on Architecture and Civil Engineering*, 24th to 25th March 2014, Singapore.

Didla, N. R., Al-Hajj, A. (2014). The need for a Quality Risk Management Methodology in the UAE Construction Projects. *At: 1st International Conference of the CIB Middle East & North Africa Research Network*, 14-16 December 2014, United Arab Emirates.

Dunn, G., Harris, L., Cook, C. and Prystajecky, N. (2014). A comparative analysis of current microbial water quality risk assessment and management practices in British Columbia and Ontario, Canada. *Science of the Total Environment*, 468(1), 544–552.

Edwards, J. R. (2001). Multidimensional Constructs in Organizational Behavior Research: An integrative Analytical Framework. *Organizational Research Methods*, 4 (2), 144-192.

Eichelberger, R.T. (1989). Disciplined inquiry: Understanding and doing educational research. New York: Longman.

El-Karim, M. S. A. B. A., Mosa El Nawawy, O. A. and Abdel-Alim, A. M. (2017). Identification and assessment of risk factors affecting construction projects. *HBRC Journal*, 13(2), 202-216.

El-Sayegh, S. M. (2008). Risk assessment and allocation in the UAE construction industry. *International Journal of Project Management*, 26, 431–438

Enshassi, A., Mohamed, S., and Abushaban, S. (2009). Factors affecting the performance of construction projects in the Gaza Strip. *Journal of Civil Engineering and Management*, 15(3), 269-280.

Faridi, A. S., and El-Sayegh S. M. (2006). Significant factors causing delay in the UAE construction industry. *Construction Management and Economics*, 24, 1167–1176.

Ghezavati, V., Shojaie A. A., Esfandiari, H., and Alavi, K. (2013). Identifying, Prioritization and Responding to Quality Risks Using COQ Approach in Construction Industry. *Caspian Journal of Applied Sciences Research*, 2(6), 21-32.

Glaser, D. N. (2002). Structural Equation Modeling Texts: A Primer for the Beginner, Journal of Clinical Child & Adolescent Psychology, 31:4, 573-578.

Goh, C. S. and Abdul-Rahman, H. (2013). The Identification and Management of Major Risks in the Malaysian Construction Industry. *Journal of Construction in Developing Countries*. 18(1), 19–32.

Hanna, A. S., Thomas, G., and Swanson, J. R. (2013). Construction Risk Identification and Allocation: Cooperative Approach. *Journal of Construction Engineering and Management*, 1098-1107.

Hemsworth, D.(2016).An Empirical Assessment Of The EFQM Excellence Model In Purchasing. *International Business & Economics Research Journal*, 15(4), 127-146.

Heravi, G. and Jafari, A. (2014). Cost of Quality Evaluation in Mass-Housing Projects in Developing Countries. Journal of Construction Engineering and Management, 140(5), 1-9.

Hinkin, T. R., Tracey, J. B., and Enz, C. A. (1997). Scale construction: Developing reliable and valid measurement instruments. *Journal of Hospitality & Tourism Research*, 21(1), 100-120.

Idrus, A. B., and Sodangi, M (2010). Framework for Evaluating Quality Performance of Contractors in Nigeria. *International Journal of Civil and Environmental Engineering*. 10(1), 31-36.

International Conference on Harmonisation(ICH); Guidance on Q9 Quality Risk Management; Availability. (2006). The Federal Register / FIND, 71(106), 32105.

ICH Q9: Quality Risk Management. Fed. Reg. 71(106) 2006: 32105–32106; www. ich.org/LOB/media/MEDIA1957.pdf.

Iqbal, S., Choudhry, R. M., Holschemacher, K., Ali, A. and Tamosaitiene, J. (2015). Risk management in construction projects. *Technological and Economic Development of Economy*, 21(1), 65-78.

Irimia-Dieguez, A. I., Sanchez-Cazorla, A., and Alfalla-Luque, R. (2014). Risk Management in Megaprojects. *Social and Behavioral Sciences*, 119, 407 – 416.

ISO (2009). *International Standard ISO 31000:2009: Risk management-principles and guidelines*. 1st ed. Switzerland: International Organization for Standardization.

Jafari, A., and Love, P. E. D. (2013). Quality Costs in Construction: Case of Qom Monorail Project in Iran. *Journal of Construction Engineering and Management*, 139(9), 1244-1249.

Jeff, F. (2012), *Build quality seen as looming threat to Dubai property market*, http://www.ameinfo.com/292661.html (7.3.2012)

Jha, K. N. and Iyer, K. C. (2006). Critical Factors Affecting Quality Performance in Construction Projects. *Total Quality Management*, 17(9), 1155–1170

Johnson-Laird, P. & Byrne, R. (1991). Deduction. Hillsdale: Lawrence Earlbaum.

Kagioglou, M., Cooper, R., and Aouad, G. (2001). Performance management in construction: a conceptual framework. *Construction Management and Economics*, 19(1), 85-95.

Kanji, G. K., and Wong, A. (1998). Quality culture in the construction industry. Total Quality Management, 9(4–5), 133–140.

Kaplinski, O. (2013). Risk Management of Construction Works by Means of the Utility Theory: a Case Study. In: 11th International Conference on Modern Building Materials, Structures and Techniques, MBMST 2013, 16 - 17 May 2013, Vilnius, Lithuania. Procedia Engineering, 57, 533 – 539.

Karimiazari, A., Mousavi, N., Mousavi, S. F., and Hosseini, S. (2011). Risk assessment model selection in construction industry. *Expert Systems with Applications*, 38, 9105–9111.

Kashutskii, S. N., Rusanova, S. V., Dikhtyarev, S. I. and Dorovskoi, A. V. (2015). Some aspects of Quality Risk Management for the Fenspiride hydrochloride (0.08 G coated tablets) production process at the pharmaceutical development stage. *Pharmaceutical Chemistry Journal*, 49(11), 771-775.

Kazaz, A., Birgonul, M. T., and Ulubeyli, S. (2005). Cost-based analysis of quality in developing countries: A case study of building projects. *Building and Environment*, 40(10), 1356–1365.

Khazaeni, G., Khanzadi, M., and Afshar, A. (2012). Optimum risk allocation model for construction contracts: fuzzy TOPSIS approach. *Canadian Journal of Civil Engineering*, 39, 789-800.

Khodeir, L. M. and Mohamed, A. H. M. (2015). Identifying the latest risk probabilities affecting construction projects in Egypt according to political and economic variables. From January 2011 to January 2013. *Housing and Building National Research Center Journal*, 11, 129–135.

Khosravi, S. and Afshari, H. (2011). A Success Measurement Model for Construction Projects. *In: 2011 International Conference on Financial Management and Economics ICFME 2011, 2nd to 3rd July 2011, Hong Kong, China*. IACSIT Press, 11, 186-190.

Kluaypa, P. and Onuh, S.O. (2010). The Development of Quality Management Model for Implementation in Thai Organisations. *In: World Congress on Engineering June 30 - July 2, 2010, London, U.K* WCE, Vol III, 1-3.

Langeroodi, S. M. M., Ehsani, R., and Hamidi, N. (2011). Presentation of a Conceptual Framework for Risk Management of Construction Projects Based on PMBOK Standard (With Case Study). *Middle-East Journal of Scientific Research*, 9(6): 797-806.

Leong, T. K., Zakuan, N., Saman, M. Z. M., Ariff, M. S. M., and Tan, C. S. (2014). Using Project Performance to Measure Effectiveness of Quality Management System Maintenance and Practices in Construction Industry. *The Scientific World Journal*, 2014, 1-9.

Liebowitz, S. (2011). Saxagliptin (Onglyza): A Case Study in Quality Risk Management. In: Pharmaceutical Quality System conference, October 4-6, Arlington, USA

Loosemore, M., Raftery, J., Reilly, C., and Higgon, D. (2006). Risk management in projects. (2nd ed.). London: Taylor & Francis.

Lopez, F., Bartolo, C. D., Piazza, T., Passannanti, A., Gerlach, J. C., Gridelli, B. and Triolo, F. (2010). A Quality Risk Management Model Approach for Cell Therapy Manufacturing. *Risk Analysis*, 30(12), 1857-1871.

Love P. E. D. and Edwards D. (2004). Forensic project management: The underlying causes of rework in construction projects. *Civil Engineering and Environmental Systems*, 21(3), 207-228.

Love, P. E. D. and Irani, Z. (2003). A project management quality cost information system for the construction industry. *Information and Management*, 40, 649–661.

Love, P. E. D., Irani, Z. and Edwards, D. J. (2004). A rework reduction model for construction projects. *IEEE Transactions on Engineering Management*, 51(4), 426-440.

Love, P. E. D. and Li, H. (2000). Quantifying the causes and costs of rework in construction. *Construction Management and Economics*, 18(4):479-490.

Low, S. P. and Ong, P. (2014). *Project quality management: Critical success factors for buildings*. Singapore: Springer.

Mahendra, P. A., Pitroda, J, R., and Bhavsar, J. J. (2013). A Study of Risk Management Techniques for Construction Projects in Developing Countries. *International Journal of Innovative Technology and Exploring Engineering*, 3(5), 139-142.

Maloney, W.F. (2002). Construction product/service and customer satisfaction. *Journal of Construction Engineering and Management*, 128(6), 522–529.

Martin, D. X. (2012). Risk and the Future of Quality. *The Journal for Quality and Participation,* 9-12.

Megha, D and Rajiv, B. (2013). A Methodology for Ranking of Causes of Delay for Residential Construction Projects in Indian Context. *International Journal of Emerging Technology and Advanced Engineering*, 3(3), 396-404.

Mire-Sluis, A., Ramnarine, E., Siemiatkoski, J., Weese, D., Swann, P., O'Keeffe, R., and Edwards, J. (2010). Practical Applications of Quality Risk Management. *Bioprocess International*. 20-32.

Motaleb, O. and Kishk, M. (2010) An investigation into causes and effects of construction delays in UAE. *In: Egbu, C. (Ed) Procs 26th Annual ARCOM Conference*, 6th – 8th September 2010, Leeds, UK, Association of Researchers in Construction Management, 1149-1157.

Noordhuizen, J. and Cannas, J. (2008). Veterinary Herd Health and Production Management and Quality Risk Management programmes in Dairy Practice: what's new? *In: XXVth World Buiatrics Congress*, July 2008, Budapest, Hungary.

Noordhuizen, J. and Cannas, J. (2009). HACCP-based quality risk management approach to udder health problems on dairy farms. *Irish Veterinary Journal*, 62, 21-25.

Nudurupati, S., Arshad, T., Turner, T., (2007). Performance measurement in the construction industry: an action case investigating manufacturing methodologies. *Computers in Industry*. 58, 667–676

Orloff, J. J. (2011). The Promise and Threat of Quality Risk Management. *Pharmaceutical Technology*. 38-40.

Parvadavardini, S., Vivek, N., and Devadasan, S. (2016) Impact of quality management practices on quality performance and financial performance: evidence from Indian manufacturing companies, *Total Quality Management and Business Excellence*, 27(5-6), 507-530.

Perkins, E. (2011). *Linking Quality Management and Risk Management: Shifting from a reactive approach of controlling variances, to proactively eliminating potential sources of failure.* Available at http://www.qualitydigest.com/inside/quality-insider-column/linking-quality-management-and-risk-management.html. (Accessed: March 1st, 2015).

PMI (2013). *A Guide to the Project Management Body of Knowledge*. 5th ed. Pennsylvania: Project Management Institute.

Popescu, M and Dascalu, A. (2011). Considerations on Integrating Risk and Quality Management. *In: Annals of Dunarea de Jos, University of Galati Fascicle*. Economics and Applied Informatics, 1, 49-54.

Qing, L., Rengkui, L., Jun, Z. and Quanxin, S. (2014). Quality risk management model for railway construction projects. *In: "2014 ISSST", 2014 International Symposium on Safety Science and Technology*. Procedia Engineering 84, 195 – 203.

Raban, C and Turner, L. (2006). Quality risk management: Modernising the architecture of quality assurance. *Perspectives*, 10(2), 39-44.

Rad, H. N. and Khosrowshahi, F. (1998). Quality measurement in construction projects. *In: Hughes, W (Ed.), 14th Annual ARCOM Conference*, 9-11 September 1998, University of Reading. Association of Researchers in Construction Management, Vol. 2, 389-97.

Rao, S., S, Solis, L. E, and Raghunathan, T. S. (1999). A framework for international quality management research: Development and validation of a measurement instrument. *Total Quality Management*, 10(7), 1047-1075.

Ren, Z., Atout, M., and Jones, J. (2008). Root causes of construction project delays in Dubai. *In: Dainty, A.(Ed) Procs 24th Annual ARCOM Conference*, 1-3 September 2008, Cardiff, UK, Association of Researchers in Construction Management, 749-757.

Salama, M., and Habib, A.P. (2009). Investigating the causes of variation within the construction projects in UAE. *In: Dainty, A. (Ed) Procs 25th Annual ARCOM Conference*, 7-9 September 2009, Nottingham, UK, Association of Researchers in Construction Management, 949-957.

Samardelis, J. and Cappucci, W. (2009). Applied Quality Risk Management: Case study - Laboratory computerized systems. *Pharmaceutical Engineering*. 29(5), 1-5.

Samson, D and Terziovski, M. (1999) The relationship between total quality management practices and operational performance. *Journal of Operations Management*, Vol 17, 393-409.

Saurina, C. and Coenders, G. (2002). Predicting Overall Service Quality.A Structural Equation Modelling Approach. Developments in Social Science Methodology, 18(1), 217-238.

Schiffauerova, A., and Thomson, V. (2006). A Review of Research on Cost of Quality Models and Best Practices. *International Journal of Quality and Reliability Management*, 23(4), 1-23.

Serpella, A. F., Ferrada, X., Howard, R., and Rubio, L. (2014). Risk management in construction projects: a knowledge-based approach. *In: 27th IPMA World Congress*, 27th September to 3rd October 2013 in Dubrovnik, Croatia. Procedia - Social and Behavioral Sciences, 119, 653 – 662.

Shah, R and Goldstein, S. M. (2006). Use of structural equation modeling in operations management research: Looking back and forward. *Journal of Operations Management*. 24 (1), 148–169.

Shanmughapriya, S. and Subramanian, K. (2015). Structural equation model to investigate the factors influencing quality performance in Indian construction projects. *Sadhana*, 40(6), 1975–1987.

Schwandt, T.A. (2001). Dictionary of qualitative inquiry (2nd ed.). Thousand Oaks: Sage.

Sokovic, M., Pavletic, D. and Pipan, K. K. (2010). Quality Improvement Methodologies – PDCA Cycle, RADAR Matrix, DMAIC and DFSS. *Journal of achievements in materials and manufacturing Engineering*. 43(1), 476 – 483.

Stevens, J. D. (1996). Blueprint for measuring project quality. *Journal of Management in Engineering*, 12(2): 34-39.

Sullivan, K. T. (2011). Quality Management Programs in the Construction Industry: Best Value Compared with Other Methodologies. *Journal of Management in Engineering*, 27(4), 210-219.

Takim, R. and Akintoye, A (2002) Performance indicators for successful construction project performance. *In: Greenwood, D (Ed.), 18th Annual ARCOM Conference*, 2-4 September 2002, University of Northumbria. Association of Researchers in Construction Management, Vol. 2, 545-55.

Takim, R, Akintoye, A and Kelly, J (2003) Performance measurement systems in construction. In*: Greenwood, D J (Ed.), 19th Annual ARCOM Conference*, 3-5 September 2003, University of Brighton. Association of Researchers in Construction Management, Vol. 1, 423-32.

Tamosaitiene, J., Zavadskas, E. K., and Turskis, Z. (2013). Multi-criteria risk assessment of a construction project. *In: Information Technology and Quantitative Management(ITQM-2013),* 16-18 May 2013, Suzhou, China. Procedia Computer Science, 17, 129 – 133.

Taroun, A., Yang, J. B. and Lowe, D. (2011). Construction Risk Modelling and Assessment: Insights from a Literature Review. *The Built and Human Environment Review*, 4(1), 87-96.

Taroun, A., Yang, J. B (2011). Dempster-Shafer Theory of Evidence: Potential usage for decision making and risk analysis in construction project *management. The Built and Human Environment Review*, 4(1), 155-166.

Toni, A. D., Nassimbeni, G. and Tonchia, S. (1995). An instrument for quality performance measurement. *International Journal of Production Economics*, *38*(2), 199-207.

Trakhees (2013). *Construction Materials Quality Control Guidelines*. 2nd ed. Dubai: Ports, Customs and Freezone Corporation.

Tse, Y, K. (2012). *Supply chain quality risk management: an empirical study of its dimensions and impact on firm performance*. Unpublished PhD thesis, University of Nottingham.

Waje, V. V., Patil, V. (2009). Cost of poor Quality in Construction. In: *Second International Conference on Emerging Trends in Engineering (SICETE)*, 16-18 December 2009, Nagpur, India. IOSR Journal of Mechanical and Civil Engineering, 16-22

Walliman, N. and Baiche, B. (2001). Your research project a step-by-step guide for the first-time researcher. 1st ed, London: SAGE Publications Ltd.

Wantara, P. (2013). Using Structural Equation Modelling to Evaluate the Service Quality, Satisfaction and Customer's Loyalty in Hypermart Department Store, Bangkalan, Indonesia. *Global Journal of Management and Business Research Marketing*, 13(8), 29-36.

Williams, M. L. (2008) Air Quality Risk Management. *Journal of Toxicology and Environmental Health*, 71(1), 9-12.

Yasamis, F., Arditi, D. and Mohammadi, J. (2002). Assessing contractor quality performance. *Construction Management and Economics*, 20(3), 211–223.

Yates, J. K. and Lockley, E. E. (2002). Documenting and analyzing construction failures. *Journal of Construction Engineering and Management*, 128(1), 8-17.

Yildiz, A. E., Dikmen, I., and Birgonul, M. T. (2014). Using expert opinion for risk assessment: a case study of a construction project utilizing a risk mapping tool. *In: 27th IPMA World Congress*, 27th September to 3rd October 2013 in Dubrovnik, Croatia. Procedia - Social and Behavioral Sciences, 119, 519 – 528.

Zafarani, E. (2011). Project Quality Management Approaches: A Comparative Evaluation of International Standards. *In: 2nd International Conference on Construction and Project Management(ICCPM-2011)*, 16th to 18th September 2011, Singapore. Singapore: IPEDR vol.1, IACSIT Press.

Zaneldin, E. K. (2006). Construction claims in United Arab Emirates: Types, causes, and frequency. *International Journal of Project Management*, 24, 453–459.

Zin, R. M., Gui, H. C. and Ali, M. C (2009). An observation of impact in implementation of quality management system by contractors. *Malaysian Construction Research Journal*. 4(1), 52-71.

Zulu, S (2007). Impact of project management on project performance: a structural equation modelling approach. *In: Boyd, D (Ed) Procs 23rd Annual ARCOM Conference*, 3-5 September 2007, Belfast, UK, Association of Researchers in Construction Management, 651-660

Appendix A

A.1 Interview Cover Letter

A.2 Interview Questionnaire Format

A.3 Interview Data/Details

A.1 Interview Cover Letter

Sub.: Invitation to participate in the interview, as part of the PhD research study

Dear Sir/Madam, Date:

I would like to invite you to participate in the interview, so as to investigate the Quality Management practices in the UAE construction projects along with their deficiencies, while seeking suggestions for improvement.

The information gathered from this interview shall be helpful to evaluate the current QM practices along with their deficiencies, while the suggestions from experts would enable to seek alternative solutions to overcome the obstacles and work towards continual improvement.

I would sincerely appreciate your valuable input to this research study, and hereby assure you that all information gathered from this interview shall be used solely for academic purposes and will be strictly kept confidential.

Thanking you,

Yours sincerely,

Naveen Ratnam Didla*(Interviewer)*
PhD student
Heriot-watt University, UK
Telephone: +971 508291480
Email: naveenratnam@yahoo.com

HERIOT WATT UNIVERSITY

A.2 Interview Questionnaire

An investigation of quality management practices in the UAE construction projects

Purpose of interview:
The aim of this interview is to investigate the quality management practices in the UAE construction projects, along with their deficiencies, while seeking suggestions for improvement.

The objectives of individual sections are:

SECTION 1 - To obtain general information about the Interviewee, company, project etc.
SECTION 2 - To identify the quality performance indicators used in construction projects.
SECTION 3 - To assess the effectiveness of the current quality management (QM) practices.
SECTION 4 - To explore and understand the deficiencies in the current QM practices along with suggestions for improvement.

Statement of confidentiality:
Please be assured that the information provided by you will be used for academic purposes only and the names of the individuals/companies shall be kept confidential.

SECTION 1: Demographic information

1.1 Name of the Interviewee: ____

1.2 Contact details(Telephone/email): ____

1.3 Please indicate your highest academic level/degree
☐ Doctorate ☐ Master's ☐ Bachelor's Other:_______________

1.4 Please indicate your professional certification
☐ CMQ/OE ☐ ISO 9001 Auditor ☐ PMP Other:_______________

1.5 Please specify your total years of experience in the construction industry
☐ Less than 10 years ☐ 10 to 20 years ☐ More than 20 years

1.6 Please specify your relevant experience in Project quality management
☐ Less than 10 years ☐ 10 to 20 years ☐ More than 20 years

1.7 What is your designation in your organization?
☐ Quality Manager ☐ Project Manager Other:____________________________

1.8 Is your company ISO 9001 certified?
☐ Yes ☐ No

1.9 Which project stakeholder does your company represent?
☐ Main Contractor ☐ Sub-contractor Other:____________________________

1.10 What is the contract value of your project in Millions (AED)?
☐ Less than 100 ☐ 100 to 500 ☐ More than 500

SECTION 2: Quality performance measurement

Which of the following indicators are used to measure quality performance in your project?

2.0	Quality performance indicators	Yes/ No
2.1	Approval rate of Technical/Engineering submittals (eg.: Material Submittals, Shop Drawings, Method Statements etc.)	
2.2	Approval rate of Material Inspections	
2.3	Approval rate of Work Inspections	
2.4	Approval rate of Tests	
2.5	Closure rate of Non-conformances	
2.6	Cost of Poor Quality	
2.7	Project delays due to quality issues/failures. (eg.: rework, resubmission etc.)	
2.8	Supplier/Sub-contractor performance rating (eg.: results of Supplier performance evaluation etc.)	
2.9	Employee satisfaction. (eg.: in terms of motivation, engagement, empowerment etc.)	
2.10	Client satisfaction. (eg.: results of customer satisfaction feedback/survey etc.)	

SECTION 3: Effectiveness of quality management practices

Please provide your rating regarding the effectiveness of the following quality management practices in ensuring the achievement of your project quality objectives/quality performance.

(0 = Very Ineffective ←——→ 5 = Very Effective)

3.0	Quality management practices	Score
3.1	Project Quality Plan(PQP)	
3.2	Document control/management system	
3.3	Supplier pre-qualification/evaluation process	
3.4	Internal review of documents done prior to submission to the Consultant	
3.5	Material inspections done for material delivered to site	
3.6	Work inspections done internally prior to inviting Consultant	
3.7	Testing activities(internal/3rd party)	
3.8	Calibration of measuring instruments/equipment	
3.9	Computation of Cost of Poor Quality (COPQ)	
3.10	Quality audits (Internal/Supplier)	
3.11	Corrective & Preventive Actions to address Non-conformances/complaints etc.	
3.12	Quality training	
3.13	Supplier performance appraisal	
3.14	Quality meetings(internally/with various stakeholders)	
3.15	Quality reporting(weekly/monthly)	
3.16	Database of lessons learned/best practices	
3.17	Quality performance/trends monitoring(using quality/statistical tools/techniques)	
3.18	Management commitment & support, including employee empowerment	

SECTION 4: Deficiencies in the current quality management practices and suggestions for improvement

(Note: Please consider the context of proactive/reactive approaches, risk-based approaches etc. while answering the below questions)

4.1	**Quality Planning**
4.1.a	In spite of having Project Quality System established & implemented, what according to you are the deficiencies in quality planning which hinder the achievement of quality objectives?
4.1.b	In your opinion, how can quality planning be improved, so as to provide greater assurance of achieving project quality objectives?

4.2	**Internal review of Technical/Engineering Submittals**
4.2.a	Despite internal review of the submittals prior to submission to the Consultant, what according to you are the deficiencies in the internal review process leading to rejections?
4.2.b	What are your suggestions for reducing/controlling the rejection rate of Submittals?

4.3	**Inspection & Testing**
4.3.a	Even though internal verification/checking (using checklists etc.) is done prior to inviting Consultant for inspection, in your opinion why do rejections of material/works/tests still occur?
4.3.b	What are your suggestions for ensuring first-time approval of inspections related to Material/work/testing?

4.4 Control of Non-conformances

4.4.a What according to you are the main causes for occurrence/recurrence of Non-conformances?

4.4.b How do you assess the impact of poor quality on project objectives (eg.: in terms of Time/cost/reputation etc.)?

4.4.c Please provide your recommendations for preventing/controlling Non-conformances.

4.5 Supplier/Sub-contractor management

4.5.a Although the selection of Suppliers/Sub-contractors is done through Supplier pre-qualification process and Supplier/Sub-contract agreements are in place, what according to you are the reasons leading to their poor quality performance?

4.5.b What measures do you suggest for enhancing their quality performance?

4.6 Continual improvement

4.6.a According to you, what are the main deficiencies/gaps in the following areas that affect quality performance/continual improvement in your project?

Leadership commitment & support:

Communication:

Training:

Auditing:

Lessons learned:

4.6.b What are your key recommendations for addressing the above deficiencies so as to ensure continual improvement in your project?

Thank you for your participation!

A.3: Interview Data/Details

S No	Interviewee	Highest academic level/degree	Professional certification	Total experience in Construction industry	Relevant experience in Project Quality Management	Designation	ISO certified	Project stakeholder	Contract Value (AED Millions)
1	Interviewee-1	Bachelor's degree	CMQ, PMP, ISO Auditor	10 to 20 years	10 to 20 years	Quality Manager	Yes	Main Contractor	More than 500
2	Interviewee-2	Bachelor's degree	CMQ, ISO Auditor	10 to 20 years	10 to 20 years	Quality Manager	Yes	Main Contractor	More than 500
3	Interviewee-3	Bachelor's degree	CMQ	10 to 20 years	10 to 20 years	Quality Manager	Yes	Main Contractor	More than 500
4	Interviewee-4	Bachelor's degree	CMQ, ISO Auditor	10 to 20 years	10 to 20 years	Quality Manager	Yes	Main Contractor	More than 500
5	Interviewee-5	Bachelor's degree	ISO Auditor	More than 20 years	10 to 20 years	Quality Manager	Yes	Main Contractor	More than 500
6	Interviewee-6	Master's degree	None	10 to 20 years	Less than 10 years	Construction Manager	Yes	Main Contractor	More than 500
7	Interviewee-7	Bachelor's degree	PMP	10 to 20 years	10 to 20 years	Project Manager	Yes	Sub-contractor	100 to 500
8	Interviewee-8	Bachelor's degree	None	Less than 10 years	Less than 10 years	Project Manager	Yes	Sub-contractor	Less than 100
9	Interviewee-9	Master's degree	ISO Auditor	Less than 10 years	Less than 10 years	Quality Manager	Yes	Sub-contractor	100 to 500
10	Interviewee-10	Bachelor's degree	None	10 to 20 years	Less than 10 years	Project Manager	Yes	Sub-contractor	100 to 500
11	Interviewee-11	Others	None	More than 20 years	More than 20 years	Project Manager	Yes	Sub-contractor	100 to 500
12	Interviewee-12	Bachelor's degree	PMP	More than 20 years	More than 20 years	Operations Manager	Yes	Sub-contractor	Less than 100

Interview participants' Demographic information **(SECTION 1: Demographic information)**

QUALITY PERFORMANCE INDICATORS (1=Yes; 0=No)		**Rating (Main Contractor)**						**Rating (Sub-Contractor)**						**Sub-score (Main Contractor)**		**Sub-score (Sub-contractor)**		**Overall score (Usage of QPI)**	
Item code	**Quality Performance indicator**	**Interviewee-1**	**Interviewee-2**	**Interviewee-3**	**Interviewee-4**	**Interviewee-5**	**Interviewee-6**	**Interviewee-7**	**Interviewee-8**	**Interviewee-9**	**Interviewee-10**	**Interviewee-11**	**Interviewee-12**	**No. of projects using the QPI**	**% of projects using the QPI**	**No. of projects using the QPI**	**% of projects using the QPI**	**No. of projects using the QPI**	**% of projects using the QPI**
2.1	Approval rate of Technical/Engineering submittals	1	0	0	1	1	1	0	1	1	1	1	1	4	67%	5	83%	9	75%
2.2	Approval rate of Material Inspections	1	1	1	1	1	1	1	1	1	1	1	1	6	100%	6	100%	12	100%
2.3	Approval rate of Work Inspections	1	1	1	1	1	1	1	1	1	1	1	1	6	100%	6	100%	12	100%
2.4	Approval rate of Testing	0	1	1	1	1	1	1	1	1	1	1	0	5	83%	5	83%	10	83%
2.5	Closure rate of Non-conformances	1	1	1	1	1	1	1	1	1	1	1	1	6	100%	6	100%	12	100%
2.6	Cost of Quality	1	0	0	1	1	0	1	1	1	1	1	0	3	50%	5	83%	8	67%
2.7	Project delays due to quality issues	1	1	1	0	1	0	0	1	1	0	0	0	4	67%	2	33%	6	50%
2.8	Supplier/Sub-contractor performance	1	1	1	0	1	1	0	1	1	1	0	0	5	83%	3	50%	8	67%
2.9	Employee satisfaction	1	0	0	1	1	1	0	1	0	0	1	1	4	67%	3	50%	7	58%
2.10	Client satisfaction	1	0	1	1	1	1	0	1	1	1	1	0	5	83%	4	67%	9	75%

Quality performance indicators used in the UAE construction projects(**SECTION 2: Quality performance measurement)**

Effectiveness of QUALITY MANAGEMENT PRACTICES (1=Very Ineffective; 5=Very effective)		Rating (Main Contractor)						Rating (Sub-Contractor)						Mean score (Main Contractor)		Mean score (Main Contractor)		Overall score (Effectiveness of QM practices)	
Item code	**Quality Management Practices**	**Interviewee-1**	**Interviewee-2**	**Interviewee-3**	**Interviewee-4**	**Interviewee-5**	**Interviewee-6**	**Interviewee-7**	**Interviewee-8**	**Interviewee-9**	**Interviewee-10**	**Interviewee-11**	**Interviewee-12**	**Mean score**	**% Mean score**	**Mean score**	**% Mean score**	**Overall score**	**% Overall score**
3.1	Project Quality Plan	5	4	4	5	5	5	1	4	4	3	3	2	4.67	93%	2.83	57%	3.75	75%
3.2	Document control/management system.	5	4	4	5	5	5	1	4	4	3	3	2	4.67	93%	2.83	57%	3.75	75%
3.3	Supplier pre-qualification/evaluation process	4	3	2	4	5	4	2	3	4	4	3	4	3.67	73%	3.33	67%	3.50	70%
3.4	Internal review of documents done prior to submission to the Consultant.	4	3	2	4	5	4	2	4	3	2	3	2	3.67	73%	2.67	53%	3.17	63%
3.5	Material inspections done for material delivered to site.	4	4	3	5	5	4	3	5	5	3	4	2	4.17	83%	3.67	73%	3.92	78%
3.6	Work inspections done internally prior to inviting Consultant.	4	4	4	5	5	4	3	4	4	3	4	3	4.33	87%	3.50	70%	3.92	78%
3.7	Testing activities. (internal/3rd party)	3	4	4	5	5	4	3	4	4	4	3	3	4.17	83%	3.50	70%	3.83	77%
3.8	Calibration of measuring instruments/equipment.	4	4	4	5	5	4	3	4	4	4	4	3	4.33	87%	3.67	73%	4.00	80%
3.9	Computation of Cost of Quality (COQ).	5	3	2	4	5	4	3	5	5	3	4	2	3.83	77%	3.67	73%	3.75	75%
3.10	Quality audits.(Internal/Supplier)	5	3	2	4	4	5	1	3	3	1	4	1	3.83	77%	2.17	43%	3.00	60%

3.11	Corrective & Preventive Actions to address Non-conformances/complaints etc.	5	3	3	5	5	5	2	4	3	2	3	2	4.33	87%	2.67	53%	3.50	70%
3.12	Quality training.	4	4	3	4	4	3	2	3	3	2	3	2	3.67	73%	2.50	50%	3.08	62%
3.13	Supplier performance appraisal.	3	4	3	4	4	5	2	3	3	2	3	2	3.83	77%	2.50	50%	3.17	63%
3.14	Quality meetings. (internally/with various stakeholders)	5	5	4	5	5	5	3	4	4	3	5	3	4.83	97%	3.67	73%	4.25	85%
3.15	Quality reporting. (weekly/monthly)	5	4	4	4	5	4	3	5	5	3	4	3	4.33	87%	3.83	77%	4.08	82%
3.16	Database of lessons learned/best practices.	3	3	2	3	4	4	1	2	2	1	2	1	3.17	63%	1.50	30%	2.33	47%
3.17	Quality performance/trends monitoring. (using quality/statistical tools/techniques)	5	4	3	4	5	5	3	4	4	3	4	3	4.33	87%	3.50	70%	3.92	78%
3.18	Management commitment & support, including employee empowerment.	4	4	3	5	4	5	2	4	4	3	4	2	4.17	83%	3.17	63%	3.67	73%

Effectiveness of Quality Management practices in the UAE construction projects **(SECTION 3: Effectiveness of quality management practices)**

Deficiencies in the current QM practices	Suggestions/Recommendations for improvement
4.1 Quality Planning	
Interviewee-1: PQP once approved by the consultant, is rarely updated during the project.	**Interviewee-1:** PQP needs to be periodically reviewed and updated to incorporate the new progressive changes. Frequency should be fixed either quarterly or as mutually agreed by Client/Consultant and Contractor as per the need of the project.
Interviewee-3: Quality objectives are mostly established without proper understanding of project/customer requirements.	**Interviewee-3:** Establishing of Quality objectives needs to consider from risk point of view so as support proactive approach in preventing quality failures. Additionally, they need to be SMART to be achieved.
4.2 Internal review of documentation for Submittals	
Interviewee-8: Adequate information/input (technical & operational requirements/procedures etc.) not provided to the Suppliers to prepare their proposals.	**Interviewee-8:** Adequate information should be provided to the Supplier needed for preparation of submittals.
Interviewee-10: Short notice given to prepare & submit which dampens the quality of the submittal, often increasing the chances of rejection by the consultant.	**Interviewee-10:** Suppliers/Sub-contractors need to be provided adequate time for preparation of their submittals.
Interviewee-4: Poor Submittal documentation due to incorrect compilation related to no. of copies/formats, forms, numbering, details, invalid/expired documents, Delivery notes, Third party test certificates etc.	**Interviewee-4:** Contractor QA/QC Engineer should be given adequate time for internal review/verification. A checklist can be prepared for each Submittal along with the list of documents which need to be attached including the required no. of copies.
4.3 Inspection & Testing	
Material Inspections	
Interviewee-5 & 6: The major reasons for the MIR rejections are the delivered material is not as per the approved material submittal from the approved source (manufacturer/Supplier) or brand/type as that mentioned in the approved Material Submittal. In some cases, the delivered material has been found to be in a damaged / unacceptable condition.	**Interviewee-5 & 6:** Verification sampling to be done based on the risk. Advanced notice needs to be given to QA/QC and Stores personnel to make necessary arrangements for receiving, checking and storing to avoid hasty checking.

<table>
<tr><td>Work Inspections
Interviewees-1,3,4 & 6:
Not adequately using proactive control measures like checklists etc.
In some cases, the rejection is repeating due to the same/similar failure cause. Testing frequency crossing more than required in the specification due to lack of proactive checking measures in place
In many cases some works/activities are carried out without the Consultant’s approval of the previous/preceding activity/works or the testing requirements.
The other key reasons for rejections are if the works are carried out by unapproved Drawings or Method statements or Sub-contractors or usage of unapproved material.
Reasons related to Poor/Incorrect Submittal Documentation /compilation are, wherein the attachments like MEP clearance, NOC, approval of previous work/activity, signed-up checklist etc are not attached.</td>
<td>Interviewees-1,4 & 6:
More focus should be put based on the trends in the previous inspections and based on the risk assessment.
Communication with the consultant needs to be improved.
Internal review needs to be increased. Not adequately using proactive control measures like checklists etc.
Checklists to be revised based on the root cause analysis.
Root cause analysis needs to be fed back into the system for continual improvement.</td></tr>
<tr><td>Testing
Interviewees-3,5 & 6:
In some cases, the test results are not fulfilling the requirements of the specification.
Testing done at unapproved laboratory. The above failures have resulted in repetition of tests or remove the completed works and reworks.</td>
<td>Interviewees-3,4 & 6:
Resting frequencies should be done as per the contract specification or as per the approved ITP.
Calibration log needs to be maintained for all testing instruments/equipment along with archiving valid calibration certificates.</td></tr>
<tr><td colspan="2">4.4 Non-conformances</td></tr>
<tr><td>Interviewees-2,4 & 5:
Root cause analysis in some cases shows lack of proactive control measures in place.
Poor effectiveness of corrective actions taken before, leading to repetition.
The basis of corrective actions is Root cause analysis in some cases shows lack of proactive control measures in place.</td>
<td>Interviewees-2,5 & 6:
Proactive approaches like Checklists, risk management techniques etc., need to be followed to avoid/prevent potential quality failures from occurring in the first place.
The repletion of failure indicates that there is no mechanism in place to enable lessons from previous failures being recorded and efforts put in to prevent them from repeating.
Decision making & prioritization to be based on database for historical information or Cost of quality.</td></tr>
</table>

4.5 Supplier/Sub-contractor management	
Interviewees-1,4 & 5: • Supplier prequalification process is done in a weak manner with no adequate review or verification and sometimes with no ground checks (factory visits etc.). • The most common influencing factors for the contractor deviation from the vendor list are lowest price and in many cases, the pressure from the top management.	**Interviewees-1,3 & 5:** • During Sub-contractors/Supplier's selection, adequate weight must be given to Quality, similar to price. Potential risks from quality point of view should be considered. Field visits should be prioritized based on the potential risks they carry. • Supplier performance database must be maintained indicating history of issues/complaints/delivery performance etc. which can be a helpful reference for decision making. • Supplier performance appraisals • Compliance statement should be used.
Interviewees-7,9 & 12: • Sub-contractors express their concern that due to the mis-coordination with sub-contractors of multiple disciplines viz., MEP, Architectural, Structural, specialized works etc., sometimes key details are not taken into account in the development of various shop drawings.	**Interviewees-7,8 & 12:** • Quality requirements need to be clearly mentioned in the sub-contract agreements/LPOs so as to avoid surprises later. • RFI needs to be raised to clarify in case of any ambiguity of details. • Communication/interaction needs to be improved through workshops, meetings etc.
4.6 Continual improvement	
Management support **Interviewees-2,11 & 12:** • Management unnecessarily interferes and put negative pressure compromising quality (favoring nepotism, pressure to complete works, price overshadowing quality etc.? • Poor leadership or inadequate management support to the cause of quality, in terms of not providing adequate resources (People/Machines/Material etc.). • Employees not adequately empowered to make decisions	**Interviewees-2,11 & 12:** • Top management needs to support employees. • Rewarding system to be implemented to motivate/encourage employees

Auditing **Interviewees-2,4 & 6:** • The audit schedule reflects elements/processes more focused on the corporate level procedures seemingly targeting the ISO certification. • The scope seems to be less focused on the project quality performance and more on financial aspects (resources/assets etc.). •	**Interviewees-2,4 & 6:** • Audits to put more focus on risk-based approach.
Quality Training **Interviewees-2,4 & 6:** • Failure in delivery of planned training sessions indicates that the opportunities to prevent potential quality failures are being repeatedly foregone. • Basis for quality training is random and not clear.	**Interviewees-2,4 & 6:** • Training plan must take into account both system/procedures and also be dynamic/prioritize from the outcome of NCRs and other rejections from Consultant. • Should take into account the high-risk areas. • Skill based training needs to be planned and implemented.
Quality Database **Interviewees- 4 & 6:** • Poor database/ monitoring system leading to ineffective decision-making	**Interviewees- 4 & 6:** • Database of lessons learned must be used for taking CAPA.

Comments/Remarks by various Interviewees (SECTION 4: Deficiencies in the current QM practices in the UAE construction projects and suggestions for improvement**)**

Appendix B

B.1 Content Adequacy Assessment Format

B.2 Content Adequacy Assessment Data/Details

B.1 Content Adequacy Assessment Format

HERIOT WATT UNIVERSITY

Content validity

Purpose:
The aim of content validity is to assess/validate the extent to which the generated measurement items reflect the theoretical definition of the respective constructs. Content validation is a process that aims to provide greater assurance that the survey instrument (questionnaire in this study) measures the content area it is expected to measure.

In this study, content validity is carried out in two parts – Part 1(*Classification of generated QRM items into distinct QRM dimensions*) and Part 2(*Operationalization of constructs*), whose individual purposes are explained in the next pages. Based on the outcome of this exercise, the retained items are finalized as measurement items in the survey questionnaire.

Statement of confidentiality:
Please feel comfortable to give responses, as we hereby assure you that the information you provide will be used for academic purposes only and the names of the individuals/companies shall be kept confidential.

Respondent details

a) Name: ____

b) Telephone: ____

c) Email: ____

d) Designation: ____

e) Academic qualification

☐ Master's ☐achelor's O☐ers ______________

f) Total experience in the construction industry: _____ years

g) Total experience in Quality Management: _____ years

h) Total experience in Risk Management: _____ years

i) Professional certification/membership (PMP, ASQ, ISO Auditor etc.)

j) Please provide highlights of your achievements (accolades/awards etc.)

PART 1: Classification of generated QRM items into distinct QRM dimensions

Purpose: The purpose of this part is to classify/categorize the quality risk management action items into four distinct QRM dimensions viz., Risk Avoidance, Risk Mitigation, Risk Transference and Risk Acceptance.
Considering the operational definitions of the QRM dimensions as mentioned below, the respondents are required to assign any one of the four dimensions to each item, which in the respondent's opinion is the most suitable one.

Operational definitions of QRM dimensions: The following are the four Quality Risk Management dimensions/strategies for managing the quality risks which affect the quality performance in construction projects.

Dimension 1: Risk Avoidance (RAV) *is a risk management strategy whereby the Contractor's project team acts to eliminate the threat or protect the project from its impact. The aim of this strategy is to ensure that potential risks/negative effects hindering the achievement of quality objectives are avoided/prevented, so as to provide greater assurance that the customer/project quality requirements would be met. They are a set of proactive measures undertaken by the project team/management, which focus on establishing and implementing a robust project quality management system, so as to avoid/prevent any potential quality failures or customer dissatisfaction.*

Dimension 2: Risk Mitigation (RMI) *is a risk management strategy whereby the Contractor's project team acts to reduce the probability of occurrence or impact of a risk. The aim of this strategy is to reduce/mitigate the occurrence or impact of adverse risks hindering the achievement of quality objectives, whereby it is imperative that taking early action to reduce the probability and/or impact of a risk occurring is often more effective than trying to repair the damage after the risk has occurred. They are a set of quality control actions taken by the project team which focus on verifying whether or not the delivery of products, works, processes, services etc., conform to the customer/project requirements, whereby any deviations or potential non-conformances are detected early, for taking appropriate corrective actions to mitigate the quality risks.*

Dimension 3: Risk Transference (RTR) *is a risk management strategy whereby the Contractor's project team shifts the impact of a threat to a third party, together with ownership of the response. The aim of this strategy is to enable the Contractor to safeguard himself from the negative consequences/impact through shifting/allocating the risk impact to other stakeholders in the Supply chain (Sub-contractors/Suppliers/Manufacturers/3rd party testing etc.), based on the risk source or who is better able to handle/manage those risks.*

Dimension 4: Risk Acceptance(RAC) *is a risk management strategy whereby the Contractor's project team is prepared to take appropriate corrective actions focused on addressing/dealing with the quality failures/non-conformances leading to customer dissatisfaction, in case they occur. This strategy requires establishing a contingency reserve, including amounts of time, money, or resources to handle the risks as they come along.*

In your opinion, please indicate to which of the four dimensions each of the items belongs to. You are required to assign any one dimension only to each item and not to leave blank in any case.

(1=Risk Avoidance; 2=Risk Mitigation; 3=Risk Transference; 4=Risk Acceptance)

Item no.	Proposed Measurement items	Dimension (1 / 2 / 3 / 4)
C1	We establish and implement Project Quality Plan so as to ensure that the client/project quality requirements are met.	
C2	Our Management demonstrates leadership and commitment to quality by providing adequate support (resources, employee motivation/empowerment etc.) needed for effective implementation of quality system.	
C3	We carryout activities to ascertain whether design enables the most efficient construction methods to be used and the planned construction activities are the most effective.	
C4	We ensure to deploy competent staff appropriately as needed for the project, considering relevant education/training, skills, experience etc.	
C5	We follow a collaborative approach to solve quality problems/issues with various stakeholders in an amicable way so as to avoid any potential disputes that may affect quality performance.	
C6	We establish and implement good controls & monitoring systems for observing trends in quality performance and take appropriate actions to avoid any obstacles hindering the achievement of quality objectives.	
C7	We establish and follow good communication protocols with all project stakeholders so as to ensure improved information sharing, coordination, decision making etc., thus avoiding any misunderstanding or ambiguity.	
C8	We believe purchasing and using modern and updated equipment could be a solution to avoid inappropriate equipment cost as much as possible.	
C9	We provide training so as to communicate various project requirements aimed at enhancing peoples' knowledge, awareness and capabilities.	
C10	We obtain clarification/confirmation through RFI (Request for Information), in case any details are not clear.	
C11	We organize/attend meetings with various stakeholders (Client/Consultant/Supplier etc.), to discuss and prevent/avoid any potential obstacles which may affect quality performance.	
C12	We avoid using defective material.	
C13	We avoid using any defective equipment/instrument which is not calibrated.	
C14	We avoid selection of Suppliers or material purely based on price/cost, wherein quality is compromised.	
C15	We avoid using unapproved Sub-contractors, Suppliers, Material, Shop drawings, Method statements etc., for executing works.	
C16	We follow a rigorous Pre-qualification process so as to ensure that only competent & reliable Sub-contractors/Suppliers are selected/chosen.	
C17	We carryout adequate rounds/levels of internal reviews of Submittal documentation so as to reduce the chances of rejection.	
C18	We provide illustrations of how various causes and sub-causes relate to creation of potential quality issues/problems so as to take appropriate precautionary/control measures.	

C19	We inspect material delivered to site, so as to ensure that only approved materials which are free from defects are received.	
C20	We ensure that the manufacturer's instructions are strictly followed for material handling, storing/protection, application etc.	
C21	We conduct field demonstration by laborers to showcase their understanding of the workmanship quality required.	
C22	We conduct Tool-box talks to communicate the quality requirements to the project execution teams & workers.	
C23	We build mock-ups and ensure the successive works are effectively done in line with these benchmarks, to enhance approval rate.	
C24	We ensure that all the measuring instruments/equipments used are calibrated and valid certificates and logs are maintained and monitored effectively.	
C25	We carryout internal inspection of our works and if we detect any non-compliance, we proactively address them before inviting the Consultant.	
C26	We conduct internal tests and 3rd party testing as per approved ITP.	
C27	We take adequate input from relevant Engineers to prepare Method statements, so as to make it more realistic/practical during implementation.	
C28	We use controls like Checklists etc., during our process of internal review/inspection, so as to crosscheck conformance to quality requirements.	
C29	We perform audits to check compliance with the project requirements and seeking any areas of improvement.	
C30	We carry out Supplier performance evaluation, to take appropriate action against any detected deficiencies, aiming at improved performance.	
C31	We make the Suppliers/Sub-contractors responsible for their goods & services, covered through Undertaking letter, Warranty/Guarantee, Performance bonds, Insurance etc.	
C32	We transfer some risks to the Insurance companies, which are generally beyond the control of the project stakeholders.(eg.: Natural disasters etc)	
C33	In case of rejection of any Supplier/Sub-contractor's submittals, we make them responsible to revise & resubmit after addressing the Consultant's comments.	
C34	We require our key Suppliers/Sub-contractors to provide us their process control data for us to keep track of the production quality.	
C35	We make the Suppliers/Sub-contractors responsible for unconditionally replacing any defective material delivered to site by them, at their own expense.	
C36	We make the Sub-contractors responsible for rectifying any defective works under their scope, with no liability (cost/time impact) to the Main Contractor.	
C37	We make the Suppliers/Sub-contractors responsible to provide the necessary training to their staff and Suppliers such that they completely understand the project quality requirements.	
C38	In case of any penalties imposed by the Client/Authority due to the quality issues arising from Supplier's goods/services, the same shall be recovered from them.	
C39	We make the Suppliers/Sub-contractors responsible for ensuring all the statutory/regulatory requirements related to their men, machines/equipment etc., are complied with.	

C40	We make our Suppliers/Sub-contractors responsible to ensure that all applicable tests related to their material/products/works are conducted and test reports submitted for approval.	
C41	We make the Suppliers/Sub-contractors responsible to inspect/audit their Suppliers products/services.	
C42	We make it clear in the Sub-contract agreement/LPO, regarding the Sub-contractor's/Supplier's responsibilities/liabilities towards fulfilling the project quality requirements.	
C43	We have set up a procedure related to control of nonconforming outputs, including carrying out root cause analysis and corrective & preventive actions.	
C44	We establish a contingency reserve, including amounts of time, money, or resources to handle the risks as they come along.	
C45	In case of rejection of our Submittals, we revise and resubmit after taking the appropriate corrective actions.	
C46	We audit the supply chain of our Suppliers/Sub-contractors based on the quality failures recorded.	
C47	In case of rejection of our material/products, we unconditionally replace them.	
C48	We ensure that our Suppliers/Sub-contractors are adequately trained to prevent recurrence of failures noticed.	
C49	In case of rejection of our works or testing, we allocate additional resources and contingency amount to unconditionally repair/Rework/Retest.	
C50	During project handing over, we deploy additional resources to complete the punch list items for smooth handover to the satisfaction of the Client.	
C51	In case of any problems with the Suppliers/Sub-contractors (eg.: poor performance, acting opportunistically/taking undue advantage etc) we keep reserved approvals for stand-by Suppliers/Sub-contractors.	
C52	In case of any quality violations (regulatory etc), we pay penalties to the Authorities/Client from the contingency amount reserve.	
C53	In case of any Customer complaints on the performance of any individual, we investigate the cause and take appropriate actions (eg warning, replacement etc.)	
C54	We resolve/address quality problems/issues with various stakeholders in an amicable way, through discussion, meetings etc.	

PART 2: Operationalization of constructs

Purpose: The purpose of this part is to assess/validate the extent to which the proposed measurement items in the construct reflect the theoretical/conceptual definition of the respective constructs. At the end of this exercise, the short listed items shall be used as measurement items in the survey questionnaire. In this regard, the respondents(Subject Matter Experts) are required to rate the extent to which the items corresponded to the conceptual definitions of the respective constructs as indicated in sections A,B & C.

Operational definitions/description:

QUALITY PERFORMANCE: Quality in construction projects is defined as the ability of the products, processes or services to conform to the established requirements as specified in the contractual agreement.

QUALITY RISKS: According to the concept of quality and strive to meet customer expectations, every risk at any stage of work that can have an effect on the quality of performance and cause negative customer satisfaction would be considered as quality risk. In this study the operational risks related to quality are considered wherein the quality risks are viewed as risk of loss resulting from inadequate or failed internal processes, systems, people and to an extent external events are considered.

QUALITY RISK MANAGEMENT: QRM in this research is defined as actions undertaken by the project team to address (prevent/reduce) quality risks, aimed at enhancing project quality performance.

Section A: QUALITY PERFORMANCE

In your opinion, please indicate the level of relevance of the following items as indicators of quality performance in the UAE construction projects.

(0=Not relevant ; 1=Relevant)

Item	Proposed Measurement items	Score
A1	Approval rate of Technical/Engineering submittals. *(eg.: Material Submittals, Shop Drawings, Method Statements etc.)*	
A2	Approval rate of Material Inspections.	
A3	Approval rate of Work Inspections.	
A4	Statutory and Regulatory compliance	
A5	Approval rate of Testing.	
A6	Defects.	
A7	Rate of completion & effectiveness of training.	
A8	Rate of completion & effectiveness of auditing.	
A9	Reworks.	
A10	Non-conformances.	
A11	Cost of Poor Quality.	
A12	Project delays due to quality issues.	
A13	Project handing-over items	
A14	Timely response in addressing customer complaints/queries. *(eg.: closing of NCRs, action items in minutes of meetings etc.)*	
A15	Client satisfaction. *(eg.: through results of customer satisfaction feedback survey etc.)*	
A16	Supplier/Sub-contractor performance. *(eg.: through results of performance appraisal etc.)*	
A17	Employee satisfaction. *(eg.: in terms of motivation, involvement, engagement etc.)*	
A18	Relationship with project stakeholders. *(eg.: in terms of communication, coordination, cooperation etc.)*	
A19	Employee turnover	
A20	Relationship with society/neighbors. *(eg.:in terms of effective communication, less disturbance/pollution etc.)*	

Section B: QUALITY RISKS		
In your opinion, please indicate the level of relevance of the following items as indicators of quality risks in the UAE construction projects. ***(0=Not relevant ; 1=Relevant)***		
Item no.	**Proposed Measurement items**	**Score**
B1	Poor understanding of the Client needs/project quality requirements.	
B2	Inadequate training provided.	
B3	Inadequate management support towards effective implementation of quality system.(in terms of providing resources, motivating, quality culture, management review etc)	
B4	Poor/unrealistic planning.	
B5	Poor information management systems/controls affecting decision making.	
B6	Careless attitude of workers.	
B7	Shortage of resources (eg.: people, plant & equipment, material etc.)	
B8	Inadequate internal reviewing/checking.	
B9	Poor documentation.	
B10	Improper construction methods (eg.: using wrong methodology, equipment, measurement etc.)	
B11	Poor material handling/storing, not done as per Manufacturer's instructions.	
B12	Defective material usage at site.	
B13	Difficulties in measuring results.	
B14	Defective works resulting in rework/delays. (eg.: due to poor workmanship, errors/mistakes during execution etc.)	
B15	Execution of works without prior approval of Consultant (eg.: using unapproved Material, Drawing, Method Statement, Sub-contractor etc.)	
B16	Inspections & Testing methods/frequency deviating from the approved Inspection & Test Plan (ITP).	
B17	Using bad equipment in poor working condition or not calibrated.	
B18	Incompetent project staff/unskilled workers	
B19	Resistance/unwillingness of project members to follow quality procedures.	
B20	Poor supervision/coordination on site.	
B21	Inadequate/incomplete information related to drawings, specifications etc.	
B22	Poor communication/coordination among various project stakeholders.	
B23	Unnecessary interference by Client.	
B24	Weak Supplier agreements/contracts leading to creation of potential quality issues/disputes.	
B25	Pressure to complete works affecting quality.	
B26	Incompetency & poor performance of Sub-contractor/Suppliers.(eg.: poor quality of submittals/products/services)	

Section C: QUALITY RISK MANAGEMENT		
In your opinion, please indicate the level of relevance of the following items as indicators of quality risk management dimension in the construction projects. ***(0=Not relevant ; 1=Relevant)***		
Item	**Proposed Measurement items**	**Score**
Risk Avoidance: *It is a risk management strategy whereby the project team acts to eliminate/avoid the threats to achieving quality objectives or protect from the impact.*		
C1	We establish and implement Project Quality Plan so as to ensure that the client/project quality requirements are met.	
C2	Our Management demonstrates leadership and commitment to quality by providing adequate support (resources, employee motivation/empowerment etc.) needed for effective implementation of quality system.	
C4	We ensure to deploy competent staff appropriately as needed for the project, considering relevant education/training, skills, experience etc.	
C5	We follow a collaborative approach to solve quality problems/issues with various stakeholders in an amicable way so as to avoid any potential disputes that may affect quality performance.	
C6	We establish and implement good controls & monitoring systems for observing trends in quality performance and take appropriate actions to avoid any obstacles hindering the achievement of quality objectives.	
C7	We establish and follow good communication protocols with all project stakeholders so as to ensure improved information sharing, coordination, decision making etc., thus avoiding any misunderstanding or ambiguity.	
C9	We provide training so as to communicate various project requirements aimed at enhancing peoples' knowledge, awareness and capabilities.	
C10	We obtain clarification/confirmation through RFI (Request for Information), in case any details are not clear.	
C11	We organize/attend meetings with various stakeholders (Client/Consultant/Supplier etc.), to discuss and prevent/avoid any potential obstacles which may affect quality performance.	
C12	We avoid using defective material.	
C13	We avoid using any defective equipment/instrument which is not calibrated.	
C14	We avoid selection of Suppliers or material purely based on price/cost, wherein quality is compromised.	
C15	We avoid using unapproved Sub-contractors, Suppliers, Material, Shop drawings, Method statements etc., for executing works.	
C16	We follow a rigorous Pre-qualification process to ensure that only competent & reliable Sub-contractors/Suppliers are selected/chosen.	
Risk Mitigation: *It is a risk management strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk.*		
C17	We carryout adequate rounds/levels of internal reviews of Submittal documentation so as to reduce the chances of rejection.	
C19	We inspect material delivered to site, so as to ensure that only approved materials which are free from defects are received.	
C20	We ensure that the manufacturer's instructions are strictly followed for material handling, storing/protection, application etc.	
C22	We conduct Tool-box talks to communicate the quality requirements to the project execution teams & workers.	
C23	We build mock-ups and ensure the successive works are effectively done in line with these benchmarks, to enhance approval rate.	
C24	We ensure that all the measuring instruments/equipments used are calibrated and valid certificates and logs are maintained and monitored effectively.	
C25	We carryout internal inspection of our works and if we detect any non-compliance, we proactively address them before inviting the Consultant.	
C26	We conduct internal tests and 3rd party testing as per approved ITP.	
C27	We take adequate input from relevant Engineers to prepare Method statements, so as to make it more realistic/practical during implementation.	
C28	We use controls like Checklists etc., during our process of internal review/inspection, so as to crosscheck conformance to quality requirements.	
C29	We perform audits to check compliance with the project requirements and seeking any areas of improvement.	
C30	We carry out Supplier performance evaluation, to take appropriate action against any	

	detected deficiencies, aiming at improved performance.	
Risk Transference: *It is a risk management strategy whereby the project team shifts the impact of a threat to a third party, together with responsibility/ownership of the response.*		
C31	We make the Suppliers/Sub-contractors responsible for their goods & services, covered through Undertaking letter, Warranty/Guarantee, Performance bonds, Insurance etc.	
C32	We transfer some risks to the Insurance companies, which are generally beyond the control of the project stakeholders.(eg.: Natural disasters etc)	
C33	In case of rejection of any Supplier/Sub-contractor’s submittals, we make them responsible to revise & resubmit after addressing the Consultant's comments.	
C35	We make the Suppliers/Sub-contractors responsible for unconditionally replacing any defective material delivered to site by them, at their own expense.	
C36	We make the Sub-contractors responsible for rectifying any defective works under their scope, with no liability (cost/time impact) to the Main Contractor.	
C37	We make the Suppliers/Sub-contractors responsible to provide the necessary training to their staff and Suppliers such that they completely understand the project quality requirements.	
C38	In case of any penalties imposed by the Client/Authority due to the quality issues arising from Supplier's goods/services, the same shall be recovered from them.	
C39	We make the Suppliers/Sub-contractors responsible for ensuring all the statutory/regulatory requirements related to their men, machines/equipment etc., are complied with.	
C40	We make our Suppliers/Sub-contractors responsible to ensure that all applicable tests related to their material/products/works are conducted and test reports submitted for approval.	
C41	We make the Suppliers/Sub-contractors responsible to inspect/audit their Suppliers products/services.	
C42	We make it clear in the Sub-contract agreement/LPO, regarding the Sub-contractor’s/Supplier’s responsibilities/liabilities towards fulfilling the project quality requirements.	
Risk Acceptance: *It is a risk management strategy whereby the project team is prepared to take appropriate remedial actions against quality failures/ risks/customer complaints, in case they occur.*		
C43	We have set up a procedure related to control of nonconforming outputs, including carrying out root cause analysis and corrective & preventive actions.	
C44	We establish a contingency reserve, including amounts of time, money, or resources to handle the risks as they come along.	
C45	In case of rejection of our Submittals, we revise and resubmit after taking the appropriate corrective actions.	
C47	In case of rejection of our material/products, we unconditionally replace them.	
C49	In case of rejection of our works or testing, we allocate additional resources and contingency amount to unconditionally repair/Rework/Retest.	
C50	During project handing over, we deploy additional resources to complete the punch list items for smooth handover to the satisfaction of the Client.	
C51	In case of any problems with the Suppliers/Sub-contractors (eg.: poor performance, acting opportunistically/taking undue advantage etc) we keep reserved approvals for stand-by Suppliers/Sub-contractors.	
C52	In case of any quality violations (regulatory etc), we pay penalties to the Authorities/Client from the contingency amount reserve.	
C53	In case of any Customer complaints on the performance of any individual, we investigate the cause and take appropriate actions (eg warning, replacement etc.)	
C54	We resolve/address quality problems/issues with various stakeholders in an amicable way, through discussion, meetings etc.	

B.2 Content Adequacy Assessment Data/Details

S No	Judge (respondent)	Designation	Academic Qualification	Total experience in Construction industry	Total experience in Quality Management	Total experience in Risk Management	Professional certification/ Membership	Highlights of achievements
1	Judge-1	Quality Manager	Bachelor's degree	17	15	8	CMQ, PMP, ISO Auditor	
2	Judge-2	Quality Manager	Bachelor's degree	12	10	4	CMQ, ISO Auditor	
3	Judge-3	Quality Manager	Bachelor's degree	18	14	6	CMQ	
4	Judge-4	Quality Manager	Bachelor's degree	19	11	5	ISO Auditor, PMP	
5	Judge-5	Quality Manager	Bachelor's degree	21	14	7	ISO Auditor	
6	Judge-6	Quality Manager	Master's degree	17	14	7	ISO Auditor	
7	Judge-7	Quality Manager	Master's degree	12	10	5		
8	Judge-8	Quality Manager	Bachelor's degree	22	20	10		Assessor of Dubai Quality Award, SKEA
9	Judge-9	Quality Manager	Others	32	25	12	CMQ, PMP, ISO Auditor	ASQ Chair
10	Judge-10	Quality Manager	Master's degree	12	9	4	ISO Auditor	
			Average	18.2	14.2	6.8		

Respondent details

Initial Item code	Score: 1=RAV; 2=RMI; 3=RTR; 4=RAC										Total Judges who put in the correct dimension	Total judges	% Judge putting in the correct dimension	No. of Judges assigning in a particular dimension				Pi	REMARKS (retained items to be carried forwarded for Content validity)
	Judge-1	Judge-2	Judge-3	Judge-4	Judge-5	Judge-6	Judge-7	Judge-8	Judge-9	Judge-10				1 (RAV)	2 (RMI)	3 (RTR)	4 (RAC)		
C1	1	1	1	1	1	1	1	1	1	1	10	10	100%	10				1.000	Retain item
C2	1	1	1	1	1	1	1	1	1	1	10	10	100%	10				1.000	Retain item
C3	3	1	1	2	2	4	1	1	2	3	4	10	40%	4	3	2	1	0.222	Discard item
C4	1	1	2	1	1	1	1	1	1	1	9	10	90%	9	1			0.800	Retain item
C5	4	1	1	4	1	1	4	1	1	4	6	10	60%	6			4	0.467	Retain item
C6	1	2	1	1	1	2	1	1	2	1	7	10	70%	7	3			0.533	Retain item
C7	1	1	1	1	2	1	1	1	1	1	9	10	90%	9	1			0.800	Retain item
C8	2	2	1	1	1	1	3	1	2	2	5	10	50%	5	4	1		0.356	Discard item
C9	1	1	1	1	1	2	1	1	2	1	8	10	80%	8	2			0.644	Retain item
C10	1	1	2	1	1	1	1	2	1	1	8	10	80%	8	2			0.644	Retain item
C11	1	1	1	1	1	1	1	2	1	2	8	10	80%	8	2			0.644	Retain item
C12	1	2	1	1	1	1	1	1	1	1	9	10	90%	9	1			0.800	Retain item
C13	2	1	1	1	1	1	1	1	1	1	9	10	90%	9	1			0.800	Retain item
C14	1	1	2	1	1	1	1	2	1	4	7	10	70%	7	2		1	0.489	Retain item
C15	1	1	1	2	1	1	1	1	1	1	9	10	90%	9	1			0.800	Retain item
C16	1	1	1	1	1	1	1	1	1	1	10	10	100%	10				1.000	Retain item
C17	2	2	2	2	2	2	2	2	2	1	9	10	90%		10			1.000	Retain item
C18	1	1	2	3	2	2	1	1	2	2	5	10	50%	4	5		1	0.356	Discard item
C19	1	2	2	2	2	2	2	2	2	2	9	10	90%	1	9			0.800	Retain item
C20	2	2	2	2	2	3	2	2	3	2	8	10	80%		8	2		0.644	Retain item
C21	2	2	1	1	2	3	2	4	1	1	4	10	40%	4	4	1	1	0.267	Discard item
C22	1	2	2	2	2	2	2	2	2	1	8	10	80%	2	8			0.644	Retain item
C23	2	2	1	2	2	2	2	2	2	2	9	10	90%	1	9			0.800	Retain item
C24	2	1	1	2	2	2	2	2	2	2	8	10	80%	2	8			0.644	Retain item
C25	2	1	2	2	2	2	1	2	2	1	7	10	70%	3	7			0.533	Retain item
C26	1	2	2	2	2	1	2	2	2	2	8	10	80%	2	8			0.644	Retain item
C27	2	2	1	1	2	2	1	2	2	2	7	10	70%	3	7			0.533	Retain item
C28	2	1	2	2	1	1	2	2	2	2	7	10	70%	3	7			0.533	Retain item

C29	2	2	2	1	2	2	2	2	2	2	9	10	90%	1	9			0.800	Retain item
C30	2	2	2	2	2	2	1	2	2	1	8	10	80%	2	8			0.644	Retain item
C31	3	3	3	3	3	3	3	3	3	3	10	10	100%			10		1.000	Retain item
C32	3	1	3	1	3	3	3	2	3	4	6	10	60%	2	1	6	1	0.356	Retain item
C33	4	3	3	3	4	3	3	3	3	3	8	10	80%			8	2	0.644	Retain item
C34	2	3	3	3	2	3	3	2	4	4	5	10	50%		3	5	2	0.311	Discard item
C35	3	3	3	3	3	3	3	3	3	3	10	10	100%			10		1.000	Retain item
C36	3	3	3	3	3	3	3	3	4	3	9	10	90%			9	1	0.800	Retain item
C37	3	3	3	3	3	3	3	3	3	4	9	10	90%			9	1	0.800	Retain item
C38	3	3	3	3	3	3	3	3	3	3	10	10	100%			10		1.000	Retain item
C39	3	3	3	3	3	3	3	3	3	3	10	10	100%			10		1.000	Retain item
C40	3	3	3	3	2	3	3	3	3	3	9	10	90%		1	9		0.800	Retain item
C41	3	1	3	1	3	3	3	2	3	3	7	10	70%	2		7	1	0.489	Retain item
C42	3	3	3	3	3	3	3	3	3	3	10	10	100%			10		1.000	Retain item
C43	4	4	4	4	4	4	4	2	4	4	9	10	90%		1		9	0.800	Retain item
C44	4	4	4	4	4	4	4	4	4	4	10	10	100%				10	1.000	Retain item
C45	4	4	4	4	4	4	4	4	4	4	10	10	100%				10	1.000	Retain item
C46	4	2	3	4	3	3	3	4	4	4	5	10	50%		2	4	5	0.389	Discard item
C47	4	4	4	4	4	4	4	4	4	4	10	10	100%				10	1.000	Retain item
C48	4	3	3	4	3	4	3	3	4	4	5	10	50%			5	5	0.444	Discard item
C49	4	4	4	4	4	4	4	4	4	4	10	10	100%				10	1.000	Retain item
C50	4	4	4	4	4	4	4	4	4	4	10	10	100%				10	1.000	Retain item
C51	4	2	1	4	4	4	4	4	1	4	7	10	70%	1	2		7	0.489	Retain item
C52	4	4	4	4	4	4	4	4	4	4	10	10	100%				10	1.000	Retain item
C53	4	4	4	4	4	4	4	4	4	4	10	10	100%				10	1.000	Retain item
C54	4	4	4	4	4	4	4	4	4	4	10	10	100%				10	1.000	Retain item

Classification of generated items into distinct QRM dimensions(Part 1)

Initial code	Judge-1	Judge -2	Judge -3	Judge -4	Judge -5	Judge -6	Judge -7	Judge -8	Judge -9	Judge -10	Total no. of Judges N	No. of Judges agreeing ÉSSENTIAL Ne	CVR= (Ne-N/2)/N/2 (Content Validity Ratio as per this study)	CVRcritical (Min as per Lawshe's study)	Remarks (retained items to be carried forward to survey questionnaire)	Final code (for retained items)
A1	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QP1
A2	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QP2
A3	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QP3
A4	1	1	0	1	0	1	1	0	1	1	10	7	0.40	0.62	Discard item	
A5	1	1	1	1	1	1	0	1	1	1	10	9	0.80	0.62	Retain item	QP4
A6	1	1	1	1	1	0	1	1	1	1	10	9	0.80	0.62	Retain item	QP5
A7	1	1	0	1	0	1	1	0	1	0	10	6	0.20	0.62	Discard item	
A8	1	1	0	1	1	0	1	1	0	1	10	7	0.40	0.62	Discard item	
A9	1	1	1	1	0	1	1	1	1	1	10	9	0.80	0.62	Retain item	QP6
A10	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QP7
A11	1	1	1	1	1	0	1	1	1	1	10	9	0.80	0.62	Retain item	QP8
A12	1	1	1	1	1	0	1	1	1	1	10	9	0.80	0.62	Retain item	QP9
A13	1	1	1	0	1	1	0	1	1	1	10	8	0.60	0.62	Discard item	
A14	0	1	1	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QP10
A15	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QP11
A16	1	1	1	1	1	0	1	1	1	1	10	9	0.80	0.62	Retain item	QP12
A17	1	0	1	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QP13
A18	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QP14
A19	0	1	1	1	0	1	1	0	1	1	10	7	0.40	0.62	Discard item	
A20	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QP15

Operationalization of Quality Performance construct

Initial code	**Judge-1**	**Judge -2**	**Judge -3**	**Judge -4**	**Judge -5**	**Judge -6**	**Judge -7**	**Judge -8**	**Judge -9**	**Judge -10**	**Total no. of Judges N**	**No. of Judges agreeing ÉSSENTIAL Ne**	**CVR= (Ne-N/2)/N/2 (Content Validity Ratio as per this study)**	**CVRcritical (Min as per Lawshe's study)**	**Remarks (retained items to be carried forward to survey questionnaire)**	**Final code (for retained items)**
B1	1	1	1	1	0	1	1	1	1	1	10	9	0.80	0.62	Retain item	QR1
B2	1	1	0	1	1	0	1	1	0	1	10	7	0.40	0.62	Discard item	
B3	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QR2
B4	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QR3
B5	1	1	1	0	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QR4
B6	1	0	1	1	1	0	1	0	0	1	10	6	0.20	0.62	Discard item	
B7	1	1	1	0	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QR5
B8	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QR6
B9	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QR7
B10	1	1	1	1	1	0	1	1	1	1	10	9	0.80	0.62	Retain item	QR8
B11	1	1	1	1	1	0	1	1	1	1	10	9	0.80	0.62	Retain item	QR9
B12	1	1	1	1	1	1	1	1	0	1	10	9	0.80	0.62	Retain item	QR10
B13	1	1	0	1	1	1	0	1	1	0	10	7	0.40	0.62	Discard item	
B14	0	1	1	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QR11
B15	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QR12
B16	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QR13
B17	1	0	1	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QR14
B18	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QR15
B19	1	1	1	1	1	1	0	1	1	1	10	9	0.80	0.62	Retain item	QR16
B20	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	QR17
B21	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QR18
B22	1	1	1	1	1	1	1	1	0	1	10	9	0.80	0.62	Retain item	QR19
B23	1	1	0	1	1	0	1	1	0	1	10	7	0.40	0.62	Discard item	
B24	1	1	1	1	1	0	1	1	1	1	10	9	0.80	0.62	Retain item	QR20
B25	1	0	1	1	0	1	1	0	1	1	10	7	0.40	0.62	Discard item	
B26	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	QR21

Operationalization of Quality Risks construct (PART 2: Operationalization of constructs – Sections A, B & C)

Initial code	Judge-1	Judge -2	Judge -3	Judge -4	Judge -5	Judge -6	Judge -7	Judge -8	Judge -9	Judge -10	Total no. of Judges N	No. of Judges agreeing ÉSSENTIAL Ne	CVR= (Ne-N/2)/N/2 (Content Validity Ratio as per this study)	CVRcritical (Min as per Lawshe's study)	Remarks (retained items to be carried forward to survey questionnaire)	Final code (for retained items)
C1	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAV1
C2	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAV2
C4	1	1	1	1	1	0	1	1	1	1	10	9	0.80	0.62	Retain item	RAV3
C5	1	1	1	1	1	1	0	1	1	1	10	9	0.80	0.62	Retain item	RAV4
C6	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RAV5
C7	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAV6
C9	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RAV7
C10	1	1	1	1	1	1	1	1	0	1	10	9	0.80	0.62	Retain item	RAV8
C11	1	1	1	0	1	1	0	1	0	1	10	7	0.40	0.62	Discard item	
C12	1	0	1	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RAV9
C13	0	1	1	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RAV10
C14	1	0	0	1	0	1	0	1	0	1	10	5	0.00	0.62	Discard item	
C15	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAV11
C16	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAV12
C17	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RMI1
C19	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RMI2
C20	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RMI3
C22	1	1	1	0	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RMI4
C23	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RMI5
C24	1	1	0	1	1	0	1	1	0	1	10	7	0.40	0.62	Discard item	
C25	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RMI6
C26	1	1	1	0	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RMI7
C27	1	0	1	0	0	1	1	1	1	0	10	6	0.20	0.62	Discard item	
C28	1	1	1	1	1	1	0	1	0	0	10	7	0.40	0.62	Discard item	

C29	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RMI8
C30	1	1	1	1	1	1	1	0	1	1	10	9	0.80	0.62	Retain item	RMI9
C31	1	1	1	1	1	1	1	0	1	1	10	9	0.80	0.62	Retain item	RTR1
C32	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RTR2
C33	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RTR3
C35	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RTR4
C36	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RTR5
C37	1	0	1	1	1	1	1	1	0	0	10	7	0.40	0.62	Discard item	
C38	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RTR6
C39	1	1	1	1	1	1	1	1	1	0	10	9	0.80	0.62	Retain item	RTR7
C40	1	1	1	0	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RTR8
C41	1	0	1	0	1	1	0	1	1	1	10	7	0.40	0.62	Discard item	
C42	1	1	1	1	1	0	1	1	1	1	10	9	0.80	0.62	Retain item	RTR9
C43	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAC1
C44	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAC2
C45	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAC3
C47	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAC4
C49	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAC5
C50	1	1	0	1	1	1	1	1	1	1	10	9	0.80	0.62	Retain item	RAC6
C51	1	1	0	1	1	0	1	1	0	1	10	7	0.40	0.62	Discard item	
C52	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAC7
C53	1	1	1	1	1	1	1	0	1	1	10	9	0.80	0.62	Retain item	RAC8
C54	1	1	1	1	1	1	1	1	1	1	10	10	1.00	0.62	Retain item	RAC9
														Content Validity Index(CVI)= 0.91		

Operationalization of Quality Risk Management constructs

Appendix C

C.1 Survey Cover Letter

C.2 Survey Questionnaire Format

C.3 Survey Data/Details

C.1 Survey Cover Letter

HERIOT WATT UNIVERSITY

---

*Sub.: **Invitation to participate in the PhD research survey related to Quality Risk Management in the UAE construction projects.***

Dear Sir/Madam,

I would like to invite you to participate in the on-going doctoral research study related to 'Quality Risk Management' covering project quality risks, quality risk management actions and impact on quality performance in the UAE construction projects.

I would sincerely appreciate your valuable input to this research study, as the information from this survey would enable to examine/analyze the relationship among Quality Risks, Quality Risk Management strategies and Quality performance. The outcome of this research study would be helpful to the project teams in dealing with quality risks in a more systematic manner, while enabling them to make more informed decisions in mitigating quality risks, thus enhancing the quality performance.

I hereby assure you that all information from this survey will be used for purely academic purposes and shall be strictly kept confidential. Hence please feel comfortable to give responses and kindly contact the undersigned researcher for any queries/clarification.

Looking forward to your participation and thanking you in advance for your contribution to the area of project quality risk management.

Yours sincerely,

Naveen Ratnam Didla
PhD student
Heriot-watt University, UK
Telephone: +971 508291480
Email: naveenratnam@yahoo.com

Attachments:

1) PhD survey questionnaire*(for your response)*
2) QRM operational definitions(*for your reference)*

Quality Risk Management – operational definitions

Purpose: The purpose of this section is to provide the QRM operational definitions applicable to this research study, for the reference of the respondents while answering the questionnaire survey.

Operational definitions/description:

QUALITY PERFORMANCE: Quality in construction projects is defined as the ability of the products, processes or services to conform to the established requirements as specified in the contractual agreement.

QUALITY RISKS: According to the concept of quality and strive to meet customer expectations, every risk at any stage of work that can have an effect on the quality of performance and cause negative customer satisfaction would be considered as quality risk. In this study the operational risks related to quality are considered wherein the quality risks are viewed as risk of loss resulting from inadequate or failed internal processes, systems, people and to an extent external events are considered.

QUALITY RISK MANAGEMENT: QRM in this research is defined as actions undertaken by the project team to address (prevent/reduce) quality risks, aimed at enhancing project quality performance.

The following are the four Quality Risk Management dimensions/strategies for managing the quality risks which affect the quality performance in construction projects.

Dimension 1: Risk Avoidance (RAV) *is a risk management strategy whereby the Contractor's project team acts to eliminate the threat or protect the project from its impact. The aim of this strategy is to ensure that potential risks/negative effects hindering the achievement of quality objectives are avoided/prevented, so as to provide greater assurance that the customer/project quality requirements would be met. They are a set of proactive measures undertaken by the project team/management, which focus on establishing and implementing a robust project quality management system, so as to avoid/prevent any potential quality failures or customer dissatisfaction.*

Dimension 2: Risk Mitigation (RMI) *is a risk management strategy whereby the Contractor's project team acts to reduce the probability of occurrence or impact of a risk. The aim of this strategy is to reduce/mitigate the occurrence or impact of adverse risks hindering the achievement of quality objectives, whereby it is imperative that taking early action to reduce the probability and/or impact of a risk occurring is often more effective than trying to repair the damage after the risk has occurred. They are a set of quality control actions taken by the project team which focus on verifying whether or not the delivery of products, works, processes, services etc., conform to the customer/project requirements, whereby any deviations or potential non-conformances are detected early, for taking appropriate corrective actions to mitigate the quality risks.*

Dimension 3: Risk Transference (RTR) *is a risk management strategy whereby the Contractor's project team shifts the impact of a threat to a third party, together with ownership of the response. The aim of this strategy is to enable the Contractor to safeguard himself from the negative consequences/impact through shifting/allocating the risk impact to other stakeholders in the Supply chain (Sub-contractors/Suppliers/Manufacturers/3rd party testing etc.), based on the risk source or who is better able to handle/manage those risks.*

Dimension 4: Risk Acceptance (RAC) *is a risk management strategy whereby the Contractor's project team is prepared to take appropriate corrective actions focused on addressing/dealing with the quality failures/non-conformances leading to customer dissatisfaction, in case they occur. This strategy requires establishing a contingency reserve, including amounts of time, money, or resources to handle the risks as they come along.*

Survey Questionnaire

HERIOT WATT UNIVERSITY

An investigation of the quality risk management practices and impact on quality performance, in the UAE construction projects

Purpose of survey:
The aim of this survey is to investigate the quality risks, quality risk management actions and impact on quality performance in the UAE construction projects. The data collected from this survey shall be helpful to examine the relationship among quality risks, quality risk management actions and quality performance.

Note:
(i) Please be assured that all information from this survey will be used for purely academic purposes and shall remain strictly anonymous.

(ii) The questionnaire consists of the following four sections which may take approximately 30 minutes and you are strongly advised to provide responses to all the items in the questionnaire, from the context of your construction project.

Section 1 - Respondent, company & project details
Section 2 - Quality Risk Management
Section 3 - Quality Risks
Section 4 - Quality Performance

Section 1: RESPONDENT, COMPANY & PROJECT DETAILS

a) Name of Respondent: ____________________

b) Telephone/email: ____________________

c) What is your highest academic qualification?
☐ Master's degree ☐ Bachelor's degree ☐ Other ____________

d) Please specify your work experience in the construction industry.
☐ < 5 years ☐ 5 to 10 years ☐ > 10 years

e) Please specify your current designation.
☐ Quality Manager ☐ Quality Engineer ☐ Other ____________

f) Do you work for Main Contractor in the UAE? ☐ Yes ☐ No

g) Is your company ISO 9001 certified? ☐ Yes ☐ No

h) In which Emirate is your project located? ____________________

i) Please indicate your project value in Millions(AED) ☐ < 100 ☐ 100 to 500 ☐ > 500

j) Please indicate your project duration in years ☐ < 1 ☐ 1 to 2 ☐ > 2

Section 2: QUALITY RISK MANAGEMENT

Please indicate (√ tick) the **extent/frequency** of the following actions which are taken in your project to reduce/control quality risks, aiming at enhancing quality performance.

(1= Never; 2=Rarely; 3=Sometimes; 4=Frequently 5=Always)

RISK AVOIDANCE: *It is a risk management strategy whereby the project team acts to eliminate/ avoid the potential threats hindering the achievement of quality objectives.*						
RAV1	We establish and implement Project Quality Plan so as to ensure that the client/project quality requirements are met.	1	2	3	4	5
RAV2	Our Management demonstrates commitment to quality by providing adequate support (resources, employee motivation/empowerment etc.) needed for effective implementation of project quality system.	1	2	3	4	5
RAV3	We ensure to deploy competent staff appropriately as needed for the project, considering relevant education/training, skills, experience etc.	1	2	3	4	5
RAV4	We follow a collaborative approach to solve quality problems/issues with various stakeholders in an amicable way so as to avoid any potential disputes that may affect quality performance.	1	2	3	4	5
RAV5	We establish and implement good controls & monitoring systems for observing trends in quality performance and take appropriate actions to avoid any obstacles hindering the achievement of quality objectives.	1	2	3	4	5
RAV6	We establish and follow good communication protocols with all project stakeholders so as to ensure improved information sharing, coordination, decision making etc., thus avoiding any misunderstanding or ambiguity.	1	2	3	4	5
RAV7	We provide training so as to communicate various project requirements aimed at enhancing peoples' knowledge, awareness and capabilities.	1	2	3	4	5
RAV8	We obtain clarification/confirmation through RFI (Request for Information), in case any details are not clear.	1	2	3	4	5
RAV9	We avoid using defective material.	1	2	3	4	5
RAV10	We avoid using any defective equipment/instrument which is not calibrated.	1	2	3	4	5
RAV11	We avoid using unapproved Sub-contractors, Suppliers, Material, Shop drawings, Method statements etc., for executing works.	1	2	3	4	5
RAV12	We follow a rigorous Pre-qualification process so as to ensure that only competent & reliable Sub-contractors/Suppliers are selected.	1	2	3	4	5

RISK MITIGATION: *It is a risk management strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk.*						
RMI1	We carryout adequate rounds/levels of internal review of Submittals so as to minimize the chances of rejection.	1	2	3	4	5
RMI2	We inspect material delivered to site, so as to ensure that only approved materials which are free from defects are received.	1	2	3	4	5
RMI3	We ensure that the manufacturer's instructions are strictly followed for material handling, storing/protection, application etc.	1	2	3	4	5
RMI4	We conduct Tool-box talks to communicate the quality requirements to the project execution teams & workers.	1	2	3	4	5
RMI5	We build mock-ups and ensure the successive works are effectively done in line with these benchmarks, to enhance approval rate.	1	2	3	4	5
RMI6	We carryout internal inspection of our works and if we detect any non-compliance, we proactively address them before inviting the Consultant.	1	2	3	4	5
RMI7	We conduct internal tests and 3rd party testing as per approved ITP.	1	2	3	4	5
RMI8	We perform audits to check compliance with the project requirements, while additionally seeking areas of improvement.	1	2	3	4	5
RMI9	We carry out Supplier performance evaluation, to take appropriate action against any detected deficiencies, aiming at improved performance.	1	2	3	4	5

RISK TRANSFERENCE: *It is a risk management strategy whereby the project team shifts the impact of a threat to a third party, together with responsibility/ownership of the response.*						
RTR1	We make the Suppliers/Sub-contractors responsible for their goods & services, covered through Undertaking letter, Warranty/Guarantee, Performance bonds, Insurance etc.	1	2	3	4	5
RTR2	We transfer some risks to the Insurance companies, which are generally beyond the control of the project stakeholders.(eg.: Natural disasters etc)	1	2	3	4	5
RTR3	In case of rejection of any Supplier/Sub-contractor's submittals, we make them responsible to revise & resubmit after incorporating the Consultant's comments.	1	2	3	4	5
RTR4	We make the Suppliers/Sub-contractors responsible for unconditionally replacing any defective material delivered to site by them, at their own expense.	1	2	3	4	5
RTR5	We make the Sub-contractors responsible for rectifying any defective works under their scope, with no liability (cost/time impact) to the Main Contractor.	1	2	3	4	5
RTR6	In case of any penalties imposed by the Client/Authority due to the quality issues arising from Supplier's goods/services, we shall recover the same from them.	1	2	3	4	5
RTR7	We make the Suppliers/Sub-contractors responsible for ensuring all the statutory/regulatory requirements related to their men, machines/equipment etc., are complied with.	1	2	3	4	5
RTR8	We make our Suppliers/Sub-contractors responsible to ensure that all applicable tests related to their material/products/works are conducted and test reports submitted for approval.	1	2	3	4	5
RTR9	We make it clear in the Sub-contract agreement/LPO, regarding the Sub-contractor's/Supplier's responsibilities/liabilities towards fulfilling the project quality requirements.	1	2	3	4	5

RISK ACCEPTANCE: *It is a risk management strategy whereby the project team is prepared to take appropriate remedial actions against quality failures/ risks/customer complaints, in case they occur.*						
RAC1	We have set up a procedure related to control of nonconforming outputs, including carrying out root cause analysis and corrective & preventive actions.	1	2	3	4	5
RAC2	We establish a contingency reserve, including amounts of time, money, or resources to handle the risks as they come along.	1	2	3	4	5
RAC3	In case of any rejection of our Submittals, we revise and resubmit after taking the appropriate corrective actions.	1	2	3	4	5
RAC4	In case of any rejection of our material/products, we unconditionally replace them.	1	2	3	4	5
RAC5	In case of any rejection of our works/testing, we allocate additional resources and contingency amount to unconditionally repair/Rework/Retest.	1	2	3	4	5
RAC6	During project handing over, we deploy additional resources to complete the snag-list items for smooth handover, to the satisfaction of Client.	1	2	3	4	5
RAC7	In case of any quality violations (regulatory etc), we pay penalties to the Authorities/Client from the contingency amount reserve.	1	2	3	4	5
RAC8	In case of any Customer complaints on the performance of any individual, we investigate the cause and take appropriate actions (eg warning, replacement etc.)	1	2	3	4	5
RAC9	In case of any quality problem/issue arising with any stakeholder, we resolve them in an amicable way, through discussion, meetings etc.	1	2	3	4	5

Section 3: QUALITY RISKS

Considering the actions taken in Section 2, please indicate (√ tick) the **overall changes in the risk levels** for the following quality risks in your project

(1=Decreased significantly; 2=Decreased; 3=No change; 4=Increased; 5=Increased significantly)

QR1	Poor understanding of the Client needs/project quality requirements.	1	2	3	4	5
QR2	Inadequate management support towards effective implementation of quality system.(in terms of providing resources, motivating, quality culture, management review etc)	1	2	3	4	5
QR3	Poor/unrealistic planning.	1	2	3	4	5
QR4	Poor information management systems/controls affecting decision making.	1	2	3	4	5
QR5	Shortage of resources (eg.: people, plant & equipment, material etc.)	1	2	3	4	5
QR6	Inadequate internal reviewing/checking.	1	2	3	4	5
QR7	Poor documentation.	1	2	3	4	5
QR8	Improper construction methods (eg.: using wrong methodology, equipment, measurement etc.)	1	2	3	4	5
QR9	Poor material handling/storing, not done as per Manufacturer's instructions.	1	2	3	4	5
QR10	Defective material usage at site.	1	2	3	4	5
QR11	Defective works resulting in rework/delays. (eg.: due to poor workmanship, errors/mistakes during execution etc.)	1	2	3	4	5
QR12	Execution of works without prior approval of Consultant (eg.: using unapproved Material, Drawing, Method Statement, Sub-contractor etc.)	1	2	3	4	5
QR13	Inspections & Testing methods/frequency deviating from the approved Inspection & Test Plan (ITP).	1	2	3	4	5
QR14	Using bad equipment in poor working condition or not calibrated.	1	2	3	4	5
QR15	Incompetent project staff/unskilled workers	1	2	3	4	5
QR16	Resistance/unwillingness of project members to follow quality procedures.	1	2	3	4	5
QR17	Poor supervision/coordination on site.	1	2	3	4	5
QR18	Inadequate/incomplete information related to drawings, specifications etc.	1	2	3	4	5
QR19	Poor communication/coordination among various project stakeholders.	1	2	3	4	5
QR20	Weak Supplier agreements/contracts leading to creation of potential quality issues/disputes.	1	2	3	4	5
QR21	Incompetency & poor performance of Sub-contractor/Suppliers.(eg.: poor quality of submittals/products/services)	1	2	3	4	5

Section 4: QUALITY PERFORMANCE

Please indicate (√ tick) the overall **changes** in the approval rate of the following in your project.
(1= Decreased significantly; 2=Decreased; 3=No change; 4=Increased; 5=Increased significantly)

QP1	Approval rate of Technical/Engineering submittals. *(eg.: Material Submittals, Shop Drawings, Method Statements etc.)*	1	2	3	4	5
QP2	Approval rate of Material Inspections.	1	2	3	4	5
QP3	Approval rate of Work Inspections.	1	2	3	4	5
QP4	Approval rate of Testing.	1	2	3	4	5

Please indicate (√ tick) your overall **level of agreement** regarding the following statements in your project.
(1= Strongly disagree; 2=Disagree; 3=Neutral; 4=Agree 5=Strongly Agree)

QP5	Defects have reduced.	1	2	3	4	5
QP6	Reworks have reduced.	1	2	3	4	5
QP7	Non-conformances have decreased.	1	2	3	4	5
QP8	Cost of Poor Quality has decreased.	1	2	3	4	5
QP9	Project delays due to quality issues have reduced.	1	2	3	4	5

Please indicate (√ tick) your overall **rating** regarding the following items in your project.
(1=Significantly worsened; 2=Worsened; 3=No change; 4=Improved; 5=Significantly improved)

QP10	Timely response in addressing customer complaints/queries. *(eg.: closing of NCRs, action items in minutes of meetings etc.)*	1	2	3	4	5
QP11	Client satisfaction. *(eg.: through results of customer satisfaction feedback survey etc.)*	1	2	3	4	5
QP12	Supplier/Sub-contractor performance. *(eg.: through results of performance appraisal etc.)*	1	2	3	4	5
QP13	Employee satisfaction. *(eg: in terms of motivation/empowerment, involvement, engagement, etc)*	1	2	3	4	5
QP14	Relationship with project stakeholders. *(eg.: in terms of communication, coordination, cooperation etc.)*	1	2	3	4	5
QP15	Relationship with society/neighbors. *(eg.:in terms of effective communication, less disturbance/pollution etc.)*	1	2	3	4	5

Thank you for participating!

C.3: Survey data details (Section 1: Respondent Demographic details)

Respondent	Highest academic qualification	Work experience in the Construction industry	Designation	Do you work for Main Contractor?	ISO certified?	Emirate in the UAE	Project Value(AED Millions)	Project duration (years)
Respondent1	Master's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	> 2
Respondent2	Bachelor's	<5	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent3	Master's	<5	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent4	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	< 100	< 1
Respondent5	Master's	>10	Quality Manager	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent6	Master's	5 to 10	Quality Engineer	Yes	Yes	Dubai	< 100	< 1
Respondent7	Master's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent8	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	< 100	< 1
Respondent9	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent10	Master's	5 to 10	Quality Engineer	Yes	Yes	Dubai	< 100	1 to 2
Respondent11	Bachelor's	>10	Quality Manager	Yes	Yes	Dubai	> 500	> 2
Respondent12	Bachelor's	>10	Quality Manager	Yes	Yes	Dubai	> 500	> 2
Respondent13	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent14	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	< 100	1 to 2
Respondent15	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent16	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	< 100	< 1
Respondent17	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	> 2
Respondent18	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent19	Master's	>10	Quality Manager	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent20	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	< 100	1 to 2
Respondent21	Master's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent22	Master's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent23	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent24	Master's	>10	Quality Manager	Yes	Yes	Dubai	> 500	> 2
Respondent25	Master's	>10	Quality Manager	Yes	Yes	Abu Dhabi	100 to 500	> 2
Respondent26	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent27	Bachelor's	>10	Quality Manager	Yes	No	Abu Dhabi	> 500	> 2
Respondent28	Master's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2

Respondent29	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent30	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent31	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent32	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent33	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent34	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent35	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent36	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent37	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent38	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent39	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent40	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent41	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent42	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent43	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	> 2
Respondent44	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent45	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent46	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent47	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent48	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent49	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent50	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent51	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent52	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent53	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent54	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent55	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent56	Bachelor's	>10	Quality Manager	Yes	Yes	Dubai	> 500	> 2
Respondent57	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent58	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent59	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent60	Master's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent61	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent62	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent63	Bachelor's	<5	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent64	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2

Respondent65	Master's	>10	Quality Manager	Yes	Yes	Umm al-quwain	> 500	> 2
Respondent66	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent67	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent68	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent69	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent70	Others	>10	Quality Manager	Yes	Yes	Ras Al Khaimah	> 500	> 2
Respondent71	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent72	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent73	Bachelor's	>10	Quality Manager	Yes	Yes	Ajman	> 500	> 2
Respondent74	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent75	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	100 to 500	> 2
Respondent76	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent77	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent78	Bachelor's	>10	Quality Manager	Yes	Yes	Sharjah	> 500	> 2
Respondent79	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent80	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent81	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent82	Others	>10	Quality Manager	Yes	Yes	Umm al-quwain	> 500	> 2
Respondent83	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent84	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent85	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent86	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent87	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent88	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent89	Others	>10	Quality Manager	Yes	Yes	Umm al-quwain	> 500	> 2
Respondent90	Bachelor's	>10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent91	Others	<5	Quality Engineer	Yes	No	Sharjah	< 100	1 to 2
Respondent92	Others	<5	Quality Engineer	Yes	No	Sharjah	< 100	1 to 2
Respondent93	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent94	Others	>10	Quality Manager	Yes	Yes	Ras Al Khaimah	> 500	> 2
Respondent95	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent96	Others	5 to 10	Quality Engineer	Yes	No	Sharjah	< 100	1 to 2
Respondent97	Bachelor's	<5	Quality Engineer	Yes	No	Ajman	100 to 500	1 to 2
Respondent98	Others	<5	Quality Engineer	Yes	No	Ras Al Khaimah	100 to 500	1 to 2
Respondent99	Bachelor's	>10	Quality Manager	Yes	Yes	Sharjah	> 500	> 2
Respondent100	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2

Respondent101	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent102	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent103	Others	>10	Quality Manager	Yes	Yes	Ras Al Khaimah	> 500	> 2
Respondent104	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent105	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent106	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent107	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent108	Bachelor's	>10	Quality Manager	Yes	Yes	Ajman	> 500	> 2
Respondent109	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent110	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent111	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent112	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent113	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent114	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent115	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent116	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent117	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent118	Bachelor's	>10	Quality Manager	Yes	Yes	Dubai	> 500	> 2
Respondent119	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent120	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent121	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent122	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent123	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent124	Bachelor's	>10	Quality Manager	Yes	Yes	Dubai	> 500	> 2
Respondent125	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent126	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent127	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent128	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent129	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent130	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent131	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	100 to 500	1 to 2
Respondent132	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent133	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent134	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent135	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent136	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	> 500	> 2

Respondent137	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent138	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent139	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent140	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent141	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent142	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Dubai	> 500	> 2
Respondent143	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent144	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent145	Bachelor's	5 to 10	Quality Engineer	Yes	No	Abu Dhabi	100 to 500	1 to 2
Respondent146	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent147	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent148	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent149	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent150	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent151	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent152	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent153	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent154	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent155	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent156	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent157	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent158	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent159	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent160	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent161	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent162	Bachelor's	>10	Quality Manager	Yes	Yes	Abu Dhabi	> 500	> 2
Respondent163	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent164	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent165	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent166	Others	5 to 10	Quality Engineer	Yes	Yes	Fujairah	100 to 500	1 to 2
Respondent167	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent168	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent169	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent170	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent171	Bachelor's	<5	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent172	Others	5 to 10	Quality Engineer	Yes	Yes	Fujairah	100 to 500	1 to 2

Respondent173	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent174	Others	<5	Quality Engineer	Yes	No	Sharjah	< 100	< 1
Respondent175	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent176	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent177	Others	<5	Quality Engineer	Yes	Yes	Fujairah	100 to 500	1 to 2
Respondent178	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent179	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent180	Others	<5	Quality Engineer	Yes	No	Sharjah	< 100	< 1
Respondent181	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent182	Others	5 to 10	Quality Engineer	Yes	Yes	Fujairah	100 to 500	1 to 2
Respondent183	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent184	Bachelor's	<5	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent185	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent186	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent187	Others	<5	Quality Engineer	Yes	No	Ras Al Khaimah	< 100	< 1
Respondent188	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent189	Others	5 to 10	Quality Engineer	Yes	Yes	Fujairah	100 to 500	1 to 2
Respondent190	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent191	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent192	Others	<5	Quality Engineer	Yes	No	Ras Al Khaimah	< 100	< 1
Respondent193	Others	5 to 10	Quality Engineer	Yes	No	Sharjah	< 100	< 1
Respondent194	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent195	Others	<5	Quality Engineer	Yes	No	Sharjah	< 100	< 1
Respondent196	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	AJMAN	100 to 500	1 to 2
Respondent197	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent198	Bachelor's	>10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent199	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent200	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent201	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent202	Others	<5	Quality Engineer	Yes	No	Sharjah	< 100	< 1
Respondent203	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent204	Others	5 to 10	Quality Engineer	Yes	No	Ras Al Khaimah	< 100	< 1
Respondent205	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent206	Bachelor's	>10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent207	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent208	Others	<5	Quality Engineer	Yes	Yes	Ras Al Khaimah	100 to 500	1 to 2

Respondent209	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent210	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent211	Others	<5	Quality Engineer	Yes	Yes	Fujairah	100 to 500	1 to 2
Respondent212	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent213	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent214	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent215	Bachelor's	>10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent216	Others	<5	Quality Engineer	Yes	No	Sharjah	< 100	< 1
Respondent217	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent218	Others	<5	Quality Engineer	Yes	No	Fujairah	< 100	< 1
Respondent219	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent220	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent221	Others	<5	Quality Engineer	Yes	Yes	Ras Al Khaimah	100 to 500	1 to 2
Respondent222	Others	5 to 10	Quality Engineer	Yes	No	Fujairah	< 100	< 1
Respondent223	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent224	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent225	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent226	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent227	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent228	Others	<5	Quality Engineer	Yes	Yes	Umm al-quwain	< 100	< 1
Respondent229	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent230	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent231	Bachelor's	>10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent232	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent233	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent234	Others	<5	Quality Engineer	Yes	Yes	Umm al-quwain	< 100	< 1
Respondent235	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent236	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent237	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent238	Others	<5	Quality Engineer	Yes	No	Ras Al Khaimah	< 100	< 1
Respondent239	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent240	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent241	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent242	Bachelor's	>10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent243	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent244	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2

Respondent245	Others	<5	Quality Engineer	Yes	No	Sharjah	< 100	< 1
Respondent246	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent247	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent248	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent249	Others	<5	Quality Engineer	Yes	No	Fujairah	< 100	< 1
Respondent250	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent251	Bachelor's	>10	Quality Engineer	Yes	Yes	Abu Dhabi	100 to 500	1 to 2
Respondent252	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent253	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Ajman	100 to 500	1 to 2
Respondent254	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent255	Others	5 to 10	Quality Engineer	Yes	No	Fujairah	< 100	< 1
Respondent256	Bachelor's	5 to 10	Quality Engineer	Yes	Yes	Sharjah	100 to 500	1 to 2
Respondent257	Others	<5	Quality Engineer	Yes	Yes	Umm al-quwain	< 100	< 1
Respondent258	Others	<5	Quality Engineer	Yes	No	Fujairah	< 100	< 1

Survey Participants’ Demographic information

C.3: Survey data details (Section 2: Quality Risk Management)

RESPONDENT	RAV1	RAV2	RAV3	RAV4	RAV5	RAV6	RAV7	RAV8	RAV9	RAV10	RAV11	RAV12	RMI1	RMI2	RMI3	RMI4	RMI5	RMI6	RMI7	RMI8	RMI9	RTR1	RTR2	RTR3	RTR4	RTR5	RTR6	RTR7	RTR8	RTR9	RAC1	RAC2	RAC3	RAC4	RAC5	RAC6	RAC7	RAC8	RAC9
Respondent1	4	5	4	5	5	5	4	5	4	4	4	3	4	4	5	5	5	4	4	4	4	4	4	5	5	5	5	4	4	4	4	4	5	5	5	4	4	4	4
Respondent2	4	3	4	4	4	4	5	4	4	4	5	5	4	4	4	4	4	3	4	4	5	3	3	4	4	4	4	3	3	3	4	4	4	4	5	4	5	4	4
Respondent3	5	5	4	5	4	5	5	5	4	4	4	5	5	5	5	5	4	5	5	4	4	5	4	5	5	5	4	4	4	5	5	5	5	5	5	4	3	4	4
Respondent4	5	4	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent5	3	3	3	3	3	3	4	3	2	2	3	4	3	3	3	3	4	3	3	2	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3
Respondent6	5	4	4	4	4	4	5	4	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	4	4	4	4	5	4	5	5	4	4	4	5	5	5	5	5
Respondent7	5	5	5	5	4	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	3	4	3	3	3	3	3	3	3	3	4	3	3	3	3	4	3	3
Respondent8	4	4	4	4	5	4	4	4	4	4	4	4	5	5	4	4	5	4	5	5	5	4	3	4	4	4	5	4	5	4	4	3	4	4	4	5	4	5	5
Respondent9	4	5	4	5	5	5	4	5	5	4	4	3	5	5	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5
Respondent10	4	4	5	4	4	4	4	4	4	5	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	3	4	4	4	4	5
Respondent11	4	3	4	4	5	4	4	4	5	5	5	5	5	5	5	5	5	5	4	5	5	4	4	4	5	4	4	4	4	4	4	4	4	5	4	4	3	4	4
Respondent12	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	4	5	4	5	5	5	5	5	5	5	5	5
Respondent13	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent14	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	4	5	5	4	5	5	4	5	5	5	5
Respondent15	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent16	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4	5	5	5	5	5
Respondent17	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent18	4	4	4	4	5	4	4	4	5	5	5	4	4	4	4	4	4	4	3	5	5	4	4	4	5	4	4	5	4	3	4	3	4	4	4	5	5	5	5
Respondent19	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent20	4	3	4	4	4	4	4	4	4	4	4	5	4	3	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	5	5	5	4	4	5	4
Respondent21	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent22	5	4	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5	5
Respondent23	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	5	4	4	4	5	4	4	4	4	4	5	5	4	4	4	4	4	4	4
Respondent24	4	4	4	4	4	4	4	4	4	4	4	5	5	5	4	4	4	5	5	4	5	3	3	4	4	4	4	3	3	3	4	4	4	4	4	4	4	4	4
Respondent25	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	3	4	4	4	4	4
Respondent26	2	3	2	3	2	3	3	3	2	3	2	3	4	4	3	3	3	4	4	4	4	2	3	3	3	3	3	3	3	2	3	3	5	5	5	4	5	4	5
Respondent27	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	3	4
Respondent28	3	3	3	2	2	2	2	3	2	2	3	3	5	5	5	5	5	4	5	5	5	3	3	2	2	3	2	2	3	3	4	4	4	4	4	5	5	4	5

Respondent29	4	4	4	3	2	3	3	3	4	4	4	4	4	4	4	4	4	4	4	3	4	3	3	3	3	3	3	4	4	3	5	5	5	5	5	5	5	5	4
Respondent30	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4
Respondent31	4	3	4	4	4	4	4	4	4	4	4	5	3	4	3	4	3	3	3	3	3	2	2	2	3	2	3	2	3	3	3	3	3	4	3	3	3	3	4
Respondent32	5	5	4	5	5	5	4	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent33	5	5	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	5	5	4	4	4	4	5	5	5	5	4	4	4	5	4	5	5	5	4	4	4	4
Respondent34	4	4	4	4	5	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	4	3	3	4	4	4	5	3	3	4	4	4	4	5	4	4	4	4	3
Respondent35	5	4	4	4	4	4	4	4	4	5	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	5	5	4	4	4	4	3	4	4
Respondent36	3	3	3	3	3	3	2	3	3	3	4	3	5	5	5	5	5	5	4	5	5	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3
Respondent37	3	3	4	2	3	2	2	2	3	4	3	3	3	3	2	2	3	4	3	4	4	3	4	2	2	2	2	3	3	3	5	5	5	5	5	5	5	5	5
Respondent38	4	3	4	4	4	4	4	4	4	4	4	5	4	3	4	4	4	4	4	5	5	4	3	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4
Respondent39	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	5	5	5	5
Respondent40	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4	5
Respondent41	3	3	3	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	4	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	4
Respondent42	4	4	5	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	4	5	4	4	3	3	4	3	3	3	3	4	3	3	4	3
Respondent43	4	4	4	4	5	4	4	4	4	4	5	4	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	4	4	3	4	4	5	5	5	4	4	4	4
Respondent44	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5
Respondent45	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	4	4	3	3	3	3	3	3	4	3	3	4	5	4	3	3	3	3
Respondent46	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4
Respondent47	4	3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4
Respondent48	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	5	5	5	4	5	5	4	4	4	4	5	5	5	5	5	4	4	4	5	4	5	5
Respondent49	4	4	4	4	5	4	4	4	5	5	5	4	5	5	4	4	5	5	5	5	5	4	4	4	4	4	4	5	5	4	4	3	4	3	4	5	5	5	5
Respondent50	4	4	4	4	4	4	5	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	5	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4
Respondent51	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
Respondent52	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	4	5	5	5	5	4	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	4
Respondent53	4	4	5	4	5	4	4	4	4	4	4	4	4	5	4	4	4	4	4	5	5	3	3	4	4	4	4	3	3	3	5	4	5	5	5	4	4	4	4
Respondent54	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	5	4
Respondent55	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
Respondent56	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	4	4
Respondent57	3	4	3	3	3	2	3	3	3	3	3	3	5	5	5	5	5	5	5	5	4	3	3	4	4	4	4	3	3	3	5	5	5	5	5	5	5	5	5
Respondent58	2	3	2	2	2	2	3	2	2	3	2	2	3	3	3	3	4	3	3	3	3	2	3	2	2	3	3	3	3	2	3	3	3	3	3	3	4	3	4
Respondent59	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	3	4	4	5	3	3	4	5	4	4	3	3	3	4	4	4	5	4	4	4	4	4
Respondent60	4	4	4	5	5	5	5	5	4	4	4	4	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	4	4	4	4	3	5	5	5	5	5	5	4
Respondent61	5	5	5	4	5	4	4	4	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	3	4	4
Respondent62	4	4	5	4	4	4	4	4	4	5	4	4	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	4	4	5	5	5	4	4	4	3
Respondent63	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent64	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	5	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4

Respondent65	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	5	5	5	4	4	4	4	5	4	4	5	4	3	4	3	4	3	3	3	3	3
Respondent66	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent67	2	2	2	3	3	3	2	3	2	2	2	3	4	4	3	3	3	4	3	4	5	2	3	3	3	3	3	3	3	2	4	4	3	3	4	3	3	4	3
Respondent68	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4
Respondent69	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent70	5	5	5	5	5	5	5	5	5	5	5	5	3	3	4	4	5	4	3	2	2	3	3	2	3	2	2	2	3	3	3	3	3	3	3	4	4	4	4
Respondent71	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	4	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent72	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	4	4	4	4
Respondent73	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	5	3	4	4	4	4	4	3	3	3	4	4	4	4	5	4	4	4	4
Respondent74	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	5	4	4	5	4	4	4	4	5	4	4
Respondent75	4	4	4	4	5	4	4	4	4	4	4	4	5	5	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5
Respondent76	4	3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	5	5	5	4	4	5	4
Respondent77	4	4	4	5	5	5	5	5	4	4	4	4	4	4	5	4	5	4	4	4	5	4	4	5	5	4	5	4	4	3	4	3	5	5	5	4	4	4	3
Respondent78	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	4	5	5	4	3	4	5	5	5	5
Respondent79	5	5	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	4	5	4	4	5	5	5	5	5	5	4	4	5	5	5	5	5	5	4	4	4	4
Respondent80	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5
Respondent81	4	4	4	3	3	2	3	3	3	3	3	4	4	4	3	3	3	4	4	3	3	3	4	3	3	3	3	4	4	3	3	3	3	3	3	3	4	3	3
Respondent82	4	4	5	4	4	4	4	4	4	4	4	4	5	5	5	5	4	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4
Respondent83	4	3	4	4	4	5	5	4	5	5	5	5	5	5	5	5	5	5	4	5	5	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	3	4	4
Respondent84	4	4	4	4	5	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	3	4
Respondent85	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	5	4	4
Respondent86	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	4	5	5	5	5	5	5	5
Respondent87	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4
Respondent88	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4
Respondent89	3	4	3	3	3	3	3	2	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	4	3	3	3	3	5	5	5	5	5	5	5	5	5
Respondent90	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	4	3	3	4	3	3	3	4	3	3	3	3	3	3	3	4	4	3	3	3	3	3	3	3
Respondent91	5	5	5	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	3	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3
Respondent92	4	4	4	4	4	4	4	5	4	4	4	4	5	4	4	4	4	5	5	4	4	3	3	4	4	4	4	3	3	3	4	4	5	5	5	4	4	4	4
Respondent93	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	4	5	5	5	5	5
Respondent94	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	4	5	5	4	5	5	5	5	5	5	5
Respondent95	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4
Respondent96	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	5	4	4	4	5	4	4	4	4	4	4	5	5	5	5
Respondent97	5	5	5	4	4	5	4	4	5	5	5	5	5	5	4	4	4	5	5	5	5	4	4	5	5	5	5	4	4	4	5	5	4	4	4	5	5	5	5
Respondent98	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4
Respondent99	4	5	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	4	3	4	3	3	3	3	3	3	3	3	4	5	5	5	4	4	4	4
Respondent100	4	4	4	4	5	4	4	4	4	4	5	4	4	4	4	4	4	5	4	4	5	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	5

Respondent101	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent102	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	3	4	4	4	4
Respondent103	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4
Respondent104	4	4	4	4	4	4	5	4	4	4	4	4	4	5	4	4	4	4	4	5	5	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4
Respondent105	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4
Respondent106	3	3	3	3	3	3	3	3	3	3	4	3	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	3	3	4	4	4	3	3	4	3
Respondent107	4	4	3	5	5	5	5	5	4	4	4	4	5	5	5	5	4	5	5	5	5	4	4	5	5	5	5	4	4	4	4	4	5	5	4	4	4	4	4
Respondent108	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	3	5	4	5	5	4	4	4	5	5	5	5	5	5	5	5	5
Respondent109	5	5	5	4	4	4	4	4	5	5	5	5	5	5	4	4	4	4	5	4	3	4	4	4	4	4	4	4	5	4	4	3	5	5	5	4	4	4	4
Respondent110	5	5	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	4	4	5	5	5	5	5	5	4	4	5	4
Respondent111	3	3	3	3	3	3	3	3	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3	3	4	3	3	3	3
Respondent112	4	4	4	2	2	2	3	2	3	3	3	4	3	3	2	3	2	3	3	3	3	3	3	2	2	3	3	3	3	3	3	4	2	2	3	3	3	3	4
Respondent113	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4
Respondent114	5	4	5	5	5	5	5	5	5	5	5	5	3	3	3	3	4	3	3	3	4	4	4	3	3	3	3	4	4	4	5	5	5	5	5	5	5	5	5
Respondent115	4	4	4	4	5	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	3	3	4	4	4	4	3	3	4	4	4	4	4	4	4	3	4	4
Respondent116	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5
Respondent117	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3	4	3	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3	4
Respondent118	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	4	4	3	4	3	3	3	3	3
Respondent119	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	3	4	5	4	5	5
Respondent120	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent121	4	4	4	4	4	4	4	4	5	5	5	4	4	4	4	4	4	5	4	5	4	4	5	4	4	4	5	5	5	4	4	4	4	4	3	5	5	5	5
Respondent122	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent123	3	3	3	4	4	5	4	4	3	3	3	3	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	5	5	5
Respondent124	5	5	5	5	5	5	5	5	5	5	5	4	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3
Respondent125	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	3	4	4	3
Respondent126	5	5	5	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	3	4	5	3	3	3	3	3	3	4	4	4	4	4	5	5	5	4	4	4	4
Respondent127	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5
Respondent128	4	5	5	4	4	4	4	5	4	4	4	4	4	3	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent129	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	5	5	5	4	5	4	3
Respondent130	3	3	3	3	3	3	3	3	4	5	4	3	5	5	5	5	4	4	5	5	5	3	3	3	3	3	3	2	3	3	3	4	3	3	3	3	3	3	3
Respondent131	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	5	4	4	4	4	4	4	4
Respondent132	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	4	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4
Respondent133	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	5	5	5	3	3	4	4	4	4	3	3	3	5	5	5	5	5	5	5	5	5
Respondent134	3	3	3	3	2	3	3	3	3	4	3	3	3	3	4	4	4	3	4	3	3	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	3	3
Respondent135	4	4	5	5	5	5	5	5	4	4	4	4	4	4	5	5	5	4	4	4	4	4	4	5	5	4	5	4	4	4	4	4	5	5	5	4	4	4	4
Respondent136	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	5	4	5	5	4	5	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4

Respondent137	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5	5	4	5
Respondent138	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	4	5	5	5	5	5	5	5
Respondent139	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent140	4	4	4	4	4	4	5	4	4	4	4	4	3	3	3	3	3	4	3	3	3	4	4	3	3	3	3	3	3	4	4	4	3	3	4	5	5	5	5
Respondent141	4	4	4	4	4	5	4	4	4	5	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5
Respondent142	4	5	4	5	5	5	5	5	4	4	4	4	4	4	4	4	5	4	4	5	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent143	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	4	4	4	4	3	3	4	4	4	4	3	3	3	4	4	4	4	5	5	5	5	5
Respondent144	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	5	5	5	5	5	5	5	4	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5
Respondent145	5	5	4	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	4	3	4	2	2	2	3	2	2	3	3	2	3	3	2	3	2	3	3	3	3
Respondent146	3	3	3	3	3	3	3	2	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	5	4
Respondent147	4	4	4	4	4	4	4	4	5	5	5	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	4	4	4	4
Respondent148	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent149	3	3	3	3	3	3	2	3	3	3	3	3	5	4	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Respondent150	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5
Respondent151	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	4
Respondent152	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	4	3	4	4	3	4	3	3	3	3	3	3	4	4	3	3	4	4	4	4	3	3	3	4
Respondent153	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4
Respondent154	5	4	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	4	4	5	5	5	5	5	5	4	4	3	4
Respondent155	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	4	5	4	5	5	5	5	5	5	5	5	5
Respondent156	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent157	3	3	3	2	2	2	2	3	3	3	3	3	3	4	2	2	3	3	3	3	3	3	3	2	2	2	3	3	3	3	5	5	5	5	5	5	5	5	5
Respondent158	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent159	3	3	3	3	3	3	3	3	4	4	4	3	3	3	3	3	4	3	3	3	4	3	4	3	3	3	3	3	4	3	3	3	5	5	5	4	4	4	4
Respondent160	5	5	5	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	3	4	4	4	4	4	5	4	4	4	5	4	4	4	3	3	3	3	3	3	3
Respondent161	4	4	4	4	4	4	4	4	5	5	5	4	5	5	5	5	5	5	4	5	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	5	5
Respondent162	5	5	5	4	4	4	5	5	5	5	4	5	5	5	4	4	4	5	5	5	5	5	4	4	4	4	4	5	5	5	5	5	4	5	4	5	5	5	5
Respondent163	4	4	4	4	4	5	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	5	4
Respondent164	4	4	4	4	5	4	4	4	4	4	4	5	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent165	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	4	5	5	5	5	5	5	5
Respondent166	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4
Respondent167	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent168	4	4	4	4	4	5	4	4	4	4	4	4	5	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	4	4	4	4
Respondent169	4	4	4	4	4	4	4	4	3	3	4	4	3	3	4	4	4	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3
Respondent170	4	5	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4
Respondent171	4	4	4	5	5	5	5	5	4	4	5	4	4	4	5	4	5	4	4	4	4	4	4	5	5	5	5	4	5	4	4	4	5	5	5	4	4	4	4
Respondent172	4	4	5	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Respondent173	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent174	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5	5	5	5	5	5	4	5	5
Respondent175	5	5	5	4	4	4	4	4	5	5	5	5	4	4	4	4	5	4	4	5	5	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	5	5	5
Respondent176	4	4	4	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	5	5	5	4	4	4	4
Respondent177	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	5	4	4	4	3	4	4	4	4	4	3	3	3	4	4	4	4	4	4	4	5	4
Respondent178	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3
Respondent179	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	4	3	3	4	4	4	4	3	3	4	5	5	5	5	5	5	5	5	5
Respondent180	4	4	4	4	4	5	4	4	4	4	4	4	5	5	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	5	4	4
Respondent181	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4
Respondent182	3	3	4	3	3	3	3	3	2	2	3	3	5	5	5	5	5	4	5	5	5	3	3	3	3	3	3	2	2	3	4	5	3	4	3	5	5	4	5
Respondent183	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	5	5	4	4	4	5	5	5	5
Respondent184	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent185	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	3	4	4	4	5	4	4	4	4	4
Respondent186	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3
Respondent187	4	4	4	4	5	4	4	4	5	5	5	4	5	5	5	5	4	5	5	5	5	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	5	5
Respondent188	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4
Respondent189	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	4	4	4	4
Respondent190	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent191	4	4	4	5	5	5	5	5	4	4	5	4	4	4	4	4	4	5	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent192	4	5	4	4	4	5	4	4	4	4	4	3	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	5
Respondent193	4	4	3	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	5	4	4	4	5	4	4	4	4	4	4	4	5	4	4	5	4
Respondent194	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5
Respondent195	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	5	5	4	4	3	3	4	4	4	4	3	3	3	5	5	4	4	3	4	4	4	4
Respondent196	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5
Respondent197	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4
Respondent198	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent199	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent200	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4
Respondent201	4	4	4	5	5	5	5	5	4	4	4	4	4	4	5	5	5	4	4	4	5	4	4	5	5	5	5	4	5	4	4	3	5	5	5	5	5	5	5
Respondent202	5	5	4	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent203	5	5	5	5	5	5	5	5	5	5	5	5	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	3	3	3	3
Respondent204	4	5	4	4	4	5	4	4	4	4	4	3	5	5	5	5	5	5	5	5	5	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent205	4	4	4	4	4	4	4	4	4	5	4	4	5	5	4	5	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent206	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	4	4	4	5	5	5	5	5	5	4	5	5
Respondent207	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5
Respondent208	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5

Respondent209	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	5	5	5
Respondent210	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5
Respondent211	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent212	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4
Respondent213	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4	5
Respondent214	3	4	3	3	3	3	2	3	3	3	3	3	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4
Respondent215	4	4	4	4	4	5	4	5	4	4	4	4	5	4	4	4	4	4	5	4	4	4	4	4	4	5	4	4	4	4	5	5	4	4	4	4	4	4	4
Respondent216	5	5	4	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent217	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent218	5	5	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	4	4	4	4
Respondent219	3	3	3	3	3	3	3	2	4	4	4	3	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	4	4	3	5	5	5	5	5	5	5	5	5
Respondent220	4	4	4	4	4	4	5	4	4	5	4	4	4	4	3	4	3	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	4	3	3
Respondent221	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4
Respondent222	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	5	5	5	4	4	4	4	5	4	5	5	5	5	5	5	5
Respondent223	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	4	4	4	4	3	3	3	4	4	4	4	5	4	4	5	3
Respondent224	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	4
Respondent225	5	5	5	4	4	5	4	4	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	4	4	4	4	5	5	5	5	5	4	4	4	5	4	5	5
Respondent226	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent227	3	3	4	3	3	3	3	3	3	3	3	3	3	3	4	4	4	3	4	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3
Respondent228	3	3	3	3	3	3	2	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	3	3	3	3
Respondent229	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent230	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent231	4	4	4	4	5	4	4	4	4	4	4	3	5	5	4	4	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4
Respondent232	4	4	4	3	3	3	3	3	3	3	4	4	3	4	3	3	3	3	3	4	4	3	3	4	4	4	4	3	3	3	3	3	5	5	5	4	4	4	4
Respondent233	4	4	4	4	4	4	4	5	5	5	4	4	5	5	5	5	4	5	5	5	5	4	5	4	4	4	5	5	5	4	4	4	4	3	4	5	5	5	5
Respondent234	4	4	4	3	3	3	3	2	3	3	3	4	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3	3	3	3	3	3	3
Respondent235	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5	5	4	5	5	5	5	5	5	5	5	5	5
Respondent236	5	5	5	5	5	5	5	5	5	5	5	5	3	4	2	2	3	3	3	3	3	3	3	2	3	3	2	3	3	3	3	3	3	3	4	4	3	4	4
Respondent237	5	5	5	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	5
Respondent238	4	4	4	5	5	5	5	5	4	4	4	4	4	4	5	4	5	4	4	4	4	4	4	5	5	5	5	4	4	4	5	5	5	5	5	4	4	4	4
Respondent239	2	3	2	3	3	3	2	3	2	3	2	3	3	3	3	3	3	3	3	2	2	2	2	3	3	3	3	2	3	3	3	4	4	4	4	3	3	4	3
Respondent240	4	4	4	4	5	4	4	4	4	4	5	4	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4
Respondent241	4	4	5	4	4	4	4	5	4	4	4	4	3	3	3	3	3	4	3	4	4	2	2	3	3	3	3	3	3	2	5	4	5	5	5	5	5	5	5
Respondent242	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	5	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5
Respondent243	4	4	4	4	4	4	4	5	4	4	4	4	5	5	5	5	5	4	5	4	4	4	4	4	4	4	4	4	5	4	4	4	5	5	5	4	4	4	4
Respondent244	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	4	4	5	4	3	3	3	4	4	4	4	4	4	4	4	4

Respondent245	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	3	5	5	5	5	4	4	4	5	5	5	5	5	5	5	5	4
Respondent246	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5
Respondent247	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5
Respondent248	4	4	4	5	5	5	5	5	4	4	4	4	4	4	5	5	5	4	4	4	4	4	4	5	5	4	5	4	4	3	4	4	5	5	5	4	4	4	4
Respondent249	3	3	3	3	3	3	3	3	3	3	3	4	3	3	4	5	4	3	3	3	3	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	4
Respondent250	4	4	4	4	4	4	4	5	4	4	4	4	4	3	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4
Respondent251	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	5	4	4	4	5	4	4	4	4	4	4	4	4	4	4
Respondent252	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	4	5	4	4	4	4	5	5	5	5
Respondent253	4	4	4	4	4	4	4	4	5	5	5	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	5	4	4	4	4	5	4	4	4	4	4	4	3
Respondent254	4	4	4	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	4	5	5	4	4	3	5	4	5	5
Respondent255	5	5	5	4	4	4	4	4	4	4	4	5	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	5	3	4	4	5	5	5	4	4	4	4
Respondent256	4	3	4	4	4	5	4	4	4	4	4	4	5	5	5	5	5	5	4	5	4	3	4	4	4	4	4	3	3	3	4	4	4	4	5	5	5	5	5
Respondent257	4	4	4	4	5	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	3	4	4	4	4	5
Respondent258	4	4	4	4	4	4	4	5	4	5	4	4	5	5	5	5	4	5	5	5	5	3	3	4	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4

Quality Risk Management

C.3: Survey data details (Sections 3: Quality Risks)

RESPONDENT	QR1	QR2	QR3	QR4	QR5	QR6	QR7	QR8	QR9	QR10	QR11	QR12	QR13	QR14	QR15	QR16	QR17	QR18	QR19	QR20	QR21
Respondent1	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	1	2	2	2
Respondent2	2	2	2	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	1
Respondent3	1	1	2	1	1	1	2	1	1	1	2	1	1	1	1	1	1	2	1	1	1
Respondent4	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Respondent5	3	3	2	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	2	2
Respondent6	2	2	2	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2
Respondent7	1	1	1	1	2	1	1	1	1	2	1	1	1	1	3	3	3	1	2	3	3
Respondent8	2	2	2	3	2	2	2	2	1	2	2	2	2	2	2	1	2	3	2	2	3
Respondent9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent10	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent11	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1
Respondent12	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1
Respondent13	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent14	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2	3	2	2	2	2	1
Respondent15	2	3	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2
Respondent16	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent17	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1
Respondent18	2	2	2	2	2	2	2	3	2	2	2	2	2	2	1	1	1	1	1	1	2
Respondent19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Respondent20	2	2	2	2	2	1	1	1	2	1	1	1	1	1	2	2	2	2	2	2	2
Respondent21	1	2	1	2	1	1	1	1	1	1	2	1	1	2	1	1	1	1	1	1	1
Respondent22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	2	2
Respondent24	2	2	2	1	3	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2
Respondent25	1	1	1	1	2	2	2	2	2	2	2	2	3	2	1	1	1	1	1	1	1
Respondent26	3	3	3	3	3	2	3	2	2	2	3	2	2	2	3	3	3	3	3	3	3
Respondent27	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2
Respondent28	2	3	2	2	2	1	2	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Respondent29	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Respondent31	2	2	2	2	2	3	3	2	3	3	3	2	2	3	3	3	3	2	3	2	2
Respondent32	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1
Respondent33	1	1	1	1	1	2	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Respondent34	2	1	2	2	2	2	1	2	2	2	2	2	2	2	2	3	2	2	2	2	2
Respondent35	2	2	3	2	2	2	2	2	2	2	1	2	1	2	2	1	2	2	2	2	2
Respondent36	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	2	2	2	2	2	1
Respondent37	2	2	2	1	2	3	3	3	2	2	3	3	3	3	2	2	2	2	2	3	2
Respondent38	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent39	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2
Respondent40	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	2
Respondent41	3	2	3	2	2	2	2	2	1	2	2	2	2	2	3	3	2	3	3	3	3
Respondent42	3	3	3	2	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2
Respondent43	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent44	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
Respondent45	1	1	1	1	1	2	2	2	3	2	2	2	2	2	1	1	1	1	1	1	1
Respondent46	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	2	2	2	1
Respondent47	2	2	3	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent48	1	1	1	1	1	1	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1
Respondent49	1	1	1	1	1	2	1	1	2	2	2	2	2	2	1	1	1	1	1	1	1
Respondent50	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent51	1	1	1	1	2	2	2	2	2	2	3	2	2	2	1	1	1	1	1	1	1
Respondent52	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1
Respondent53	2	2	2	2	3	2	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2
Respondent54	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	3	3	2	2
Respondent55	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	1	2	2	2	2	2
Respondent56	2	1	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3	3	3	3	2
Respondent57	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Respondent58	2	3	3	2	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	2	1
Respondent59	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	1	1
Respondent60	1	1	1	1	1	2	2	2	2	3	2	2	2	2	1	1	1	1	1	2	2
Respondent61	1	1	2	1	1	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent62	3	3	3	3	3	2	2	2	2	2	1	2	2	2	1	1	1	1	1	1	1
Respondent63	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent64	1	1	1	1	1	1	1	1	1	1	2	1	1	1	2	2	2	1	2	3	3
Respondent65	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Respondent66	1	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1

Respondent67	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2	2	1	1	2	2
Respondent68	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent69	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1
Respondent70	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2
Respondent71	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent72	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
Respondent73	2	2	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2
Respondent74	2	2	2	2	3	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2
Respondent75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	2	2	2	2	2
Respondent76	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	1	2	2	2	2
Respondent77	2	2	1	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Respondent78	1	1	1	1	1	1	2	1	2	1	1	1	2	1	2	2	2	2	2	2	2
Respondent79	1	1	1	1	1	2	2	2	2	1	2	2	2	2	1	1	1	1	1	1	1
Respondent80	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent81	1	1	1	1	2	2	1	2	2	2	2	2	2	2	1	1	1	2	2	1	1
Respondent82	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	1
Respondent83	2	2	2	2	2	2	2	2	2	2	1	2	2	2	3	3	3	3	3	3	2
Respondent84	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2
Respondent85	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	1	1	2	2
Respondent86	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent87	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent88	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent89	2	2	2	2	2	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	1
Respondent90	2	2	1	2	2	3	3	3	2	3	3	3	3	3	3	3	2	3	3	3	3
Respondent91	2	2	2	2	2	3	2	3	3	3	3	2	3	2	2	2	2	2	2	2	1
Respondent92	1	1	1	1	1	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
Respondent93	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1
Respondent94	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent95	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	3	3
Respondent96	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent97	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent98	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent99	3	3	2	3	3	2	2	2	2	2	2	2	2	2	3	3	3	1	2	3	2
Respondent100	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2
Respondent101	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Respondent102	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2

Respondent103	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	3
Respondent104	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1
Respondent105	2	2	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2	2
Respondent106	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent107	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Respondent108	2	2	2	3	2	1	2	1	1	1	2	1	1	1	2	2	2	2	2	2	2
Respondent109	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	2	1	1
Respondent110	2	2	1	2	2	2	2	2	2	2	1	1	2	2	2	1	2	2	2	2	1
Respondent111	2	2	2	2	2	3	3	2	3	3	3	3	3	3	2	2	1	3	2	2	2
Respondent112	2	2	2	2	2	3	3	3	3	3	3	3	2	3	3	2	3	3	3	3	3
Respondent113	1	1	1	1	1	2	2	2	3	2	2	2	3	2	1	1	1	1	1	1	1
Respondent114	2	2	2	2	2	1	1	1	1	1	1	1	2	1	2	2	2	1	1	2	2
Respondent115	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent116	2	2	2	2	2	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1
Respondent117	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	1
Respondent118	3	3	3	3	3	3	3	3	3	2	3	3	3	3	2	2	2	2	2	2	2
Respondent119	1	1	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent120	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	2	1	2	2	2
Respondent121	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent122	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
Respondent123	2	2	2	2	1	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1
Respondent124	2	2	2	2	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	2	2
Respondent125	3	2	3	2	3	3	3	3	3	3	3	2	2	3	3	3	2	3	3	3	2
Respondent126	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	2	2	3	3
Respondent127	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1
Respondent128	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1
Respondent129	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent130	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent131	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	2	2
Respondent132	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent133	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Respondent134	2	2	2	2	2	3	3	3	2	3	3	3	3	3	2	2	2	2	2	2	1
Respondent135	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	3	3
Respondent136	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	3	2	2	2	2
Respondent137	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent138	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2

Respondent139	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent140	3	3	3	3	3	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	2
Respondent141	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Respondent142	2	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	1	1	2	2
Respondent143	1	1	1	1	2	2	2	3	2	2	2	3	2	2	2	2	2	2	3	2	3
Respondent144	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent145	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Respondent146	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3	3	3	3	2
Respondent147	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent148	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
Respondent149	3	3	3	3	3	3	3	3	3	3	3	2	3	3	2	2	2	2	2	2	2
Respondent150	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent151	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
Respondent152	3	3	2	3	3	2	1	2	2	2	1	2	2	2	3	3	3	3	3	2	2
Respondent153	2	2	2	1	2	2	2	2	2	2	2	2	2	3	2	2	2	1	2	2	2
Respondent154	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1
Respondent155	1	1	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1
Respondent156	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1
Respondent157	3	3	3	3	3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent158	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent159	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2
Respondent160	2	2	2	2	2	2	2	1	2	2	2	2	2	2	1	1	1	1	1	1	1
Respondent161	1	2	1	1	1	2	2	2	2	2	2	2	2	2	1	1	2	1	1	1	1
Respondent162	1	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1
Respondent163	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2
Respondent164	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent165	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent166	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2
Respondent167	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent168	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2	1	2
Respondent169	2	2	1	2	2	2	2	2	2	2	2	2	1	2	3	3	2	3	3	3	3
Respondent170	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Respondent171	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent172	1	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Respondent173	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent174	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2

Respondent175	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Respondent176	2	2	2	2	1	2	2	2	2	2	2	3	2	2	1	1	1	1	1	1	1
Respondent177	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent178	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2
Respondent179	3	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3
Respondent180	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	3	2	2	2	2
Respondent181	2	1	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	2	1
Respondent182	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Respondent183	2	2	2	2	2	1	1	1	1	2	1	1	1	1	2	2	2	3	2	2	2
Respondent184	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent185	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	1	2	2	2	2	2
Respondent186	3	3	3	3	3	2	1	1	2	2	2	2	2	1	2	2	2	2	2	2	2
Respondent187	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	2	2	2	2	2	3
Respondent188	1	1	2	1	1	2	2	2	2	2	2	1	2	2	2	3	2	2	2	2	1
Respondent189	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2
Respondent190	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent191	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
Respondent192	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
Respondent193	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent194	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	2
Respondent195	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent196	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
Respondent197	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2
Respondent198	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Respondent199	1	1	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1
Respondent200	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Respondent201	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent202	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent203	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2	2	3	3
Respondent204	2	2	1	2	2	2	2	2	2	2	2	2	2	3	1	1	1	1	1	1	1
Respondent205	2	2	2	2	2	2	3	2	3	2	2	2	2	2	2	2	2	2	2	2	2
Respondent206	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent207	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent208	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
Respondent209	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Respondent210	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Respondent211	2	2	1	2	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1
Respondent212	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Respondent213	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
Respondent214	2	2	2	1	2	3	3	3	3	3	3	3	3	2	2	2	2	1	1	2	2
Respondent215	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1	1	1	1	1	1
Respondent216	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
Respondent217	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent218	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Respondent219	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent220	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2
Respondent221	1	1	1	1	1	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	1
Respondent222	2	2	2	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1
Respondent223	2	2	2	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	3	3
Respondent224	1	1	1	1	1	1	1	2	1	1	1	1	2	1	2	2	2	2	2	2	2
Respondent225	1	1	2	1	1	1	1	1	1	2	1	1	1	1	2	2	2	3	3	2	2
Respondent226	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2
Respondent227	3	3	3	3	2	2	2	2	2	2	2	2	2	2	3	2	3	3	3	3	3
Respondent228	2	2	1	2	2	3	3	2	3	2	3	3	3	3	3	3	3	3	3	2	2
Respondent229	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1
Respondent230	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2
Respondent231	1	1	1	1	1	2	2	2	2	1	2	1	2	2	1	1	1	1	1	1	1
Respondent232	3	1	3	3	3	2	2	2	2	2	2	2	2	2	3	3	2	2	3	3	3
Respondent233	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1
Respondent234	2	2	2	2	2	3	2	3	2	3	3	3	3	3	3	2	3	3	3	3	2
Respondent235	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Respondent236	3	3	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent237	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent238	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1	2
Respondent239	2	2	2	2	2	3	3	2	3	3	3	3	3	2	2	2	1	2	2	2	1
Respondent240	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
Respondent241	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent242	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Respondent243	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2
Respondent244	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2
Respondent245	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
Respondent246	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2

Respondent247	1	1	2	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1
Respondent248	1	1	1	1	1	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2
Respondent249	3	3	3	3	3	2	2	1	2	2	2	1	2	2	2	2	2	2	2	3	3
Respondent250	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	3
Respondent251	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2
Respondent252	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	1	1	2	2
Respondent253	2	2	1	3	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	2	2
Respondent254	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2
Respondent255	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
Respondent256	2	1	2	2	2	2	2	2	2	3	2	2	2	2	1	1	1	1	1	1	1
Respondent257	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Respondent258	1	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1

Quality Risks

C.3: Survey data details (Section 4: Quality Performance)

RESPONDENT	QP1	QP2	QP3	QP4	QP5	QP6	QP7	QP8	QP9	QP10	QP11	QP12	QP13	QP14	QP15
Respondent1	4	4	4	4	5	5	5	5	5	4	4	4	5	5	4
Respondent2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent3	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5
Respondent4	5	5	5	4	5	5	5	5	4	5	5	5	5	5	5
Respondent5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Respondent6	4	3	4	4	5	4	5	5	5	5	5	5	4	4	4
Respondent7	5	4	5	5	5	5	5	5	5	3	3	3	5	4	5
Respondent8	4	5	4	5	4	4	4	4	4	4	3	4	4	4	4
Respondent9	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4
Respondent10	4	4	4	4	4	3	4	4	4	4	5	4	4	5	4
Respondent11	4	4	4	4	4	5	4	4	4	4	4	3	4	4	4
Respondent12	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent13	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5
Respondent14	5	5	4	5	5	5	5	5	5	4	4	4	4	4	4
Respondent15	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
Respondent16	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5
Respondent17	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5
Respondent18	5	4	5	5	4	4	4	4	4	5	5	5	5	5	5
Respondent19	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5
Respondent20	4	3	4	4	4	4	4	4	4	4	3	4	3	4	3
Respondent21	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent22	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5
Respondent23	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4
Respondent24	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4
Respondent25	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4
Respondent26	3	3	3	3	4	4	4	4	4	3	4	3	3	3	4
Respondent27	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent28	5	5	5	5	5	5	5	5	5	4	4	4	5	5	5
Respondent29	4	4	4	4	4	4	4	5	4	4	4	4	3	3	3
Respondent30	5	5	5	5	4	5	4	4	4	4	4	4	4	4	4
Respondent31	4	3	4	3	3	3	3	3	3	3	3	3	3	3	3

Respondent32	5	5	4	5	5	4	5	5	5	5	5	5	5	5	5
Respondent33	5	5	5	5	4	4	4	4	4	5	5	4	5	5	5
Respondent34	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
Respondent35	4	4	4	4	4	3	4	4	4	4	4	4	3	3	3
Respondent36	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4
Respondent37	4	4	4	4	3	4	3	3	3	4	5	4	3	4	3
Respondent38	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent39	4	3	4	4	4	4	4	4	4	4	4	4	4	5	4
Respondent40	5	5	5	5	4	4	4	4	4	5	5	5	5	5	4
Respondent41	3	4	4	3	4	4	4	4	4	3	3	3	3	3	3
Respondent42	3	3	3	4	3	3	3	3	3	4	4	4	3	3	3
Respondent43	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent44	5	5	5	5	5	5	4	5	5	5	4	5	5	5	5
Respondent45	3	3	3	3	4	4	4	4	4	5	5	5	5	5	5
Respondent46	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4
Respondent47	4	4	4	5	4	4	4	4	4	4	4	4	3	3	3
Respondent48	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5
Respondent49	5	5	5	4	4	4	4	4	4	5	5	5	5	5	5
Respondent50	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4
Respondent51	5	5	5	5	4	4	4	4	4	5	5	5	5	5	5
Respondent52	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent53	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4
Respondent54	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent55	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4
Respondent56	4	4	4	4	4	4	4	4	4	3	3	4	4	4	4
Respondent57	5	5	5	5	4	4	4	5	4	5	5	5	5	5	5
Respondent58	4	4	5	4	3	3	3	3	3	3	3	3	3	4	3
Respondent59	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4
Respondent60	5	5	5	5	4	4	4	4	4	5	5	5	4	4	4
Respondent61	5	5	4	5	4	4	4	4	4	4	4	4	4	4	4
Respondent62	3	3	4	3	4	4	4	4	4	5	5	5	5	5	4
Respondent63	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent64	5	5	5	5	4	4	4	4	5	4	4	5	5	5	5
Respondent65	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4
Respondent66	5	5	5	5	4	4	4	4	4	4	4	4	4	5	4
Respondent67	4	3	4	4	3	3	3	3	3	4	4	4	4	4	4

Respondent68	4	4	4	4	4	4	5	4	4	4	4	3	4	4	4
Respondent69	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent70	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4
Respondent71	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5
Respondent72	4	4	4	4	4	4	4	3	4	4	4	4	4	4	5
Respondent73	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4
Respondent74	4	4	4	3	4	4	4	4	4	4	4	4	5	5	5
Respondent75	4	4	4	4	4	3	4	4	4	4	5	3	4	4	4
Respondent76	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent77	4	4	4	5	4	4	4	4	5	5	5	5	5	5	5
Respondent78	5	5	5	5	4	4	4	4	4	4	4	4	4	4	3
Respondent79	5	5	5	5	4	4	4	4	4	5	5	5	5	4	5
Respondent80	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent81	3	4	3	4	4	5	4	4	4	5	5	5	5	5	4
Respondent82	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent83	4	5	4	4	4	4	4	4	4	3	3	3	3	3	3
Respondent84	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4
Respondent85	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4
Respondent86	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent87	4	4	3	4	4	4	5	4	4	4	4	4	4	4	4
Respondent88	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5
Respondent89	4	4	4	4	3	3	3	3	3	4	4	4	4	4	4
Respondent90	4	4	4	4	3	4	3	3	3	3	4	3	3	3	4
Respondent91	4	4	5	4	3	3	4	3	3	4	4	4	4	5	4
Respondent92	5	5	5	5	4	4	4	4	4	4	4	4	4	4	3
Respondent93	5	5	5	4	5	4	5	5	5	5	5	5	5	5	5
Respondent94	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent95	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4
Respondent96	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4
Respondent97	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent98	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4
Respondent99	3	3	3	3	4	4	4	4	5	3	3	3	4	3	4
Respondent100	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent101	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5
Respondent102	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent103	4	4	4	4	4	4	4	3	4	4	4	5	4	4	4

Respondent104	4	4	4	4	4	5	4	5	4	4	4	4	4	4	4
Respondent105	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
Respondent106	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4
Respondent107	5	5	5	5	4	4	4	4	4	4	4	5	4	4	4
Respondent108	4	4	4	4	5	4	5	4	5	4	4	4	5	5	5
Respondent109	5	5	5	5	4	4	5	4	4	4	4	4	4	4	4
Respondent110	4	4	4	4	4	4	4	4	4	4	4	4	4	5	3
Respondent111	4	3	4	4	3	4	3	3	4	4	4	4	4	4	4
Respondent112	4	4	4	4	3	3	4	3	3	3	3	3	3	3	3
Respondent113	5	5	5	5	4	4	4	4	4	5	5	5	5	5	5
Respondent114	5	5	5	5	5	5	4	5	5	4	5	4	4	5	4
Respondent115	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5
Respondent116	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5
Respondent117	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent118	3	3	3	3	3	3	3	3	3	4	4	4	4	3	4
Respondent119	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4
Respondent120	5	5	5	5	5	5	5	5	5	4	4	4	4	4	5
Respondent121	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent122	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4
Respondent123	4	4	4	4	3	3	3	3	4	5	5	5	5	5	5
Respondent124	4	4	5	3	3	3	3	4	3	3	3	4	3	3	3
Respondent125	3	4	3	3	3	3	4	3	3	3	3	3	3	3	3
Respondent126	5	5	5	5	4	4	4	4	4	3	3	3	4	4	4
Respondent127	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5
Respondent128	4	5	4	4	5	5	5	5	5	4	4	4	4	4	4
Respondent129	4	4	4	4	4	5	4	4	4	4	5	4	4	5	3
Respondent130	3	3	4	3	4	4	4	3	4	4	4	4	4	4	4
Respondent131	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent132	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent133	4	4	4	5	5	5	5	5	5	4	4	4	4	4	4
Respondent134	4	4	4	4	3	3	3	3	3	4	4	4	4	4	4
Respondent135	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4
Respondent136	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4
Respondent137	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4
Respondent138	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent139	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Respondent140	3	3	3	3	4	4	5	4	4	4	4	4	4	4	4
Respondent141	4	4	4	4	5	5	5	4	5	4	4	4	4	4	4
Respondent142	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent143	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent144	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5
Respondent145	3	3	3	3	4	4	4	4	3	5	5	5	5	5	5
Respondent146	4	4	4	4	4	4	4	4	4	3	4	3	3	3	3
Respondent147	4	4	4	4	4	4	4	4	5	4	4	5	4	4	3
Respondent148	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5
Respondent149	3	4	3	4	3	3	3	3	4	4	4	4	4	4	4
Respondent150	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5
Respondent151	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent152	3	3	3	3	4	4	4	3	4	3	3	4	3	3	3
Respondent153	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4
Respondent154	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4
Respondent155	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent156	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5
Respondent157	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4
Respondent158	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5
Respondent159	4	4	4	4	4	4	3	4	4	4	5	4	4	4	4
Respondent160	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5
Respondent161	5	5	5	5	4	4	4	4	4	5	5	5	5	4	5
Respondent162	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4
Respondent163	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent164	5	5	5	4	4	4	5	4	3	4	4	4	4	4	4
Respondent165	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent166	4	4	5	4	4	4	4	4	5	4	4	4	4	4	4
Respondent167	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5
Respondent168	4	4	4	5	4	4	4	4	4	5	5	5	5	5	5
Respondent169	4	4	4	4	4	5	4	4	4	3	3	3	3	4	3
Respondent170	4	4	4	4	5	5	5	4	5	4	4	4	4	4	4
Respondent171	4	4	4	4	4	4	3	5	4	4	4	4	4	4	4
Respondent172	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent173	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4
Respondent174	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent175	4	4	4	4	5	4	5	5	5	4	4	4	4	4	4

Respondent176	5	5	5	5	4	4	4	4	3	5	5	5	5	5	5
Respondent177	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent178	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent179	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4
Respondent180	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4
Respondent181	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent182	4	4	4	4	4	4	4	5	4	5	5	5	5	5	5
Respondent183	4	4	4	4	5	5	4	5	4	4	4	4	4	4	4
Respondent184	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4
Respondent185	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4
Respondent186	3	3	4	3	4	4	4	4	4	4	4	5	4	5	4
Respondent187	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4
Respondent188	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent189	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4
Respondent190	4	4	5	4	4	4	4	4	4	4	4	4	4	4	5
Respondent191	4	5	4	5	4	4	4	4	5	4	4	4	4	4	4
Respondent192	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent193	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4
Respondent194	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent195	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent196	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5
Respondent197	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent198	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5
Respondent199	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5
Respondent200	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4
Respondent201	4	4	5	4	4	4	5	4	4	4	4	4	4	4	4
Respondent202	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5
Respondent203	4	4	4	4	4	4	4	4	4	3	3	3	4	4	4
Respondent204	4	4	3	4	4	4	4	4	4	4	4	4	4	5	4
Respondent205	4	4	4	3	4	4	4	4	5	4	4	4	4	4	4
Respondent206	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent207	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5
Respondent208	5	5	5	5	5	4	5	4	5	5	5	5	5	5	5
Respondent209	5	5	5	4	5	5	5	5	5	5	5	5	4	4	4
Respondent210	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent211	4	4	4	4	5	5	5	5	5	5	4	5	5	5	5

Respondent212	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4
Respondent213	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent214	4	4	4	4	3	4	3	4	3	4	4	5	4	4	4
Respondent215	4	4	4	4	4	4	4	4	4	5	5	5	5	5	4
Respondent216	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent217	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5
Respondent218	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5
Respondent219	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5
Respondent220	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent221	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4
Respondent222	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5
Respondent223	4	4	4	5	4	4	4	4	4	4	4	5	4	4	4
Respondent224	4	4	4	4	5	5	5	5	5	4	4	4	4	4	5
Respondent225	4	4	4	4	5	5	4	5	5	4	4	4	4	4	4
Respondent226	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5
Respondent227	3	4	3	3	4	4	5	4	4	3	3	3	3	3	3
Respondent228	4	4	4	4	3	3	3	3	3	3	4	3	3	3	4
Respondent229	5	5	4	5	5	4	5	5	5	5	5	5	4	4	4
Respondent230	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent231	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent232	3	3	3	3	4	4	4	4	4	3	3	4	3	3	4
Respondent233	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent234	4	5	4	4	3	3	4	4	3	3	3	3	3	4	3
Respondent235	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent236	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent237	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4
Respondent238	5	4	5	5	5	5	5	4	5	4	4	4	4	4	4
Respondent239	4	4	4	4	3	3	3	3	4	4	4	4	4	4	4
Respondent240	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5
Respondent241	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent242	4	4	5	4	4	4	4	4	4	4	4	5	4	4	4
Respondent243	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
Respondent244	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent245	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4
Respondent246	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Respondent247	5	5	5	5	5	5	4	5	4	5	4	5	5	5	5

Respondent248	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent249	3	3	4	3	4	4	4	4	4	4	4	4	4	4	4
Respondent250	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent251	4	4	3	5	4	4	4	4	4	4	4	4	4	4	4
Respondent252	4	4	4	4	5	5	5	4	5	4	4	4	5	5	5
Respondent253	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5
Respondent254	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Respondent255	4	4	5	4	4	4	4	4	4	4	4	4	4	4	5
Respondent256	5	5	4	5	4	4	4	4	4	5	5	4	4	4	4
Respondent257	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4
Respondent258	5	5	5	5	4	4	4	4	4	5	5	5	5	5	5

Quality Performance