QATAR UNIVERSITY

COLLEGE OF ENGINEERING

CRITICAL ASSESSMENT OF POST-AWARD CONTRACT ADMINISTRATION PERFORMANCE IN CONSTRUCTION PROJECTS

BY

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the College of Engineering

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ABSTRACT

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Title: Critical Assessment of Post-Award Contract Administration Performance in Construction Projects

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While proper construction contract administration (CCA) is a core competency and a principal success factor for projects, the process is inevitably complex and improper performance of the associated tasks and processes may lead to disputes whilst further imposing unnecessary risks to the project. Therefore, there is a need for an extensive investigation of factors that affect CCA performance. This study proposes an assessment tool to improve the CCA implementation by introducing an operational, systematic, and multidimensional contract administration performance model (CAPM) at the project level. Past research, semi-structured interviews, and a two-round Modified Delphi study were employed to identify the importance of 93 indicators that affect CCA performance in 11 process groups. The worst-case scenario of the mode score, mode value, and standard deviation to mean ratio (SDMR) were conducted to check the overall agreement on Delphi rounds. The mean value and IRA analyses were applied to quantify the significance and strength of the agreement of the identified items. The agreement level represents 94.6 and 100 % of the proposed factors and groups, respectively. After the Delphi study, the data collected from 366 construction professionals through an online survey was utilized to develop a Fuzzy- Structural Equation Model (SEM). The second-order Confirmatory Factor Analysis of the SEM supported and validated the research hypotheses. Upon model validation, a

Construction Contract Administration Performance Index (CCAPI) was formulated, an alternative short model with 33 factors was introduced, and CAPM cross-platform mobile app was developed. Models were practically utilized in the 13 construction projects to capture and benchmark the CCA performance levels. The study captured a significant correlation between CCA indicators, groups, and overall performance. Communication & relationship; performance monitoring & reporting; and quality & acceptance management were the top 3 groups that affect CCA performance. The study set 30 recommendations for construction professionals. Moreover, the practical model implementation showed that contractual risk management might need further attention.

Keywords: Fuzzy Set Theory (FST), Construction Contract Administration, Performance Index, Structural Equation Modeling (SEM), Construction Projects, Performance Management, Mobile App.

DEDICATION

To My Whole Family

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LIST OF SYMBOLS AND ACRONYMS

ADF	:	Asymptotic-Distribution-Free
AGFI	:	Adjusted Goodness of Fit Index
AIA	:	American Institute of Architects
AIC	:	Akaike Information Criterion
AMOS	:	Analysis of Moment Structure
API	:	Application Programming Interface
ASV	:	Average Shared Variance
AVE	:	Average Variance Extracted
BIC	:	Bayesian Information Criterion
BOQ	:	Bill of Quantity
BOT	:	Build, Operate and Transfer
c.r	:	Critical Ratio
CAPM	:	Contract Administration Performance Model
CB-SEM	:	Covariance-Based SEM
CCA	:	Construction Contract Administration
CCAPI	:	Construction Contract Administration Performance Indicator
CFA	:	Confirmatory Factor Analysis
CFI	:	Comparative Fit Index
CLI	:	Command Language Interpreter
CM-PAM	:	Contract Management Process Assessment Model
CMS	:	Communication Management System
CR	:	Construct Reliability, also known as Composite Reliability

CSS	:	Cascading Style Sheets
DAB	:	Dispute Adjudication Board
DB	:	Design and Build
DBB	:	Design, Bid and Build
DBFO	:	Design, Build, Finance and Operate
DBO	:	Design, Build and Operate
df	:	Degrees of Freedom
DLP	:	Defects Liability, also known as Defects Notification Period
DMS	:	Document Management System
DV	:	Discriminant Validity
EFA	:	Explanatory Factor Analysis
EOT	:	Extension of Time
FIDIC	:	International Federation of Consulting Engineers
F-SEM	:	Fuzzy Structural Equation Modeling
FST	:	Fuzzy Set Theory
FW	:	Factor Weight
GCC	:	Gulf Cooperation Council
GCOC	:	Qatar General Conditions of Contract
GDP	:	Gross Domestic Product
GFI	:	Goodness of Fit Index
GLS	:	Generalized Least Squares
GOF	:	Goodness-Of-Fit
HTML	:	Hypertext Markup Language

IACCM	:	International Association for Contract & Commercial Management
ICC	:	International Chamber of Commerce
ICE	:	Institution of Civil Engineers
ICT	:	Information Communication Technology
IJV	:	International Joint Ventures
IRA	:	Inter-Rater Agreement
JCT	:	Joint Contracts Tribunal
KPI	:	Key Performance Indicator
LOA	:	Letter of Acceptance also known as Letter of Award
MDB	:	Multilateral Development Banks
MEED	:	Middle East Business Intelligence
MOU	:	Memorandum of Understanding
NAN	:	Not Applicable Variables
NEC	:	New Engineering Contract
NFBTE	:	National Federation of Building Trades Employers
NFI	:	Normal Fit index
NNFI	:	Non-Normal Fit index
OLS	:	Ordinary Least Squares
PCC	:	Practical Completion Certificate
PGFI	:	Parsimonious Goodness of Fit Index
PLS-SEM	:	Partial Least Squares-Based SEM
PMP	:	Project Management Plan
PQP	:	Project Quality Plan

PSC	:	Professional Services Contract, also known as Professional Services Agreement (PSA)
p-values	:	The Significant Values
PWA	:	Public Works Authority (ASHGAL)
QCCI	:	Qatar Chamber of Commerce and Industry
QICDRC	:	Qatar International Court and Dispute Resolution Centre
QMS	:	Quality Management System
RFI	:	Request for Information
RFP	:	Request for Proposal
RFW	:	Relative Factor Weight
RGW	:	Relative Group Weight
RIBA	:	Royal Institute of British Architects
RMSEA	:	Mean Root Squared Error of Approximation
rs	:	Spearman's Rank Correlation Coefficient
SABIC	:	Sample-Size Adjusted BIC
SD	:	Standard Deviation
SDKs	:	Software Development Kits
SDMR	:	Standard Deviation to Mean Ratio
SEM	:	Structural Equation Modeling
SFL	:	Standardized Factor Loadings
SMEs	:	Small Medium Enterprises
SPSS	:	Statistical Package for Social Sciences
SRMR	:	Standardized Root Mean Square Residual

W	:	Kendall's coefficient of concordance
WLS	:	Weighted Least Squares
$\chi 2$	:	Chi-Square

CHAPTER 1 : INTRODUCTION

1.1 INTRODUCTION

Conventionally, a construction project is organized into a series of tasks, processes, activities or operations undertaken by different entities with different levels of interest and involvement in the project. Further, the construction industry operates in a dynamic environment where a change in one area or process may affect other areas or processes, either directly or indirectly. Moreover, construction involves many people, activities, resources, and knowledge that require strong tools to manage relationships, obligations, and interactions among different stakeholders. An effective contract administration is one of such promised powerful tools that act with the changing environment and required compliances with required obligations. Oppositely, improper contract administration may lead to deficient processing that may negatively affect the project time, cost, and quality.

Based on the extensive literature review of "contract administration," "administrator roles, and responsibility," "impact on project performance", this study acknowledges a gap quantifying the contract administration performance and gathers the whole performance in a single index. Discussion of the problem and gap that are leading to this research work which will be explained in the next sections.

1.2 RESEARCH BACKGROUND

1.2.1 Construction Industry

The construction industry is one of the major labor-intensive production sectors in countries (Sertyesilisik 2007) and develops a demand for other related industries. It is one of the most complex industries and involves a variety of activities, stakeholders, and business sectors and therefore considers risky and challengeable (Tatarestaghi et al. 2011). Over the past decades, several researchers have studied the reform of the construction process aiming to improve its project performance(Seaden and Manseau 2001; Smyth 2010) and measure various project performance indicators and found that this industry was behind many other sectors. Also, the industry has a bad reputation due to internal issues such as poor performance, bad coordination, several project failures, oppositional relationships between the stockholders, and environmental pollution (Barrett et al. 2008).

The industry projects show several weaknesses, such as extra costs, time delays, negative environmental impact, disputes, and conflicts among parties. As a result, the projects' owners, contractors, and public bare the negative consequences. The Middle East and Gulf Council of Cooperation are not an exception for such weakness and PMI PM-Network (April 2014), announced for overbudgeting and delaying of 64 and 80 % of Middle East capital projects in 2012. Not only this but the delay extended over six months for more than half of those projects. In June 2015, Middle East Business Intelligence (MEED) stated: "more than 95 % of GCC projects were delayed, and 71 % were over budget ". Furthermore, megaprojects suffered more than other projects, and 90 % of the mega-projects exceeded the budget to 50 percent (Flyvbjerg 2014). It's not only the cost but also, reductions in benefits that reaching 50 % are also common. The phenomena are not limited to a specific sector (i.e., public or private) or a geographical area (i.e., developed, and undeveloped countries) (Flyvbjerg 2014).

1.2.2 Contract Administration

Projects are the core business of the construction industry and each project has its own contract, which is the principal element of every project activity. The contract is not self-enforcing but requiring proper administration. The management and administration of contracts are becoming not only a fundamental part of project management but also a core competency for the overall business management. Also, the globalization and current huge volume of contracts increase the recognition of the importance of effective and contract administration processes to all parties (Ntiyakunze 2011). The literature reveals that many projects are facing contract administration issues and the overall construction procurement management attainted a lot of attention within the project management domain. Overcoming such issues and challenges is difficult without proper management tools to administer and measure the performance of the contract administration process.

The term “Construction contract administration” represents a certain third-party contractual function associated with the post-award phase of a project, which starts after signing a contract and continues until issuing the performance certificate. The third party is the so-called “Contract Administrator,’ and has different titles such as the Engineer, Architect, Certifier or Project Manager under the different standard forms of contract. The contract administrator deals with the implementation of the contract, associated daily operations, issues, performance measures, payments, variations, change orders, exchange information, communication among parties, commissioning, handover, defects rectification works up to the final close of the project (Ofori 2014). Although a single person takes the final decision, most of the time the project team handles the function. A quantity surveyor often handles claims and applications for payments, project planner assesses the extension of time, field inspector examines the physical work done, and senior technical engineers handle requests for information, drawings, and submittals. The roles and functions of individuals require close monitoring to avoid unnecessary consequences on other areas. An example is a delay or incorrect payment application review that will affect the contractor’s cash flow and consequences are a delay, disturb relations and more risk.

Despite the importance of contract administration, several authors report that contract administration is an area that needs development in developing countries (Niraula et al. 2008; Niraula and Kusayanagi 2011). It is considered as the most serious challenge facing project stakeholder (Rendon 2007). According to Jackson (2010), the main reason that the project is suffering is poor contract administration procedures. PMI (2016) reveals that weak contract administration is a principal cause of problems on a construction project among other factors. Poor contract administration causes several problems in traditional contracts (Ogwueleka 2015). Yap (2013), lists poor contract administration among the top factors which lead to terminate a construction project because of several problems such as incomplete documents, deficiencies in the scope of work, specifications or drawings in terms of ambiguities, discrepancies, mistakes, use inappropriate dispute resolution method. Further, several researchers emphasize the need to train staff on good administrative practices (Jackson 2010; Kayastha 2014; Niraula et al. 2008) and the need for contract experts (Park and Kim 2018).

Globally, the achievement of effective contract management may be hindered by various challenges, barriers, or factors. The International Association for Contract & Commercial Management (IACCM 2003) pointed out that contract management is regarded as the main source of operational weakness in more than 70% of international corporations, and improvement of contract management would enhance risk management and decrease cost. Therefore, 60% of global companies have started to tackle the contract management problem. The two statements reflect the growing realization of underperformance of poorly managed contracts.

Regionally, Gulf Cooperation Council (GCC) and the Middle East countries are implementing an enormous number of projects (Sadek and Kulatunga 2013). In Qatar, the workload continues to focus on arrangements for the 2022 FIFA World Cup and the related infrastructure projects (AECOM 2016). As a result, the construction industry continues to stay as a key element in the region plans. The huge projects and investment will require proper contract administration.

Failure to administer, understand and comply with the contract properly leads to making the dispute more than double the global in the Middle East (Harris 2013). Furthermore, Arcadis (2017) presents poor contract administration as time-consuming and is the main source of disputes in Europe, Asia, the Middle East, and North America. What's more, several authors study the consequences of poor contract administration and inefficient management of contracts. The consequences are listed as working against sustaining the industry, heavy fine for non-compliance, substantial loss of savings, incur resources waste, delay in time, productive lose, the presence of several non-value added activities (Saxena 2008), poor control of operations, low rate of satisfying customers, unwanted costs, and more risks (Awwad et al. 2016). The poor contract administration is wasteful and causes problems in contractor-owner relations (Al Jurf and Beheiry 2010; Al Jurf and Beheiry 2012; Gunduz and AbuHassan 2016); delays (Al Jurf and Beheiry 2010; Al Jurf and Beheiry 2012; Ayarkwa et al. 2014; Maki 2016; Salama et al. 2008; Thorat et al. 2017); cost overrun (Abusafiya and Suliman 2017; Adindu and Oyoh 2011; Awwad et al. 2016; Ayarkwa et al. 2014; Farooqui et al. 2014; Salama et al. 2008); reduce profit margins; un-necessary changes; dispute (Abotaleb and El-adaway 2017; Arcadis 2018; Ayarkwa et al. 2014; Farooqui et al. 2014; Love et al. 2007); claims (Ayarkwa et al. 2014; Ntiyakunze 2011; Nyarko 2014); conflict, (Ntiyakunze 2011)project failure (Chow and Ng 2007), bureaucratic procedure (Kasiem 2008), abandoned project (Yap 2013) and more waste and finally eliminate refit margin (Okere 2012). Abotaleb and El-adaway (2017), state that studies still show poor contract administration as the leading cause of disputes.

Garrett and Lee (2010); argue that well-established contract management processes can develop a great deal, grant extra savings, and provide a competitive advantage for the organization over other competitors. Joyce (2014) argues that an effective contract administration program can be used as a risk management tool for all parties. It is worth to state that proper implementation of the contract management process constitutes time, cost, and management effort (Oluka and Basheka 2014).

The consequences of the poor administration and benefits of proper administration necessitate an additional urgency to investigate the contract administration process and identify the elements that contribute to good contract administration practice and establish an efficient and effective process to maintain a strong relationship between the parties (Bin Zakaria et al. 2013). Further, Watermeyer (2013) argues that management and control of the overall contract administration process need a reasonable, methodical, and auditable method in order to safeguard the efficient and effective implementation of CCA tasks.

A number of limited frameworks and models have been established and assessed within the context of the contract administration (Solis 2016) in specific regional areas and organizations. One of the first models was developed by Garrett and Rendon (2005) for the contract management maturity model (CMMM) using key process areas and key practice activities for general procurement management. Another structured assessment framework was proposed by Bartsiotas (2014) and was based on the policies, guidelines and procedures within the procurement organizations of the United Nations (UN). Okere (2012) used 40 CCA activities to investigate the correlation between contract administration practices and project performance within the Federal and State Departments of Transportations (DOT) in the United States. Similarly, Joyce (2014) used 33 key activities organized in 5 process groups to establish a conceptual framework for the state corporations in Kenya. By using a regression analysis model, the author concluded that effective contract management affects the operational performance of an organization. Solis (2016), proposed a contract management framework for the Dutch wastewater industry. The framework contained 96 key CCA activities in 7 groups. Surajbali (2016) investigated the contract administration within the general procurement framework of South Africa. The framework contained 9 key activities of contract management. Likewise, similar studies were conducted to identify the determinants and constraints that affected the procurement performance of the public sector in Uganda and Bangladesh (Ahmed 2015; Oluka and Basheka 2014). With 21 key factors, Park and Kim (2018) assessed the contract management capabilities required for enhancing the international competitiveness of Korean construction companies. At the governmental level, the Australian National Audit Office identified 13 areas that had to be managed effectively during the post-award phase (ANAO 2012). The National Audit Office of the United Kingdom developed another framework with 11 process groups to fill the gap in good practices and benchmarking tools (NAO 2016). Furthermore, the governmental entities in the UK, New Zealand, USA, Qatar, Zambia, and Sri Lanka published manuals for the best practices in contract administration (Crampton 2010; DGS 2010; Mwanaumo et al. 2017; Northwood and Group 2011; OFPP 1994; PWA 2017; Treasury 2017). The main process groups that can be found in these documentations are stakeholder management, risk management, contract monitor and control, change management, dispute management, contract records, and closeout.

Table 1.1: Comparizon between previous CCA/CM models

	Ahmed (2015)	NAO (2016)	Appiah Kubi (2015)	Bartsiotas (2014)	Garrett and Rendon (2005)	Joyce (2014)	Okere (2012)	Oluka and Basheka (2014)	Solis (2016)	Surajbali (2016)
No of constructs covering CCA	8	11	10	10	2	5	6	6	7	8
No of indicators covering CCA	58	94	72	112	21	32	62	40	93	27
Project specific	Y	Y	Y	N	N	Y	Y	N	N	N
Post-award Specific	N	Y	Y	Y	N	N	Y	N	N	N
Construction specific	Y	N	Y	N	N	N	Y	N	Y	N
Context	Bangladesh	UK	Ghana	UN	General	Kenya	USA/ Infra	Uganda	Netherlands/ W. Water	South Africa
Data size	34	N	42	262	N	35	66	96	13	20
Sample type	Purposive	N	Purposive	Purposive	N	Random	Random	Random	Purposive	Purposive
Target sample	Practitioners	N	Practitioners	Staff	N	Contractors	Employees	Practitioners	Practitioners	Practitioners
Instrument	Interviews & Questionnaire	N	Questionnaire	Questionnaire	N	Questionnaire	Piolt Study & Questionnaire	Questionnaire	Interview & Case Studies	Interviews
Analysis tool	Descriptive (Frequencies)	N	RII	Comparative Analysis	N	Linear Regression & ANOVA	Pearson Correlation & Multiple Regression	Standard Division/ Mean	Content Analysis / Exploratory	Qualitative
Indicator rating	Y	N	Y	Y	N	Y	Y	Y	N	N
Construct rating	N	N	Y	N	N	N	N	N	N	N
Construct index	N	N	N	Y	N	N	N	N	N	N
Overall index	N	N	N	N	N	Y	N	N	N	N

1.3 GAP AREA

Some authorities, researchers, and leading industry experts have discussed the subject of effective contract administration for many years but without having quantifiable measures. Despite its importance, limited scientific researches have been carried out to investigate the factors that affect contract administration performance, and researchers are unable to empirically quantify the determinants of effective procurement management/ contract administration (Ahmed 2015).

The literature –as shown in the next chapter- shows that implementation of project performance measures in construction firms (including the area of contract administration) is at the initial stage (Deng et al. 2012). Furthermore, literature observes challenges and ineffectiveness in contract administration aspects (Al Jurf and Beheiry 2010; Al Jurf and Beheiry 2012; Love et al. 2007; Okere 2012; Rendon 2010) and lack of the ability to sustain consistent performance (Okere 2012) but did not indicate how to close the gap between contract administration practices and performance measures. The following drawbacks were concluded from available models and studies: -

1. Previous studies almost exclusively focus on certain organizational policies, procedures, and guidelines for the purpose of capturing the essence of CCA within a region, organization, or form of contract. Therefore, their contributions are limited to this context and do not cover the global concept for CCA. Also, the literature reveals the need for a more coordinated and structured approach to contract administration activities (Bartsiotas 2014; Elsey 2007) in order to reduce the challenges at the post-award level (Appiah Kubi 2015) and to propose a global framework for contract administration (Solis 2016).
2. Some studies such as Bart iotas, Garrett & Rendon models focused on organization-level and are not specific to demonstrate the contract administration performance at

the project level. Also, other studies such as Okyere's model concentrates on contractor's activity and practices and does not address the employer side factors.

3. Specific issues affecting project performance, such as late approval of drawings; timely response to a request for information, prompt reply to submittals are not addressed specifically within the previous studies.
4. The analysis tools used in the different models are either simple descriptive statistics, equal-weighted criteria, relative importance indicator, or scorecards and stop at the activities (indicators) level. Yet, a powerful analysis tool enables us to abstract or arrive at an overall contract administration performance index is used.

Therefore, there is a need for a conceptual framework that covers the global view of CCA activities, the worldwide best practices, the success factors, the operational procedures, the provisions of the professional service agreements and the conditions of contract in one framework that can be applied to a wide range of projects. Moreover, there is room for further investigation to quantify the contract administration performance within the construction projects by using a more powerful analytical tool.

1.4 RESEARCH PROBLEM

Inadequate management of the contract administration process may lead to project delays, re-works, hinder the progress, disturb the relationship between the prime project stakeholders, and cause overall project cost to overrun. Although the basic provisions of contract administration and activities are expressly stated in the standard forms of contracts, they are sometimes are misunderstood, misapplied, underestimated or missed. As a result, disputes occur, and the overall performance of the project is affected. Therefore, the client, consultant, and the contractor need a framework and model to effectively and efficiently manage, measure, monitor and control the performance of those CCA activities.

1.4.1 Research Questions

Poor CCA may be avoided and proper CCA can be attained by establishing a well-constructed instrument to measure the operational performance of CCA activities from the start of the construction phase up to close out of the project. The problem statement of the present study is to answer the following questions:

1. What are the required key performance indicators and constructs to measure the contract administration performance?
2. Can the key performance indicators be incorporated into a practical multidimensional framework, and quantitative model to measure contract administration performance?
3. Moreover, how can the "Construction Contract Administration Performance Index" be applied within the context of construction projects?

1.5 OBJECTIVES

Guide by the practice-driven nature of the construction industry, the main aim of this study is to investigate and assess current practices of contract administration and establish a measurable framework for effective implementation of contract administration in construction projects. Upon providing the framework, the employer and the contract administration team can start cycles of improvements to the current practices. The detailed objectives are to:

1. Examine the CCA environment, practices, and current performance, this includes review the concept of the construction contract, the project delivery methods, different types of contract and international standard forms of contract;
2. To identify the indicators and constructs contributing to contract administration performance through comprehensive literature review covering the global view of contract administration, contract administration obligations under standard forms

challenges impacting contract administration, poor contract administration, effective administration and best practices, CCA critical success factor and CCA / CM previous models and frameworks

3. Through industry expert consensus, cross-validate the CCA indicators that may significantly affect CCA performance and establish a global performance framework;
4. Examine the causal relationship between CCA indicators and CCA performance indicators then set theory for measuring the performance of contract administration in full and short models;
5. Establish a quantified overall Construction Contract Administration Performance Index (CCAPI), which would be able to measure, monitor, and benchmark the contract administration performance during the construction stage;
6. Introduce Mobile App assessment tool (CAPM);
7. Examine the proposed framework in 10 to 15 international construction projects and benchmark the results; and
8. Proposing some key recommendations to enhance CCA practices and performance.

This research targeted small, moderate and major projects executed by governmentally recognized grade “A” contractors and supervised by governmental accredited grade “A” consultants having a well-established quality management system to ensure implementation of the mandatory processes and availability of records.

1.6 RESEARCH METHODOLOGY

This contribution shall use an empirical approach and shall consist of five main phases and several steps as shown in Figure 1.1 as follows:

1. The preliminary phase includes a literature review to identify the research problem, define the knowledge gap, and the research questions. This is followed by

establishing the study objectives, scope and then perform a structured review of literature related to the research scope. Also, the research methodology will be established by the end of this stage.

2. The factor identification and validation phase aims a preliminary framework for construction contract administration performance (CAPF) through literature review and semi-structured interviews with 3-4 construction experts. This to be followed by Delphi Study to cross-validate proposed a framework and secure expert consensus.
3. Data collection and analysis phase includes an on-line questionnaire (industry survey and collects data from 300-400 construction industry practitioners in order to investigate the importance of contract administration indicators and then use Fuzzy Structural Equation Modeling (FSEM) to validate the research hypotheses. The study research hypotheses are based on the framework formulated in the previous phase.
4. The development and validation phase includes develop a quantitative Construction Contract Administration Performance Index (CCAPI) and verify the results within real cases of construction projects. The data collections will be based on observations, workshops, reports, durations, available manuals, policies, procedures, communications, logs, records, resources, …etc.
5. The conclusion phase includes reporting of findings from previous phases and recommendation to enhance CCA performance.

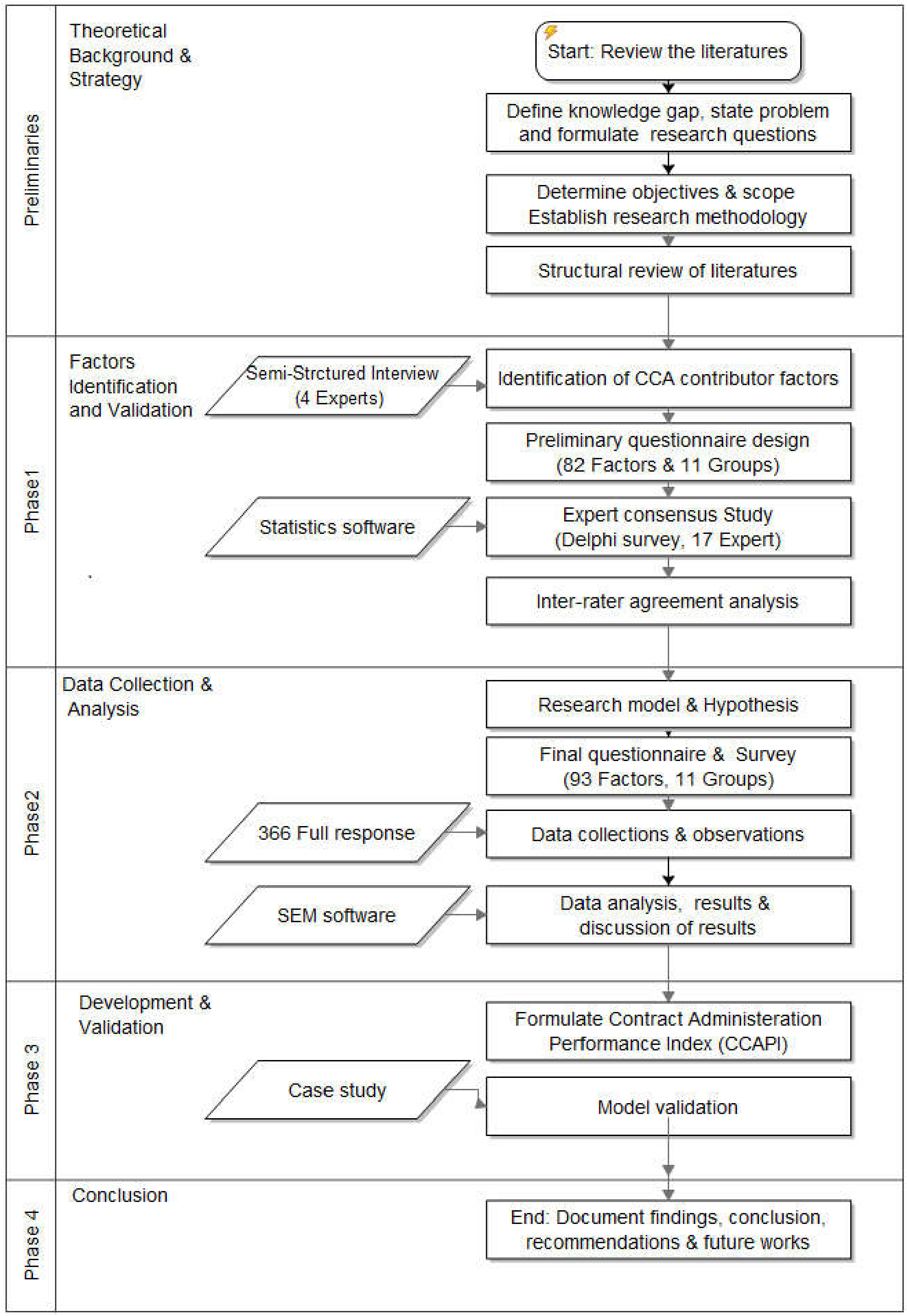

Figure 1.1: Research methodology

1.7 SIGNIFICANCE AND CONTRIBUTION OF RESEARCH

This study fills the gap identified within the area of CCA performance by presenting an operational, systematic and multidimensional performance assessment framework and model that containing the global view of contract administration, contract administration obligations under standard forms, strategies to overcoming challenges impacting contract administration and avoiding, poor contract administration, effective administration and best practices, CCA critical success factor and CCA / CM previous models and frameworks.

Table 1.2 shows the novelty and contribution of this works to the body of knowledge when compared to previous works.

Table 1.2: Comparison between previous studies and this study

Criteria	Previous Works	This Study
Domain and Context	General procurement or specific to a certain geographical area, context, or project type	The Global view of CCA supported by international conditions at the project level
Model Component	More on policies & procedures	Operational indicators Strategies to avoid poor CCA Best practices
Model	Single Model	Full and short models
Constructs/ Indicators	5 /29 to 10/111	11/93
Data Analysis	No consensus measures, qualitatively analyzed; or Linear regression; or Simple statistics (ANOVA/ T-test) or Rating (RII)	1- Several Consensus measures 2- Reliability and validity 3- F-SEM 4- Sectors difference 5- Organizations difference 6- Relative effect
Performance Indicator	None	CCAPI
Software Tool	None	CAPM Mobile App
Implementation	Very limited, compare indicators only	13 Projects

The outcome will benefit professionals and researchers due to the several indicators that fit the different nature, type, and stages of construction projects to ensure proper management. It, therefore, provides a good means of objectively and subjectively assessing the CCA performance. The significance of this research is related to changes in the way of administering and reporting the contract administration. As one of the first studies of its kind, the study outcomes contribute to:

1. Identify the leading indicators to satisfy proper contract administration requirement at the project level; and
2. Provide systematically established performance metrics to evaluate specifically the proper implementation of the contract administration.
3. Help the contractors, consultant, and owners identify system weaknesses, safeguard the employer's wellbeing in fulfilling the contractual obligations for avoiding avoidable claims, unnecessary delays, cost overruns, and disputes. The Construction Contract Administration Performance indicators can be used as 1) task list for roles, the responsibility of the CCA team;2) assist the project administrator, and his team ensure their compliance with contractual obligations and functions; 3) a comparison tool to investigate uniformity of CA implementation among different projects within the same organization or in different organizations; 4) enhancing the ability to carry out proper CA practices, and 5) measure effectiveness or capability in any specific contract administration process

The results obtained from CCA performance evaluation can be used to: 1) calculate and evaluate the CCA performance in different areas of responsibilities or measure the effectiveness of CCA team members; 2) compare different sites performance and provide feedback on performance over time; 3) assist the CCA organization to recognize the issues affecting performance; 4) identify training needs to improve CCA performance in certain areas and measure the impact of training on performance; and 5) Provide appraisal for CCA team for their recognized performance. In addition, the study provides a global Contract Administration Framework for further researches.

1.8 STRUCTURE OF DISSERTATION

This work is described in the following ten (10) chapters:

Chapter 1 sets the background of the study, gap area, research problem, research questions, aim and objectives, research methodology, significance and contribution of the research.

Chapter 2 describes a general overview of the construction industry, the contract, structure of the construction contract, the key stakeholders, project life cycles, procurement strategies, and the different project delivery methods. contract types and some international forms of contract.

Chapter 3 explains the global view of contract administration, contract administration obligations under standard forms, challenges impacting contract administration, poor contract administration, effective administration and best practices, CCA critical success factor and CCA /CM previous models and frameworks. The development of a preliminary construction contract administration performance model (CAPM) is established by the end of Chapter 3.

Chapter 4 describes the methodology, which is established for collecting and analyzing the research data and information. The research methodology sequence shows the flow of the study to realize the study objectives.

Chapter 5 depicts the preliminary questionnaire, the results of semi-structured interviews with 4 construction experts to enhance the questionnaire, implementation of the Delphi study and the different consensus analysis measures and Inter-Rater Agreement analysis for the proposed indicators and constructs.

Chapter 6 includes the theoretical background of the Fuzzy Set Theory (FST), membership function, and the Structural Equation Modeling (SEM) techniques.

Chapter 7 deals with model development and analysis. It contains the final research questionnaire, respondents' demographic characteristics, data collection, data analyses, development of construction contract administration performance measurement and structural models, and hypotheses testing.

Chapter 8 explains, the assignment of relative weights to indicators and constructs, establishment of CCAPI, introduces an alternative short model, introduces the CAPM mobile app, practical implementation of the proposed model in 13 construction projects with basic rating guidelines, benchmarking the CCA performance according to CCAPI, and validation of the short model results.

Chapter 9 contains a discussion of the results in terms of components of the CCAPI components, the ranking of constructs and indicators.

Chapter 10 provides an overall summary of the research works, conclusion, recommendations to construction professionals, limitations, and recommendations for future researches into the contract administration area.

CHAPTER 2 : PROJECT & PROCUREMENT MANAGEMENT

2.1 INTRODUCTION

This chapter intends to provide a theoretical and practical background to the construction professionals and studies involved in procurement management, contract management, and contract administration. It affords a view of the research environment and presents a brief literature review for contracting parties, project life cycle, contract fundamentals, procurement strategies, and standard forms of contract.

2.2 THE CONSTRUCTION INDUSTRY

The construction industry is regarded as one of the major production sectors of a country (Sertyesilisik 2007). It develops a demand for other related industries such as cement, ceramics, paint, steel, construction chemicals, building technologies, and equipment manufacturer. Therefore, the industry is a labor-intensive industry developing a high employment rate for unskilled, semiskilled, and skilled labors. Therefore, the construction industry is a key contributor to the economic performance of countries and indicates economic health. The construction is regarded as one of the most complex industries that comprise a variety of activities, stakeholders and business sectors and therefore considers risky and challengeable (Tatarestaghi et al. 2011). It requires the establishment of efficient and effective processes and maintains a strong relationship between the parties as well (Bin Zakaria et al. 2013).

Construction industries fall behind other industries, and construction projects exhibit several weaknesses such as time lags, cost overruns, and conflicts among contracting parties. The construction industry is more challenging than other industries due to five main factors namely: 1) the unique nature of its project; 2) every project is one-of-a-kind; 3) many conflicting parties are involved; 4) projects are constrained by time, money, and quality; and 5) associated high risk. Also, the industry may have a bad reputation due to poor performance, bad coordination, several project failures, oppositional relationships between the stockholders and environmental pollution caused by its projects (Barrett et al. 2008). Moreover, the bad image is caused by several other factors such as adverse conditions, economic recessions, wage and material cost increases, and heavily unplanned competition. Over the past decades, several researchers have studied the reform of the construction process aiming to improve its project performance (Smyth 2010) and measure various projects performance indicators such as labor productivity, client satisfaction, research and development expenditure, and skills level and found that this industry is behind many other sectors.

2.2.1 Stakeholders of the Construction Industry

Conventionally, a project is consisting of a series of tasks, processes, activities or operations undertaken by different entities with various interests and/or different roles of involvement in the project. Project stakeholders are persons, groups, institutions, organizations or others who are either directly involved in or may be impacted by the project in positive or negative ways (Kasiem 2008). Molwus (2014) defines stakeholders of the construction project as organizations, groups or individuals who contribute to the project and have a sort of right or ownership, or they will receive a benefit or loss from the project or its outcome. Winch (2010), classifies the contractual relationship between the project's owner and other stakeholders into external stakeholders and internal ones. The internal stakeholders are having a direct contractual relationship with the project owner while the external stakeholders have some interests in the project. Internal stakeholders include the demand-side group and supply-side group. The demand side group represents the client and its employees,' financiers, tenants, and suppliers hired by the client. The supply side group represents the principal contractors, trade contractors, material suppliers, architects, consultant, and engineers. The external stakeholder group contains private sub-group and public sub-group. The private sub-group represents residents, environmental lists, conservationists, archaeologists, non-governmental organizations, landowners, and media. The public sub-group represents regulatory agencies, international agencies, and the government.

The construction project involves three prime stakeholders, namely are 1) the employer (sometimes called the client or owner), 2) the contractor, and 3) the consultant. The client is the main body secures the funds and initiates the project such as the government (public body represented by the various ministries, departments, and agencies) or private organizations (real estate developers, investors, and homeowners). Under the contract, the client has the right to give notices for claims, order replacement of work items/plant that is not performing as intended and extend the defects liability/ notification period because of damage or a defect attributable to the contractor. According to Treasury (2017), failure of the contractor to remediate any damage or defect within the period notified by the employer or a reasonable time entitles the employer to:1) carry out the work and deduct incurred costs from any amount due or became due to the Contractor; 2) direct the Engineer to determine the reduction in the contract value by an amount equivalent to the remedy works required; and 3) terminate the Contract in-part and then recover all sums paid in addition to financing costs, site clearing costs and dismantling costs with respect to gross damage of defect which will prevent proper usage, as intended, of the whole work or the major part of the works. The employer designates a representative who has approval authorization and binding decision-making authorization. By default, the employer is responsible for producing certain information necessary for the contractor, paying the contractor on time, and providing fees, needed permits, and survey information to the contractor (El-adaway et al. 2013). Sertyesilisik (2007), summarizes the key employer's obligations as to provide on-time site possession, to pay the contractor on time, not to prevent/ hinder the construction progress, to take over the work satisfactorily completed and to provide all necessary permissions, approvals or other decisions on time as required by the contract.

The second prime stakeholder is the consultant. The consultants are either in-house or outsourced project professionals from different disciplines (Molwus 2014). Professional consultant organizations are engaged to conduct professional services such as architects, design, supervision, specialist consultation, quantity surveying, claims consultation cost estimate, and project management. The consultant is coordinating and cooperating with the contractor to construct the project and achieve the employer's goals. The consultants have interests in performing professional duties to the employer (Molwus 2014). In traditional contracts, the consultant has no direct contractual obligation to the contractor and is appointed for contract administration and works supervision with the predetermined roles and obligation to act on behalf of the employer or as an agent of the employer (Kasiem 2008). According to Mehta et al. (2013), the consultant administrates the works, oversee the construction and certify the work in general conformity with the contract. The consultant duties include: 1) report the progress of work to the owner; 2) protect the owner against the contractor's defective and deficient works; 3) examine and approve mock-up samples, material submittals and shop drawings;4); prepare site instructions and change orders and provide supplemental instructions/ information when required; 5)review owner-contractor correspondences and advise the employer with the appropriate action; 6) certify payment applications (money owed to the contractor) and prepare a recommendation for payment; 7) carry out substantial completion and final completion inspections; 8) review warranties and other project closeout documentation; 9)hand over complete closeout records to the employer; and 10)interpret the contract clauses/documents and advice the contracting parties.

The contractor is regarded as one of the most important players in construction (Sweis et al. 2014). The contractor is a person, firm or company responsible for assembly of the materials, equipment, and components required to execute the works under the awarded contract. The main contractor's interest is to successfully finish the work and perform the contractual obligations to the contracts for the sake of getting paid and get further projects (Molwus 2014). In many cases, the client and/or consultant select the contractor based on a price basis (Sweis et al. 2014). Depending on the conditions of contract and types of the delivery system, the legal obligation of the contractor is to produce what has been described in the contract and when changes arise, the consent of all parties is required. The contractor will be guided by design to build the project (Ting 2013). The contractor's overall responsibilities within the contract are to build the works safely in accordance with the stipulated quality standard, within the agreed period and within the agreed price. In addition, the contractor is expected to complete any outstanding works and any notified defects within such reasonable time as instructed or within the defect liability period and prior to issuing the final certificate. The contractor shall bear the cost of remedies for any defects, repair, replacement, and/or damages related to the contractor's default. Furthermore, the contractor is expected to comply with and adhere to any other relevant contractual and statuary requirements, regulations, and laws during the performance of the contract (Robinson 2011). Sertyesilisik (2007), summarizes the key contractor's obligations as to give notices, to deliver the accomplished works to the employer, to act professionally, and to honor commitments of fulfilling his obligations. The contractor designates a representative (superintendence) who has binding decision-making authorization. El-adaway et al. (2013), briefly lists the contractor's responsibilities to includes: 1)report any nonconformity, inconsistencies/ mistakes to the engineer; 2)perform contract document review within the contractor's capacity; 3)supervise and direct the work, control construction, establish means, ways, techniques, sequences, and procedures of works;3) coordinate all portions of work; 5) control actions of its agents/sub-contractors, labors, and staff; 6) pay labor, building permits, materials, royalties, relevant taxes, and license fees as specified; 7)prepare and submit shop drawings and materials submittals for approval; 8) present evidence of conforming to design intent; 9) indemnify the employer from contractor's defaults and damages; and 10) make itself familiar with the site conditions and contract documents. Table 2.1shows the main roles and responsibilities of the three prime stakeholders within a project.

Table 2.1: Typical responsibilities of prime project stakeholders (Rumane 2011)

Owner	**Consultant (Design/ Supervision)**	**Contractor**
Fulfillment of contractual obligations including access to the site, timely payment and owners required information	Fulfillment of contractual obligations,	Fulfillment of contractual obligations
Compliance with applicable regulations, laws, standards, codes, and practices		
provide funding	Meeting the professional standards	Interpretation of drawings and specifications as a whole
Provision of necessary real estate or rights of way	Development and drafting of well-defined contract documents	Construction of facility as described in contract documents
Provision of project goals and objectives	Responsiveness to project schedule, budget, and program	Management of HSE and construction site activities
Fulfillment of insurance and legal requirements	Provision of construction phase design services	Management, quality control and payment of subcontractors and vendors
Assignment of responsibility for site safety		
Completed work Acceptance		

The relationship among the employer, the consultant, and the contractor depends mainly on the form of contract. (Knutson et al. 2004). For the design-bid-build (traditional) contract, the employer entered into two separate contracts, one with a contractor and another one with a consultant as an external contract administrator. Therefore, there is no direct contractual relationship between the contract administrator and the contractor but to coordination within the delegation given by the employer (El-adaway et al. 2013). For the design-build contract, the employer has one contract with the contractor and the designer, and he may assign a separate consultant to administrate the employer's part of the contract.

In addition, other organizations such as the project manager, subcontractors, and suppliers are involved in the project and linked to one of the above prime stakeholders (Molwus 2014; Sadek and Kulatunga 2013). Also, there are secondary stakeholders who can impact or impacted by the project but has no contractual relationship with the project. For each prime stakeholder, the contract is managed by senior professionals to make certain that all involved parties can quickly and effectively meet their assigned obligations and exercise modifications to the contract when required. Manager's main role is to ensure that each party has enough persons, equipment, and expertise required to deliver the expected results and balance the different stakeholders' demands and expectations. The stakeholder input varies with the roles and involvement of each party, but the operation procedures remain somewhat similar (Pooworakulchai et al. 2017). The different stakeholders' interests may conflict, and therefore, the management of stakeholders is essential for projects. Knowledge of the contract, contract administration, construction management, and general project management fundamentals are essential for the prime construction stakeholders and especially project managers (Pooworakulchai et al. 2017).

2.2.2 Project Life Cycle

The life cycle of any project means phases that describe the project implementation from start to end (PMI 2013). It contains several phases and activities, as shown in Figure 2.1. It starts with identifying the market needs and considers several alternatives in the conceptual planning stage then addresses the financial arrangement, the technological and economic feasibility of each alternative for the sake of selecting the optimal project. This stage will be concluded by time and cost planning in addition to the scope of the project. The next stage is to carry out detailed design and engineering and establish a cost baseline. Upon completion of the design and deliver document for tendering, the procurement starts with tendering, selection of contractor, award contract, and sign an agreement with the selected contractor. The contractor and the employer, along with its agents start the construction stage for the sake of transferring the project into a real physical structure or facility. The construction ends up with the commissioning of the constructed facility. After commissioning, the facility management takes over the constructed facility until the end of the facility service life. Once expired, the original project life cycle ends up with the demolition stage or conversion into a different scope.

2.3 CONTRACT

Generally, there are several forms of contracts amongst individuals or organizations in every aspect of our life. Contracts are either oral or written agreement (e.g., launch order & apartment rental contract). Contract bonds parties for the specific duration of time develops a unique relationship among parties for their benefits and is necessary to protect both parties. In construction, the temporary nature and presence of several stakeholders in construction projects mandate the establishment of formal contracts to define the working relationship, communication, commitment, rights, and obligations. Understanding and evaluating, size, and nature of the project and the different parties' roles will determine the most effective contractual arrangement for a project (Ting 2013). The next section shall focus on construction contract definition, associate legal terms and concepts and elements of contract documents.

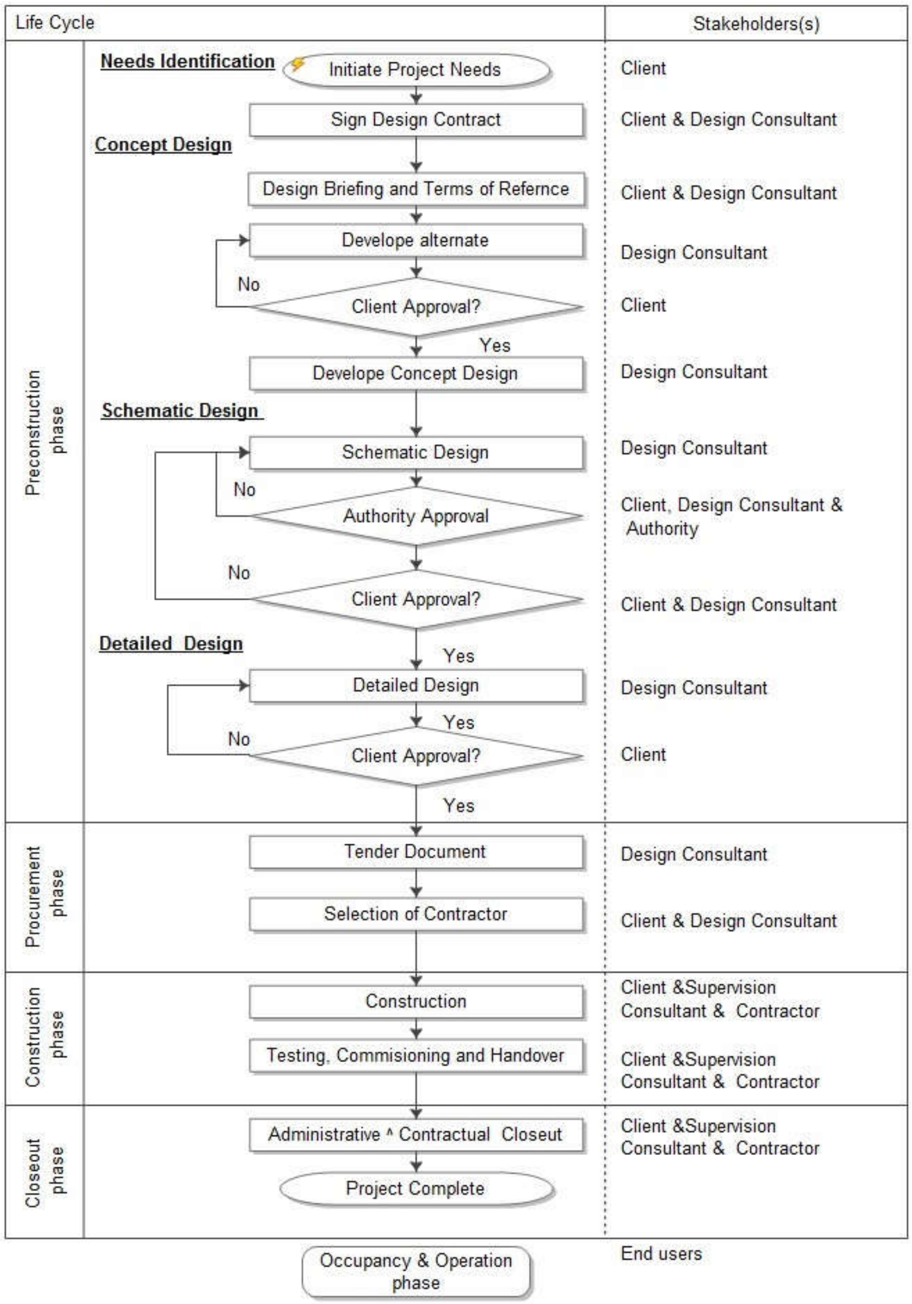

Figure 2.1: Project lifecycle and traditional contract process

2.3.1 Definition of Contract

The contractual relationship changes from a simple transaction to very complex transactions and contracts can be viewed and defined by different forms (Saxena 2008). The simple definition of a contract is "an agreement defines the relationship between the contracting parties," or *"a legally binding agreement," or "a mutual agreement between two parties*," or "*an agreement enforceable at law*," but not all agreements are contracts.

In general, the contract is a vehicle or a tool to assist and enable cooperation between parties (Puil and Weele 2014), and it has several definitions. American Law Institute (1981) defines a contract as "*a promise or a set of promises for the breach of which the law gives a remedy or the performance of which the law in some way recognizes as a duty*.". According to Phillips (1999) , a contract is "*an exchange of promises between two or more parties doing or refraining from doing an act which is enforceable in a court of law*". According to Bunni (2005), a contract is "*an agreement between two or more parties in which each party binds himself to do or forbear to do some acts, and each acquires the right to what the other promise*s". Morris and Pinto (2010) see the contract as "*two parties' agreement under which one party promises to do something for the other in return for a consideration, usually a payment. It is also the foundation for the relationship between the parties*". According to Joyce (2014), a contract is "*a set of documents, that clearly form the intent, boundaries, and extent of the relationship between executing parties, along with the rights and responsibilities of the entities engaged and is governed and restricted by law*" . According to Tataresteghi et al. (2011), a contract is a legally binding agreement to fulfill all the terms and conditions outlined within the agreement. According to (Chandak et al. 2015), "*a contract is basically commitment between two consenting parties, which, if breached,* *remedial protection can be sought under the law by the affected party, since the law recognizes its performance as the rightful duty*".

There is no actual requirement that a contract must be written, but oral contracts are essentially impossible to enforce in construction because of the lack of evidence regarding the scope of the agreement and written contracts eliminate problems by removing any doubt about the agreed-on terms (Knutson et al. 2004). Successful contracts require writing documents in clear, simple, easily read the language, and administrate the contract experienced person (Saxena 2008). The clear contract is valued as a powerful management tool with built-in guides through the expressed terms (Newboult 2016). The expensive, complex, and time-consuming characteristics of the construction projects require a well-written contract with specific duties and obligations for each participant (Chui and Bai 2010).

Particularly, the construction contract is a procurement contract with scope construction implementation. It comprises several non-technical documents (i.e., agreement, general & particular conditions) connect to the work and provide rights and obligations of each party (Chui and Bai 2010). Construction contracts classified as a standardized contract or a custom contract (Thompson 2006). The project type and the state of implementation may vary the standard forms (Tatarestaghi et al. 2011). The construction contract has many types and selection of certain types to meet the project objectives depends on pricing strategy and the contracting strategy for a specific project (Tatarestaghi et al. 2011).

Several authors have stated different definitions of the construction contract. Particularly, the building and construction contract is defined as "an agreement between an employer and a contractor that the contractor will construct a specified structure or facility for the employer, to meet a specified quality standard and within a specified time, in exchange for a specified sum of money, which the employer will pay" (Goldfayl 2004). Loots and Charrett (2009) refer construction contract is an arrangement that a party undertakes to carry out building works or to supply associated goods and services for the other party. Pooworakulchai et al. (2017) point out the construction contracts as the tools used for expressing the intentions of contracting parties and identifying the stakeholders' rights and duties.

In brief, the construction contract is enforceable by a legal agreement between an employer (principal) and a contractor (agent). Parties-with intention- agree together to construct a project within the scope defined through the design, specifications, and bill of quantity documents. The contractor comes to an agreement for valuable consideration to perform the works specified within the scope of a contract such as design, fabrication, erection, alteration, demolition or repair works on a place under the property/concession of the other party.

2.3.2 Success of Contract

From the perspective of project management, a successful project/ contract meets its objectives represented by on-time completion, budget constraint, quality specified in the specifications and stakeholders' expectations (Abedi et al. 2011; Zakaria et al.) but the project cannot be considered as a failed project when it serves its intended purposes. Miller et al. (2012), measures the success of contracts into nine output categories. Those categories include three outcomes (schedule, satisfaction, and cost) and six processes (unproblematic process, well-defined requirements, communication, contract type, efficient, adherence to regulation). Elsey (2007), argues management of the contract is successful if the following conditions can be tracked: 1) service delivery satisfies the contracting parties; 2)parties achieve the anticipated benefits and values; 3)contractors are cooperative and responsive; 4)Obligations are known by the client; 5) the dispute does not exist or manageable; 6) a surprise does not exist or manageable; 7) effective management of changes and issues; and 8) efficiencies are realized through satisfactory progress.

2.3.3 The Contract in the Public & Private Sectors

According to Patajoki (2013), public procurement means acting on behalf of a public authority or the government to obtain goods, services, and works for the interest of the public. Public and private organizations have different organizational goals, operations, styles of management, organizational structures, which affect the procurement procedures at the operational level, as shown in Table 2.2. The public procurement is controlled by heavy legislation and regulations while the private sector is not ordered by the same legislation but aims profit. The public regulations aim to ensure the effective use of public funds, transparency, competition, and equal treatment among all tenderers in a fair way without discrimination. Due to rigidity in public procurement, sector contract cannot be modified after it comes into force; therefore, poorly drafted contract sometimes results in problems in the contractual relationship with a probability of incurring a high cost. The private sector has more flexibility to change the contract even after signing off. Furthermore, public procurement contains several unilateral terms in the contract, which may affect the parties' relationship. Also, in public procurement, the contract forms the relationship between the contracting parties, but in the private sector where flexibility is available, the relationship formulates the contract (Carolina et al. 2012). In several instances, public procurement employees the lowest bidder (Gunduz and Karacan 2009). The public clients are a focus on ensuring that the project shall support the organization's strategy, offer to fund, proper consumption of resources, proper public funds, and an effective procurement process that serve the public interest (Molwus 2014). The feasibility offered in administrating private sector contracts may not be applied public sector due to the legalization and role constraints.

Table 2.2: Comparing public and private sectors -buyer perspective (Patajoki 2013)

Criteria	Buyer Perspective	
	Public Sector	**Private Sector**
Objectives of buying	Support the functions of service agencies, execute social, economic policies	Profit maximization, good services, etc.
Vendor choice criteria	Based on competition, efficiency, fairness, and openness	Flexible criteria
Information disclosure	Transparency is required	No transparency is required
Procurement procedures	Rooted in legislation	More freely chosen procedures
Stakeholders	Contractual partners, citizens, politicians, etc.	Contractual partners, owners, etc.

2.3.4 Legal Terms and Concept of Contract

2.3.4.1 Offer and Acceptance

Offer and acceptance are the main elements of a contract (Thompson 2006). The offer means a proposal produced by a person to another of particular terms of performance with the intention that such other person accepts it (Treasury 2017). The offeror (promisor) is making a definite offer and communicating it to offeree for the sake of unqualified and unconditional acceptance (Sertyesilisik 2007). Conditional acceptance does not legally constitute acceptance but considered as a counteroffer and has to be taken by the Offeror. A binding contract comes into effect after acceptance.

2.3.4.2 Enforcing a contract by law

Enforcing by law is an element of a valid contract (Thompson 2006). The prerequisites, principles or criteria of a contract to be valid and enforced by law are the intent, agreement, consideration, legal capacity, and legal objectives. The intent means the parties' intention to develop a legal deal. The agreement means a definite offer by a party and an acceptance by another party. The consideration means the exchange of an act or a promise of an act. The legal capacity means each party must have the capacity by law to enter a contract. The legal objectives mean lawful objectives must be fulfilled (Emery 2013). The rules and principles vary from one country to another (Knutson et al. 2004). The valid contract has the following elements: 1) agreement between the contracting parties. Two or more parties, one party cannot make bargains with oneself by low; 2) parties intention to generate a legal obligation; 3) adherence to the prescribed forms and/or agreement modes; 4) the capacity of the contracting parties to bind themselves in a contract; 5)the legal and possible object of the agreement.

The presence of the following factors will spoil a contract and make it null: 1) error/mistake: 2) incapacity; 3) duress: 4) undue influence: 5) illegality: and 6) fraud or misrepresentation.

2.3.4.3 Good faith

Most of the civil codes recognize the independence of contract independence and allow contracting parties to decide their terms and conditions within a contract, but these should not violate any mandatory provision of public policy and/or the law. The general principle in most of the civil codes is that parties must perform their obligation in line with the contract contents and in a good-faith manner (Glover 2007). Furthermore, interpretation of a contract will be used stipulated terms, customs requirements, the concept of good faith and equity. The concept of good faith is considered in the Civil law jurisdictions of Qatar and Qatar Civil Code. Article 172 of Law Number 22 of 2004 states that the contract must be executed according to its contents and in a manner consistent with the good faith requirements. Also, it states that the contract is not limited to obliging a contracting party to its contents but also contains its own requirements in line with the law, custom, equity and the obligation's nature. Under the construction law, contracting parties are required to act in good faith during the performance of their obligations. For example, the employer is to cooperate in dealing with change in a fair and timely manner. The contractor steps to avoid delaying the works are another example of good faith.

2.3.4.4 Discharge of Contracts

A contract could be discharged under one of the following 5 situations: 1) Performance completed; 2) agreement of parties to discharge;3) breach of contract by one party; 4) operation of law; 5) case of frustration (i.e. when an unforeseen event significantly affect the performance of the contractual obligations) (Treasury 2017).

2.3.4.5 Breach of Contract

When one contracting party breach the contract, the other contracting party might pursue legal remedies to relief his obligations. Legal remedies include: 1) damages recovery from the defaulting party; 2)certain performance; 3)gain a restriction making the defaulting party act and/or cease from taking certain acts (Treasury 2017). Damages resulting from a breach of contract are granted based on the basic principle that "the sum to be awarded should, as nearly possible be a sum which will put the defaulted party in the position which he would have enjoyed if the wrong had not happened". damages include compensation loss of profit and actual losses as well. Damages are classified as general damages and special damages. An example of the general damage is direct loss experienced by a plaintiff; profits not attained like others in a similar condition. Special damage occurred when the damaged party suffered circumstances. Liquidated damage is pre-agreed and stated quantum of damages that can be recovered if the breach occurred. Courts examine the terms of the contract to establish whether what is termed as liquidated damages is a penalty or not (Treasury 2017).

2.3.4.6 Contract Interpretation

A contract has to be interpreted entirely, and contract words have to be understood in line with the ordinary and natural meaning, and everyday usage of words. Generally, looking at the parties' intentions when entered into the contract will lead to determining the meaning of a contract. The differences in interpreting the contract would cause construction conflict. When the unclear intention is discovered, the court refers to any custom/ usage in a particular area in order to determine the intention. The key to contract interpretation is to give effect to the parties' expressed intention of the, as stated in their agreement. In many instances, the contract will involve several conflicting documents. In the event of conflicts between different documents, the provisions of the contract would define the document precedence or order of priority. When the order of precedence is mentioned, roles that should be followed as follows:

1. The importance of document content establishes its priorities;
2. Order of time sets priority (i.e., the last document having the top priority);
3. Where multiple formats describe/contain the same subject (i.e., specifications and drawings), The more detailed description –such as words and text - has priority over;
4. Documents are complementary to each other and must be read and interpreted as a whole where documents are made part of another document; and
5. All forms of interpretation must be in line with the whole contract language the party's intention (Knutson et al. 2004).

The "contra proferentem" (interpretation against the drafter) rule is a legal rule of interpretation.

2.3.5 Contract Documents

The contract documents are those documents, which together constitute the contract and include nontechnical documents and technical documents. The nontechnical documents comprise several elements such as agreement, letter of intent conditions of contract and instructions to tenderer and connect to the work and provide rights and obligations of each party (Chui and Bai 2010). The technical document contains drawings, specifications, bill of quantities, and schedule of rates. Likewise, PMI (2016) refers to contract documents to a set of documents that include conditions of a contract specifying how the project will be administered, reference standards applicable to the project, technical specifications and drawings outlining the requirement of material, equipment and installations and the deliverables required. It may include other documents, which the owner is contractually obliged to provide to the contractor under a specific form of contract (Treasury 2017). Adequacy of contract documents is regarded as a major success factor for a project (Sadek 2016). Contract documents commonly contain the following documents with descending order priority unless otherwise stated in the agreement, instructions to the tenderer or the general conditions. Contract Agreement;

1. The Letter of Acceptance (LOA);
2. Memorandum of Understanding (MOU), if any;
3. Instructions to Tenderer;
4. The Addenda (Circulars and/ or Questions and answers);
5. The General and Particular Conditions of Contract;
6. The Project Specifications;
7. The project Drawings;
8. The priced Bill of Quantities/ Schedule of rates;
9. Other proposal offered by the contractor - if any; and

10. Supplementary Information (if any) and other documents that may be contained in the Contract.

2.4 PROCUREMENT MANAGEMENT

Procurement management is an essential element that must be performed during the whole life cycle of the contract. Implementations constitute different tasks and priorities throughout the different phases. The term procurement is a general term representing all the client's tasks required to construct or refurbish a building (Joint Contracts Tribunal 2011). Procurement management's ultimate goal to be successful is to provide the required product, goods, and/or services on time and in a cost-effective way. According to Garrett (2010); Morris and Pinto (2010), project procurement management includes the processes required to outsource products, goods, and/or services. It includes all contract management and purchase order required. The following processes are included in this area, as shown in Figure 2.2 b.

1. *Procurement Planning:* the process is to determine what to procure and when. It includes decisions like make-or-buy analysis, outsourcing and partnering, and selection of contract type.
2. *Solicitation Planning:* the process is to document product requirements and identify potential sources and evaluation criteria.
3. *Solicitation:* the process is to obtain quotations, bids, offers, or proposals. It includes the development of qualified sellers' lists, contacting prospective sellers, and conducting a bidder's conference.
4. *Source Selection:* the process is to choose potential sellers. It includes activities like screening and weighting, proposal scoring, negotiation of a contract, strategies, decision making and elements of a contract

5. *Contract Administration:* the process is part of the post-award phase to manage the relationship with the seller. It includes practices like roles, responsibilities, coordination, meetings, official notices, responsibilities of project performance, procedures for change control, and payment system. Also, it includes monitoring and measuring performance, changes, and payments.
6. *Contract Closeout:* the process is to complete and settlement of the contract. It includes contract documentation, final claims settlement, termination of contracts, document lessons learned, and resolution of any open items.

In construction and after the establishment of the procurement strategy, the contract lifecycle passes through two main phases, the contract establishment phase, and the implementation phase. Preparation of tender document, tendering, selection of a contractor, and awarding takes place in the first phase. The second phase starts with a sign the contract and includes execution of the contract, turn over completed works, and contract completion activities, as shown in Figure 2.2c.

2.4.1 Contract Management and Construction Administration

An accurate definition of terms within the industry standards is essential for having a common point of reference and common understanding. Several authors and researchers have discussed the contract administration and contract management but rarely agreed on what is meant by both terms.

While Joyce (2014), see contract management as those activities relating to contract administration, Bartsiotas (2014), defines it as the management of contracts made by others (Garrett 2010). CSI (2005) highlights the difference between contract management and contract administration as the difference in timing and whether the contracting parties entered into a contract or not.

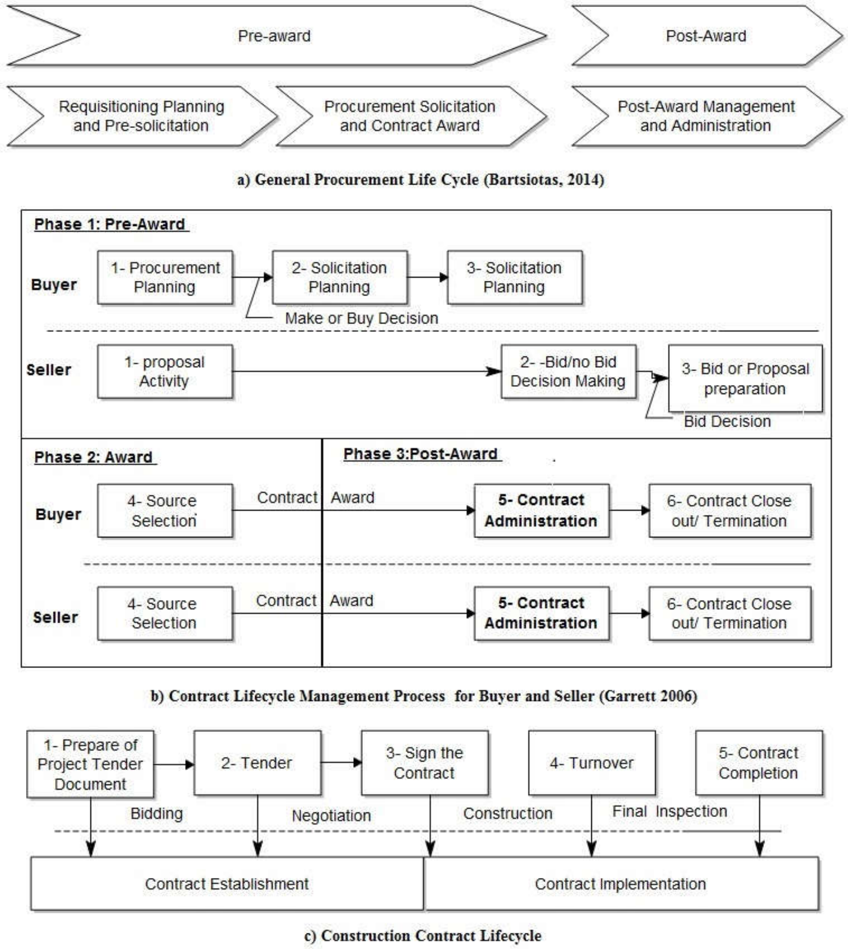

Figure 2.2: General contract and construction contract lifecycles

On one side, contract management is a lifecycle management process that called for the systematic and efficient administration of contract establishment, accomplishment, and analysis in order to maximize the performance and to eliminate/ minimizing associated risk (Elsey 2007). Similarly, PMI (2016) refers to the purpose of contract management to provide contract oversight and authority to manage contract establishment, implementation, and analysis to maximize financial and operational performance while minimizing risk by experienced, knowledgeable staff. Another perspective for contract management is cited by Surajbali (2016) as contract management comprises of two stages: 1)managing contract content, and 2) managing contract process. According to (Chandak et al. 2015), contract management is about solving or decreasing problems and reaching the project completion. Good contract management in the pre-award phase requires a well-prepared tender document, clear specification, accurate estimates, and effective evaluation procedures for contractor's selection, award the works to the proper contractor, use the right form of contract. Also, contract management includes those activities relating to contract administration (Joyce 2014).

Administration means the act of managing duties, responsibilities, or rules. Jackson (2010), defines contract administration as red tape and paperwork associated with the construction of a project and deals with relationships and managing all the business affairs related to the contract parties and their obligations. Similarly, Kerzner (2013) defines contract administration as a process dedicated to ensuring that each party is performing as required by the requirements of the contract. According to Rendon (2011), contract administration is a process of monitoring the performance of the contractor in accordance with the terms and conditions described in the contract and continue from signing the contract until the contract closed-out or terminated. According to Ofori (2014), contract administration is an area of contract management that deals with the contract execution phase after signing a contract to extends to the final closeout. PMI (2016) sees the construction administration as an administrative function that should be practiced by all entities with respect to the scope of work. The industry refers to construction contract administration to activities related to administering the contract during construction by a third party assigned by the employer (CSI 2005). The third-party has different titles such as "Engineer," "Architect," or "Certifier" under the different standard forms.

For the purpose of this study and to remove the conflict between contract administration and management, the author would refer contract management as a multi-stage process that goes through the entire contracting process from procurements planning up to deliver specific objectives (pre-award, and post-award phases). The process of make sure that the contractual obligations of each contracting party are efficiently and effectively fulfilled and the entitlements of each contracting party are established and maintained throughout the contract lifecycle (Treasury 2017). On the other hand, contract administration means all functions assigned to the contract administrator and his/her team to warrant that construction is in general conformance with the contract documents from the time of signing a contract until the work is accepted, or the contract is terminated, final payment has been made, and any disputes have been resolved. It deals with the implementation of the contract and the associated daily operations and issues from both contractual and technical standpoint to include performance measures, payments, variations, and change orders, information and communication management, and poor performance management.

2.4.1.1 Construction Administration as Process

The general view of the contract administration is seen as a management process with well-known systemic practices formulated to comply with the contract requirement, maintain good relations with the employer, manage changes, resolve disputes, resolve claims, and avoid litigation at the project level. The input, tools, techniques, and outputs are shown in Figure 2.3 s. Within the project life cycle, PMI (2013) sorts the process into five phases, namely initiating (contract execution); planning (establishes contract administration plans), execution (perform the contract); monitoring and control (demonstrate compliance, mitigate the impact of changes, disputes, claims, proposal, and payment); and the last phase is the closeout phase (contract closeout). PMI (2013), rephrases the name contract administration into control procurements but maintain the same function.

Figure 2.3: The control procurement process PMI (2013),

According to (Niraula et al. 2008), Contract administration is the process in charge of dealing with day-to-day contractual issues. Construction contract administration deals with major critical areas such as risk identification, roles, and responsibility, execution process, payment certification, change management, schedule control, cost management and quality control/assurance, dispute, claim, and settlement. From the employer side, the functions carry out by contract administration is the main tool for effective project management.

2.4.1.2 Construction Administration as Services

Contract administration is a service produced by professionals. When the employer does not have the capacity, the employer delegates contract administration to a third parties consultants, to administer and supervise the work until completion (Akoa 2011). When buying in such services, the contract administration would have the characteristics of the service contract. services are non-tangible items that are sold, produced, and often consumed simultaneously. Service includes processes, people, and sometimes goods. It is measured by proper performance, processes, or desired outcome defined by the procurer/ buyer. Service delivery is a continuous process and requires continual interaction among parties. The quality of the service is discovered by starting the implementation of the service, and the quality assessment is commonly subjective and based on facts. The outcome of the service is impacted by the process established to deliver the service. Commonly, service procurement is complex than and a successful relationship is key to successful service implementation.

2.4.1.3 Construction Administration Function

The main function in the contract administration includes different elements, components, and processes to include: Contract administration planning (Garrett 2010; Goldfayl 2004; Hill 2010; Kerzner 2013); Contract performance management (Bin Zakaria et al. 2013; Garrett 2010; Goldfayl 2004; Kerzner 2013; Levy 2010; Niraula et al. 2008); Contract change management (Bin Zakaria et al. 2013; Garrett 2010; Goldfayl 2004; Hill 2010; Kerzner 2013; Levy 2010, Niraula, 2008 #50; Ofori 2014 ; PMI 2016); Subcontractor coordination and safety programs (PMI 2016); Claims & dispute resolution and handle problems (Goldfayl 2004; Kerzner 2013; Levy 2010; Niraula et al. 2008; PMI 2016); Execution/ Accept or reject deliverables (Kerzner 2013; Levy 2010; Niraula et al. 2008) ; Effective communication /owner relations (Garrett 2010; Goldfayl 2004; Jackson 2010; Levy 2010) ; Design clarification and constructability problem solving (PMI 2016); Invoices and payments (Garrett 2010; Goldfayl 2004; Kerzner 2013; Levy 2010; Niraula et al. 2008; PMI 2016); Documentation (Garrett 2010; Hill 2010; Jackson 2010); Submittal review/approval (PMI 2016); Diversity utilization reviews (PMI 2016); Risk monitoring and control (Bin Zakaria et al. 2013; Kerzner 2013; Niraula et al. 2008; PMI 2016); Quality and daily operation & Rectifications (Jackson 2010; Kerzner 2013; Niraula et al. 2008; Ofori 2014); Sustainability and environmental compliance status (PMI 2016); Commissioning (Kerzner 2013; Ofori 2014); Closeout (Kerzner 2013; Ofori 2014; PMI 2016 ; Treasury 2017). Within the context of this study, the candidate observed that that technical function of contract administration, such as approvals of submittal and material, response to a request for information, contributes to the poor contract administration area. Contrary to the above, the project contract administration may be represented as management of financial, HSE, quality, schedule, human resource, and procurement. Although the presentation is different, the function and content remain the same.

2.4.1.4 Need for Contract Administration

Since contracts are not self-enforcing, contract administration is required to monitor and control contract implementation. Contract administration is needed for: 1) overcome challenges associated with the construction industry (Gitonga et al. 2017; Gitonga et al. 2017); 2) ensure the achievement of the project objectives and ensure project compliance (Niraula et al. 2008); 3) to inform contracting parties about their roles, responsibility, and the obligation to the contract; 4) compensate for rightful due; 5) avoid the suffering of the project Jackson (2010); 6) support the contractor in controlling project's overmanning during construction Gunduz (2004); 7) satisfy the entity's requirements, ensure on-time delivery, and protect the entity's financial interest; 8) provides accurate tracking tools and addresses disputes and conflicts on time (Puil and Weele 2014). Furthermore, contract administration is needed to deliver the scope to the performance and quality requirement, adherence of both parties to the conditions of the contract, the achievement of the objectives or entering into the agreement, maintain an open relationship between the contracting parties and resolve issues and pay the contractor for the works satisfactory performed

2.5 PROCUREMENT STRATEGIES

The procurement strategy means the selection of organizational and contractual policies essential for the proper execution of a specific project. The project procurement defines the outline of authorities and responsibilities for each party. At the early stage of a project, the owner decides which procurement strategy will be followed. The development of the Procurement strategy comprises a full assessment of the varieties available for the management of design and construction in order to increase the potential of realizing the project objectives. According to Whyte and Macpherson (2011), the right strategy involves four key decisions:

1. Establish the project objectives and constraints;
2. Decide on a suitable project delivery method (also, so-called procurement method);
3. Choosing a correct contract form and type; and
4. Choosing a proper contract administration practice.

Ting (2013) argues that procurement strategy selection is essential in identifying the contractual relations, and proper selection leads to the successful execution of a project. In addition, the author argues that improper selection of the procurement strategies will affect the subsequent procedures of tendering strategies and selection of the standard form of contract. The potential domino effect of inappropriate choice of the procurement strategies is seen as difficulties in the administration of the contract plus time and cost overruns. In the best scenario, the contract will not be optimal for the case (Whyte and Macpherson 2011). The procurement strategy adopted by the client affects the choice of the standard form even before the involvement or assignment of the contractor.

2.5.1 Project Delivery Methods

The project delivery method addresses the relationships between the employers, contractors, and consultants involved in building a project. The project delivery method concerns the integration between project parties (project organizational structure). It deals with the size and nature of the work, design team selection (in-house, consultant or contractor), supervision process selection, client expertise dedicated to the project. Sadek (2016) argues that appropriate procurement methods are considered as one of the major project success factors and emphasizes that selection of contract type depends on the procurement method and other constraints such as risk transfer ways, pricing, performance responsibility, complexity, and cost certainty. Successful projects are supported by an appropriate procurement system between the client, consultant, and contractor. Based on the project delivery method, the construction contracts are categorized as 1) Design-Bid-Build Contract; 2) Design-Build Contract; 3) Management; Contract and 4) Management/relationship hybrids (i.e., Alliances).

2.5.1.1 Design-Bid-Build Contract

Design-Bid-Build Contract (also known as a traditional contract, general contract, construction contract, and employer-design contract) requires a contractor to perform works that are designed by a consultant appointed by the employer or the employer itself (Sertyesilisik 2007; Ting 2013; Windapo and Adediran 2017). It is appropriate for large projects and is the most common project delivery methods (Abotaleb and El-adaway 2017; Windapo and Adediran 2017).

2.5.1.2 Design and Build Contracts

Design and Build (DB)contracts are also known as a "Design and Construct Contract," "Package Deal Contract," or 'Turnkey Contract." (Ting 2013). The works are designed and built by the contractor to satisfy the employer's defined requirement (Sertyesilisik 2007; Ting 2013; Zakaria et al.). It maintains a single source for design and construction responsibilities by the contractor (Windapo and Adediran 2017). Sometimes, the employer designs a certain item of works that is designed. Usually, Payments are made in lump sums with interim measurement work progress. It is the second most common project delivery methods (Abotaleb and El-adaway 2017) and is outperforming compared with a traditional design-bid-build contract in terms of changes, rework and practice (Hale et al. 2009). Under the design and build contract, there are three types:

1. *Design-Build Contract:* the contractors have the full burden of the design obligations involving the whole is the main concept when drafting the contract document;
2. *Turnkey Contract (Package Deal):* the client lists his requirement, and the contract returns a complete or conceptual proposal. In turnkey contracts, the contractor carries out all works from conceptual design to the first stage of operations. Lump-sum payment contract is the most common type in turnkey;
3. *Contractor's Design for Specific Elements:* it is a sort of the 'work and materials' contracts with a limited design provision by the contractor.

Additional subtypes that can be listed are build-operate-transfer, public-private partnership, and private finance initiative contracts (Windapo and Adediran 2017).

2.5.1.3 Management Contracts

Commonly, the management contract is for large and complex projects. The client employs a 'management contractor' to select, manage, coordinate, and supervise, many specialists assigned to carry out the works (Ting 2013; Windapo and Adediran 2017). The management contractor manages the contract fees and does not execute any construction work. A construction management contract is a subset of the management contracts (Windapo and Adediran 2017). The employer has a contractual relationship with the specialty contractors and engages a "construction manager" to provide the project management, supervision services, and coordinate between specialists. Likewise, the employer hires an agent in order to develop a relationship with subcontractors (Sertyesilisik 2007). The construction manager agrees to manage trade/specialist contractors, but the employer has still participated in the project. The contract defines the construction manager's scope to include an arrangement of specialist contracts and administers their contracts with the client. The client continues to bear the risks (Ting 2013).

2.5.1.4 Hybrids Contract

Hybrids contract is a combination of two or more the basic contract types (Ting 2013), examples are:

1. *Develop and Construct Contract:* It has the same major features of the design-build contract, except that independent professionals of the employer will prepare the conceptual design before the DB contractor is assigned.
2. *Design and Manage Contract:* It has the same major features of the management contract, with a particular difference that the contractor is responsible for arranging the detailed design or manage the process (Windapo and Adediran 2017).
3. *Design and Construction Management Contract:* It has the same major features of construction management but preparing the detailed design or managing the design process is the responsibility of the construction manager.

The criteria required to select an appropriate project delivery method may contain project size, market, finance, and speed to complete, certainty in cost and time, flexibility in design changes, quality, complexity, risk, price competition and dispute solving. Table 2.3 gives a comparison of the three main project delivery methods, in terms of speed of starting construction, the complexity of operations, quality, flexibility, the certainty of cost, competition between contractors, responsibility for design and construction, risk burden and summary.

Table 2.3: Comparison between the project delivery methods (Ting 2013)

Criteria	Design-Bid-Build	Design and build	Management
Speed	Slow because information should be available at tender stage.	Relatively fast. Design and building proceed in parallel (fast-tracking)	The fastest. An early start is possible
Complexity	Straightforward, except for nominated subcontractors	Integrating DB expertise within one Organization	Complex management operation
Quality	The client establishes the required level of quality and material	Contractor control over quality and material	Managing contractor control over quality and material
Flexibility	Client controls design and variations	The contractor has flexibility in design, detailing and alternatives	Management contractor adjusts program and costs for client changes
Certainty	Certainty in cost and time	Guaranteed cost and time	The client is committed to starting construction on project drawings specifications and a cost plan only
Competition	Competition is available to all tenders. Negotiated tenders reduce Competition	The client gains no benefits if contractor pursues more competitiveness for specialist work and materials.	Management contractor expertise is the key, not the fees. Competition exists at the works packages level
Responsibility	Separates responsibilities for Design and construction	Single source responsibilities for Design and build	Success depends on the management contractor's skills.
Risk	Fair and balanced between the parties	Fully burden by the contractor	Mainly burden by the client
Summary	Benefits in cost and quality but at the expense of time	Benefits in cost and time but not quality	Benefits in time and quality but at the expense of cost

2.5.2 Type of Contract

The choice of a certain contract type is the project owner's decision in consultation with the legal advisor and construction professionals as a part of the procurement strategy decisions. The proper contract type will somewhat grant achieving the established objectives and constraints. Each project delivery method and type of contract require a differing level of administration.

The selection of a certain type of contract depends on the kind of work and the conditions under which it is being performed (Knutson et al. 2004). According to Tatarestaghi et al. (2011), factors affecting the selection of the appropriate type of contract are the amount of involvement of the employer (and therefore, the contract administrator involvement), the project's location, and technical complexity. Butuza and Hedre (2010) lists those factors as project characteristics and particular client organization, the scope of the works, client's measure of control, accountability, contractor's selection, the certainty of the final cost, completion time, restrictions, expected construction changes, risk transfer and supply chain, and building relationships. According to (Sadek and Kulatunga 2013), the selection of the type of contract depends on the methods of procurement considered to achieve specific project objectives and the constraints of pricing, risk transfer, complexity, responsibility, and certainty of cost.

According to Butuza and Hedre (2010), construction contracts can be classified into four categories namely:1) traditional, 2) cost-reimbursable, 3) contracts management, 4) other forms of contractual arrangements (Partnership, Contracts Construction Type, Ownership, Operation, Transfer, Two-Stage Bidding, Contracts in Series, Design and Construction Contracts, Turnkey Contracts, and Overall Contract). Based on the financial terms and method of compensation, there are four main types of contract (Joint Contracts Tribunal 2011):

1. *Lump-Sum Contracts:* It is typically used for buildings contracts where contract sum id fixed. It can be sub-categorized into 1) Lump sum with quantities, 2) Lump sum without quantities. Lump-sum with quantities is where accurate BOQ is prepared before bidding to allow contractors to submit a single lump sum price for the work (Knutson et al. 2004). If BOQ is provided, its correctness cannot be granted but to be used for information only. The contractor bears the full burden of quantity and price risks (Hillig et al. 2010; Puil and Weele 2014; Sertyesilisik 2007). In a competitive fixed lump-sum contract, adversarial relationships sometimes exist

between contracting parties due to financial disputes and risk allocation (Kaka et al. 2008).

2. *Measurement Contracts (Unit Price Contract):* It is commonly used for heavy/highway work where the accurate drawings and quantities cannot be taken off and subject to field measures (Knutson et al. 2004). During the design stage, the client prepares preliminary quantities-but not accurately- subject to the final measurement. The contract sum is finalized by the end of construction based on the priced schedule of rates at the tender stage and execution drawings, field measurement of the constructed works. The contractor has no risk towards the material or workmanship estimation (Sertyesilisik 2007);
3. *Cost Reimbursement Contracts (Cost-Plus or Prime Cost Contract):* It is commonly used in situations when it difficult for either the owner or the contractor to predict their costs during the negotiation, bid and award process (Knutson et al. 2004). The contractor undertakes a contract based on actual costs of labor, plant, and materials in addition to a certain amount to include contractor's overheads and profit. Also, the contractor's overheads and profit amount is either a fixed sum, a percentage or percentage/ fixed sum plus incentives (Sertyesilisik 2007); and
4. *Incentive Contracts:* The owner offers a bonus for early completion of the contractor Incentive Contracts. A sub-type innovative form of incentive contracts is an A+B contract, which means cost plus time. The owner assigns a value to each day to execute the contract. The contractors will then bid a price to execute the works and a number of days required for the works. The low bidder is determined as the low total cost submitted plus time values (Knutson et al. 2004).

2.5.3 Standard Forms of Contracts

The standard form of contract is sometimes called "Standard General of

Conditions of Contract (Sadek and Kulatunga 2013)", "Adhesion Contracts" or " Boilerplate" (Knutson et al. 2004; Thompson 2006). It consists of a set of conditions that are performed by parties without substantial negotiation (Gillette 2009). It provides the basic legal framework, a legal relationship, regulated commercial relationship, standard administrative procedures, and standard duties and powers of the contract administrators (Ting 2013). Recently, the standard conditions are being used as a guide for good project management procedures, and involved management needs to refer to it on almost a daily basis activity (Salwa 2017). Several construction forms are issued in order to standardize the contractual clauses and enforce parties to have the same understanding (Sadek and Kulatunga 2013). Therefore, standard forms have been developed and have been used in national and international projects because they can fit a wide range of regular works. They have been tested in the courts, and their legal interpretations are well known (Chui and Bai 2010; Shnookal and Charrett 2010), satisfy the equitable principle and allocates well-known risk between the parties; save the time required to negotiating contract content (Sadek and Kulatunga 2013). Industry professionals and practitioners are aware of the regulated relationships and obligations of the standard forms (Chui and Bai 2010).

Inappropriate selection of the standard form will often mean that the project objectives are not fully utilized, and then there is an increase in the dispute's potentials. Also, continual changing/revising of existing, standard forms is somewhat ineffective, confuse users, and increase litigation cases (Ting 2013).

Morris and Pinto (2010) state that the standard forms provide a predictable and anticipated contractual basis save writing and negotiating times, smooth management of the contract, and avoid drafting mistakes. The independent professional organizations develop the standard forms revisions to improve efficiency and to exploit the experience attained from the repetitive implementation of these forms and consolidate a fair and just contract (Salwa 2017). Chui and Bai (2010) and Shnookal and Charrett (2010) agrees with Morris and list the advantage of using standard forms as: 1)the familiarity of the rights and obligations of the standard forms will improve the efficiency of contract administration; 2)the Contractors are familiar with the risk associated with certain types of standard forms and, therefore, will price reasonably (no hidden risk or unforeseen risks); and 3) the familiarity with the standard forms will reduce the time and cost of negotiation.

Although standard forms have several advantages in use, literature reported some disadvantage of using standard forms such as:

1. The complexity of projects requires multi-disciplined forms while traditional standard forms are dealing with one discipline (i.e., civil or mechanical or electrical or building, …) (Iyer et al. 2008).
2. In many standard forms, clarity of understanding is a concern. Bunni (2005) revealed that only 4% of the population could understand about 86% of the FIDIC 1977 clauses, the readability level of clauses is equivalent to an intelligence quotient level of 130 or above, which is 'difficult' level. (Ting 2013) has quoted comments of Broome & Hayes (1997) stating that JCT, ICE, and FIDIC conditions contain long sentence, poor layout, and many redundant legal terms;
3. The sponsoring organization has a great influence on the draft of the standard forms
4. The absences of judicial knowledge lead to take difficult decisions causing a dispute
5. The complex legal language of the form fails beyond the understanding of normal contract administrators and parties.
6. Misinterpretations of new revisions and depends on obsolete versions.

7. The standard form is important and vital for effective contract administration because contract administration must focus on the administration of the form and its provisions.

Sadek (2016), studies practices of the standard construction contracts from 2005 and onward for 10 years in the Middle East to investigate the major modifications done and to improve the performance. The study concludes the main reasons to change the standard conditions are either to protect one party or to give more flexibility to the other party. Generally, choose the appropriate contract form is a very critical decision to be carefully taken (Thompson 2006). The use of a certain form is subject to the type of project, the owner requirement, the preferred consultant form, the nature of a project, and the funding method. The nature of standard contract forms shall be further investigated within the next sections.

There are different forms of contracts based on procurement form/procurement methods. This can be categorized as 1) Construction Contract where the contractor performs the employer's designed works; 2) Design-Build Contract where the contractor designs and builds the works; 3) Engineering, Procurement and Construction (EPC) /Turnkey Contract where the contractor performs all stages from conceptual design to handing over of full operational works; and 4) Design-Build-Operate Contract where a contractor designs, builds and continues to operate the works for a certain period.

The items that should be specified within the General Conditions of Contracts are: 1) The responsibilities, liabilities, entitlements, duties, and obligations of parties; 2) The contract administrator roles and responsibilities; 3) Allocation of risks; and 4)The procedures required for the different stages of the contract to include commencement of works to handing over, defects notification period, changes, claims and dispute resolution, suspension of works, termination of contract, and contract closeout.

2.5.3.1 International Federation of Consulting Engineers (FIDIC)

FIDIC contracts are widely used as a family of standard forms of Contracts by international funding agencies and international as well as national projects in many countries (Bunni 2005; Chandak et al. 2015; Shnookal and Charrett 2010) and in most of the projects funded by international banks (Shnookal and Charrett 2010). The massive usage of FIDIC forms as international benchmarks is due to an efficient allocation of risks, tradition, fairness, respect, and a balanced approach (Klee et al. 2015). The FIDIC forms of the contract are applicable for a wide-ranging of the project, each for has a unique cover color, and the selection of specific form depends on the type of project, availability of design, long-term operation and maintenance requirement and risk allocation. The standard forms are as follows: -

1. FIDIC Construction Form of Contract - Red Book 1999,
2. FIDIC Construction Form of Contract MDB Harmonized - Pink Book 2010,
3. FIDIC Plant and Design-Build Form of Contract - Yellow Book 1999,
4. FIDIC Conditions of Contract for EPC Turnkey Projects-Silver Book;
5. FIDIC Short Form of Contract -Green Book 1999;
6. FIDIC Form of Contract for Dredging and Reclamation Works - Blue-Green Book 2006;
7. FIDIC Form of Contract for Design, Build and Operate - Gold Book 2008;
8. FIDIC Form of Subcontract for Construction -2011; and
9. FIDIC Model Services Agreement for Consultancy Services - White Book 2017

FIDIC forms remain the contract of preference in the bulk of the Middle East projects (Glover 2007; Sadek 2016) includes Qatar. Sadek and Kulatunga (2013), state that more than 50 percent of the Middle East contract uses FIDIC standard form. The study reveals that FIDIC red Book 1987 represents 28% of the standard forms adopted in the Middle East, while the New Red Book 1999 is the second with 24% adoption. Internationally, the most commonly adopted form is the red book (Hillig et al. 2010; Shnookal and Charrett 2010).

According to Chandak et al. (2015), the FIDIC forms of contract fairly balanced risk, rights, and obligations between contracting parties and well-defined the role and responsibility through clear and complete conditions. The FIDIC forms have five basic principles 1) use fair and independent third party (the Engineer) to administering the contract and work as a client agent; 2) not expecting the contractor to price for unforeseen risks; 3) if the employer has his own risk and responsibility risk of events that may never occur, events outside the contractor and risks not covered by insurance),; 4) building good welling concept, cooperation, and coordination among the employer, contractor, and engineer to finish a satisfactory project, and 5) establish trust and confidence between contracting parties.

2.5.3.2 Joint Contracts Tribunal (JCT)

In association with the National Federation of Building Trades Employers (NFBTE), the Royal Institute of British Architects (RIBA) established the Joint Contracts Tribunal (JCT) in the United Kingdom in 1930. The first standard forms of construction contracts were introduced in 1937, and the latest edition is JCT 2011. Currently, JCT is a primary source of contract related references such as guide, partnering, homeowner contracts, collateral warranties, and agreements documents (Sadek 2016).

2.5.3.3 American Institute of Architects (AIA)

The American Institute of Architects (AIA) was founded to promote the scientific and applied perfection of AIA's members and promote the profession in 1857 (Thompson 2006). Currently, AIA covers all phases of the construction industry through over 100 contracts and forms (Sadek 2016) and the following series are established by AIA (El-adaway et al. 2016):

1. series A: owner-contractor agreements, this series contains the most used contract in the US "AIA document A201- General Conditions of the Contract for Construction", (Chui and Bai 2010; El-adaway et al. 2013; Thompson 2006);
2. series B: Owner-architect agreements, AIA Document A401, AIA Document B141, AIA Document B102;
3. series C: Other agreements;
4. series D: Miscellaneous documents;
5. series E: Exhibits;
6. series F: Reserved; and
7. Series G: contract administration and project management forms

2.5.3.4 New Engineering Contract (NEC)

The New Engineering Contract (NEC) is a set of standard forms issued by the Institution of Civil Engineers in the United Kingdom and is in use for numerous construction and engineering projects (Shnookal and Charrett 2010). NEC forms have replaced the ICE forms since 2011 (Sadek 2016). The main advantage of NEC forms is related to the proactive and collaborative approach to managing early warning and program of work; clear, plain English drafting style; and no legal terms but simple natural language. The current edition is NEC3 and it was published in 2005. The contracts available in the suite are:

1. Professional Services Contract (PSC);
2. Engineering and Construction Contract;

3. Engineering and Construction Subcontract Contract;
4. Engineering and Construction Short Contract;
5. Engineering and Construction Short Subcontract;
6. Framework Contract;
7. Term Service Contract;
8. Term Service Short Contract;
9. Supply Contract/Short Supply Contract;
10. Adjudicator's Contract; and
11. Guidance Notes and Flowcharts.

2.6 QATAR CONSTRUCTION INDUSTRY

2.6.1 Overview of Qatar

Qatar occupies a small peninsula on the northeasterly coast of the Arabian Gulf, surrounded by a Saudi Arabia border from the south and the Arabian Gulf from other sides. The small nation has a population of around 400,000 Qatari citizens and over 2.0 million residences and expertise from several nationalities. In addition to the 15 billion barrels of proven oil, Qatar has about 14% of the world's total and the third largest gas reserves (26 trillion m3) in the world. This has put Qatar at the top of the list of per-capita income countries in the world, at $90;000 per capita (IMF 2015). Qatar is using the huge income of oil and gas at transforming itself into a 'knowledge-based economy' from a hydrocarbon economy by 2030. Despite the global economic downturn, Qatar has continued to prosper with continued growth in GDP over the last few years. Economic policies are concentrated on developing and attracting investment in non-hydrocarbon sectors, but currently, more than 50% of GDP comes from oil and gas, amounting to 85% of exports and approximately 70% of government revenues, according to the World Factbook (2016).

In Qatar, the workload continues to focus on arrangements for the FIFA World Cup 2022 and the related infrastructure projects (AECOM 2016). As a result, several capital investments are being funded, and the construction industry continues to stay as a key element of the nation's plan. Qatar shall continue to invest around $220 billion in capital projects and infrastructure over the next few years. The construction is regarded as one of the largest industries in Qatar; the sector shared 14.5, 15.6 and 17.5 % percent of real Gross Domestic Product (GDP) in 2014, 2015 and 2017, respectively, and is still the main contributor to economic growth during the coming years. The construction output is increased from QR 52.5 to 88 Billion for the period between 2014 to 2017, with the highest sectorial growth in the economy by (14.5%) and follows far behind by the manufacturing sector with an average annual growth of only 2.6 % (Authority 2018). In 2018, the construction sector is contributed to 1.8 % of the total expected growth of 2.6%. With an expected growth rate of 5.2 %, the construction will contribute to at least 50 % of this growth rate between 2018 to 2020. Not only this but construction activities intensively employees around 41% of the total labor force due to the construction booming and speed up large-scale/ mega infrastructure projects for the FIFA 2022 session (Authority 2018; Statistics 2016). While the government committed to allocating 40% of its budget to infrastructure projects, the workload continues to focus on arrangements of sports facilities and the related projects (AECOM 2016).

2.6.2 Qatar Contracting System

Like other contracts, construction contracts should follow the applicable local laws. Validation and interpretation of the express and implied terms of any particular contract would be done within the context of the statutory rules and common law. Frequently, the law imposes liabilities/ responsibilities not mentioned in the contract and voids the expressed terms when it is illegal, contrary to public order or ethics. For this reason, the construction industry professional should be aware of and familiar with the contracting system. According to (Jones et al. 2017) The following laws regulate Qatar construction industry:-

1. Law no. 24 of 2015 on "Regulation of Tenders and Auctions." effect on June 2016.
2. Law No. 22 of 2004- Qatar Civil Code
3. Law No. 11 of 2015 – the New Commercial Companies Law;
4. Law No. 1 of 2015 – the Labor Law
5. Law No. 40 of 2002 – the Customs Law.
6. Law No. 19 of 2005 and No. 2 of 2014, -the Engineering Law
7. Law No. 30 of 2002 –the Environment Protection
8. Law No. 8 of 2009 -the Human Resources Law
9. Law No. 21 of 2009 -the Income Tax Law.
10. Law No. 2 of 2009 - Qatar Financial Centre and the associated Qatar International Court and Dispute Resolution Centre (QICDRC)

Under Qatar Civil Law, parties have great freedom to contract except in case of 1) deceit or gross mistake (article 259), decennial liability (Article 711) and reduction of liquidity damage to a reasonable margin through court or arbitral tribunal (Article 171 (2). The concept of freedom of contract gives the contracting parties the right to freely enter into a contract, choose the other party and start/end the contract at any time (Klee et al. 2015). Also, the concept of "privity of contract" is recognized in Qatar law which means contract rights and obligations are dedicated to the contracting parties, and this concept removes any contractual link between the contract administrator and the contractor (Grose and Shlah 2015).

According to the Qatar Civil Code provisions in relation to contract administration roles is the decennial liability. Decennial liability is a statutory liability stated by articles 711–715 of the Qatar Civil Code. It imposes joint and several liabilities on designer/ architects, engineers, supervisory engineers and building contractors for total / partial collapse; or structural defects which threaten the stability or safety of a building or fixed structure for a period of up to ten years after handover (Grose and Shlah 2015). According to Newboult (2016), the employer approvals do no relief the liable parties from their liability under the law. What is more, decennial liability enforced by law, commonly not mentioned in the contract, and cannot be transferred to sub-contractors.

2.6.3 Qatar Standard Forms of Contract

Several states have developed local standard contracts that may possess some deviations from the international standard contracts (Sadek 2016). The main aim of the national forms is to suit the local market and national legal framework. Qatar construction governmental project relies on the standard forms of contract to establish a contractual relation, the authorities and professional bodies draft the standard forms. According to AECOM (2016), the Public Works departments -currently Public works Authority (ASHGAL) - through the Ministry of Municipal Affairs and Agriculture - currently Ministry of Municipality and Environment - and the Qatar Petroleum Company are the main two bodies to issue standard forms of construction contracts in Qatar. The majority of public and Capital projects are awarded lump-sum contracts includes specifications and drawings in addition to bills of quantities for reference. The private sector is adopting similar arrangements. Few numbers of projects use design-build or cost-plus contracts for smaller scale, fit-out or highly specialist work.

2.6.3.1 Qatar General Conditions of Contract (1987-2010)

This form of the contract is the first local condition of contract published in Qatar by the Ministry of public works in 1987 and amended over the years. It contained

76 clauses in the bi-language version and was structured in a similar way to the FIDIC Red book 1984 edition. A consolidated edition is published by the Contracts & Engineering Business Affairs of Public Works Authority for the State of Qatar in May 2007 to amend and compile a version of the 1987 edition. Ashghal (PWA) is a government authority responsible for drafting construction forms of contract in Qatar. Local companies are familiar with the home-based forms of PWA and know the associated contractual risks. Most of the private sector and governmental projects apply General Conditions for the State of Qatar 1987 and 2010 editions while FIDIC and other international forms will be used for international projects.

2.6.3.2 Professional Service Agreement, 2010 Edition

The binding relationship between the client and the consultant is formally regulated through a service agreement, so-called professional services agreement. In Qatar, the "Professional Services -General Conditions of Engagement (2010)" has replaced the first Qatari agreement issued in 1984. The latest revision is Revision A and has been issued in April 2013. During construction, the consultant is appointed under the terms and conditions of the PSA to assess the engineer and provide one or all of the following services: 1) project management and administration; 2) General and site supervision (includes acceptance, close-out, and warranty activities); 3) Post-contract quantity surveying.

2.7 PERFORMANCE MANAGEMENT

Performance management aims to measure the ability to meet specific objectives. Performance measurement at the project level is to evaluate the performance (and success) of the project lifecycle, communicates results to practitioners, and identify areas of improvement in order to remain successful. On the other side, some organizations measure insufficiently in order to start the improvement program and spread lessons learned from other projects (Deng et al. 2012). Key performance indicators are the measurement tools for the success criteria and are suggested to evaluate the project performance from start to completion. Success criteria are projected outcomes or organization achievements that are required to consider. To date, the continuous development of performance measures indicates that there is no agreement on how to measure project performance and what are the key performance indicators or success criteria

Early in the 1960s, the project performance was measured on finishing, and an operational basis, and then the earlier studies in the 1980s introduced the concept of the triple constraints in terms of time, cost, and scope/ quality. Korde et al. (2005), carry out the extensive review on 122 papers addressing construction performances, development of construction predictive models and factors influencing the performance measures between 1985 to 2005. Korde et al. (2005)categorized the performance criteria into time, cost, productivity, and overall performance dimensions. Based on firm project management practices, Ling et al. (2008) evaluated the project performance of international firms in China and concluded the performance measures like cost, time, quality, profit margin, and owner satisfaction. PMI (2013) extends the iron triangle by adding the degree of customer satisfaction, constraints of scope, resources, and risk to the project performance indicators. Currently, safety, site disputes, and environmental performance are also added to the performance measures. Kerzner (2013), sets the criteria was to complete the project within time, budget, budget, meeting specification requirement user/customer acceptance, when it used as a reference, agreement on scope changes, without disturbance of the workflow or changing the corporate culture. Gan and Li (2013), identifies successful criteria for sustainable large-scale infrastructure projects in China. The research identified 15 successful criteria and presented the traditional iron triangle, social aspect of sustainable, economic aspect of sustainable construction and environmental aspect of sustainable construction as the most important success criteria of a sustainable large-scale infrastructure project. The most important finding was that different infrastructure projects have different characteristics and therefore the success criteria could be different.

Alias et al. (2014), summarizes the performance indicators from literature as construction cost, construction time, quality, construction, time & defects predictabilities, service satisfaction by the client, and client satisfaction with the product. The performance measures of the process used to use the dimensions of variety, cost, quality, and time. The cost of contract administration is insignificant when compared with the quality and the time requirement during execution. Within the context of contract administration, the performance metrics are processing time, lead time, time to submit, the number of submissions, the number of reviews, and a number of activities/procedures (Garrett and Lee 2010).

Contract administration performance can be classified as.

- Poor Administration: inconsistently produces the required paperwork on time. Invoice accuracy needs improvement: little or no documented status reporting.
- Standard Administration: usually produces required paperwork, including accurate invoices and reports in a timely manner. Rarely are invoice inaccuracies found
- Effective Administration: always produces required paperwork, including accurate invoices and reports in a timely manner. Invoices and reports always accurate, timely, and useful. Aggressively finds and implements process improvement designed to improve contract administration.

2.7.1 Efficiency and Effectiveness Measures

Efficiency is a measure of productivity which deals with increasing output for a particular input (or minimizing input for a specified output) while maintaining the same quality. (Watermeyer 2013). It requires minimal use of effort, resources, or cost by "doing things right" (Elsey 2007). According to Zakaria et al. (2013A), construction process efficiency can be represented as effective communication, efficient time management, efficient waste management, and efficient waste avoidance

Effectiveness' deals with the successful achievement of the intended outcomes or goal or purpose of an activity or simply how well outputs achieve desired outcomes. The outcome represents the short-term/medium-term effects of the outputs, and the impact represents the longer-term effects that produced from the output (Watermeyer 2013). Effectiveness is simply meant "doing the right thing" or "getting the job done" (Elsey 2007), The meaning of efficiency and effectiveness within a process are shown in Figure 2.4.

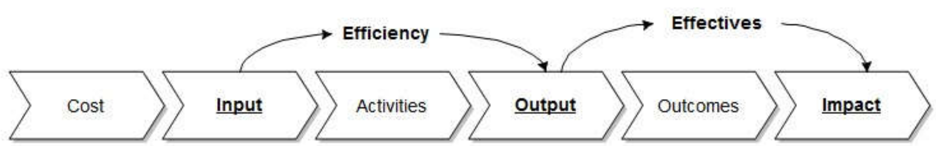

Figure 2.4: Efficiency and effectiveness within a process (Watermeyer 2013)

2.8 CHAPTER SUMMARY

The literature presented within Chapter two gives an overview of the construction industry, stakeholders of the construction industry, project life cycle, contract definitions, and associated legal terms and contract in public & private sectors. Furthermore, Chapter two gives an insight view of contract documents, the main types of project delivery methods and commonly used international standard forms of contracts. The chapter ends with an overview of the Qatar construction industry, the national contracting system, Qatar general conditions of contract and professional service agreement, 2010 edition.

The reviewed literature demonstrates that there is not much difference between Qatar's general conditions of contracts and the FIDIC Red book. Therefore, the validation of the research output throughout the Qatari projects is valid for other international projects, as well. Not only this but also, the traditional contract (design-bid-build) continues to form the majority of the national and international contracts; therefore, the research limitation mentioned in chapter one will cover a wide range of ongoing and future projects.

The next chapter is intended to focus on contract administration functions, the administration team roles and responsibilities, and the development of an initial performance assessment model from the literature.

CHAPTER 3 : CONTRACT ADMINISTRATION FRAMEWORK

3.1 INTRODUCTION

This chapter provides an in-depth literature review for the elements of the construction contract administration framework that are extracted from the following topics:

1. The global view of contract administration;
2. Contract administration under conditions of contract (Qatar; FIDIC: Red Book; AIA; JCT; NEC) and professional service agreements/contract (Qatar; FIDIC White Book);
3. Strategies to overcome challenges facing CCA and to avoid poor CCA;
4. Elements of effective contract management and best practices;
5. Critical success factor in contract administration; and
6. Contract administration/ management models and frameworks

3.2 GLOBAL VIEW OF CONTRACT ADMINISTRATION

The contract administrator is obligated to and responsible for carrying out certain duties, tasks, and activates as required by the statute, contract provisions, and common law. Sometimes the role of the contract administrator is not fully understood by the other parties, or the contract administrator himself is not aware of his duties and obligations. If the contract administrator is independent origination (consultant), the main responsibilities of the consultant are set out in a standard form agreement between the consultant and the owner and are more listed within the contractor's general conditions of the contract between the employer and the contractor. Such functions are classified into two main categories 1) expressed functions specified in the contract, and

2) other functions implied to the contract. The key function is obligatory, while the implied functions/tasks are aimed to facilitate the smooth execution of the contract and increase contract administration efficiency (Garrett 2010; Goldfayl 2004; Hill 2010). Terms of engagement are the first place to define the engineer's duties and authorities. In other words, the authority of the Engineer is limited to the terms of his engagement with the client.

3.2.1 The Contract Administrator

The contract only is not sufficient to resolve the issues, and the difference of knowledge between the employer and the contractor and the presence of a knowledgeable third party is required to resolve issues (Niraula et al. 2009). The employer hires a professional "Contract Administrator" to act as the client's agent and certifier to oversees the certification of works properly carried out has decision-making functions and deals fairly and independently between the employer and the contractor for the duration of construction (Fawzy and El-adaway 2012; Klee 2015; Murdoch and Hughes 2008; Ndekugri et al. 2007). The third-party can be one of the employer's senior staff or external body. In common practice, the third part will be appointed from among the employer's staff, and when the employer has not enough experience to manage the contract, the client assigns an architect or a professional consultant (person or firm). The administrator is the key contact between the employer and the contractor/ construction teams, has significant powers, is loaded with numerous responsibilities, and is required to perform many duties. Many times, his tasks and responsibilities are extensive and challenging. By assigning a contract administrator, the employer will transfer the majority of the day-to-day responsibilities of the project to the contract administrator (Cunningham 2016). The employer must appropriately delegate his authority to the engineer. Too much delegation means bypassing the Employer on important issues, and too little delegation places a heavy burden on the employer's shoulder (Kayastha 2014). The contract administrator role is important and influences the contracting parties' relationship. Klee et al. (2015), see the main function of the employer's contract administrator under a professional services agreement as achieving the triple constraints in a fairway. Traditionally the third-party function is a part of the architect's duties (Goldfayl 2004). The involvement of different non-architect bodies to undertake the architect's role generates other terms concerning the scattered function of the architect (Hughes and Murdoch 2001). The contract administrator has different titles under the different standard forms such as "Engineer" in FIDIC, an" Architect" in JCT, "Project Manager" NEC, "principal-agent," or "Certifier" under other forms.

The contract administrator is not a party to the contract (Kayastha 2014; Robinson 2011). The employer is responsible for ensuring the proper performance of the contract administrator, and the contractor is obligated to transfer any objection to the Engineer's action to the Employer (Kayastha 2014).

3.2.1.1 Limitations of the Contract Administrator's Functions

According to several authors (FIDIC 1999; Miller et al. 2012; Murdoch and Hughes 2008; Treasury 2017), the contract administrator has several roles and responsibilities under the terms of the contract, but he has no authority in many cases. Compilation of circumstances where the contract administrator has not authority includes: 1) change the contract, discharge any contractual duties, obligations or responsibilities of any party; 3) instructing un-authorized variations unless the employer clearly delegate the engineer to do so or the contract provisions allow the engineer to issue variations within a specified limit; 4) approving contractor's proposals; 5) ordering extra work already impliedly in the contract; 6) acting under clauses or sub-clauses belongs to the employer and does not lie within the contract administrator's roles and responsibilities; 7) determining a cost and/or time impact for unforeseeable physical conditions unless otherwise stipulated instructing a variation outside the contract scope; 9) instruct the contractor to start working before signing the contract; 10) extend the term of the contract without a formal written amendment; 11) request the contractor to perform work not required by the contract document; 12) settle disputed claims with a contractor the employer consent; 12) give instructions interfere with the contractor's methods of working and temporary works (except for contractor's methods are contrary to the project specification, compromise the permanent work quality or unsafe); and 14) give commitments that could change the price, quantity, quality, delivery or terms and conditions.

According to Wearne (1992), contract Administrator has no authority to renegotiate or terminate the contract, and that authority remains at the level of the persons delegated to enter into a contract. The employer not liable for the consequence of the Engineer's acts exceeding the scope of authority, and the engineer is personally liable for breach of warranty of authority. Also, the employer should not exercise any restraints on the contract administrator's authority unless the contractor agrees (Bin Zakaria et al. 2013). The administrator's assessment, decision, or determination should be honestly and reasonably taken (Abdul-Malak and El Masri 2016) but his decisions are open to re-establishment by the dispute resolution board (Bin Zakaria et al. 2013). Some contracts make the administrator's decision final and conclusive, and the contractor's dispute can be dealt with the litigation process.

3.2.1.2 Dual Conflicting Roles of the Contract Administrator

The contractual engagement of the contract administrator by the employer can be seen as a conflict as this type of assignment may miss the dependence requirement in making decisions. Sometimes, the administrator is not authorized to make a fair and timely determination on the legitimate claims submitted by a contractor (Klee et al. 2015). The contract administrator employed by the employer to act as the employer's agent to protect the employer's interest, but at the same time, he is required to make determinations that may be against his employer. FIDIC obligated the engineer to make a fair determination under the contract, considering all relevant circumstances. In JCT, the architect carries out the design functions and at the same time, maybe appointed as the contract administrator to deal with problems generated by his design. Such conflicting role of the contract administrator as impartial or fair certifiers and the same time an agent to the employer makes an area of concern. (Arcadis 2018) reports insufficient authority delegated to an engineer or project manager to make decisions on behalf of an employer, the main reason for middle east disputes from the employer side is a failure to properly administer the contract by the contract administrator and the need for a truly independent certifier to avoid disputes. Some believe that an "impartial Engineer" being paid by the Employer does not make sense (Bunni 2005). The Employer can use the engineer to prepare a claim for him but at the same time, decide for the contractor's claim or counterclaim (FIDIC 1999, clause 2.5, 3.5 & 20.1). The Employers involvement in day-to-day activities reduces the Engineer's powers to act independently to all parties (Robinson 2011).

According to Ndekugri et al. (2007); and Salwa (2017), the concept of the engineer's independence and impartiality in practicing a professional discretion in the FIDIC old red book is criticized by some civil lawyers, employers, contractors and professional. Akulenka (2013), studies the dual roles of the contract administrator in the UAE. The study investigates the impartiality of the engineer under the FIDIC Red Book in the UAE and suggests that the Engineer is not seen as an impartial body due to the Employer's intervention.

The Engineer acts as a true agent of the Employer, irrespective of the contractual provisions due to the following reasons:1) employer limits the engineer's authority related to the cost or time variations; 2)employer delays and/ or reject the contractor's claims entitlement by holding ''the specific approval'' for the engineer to proceed; 3) sometimes, the local contract necessitates the engineer to approach the employer for approval, and the employer rejects such determination; 4) the engineer has no authority to act without the employer's approval in several locally modified forms; 5) the engineer/engineer's organization seeks future business from the same employer and therefore acts in the employer's favor; and 6) if the engineer made the design and his design or contract document is at fault, the engineer avoids a determination that may expose his organization.

Klee et al. (2015) argued that sometimes, the contract administrator's agreement (Provisional Service Contract-PSA) and the main contractor's contract are not compatible but conflicting. PSA abides the contract administrator. Therefore, the contract administrator is effectively controlled by the employer. In addition, the employer practices his right to instruct the contract administrator, and such instructions may contradict with his function as a neutral mediator to the contractor's contract.

To resolve this conflict, the Institute of Civil Engineering (ICE) developed a new model by dividing the engineer's functions into four separate post- holders: project manager, a supervisor, an adjudicator, and a designer. The project manager has a key role in managing the contract for the sake of achieving the employer's overall objectives. The supervisor has a key role in monitoring the work to ensuring compliance. The adjudicator is in charge of resolving disputes. The designer is to design works and provide specifications.

Akulenka (2013), suggests several solutions for the problem of the engineer impartiality includes: 1) separation of the engineer’s role through different entities; 2) stepping away from the engineer’s involvement in the standard dispute resolution process; 3) synchronizing the consultant agreement and the construction contract with particular attention to the roles and power of the engineer; 4) improve local laws and legislation with respect to the engineer role; 5) appointing the engineer by a third party (i.e., DIAC, DIFC, ICC, ADCCAC) similar to the arbitrator’s appointment, tripartite agreement; 6) regulate the engineer assignment by the independent regulatory body (i.e., RICS); 7) expose the engineer’s contract with the employer to the contractor and gives the contractor the right to object or amend; and 8) the engineer’s decision should not subject to the employer’s approval.

3.2.1.3 Expectations of the Contract Administrator

As similar to any position, the contract administrator should be familiar with the requirements of its position and the expectations required. PMI (2016), highlights the importance of proper interpretation and understanding of the general conditions, particular conditions, and other procurement documents to carry out the contract administration function. Such functions are to be carried out by the contract administrator. Contract administrators should exercise reasonable and professional skills, care, and diligence during the performance of the contract administration services. According to Cunningham (2016), the contract administrator is expected to be:1) capable of applying the administrative procedures; 2) possess an in-depth understanding of the contractual obligations; 3) able to communicate with the two contracting parties on contractual issues; 4) able to establish and maintain records to turn over to the employer/ end-user at the contract completion; 5) able to set and communicate an effective strategies; 6) capable of advising the contracting parties on their contractual rights and obligations; and 7) able to understand the construction contract as a whole.

3.2.2 Main Functions of Contract Administration

In general, the contract administrator provides the essential technical expertise for successful contract execution and has a major influence to positively impact the outcomes of the overall administration process (Miller et al. 2012). The contract administrator is responsible for overseeing the contract and execution of works (Abdul-Malak and El Masri 2016). The contract administrator is deeply involved in seven main processes, namely: 1) certification/ determination, 2) time-related considerations, 3) programming, 4) substantial completion and taking over, 5) liquidated damages, 6) claims, and7) dispute resolution. According to Ndekugri et al. (2007), the duties and powers of the engineer are categorized into five categories: 1) design; 2) communication; 3) quality control; 4) certification; and 5) determinations. The first four duties are solely the employer's agent duties, while the fifth one implies some fair acts by the Engineer. Cunningham (2016), study the contract administrator's role under the different standard building contracts in Ireland. The author lists 8 key roles for the contract administrator namely:1) the employer's agent; 2) advising the employer; 3) instructions to the contractor; 4) information to contractor; 5) administration of the contract; 6) meetings; 7) certification; and 8) achieving project objectives.

Contract administrator tasks are performed through correspondences, communications, and meetings. Meetings are a central means of communication on construction projects. The architect or project designer or the design consultant can be involved in contract administration, and its role/ involvement will have several categories, as shown in Table 3.1.

In brief, the key functions of the contract administrator are: 1) monitoring performance, 2) payment certification, 3) withholding payments, 4) contract variation/

change management, 5) dispute resolution, 6) maintaining contract administration files, 7) construction supervision, quality control, and quality assurance, and 8) performance (maintenance) certificates. details of each function are addressed in the next section.

Table 3.1: Architect functions, role, and degree of participation (Thompson 2006)

Degree of Participation	Category of Role	Definition of Function	Example
Active	Primary lead	Performs the principal function of contract administration	Authority required starting inspection or testing
	Quasi-judicial	Decides disputes determine claims and judge quality. Acts as an arbiter between parties	Interpret and decide matters concerning performance
Neutral	Secondary support	Assists in contract administration issues	Prepare Change Orders
	Supervisory	Performs managerial role in contract administration	Provide administration of the Contract
Passive	Reviewer	Reviews the work required	Review Claims
	Advisory	Acts as advisor to the contracting parties	keep the employer familiar with and informed about the progress and quality of the Work

3.2.2.1 Monitoring Performance

The prime function of the contract administrator is to make certain that the performance of the contractor agrees with the provisions of the contract, and the employer is kept informed of all issues, problems (Treasury 2017). the contractor establishes a schedule and provides updates routinely, and the contract administrator follows up the contractor's program and updates (Jaeger and Hök 2010). as time is the essence of the construction contract, failure to achieve the specified time for completion constitutes consequences (liquidity damage). The power of the contract administrator to decide if the contractor is entitled to an extension of time or not is called "time-related considerations" (Jaeger and Hök 2010).

3.2.2.2 Payment Certification

The contractor is responsible for preparing only due to payment application with all supporting data to the contract administrator (El-adaway et al. 2013). The contract administrator reviews the contractor's statement (valuation or payment) and certifies the actual work completed during the period specified in the contractor's valuation. The review is done against individual rates and quantity stated in the Bill of Quantities or the schedule of rates, and issue recommendations for payment certificates (Treasury 2017). Payment certificates are classified as an interim payment, penultimate payment, and final certificates (Cunningham 2016). A final certificate discharges the contract and acknowledges that the contract completed. The contract administrator issues the final certificate in favor of the contractor when: 1) all works are completed work as per the contract requirement; 2) the contract amount and period have been properly adjusted; and 3) any outstanding balance on the final account.

Any contract includes provisions for payments, and when such provisions are misunderstood and misapplied. it causes a major impact on project financial flow and the contractor (Abotaleb and El-adaway 2017). Abotaleb and El-adaway (2017), argue that the need to educate stakeholders about contractual considerations and successful administration and propose a contract administration guideline for enhancing the administration of the payment clauses under different forms of contract. The common payment problems are: 1) holding payment of certified amount; 2) delay in progressing payments; 3) delay in certifying the final account; 4) late release of retentions; 5) delay in completing valuation of variations; 6) erroneous payment procedure; and 7) deduct from payments without contractual ground.

Payment affects the overall performance of the project. The cash flow is impacted by delays in approving invoices, settling cost-related claims, settling the payment, and releasing due retentions. If the employer does not release the money, the contractor shall incur additional transaction costs and try to reduce these costs by decrease manpower or degrade the quality to save some money. The contractor may end with a high risk of insolvency. Disputes are commonly generated from delayed payment, irregular payments, faulty processing of valuations, and variation-related payments.

3.2.2.3 Withholding Payments

During the performance of the contracts, it may be necessary to protect the employer's rights, and the contract administrator may withhold/deduct contractor's payment (in full or partial) due to: 1) over-payments due to errors in the previously certified payment; 2) employer's termination of the contract; 3) claimed costs without the proper supporting document or substantiation; 4) defective and non-compliance works until completion of the required remedies; and 5) contractor failure performs certain works until performing. When the contract administrator holds a payment application, he must write the reasons for withholding any payment applied to the owner and contractor. When the causes of withholding payment are remediated, the corresponding amount will be released. The contractor may be able to stop work to demand delayed payment and unjustified withholding payment. If the contract administrator does not issue a certificate for payment or the employer does not pay within specified time days of the date, the contractor is entitled to submit written notice to the employer/ contract administrator to stop the works accordingly until receipt of what is due. Also, the contractor may be entitled to compensation in terms of time and cost (El-adaway et al. 2013).

3.2.2.4 Contract Variation/ Change Management

Changes to the contract are originated from the contractor's claim, Engineer's justification for changes, a new statutory requirement after awarding or within a certain time before the tender closing, and employer modified or new requirement. In addition, PMI (2016) states that changes can result from an infinite number of factors and several documents such as: 1) request for information (RFI) initiated by the contractor and responded by the supervisory consultant; 2) response to design clarification, correction of design errors/ omissions by the project designer/ architect; 3) work/scope change directives; 4) Supplemental instructions or drawings issued by the Engineer; 5) unknown conditions, unforeseen events under the employer's risk events; 6) change order requests and/or proposal; and 7) interpretations of the regulatory requirement.

According to Qatar GCoC (CEBA 2007), the contract administrator shall make variations to the works or any items of work included in the contract to: 1) increase or decrease the quantity; 2) omit works; 3) change the characteristics, quality or kind of work; 4) changes in the level, position, lines, and/or dimensions of any part of the Works; and 5) perform additional work within ascertain the amount of price.

Among other stakeholders, the contract administrator should identify changes in a timely manner and advise the owner of a positive or negative effect on the project. The designated competent authority, as defined by the employer in the contract, should approve change orders. On governmental projects and some larger projects, the employer may establish a control board to analysis, approve or reject changes (PMI 2016). The contract administrator is responsible for managing and issuing –in writing- instructions as a variation to the contract when delegated. Subject to the relevant authorities' approval, changes to the contract scope or changes in project boundary requires the contracting parties to agree on affecting an amendment to the contract. Contract amendment includes change of the contract price, changed completion time, new scope, and revised project boundary (CEBA 2007). The contract provides a set of claim management rules and breaking the claim management rules may diminish the claimer's right and may influence the claim assessment. It is essential to have experienced staff to manage claims and follow the rules (Jaeger and Hök 2010).

3.2.2.5 Conflict and Dispute Resolution

Conflict is a difference of opinions, thoughts, or interests and the contractor's dis-satisfaction, mistrust, disagreements over contract administrator ‘s decisions cause a conflict. Construction contract clauses can cause differences in understanding of the rights and obligations of the contracting parties for certain circumstances. Several authors argue that conflicts are common and unavoidable in construction (Niraula et al. 2008). Dispute potentials frequently arise from contract clauses related to: 1)drawings,2) physical obstruction, 3) suspension,4) possession of the site, 5)an extension of time, 6) variation, and its valuation, and 7) termination of the contract (Kayastha 2014). Poor contract administration is ranked as the second top causes of conflicts in contractual claims (Nyarko 2014).

With time, unresolved conflict becomes a dispute between the employer and the contractor. Dispute resolution is a multi-level process that aiming to reach an agreement between the contracting parties. Construction dispute is mainly generated from disagreement on contractual discrepancies, changes, additional works, time extension, payment process, quality issues, technical issues, specifications, conflict, information availability, administration, and management decisions. Disputes are caused by several factors includes the large size of works, poorly prepared contracts, multiple contracting parties, miss-understanding assignments, role and responsibilities, inadequate planning, financing issue, organizational complexity, and communication problems (Merritt and Ricketts 2001). Also, disputes may generate from misunderstanding and wrong interpretation of contract clauses (Bin Zakaria et al. 2013), improper allocation of risks, incomplete design, breach of obligations and extensions of time claims (El-adaway et al. 2013). Also, disputes arise when the contractor is not familiar with the clauses provided in the contract (Bin Zakaria et al. 2013). In construction, disputes occur due to several factors, as shown in Figure 3.1.

Disputes arise because the contract administrator does play his assigned role effectively (Odeh and Battaineh 2002). Also, the contractual dispute is an indicator of parties' failure to satisfy their own contractual obligations. (Sadek 2016). As a result, complicated litigation or arbitration case cost overrun, the collapse of communication, and a disturbed relationship occurs. Also, as a result, disputes can significantly impact work success and relationships (Sertyesilisik 2010) and engagement of the court to resolve disputes will render the project completion as impossible (Klee et al. 2015). Each contracting party is a responsibility to know what the contract states (El-adaway et al. 2016). On the other hand, disputes have a negative impact on the project cost, target dates, and quality of construction projects (Abotaleb and El-adaway 2017). Therefore, Proper dispute resolution requires early identification of problems, effective communication, and formalizing of the resolution process in writing. It considered a core skill of successful contract management and administration.

Standard form introduces an alternative dispute resolution mechanism to resolve disputes. Traditional for of dispute resolutions is arbitration, while the mediation, dispute reviewing, or dispute adjudication are modern forms of dispute resolution (Jaeger and Hök 2010). The common dispute resolution methods include several methods such as litigation, arbitration, mediation, conciliation (conciliate by seeking concessions), adjudication, minitrials, partnering, facilitated negotiation and expert determination (Sertyesilisik 2007). If the dispute remains unresolved, parties may possibly go through litigations (Bin Zakaria et al. 2013). Qatar GCoC (CEBA

2007) established the mechanism of resolution dispute through the engineer and then jumped directly to litigation. Typically, disputes start a year or two after project commencement (Arcadis 2017).

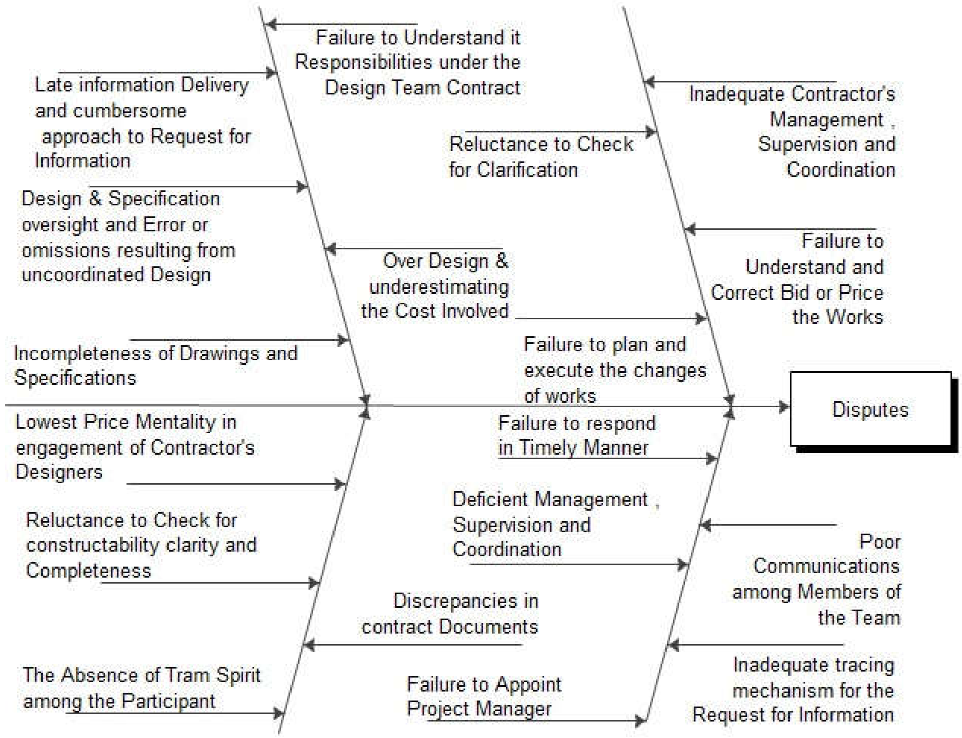

Figure 3.1: Main causes of disputes in construction -Fishbone diagram

Implementing a dispute resolution strategy is one of the proactive methods to reduce dispute and develops a teamwork environment and may lead to preventing disputes from arising (Treasury 2017). The most effective dispute resolution methods are party-to-party negotiation, arbitration, and mediation/ adjudication. The most effective ways to avoid disputes are proper contract administration, accurate contract documents, fair and appropriate risks and balances in contracts, and the presence of truly independent certifiers (Contract Administrator). Another effective way to reduce, if not to eliminate, disputes better understands and interpretation of the contract language, especially regarding assignments, roles, and responsibilities.

3.2.2.6 Maintaining Contract Administration Files

Project records are very important for substantiating any claims/issues and provide objective evidence of complying with the contract requirement. Determination of the contract administration process, dispute resolution process, or court actions are based on the project records (Treasury 2017). The proper contract administration files/ records contain copies of the following applicable documents (Treasury 2017): 1) Contract document and amendments; 2) specifications, drawings or standards incorporated by reference; 3) contractor's submittal requirements list; 4) information supplied to the contractor list; 5) claim notifications, particulars, and evaluations; 6) a schedule of compliance reviews and correspondence and approvals; 7)contractor's records, returns, data, submittals, and reports; 8) routine records such as approval requests and inspection requests and reports; 9) notices to proceed, notices for suspension of works, requests for corrective action and change orders; 10) quality plan/ program, methodology of works, and contractor's work programs; 11) records, of minutes of meetings, meeting agenda and attendance sheets; and 12) contractor's statements and payment certificates.

3.2.2.7 Supervision of Construction, Quality Control, and Quality Assurance

Contract Administrator is entitled to inspect all works carried out (Murdoch and Hughes 2008). The contract administrator is responsible for works' supervising and ensuring compliance with the requirements of the contract in terms of the intent of the design, quality of works, and quality materials, plants, and workmanship. The contract administrator or his representative (supervisory consultant, inspectors, engineers,…etc.) shall make sure the quality of works through inspections, testing, and audits against well-defined and established quality control and quality assurance procedures/ plans (Treasury 2017).

3.2.2.8 Practical and Performance (Maintenance) Certificate

Upon satisfaction of the contract administrator with the completed works, a practical (substantial) completion certificate may be issued, and the employer would take over the works (Cunningham 2016). The defect liability period starts with the issue of the certificate (Jaeger and Hök 2010). FIDIC uses the term "taking-over certificate" to represent the date when the contractor completes the works as per the contract requirement, but there are still minor outstanding works/snags that will have no effect on the intended purpose or using the project (Newboult 2016). The employer refuses or fails to give good reasons not to take over the completed works notified by the contractor's means that the work thought to be handed over. Upon the issue of a hand-over certificate, the contractor is released from the care of work provisions, and a certain percentage of the retention will be released to the contractor.

Performance (completion/defects) certificate is a certificate issued by the contract administrator within a specific period (i.e., 28 days) upon successful completion of all the works and elapse of the latest date of defect liability period. By this certificate, the contract administrator admits the successful rectification of defects. releases the balance retention and fulfills one of the prerequisite requirements to issue the Final Certificate (Cunningham 2016). The contractor's failure to submit all required documents, the test works, and remediate all defects and damages shall give a reason to the Engineer to withhold the Certificate. The performance certificate discharges the contractor's obligations (Treasury 2017). Murdoch and Hughes (2008), argues that the contract administrator's power directly comes from the certification clauses. Also, (Cunningham 2016) argues that the key aspects of contract administration are decision-making and certification.

3.2.3 CCA Additional Responsibilities

3.2.3.1 Termination of Contract

Termination of the contract relieves the contracting parties from unperformed/uncompleted obligations according to the agreed terms and conditions. There are two distinct situations to terminate a contract. The first is a termination for convenience and the second is a termination for default (Treasury 2017). A termination for convenience (sometimes called no-fault termination) permits the employer to termination part of or the whole contract at the employer's sole preference. The employer shall send detailed notice of his intent to terminate the contract or part of the contract to the contractor, the engineer, subcontractors/ suppliers and shall compensate the contractor for the terminated work, performed work, or incurred costs before the effective date of termination (Treasury 2017). Termination for default is attributing to the decision to complete the work by another contractor and terminate the contract due to a contractor's breach or default that allows termination and within the contractor's control. Sometimes. The Employer has the right to claim costs re-procurement/ retendering, and the contractor is liable for actual employer's damages and incurred costs unless otherwise stipulated in the contract (Treasury 2017). Sometimes the termination decision may not be the best option, and the Employer may have to consider the following factors before making a termination decision: 1) does the employer has done reasonable possible things to help the contractor to finish the work; 2) applicable contract provisions and regulations; 3) the specific contractual failure constitute termination; and 4) consider the pros and cons of permitting the contractor to stay or employing a new one (Readiness of the other contractors, the time required to engage, cost, and/or resources required for re-contract, recoveries from the defaulted contractor).

The contract administrator's role in termination is to support the employer with any recording requirement or calculation necessary to process the termination decision. The contract administrator is not involved in the termination decision but is required to negotiate the termination process and the appointment of the new contractor in order to minimize the loss of funds (Fageha 2014).

3.2.3.2 Force Majeure Clauses

When a failure to perform occurs due to grounds outside the control of the contracting parties, or when extraordinary circumstance outside the parties' control, or which could not have been reasonably foreseen at the time of entering into contract prevents one or both parties from fulfilling their obligations then termination of the contract for default may not be taken place. Samples of such events or circumstances are war, embargoes, strike, or an event described as an act of God (such as a volcanic eruption, hurricane, earthquake, flooding, and similar) (Treasury 2017).

The contract administrator role in Force Majeure events is to support the employer with any recording requirement or calculation necessary.

3.2.3.3 Issue Notice to Correct

when the contractor fails to fulfill any obligations, the contract administrator's role is to notify the contractor through a "Notice to Correct". The contractor's failure to comply with those notices allows the employer to use the "termination for default" clauses (Treasury 2017).

3.2.3.4 Closure of Contract

During the defect's liability period (time from issuing Practical or Partial Completion Certificate (PCC) of Maintenance or Completion Certificate), the Engineer has the power to request the contractor to investigate the defects' causes. The contractor shall bear the cost of testes and remedies if he is responsible for the cause of such defects. Defect notification period FIDIC is limited to a maximum of two years in FIDIC (Hillig et al. 2010). The contract closeout process is to verify that contracting parties have discharged their responsibilities and fulfilled their contractual obligations. A contract is completed if all the following cases takes places: 1) completion of all works, defects, and remedies; 2) delivery and acceptance of all reports, manuals, as-built records; 3) completion of all administrative actions; 4) resolving all contract issues; 5) resolving all property, inventory, and ownership issues; 6) return of all employer's material and equipment; 7) the contract administrator has issued final acceptance (if applicable); and 8) the contractor receives the final payment, and the employer receives and final account (Final Statement).

Contract closeout can take place in 5 main situations as follows: 1) complete the required performance of the contract; 2) contract Termination; 3) the occurrence of force majeure and special risks events; 4) mutual agreement to amend the contract; and 5) a decision of a court having jurisdiction.

The contract administrator's role is to ensure completion of all administrative matters, review, issue and certifies the related certificates. Also, parties would examine the success of the contract and document any lessons learned during the course of the contract.

3.2.3.5 Final Account

Final accounts for the construction project represent the final overall due cost of the project includes the cost associated with defect liability period, reconciliation of all changes, outstanding payment as stated in the contract (Zakaria et al. 2013A). The final account starts at the end of the defect liability period and after completing all the predecessor stage. One of the prime tasks of the contract administrator is to ensure processing the final account within a stipulated period to avoid bearing the Contractor's any additional cost or losses (Odeh and Battaineh 2002). Contract administration factors affecting the successful closing of the final account are overuse claim assessment time, unethical acts of employees, outstanding/additional work during the period of maintenance, rationalization of contract rates, communication gap, late certification, /shifting retired key persons, (Odeh and Battaineh 2002). In order to avoid problems in the final account process, the contract administrator should remind all parties to maintain proper records (Naoum and Egbu 2015). The proper closing of the final account without delay shall support the contractor with working Capital and avoid bankruptcy (Zakaria et al. 2013A).

3.2.4 CCA Contribution to Achieving Project Objectives

The standard and ultimate goals of any project are to be completed safely, within time and budget and in accordance with the quality level described. Contract administrator has a great role and responsibility to achieve these objectives and control factors affecting them (Cunningham 2016).

3.2.4.1 Safety

Although the contract administrator is in charge of the overall project safety, the function and obligation are completely the contractor's obligation

3.2.4.2 Time

During construction, the contract administrator performs a prime role to enable the contractor to maintain the date for completion and period of the contract. Time overruns (extensions or delays) are commonly occurring in construction, and the likelihood of time overruns increase relative to the complexity and scale of the project. From the contract administrator perspectives, time overruns occur due to incomplete design/ tender/ design, delayed site possession, unforeseen conditions, weather events, late response to requests for information (RFI), late issue of contract administrator's instructions, employer defaults, and Employer late changes. According to Cunningham (2016), the contract administrator role for time management and control includes activities related to request the contractor to submit feasible and detailed program of work, ensure program is loaded with resources and cost, ensure proper tracking of the program, fairly examine the contractor's entitlement for extension of time, request consistency/recovery plans when to schedule performance index/ critical activities percentage go behind a certain values, require a monthly progress report, monitoring and controlling progress against the program.

3.2.4.3 Cost

During construction, the contract administrator performs a prime role to maintain the contract sum and approved budgets. Cost overruns are commonly occurring in construction, and the likelihood of cost overruns increases relative to the complexity, scale, and duration of the project. From the employer perspectives, cost overruns occur due to incomplete design/ tender/ contract documentation, provisions of material and labors prices inflation not transferred to the contractor, unforeseen events, changes in prime cost sums, contract administrators instructions, variation orders, employer defaults, Employer changes and contractor's claims (Cunningham 2016). According to Cunningham (2016), the contract administrator role for effective cost management includes activities related to not issuing cost-related instructions cost unless approved by the employer; try to balance cost overruns with cost-saving, establish a reporting system for the current and forecasted financial status and ensure proper engineering estimates for instructions before issuing it (Cunningham 2016). Sometimes, the contract administrator may propose suggestions of workable solutions to avoid over budgets to the employer or improving the quality of an item of works. This may lead to an increase in the construction cost but reduce the overall life cycle cost (Kanit et al. 2007). Therefore, cost management and control are one of the most challenging aspects of contract administrators as an employer's agent. The contract administrator will be able to minimize the potentials of cost overruns through effective cost management.

3.2.4.4 Quality

In the long term, the main reason for client dissatisfaction is the frequent detection of a defective product or service. Several contract clauses require the contractor to perform and finish the works in accordance with the contract documents and satisfy the contract administrator. The contract provisions give the contract administrator the right to judge the contractor's works quality. The contract administrator or his delegated personnel (consultant or inspector) has the authority to instruct the contractor to re-open work for inspection, remove/ replace defective work and materials, remove incompetent persons, perform the test, access to the contractor's workshops. Therefore, the contract administrator has several roles in managing quality and confirming the works are performed in accordance with the design intent and specification requirement. The contract administrator should schedule site visits to the site to detect defects and non-compliant work as early as possible. If the Contract Administrator is a third-party organization, the schedule of visits is established through the contract administrator contract with the employer. According to Cunningham (2016), the contract administrator role for effective quality management measures includes establishi4ng a management system to ensure inspection of incoming materials quality, authorities of the inspector to inspection and test materials, and workmanship and procedures to rectify of noncompliant work.

3.3 CONTRACT ADMINISTRATION UNDER STANDARD FORMS

3.3.1 CCA Roles under FIDIC Red Book: 1999

Internationally, the most commonly used form of contract is the Red Book (Hillig et al. 2010; Shnookal and Charrett 2010; Thompson 2006). Therefore, a detailed explanation of the contract administrator roles under FIDIC is discussed in this section.

According to Abdul-Malak and El Masri (2016), the classification of the different roles of the engineer under the contract would help in deciding the best allocation of the contract administration roles among the employer's assigned/ delegated entities. The study focuses on the new red book in which the Engineer term has been cited in 93 sub-clauses. The number of citations represents 61 % of the total sub-clauses within the form. It is an indication of the importance and extends of the role of the Engineer/ Contract Administrator. The authors identify 33 distinct roles for the Engineer. The nine heaviest roles forming 80 % of the engineer's act/react situations are making a determination, instructing, agreeing, requiring requests, giving notices, consenting, and certifying and approving and varying works. From the perspective of the clause-by-clause analysis of the engineer's roles, the contractor's claim (Sub-Clause 20.1) contains eight roles. Six roles are heavily listed in variation procedures (Sub-Clause 13.3), work to be measured (Sub-Clause 12.1), testing (Sub-Clause 7.4), and delegation of the engineer (Sub-Clause 3.2). Five roles are heavily listed in day work (Sub-Clause 13.6), interference with testing on completion (Sub-Clause 10.3), inspection (Sub-Clause 7.3), and unforeseeable physical conditions (Sub-Clause 4.12). Further, the author's analysis shows that the engineer is at the receiving end (reactive role) of submittals, requests, and claims from the contractor for around 70 percent of the situation. The Engineer deals with technical issues in 62 percent, deal with administrative roles in 25 percent and deal with managerial roles 13 percent, respectively of the listed roles. The Engineer should work as an independent professional in 67 percent of the situation.

The principal contracting parties involved in FIDIC forms are the employer as the first party and the contractor as the second party. The employer assigns an "Engineer" for the purpose of the contract in place and notifies the contractor in writing. The role of the engineer in FIDIC (Sub-Clause 3.1) is to act as the employer's agent, designer, supervisor, certifier, and decision-maker (Hillig et al. 2010). He has to act fairly (make fair determination') and imperially on behalf of the employer as an independent professional with any intentions of the contractor, the employer, or the Engineer representative under clause 3.5. FIDIC (1987), requires the engineer's decision or actions to be impartially taken, but FIDIC (1999) requires the engineer to act as the employer agent (Shnookal and Charrett 2010). When the terms of the engineer's appointment call for obtaining a particular employer's approval conditions, the engineer should do so. The engineer main tasks are supervision, monitoring progress and reporting sites status, certify payments and valuation, assess changes and final account, assess contractor's requested for extension of time, determine completion of the project, process project's handover, issue defect lists, approve sub-contractor prequalification requests and process termination of the contract when required. Salwa (2017), reveals the overall role of the engineer under FIDIC is to administer the contract, monitoring construction, and certifying payment.

The employer or the engineer appoints and delegates the engineer's representative to perform some duties under another clause 3. The prime engineer's representative duties are to oversee the contract, supervise works, control workmanship, and quality and examine permanent materials and equipment. The engineer's representative is not authorized to release or waive any contractor's obligations or duties under the contract except as explicitly stated. In addition, he has no authority to order any work causing delay, works involve additional payment or make variations. In addition, the engineer is not authorized to amend the contract, as well. Within the terms of the Engineer's representative delegation, any instructions, consents, agreements, or approvals provided by the engineer's representative shall have the same power of the Engineer's instruction and shall bind the employers and the contractor. However, the engineer's representative failure to disapprove any work or materials shall not affect the engineer's power to reject such work or materials and to order the pulling down, removal or breaking up thereof.

3.3.2 CCA Roles under JCT: 2011

Under JCT form, the architect plays dual roles in administrating and supervising the contract (impartial certifier). The first role is to works as an employer's agent, prioritize the client's requirements, supervise construction, control quality, and workmanship matches the contract provisions. The second role is to work as an independent decision-maker. Between the two contradicting roles, the architect must act impartially to both the employer and the contractor. The architect has the power, duties, and responsibility to issue/certify instructions, submission to authorities having justification, monastery, time claims, losses and expenses, certificates as well as valuations (Sadek 2016).

3.3.3 CCA Roles under NEC3: 2005

Under NEC, the person in charge of the contract administration function is the Project Manager (El-adaway et al. 2016), While FIDIC requires the contractor to claim after the risk has occurred, NEC tries to avoid surprises. Early warning 'no-surprise' means that the project manager and contractor are obligatory to notify each other of any matter, which could affect the project constraints. It is proactive in reducing risk and focus on reducing problems. NEC has probably may advantage over FIDIC and JCT particularly in clarity, flexibility, explicit project management procedures, partnering and teamwork, risk management, objective measurements of weather and ground condition risks and variations.

3.3.4 CCA Roles under AIA, A201: 2007

Under AIA, the person in charge of the contract administration function is the Architect. The architect is an individual qualified to interpret the contract and acts as an owner's representative during construction. The architect concludes his role by issuing the final payment certificate. The architect- contractor relationship is a key issue in the completion of the work (El-adaway et al. 2013). The architect may have representatives to help in performing the architect's responsibilities at the site (Section 4.2.10). The main duties, roles, and responsibility of the architect under AIA –A201, 2007 forms include: 1) reports to the owner the progress, quality, and deviations and keeps him informed about issues (4.2.3); 2) communicates with the owner and the contractor (4.2.4); 3) authority to reject non-compliance works; and call for further inspections and testing (13.5); 4) authority to withhold or invalidate payment certificates (9.5.1); 5) responsibility for reviewing and certifying the contractor 's payments (4.2.5); reviewing and approving the contractor's submittals and shop drawings for compliance with the design concept (4.2.7); 6) responsibility for taking proper actions regarding the submittals schedule (3.10.2); responsibility to avoid claims for the delay (8.3); 7) authority to issue minor change orders and directives, (4.2.8); 8) authority to establish the substantial completion and final completion dates (4.2.9); 9) responsibility to interpret and make decisions to the owner or contractor or may request matters concerning performance and make reasonable decisions consistent with the intent of the contract documents (4.2.11and 4.2.12); 10) reviewing and responding to Requests for Information;11) carrying- out continuous inspections at the site (inspection intervals either lift to design's judgment and owner-architect agreement) and the architect is not anticipated to notice every single deviation from the contract documents; 12) not responsible for the contractor's actions; and 13) not authorized to stop work but this right is kept to the client's rights (2.3).

3.3.5 CCA Roles under Qatar Conditions:2010

Under GCoC (2010), the employer shall assign an engineer to act on behalf of him, the Engineer may assign some of his roles and responsibilities to an Engineer's representative (such as technical issues) and assignment of the Engineer representative does not limit the power of the Engineer to approve/ disapprove any items approved by the Engineer's respective.

The contract administration is assigned to the engineer as defined in clause (1.1.d) and the Engineer representative (1.1.e). The engineer duties, responsibilities and authorities comprises the overall control and supervision of the works including the essential decision on giving consent for sub-letting (4), explain contract documents (6.2), supply further drawing and instructions (6.2), make determination for adverse physical conditions and artificial obstructions(12.2), give instructions and directions related to works (13, approve program of work (14), approve contractor's superintendence (15), object any of contractor's employee (16.1), give setting out references (17), request watching and lighting measures (19), issue instructions relate to care of work (20.1), review insurance policies and payment of premiums, (21 to 24), give orders to deal with discovery of historical staff such as coins, fossils, antiquity or valuable articles (27), make determination with respect to settlement of extraordinary traffic claims (30.3), issue directions with respect to opportunities for other contractors

(31), stratify with clearance of site on completion (33.2), cleaning the works by others upon the contractor failure (33.3), inspect contractors wages books (34.3), stratified with the contractors conditions of employment (34.5),access to return of labors record (35), give direction in relation to quality of workmanship and material and tests requirement (36.1), order additional tests not provided by the contract (36.4), full rights to access to site (37), rights to examine of work before covering up (38.1), power to order removal of improper work and material (39.1), issue order to suspend the progress (40.1), issue orders regarding commencement of works (41), grant an extension of time regarding site position issues (42), make determination on extension of times of completion (44), give permission for night and Friday works (45), give opinion on rate of progress (46), certify completion of works (s 47.2 & 48), satisfied with execution of work of repair during maintenance period (49.2), required the contractor to search for causes of any defect (50), make written variations, valuation to works and fix rates (51.1), authorize payment to be made for contractor's claim(52),give consent to remove certain plant (53.7), approval and rejection of materials (54), ascertain by make admeasurements for variations and interim payments (56.1), examine foundation and works (56.2), approve vouchers and quotations of daywork (57.2). give directions for prime cost items (58.2), give directions to use of provisional and contingency items (58.3), consider the contractor's rejection for a nominated sub-contractor (59.1), review payment to nominated sub-contractors (59.2), examine and approve contractor's monthly statement (60.1), determine release of retention values (60.3), make corrections for interim payments (60.5), examine and approve value of final account (60.8), certify maintenance certificate and end of maintenance period (62.1), make valuation at date of forfeiture (63.2), establish urgent repair cases (64), establish damage to works, etc. by special risks (62.2), determine payment if contract terminated

(65.7), involvement in settlement of disputes - litigation (67.1), agree on constructional plant, temporary works, and materials (71.1), monitor compliance with transportation and shipment requirement (76.1).

3.3.6 CCA Roles under FIDIC White Book:2017

According to Treasury (2017), the form key features are: 1) the term Employer is replaced with Client; 2) the consultant is obligated to undertake a reasonable care, skill, and due diligence while performing his obligations ; 3) the consultant key personnel are subject to the client's acceptance, but the consultant is not obligated to keep the same personnel for the project duration; 4) The form favors the consultant in relation to indemnities, insurance, and compensation; and 6) the client has the right to amend the form to suit his specific requirements. Under the white book, the client and the consultant should act in good faith and mutual trust concepts. The consultant designs work that "fitness for purpose" and is obligated to carrying out its services with reasonable skills, care, and diligence. If the client does not pay the amount due to the consultant, the consultant has the right to waive any related employer's intellectual property provisions under the contract. Furthermore, the Client responsible for the correctness, completeness, and consistency of the client-supplied information. Under construction administration provisions, the consultant would be indemnified even where the relevant claim may be its own fault but and the client indemnifies the consultant to any claims arising out of or associated with the contract.

3.3.7 CCA Roles under Qatar PSA: 2010

Under the PSA, the Engineer is authorized to certify payments, give instructions but has no authority for issuing waivers, terminating Services or relieving any parties of any duties or obligations (PWA 2010). The consultant obligations include exercising all reasonable care, skill, and diligence in the discharge of the services in accordance with good design, engineering, and construction practices (PWA 2010). The consultant other obligations include: 1) written advice, reports, and recommendations; 2) advice regarding good design, engineering and construction practices used elsewhere ; 3) obtaining the prior approval to any change, modification or variation which can influence costs and/or quality and/or time (except in emergency cases); 4) indemnify and keep harmless the client against all claims, damages, losses, fines, and expenses that arise out of or in relation to consultant's services; 5) preparation of all required documents required to complete the services and obtain approval; 6) notify for any defects, errors, discrepancies, inaccuracies, inconsistencies in any of the documents; 7) comply, with all applicable laws, regulations, standards, and instructions; and 8) coordination with third parties keep the engineer informed of any matters and copies of all correspondence to the engineer.

Under Qatar PSA 2010 edition; the consultant particular obligations include: 1) handing over site to contractor; 2) managing construction; 3) contractors' work; 4) coordinating meetings & reports; 5)following-up & updating schedules; 6)following-up cash-flow and estimates; 7) control of quality; 8) quality program; 9) technical supervision; 10) contract's interpretation; 11) record keeping; 12) variations; 13) acceptance of works at completion; 14) final acceptance of works; 15) processing contractors' certificate of payments; 16) auditing the contractor's system; and 17) effecting final payment.

3.4 CHALLENGES IMPACTING CONTRACT ADMINISTRATION

Various challenges, barriers, or factors may hinder the achievement of an effective contract administration. This section will discuss a few of the more prominent problems in the contract administration area which include the pre-awarding phase.

According to Ting and Whyte (2009), contract administration is affected by many factors related to the form of contract that includes issues coverage, clarity issues, completeness and comprehensiveness, international efficiencies issues, and the stakeholders' mentality. Pooworakulchai et al. (2017), study internal and external factors affecting the contract administration in both governmental and private projects in order to improve the management of contracts in governmental projects. The authors divide the pre-contract factors affecting contract administration during the construction period into three main groups, namely quality, time, and cost and the authors establish three key components model (personnel, documentation, and context) for the factors affecting contract administration, as shown in Figure 3.2.

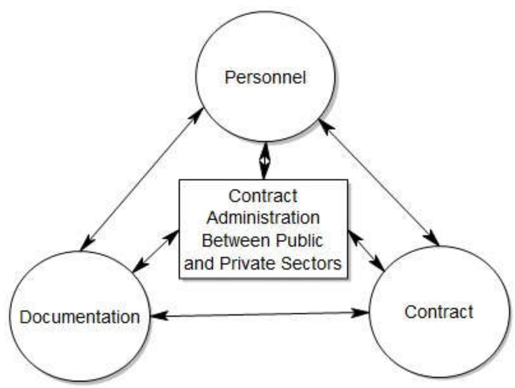

Figure 3.2: Personnel-Documentation-Contexts Model for factors affecting contract administration (Pooworakulchai et al. 2017)

Puil and Weele (2014)listed ten employers' problems in managing contract management as: 1) objectives misalignment between the project client and contractor; 2) the employer lacks knowledge and expertise; 3) active involvement of engineering and other consultants for the sake of business; 4) contract management; 5) inefficient decision-making; 6) frequent scope and planning changes; 7) misunderstanding of what has been agreed; 8) payment problems; 9)local political pressure; and 10) transfer of the responsibility. Park and Kim (2018) cite that inappropriate contract document interpretation, negligence, contractual knowledge, foreign culture issues, communication gap, and absent of change orders necessary documents as the leading reason contract management failure in Korean international projects. Sertyesilisik (2007), sorts the problems in contact into five areas, namely: financial, temporal, compliance, production drawings, and clauses. Ssegawa-Kaggwa (2008) studies the constraints that inhibit the performance of construction enterprises and classify it into three groups, namely: 1) the client/representative, 2) business environment, and 3) enterprise/ contractors' deficiencies. The client/ representative constraints are more contract administration related and contain improper conditions, inadequate documents, inadequate management, and supervision, delayed interim and final evaluations, the industry structure, variability in the workloads, finance issues, and lack of qualified staff.

Ahmed (2015), refers to the contract management challenges to lack of understanding of project management and procurement processes, skilled personnel, transparency, and poor record-keeping. Sebastian and Davison (2011), summarizes the cause of problems in different procurement method of the building process as segregate design and construction; shortage of integration, shortage of effective communication, uncertainty in construction; changeable environment; changeable clients' priorities and expectations; growing project complexity; and economic changes.

Surajbali (2016), reveals that the main challenges exist in contract administration/ management area are the shortage of capacity, skills, and knowledge of key persons; improper communication through organization; shortage of staff; absence of a dedicated unit to manage contract; shortage of policies and shortage of procedures; shortage of contract monitoring; and insufficient training. Puil and Weele (2014) argued that the major problem facing the contracting parties is to convert conflict into cooperation between them and overcome the conflict of interest through negotiation, incentivizes, and improved communications flow. Rendon (2010) lists several challenges associated with contract management such as contract managers experience, budget or timeline constraints hamper, unidentified project status, inadequate resources, conflicts regarding payments, lack of cooperation and inflexibility, changes, tracking global contracts, language difference, identify contract activities and tie to schedule, diverse locations of data, corruption, delayed payments, poor planning, statutory amendments, insufficient use ICT and improper payment procedures.

Joyce (2014) lists the challenges involved in contract management practice as; 1) unclear project scope hinders effective contract management practice; 2)Unrealistic timeline and budgets prevent effective contract management practice; 3)Corruption hampers successful contract management implementation; 4)Inflexibility is a setback to proper contract management practice; 5) Conflicts regarding payments prevent successful contract management practice; 6) Lack of cooperation limits effective contract management practice; 7)Statutory amendments make it hard for effective contract management implementation; 8) Successful contract management practice can fail due to difficulty in managing data in different locations; 9) It is challenging to track global contracts; 10) Insufficient use of ICT limits proper contract management practice; 11) Others. Henriod and Le Masurier (2002), study the causes of contract failure from the perspective of disputes in the contract. The authors list 11 consultant-related main factors causing project failure and construction disputes and consequently impact the contract administration and management functions as 1)Qualifications and experience of consultant staff; 2)Replace qualified personnel with less qualification; 3) Incomplete site investigation and design input information; 4) Poor drawings or specifications; 5) Errors or omissions in drawings or specifications; 6) Conflict among contract/drawings/specifications;7) Poor estimating / cash flow projections; 8) Insufficient programming and scheduling; 9)Arrogance, condescension or intransigence by consultant / client; 10) Poor communications; 11)Corruption.

Several studies in the area of cost, time, and disputes highlight the need for proper contract administration or improper contract administration practices. As a result, several challenges facing contract administration and management are identified. Some challenges are related directly to contract administration activities, whilst many challenges are more related to the organization's structure and preceding activities of the contract management lifecycle. 154 challenges and issues are listed in Appendix A.

3.4.1 Poor Contract Administration

The traditional contracting system has several problems associated with poor contract administration (Ogwueleka 2015). The inability to run into project performance will result in "out of business case;" spend money and effort on arbitration litigation and alternative dispute resolutions. Park and Kim (2017), highlights deficient performances of contract and claim management in several phases of the procurement life cycle as a result of a shortage of contract management experts.

The consequences of poor contract administration and inefficient management of contracts are working against sustaining the industry; heavy fine for non-compliance; substantial loss of savings; incur resources waste; delay in time; productive lose; the presence of several non-value added activities (Saxena 2008); poor control of operations; low rate of satisfying customers; unwanted costs; and more risks (Awwad et al. 2016). The poor contract administration is wasteful and causes problems in contractor-owner relations (Al Jurf and Beheiry 2010; Al Jurf and Beheiry 2012; Gunduz and AbuHassan 2016); delays (Al Jurf and Beheiry 2010; Al Jurf and Beheiry

2012; Ayarkwa et al. 2014; Maki 2016; Salama et al. 2008; Thorat et al. 2017); cost overrun (Abusafiya and Suliman 2017; Adindu and Oyoh 2011; Awwad et al. 2016; Ayarkwa et al. 2014; Farooqui et al. 2014; Salama et al. 2008); reduce profit margins; un-necessary changes; dispute (Abotaleb and El-adaway 2017; Arcadis 2018; Ayarkwa et al. 2014; Farooqui et al. 2014; Love et al. 2007); claims (Ayarkwa et al. 2014; Ntiyakunze 2011; Nyarko 2014); conflict, (Ntiyakunze 2011)project failure(Chow and Ng 2007), bureaucratic procedure (Kasiem 2008), abandoned project (Yap 2013) and more waste and finally eliminate refit margin (Okere 2012). It is considered as the most serious challenge facing project stakeholder Rendon (2007). Abotaleb and El-adaway (2017), state that studies still show poor contract administration as the leading cause of disputes. According to Khekale and Futane (2013), unresponsive contract administration may lead to contractor's claims. Sometimes poor contract administration is caused by corrupt practices (Kasiem 2008). Excessive use of variations; and can be tracked in today's running and completed projects (Okere 2012).

According to Jarkas and Mubarak (2016), poor contract administration that reduces liquidity in the markets, and employer changes are currently the main causes of disputes in GCC states. Yap (2013), lists poor contract administration among the top factors which lead to abound a construction projects because of several problems such as incomplete documents, deficiencies in scope of work, specifications or drawings in terms of ambiguities, discrepancies or mistakes, dispute resolution mechanism is not included in contract or used inappropriate dispute resolution method. Cunningham (2016), illustrates samples of poor contract administration and its consequences. A sample of poor contract administration includes the late issue of information; the late issue of instructions causes delays and incurs additional costs. Another sample is the Employer's failure to pay on time or pay the full amount would damage the working relationships and causes cash flow difficulties. Bent and Thumann (1994), argues that poor contract administration adds artificial and unnecessary risk to the project. Such risks introduce through poor communication, failure to meet obligations, improper coordination essential works, use of difficult terms several parties to the contract, incompatible parties, improper address of statutory or requirement. Equally, the poor contract administration results in a failure to sustain construction and economy because of their systemic and ripple effects (Okere 2012). The poor contract administration by the contractor leads to resources waste, time waste, loss of productivity, the presence of several non-value-added activities. Such consequences drive against the sustainability of the construction industry (Okere 2012). To avoid delay in contract executions, the employer should allow early possession to the site, the early appointment of consultant and contract administrator, and proper coordination with the local authority (Kayastha 2014).

Also, Okere (2012) listed some issues related to contract administration, such as delay of contractor's payment for work done; "bureaucratic" payment certificate procedure; poor financial management; and unavailable funds to pay the contractors. The current practice of the prime stakeholders focuses on the daily requirements of the project and does not pay great attention to the contract terms and conditions. According to Surajbali (2016), the key risk items associated with contract management are unclear roles and responsibilities, unclear deliverables of contract; lack of resourcing; inadequate capacity of staff and finance; inadequate contract performance measurement; inadequate contractor performance; contract changes; inadequate payments; conflict of interest; relationship among stakeholder; improper systems, procedures, and guidance; management of document; failure of service; reputational risk and extra cost.

The consequences of poor contract administration/management have a direct impact on the contractor's and work performance and, consequently, the project delivery. The full list of challenges and issues facing contract administration are listed in appendix A.

3.5 EFFECTIVE ADMINISTRATION AND BEST PRACTICES

Efficient procurement management is a prerequisite to efficient contract administration. Efficiency consists of proper planning and on-time selection of a qualified architect/designer, selection of a competent contractor, and reputable consultant/ engineer. Further, competent engineer, clear contract documents and complete specification, balanced risk-sharing provisions, adequate design include correct site investigation, and well-defined performance standards are leading indicators to have efficient contract administration with a minimum dispute in the construction phase (Kayastha 2014).

The key elements of effective contract management are clear processes; clear contract management plans; lessons learned from contract management practice; particular definition of roles(Cruz and Marques 2013); effective evaluation procedures; presence of knowledgeable contract manager (Uher and Davenport 2009); build qualified team (Greve 2008); flexibility or adaptability (Joyce 2014); development; maintenance of good cooperation and communication; timely response; dispute resolution; establish procedures to reviewed; reject/accept changes; risk management; and corrective/preventive measures (Jha 2013). According to Pooworakulchai et al. (2017), the main elements to attend efficient and effective management are people, documentation, and contexts. According to Cunningham (2016), effective contract administration elements are detailed planning and preparation, effective procedures, clear and timely communications, prompt action, and effective team approach.

Effective contract administrations include not only the understanding but also management of the responsibilities, roles, obligations, liabilities, and powers of the contracting parties. Also, it includes administrating the provisions, procedures, and practices required by the contract (Ting 2013). Elements of effective contract administration are shown in Table 3.2.

Table 3.2: Effective contract management/ administration elements

SN	Element	References
1	Proper planning	Kayastha (2014); Cunningham (2016)
2	Timely decision-making/ action	Kayastha (2014); Cunningham (2016)
3	Selecting a qualified architect/designer	Kayastha (2014)
4	Competent contractor	Kayastha (2014)
5	Reputable, competent & knowledgeable consultant/ engineer	Kayastha (2014); Uher and Davenport (2009)
6	Clear contract documents and complete specifications	Kayastha (2014)
7	Well defined standards	Kayastha (2014)
8	Balanced risk-sharing provisions	Kayastha (2014)
9	Adequate site investigation	Kayastha (2014)
10	Clear roles and responsibility	Ting (2013)
11	Ethical business conduct	Ahmed (2015); and Appiah Kubi (2015)
12	Avoid conflict of interest	Surajbali (2016); Ndekugri et al. (2007); Salwa (2017)
13	Timely response	Jha (2013)
14	Contract early mobilization	Ahmed (2015); and Appiah Kubi (2015)
15	Record keeping	Ahmed (2015); ANAO (2012); Crampton (2010); Robinson (2013);
16	Good cooperation	Jha (2013); (Rendon 2010); and (Joyce 2014)
17	Timely communication	Cunningham (2016); and Jha (2013)
18	Managing relationships	(Alias et al. 2014); and ANAO (2012)
19	Performance management	(Solis 2016); NAO (2016); ANAO (2012);and Jha (2013)
20	Contract monitoring	Wysocki (2012)
21	Clear processes	Cruz and Marques (2013)
22	Establish procedures for changes	Jha (2013)
23	Clear contract management plans	Cruz and Marques (2013)
24	Build an effective team	Greve (2008); Cunningham (2016)
25	Effective procedures	Cunningham (2016); Ting (2013)
26	Managing disputes and Dispute resolution	Jha (2013)
27	Work towards contract completion	Appiah Kubi (2015); and Bartsiotas (2014)
28	Lessons learned from contract management practice	Cruz and Marques (2013); and (Deng et al. 2012)
29	Formulate a 'win-win' situation culture	Wysocki (2012)
30	Flexibility or adaptability	Joyce (2014)
32	Risk management	Jha (2013)
33	Corrective / preventive measures	Jha (2013)

Effective contract administration leads to minimizing disputes and allowing contracting parties to mitigate the associated consequences (Abotaleb and El-adaway 2017). Joyce (2014); and (Surajbali 2016), argues that an effective contract administration program can be used as a risk management tool for all parties. It worth to state that proper implementation of the contract management process constitutes time, cost, and management effort (Oluka and Basheka 2014) but the benefit will safeguard all entities. Abotaleb and El-adaway (2017), argue that proper contract administration is a primary factor in reducing disputes. The main outcome of effective contract administration is the achievement of project objectives (Cunningham 2016).

3.6 CCA CRITICAL SUCCESS FACTOR

The concept of success and project success factors means different things to different people and leads to disagreements (Rendon 2010). Since the 1960s, researchers of project management have been trying to find and explore which factors lead to success. The concept was introduced by Daniel's in 1961 in the automotive industry in the US. Daniel Ronald discussed the problem of insufficient management information for establishing objectives, configuring strategies, constructing decisions, and measuring the output against established goals. The success factors are described as only three to six factors that decide success (Daniel 1961). Gemuenden and Lechler (1997), share the same understanding of CSFs and state CSFs are few things, which must go well to warrant an organization or manager's success. Alias et al. (2014) study summarized the success factors from literature as senior management support, skilled designers, skilled project managers, troubleshooting, the motivation of the team, participants' commitment, a detailed and strong plan, adequate communication channels, effective feedback, effective control, and adequate budget.

Compared with project management, critical success factors literature in the contract management area is not as extensive, and when studied, it covers specific aspects of procurement (Park 2009). Alias et al. (2014) studied 188 individual success factors that contribute to the overall procurement life cycle performance in South Korea. 20 CSFs are identified in contract/administration area, and the top-ranked 10 factors are disputes resolution procedure; mutual/trusting relationships; changes in contact; city planning regulations; the threat of litigation; inclusion of all risks; implement of partnering; recently procured similar projects; long and short-form; commercial bid evaluation. Rendon (2010) studies critical success factors of project management practices and establishes a conceptual framework based on five latent factors, namely action of management; procedures related to project; factors related to human; project-related factors; and external issues. Jha (2013), carries out survey-based research on critical success factors of contract management in governmental USA agencies. The results indicate similarities between critical success factors of contract management and project management as well. The author categorizes the CM-CSF in 7 categories namely; workforce; processes; relationships; resources; leadership; policies ; and requirements. Rendon (2007) discusses the attributes of project success and failure within Indiana construction projects and groups within the cost, schedule, quality, and no-dispute areas. The author listed 28 success variables within the no dispute criterion and 22 failure attributes. The top-ranked success attributes are the competence of the project manager; support of top management; and competence of the owner while the highest failure attribute is listed as ignorance; lack of project manager knowledge; hostile socio-economic environment; the lake of project participant's decisions; faulty conceptualization; negative attitude; and tough climatic conditions. Communication is the indicator of successful contract administration.

3.7 CCA /CM PREVIOUS MODELS AND FRAMEWORKS

The contract administration model provides a designed approach to administrating a contract and assists in identifying the activities required for ensuring successful administration. It does not necessitate that all such activities should be a card out within a contract. The complexity, variable size, risk profile, and nature of a contract will determine the nature and extent of the contract administration activities (Surajbali 2016). There are limited evaluation models, which might be considered while evaluating the performance of the contract administration processes. Some works are listed in the next pages.

According to Garrett and Rendon (2005), the first development of their maturity assessment tool for contract management for the current competence at the organizational level started in 2003. The model is a framework based on software and maturity models of project management. The main objective of the tools is to measure the effectiveness or of the organizations' contract management process, assess the accomplishment of major processes during the contract execution, and provide a framework for improving the level of performance. The model assesses the organization's capability in the main six-contract management sub-process namely; procurement planning; solicitation planning; solicitation; source selection; contract administration; and contract closet. Maturity levels establish five levels, namely: ad hoc, repeatable (basic), defined (structured), managed (integrated with other functional areas), and optimized levels to measure compliance. The model qualified only 10 key CCA activities.

Figure 3.3 summarizes the six dimensions that establish the association between contract administration practices and performance of the general contractors on governmental projects by Okere (2012). Measurable operational factors (dependent variable) are categorized under each dimension. Dependent variables are measured through cycle time, throughput rate, rework, waste, and quality (getting it right the first time). The concept is to compare the project-specific measures with another successful project baseline. For example, shorter times mean that the contractor is responsive, and the level or degree of responsiveness is an indication for meeting the objectives of contract administration. The relevant indicators are built on using the right processes and consistent practices, availability of required capabilities, and achieving the performance requirement. The dependent variables (62 indicators) are validated by applicable policies, standards, and questionnaires to 18 contract administration experts. The dependent variables are chosen from an extensive literature review and contract administration body of knowledge. After validation of the questionnaire by a pilot study, 66 random samples were collected by the web-based questionnaire. Relationships are established through descriptive statistics. A quantitative correlational research design method was used to investigate the association between contract administration performance (dependent variable) and 6 independent variables. The study indicates a strong correlation between the allocation strategies of resources and contract administration performance but failed to address other independent variables. Furthermore, the study did not provide the required predictive model correlating the dependent and independent variables.

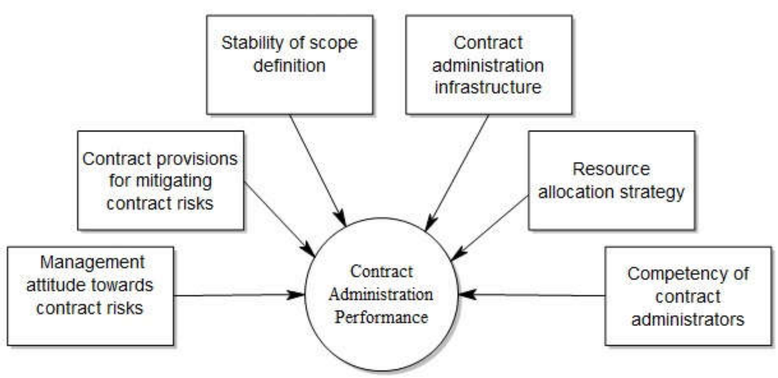

Figure 3.3: Practices affecting Contract administration performance (Okere 2012)

Oluka and Basheka (2014), carry out a study on constraints and determinants of the effective contract management for general procurement of public sector in Uganda. The authors use contract management terms to mean contract administration function and identify six determinate categories and 46 indicators. The determinants are: 1) putting in place structure and resources; 2) ensuring the right people are in place; 3) clear roles and responsibilities; 4) feedback and communications mechanisms; 5) payment and incentives; and 6) managing risks. The study shows the six top constraints as a shortage of political wellness to monitor contracts properly, shortage of capacity to manage and monitor contracts with various stakeholders, shortage of process integrity, shortage of reliable and un-costly dispute resolution mechanisms, too burdensome flexibility when handling regulations, undefined cost overrun due to inflation. Based on a self-administrated questionnaire with 96 response from procurement's practitioners within Uganda using simple mean and standard division statistics, the study reveals that major indicators affecting the effective contract management were identifying processes and establish contract management plan; capturing lessons learned and key data; job descriptions with clear roles; and knowledge of contract management. The author emphasized the importance of and training in parallel with coordination with other stakeholders.

Bartsiotas (2014) focuses on the current United Nations practices and methods to manage post-contracts for goods and services to identify the good administration practices, lessons learned, improvement areas, for the sake of improving the coherence of the overall procurement system. The study uses a model developed by the UN Joint Inspection Unit, which called the Contract Management Process Assessment Model (CM-PAM). The model development is based on the Contract Management Maturity Model by Garrett and Rendon; the United States Government Accountability Office

Framework for Assessing the Acquisition Function at Federal Agencies; the Contracting Capability Maturity Model of the International Association for Contract & Commercial Management (IACCM); and the OECD MAPS methodology. As shown in Figure 3.4, the model provides a structured assessment tool to enable UN procurement organizations to recognize its development level in post-contract management processes and to highlight the contract management strengths and weaknesses.

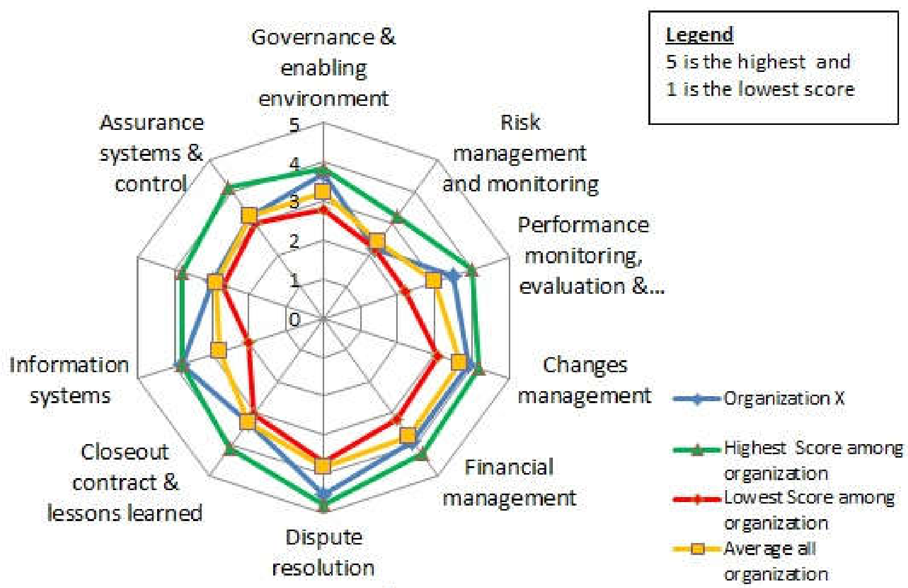

Figure 3.4: Contract management model (Bartsiotas 2014)

Each group of the CM-PAM has several items (formulated as process statements); and measured on a five-point Likert scale (1-never; 2- seldom; 3- sometimes; 4-most of the time; 5-always) to measures the level of development. The CM-PAM assesses the levels of development but does not use statistics. Consistencies, strengths, and areas for improvement are qualitatively analyzed. A questionnaire was distributed to 983 UN staff and data collected from 262 staff in terms of the level of development. The results presented as a comparative ranking of an organization against an aggregate ranking (Maximum, average and minimum score among organizations) of UN organizations and recommendations were drawn on the strength and weakness of each UN organization at the group level was indexed but without drawing an overall performance level

Appiah Kubi (2015); carried out similar works in Ghana. The study used SPSS, and Relative Importance Index to rate the strength of implementation in Ahafo Ano North District Assembly, Ghana by 42 procurement practitioner (purposive samples) throughout semi-structured questionnaires. The research finding determined underperformance in risk management, performance monitoring, contract close-out and information systems. The study emphasized that the post-award process groups need improvement by developing policies, rules and procedures; use integrated and multifunctional team approach; and use Enterprise Resource Planning in contract administration. The model provides consistency of the implementation of contract administration throughout the organization regardless of the organization structure or contract value or volume. The model lists key contract administration activities that can be applied to several organizations level at different firms.

Joyce (2014), uses a conceptual framework comprises of contract management as a latent factor and the operational performance as dependent variables. Independent variable includes five variables, namely: 1) contractor monitoring and acceptance management; 2) managing the contractor relationship; 3) contract administration; 4) dispute resolution; and 5) contract closure. The operational indicators include procurement cycle time, efficiency, relationship, defect rate, and flexibility. Random sample data collected through a questionnaire on a five-point Likert scale from 35 state corporations in Kenya. Joyce uses descriptive statistics and simple linear regression analysis to analyze the data and correlate the contract management operational

Performance index with the five independent variables. The operational performance is measured through cycle time (speed), enhancement of the organizational efficiency maintains relationships, introduces flexibility, and reduces defect rates. The operational performance indexes are calculated as a summation of the independent variables. The findings indicated that effective contract management practiced exists within the studied sample, which has a positive effect on their operational performance. The study revealed that effective contract management improves operational performance. The key recommendations were steady training, suitable information systems in addition to improved flexibility and improved risk management to improve the effectiveness of CCA. Although the study presents an overall performance index, it does not provide evidence on how such an index calculated from the dependent and independent variables and what is the contribution of each variable.

Similarly, Ahmed (2015), performs an exploratory study to identify the determinants and constraints affect effective public procurement performance in Bangladesh in order to provide a base for improving policies and practices in the area of effective procurement management. The key determinants are shown in Figure 3.5. The constraints' categories are socio-political, ethical, and financial issues. The study findings conform to the previous literature of the developed countries and broadly examine the public procurement system rather than a specific industry.

According to NAO (2016), the National Audit Office established qualitative a contract management good practice framework in 2008- because of the non-availability of good practice standards, benchmarking tools or a framework help to improve contract management at that time. The model has been used by several governmental bodies to improve and audit contract management activities. NAO publishes the second edition of the framework in 2016, as depicted in Figure 3.6. The framework lists the eleven-key planning and delivering areas for the operational phase of the contract. Some areas are not relevant to all contracts. Contract development, supplier development, and market management areas are important for high-risk contracts.

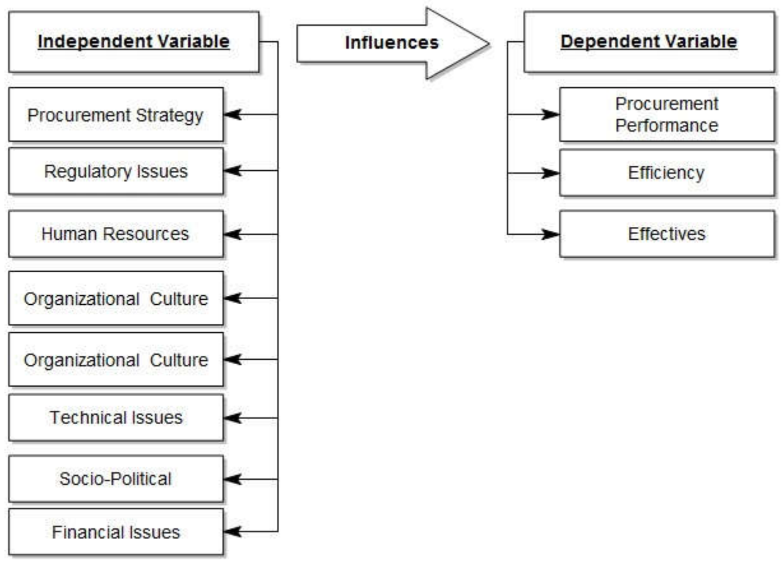

Figure 3.5: Procurement performance conceptual model (Ahmed 2015)

Figure 3.6: Good practice contract management framework (NAO 2016)

Solis (2016) qualitatively develops a functional oriented performance model for the Dutch wastewater industry. The model consists of contract setup; document management; performance management; risk management; changes management; relationship management; and contract closure groups. The model is based on integrated contracts where the scope includes design, build, operate and maintain works. The study uses an interview with 19 construction practitioners and 3 case studies to validate the model through content analysis and without statistics. The study revealed that management would focus on the soft skills of staff, a good relationship also promotes collaboration to achieve the contract goals. Further, the study recommended changing the contract when clauses in case the contractor falls in default.

Surajbali (2016), investigates the post-award contract administration key activities within the general procurement framework of South Africa. The author initially categorizes the challenges facing contract administration and then establishes a framework for managing the contract. The framework contains nine key activities of contract management as a regulatory framework, role players, relationship management, governance and oversight, risk management, organizational arrangements, resourcing and skills development, contract management systems, planning and managing contract and contractor performance, and dispute resolution. Contrary to other models/ frameworks, this study does not provide any detailed activities for contract management. It stops at the group level without having any statistical analysis for the impact of each group. The study concluded the need for a suitable contract management process flow and suitable organizational structure.

Within the previous models, the key contract administration/ management is being arranged or dimensioned in a different way, but still, identifying the same basic requirements for effective administration. The identified activities are almost similar and relate to the implementation of contract management and administration activities.

3.8 SUPPORTING THEORIES

Contract administration strategies focus on two main approaches: the conventional approach and the relational approach. The conventional approach is drawn from economic theory and is largely based on principal-agent theory. The relational approach is based on organizational theory. The aim of both strategies is to ensure that CCA will perform as expected. The predictions of performance are based on a dyadic exchange between parties (Carboni 2012). this study will focus on the conventional approach of relevant theories.

3.8.1 Agency Theory

In 1976 Jensen & Meckling suggest the Agency Theory (also, so-called principal-agent theory) to deal with agency relationships between two parties, the first one is known as the principal and the second one the agent. The theory is developed to illuminate difficulties that may happen due to separation of ownership from control (Carboni 2012) and it emphasizes the reduction of those problems. The theory supports the implementation the various governance approaches to control the agents' actions with corporations. Both parties engage in an association wherein the principal delegates some tasks and decision-making authority to the agent to act on the principal behalf. The agency theory assumes the following issues in the agency relationship (Carboni 2012; Kim 2015; Kleiren 2008; Marigat 2018; Rendon 2010):

1. The goal's conflict of interest between both parties as each party would play on their own interest "agency problem".
2. The agent has more competency, is more involved, and is more informed than the principal "asymmetry of information problem" between the two parties which

would favor the agent and may lead to inefficiency. The divergent interests would occur, and the agent will act opportunistically if not thoroughly monitored and this will lead to moral hazard to the principal due to information asymmetry.

3. The agent may misrepresent its ability to perform to win the contract/job causing "adverse selection problem".
4. The agent acts as "risk-averse" and pushes risks to the principal while principals are risk-neutral and profit-seekers "risk-sharing problem"

To manage the above issues, the principal approach may be oriented in two directions, the first to establish a system to assist the measurement of the agent's performance in terms of behavioral inputs and contract outcomes. The second approach is to set incentives/penalties to enforce the agent to achieve the principal objectives. Also, during the execution of the contract, the agent performance may be in question in terms of proper execution of the delegated works and availability of the required competency/ expertise levels (Marigat 2018). In order to avoid these issues, the principal's requirements should be clearly presented to the agent and the agent should have the competency to meet the principal requirements (Oluka and Basheka 2014). While Marigat (2018) argues that the principal is would able to observe and monitor agents' performance Kleiren (2008) argue that the principal would not be able to observe the agent's performance due to information asymmetry. When the contract specifies the performance requirement and the performance can be tracked, the conventional strategy is effective (Carboni 2012) to manage the agent performance.

In construction, the Employer (principal) engages and delegates the contract administration to his employees, consultant architect or engineer (agent) to perform some tasks on the Employer's behalf. Thus, the agent is contractually authorized to act on behalf of the employer to create a legal relationship with the contractor, and / or suppliers. One of the well-known agency problems is the unpleasant selection of a low-quality agent causing poor contract administration performance. Also, the information asymmetry between the employer and the CCA team often leads to a far performance from the employer's needs. The professional service agreement/ contract regulates and defines each parties' roles and responsibilities. The theory fits the study scope and the issues in agency relationship are commonly occur in construction contract administration as follows:

1. CCA team (outsourced or in-house) should be qualified and competent to perform the agency roles as specified in the contract;
2. The outsourced organization may have their own interest to save costs and provide incompetent persons, not acts or underperform the required service and delay decisions. Such conflict leads to the execution of services (practice) against the / employer's objectives and may cause, cost and quality issues.
3. The contract administration function is well defined in the conditions of contract and the professional service agreement, therefore, the CCA team would execute their roles and responsibility at a predetermined performance level. Such performance levels should be closely measured and monitored.

3.8.2 Technology Acceptance Model (TAM)

Davis in 1986 developed Technology Acceptance Model (TAM) to explain users' acceptance to use technology (Marigat 2018). This theory is based on ease of use new system and value of the system to improved performance, enhanced productivity, effectiveness and efficiency in operations, planning, communication, and decision making. The model relates to the study because the use of ICT (technology adoption) will improve work performance, reduce transmitting time and support fast decision making. Also, the proposed framework and model are a new system to improve performance.

3.8.3 Resource-Based View and Competency-Based View

The resource-based view (RBV) states that resources (i.e. physical, human capital, and organizational capitals) are fundamental elements for the organization's competitive advantage and that improve efficiency or effectiveness It assumes unique resources would make the organization unique (Marigat 2018). the assignment of enough numbers of staff to perform CCA functions is crucial to the overall success.

The competence-based view (CBV) states that competitive advantage is a function of the firm's core competencies. The project success dependents heavily on hiring a competent CCA team or competent organization with experience, skills and training to perform the services properly (Hawkins et al. 2011). Also, CCA requires unique resources that having especial competency in arras of communications, performance monitoring and reporting, finical management, changes and changes control, and dispute management.

Therefore, the CCA framework would consider a separate construct for the resources (team) as a supporting function. and the core competency of the required function as a group of groups.

3.9 THE PROPOSED FRAMEWORK (CAPF)

Best practices and results of contract management and administration can be reached by developing, maintain, monitor the right processes, structure, resources, tools, methods, and techniques to administrate the contract at the project level and maintain issues within control. Therefore, the appropriate measure of the process can guide the required actions toward continuous improvement. The effective contract administration uses a well-established methodology, integrates methods of performance evaluation with the change control process of a contract, and executed by qualified cross-functional team Okere (2012). The performance of Contract administration can be indirectly measured through factual metrics. Such metrics result from understanding the indicators associated with the administration of contract and performance practice.

The literature review demonstrated the importance of contract administration to ensure the successful implementation and execution of the contract. The objective of this section is to identify a framework for contract administration and to determine suitable contract administration activities based on the reviewed literature. Contract administration starts upon signing a contract, the contract administrator and his team would start to plan for managing contract, risk management/ contract management tool, manage contract and contractor performance, manage payments and changes, conduct periodic meetings with key players, coordinate between different parties, manage disputes, issue certificates, produce enormous reports till contract close-out. Such activities require well planning, building an adequate team, and introduce governance and oversight for the whole contract. Comprehensive literature review in the area of management and administration of the contract, determinants of contract administration, problems in contract management/administration, roles and responsibilities of contract administrator, effective contract administration, critical success factors leads to identify 110 indicators and eleven groups (latent factors) affecting the performance of contract administration. Details of each grouped indicators with respect to their referenced studies/ contract detail in Table 3.4 to Table 3.14.

Analysis of the previous models mixes the contract administration function as a sub-process under contract management with the overall contract management lifecycle. To sort factors related to contract administration, some groups would be eliminated. The key activities or groups, which are not relevant to contract administration, are procurement planning, supplier development, the stability of scope definition, source selection, solicitation, solicitation planning, market management, and contract development. Further, it would be noted that key activities/ rarely cited can be grouped with other massively cited areas. Based on the literature review, Table: 3.3Table: 3.3 compiles the different key constructs (dimensions) for contract management/ administration models and frameworks.

Table: 3.3 Constructs of contract administeration framework (CAPF)

Dimension (Construct)	**Appiah Kubi (2015)**	**Bartsiotas (2014)**	**Crampton (2010)**	**Doloi (2013)**	**Joyce (2014)**	**Kayastha (2014)**	**Miller et al. (2012)**	**Moore (1996)**	**Mwanaumo et al. (2017)**	**Okere (2012)**	**Oluka and Basheka (2014)**	**Park and Kim (2018)**	**Solis (2016)**	**Taccad (1999)**
Project Governance & Start-up	√	√	√			√	√		√				√	
Contract Administration Team Management	√	√	√	√						√	√			
Communication & Relationship Management			√	√	√		√	√			√		√	
Quality & Acceptance Management	√	√	√	√		√		√	√					√
Performance Monitoring & Reporting Management	√	√	√	√	√		√	√	√				√	√
Document & Record Management	√	√											√	
Financial Management	√	√	√				√		√		√	√		√
Changes & Changes Control Management	√	√	√			√		√				√	√	√
Claims & Disputes Resolution Management.	√	√	√		√	√			√			√		√
Contract Risk Management	√	√	√	√						√	√		√	
Contract Close-Out Management	√	√	√		√				√			√	√	√

3.9.1 Project Governance & Start-up Management

The latent factor covers establishment of quality management system and project management plan (concentrate on contract administration), project audits, review contractor’s systems and plans, corrective actions, project ground roles, issue instructions to start subletting/ specialist works, authorities process and approvals of contractor's personnel and sub-contractors as shown in Table 3.4. The governance plans are the first step to manage the project (El-Sabek and McCabe 2018).

Table 3.4: The preliminary list of CCA indicators in "Project Governance & Start-up Management" group

Code	Indicator	References
F01.01	Establishment of the overall project management plan (PMP) to outline service delivery	Ahmed (2015); NAO (2016); Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Joyce (2014); Oluka and Basheka (2014); Solis (2016); and Taccad (1999)
F01.02	Review of the contractor's quality management system	Crampton (2010); PWA (2017); Robinson (2013);and Taccad (1999)
F01.03	Review of contractor's health, safety and security plan	Moore (1996); Robinson (2013); and Taccad (1999)
F01.04	Review of contractor's environmental management plan	Crampton (2010); Robinson (2013)
F01.05	Consent on the contractor's baseline Program	Close (2011); Crampton (2010); Cunningham (2016); Gyadu-Asiedu (2009); Moore (1996); Mwanaumo et al. (2017); Northwood and Group (2011); Surajbali (2016); Taccad (1999); Taccad (1999); and Treasury (2017)
F01.06	Consent on contractor's proposed key staff	Mwanaumo et al. (2017); Okere (2012); Robinson (2013); and Treasury (2017)
F01.07	Consent on proposed subcontractor qualifications	Moore (1996); Robinson (2013); Taccad (1999);and Treasury (2017)
F01.08	Kick-off meeting to discuss contract with related parties	Appiah Kubi (2015); Bartsiotas (2014); Garrett and Rendon (2005); Hidaka and Owen (2015); Moore (1996); Northwood and Group (2011); Rendon (2011); Solis (2016); (Taccad 1999); and Treasury (2017)
F01.09	Assistance to the employer in reviewing coverage of contract securities (bonds and insurances)	Appiah Kubi (2015); Bartsiotas (2014); Close (2011); Crampton (2010); Cunningham (2016); Hidaka and Owen (2015); Moore (1996); Mwanaumo et al. (2017); Northwood and Group (2011); Oluka and Basheka (2014); Park and Kim (2018); Robinson (2013); Solis (2016); Taccad (1999); and Treasury (2017)
F01.10	Assistance to the employer in hand over the project to the contractor	ANAO (2012); Close (2011); Crampton (2010); Cunningham (2016); DGS (2010); Gyadu-Asiedu (2009); Joyce (2014); Moore (1996); Northwood and Group (2011); Robinson (2013); Solis (2016); and Treasury (2017)
F01.11	Assisting the employer in appointing nominated subcontractors	Northwood and Group (2011); Robinson (2013); and Treasury (2017)
F01.12	Removal of any person intentionally violating the requirement with reasons from site	Cunningham (2016); Mwanaumo et al. (2017); and Robinson (2013)

3.9.2 Contract Administration Team Management

The latent factor covers the formation of the contract administration team, assign roles and responsibility, and capacity-building activities such as training and staff performance evaluation, as detailed in Table 3.5.

Table 3.5: The preliminary list of CCA indicators in "Contract Administration Team Management" group

Code	Indicator	References
F02.01	Selection of competent Persons (relevant qualifications, skills, knowledge, and experiences)	Ahmed (2015); ANAO (2012); Appiah Kubi (2015); Bartsiotas (2014); Doloi (2013); Gyadu-Asiedu (2009); Joyce (2014); Okere (2012); Oluka and Basheka (2014); Pollaphat and Zijin (2007); PWA (2017); Robinson (2013); Solis (2016); and Taccad (1999)
F02.02	Early assignment of CCA team from different disciplines (i.e., architect, MEP, QS, planner, etc.)	Ahmed (2015); Appiah Kubi (2015); Bartsiotas (2014); Gyadu-Asiedu (2009); Oluka and Basheka (2014); Pollaphat and Zijin (2007); PWA (2017); and Taccad (1999)
F02.03	Identification of roles and responsibilities within the CCA team	Ahmed (2015); ANAO (2012); Appiah Kubi (2015); Bartsiotas (2014); Close (2011); Crampton (2010); Doloi (2013); Gyadu-Asiedu (2009); Joyce (2014); Memon et al. (2015); Miller et al. (2012); OFPP (1994); Oluka and Basheka (2014); Robinson (2013); Solis (2016); Surajbali (2016); Taccad (1999); and Treasury (2017)
F02.04	Availability of training programs for contract administration practices	Ahmed (2015); Appiah Kubi (2015); Bartsiotas (2014); Memon et al. (2015); and OFPP (1994)
F02.05	Regular assessment of staff performance (on time, consistent, fair, etc.)	Ahmed (2015); Appiah Kubi (2015); Bartsiotas (2014); Cunningham (2016); Garrett and Rendon (2005); Gyadu-Asiedu (2009); Joyce (2014); Northwood and Group (2011); OFPP (1994); Oluka and Basheka (2014); Rendon (2011); Solis (2016); and Treasury (2017)
F02.07*	Staff compliance with relevant technical requirement (specification, statutes, regulations)	Appiah Kubi (2015); Bartsiotas (2014); Garrett and Rendon (2005); Hidaka and Owen (2015); Mwanaumo et al. (2017); Okere (2012); Rendon (2011); and Robinson (2013)
F02.08*	Staff compliance with code of ethics (avoid conflict of interest, fraud, corruption, etc.)	Ahmed (2015); ANAO (2012); Appiah Kubi (2015); and Bartsiotas (2014)

- Items revised, shifted or omitted after the semi-structured interview with construction processionals

3.9.3 Communication & Relationship Management

The latent factor covers communication and relationship management activities such as roles of establishing relationships, feedback protocol, information distribution, meetings, joint decision-making, correspondences, and contracting party's consultation/ discussions as detailed in Table 3.6.

Table 3.6: The preliminary list of CCA indicators in "Communication & Relationship Management" group

Code	Indicator	References
F03.01	Development of communication systems (stakeholder, communication matrix, flow, etc.…)	ANAO (2012); Close (2011); Crampton (2010); Doloi (2013); Gyadu-Asiedu (2009); Northwood and Group (2011); Pollaphat and Zijin (2007); PWA (2017); Robinson (2013); Solis (2016); Surajbali (2016); and Surahyo (2018)
F03.02	Communication of project management plan (PMP) to all involved parties	Surajbali (2016); and Cruz and Marques (2013)
F03.03	Advising the employer on its functions (risk, responsibilities, obligations, etc.)	Cunningham (2016); Northwood and Group (2011); Oluka and Basheka (2014); Pollaphat and Zijin (2007); Robinson (2013); and Treasury (2017)
F03.04	Measurement of employer's satisfaction during the contract lifespan	Appiah Kubi (2015); Bartsiotas (2014); Pollaphat and Zijin (2007); and Solis (2016)
F03.05	Prior agreement of the employer for any changes in scope/ quality	Crampton (2010); and Treasury (2017)
F03.06	Regular progress meetings with employer and contractor to address issues and assign actions	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Cunningham (2016); Memon et al. (2015); Northwood and Group (2011); Oluka and Basheka (2014); PWA (2017); Solis (2016); Surajbali (2016); Surahyo (2018); and Treasury (2017)
F03.07	Coordination with third parties (other contractors, utility agencies, designers, etc.)	Moore (1996); Northwood and Group (2011); PWA (2017); Robinson (2013); Solis (2016); and Treasury (2017)
F03.08	Timely response to the contractor's queries (RFI, clarifications requests, etc.)	Crampton (2010); Cunningham (2016); Northwood and Group (2011); Solis (2016); Surahyo (2018); and Treasury (2017)
F03.09	Joint resolution of operational issues at field level	Crampton (2010); Cunningham (2016); Doloi (2013); Joyce (2014); Memon et al. (2015); Oluka and Basheka (2014); PWA (2017); Solis (2016); and Surajbali (2016)

Table 3.6: The preliminary list of CCA indicators in "Communication / Relationship Management" Group (continued)

Code	Indicator	References
F03.12*	Documenting all communications between employer' and the contractor	Oluka and Basheka (2014); Solis (2016); and Treasury (2017)
F03.13*	Prior agreement of the employer for expenditure of additional cost	Appiah Kubi (2015); Bartsiotas (2014); Close (2011); Crampton (2010); Cunningham (2016); Northwood and Group (2011); and Robinson (2013)
F03.14*	Prior agreement of the employer for extending the contract time	Close (2011); Okere (2012); and Robinson (2013)
F03.15*	Management of employer-contractor relationships through understanding of contract provisions	Abotaleb and El-adaway (2017); Ahmed (2015); NAO (2016); ANAO (2012); Appiah Kubi (2015); Bartsiotas (2014); Close (2011); Crampton (2010); Cunningham (2016); DGS (2010); Doloi (2013); Garrett and Rendon (2005); Gyadu-Asiedu (2009); Hidaka and Owen (2015); Joyce (2014); Kayastha (2014); Memon et al. (2015); Miller et al. (2012); Moore (1996); Mwanaumo et al. (2017); Ndekugri et al. (2007); Newboult (2016); OFPP (1994); Okere (2012); Oluka and Basheka (2014); Park and Kim (2018); Pollaphat and Zijin (2007); Rendon (2011); Robinson (2011); Robinson (2013); Solis (2016); Taccad (1999); and Treasury (2017)
F03.16*	Approaching both parties to reach agreement on issues (partnering sessions, open discussions, etc.)	Ahmed (2015); Doloi (2013); Gyadu-Asiedu (2009); Miller et al. (2012); Okere (2012); Robinson (2013); and Treasury (2017)
F03.17*	Regular technical meetings with the contractor to address technical issues includes running reviews	Close (2011); Cunningham (2016); Doloi (2013); Gyadu-Asiedu (2009); Joyce (2014); Memon et al. (2015); Northwood and Group (2011)
F03.18*	Cooperation with the contractor to assess the causes of any defect	Mwanaumo et al. (2017); and Robinson (2013)

- Items revised, shifted or omitted after the semi-structured interview with construction processionals

3.9.4 Quality & Acceptance Management

The latent factor covers the quality control and assurance process, acceptance of completed works, and daily site operations activities. It includes sufficient supervision staff, timely issue of design/ additional information to the contractor, resolve contract document problems, timely review of the engineering documents, detection of defects, corrective and preventive measures, issues certificates, ensure compliance with HSE and environmental requirement as detailed in Table 3.7.

Table 3.7: The preliminary list of CCA indicators in "Quality & Acceptance Management" group

Code	Indicator	References
F04.01	Auditing the contractor's quality management system	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Moore (1996); Mwanaumo et al. (2017); PWA (2017); Robinson (2013); Surahyo (2018); and Treasury (2017)
F04.02	Timely issuance of any further supplementary information (drawings, survey points, etc.)	Ahmed (2015); Close (2011); Cunningham (2016); Doloi (2013); Kayastha (2014); Northwood and Group (2011); Robinson (2013); Surahyo (2018);and Treasury (2017)
F04.03	Timely review of construction material prior to use (submittal review, samples)	Ahmed (2015); Appiah Kubi (2015); Bartsiotas (2014); Northwood and Group (2011); Oluka and Basheka (2014); PWA (2017); Robinson (2013); and Treasury (2017)
F04.04	Timely review of shop drawings	Kayastha (2014); Ndekugri et al. (2007); and Surahyo (2018)
F04.05	Auditing the contractor's compliance with health, safety and security requirements	Crampton (2010); Northwood and Group (2011); PWA (2017); Robinson (2013); and Treasury (2017)
F04.06	Auditing of the contractor's compliance with environmental requirements	Gyadu-Asiedu (2009); Northwood and Group (2011); and Treasury (2017)
F04.07	Verification of quality of work items throughout timely inspections	Close (2011); Crampton (2010); Cunningham (2016); DGS (2010); Gyadu-Asiedu (2009); Joyce (2014); Moore (1996); Mwanaumo et al. (2017); Northwood and Group (2011); PWA (2017); Robinson (2013); Surajbali (2016); (Taccad 1999); and Treasury (2017)
F04.08	Control of non-compliance works	Cunningham (2016); Doloi (2013); Garrett and Rendon (2005); Miller et al. (2012); Mwanaumo et al. (2017); Northwood and Group (2011); Rendon (2011); Robinson (2013); Taccad (1999) and Treasury (2017)
F04.11*	Establishment of quality assurance system	Crampton (2010); Gyadu-Asiedu (2009);Joyce (2014); Mwanaumo et al. (2017); PWA (2017);and Surajbali (2016)
F04.12*	Advice on tests requirement (laboratories, off-site tests, service of a third-party specialist, etc.)	Crampton (2010); Mwanaumo et al. (2017); PWA (2017);and Robinson (2013)
F04.13*	Works compliance with the statutory requirements	Crampton (2010); Cunningham (2016); Hidaka and Owen (2015); Moore (1996); and Northwood and Group (2011)

- Items revised, shifted or omitted after the semi-structured interview with construction processionals

3.9.5 Performance Monitoring & Reporting

The latent factor covers performance management activities such as establishing realistic KPIs, measure customer satisfaction, reporting issues, routine reports to the employer, and sending notifications as detailed in Table 3.8.

Table 3.8: The preliminary list of CCA indicators in "Performance Monitoring & Reporting Management" group

Code	Indicator	References
F05.01	Establishment of monitoring and reporting system (performance indicators (KPI), reporting, etc.)	Ahmed (2015); NAO (2016); ANAO (2012); Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Garrett and Rendon (2005); Hidaka and Owen (2015); Joyce (2014); Memon et al. (2015); Miller et al. (2012); Northwood and Group (2011); Okere (2012); Oluka and Basheka (2014); Pollaphat and Zijin (2007); Rendon (2011); Solis (2016); Surajbali (2016); and Taccad (1999)
F05.02	Separate reporting structure for a major issue to keep the employer informed (additional cost, delays, time extensions, quality concerns, claims, etc.)	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Cunningham (2016); DGS (2010); Doloi (2013); Gyadu-Asiedu (2009); Joyce (2014); Moore (1996); Northwood and Group (2011); Oluka and Basheka (2014); Park and Kim (2018); PWA (2017); Solis (2016); Taccad (1999); and Treasury (2017)
F05.03	Regular progress reports to the employer	Bartsiotas (2014); Moore (1996); Park and Kim (2018); Pollaphat and Zijin (2007); PWA (2017); Surahyo (2018); Taccad (1999); and Treasury (2017)
F05.04	Review of the contractor's reports	Moore (1996); Northwood and Group (2011); PWA (2017); Robinson (2013); Solis (2016); (Taccad 1999); and Treasury (2017)
F05.05	Monitoring of contractor's relationship with subcontractors	Moore (1996); Robinson (2013); and Taccad (1999)
F05.06	Monitoring of the contractor's resources including equipment, materials, and personnel	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Gyadu-Asiedu (2009); Mwanaumo et al. (2017); OFPP (1994); Okere (2012); Pollaphat and Zijin (2007); Robinson (2013); and Treasury (2017)
F05.07	Monitoring the contractor care of the works includes the owner's provided properties	Moore (1996); Robinson (2013); and Taccad (1999)
F05.08	Notifications to the contractor for recovery schedule when progress is slow in relation to the approved Program	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Cunningham (2016); Miller et al. (2012); Moore (1996); Mwanaumo et al. (2017); Northwood and Group (2011); PWA (2017); Robinson (2011); Robinson (2013); Solis (2016); Surajbali (2016); Taccad (1999); and Treasury (2017)
F05.09	Monitoring of contractor's arrangements to minimize public interferences	Robinson (2013)
F05.10	Notification to the contractor on failure to carry out any contractual obligation	Park and Kim (2018); and Treasury (2017)

3.9.6 Document & Record Management

The latent factor covers the critical issues with respect to contract records such as the system of electronic and integrated record management, as detailed in Table 3.9.

Table 3.9: The preliminary list of CCA indicators in "Document & Record Management" group

Code	Indicator	References
F06.01	Establishment of document management system (issuing, distributing, receiving, filing, etc.)	Appiah Kubi (2015); Bartsiotas (2014); DGS (2010); Northwood and Group (2011); Park and Kim (2018); PWA (2017); Solis (2016); Surajbali (2016); and Treasury (2017)
F06.02	Use of information communication technology (ICT) in administering the contract	Bartsiotas (2014); Doloi (2013); Gyadu-Asiedu (2009); OFPP (1994); Oluka and Basheka (2014)
F06.03	Registration of all project documentations (logs)	Crampton (2010);and Solis (2016)
F06.04	Collection of contract management statistics from project record (dashboards, safety statistics)	Appiah Kubi (2015); Bartsiotas (2014); and Solis (2016)
F06.05*	Audit of the contractor's documentation system	Moore (1996); Mwanaumo et al. (2017); Northwood and Group (2011);
F06.06*	Maintaining up to date records	Ahmed (2015); ANAO (2012); Crampton (2010); Joyce (2014); Northwood and Group (2011); Oluka and Basheka (2014); PWA (2017); Robinson (2013); Solis (2016); Surajbali (2016); and Treasury (2017)
F06.07*	Maintaining all project documentation in a safe area	Bartsiotas (2014); Crampton (2010); and Park and Kim (2018)

- Items revised, shifted or omitted after the semi-structured interview with construction processionals

3.9.7 Financial Management

The latent factor covers the payment and financial management key activities necessary to avoid cost overrun, shortage of funds, and related disputes as detailed in Table 3.10.

Table 3.10: The preliminary list of CCA indicators in "Financial Management" group

Code	Indicator	References
F07.01	Establishment of a system for payment processes and budget control	NAO (2016); Bartsiotas (2014); Memon et al. (2015); and Solis (2016)
F07.02	Timely, issuance of instructions to expend provisional sums	Northwood and Group (2011); Robinson (2013); and Treasury (2017)
F07.03	Certification of due payments within time as stipulated in the contract	Abotaleb and El-adaway (2017); Appiah Kubi (2015); Bartsiotas (2014); Close (2011); Crampton (2010); Cunningham (2016); DGS (2010); Doloi (2013); Garrett and Rendon (2005); Gyadu-Asiedu (2009); Hidaka and Owen (2015); Joyce (2014); Miller et al. (2012); Moore (1996); Ndekugri et al. (2007); Northwood and Group (2011); OFPP (1994); Okere (2012); Oluka and Basheka (2014); Park and Kim (2018); PWA (2017); Rendon (2011); Robinson (2013); Surajbali (2016); Surahyo (2018); Taccad (1999); and Treasury (2017)
F07.04	Advice the employer of the time limits for processing payment	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); DGS (2010); Northwood and Group (2011); Robinson (2013); and Taccad (1999)
F07.05	Assessment of the contractor's compensation for delayed payments	Abotaleb and El-adaway (2017); Ahmed (2015); Okere (2012); Park and Kim (2018); and Robinson (2013)
F07.08*	Issuance of accurate engineering estimates to the employer	Crampton (2010); Cunningham (2016); Gyadu-Asiedu (2009); Park and Kim (2018); Pollaphat and Zijin (2007); and PWA (2017)
F07.09*	Timely, issuance of instructions to expend prime cost items	PWA (2017)
F07.10*	Records of any measurement required for payment (work performed, day work record, etc.)	Close (2011); Mwanaumo et al. (2017); Northwood and Group (2011); Robinson (2013); and Treasury (2017)

- Items revised, shifted or omitted after the semi-structured interview with construction processionals

3.9.8 Changes & Changes Control Management

The latent factor covers the key activities of contract administration to control changes and allow only authorized changes. Such activities include the establishment of change/ change control team, assessment of changes, urgent changes, assessment of differing site conditions, and value engineering, as detailed in Table 3.11.

Table 3.11: The preliminary list of CCA indicators in "Changes & Changes Control Management" group

Code	Indicator	References
F08.01	Establish change control procedures (i.e. managing, controlling, and negotiating changes)	ANAO (2012); Appiah Kubi (2015); Bartsiotas (2014); Cunningham (2016); Doloi (2013); Garrett and Rendon (2005); Gyadu-Asiedu (2009); Hidaka and Owen (2015); Joyce (2014); Kayastha (2014); Miller et al. (2012); Gunduz (2002); Mwanaumo et al. (2017); Okere (2012); Oluka and Basheka (2014); Rendon (2011); Solis (2016); Surajbali (2016); and Treasury (2017) ;
F08.02*	Timely evaluation of contractor's proposals for changes inclusive value engineering	Close (2011); Crampton (2010); Garrett and Rendon (2005); Hidaka and Owen (2015); Moore (1996); PWA (2017); Rendon (2011); Robinson (2013); Surahyo (2018);and Taccad (1999)
F08.03*	Suggestions of workable solutions to avoid over budgets to the employer	Ahmed (2015); Cunningham (2016); Miller et al. (2012); Mwanaumo et al. (2017); and PWA (2017)
F08.04	Instructions to execute changes involving work of incidental nature to the contractor	Moore (1996); Northwood and Group (2011); Robinson (2013); and Treasury (2017)
F08.05	Issuance of change orders on employer's approved changes requests with a detailed scope of work	Close (2011); Crampton (2010); Northwood and Group (2011); Okere (2012); Oluka and Basheka (2014); Park and Kim (2018); PWA (2017); Robinson (2013);and Taccad (1999)
F08.06*	Timely, issuance of instructions for dealing with remains found on site (fossils, coins, articles of value, etc.)	Doloi (2013); Northwood and Group (2011); Robinson (2013); and Treasury (2017)
F08.07*	Assessment of potential changes (demand, causes, scope, impact, etc..)	Crampton (2010); Northwood and Group (2011); Park and Kim (2018); PWA (2017); and Solis (2016)

- Items revised, shifted or omitted after the semi-structured interview with construction processionals

3.9.9 Claims & Disputes Resolution Management

The latent factor covers the key activities of contract administration to minimize disputes and problems. Such activities include a fair assessment of the contractor's claims, timely response, and settlement of claims and avoid litigations. It extends the contract administration function to support the client when other dispute resolution procedures are exhausted, and legal cases cannot be avoided as detailed in Table 3.12.

Table 3.12: The preliminary list of CCA indicators in "Claims & Disputes Resolution Management" group

Code	Indicator	References
F09.01	Establishment of claims and disputes resolution system	Cunningham (2016); Hidaka and Owen (2015); Joyce (2014); Memon et al. (2015); Oluka and Basheka (2014); PWA (2017); and Surahyo (2018)
F09.02	Notification to the contractor for the employer's rights to claim (failed tests, clearances, remedial works, etc.)	Abotaleb and El-adaway (2017); Mwanaumo et al. (2017); Newboult (2016); Northwood and Group (2011); Robinson (2013); Taccad (1999); and Treasury (2017)
F09.03	Assessment of contractor's entitlement for extension of time for completion	ANAO (2012); Bartsiotas (2014); Close (2011); Cunningham (2016); Kayastha (2014); Mwanaumo et al. (2017); Northwood and Group (2011); Okere (2012); Park and Kim (2018); Robinson (2013); Solis (2016); Surahyo (2018); Taccad (1999);and Treasury (2017)
F09.04	Assessment of contractor's entitlement for additional payment	Appiah Kubi (2015); Close (2011); Mwanaumo et al. (2017); Northwood and Group (2011); Okere (2012); Park and Kim (2018); Robinson (2013); Surajbali (2016); Surahyo (2018); and Treasury (2017)
F09.05	Negotiating additional cost and durations claims with the contractor	Appiah Kubi (2015); Bartsiotas (2014); Moore (1996); Park and Kim (2018); Solis (2016); Surahyo (2018); and Taccad (1999)
F09.06	Assisting the contracting parties to select alternative dispute resolution method	ANAO (2012); Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Garrett and Rendon (2005); Memon et al. (2015); PWA (2017); Rendon (2011); Solis (2016); Surajbali (2016);and Taccad (1999)
F09.07	Represent the employer in alternative dispute resolution proceedings	Bartsiotas (2014); Okere (2012); and Robinson (2013)
F09.08	Legal support to the employer when other dispute resolution procedures are exhausted	Appiah Kubi (2015); and Bartsiotas (2014)
F09.09	Works to defend the employer against artificial claim situations.	Mwanaumo et al. (2017); and PWA (2017)

3.9.10 Contract Risk Management

The latent factor covers the key activities of contract administration to reduce the contractual risks. Such activities include risk identification and register, accountability for risk mitigation plans, proactive steps to reduce design and construction-related risks, involve the contractor in risk management, and ensure enough resources as detailed in Table 3.13.

Table 3.13: The preliminary list of CCA indicators in "Contract Risk Management" group

Code	Indicator	References
F10.01	Involvement of contractor in contract risks management process	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Solis (2016)
F10.02	Assignment of responsibility for implementing any necessary risk mitigation to the relevant party	Appiah Kubi (2015); Bartsiotas (2014); and Solis (2016)
F10.03	Advice employer regarding design review findings in the early stage of the project	Crampton (2010); Moore (1996); Pollaphat and Zijin (2007); PWA (2017); (Taccad 1999); and Treasury (2017)
F10.04*	Identification and quantification of anticipated risk (service failure, damage, changes, fraud, etc.)	NAO (2016); ANAO (2012); Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Gyadu-Asiedu (2009); Joyce (2014); Oluka and Basheka (2014); PWA (2017); and Solis (2016)
F10.05*	Assist contracting parties in the implementation of actions to mitigate risk	Solis (2016); and Treasury (2017)

- Items revised, shifted or omitted after the semi-structured interview with construction processionals

3.9.11 Contract Close-Out Management

The latent factor covers the key activities of contract administration to ensure proper administrative and contractual closeout of the contract. It includes unusual scenarios such as suspension and termination of the contract. Such activities include structured closeout procedure, the return of deployed resources, final inspections process, completion certificates, closeout records, defect liability period, defect rectification/ compensation, documenting and sharing lessons learned as detailed in Table 3.14

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Table 3.14: The preliminary list of CCA indicators in "Contract Close-Out Management" group

Code	Indicator	References
F11.01	Development of close-out procedures with checklists (final acceptance, substantial completion, site clearance, final reports etc.)	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); DGS (2010); Garrett and Rendon (2005); Hidaka and Owen (2015); Mwanaumo et al. (2017); PWA (2017); Rendon (2011); Surajbali (2016); Surahyo (2018); and Treasury (2017)
F11.02	Communication of closeout activities to all stakeholders (end-user, legal, finance, etc.),	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); OFPP (1994); and PWA (2017)
F11.03	Verification of physical works completion (testes on completion, final inspection, etc.)	Crampton (2010); DGS (2010); Garrett and Rendon (2005); Hidaka and Owen (2015); Joyce (2014); Miller et al. (2012); Moore (1996); Mwanaumo et al. (2017); Northwood and Group (2011); Park and Kim (2018); PWA (2017); Rendon (2011); Robinson (2013); Surajbali (2016); Surahyo (2018); Taccad (1999); and Treasury (2017)
F11.04	Review of contract close-out document (as-built, manuals, warranties, clearance certificates, etc.)	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Garrett and Rendon (2005); Hidaka and Owen (2015); PWA (2017); Rendon (2011); Robinson (2013); and Treasury (2017)
F11.05	Timely, issuance of taking-over certificate with associated snags	Close (2011); Crampton (2010); Cunningham (2016); Joyce (2014); Mwanaumo et al. (2017); Newboult (2016); Northwood and Group (2011); Park and Kim (2018); PWA (2017); Robinson (2013); and Treasury (2017)
F11.06	Timely, release the first half of the retention upon issuing taking over (completion) certificate	Robinson (2011); Robinson (2013); and Treasury (2017)
F11.07	Approval of return of deployment of the contractor's resources	Garrett and Rendon (2005); Hidaka and Owen (2015); Rendon (2011); Robinson (2013); Solis (2016); and Treasury (2017)
F11.08	Periodic inspections of the works during defects notification period (snags, defects, maintenance, etc.)	Crampton (2010); Moore (1996); Park and Kim (2018); PWA (2017); Robinson (2011); Robinson (2013); Taccad (1999); and Treasury (2017)
F11.09	Timely, issuance of performance certificate when the contractor's obligations are fulfilled	Crampton (2010); Joyce (2014); Mwanaumo et al. (2017); Park and Kim (2018); Robinson (2013); Solis (2016); and Treasury (2017)
F11.10	Documentation of lessons learned, and best practices	Ahmed (2015); Appiah Kubi (2015); Bartsiotas (2014); Garrett and Rendon (2005); Hidaka and Owen (2015); Oluka and Basheka (2014); Rendon (2011); and Solis (2016)
F11.11	Processing contractor's final account (contract adjusted sum)	Appiah Kubi (2015); Bartsiotas (2014); Crampton (2010); Hidaka and Owen (2015); Moore (1996); Mwanaumo et al. (2017); Northwood and Group (2011); PWA (2017); Robinson (2013); Solis (2016); Surajbali (2016); and Taccad (1999)

Table 3.14: The preliminary list of CCA indicators in "Contract Close-out Management " group (continued)

Code	Indicator	References
F11.12	Issuance of instruction with respect to suspension of works	Close (2011); Robinson (2013); Taccad (1999); and Treasury (2017)
F11.13	Management of process leading to a notice of termination	Appiah Kubi (2015); Bartsiotas (2014); Garrett and Rendon (2005); Hidaka and Owen (2015); Joyce (2014); Mwanaumo et al. (2017); Rendon (2011); Robinson (2013); Solis (2016); and Taccad (1999)
F11.14*	Collection of the employer authorization to issue a certificate	Robinson (2013)
F11.15*	Maintain the employer entitlement to an extension of the defects notice period due to major defect	Robinson (2013); and Treasury (2017)
F11.16*	Timely, release the second half of the retention, and bonds by the end of the defects notification periods	Abotaleb and El-adaway (2017); Crampton (2010); Robinson (2013); and Treasury (2017)
F11.17*	Assessment of consequences of suspension	Kayastha (2014)
F11.18*	Assessment of contractor's compensation for termination	Robinson (2013); Taccad (1999); and Treasury (2017)

- Items revised, shifted or omitted after the semi-structured interview with construction processionals

3.10 CHAPTER SUMMARY

The above literature gives evidence that the contract management and administration terms do not have a single definition or a consistent meaning, but the term covers different activities. Further, equally contract administration and contract management terms are common in literature and are normally used in an either blurred or even similar manner. Within the general procurement management, the literature reviewed has revealed that the contract administration and management activities are almost the same, regardless of the organizational structure, activities names, or category. The activities deal fundamentally with the same requirements for the management of a contract. Contrary and for the purpose of this research, construction contract administration is a function of a third party assigned by the employer to ensure each party fairly and impartially meets their contractual obligations.

The importance of contract administration, consequences of poor contract administration is supported by the literature review. The necessity to have a framework or model for contract administration is highlighted in the literature review. The contract administration framework should include elements such as governance, processes, tools, and reporting mechanisms that will guide the successful implementation, administration, and closeout of the construction contract. Twelve latent factors' framework for performance indicator of the contract administration has been proposed. Further, 107 critical activities for the successful administration of contracts have been identified.

None of the literature reviewed models explain or predict the quantified contract administration's overall performance, and the next chapter provides the research methodology to quantify the contract administration performance.

CHAPTER 4 : THE RESEARCH METHOD

4.1 INTRODUCTION

This chapter introduces the research design and the detailed process required to answer the research questions, achieve the objectives of the research, and select an appropriate approach for the research. The current research methodology uses an exploratory sequential mixed method in research design. It contains both quantitative and qualitative approaches such as comprehensive literature review, interviews with industry professionals, Delphi study, and questionnaire survey. Also, it contains, sampling design, target population, and the instrument for data collection.

4.2 THE RESEARCH QUESTIONS

Cooper and Schindler (2014), define research as a systematic inquiry to provide information to solve managerial problems. The problem statement of the present study is presented in Chapter 1, and the next sections introduce three major research approaches.

4.3 THE RESEARCH WORLDVIEW

A research worldview (also called paradigm or philosophy) is the foundation or theoretical framework on which people view events and an understanding of a research problem of a study (Fellows and Liu 2008). By other meanings, the research worldview means the basic beliefs (assumptions) that guide the overall research (Ssegawa-Kaggwa 2008). The worldview represents the top of the researcher pyramid, followed by research methodology, method, and techniques (Jonker and Pennink 2010). A worldview consists of 4 philosophies:

1. Postpositivist philosophy deals with reducing knowledge into discrete variables for hypothesis testing in a deterministic and reductionistic way. The researcher assumes a theory and tests it with empirical data. It includes a quantitative approach, collects quantifiable data, and conduct statistical analysis
2. Constructivist philosophy is the qualitative interaction between individuals to develop theory through a collection of qualitative data and conduct textual/photo analysis.
3. Transformative philosophy is focused on marginalized society individuals or social justice issues that required to be studied. Commonly, the research covers acts that may change the participants' lives.
4. Pragmatist philosophy deals with practical solutions to a problem. Using all available approaches (i.e., mixed method).

4.3.1 The Research Approaches/ Strategies

Creswell (2014) explains the research approach- which will guide the research design as- the decision generated from the philosophical worldview, research methods, and strategies of inquiry (also called research methodologies or designs. The more common research approaches (Also, called research strategies or methodologies of inquiry) consist of 3 main categories, namely the quantitative, the qualitative, and mixed-method strategies. The selection of a certain approach is based on the study problem, the experience of the researcher, and the audiences (Creswell 2014). The philosophies are different in their approach to research, as shown in Table 4.1.

1. Qualitative research approach (alternative names such as objectivist, positivist, scientific, experimentalist, traditionalist, or functionalist) explores the meaning of a human or social problem in which the researcher seeing a phenomenon and report conclusions. Fellows and Liu (2008), see the qualitative research as a predecessor

to quantitative research for new studies to address questions such as what, how much, how many;

2. Quantitative research approaches (alternative names interpretive, subjective, phenomenological, humanistic, constructivist or post-modern) attempt precise measurement of something or examining the relationship among variables to test an objective theory (Creswell 2014). Quantitative approaches implement a scientific method based on a study of theory and literature and establish objective propositions and hypotheses to be tested (Fellows and Liu 2008). The quantitative methods give proved, repeated, and generalized results but it may not be able to explain many social phenomena which can be explained by the qualitative method; and
3. The mixed-method is a midway philosophy compiles quantitative and qualitative method (also known as realists or pragmatists). The mixed-method is considered a more suitable approach because it compiles the advantage of the quantitative and qualitative methods (Creswell 2014; Fellows and Liu 2008). The quantitative and qualitative approaches are most often complementary to each other. The mixed-method has three types (Creswell 2014):
    a. A sequential mixed-method strategy implements quantitative and then qualitative methods and vice versa. Explanatory sequential design starts with quantitative data and followed by qualitative data to explain the quantitative data. Exploratory sequential design starts with qualitative data that build to determine quantitative data to explain the qualitative data.
    b. Concurrent mixed-method strategy implements the quantitative and qualitative methods simultaneously in data collection, integrate data then analyses.

c. A transformative mixed-method strategy implements a theoretical lens and then collect quantitative and qualitative data.

Table 4.1: Research approaches (Cooper and Schindler 2014)

Tends	Qualitative Approaches	Quantitative Approaches	Mixed Methods
Assumptions	Constructivist/ transformative	Postpositivist	Pragmatic
Strategies of inquiry	Phenomenology, grounded theory, ethnography, case study, and narrative	Surveys and experiments	Sequential, concurrent, and transformative
Methods	Open-ended questions. Emerging approaches Text or image data	Closed-ended questions Predetermined approaches Numeric data	Open & closed-ended questions, & predetermined & Emerging approaches Quantitative and qualitative Data and analysis
Researcher	Position himself	Verifies theories or explanations	Collects both quantitative & qualitative data
	Collects participant meanings	Identifies variables	Develops a rationale for mixing
	Focuses on a single concept or phenomenon	Relates variables in questions or hypotheses	Integrates data at different stages
	Brings personal values into the study	Uses a standard of validity & reliability	Presents visual pictures of the procedures in the study
	Studies the context or setting of participants	Observes & measures numerically	Employs the practices of both qualitative and quantitative research
	Validates the accuracy of findings	Uses unbiased approaches	
	Makes interpretations of data	Employs statistical procedures	
	Develops an agenda for change or reform		
	Collaborates with the participants		

4.4 RESEARCH METHODS

A systematic assessment of the research process forms the basis to select an appropriate strategy and data collection methods. The research methods are shown in Figure 4.1. The research taxonomy is divided into 6 phases. The first phase is the research philosophies followed by the study description, strategies, time horizon, data collection methods, and types of analysis.

4.4.1 Types of Research Study

The research study description is to justify the most appropriate research methodology. Research studies related to a hierarchy of inquiry. It deals with understanding the phenomenon's hierarchy. Types of research studies are presented into four types, namely: explanatory, descriptive, relational, explanatory, and predictive studies (Cooper and Schindler 2014; Fellows and Liu 2008).

1. The descriptive study helps to understand and document the existence of a phenomenon to answer questions like what, when, who, and where.
2. The explanatory study helps to explain the concept required for identifying and developing a study pattern(s) not available in the literature. It is an extension of descriptive study where the reasons for the phenomenon can be clarified

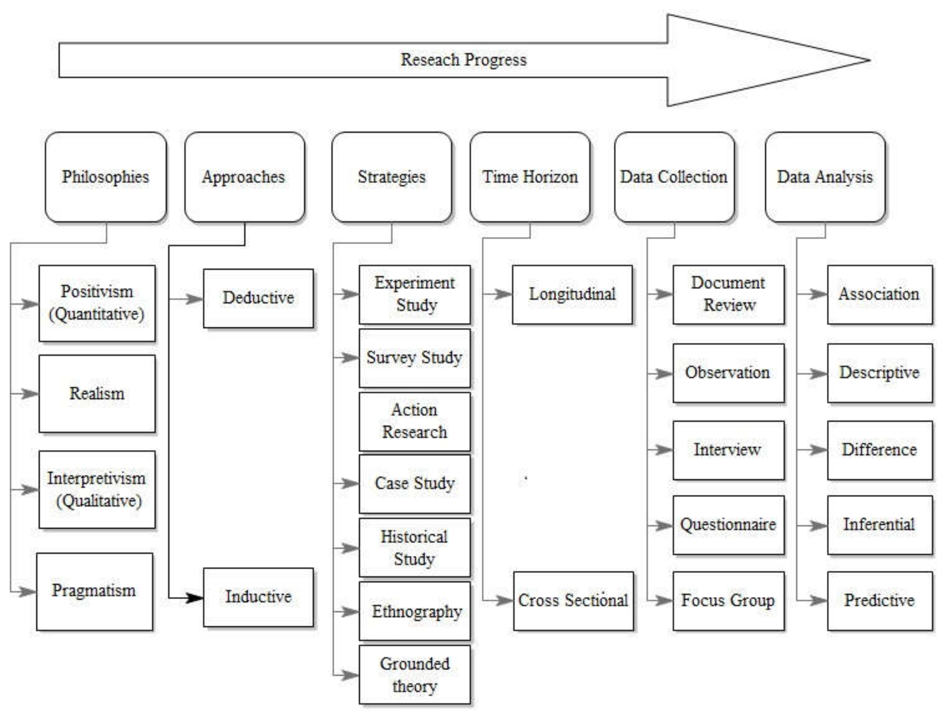


Figure 4.1: The research methods (Saunders et al. 2009; Ssegawa-Kaggwa 2008)

3. The relational study identifies variables and the relationship between variables in order to answer how and why variables. The relational study is divided into two main categories, namely correlational and causal studies.
    (a) The correlational study defines the relationship between the variables.
    (b) The causal study defines which variable causes the change in the other variable through cause and effect pattern. The variable that leads to change is called an independent variable, and the other variable is called the dependent variable.
4. The predictive study is a replication and generalization of the causal relationship to form a theory or model to predict the outcome of a situation (forecast) and to answer why and how questions.

The current study is not explanatory because the topic is not new except in the sense of how they can be quantitively measures. It investigates the relational between the measurable factor and the latent dimension. The nature of the CCA performance problem favored a causal/predictive study type.

4.4.2 Research Strategies

research strategy (also called research styles) is a result of combining the research aims, actions, philosophies, analysis, and selection. The research strategy provides specific procedures to identify the study subjects, sampling method, data source, data collection, and interpretation of results. The main research strategies are classified as ethnography, historical, case study, survey, action research, and experiment strategies (Cooper and Schindler 2014; Fellows and Liu 2008; Saunders et al. 2009).

1. Ethnography strategy: the strategy involves the researchers to engage themselves as part of the subject environment.
2. Historical strategy: the strategy involves studying past events throughout the collection and interpretation of information from documentation and interviews.
3. Case study strategy: The strategy (also called case history) is focused on a deep review of selected cases because cases offer critical, extreme, or unusual cases (Cooper and Schindler 2014). It represents the depth of information for the only studied cases and, therefore, may not be generalized to other cases.
4. Survey strategy: the strategy is focused on collecting and interpreting information from a group of people. It represents the breadth of information and, therefore, may be generalized to other cases.
5. Action research strategy: the strategy is to address complex, practical problems with little historical information through changing or improving practices of a processor people.
6. Experiment strategy: the strategy is to standard procedures to explain how or why a phenomenon occurs (cause and effect relationship) within a controlled environment through standard procedures. It contains independent and dependent variables. Internal and external validity is tested within the experiment (Cooper and Schindler 2014).

The current research uses the survey research strategy to study the importance of the identified factors on the performance of CCA through a random sample of construction practitioners.

4.5 Data Collecting Methods

The data collection is associated with the methods to collect data for further investigation or interpretation (Cooper and Schindler 2014). The main data collection methods are categorized into 5 groups namely, document review, observation, interview, questionnaire, and focus groups.

1. Document Review: it involves studying past events through a review of the document and records.
2. Observation Method: it involves the researcher to record the phenomenon in as it happens. The demerit came are:
   (a) first the researcher presence may impact the behavior of the participant, and
   (b) second the time-consuming observations.
3. Interview: It involves the researcher to conduct telephone, video conferences, and/ or a face-to-face discussion with the participants. The researcher asks structured, semi-structured, or unstructured questions to collect data. The structured questions are completely predetermined by the interviewer, while unstructured questions introduce briefly about the study topics. Semi-structured questions lay between the other two extremes (Li 2012). The demerit is interviewer may bias the respondent.
4. Questionnaire: it involves the researcher to predefined questions to anonymity respondents. The merit is covering several subjects without consuming a long time. The demerit is related to the quality of the questionnaire and the understanding of the respondent to the subject.
5. Focus groups: it involves the trained moderator to conduct iterative discussions with a selected group (6-10 participants) for 90 to 120 minutes to collect the width and depth of information or exchange of ideas in a short time. However, the demerit

comes from the difficulty in analyzing the responses and needs of a qualified and experienced facilitator (Cooper and Schindler 2014).

Triangulation is the technique to adopt multiple data collection methods in single research to obtain a higher validation of results and avoid bias (Holden and Lynch 2004). It uses qualitative and quantitative techniques together to study the topic (Fellows and Liu 2008), as shown in

Figure 4.2. For better results, the study should include a prime data collection method and supported by complementary methods.

This study uses the Delphi method and self-administrated questionnaire to the industry practitioners as a principal data collection method while uses interviews as a complementary method to prepare an appropriate questionnaire.

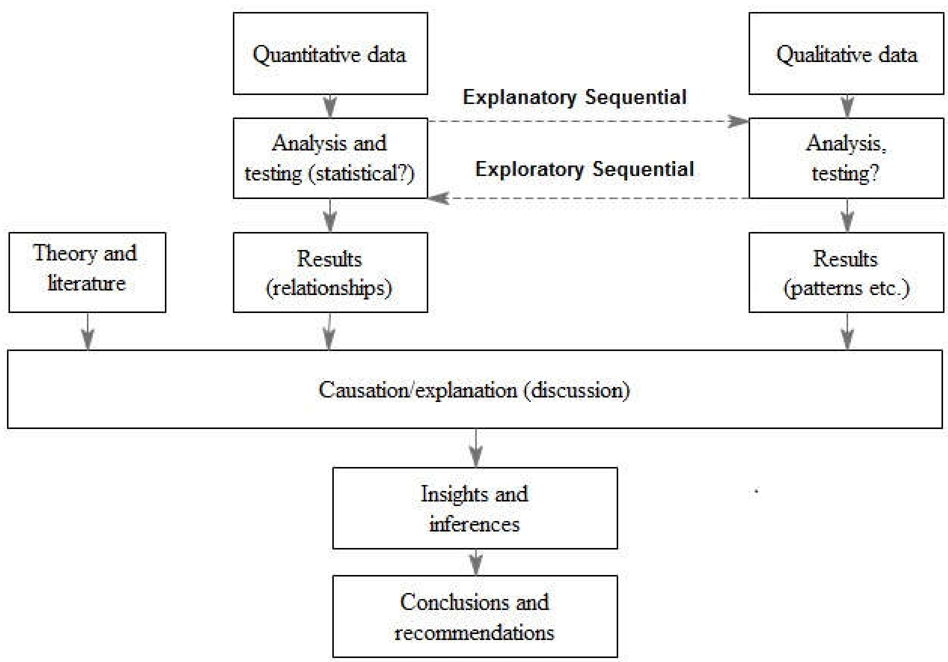


Figure 4.2: Triangulation of data (Creswell 2014; Fellows and Liu 2008)

4.5.1 Data Analysis

The main data analysis types are content & factor analysis, descriptive, difference, associative, inferential, and predictive analysis. Each category may have its own statistical techniques. The statistical analysis includes two main types called parametric and non-parametric analysis. The parametric applicable for random, normal distribution and homogeneous or equal variance samples. The brief description for each data analyzes categories

1. Content & factor analysis: The exploratory phase of the qualitative studies uses this type to identify factors causing a phenomenon and associated patterns.
2. Descriptive data analysis: it describes the response pattern of a subject using standard descriptive statistics (mean, standard deviation, mode, median, etc.).
3. Differential analysis: it deals with the variances among the study groups using statistical tests like ANOVA and t-test.
4. Associative analysis: it deals with a relationship among variables and may indicate the relationship direction.
5. Inferential analysis: it deals with drawing conclusions from a small sample of subjects to represent the overall population. Sample statistics are used to estimate the population parameters based on the tested hypothesis.
6. Predictive analysis: it deals with predicting or forecasting the likely outcomes from a developed theory or model. It includes regression analysis, time series, and simulation.

This research study uses most of the statistical analysis methods. The content analysis is used to analyze the respondent's feedback during interviews. Descriptive analysis was used to classify the participant profile of the Delphi method, Delphi outcome, and the industry survey. The inferential analysis and associative analysis are used to test the hypothesis relationship through SEM analysis.

4.6 RESEARCH DESIGNS PROCESS

Research designs (also called strategies of inquiry) are inquiry types within the research approach to providing a specific track for the research design procedures. Research Design is simply defined as a systematic plan for data collection for the sake of providing answers to specific questions. The research design process includes the development of an instrument for collecting data. The selection of a proper design depends on the type of the investigated problem, the expertise of the researcher, and the population of the study (Creswell 2014).

This study uses a questionnaire approach. In order to ensure the quality of the measuring instrument, the instrument development process is divided into preliminary and piloting stages. The measurement questions are issued as a draft in the preliminary stage. The draft is given to 4 professionals involving academic staff, a quantity surveyor, 1 project manager, and one contract manager. The professional's engagement at this stage is to enhance the questions' quality and provide feedback on missing and repetitive factors. In the piloting stage (Delphi study), the questionnaire is tested by 17 experts from the employer, contract, and consultant sides before publishing the study prime questionnaire. The Delphi study aims to improve questions' quality, provide feedback on missing & repetitive factors, and validate the framework.

4.6.1 Questionnaire Administration

The administration of the research questionnaire means the way of managing the measurement instrument to the study subjects. The researcher uses a self-administered and web-published survey. The demerits of this approach are low response rates and incomplete responses. To improve the response rate; repeated emails, workshops, communicate through phone calls were conducted until collecting the target responses.

4.6.2 Type of Data and Scale of Measurement

In general, data and scale of measurement are classified as nominal, ordinal, interval, and ratio (Fellows and Liu 2008; Leedy and Ormrod 2010). The successor types have the characteristics of the predecessor type and the statistical possibilities plus more characteristics.

1. Nominal data is a scale measured as discrete units or categories with no order or interval for classification (i.e., male or female). The statistical possibilities include mode, percentage values, $\chi 2$ to measure central tendency.
2. Ordinal data is a scale measured as values (i.e., more or less, larger or smaller) which can be ordered -but without specifying the interval size- to the ordering of objects and objects properties. The statistical possibilities additionally include percentile rank, rank correlation, and median to measure of dispersion.
3. Interval data is a scale measured as of equal intervals or degrees of difference for the descriptive purpose. The statistical possibilities additionally include product-moment correlation, mean, and standard deviation.
4. Ratio data is a scale measured as of equal intervals with a zero origin for general purposes. The statistical possibilities additionally include mean and the percentage.

4.6.3 Response Strategies and Scaling

The participants are required to make their own judgments on the importance of factors being measured. The scaling procedure assigns numbers to the properties/factor. The scales required for the response strategies are either rating, ranking, or categorizing. In rating scales, the respondent rates the questions without consideration of any other things. On a ranking scale, requires the participant to consider the ordering of the object while rating. In categorizing, the participant classifies the objects to fit within a certain group. Likert scale unit dimensional scales such as 1-to-5, 1-to-7, or 1-to-9.

This study uses open-ended questions in the early stage of the questionnaire preparation to explore new factors. In subsequence stages, the researcher categorizes the identified factors in a close-ended form to rate the importance of each identified factor on a Likert scale 1 to 5 (i.e., not important to extremely important). After analyzing the data, the results are ranked within each category. According to (Dawes 2008), the five- or seven-point formats would appear to be the most command format. The study selected 5 points scale (Ahmed 2015; Appiah Kubi 2015; Joyce 2014; Memon et al. 2015; Pollaphat and Zijin 2007).

4.6.4 Characteristics of Efficient Measuring Instrumentation

Efficiency means the capability of a study to collect high-quality data with a high rate of responses from respondents(Ssegawa-Kaggwa 2008).

4.6.4.1 Measuring Instrument Efficiency

Gathering high-quality data requires a clear, direct questionnaire, a reasonable number of questions, and keeping the participant interest. Cooper and Schindler (2014) discuss the attributes of the efficient measuring instrument in four aspects, namely, 1) theme coverage, 2) layout/structure/ presentation, 3) length, 4) care for the respondent. The instrument must cover the study themes, and the purpose of the instrument should be well communicated. Questions should be readable with appropriate font and layout. Open-ended questions should have enough space for the participant's answer. The researcher may offer the study results to the participant and should highlight the confidentiality and anonymity of information. Those requirements are considered in designing the measuring instrument.

4.6.4.2 Measuring Questions Efficiency

Ssegawa-Kaggwa (2008) discusses the attributes of measuring questions efficiency in five aspects, namely: 1) objective/content, 2) question design, 3) question layout, 4) response strategy, 5) instruction. Each question should have clear purpose, not biased, appropriate length, without ambiguity, and with standard known terminologies. The question layout should have an effective flow strategy and proper ordering. Questions should have an effective response strategy to make an easier response. The researcher should provide clear instructions for the needed response with examples, as appropriate. Those requirements are considered in question design.

4.6.4.3 Measurement Process Effectiveness

Effectiveness is an indirect relation to obtaining accurate and reliable results. The results are linked to practicality, validity, and reliability of measurements. Practicality means clear questions, the right administration method, and an easily completed questionnaire (Ssegawa-Kaggwa 2008).

In a simple way, validity could be defined as does we measure what we really planned to measure (Leedy and Ormrod 2010)). Validity is divided into external validity and internal validity. Internal validity relates to the achievement of the intended objective through measurement. External validity relates to extending results to the entire population (i.e., generalization) (Creswell 2014). The strategies to ensure internal validity includes mixed-method and triangulation of data, member checking, repeated observations of similar phenomena, peer examination, clarification of researcher bias(Creswell 2014), and detailed report of data collection and analysis (Creswell 2014). Internal validity has three elements, namely content validity, construct validity, and criterion validity (Ssegawa-Kaggwa 2008) as follows:

1. Content validity deals with a degree at which the measurement questions cover the subject being measured. It could be enhanced by using more experts during the pre-test and pilot phase of the study.
2. Construct validity deals with measurable factors that are hard to segregate and observe in a direct way. It is tested by statistical techniques such as correlational and confirmatory factor analysis.
3. Criterion validity is related to correlate the meaning of the instrument data with equivalent data of the same criterion.

Reliability relates to the consistency of the results regardless of who did the study, when the study was carried out, the population investigated and the setting of the research. In other words, if the study repeated, it will give similar results.

Within this research, external validity is examined through the measurement of CCA performance on ongoing projects (El-Sabek and McCabe 2018), while mixed-method and triangulation are used to confirm internal validity (Creswell 2014).

4.6.5 Sources of Measurement Errors

Research errors reduce the accuracy and reliability of the results (Ssegawa-Kaggwa 2008). The types of errors are the instrument errors (errors in design instrument validity), measuring process and researcher errors (errors in sampling, administration, data collection, and analysis), and respondent errors (errors in respondent assumption, level of knowledge, answerability, and willing to participate).

4.7 THE CURRENT RESEARCH FRAMEWORK

This research adopted pragmatism philosophical worldview, with exploratory sequential mixed-method strategies.

A comprehensive literature review is carried out to review CCA environment, practices, and current performance (Objective 1) and then is followed by reviewing the indicators (also called key factors, tasks, or determinants) affecting CCA function (Objective 2). Triangulation is carried out between the review of over 100 previous studies and the results of a set of semi-structured interviews with 3 construction professionals, and one academic staff is carried out. The triangulation process reduces the identified factors from 110 to 82 factors and removes overlap and duplications. The list converted into a preliminary questionnaire for further validation, rating, and providing feedback by industry experts through a two-round Delphi study. The industry experts cover the clients, contractors, consultant organizations. The output of the Delphi study is further examined by the Inter-Rater Agreement analysis technique (confirm Objective 2 by Objective 3). CCA survey questionnaire is designed and then published to around 1000 industry practitioners, and 366 responses were collected (Objectives 4 & 5). The data are statistically analyzed to identify the important of CCA indicators (Objective 3), Examine the causal relationship between CCA indicators, constructs and CCA performance (Objective 4), and Establish a quantified overall performance indicator (Objective 5). Support construction professionals with mobile assessment tools (Objective 6). The model tested within a pilot project (Objective 7) and findings from the overall process are concluded in a recommendation (Objective 8), as shown in Table 4.2.

4.7.1 Literature Review

The systematic literature review is being used to offer a critical overview of the current understanding of the research topic under study. The review builds a material collection, descriptive analysis, category selection, and material evaluation/ presentation. The qualitative approach collects data related contract administration environment, practice, and issues (Objective 1) and establish the need for measuring

CCA performance. A comprehensive desktop search was conducted in Scopus, EBSCO, Science Direct, Web of Science, Springer Link, Wiley Online Library, Scopus, Since Direct, Google Scholar, and Google as shown in Figure 4.3. The databases present 1077 non-duplicated articles, this result is then filtered by title analysis, abstract analysis, and text analysis, which resulted in identifying around 155 study, and 38 direct related types of CCA model research.

Table 4.2: Research methods adopted to achieve each objective of this study

NO	Objective	Strategy / Research Methods/ Analysis Techniques
1	Examine the CCA environment, practices, and current performance	Literature review
2	To identify the indicators and process groups contributing to contract administration performance	An exploratory sequential mixed approach Literature review 4 semi-structured interviews Preliminary factor list
3	Determine and cross-validate the CCA indicators that can significantly affect CCA performance	The exploratory sequential mixed approach Preliminary Questionnaire design 17 Expert opinion (Delphi survey) and Data analysis • Kendall's coefficient of concordance (W) • Chi-Square analysis • Ranking based on the mean score • The Inter-Rater Agreement analysis technique • Literature re-review
4	Examine the causal relationship between CCA indicators and CCA performance indicators then set theory for measuring the performance of contract administration. in full and short model	The exploratory sequential mixed approach Literature review Model building (hypothesis) Questionnaire survey Data collection (N=366) Data analysis: SEM Model testing: CFA & SM Model validation: CFA & SM
5	Establish a quantified overall Construction Contract Administration Performance Indicator- CCAPI	Literature review SEM analysis output Relative effects
6	Introduce Mobile App assessment tool- CAPM	Cross-platform programming
7	Examine the proposed framework through pilot projects, measure and benchmarks the CCA performance.	Case Studies Observations
8	Proposing recommendations to enhance administrative practices/ performance	Content analysis for the overall research

4.7.2 Semi-Structured Interviews

Interviews are one of the most commonly used data collection methods (Li 2012). The respondents provide their deep and detailed view on the specific topic. A semi-structured interview is suitable for exploring the respondents' opinions with respect to complex issues. Compared with the questionnaire survey, it has a high response rate due to the face-to-face interaction between the interviewer and respondent but sometimes costly and time-consuming. It can be used in combination with other data collection methods to improve validity.

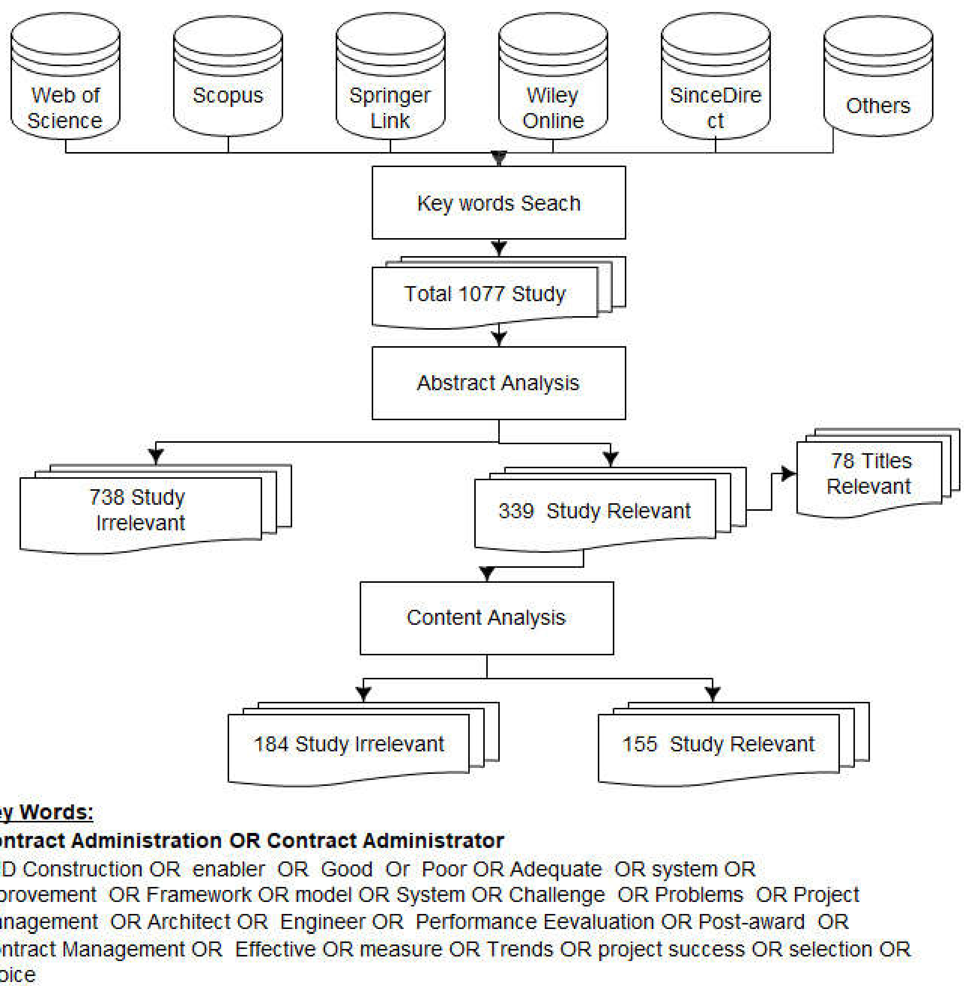


Figure 4.3: Literature review summary

In this research, the literature review of CCA indicators (indicators) is followed by a set of semi-structured interviews with three construction experts and one academia. The semi-structured interview is selected for the sake of exploring additional factors, reduces redundantly and overlaps between factors, improves the readability of the final questionnaire, and enhances the overall quality of the questionnaire before proceeding with the next stages (objective2). The information collected from the semi-structured interviews is recorded. Content analysis is conducted to produce meaningful information ahead of the Delphi study. Semi-structured interview reduces the identified factors from 110 to 82 factors. In addition, it leads to using plain English, shorter statements, modify indicators easy understanding of the respondents, eliminate redundancy among factors, and re-assign factors to their relevant groups. The details are discussed in Chapter 5.

4.7.3 Delphi Method

Delphi: it is a designed research method to control bias and ensure the appropriate qualification of the participants (Hallowell and Calhoun 2011; Hallowell and Gambatese 2010). The Delphi technique is chosen as primary data collection and validation strategy for this study for the following reasons as demonstrated through literature: 1) in general, this technique is visible in areas of a lack of agreement or incomplete knowledge is seen; 2) it is able to provide a direction for an industry's existing and future practices direction (Hsu and Sandford 2007); 3) it is a powerful and reliable empirical technique for collecting experts' consensus in construction; 4) the anonymity built in the technique procedures reduces the research's bias; and 5) it overcomes the problem of acquiring the expert panel time and presence in one place. The semi-structured interview is followed by a Delphi survey for the sake of rate the importance of the identified factors, give feedback and propose additional factors as discussed in detail in Chapter 5.

4.7.4 Structural Equation Modeling

Structural Equation Modeling (SEM) is a second-generation multivariate analysis applied to theoretical explorations and empirical evidence, which specifies, estimates, and tests theoretical relationships. SEM produces regression weights, variances, covariance, and correlations in its iterative procedures converged on a set of parameter estimates. The detailed explanation of the SEM background is shown in Chapters 6 and 7.

4.7.4.1 Justification for the use of SEM

The past few decades demonstrated a significant acceleration in implementing SEM methods in management research and as the primary data analysis tool (Jakhar and Barua 2014). Also, the application of SEM within construction management appears in many studies (Abusafiya and Suliman 2017; Gunduz et al. 2017; Isa et al. 2015; Memon and Rahman 2013; Molenaar et al. 2000; Ozorhon 2007; Sarkar et al. 1998; Yap 2013). SEM is used to examine and assess the causal relationship using a combination of statistical data and qualitative causal assumptions (hypothesis). According to Punniyamoorty (2012), SEM is the best method because it does not have a limitation on the number of variables. Also, the confirmatory approach rather than the exploratory approach creates no difficulty in hypothesis testing. In addition, the method considers and estimates the measurement error. It can include both observed and latent variables and it requires less dependence on statistical methods (Gunduz et al. 2017; Punniyamoorty 2012). The unique features of SEM are its power to offer parameter estimates for the relationship among unobserved variables (Hair et al. 2014). Indeed, the benefit of SEM models over other statistical approaches is that SEM allows us to perform a complex, multidimensional, and more accurate analysis of empirical data considering different aspects of reality and theoretical constructs (Tarka 2018).

The main advantage of SEM over the multi-criteria decision-making (MCDM) methods such as Analytic Hierarchy Process are: 1) MCDM provides an analytical analysis (ranking) while SEM is supported by the power of statistical analysis; 2) number of data required for SEM is much less than AHP for the same variables(the computational requirement is very high even for a small problem); 3) AHP consistency index will measure only inconsistency of a pairwise comparison while SEM has several measures for reliability, validity goodness of fit; 4) SEM will test the relationships between latent variables (causal analysis)while AHP will not.

Coupled with SEM, fuzzy methods consider the vagueness of the views during the item rating as detailed in Chapter 6. Thus, gives a more reliable result.

4.7.5 Hypotheses

Depend on the research type, studies are controlled by a hypothesis, construct, or proposition. The researcher develops and testes a null hypothesis to either or not to support the assumed proposition. Hypothesis refers to a proposition formulated for empirical assessment (Cooper and Schindler 2014). A hypothesis guides the direction of study, identifies facts from information, selects an appropriate research design, and offers a basis for making conclusions. The main three types of hypotheses are: 1) Descriptive hypothesis to teste the presence of a variable within a phenomenon; 2) Correlational hypothesis to test the relationship among variables; and 3) Explanatory hypothesis to test both relationship and causality among variables (dependent and independent) and the relationship direction (proportional or inverse).

4.7.5.1 The Research Hypotheses

Based on the literature review, and output of the Delphi study, a research model, was hypothesized to investigate the causal relationship between CCA performance and the performance of indicators and constructs in construction projects. The satisfactory performance of the CCA is reflected in a higher level of implementation of the CCA indicators. The research 12 main hypotheses are.

1. HO1: Project Governance & Start-up has a significant positive impact on the performance of CCA.
2. HO2: Contract Administration Team Management has a significant positive impact on the performance of CCA.
3. HO3: Communication & Relationship Management has a significant positive impact on the performance of CCA.
4. HO4: Quality & Acceptance Management has a significant positive impact on the performance of CCA.
5. HO5: Performance Monitoring & Reporting Management has a significant positive impact on the performance of CCA.
6. HO6: Document & Record Management has a significant positive impact on the performance of CCA.
7. HO7: Financial Management has a significant positive impact on the performance of CCA.
8. HO8: Changes & Changes Control Management has a significant positive impact on the performance of CCA.
9. HO9: Claims & Disputes Resolution Management has a significant positive impact on the performance of CCA.
10. HO10: Contract Risk Management has a significant positive impact on the performance of CCA.
11. HO11: Contract Close-Out Management has a significant positive impact on the performance of CCA.

12. HO12: the 11 constructs are positively predicting the construction contract administration performance index at the project level.

4.7.6 The Design of the Measuring Instrument (Final Questionnaire)

A survey questionnaire is a measuring instrument to collect unbiased perceptions from the participant and collect a large set of data that can facilitate the generalizability of the findings. The concerns related survey questionnaire is the weak control of the quality and reliability of the data with an increase in the sample size. The disadvantage comes from errors in question design, low response rate (25-35%), and level of confidence in response (Li 2012). Analysis questionnaire survey data is focused on finding a pattern or theory to support or not support the research hypotheses. Statistical analysis of the questionnaire data includes non-parametric tests, parametric tests, regression, correlation, time series, and index numbers.

In this research, an online questionnaire survey is conducted to recognize the important factors of CCA projects, test the relationship between CCA indicators and constructs, and establish overall performance indicators (Objectives 4 & 5). It is designed based on the variables that can cause a significant effect on the CCA performance as identified in the literature, explored in a semi-structured interview, and rated in the Delphi study (appendix B and appendix C) and the final questionnaire is shown in Appendix D. The data is filtered for outliers and non-serious response. The model is hypothesized, tested, and validated using the confirmatory factor analysis and structural model by using AMOS v24, Analysis of Moment Structure as detailed in Chapter 7.according to Cooper and Schindler (2014), the questionnaire contains three types of measurement questions administrative, classification, and target questions as discussed below:

4.7.6.1 Introductory (Administrative) Information

The first part of the measuring instrument (questionnaire) starts with the introductory part to the participants. It contains information relates to the researcher, research scope, research method, instruction to complete the survey, and confidentiality and anonymity of any gathered information. This research does not require any respondent identifications or organization names (Appendix D).

4.7.6.2 Classification Questions

The classification questions are related to the study subject (respondents and their profile). Classification questions pursued to classify the respondents' attributes or the demographic profile - but not to recognize any personal information. In this research, ten questions inquiring the profile of the respondents. Questions include; years of experience, professional registration, training in contract and contract administration, organization type, the area of expertise, project type, and form of contract.

4.7.6.3 Targets Questions (CCA Performance Model)

Target questions are relevant and directly address the research questions. The questions of the measuring instrument are designed into either funnel or sectional approaches. In the funnel approach, Questions are arranged into simple to complex order, wide to narrow order or general to a specific order. In sections approach, the instrument is separated into question groups. The groups represent the different sections of the study. The section approach is adopted within this study. The target questions, therefore, pursues to investigate the key factors affecting CCA performance. Target questions consist of 93 plus 11 statements, and respondents are asked to express their perception of the importance of an instance measured on the five-point Likert scale.

4.8 DATA ACQUISITION & SAMPLING FRAME

The sampling concept is important for justifying the selection of a suitable sampling method, size, and how to deal with the non-response. The following section discusses the data acquisition for objectives 3, 4 & 5.

4.8.1 Sampling Methods

Sampling means the technique of choosing some of the members of a population to represent the entire population in a study. Sampling technique is used because of lower cost, more accurate results, data collection in a faster way, and population elements availability (Cooper and Schindler 2014). The sampling groups are divided into either a non-probability or probability sampling group. Members of non-probability sampling are subjectively selected with no known chance, while members of the probability sampling have an equal chance. Probability sampling is more precise and does not include researcher bias in selection (Ssegawa-Kaggwa 2008). Probability sampling includes different types such as systematic, simple random, cluster, and simple or proportional stratified sampling (Cooper and Schindler 2014). The literature review indicates that random sampling is the most suitable method for management studies as it avoids the researcher's bias and covers a wide range of participants (Cooper and Schindler 2014).

4.8.2 Sample Size

SEM requires a minimum sample size of 100. For instance, research has shown only 10% of samples with the smallest ratio between the sample size and the indicators ratios (2:1) would produce correct results. In this research, the questionnaire distributed to around 1000 construction practitioners and 366 complete data is collected. Details of sample size and requirement are shown in Chapter 7.

4.8.3 Catering for No-Response & Non-Serious Responses

The no-response cases reduce the size of the sample and increasing standard errors. Non-response can be significantly avoided by appropriate follow-up strategies, the strategies required to improve the response rate includes several rounds of the questionnaire, repeated mailing, drop and collect documents, and reminders. This study adopted a higher mailing number, rounds of questionnaire mailing, drop- and collect questionnaires, face to face data collection, and telephone reminders to get a higher response rate. On the other side, Non-serious responses mean similar answers for all questions or response is in contrast with most of the other responses.

4.8.4 Data Analysis & Model Formation

SPSS computer program is used for descriptive statistical analysis of the respondent's demographic information. The model assessment, validity, formation of the measurement model, the formation of the structural model, and hypothesis testing results are also detailed in Chapter 7. The calculations of the relative weights of the 11 different latent factors are performed based on the findings of Chapter 7, and The CCA performance index is formulated in Chapter 8. SPSS and AMOS are adapted to quantitatively, analyze and validate the research hypotheses (objectives 4 & 5). The CAPM model is practically implemented in 13 construction projects to assess their implementation for CCA tasks (0 not implemented, 100 fully implemented, and not applicable). The CCA performance level for each construct (latent factors) and overall index are calculated.

4.8.5 Discussions and Recommendations

Each construct effect and its indicators and ranking of indicators are discussed in Chapter 9. Recommendations for improvement to construction professionals are in Chapter 10.

4.9 ETHICAL CONSIDERATIONS

Research ethics is referred to as the principles and behavior standards maintained by the researchers during any research study. Most of the researchers in the social sciences and management fields are related to human, intellectual property, and enterprise information. The researcher should pay attention to data collection from human subjects, the safe storage of data, the use of data, and the disposal of data (Li 2012). Within this study, the others' work has been acknowledged through the proper citations. The research process design; and data collection, analysis, and interpretation are carried out in a practical objective way. Several measures have been taken to ensure the objectivities and accuracy of the results. The study ethical concerns are addressed by the introductory letter/ Email/ questionnaire introduction, and/or phone calls to the participant to include: 1)the participants' right to engage in a voluntary response; 2) communication of the study purpose and process to participants; 3) communication of required questionnaire instructions; 4) confidentiality and anonymity of information are also communicated; 5) respondents can obtain the study findings and results when the study is completed; and 6) Data are safely stored, and no confidential information should be presented within the context of the research- unless otherwise prior approval is granted.

4.10 CHAPTER SUMMARY

This chapter starts with the various methods and techniques of research and then followed by a selection of appropriate methodology and research processes. The reasons and background to use the questionnaire survey to collect data are discussed. The outline of methods of data analysis is briefly discussed, and a detailed explanation is offered in the following chapters.

The world view of this research is pragmatist philosophy deals with practical solutions to the CCA performance measure using an exploratory sequential mixed approach. The nature of the CCA performance problem favored the causal/ predictive type of study. Thus, generalization (replication) of the causal relationship to form a theory or model can be obtained. Also, a survey strategy is selected to represent the breadth of information and, therefore, may be generalized to other cases. Triangulation is adopted for data collection to obtain higher validity. Content data analysis is used to analyze the respondent's feedback during the interview and the Delphi study while descriptive data analysis is used to classify the participant profile. The inferential analysis and associative analysis are used to test the relation hypothesis through SEM analysis. Research internal validity is ensured by implementing a mixed-method research strategy, triangulation of data, peer examination and detailed report of data collection and analysis. Within this research, external validity is examined through the measurement of CCA performance on ongoing projects.

CHAPTER 5 : PRELIMINARY QUESTIONNAIRE AND DELPHI STUDY

5.1 INTRODUCTION

This Chapter presents the preliminary questionnaire preparation and Delphi survey to achieve Objective 2" identify the indicators and constructs contributing to contract administration functions" and objective 3 "determine and cross-validate the CCA indicators that can significantly affect CCA performance" and then address the most significant indicators and groups. Objective 2 is collected from literature and further re-defined through a semi-structured interview with industry professionals while objective 3 is obtained through a multi-round Delphi study.

5.2 PRELIMINARY QUESTIONNAIRE

Chapter 3 presents a comprehensive literature review to identify the indicators affecting CCA performance. Table 3.8 to Table 3.18 shows a total of 110 indicators identified from the literature.

5.3 SEMI-STRUCTURED INTERVIEW

One of the most commonly used data collection methods is interviews (Li 2012). In this research, the literature review of CCA indicators is followed by four semi-structured interviews with four construction professionals. Face-to-face interviews with the experts were conducted because their experiences will enhance the collected indicators of the study (Cooper and Schindler 2014). The experts are having over 30 years' experience in international projects and are holding positions of professor in project management, contractor's executive manager, consultant's contract manager, and employer 's project director. The indicators collected from literature were presented as preliminary questionnaire items to elicit the experts' views and opinions concerning:

(1) any missing indicators that could be added, (2) any redundant or overlapped indicators, (3) applicability and implementation of the proposed indicators on construction projects, (4) possibility of enhancing the language, and (5) how to enhance the overall quality of the questionnaire. The comments, notes, and feedback received from the experts led to improve the preliminary questionnaire by shortening the questionnaire items, use clear and short language, and remove the overlap between indicators. Notes are collected from the semi-structured interviews, and content analysis is conducted to produce meaningful information ahead of the Delphi study. As shown in Table 5.1, the semi-structured interview reduces the identified indicators from 110 to 82 indicators. In addition, it leads to using plain English, shorter statements, modify indicators for easy understanding by the respondents, and eliminate redundancy among indicators. Further, the interviewer emphasizes the importance of establishing a system under each group; and focus on planning and operational tasks. The 82 indicators are shown in Appendix C "Delphi Study- Second Round Questionnaire".

Table 5.1: 28 Omitted/revised indicators through the semi-structured interviews

Indicator	Interviewers feedback & Justification
F02.07 "Staff compliance with relevant technical requirement (specification, statutes, regulations) "	Overlapped with "Assignment of technically competent CCA team."
F02.08 "Staff compliance with code of ethics (avoid conflict of interest, fraud, corruption, etc.) "	Overlapped with F01.12 "Removal of any person intentionally violating the requirement with reasons from the site."
F03.12 "Documenting all communications between employer' and the contractor "	Overlapped with F03.02 "Effective communication of PMP requirement to all involved parties."
F03.13 "Prior agreement of the employer for the expenditure of additional cost "	Consolidated with F03.06 "Agreement between employer and CCA team for any proposed change(s) inclusive time and cost."
F03.14 "Prior agreement of the employer for extending the contract time "	Consolidated with F03.06 "Agreement between employer and CCA team for any proposed change(s) inclusive time and cost."
F03.15 "Management of employer-contractor relationships through an understanding of contract provisions "	Cannot be measured
F03.16 "Approaching both parties to reach agreement on issues (partnering sessions, open discussions, etc.) "	Part of F03.01" Establishment of a communication management system."

Table 5.1: 28 CCA indicator omitted/revised through the semi-structured interviews (continued)

Indicator	Interviewers feedback & Justification
F03.17 "Regular technical meetings with the contractor to address technical issues includes running reviews "	Consolidated with F03.10 “Regular meetings with employer and contractor to address issues and assign actions.”
F03.18 "Cooperation with the contractor to assess causes of any defect "	Overlapped with F03.16 “Timely, management of operational issues at field level between the contractor and CCA team.”
F04.11 "Establishment of quality assurance system "	Redundant with the overall process & review Contractor Plans
F04.12 "Advice on tests requirement (laboratories, off-site tests, service of a third-party specialist, etc.) "	Overlapped with F01.02 “Review of the contractor’s quality management plan.”
F04.13 " Works compliance with the statutory requirements "	Overlapped with F04.10 “Control of non-compliance works.”
F06.05 "Audit of the contractor’s documentation system "	Overlapped with F4.02 “Auditing the contractor's quality management system implementation
F06.06 "Maintaining up to date records "	Consolidated with F06.06 “Maintaining updated project documentation with registers.”
F06.07 "Maintaining all project documentation in a safe area "	Overlapped with F06.01 “Establishment of a document management system.”
F07.08 "Issuance of accurate engineering estimates to the employer "	Overlapped with F08.05 “Timely processing of change orders on change requests.”
F07.09 "Timely, issuance of instructions to expend prime cost items "	Deleted,
F07.10 "Records of any measurement required for payment (work performed, day work record, etc.) "	Part of with F07.01 “Establishment of a financial management system.”
F08.06 "Timely, issuance of instructions for dealing with remains found on site (fossils, coins, articles of value, etc.) "	Part with F08.01 “Establishment of a change control system” Rare Case
F08.07 "Assessment of potential changes (i.e., demand, causes, scope, impact, etc.) "	Overlapped with F08.01 “Establishment of a change control system.”
F09.09 "Works to defend the employer against artificial claim situations. "	Overlapped with F09.02 “Timely, notification of the contractor about the employer's rights to claim”
F10.04 "Identification and quantification of anticipated risk (service failure, damage, changes, fraud, etc.) "	Rewarded as F10.01 Periodically, assessing the contractual risks with the help of the contractor
F10.05 "Assist contracting parties in the implementation of actions to mitigate risk "	Rewarded as F10.03 “Assignment of responsibility to the relevant party for each contractual risk event.”
F11.14 "Collection of the employer authorization to issue a certificate "	Overlapped with F11.3 “Communication of closeout activities to all stakeholders.”
F11.15 "Maintain the employer entitlement to an extension of the defects notice period due to major defect "	Overlapped with F09.02 “Timely, notification of the contractor about the employer's rights to claim”
F11.16 "Timely, release the second half of the retention, and bonds by the end of the defects notification periods "	Reworded and consolidated with as F11.07 “Timely release of the retention upon releasing relevant certificate “
F11.17 "Assessment of consequences of suspension "	Reworded and consolidated with F11.15 “Properly, management of suspension of the work process.”
F11.18 "Assessment of contractor’s compensation for termination "	Reworded and consolidated F11.1 7” Properly, management of termination of the contract process

5.4 DELPHI METHOD

The 110 indicators identify from the literature and are triangulated to develop 82 indicators for further investigation by a Delphi study. After the semi-structured interview with four professionals. The questionnaire was circulated to 19 experts for their score, and feedback to warrant the survey tool validity. The 82 indicators are categories into 11 main CCA groups. Data are collected from 17 experts (90 % response rate and two experts decline to participate in the study due to their business plans. An additional 11 indicators are identified after the first cycle of Delphi study to include: F01.13- Review the contractor's Logistics plan; F01.14- Review contractor's proposed laboratory (PWA 2017); F01.15- Avoid bureaucracy and lengthy process; F02.06- Set Performance Dialogue for CCA Team spirit; F03.10- The managing interface between contractors (El-Sabek and McCabe 2018); F03.11- The clear language of communication (PWA 2017); F04.09- Track corrective actions (PWA 2017); F04.10- Managing design and design development during construction; F07.06- Advice the Employer in contingency planning/ additional funds (PWA 2017); F07.07- Collect quotations for price estimates and contractor's price negotiations. (PWA 2017); and F10.04- Monitor the contractor's financial status and bankruptcy potential. The next section will provide background about the Delphi study before going through the data acquisition and analysis.

5.4.1 Delphi Study Background

Due to the practice-driven nature of the construction industry, collective knowledge and experience of selected experts from the same field would support the solution of the industry problems. Hallowell and Gambatese (2010) noticed an increasing number of researchers implemented the Delphi method since the 1990s in construction.

In the early 1950s, the Rand Corporation of the United States established a project called Delphi to predict the future advancements in technology through a new methodology for the Air Force (Gad and Shane 2012; Hallowell and Gambatese 2010; Hsu and Sandford 2007; Manoliadis et al. 2009). Delphi is commonly used in academic researchers in the field of social sciences (Skulmoski et al. 2007) and construction (Hallowell and Gambatese 2010) to provide a real-world knowledge in real-time (Hsu and Sandford 2007). It is a designed research strategy to control bias and ensure the appropriate qualification of the participants (Hallowell and Calhoun 2011; Hallowell and Gambatese 2010). The Delphi intent is to obtain a consistent consensus of qualified and carefully selected experts by exposing them to a set of updated questionnaires coupled with controlled opinion feedback (Dalkey and Helmer 1963). The method is a suitable technique for collecting objective opinions in a subjective or complex area. It contains a formal and structured communication method to collect unbiased information/ data from a selected number of experts on a complicated problem (Chan et al. 2001) while keeping the experts free to judge (Hallowell and Gambatese 2010).In addition, It contains an iterative process where consensus is regularly attained through subsequent rounds of experts' opinion, judgment, and feedback on a specific subject, uncertain issue, or specific topic (Chan et al. 2001; Hallowell and Gambatese 2010). Although, the collective judgments of experts may be subjective Delphi approach is still more objective in its outcomes than individual statements (Hsu and Sandford 2007; Xia and Chan 2011). The Delphi method is useful in several situations such as unattainable objective data, the absence of empirical evidence, or when carrying out experimental research is unrealistic or unethical (Hallowell and Gambatese 2010). Delphi is used for a problem that cannot be directly analyzed by analytical techniques, questions require intuitive judgment, and expert disagreement occurs. The advantage of Delphi includes ease of implementation, selection of highly qualified experts, allows for experts' input, and the ability to control judgment-based bias (Gad and Shane 2012). Therefore, Delphi is more appropriate than other subjective research approaches, such as traditional surveys or interacting groups (Hallowell and Gambatese 2010). Delphi's study has 4 main differences from other studies: 1) panelists are selected based on pre-set objective criteria; 2) multiple rounds surveys directed towards achieving consensus; 3) facilitator provide feedback during each round; 4) panelists remain anonymous (Hallowell and Calhoun 2011). The main intent of the Delphi study is to provide anonymous feedback. The feedback process is the way for keeping the individual informed about the opinions of other anonymous counterparts and reassess (Hsu and Sandford 2007). In addition, it provides indirect communication among participants to arrive at a high level of consensus (Ameyaw et al. 2016; Hallowell and Gambatese 2010). The most common feedback process between rounds is the measures of central tendency measures (mean, median, or mode) and dispersion level (standard deviation, and/or quartile range) (Hsu and Sandford 2007). Reporting reasons are rarely used in the feedback process but argue against giving more results that are more accurate.

5.4.1.1 Delphi Method in Construction

Ameyaw et al. (2016) Investigate 88 papers implementation Delphi as a primary or secondary research method in construction. Accordingly, the Delphi techniques are heavily used in Construction in several research areas covering:

1. *Project planning and design:* to study indicators affecting the decision making, project location, engineering design and pre-project planning, risk associated with the type of project, contractual and cost risks;

2. *Contracting issue:* to study topics such as criteria for project procurement and different evaluation type of projects such as Public-Private Partnership and Design-Built projects.
3. *Labor and personnel issues:* to study irregular behavior, professional attributes, engineer competences, and safety management;
4. *Organizational issues*: such as corporate financing, corporate competencies, and business, organization culture & design;
5. *Information Technologies*: such as effectiveness and outcomes of innovative technologies and systems;
6. *Cost and Schedule*: such as forecasting and evaluation tools; and
7. *Construction Materials and Methods:* to evaluate the effectiveness of a variety of technologies and methods in construction.

5.4.1.2 The Delphi Study Process

The method starts with selecting a certain number of qualified experts (panelist). Panel members are unknown to each other and answer a set of updated questionnaires through several rounds. The previous round produces new information for panelists for usage in the next round to allow experts to modify their assessments. Rounds are continued until getting consensus (Chan et al. 2001). The classical Delphi procedures usually comprise two or more rounds of the survey. Round 1 is to seek opinions on a certain issue from the panelists in an open-ended way and convert it into a more structured questionnaire. Round 2 is to request the panelists to rate the questionnaire items. Within around 2, initial disagreement and agreement of panelists can be identified (Hsu and Sandford 2007). Round 3 is to provide consolidated results (feedback) from the previous round and require the panelists to freely reconsider the ratings. The facilitator can request participants to stipulate the reasons for not agreeing on other expert's consensus (Hsu and Sandford 2007). In each subsequent round, the study facilitator prepares an anonymous brief of the panelist's estimates (commonly in terms of mean, median, or deviation) from the previous survey round and requests the experts to revisit their previous response in light of the other panelist's opinion. (Hallowell and Gambatese 2010; Hsu and Sandford 2007). Rounds may continue until a consensus for some or all the items of the questionnaire. If the questionnaire items can be established through literature and/or interviews, the traditional open-ended question round is not required (Hon et al. 2012). This approach is called the modified Delhi scenario (El-Sabek and McCabe 2018).

5.4.1.3 Key Requirements for the Modified Delphi Method

The reliable output may be collected from a Delphi study with appropriate design and execution of the study. Proper design and execution include the proper formulation of questions, proper selection of experts, appropriate bias control, reliable analysis method, and enough feedback cycles (Chan et al. 2001). Therefore, and as stated earlier, Delphi is an iterative estimating procedure that has three unique characteristics, namely: anonymity, iteration with controlled feedback, and statistical response (Chong and Oon 2016; Manoliadis et al. 2009; Skulmoski et al. 2007). First, anonymity is used to allow any participant to freely express his/her opinion without any pressure or influence from other members of the panelist. Second, iteration is a chance for experts to re-assess their previous opinions considering the overall experts' views. Controlled feedback exposes the other experts' views and allows participants to explain or modify their judgment. Third, statistical aggregation of overall experts' response tolerates for quantifying analysis and explanation of data.

5.4.2 Delphi Panelists

Quality of the output depends mainly on the experts involved in a Delphi study, and the process success is highly affected by the unbiased judgment of the experts (Albert et al. 2017). The expert sample should be an unbiased representative sample. Experts mean professionals or researchers had in-depth knowledge, sound experience in the field of study (Chan et al. 2001). The additional requirement includes a certain degree of involvement, professional qualifications, and relevant publications (Ameyaw et al. 2016). Hallowell and Gambatese (2010), focus on academic qualifications- which may not be practically available in several situations- and suggest targeting at least four of the following eight requirements in expert selection: 1)Authors in a peer-reviewed journal (at least three articles); 2) Speaker or potential speaker at a conference; 3) Academia staff at an accredited institute of higher education; 4) Editor of a book or book chapter on construction-related topics; 5) Member or chair of a recognized committee; 6) Professional experience in the construction (minimum 5 years); 7) Advanced degree in a related field (minimum of B.Sc.); and 8) Professional registration. Contrary, Skulmoski et al. (2007) focus on a practical aspect of the expertise selection and expect the potential participants to meet four requirements, namely: 1) knowledge and experience; 2) capacity and willingness; 3) availability of time; and 4) effective communication skills. The majority of researchers in Construction Engineering and Management used 8 to 20 experts in their researchers (Ameyaw et al. 2016). Hallowell and Gambatese (2010) consider the drop out of numbers with time due to other commitments or disinterest and require a minimum of eight number of experts.

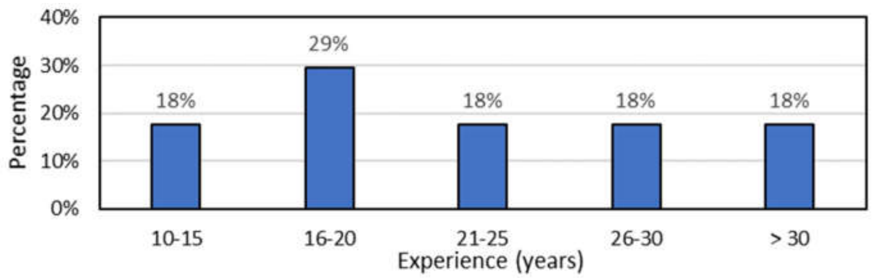
To ensuring the validity of this Delphi study, the following pre-set criteria are formulated to identify appropriate experts having various backgrounds, such as engineers, architects, and quantity surveyors, to obtain an overall view on the contract administration's important activities as follows: 1) Experts have extensive practical experience in the construction (i.e., 15 years and above or 10 years with a postgraduate degree in construction); 2) Currently working in relevant organizations in the construction industry; 3) Minimum B.Sc. degree holder; 4) Experts are involved in the project construction management and contract administration to ensure that basic knowledge of contract administration functions is available; 5) Registered professional; and 6) The willingness of the experts to participate in a multi-round survey/ interview. Seventeen members of the panelists with a wide range of professionalism have been selected as experts for this study, as shown in Table 5.2.

Table 5.2: Experts panelist

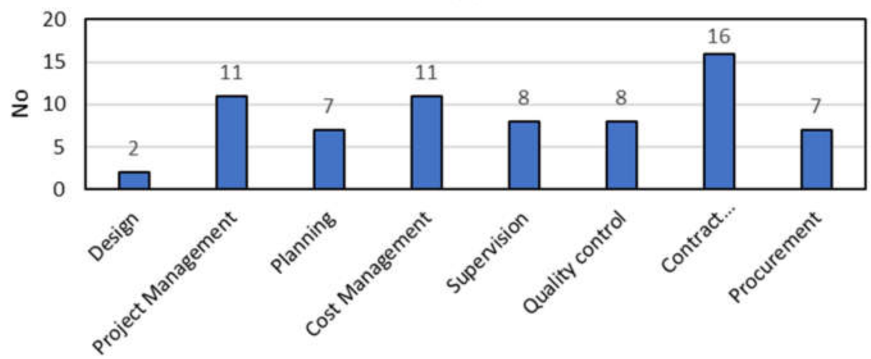
No.	Position	Experience (Years)	Sector	Organization	Project Type**
1	Director, Ph.D. PMP	25	Private	Consultant	AB
2	Head of Business Unit	37	Private	Employer	ABCD
3	Contract Manager	29	Private	Consultant	ABC
4	Project Manager, PMP	19	Public	Consultant	ABC
5	Project Manager, PMP	24	Private	Consultant	A
6	Senior QS, Chartered	28	Private	Consultant	A
7	QS, Master	10	Private	Consultant	A
8	Quality Manager	15	Private	Consultant	A
9	Engineer	16	Public	Contractor	A
10	Senior Planner, Master	10	Public	Employer	ACD
11	Senior Civil Engineer	20	Public	Employer	AC
12	Director	38	Private	Employer	A
13	Technical Manager	16	Private	Contractor	A
14	Quality Manager	23	Private	Contractor	A
15	Project Manager	30	Public	Contractor	ACD
16	Contract Manager, QS	33	Private	Contractor	AC
17	Contract Manager, QS	18	Public	Contractor	A

**Key: A= Building construction, B= Industrial facilities, C=Infrastructure, D= Roads

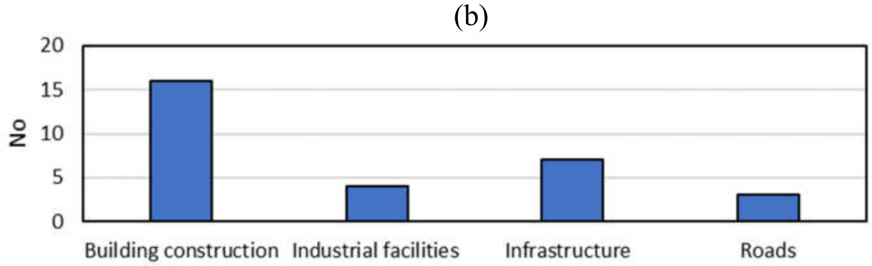
Their distribution is four from client/ client representative organizations, seven from consultant organizations, and 6 from contractors. Experts deals with Public and private projects are 6 and 11, respectively. All experts are registered Engineers with a minimum of 15 years in the construction or 10 years minimum experience and postgraduate degree. In addition to the individual experts' selection criteria, the selected expert's group represented a variety of construction professionals to provide a real perspective and a balanced view. Figure 5.1a shows that 82 % of the experts have more than 15 years of experience in construction, while Figure 5.1b and Figure 5.1c show the experts' familiarity with the different processes and types of constructions. Figure 5.2a shows that 16 (94%) experts have training in contract or contract administration, Figure 5.2b shows that 10 (59%) experts have certificates in contract or contract administration, Figure 5.2c shows that 6 (35 %) of the expert have public sector background, and Figure 5.2d shows that only 6 (35 %) of the expert are contractors.



(a)



(b)



(c)

Figure 5.1: Expert panelist experience: (a)years of experience; (b) trade experience; and (c) project type of experience

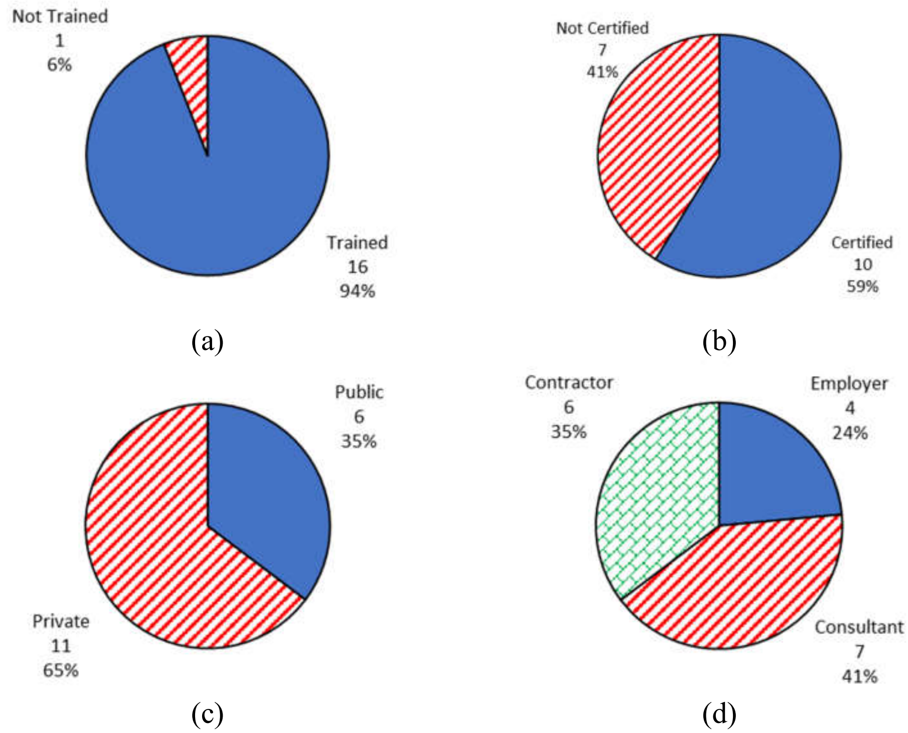


Figure 5.2: Expert panelist qualification, and sector: (a) training; (b) contract management certificate; (c) sector; and (d) organization

5.4.3 Statistical Analysis for Modified Delphi Data

According to Ameyaw et al. (2016), Delphi surveys are carried out for inter-group comparison, consensus measurement, and correlation analysis. Spearman Rank Correlation test, Kruskal-Wallis test, and Wilcoxon Signed-Rank test are the most common statistical analysis techniques for inter-group comparison (Albert et al. 2017). Deviation, Chi-square ($\chi2$), and Kendall's Coefficient of Concordance (W) are commonly used for consensus measurement (Ameyaw et al. 2016). The correlation analysis uses the Pearson Correlation Matrix test (Xia and Chan 2011). For the inter-group comparison:

1. Spearman's Rank Correlation Coefficient (rs) is employed to examine the inter-group comparison if the computed rs exceeds the 0.05 critical value. In such cases,

consistency is attended among the participants' groups;

2. Wilcoxon Signed-Rank and Kruskal-Wallis employed to examine the significant difference among the views of experts. If the computed statistics are less .05 to 0.10, then consensus is attended among panelist groups.

5.5 DELPHI SURVEY - DATA ANALYSIS AND RESULTS

Likert scales are an ordinal level of measurement, which provides a rank order to the response categories and is repeatedly used in inquiring opinions and attitudes (Cohen et al. 2007). According to Ameyaw et al. (2016), previous literature uses a Likert scale with 3 to 12 points to measure the experts' opinion on a particular subject while the five-point Likert scale is the most commonly used scale in several construction management studies (El-Sabek and McCabe 2018; Khan 2016; Ozdemir 2015). The centesimal system is used in a few studies. The Delphi study is selected to identify further indicators and rank the importance of CCA indicators. Through literature review, the five or seven-points appeared to be the most common format (Dawes 2008), and 5 points were used in similar management areas (Joyce 2014; Ozdemir 2010; Pollaphat and Zijin 2007). the scale meaning is: 1=Not at all important; 2=Slightly important; 3=Moderately important; 4=Very important; and 5=Extremely important. The experts' consensus is examined through mode simplified consensus analysis, mean score, Chi-Square analysis ($\chi 2$), Kendall's coefficient of concordance (W), and IRA analysis. IBM-SPSS V 25, and Microsoft Excel are used for analysis.

5.5.1 Normality Test

According to Kalaian and Kasim (2012), nonparametric statistical methods are advisable for less than 30 experts and/or the non-normal distribution of responses (skewed). Shapiro-Wilk Test is used to assessing the normality of data for small sample sizes (i.e., < 50 samples). The data significantly deviate from a normal distribution if the p-value is less than 0.05 (Field 2009; Zahoor et al. 2017). Shapiro-Wilk test (W) examine the correlation between a given data and ideal normal scores. The closer the test value to one means normally distributed data and acceptance of the null hypothesis, the data is normally distributed. The formula for the W value is:

$$W = \frac{\left(\sum_{i=1}^{n} a_i \, x_{(i)}\right)^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{5.1}$$

Where:

a_i = constants generated from the covariances, variances, and means of the sample from a normally distributed sample

$x_{(i)}$ = order statistic of a statistical sample

x_i = sample values

n = sample size

$\bar{x}$ = sample mean

In the first round, the significant values show that 81 out of 82 indicators are less than 0.05. In the second round, the significant values show that all indicators are less than 0.05. Likewise, the significant values for the indicators groups in both rounds 1 and round 2 are less than 0.05. Therefore, data are considered as significantly deviate from a normal distribution. Based on the above, nonparametric estimates are used in the succeeding sections to assess consensus.

5.5.2 Reliability Test

Reliability is defined as the degree of consistency, which measures the attribute; it is supposed to be measured. Reliability increases with less variation in the instrument repeated measurements. Cronbach's alpha coefficient values are used to measure the reliability of the questionnaire. Cronbach's Alpha can be written as a function of correlation of each item with the sum of all the other items (Cohen et al. 2007). Cronbach's alpha is varying between 0 and 1; the closer the value to one, the greater the internal consistency of items in the instrument is being assumed. Cohen et al. (2007) set the following guidelines for Cronbach's alpha coefficient meaning: 1) 0.90 very highly reliable, 2) 0.80–0.90 highly reliable, 3) 0.70–0.79 reliable, 4) 0.60–0.69 minimally reliable, and 5) <0.60 unacceptably reliability. Cronbach's Alpha is used to measure the internal consistency for each expert group, for each sector in each round, and the mean of the whole group of the questionnaire. Table 5.3 shows that none of the Cronbach's alpha values falls below 0.7. Therefore, the respondent's data are considered to be consistent and reliable for further analysis (Zahoor et al. 2017). Therefore, the reliability of the questionnaire is proven to be satisfactory.

Table 5.3: Cronbach's Alpha (∝)test statistics for Delphi study

Cronbach's Alpha (∝)	**Expert Groups**					
	Overall	**Public**	**Private**	**Employer**	**Consultant**	**Contractor**
Round 1						
Indicators	0.98	0.98	0.98	0.99	0.98	0.99
Groups	0.89	0.78	0.92	0.83	0.92	0.88
Round 2						
Indicators	0.97	0.95	0.97	0.95	0.98	0.96
Groups	0.90	0.89	0.93	0.85	0.93	0.90

5.5.3 Number of Rounds

Although literature concerning Delphi studies does not provide firm guidance for the optimum number of rounds, researchers use the anticipated consensus level to establish the number of rounds. The majority of researchers reached consensus after 2 or 3 rounds, and few extend to 6 rounds (Ameyaw et al. 2016). Lucko and Rojas (2010) require at least two rounds, while Hallowell and Gambatese (2010), require a minimum of three rounds and consistency of the results over the last two rounds is subject to analysis.

In this research, in addition to the literature review round, two participant rounds are proposed. In the first round, participants were requested to list additional indicators affecting contract administration performance and provide their comments on the indicators collected from the comprehensive literature review, if any. The first round to pursue general agreement on the contract administration activities and discover missing activities and groups. The first round secures feedback from participants and opportunities for improvement and corrections to be made (Chong et al. 2011).In the second round, the facilitator compiles the first-round results requests experts to provide ratings to the tabulated tasks, based on a 5-point Likert scale. The second round comprised two main activities. The first activity was to confirm and verify the given results in the previous round (Chong et al. 2011). Next, the experts were required to rate the importance of contract administration tasks. All rounds were conducted using Excel sheet questionnaires. Seventeen valid responses are received in the first round, with a 90% response rate. 15 The questionnaire collected by Email and 2 by hand. The data from the first round are analyzed to examine consensus by four techniques, simple consensus percentage calculation, a ranking based on the mode scores, $\chi 2$, and W. In the second round, central tendency mode scores of all the indicators are presented to the experts along with round one summary feedback. An agreement among the different groups of participants is attended, and the strength of the agreement level is examined through the IRA as detailed in the following sections.

5.5.4 Terminating Delphi Data Collection

Termination of the rounds of the Delphi study requires sound judgment and sound statistical techniques. Termination of the rounds takes place if the experts stick to their previous rating or agreement has been reached. Nonparametric data requires nonparametric statistical methods to make decisions about terminating the Delphi rounds (Kalaian and Kasim 2012)

5.5.4.1 Terminating Based on No Changes in Expert's Rating

Kalaian and Kasim (2012) Suggest using Spearman's Rank Correlation Coefficient (r_s) or Wilcoxon Paired Signed-Rank test to assess differences in the expert's rate on an item from two consecutive rounds. r_s is a non-parametric test used to check the variance between of collected data. Typically, r_s is suitable for ordinal data (Cohen et al. 2007). Those tests do not require the assumptions of normality or homogeneity of variance. The closer rs to 1, the greater the correlation (rs =1 represents perfect agreement) while rs near to or less than zero indicates no agreement between rankings from the two consecutive rounds Kalaian and Kasim (2012). r_s is given by:

$$r_s = 1 - \frac{6\sum_1^m Di^2}{n^3 - n} \quad (5.2)$$

Where:

Di = difference between the ranks of the responses on i object from two consecutive rounds

m = total number of objects(indicators)

n = total number of experts in a panel

The critical values of Spearman's rank correlation coefficient, at α = 0.05, n=17 is 0.488. The calculated minimum rs = 0.91 is greater than the critical values of rs and is close to 1, as shown in Table 5.4. Then, the relationship is significantly strong, and the subject items should not be contained in the following round of the Delphi survey. Therefore, the Delphi study can be terminated. likewise, 16 participants are slightly changing their rating in the second round, and one expert stick to his original position.

Table 5.4: Spearman's Rank Correlation Coefficient between the ratings of the experts between rounds 1 and 2

Expert #	r_s	Expert #	r_s
1	0.99	10	0.94
2	0.99	11	0.97
3	0.93	12	0.99
4	0.91	13	0.96
5	0.99	14	0.97
6	1.00	15	0.96
7	0.99	16	0.96
8	0.99	17	0.98
9	0.91		

5.5.4.2 Termination Based on Simple Measurement of Consensus

Simple Measurement of Consensus depends on the criteria for deciding consensus on a topic. Most of the criteria are related to the specific ratio or percent of the votes falls within a defined range, such as: 1) at least 80 percent of respondents (Score) is within 2 categories on a 7-point scale (Hsu and Sandford 2007); 2) at least 70 percent of response is higher than or equal to 3 on a 4-point Likert-type scale (Hsu and Sandford 2007); 3) the median must be at 3.25 or higher (Hsu and Sandford 2007); and 4) at least 70 percent of response is higher than or equal to three on a five-point Likert- scale (El-Sabek and McCabe 2018). In this research, the criteria proposed for expert consensus is determined *a priori* as: 1) greater than 80 percent experts' agreement within 3 of the 5 categories of importance (equation 5.3); and 2) and the mode is higher than 3.25. The mode has been chosen over the mean because it better reflects the central tendency of the ordinal scale without taking into consideration the outliers, and also because most rating clustered around two to three points only (El-Sabek and McCabe 2018).

$$Score\ (for\ ea\ ch\ round) = \frac{\sum_3^5 number\ of\ votes}{\sum_1^5 number\ of\ votes} x\ 100 \qquad (5.3)$$

Table 5.5 shows the detailed scores and mode of rating for both round 1 and round 2 for the process groups. All group consensus is attended in both rounds.

Table 5.5: Evaluation of CCA groups- Delphi rounds 1 & 2

	Round 1							**Round 2**						
	Scale					**Score**		**Scale**					**Score**	
Code	1	2	3	4	5	**(%)**	**Mode**	1	2	3	4	5	**(%)**	**Mode**
G01	0	0	1	3	14	100	5	0	0	0	3	14	100	5
G02	0	0	2	5	11	100	5	0	0	0	6	11	100	5
G03	0	0	0	11	7	100	4	0	0	0	13	4	100	4
G04	0	0	0	11	7	100	4	0	0	0	12	5	100	4
G05	0	0	0	7	11	100	5	0	0	0	3	14	100	5
G06	0	0	1	4	13	100	5	0	0	1	2	14	100	5
G07	0	0	0	7	11	100	5	0	0	0	6	11	100	5
G08	0	0	1	7	10	100	5	0	0	0	5	12	100	5
G09	0	0	3	6	9	100	5	0	0	0	6	11	100	5
G10	0	1	0	12	5	94	4	0	0	1	11	5	100	4
G11	0	0	2	5	11	100	5	0	0	0	6	11	100	5

As shown in Table 5.6, the expert panelist agrees on 81 CCA indicators out of 82 indicators in the first round while all scores are higher than or equal to 88 % for the 93 CCA indicators in the second round. The percentage of the agreement represents 98.7 % and 100 %, respectively. The respondents suggested 11 new indicators to be incorporated into the study (i.e., F01.13, F01.14, F01.15, F02.06, F03.10, F03.11, F04.09, F04.10, F07.06, F07.07, and F10.04). The second round is continued to provide feedback to the respondents and to examine the agreement on the new 11 indicators identified in the first round. The percent of the agreement is higher than 80 percentages for all indicators except F02.04, where the percentage is only 76 %. All mode values in rounds 1 and are greater than or equal 4 except 4 indicators (i.e., F02.05, F03.04, F11.07, and F11.08) where the mode is only 3.

Table 5.6: Evaluation of CCA indicators- Delphi rounds 1 & 2

	Round 1							Round 2						
	Scale					Score		Scale					Score	
Code	1	2	3	4	5	(%)	**Mode**	1	2	3	4	5	(%)	**Mode**
F01.01	0	0	1	5	11	100	5	0	0	0	4	13	100	5
F01.02	0	0	2	5	10	100	5	0	0	1	3	13	100	5
F01.03	0	0	1	5	11	100	5	0	0	1	4	12	100	5
F01.04	0	0	5	7	5	100	4	0	0	2	13	2	100	4
F01.05	0	0	0	6	11	100	5	0	0	0	4	13	100	5
F01.06	0	0	5	7	5	100	4	0	0	2	11	4	100	4
F01.07	0	0	3	9	5	100	4	0	0	0	14	3	100	4
F01.08	0	0	1	6	10	100	5	0	0	1	2	14	100	5
F01.09	0	0	4	7	6	100	4	0	0	2	11	4	100	4
F01.10	0	0	4	6	7	100	5	0	0	2	6	9	100	5
F01.11	1	1	5	4	6	88	5	1	0	1	7	8	94	5
F01.12	0	3	4	2	8	82	5	0	0	1	7	9	100	5
F01.13				1				0	1	1	11	4	94	4
F01.14				1				0	0	3	10	4	100	4
F03.15				1				0	0	0	11	6	100	4
F02.01	0	0	3	4	10	100	5	0	0	0	5	12	100	5
F02.02	0	0	1	9	7	100	4	0	0	0	12	5	100	4
F02.03	0	0	4	5	7	100	5	0	0	0	8	9	100	5
F02.04	0	4	4	5	4	76	4	0	2	1	9	5	88	4
F02.05	0	2	7	3	5	88	3	0	1	8	6	2	94	3
F02.06				1				0	1	4	10	2	94	4
F03.01	0	0	2	4	11	100	5	0	0	0	4	13	100	5
F03.02	0	0	3	6	8	100	5	0	0	1	6	10	100	5
F03.03	0	2	5	3	7	88	5	0	2	2	6	7	88	5
F03.04	0	0	7	5	5	100	3	0	0	7	6	4	100	3
F03.05	0	0	2	4	11	100	5	0	0	0	4	13	100	5
F03.06	0	0	0	12	5	100	4	0	0	0	12	5	100	4
F03.07	0	0	1	7	9	100	5	0	0	0	8	9	100	5
F03.08	0	0	1	7	9	100	5	0	0	0	5	12	100	5
F03.09	0	0	2	10	5	100	4	0	0	0	13	4	100	4
F03.10					1			0	1	2	4	10	94	5
F03.11				1				0	0	0	4	13	100	5
F04.01	0	0	1	7	9	100	5	0	0	1	5	11	100	5
F04.02	0	1	1	9	6	94	4	0	0	1	11	5	100	4
F04.03	0	0	0	9	8	100	4	0	0	0	10	7	100	4
F04.04	0	0	0	7	10	100	5	0	0	0	5	12	100	5
F04.05	0	0	1	7	9	100	5	0	0	0	5	12	100	5
F04.06	0	0	2	9	6	100	4	0	0	1	13	3	100	4
F04.07	0	0	0	10	7	100	4	0	0	0	12	5	100	4
F04.08	0	0	1	9	7	100	4	0	0	0	11	6	100	4
F04.09				1				0	0	0	11	6	100	4
F04.10					2			0	0	1	5	11	100	5
F05.01	0	0	2	4	11	100	5	0	0	1	2	14	100	5
F05.02	0	0	2	11	4	100	4	0	0	1	13	3	100	4
F05.03	0	0	4	7	6	100	4	0	0	3	10	4	100	4
F05.04	0	0	4	8	5	100	4	0	0	3	12	2	100	4
F05.05	0	1	5	7	4	94	4	0	0	3	11	3	100	4
F05.06	0	1	1	10	5	94	4	0	0	2	11	4	100	4
F05.07	0	0	3	10	4	100	4	0	0	1	14	2	100	4
F05.08	0	0	0	8	9	100	5	0	0	0	5	12	100	5
F05.09	0	1	3	8	5	94	4	0	0	0	13	4	100	4

Table 5.6: Evaluation of CCA indicators- Delphi rounds 1 & 2 (continue)

	Round 1							Round 2						
Code	Scale					Score (%)	Mode	Scale					Score (%)	Mode
F05.10	0	1	0	6	10	94	5	0	0	0	4	13	100	5
F06.01	0	0	4	1	12	100	5	0	0	2	2	13	100	5
F06.02	0	2	4	5	6	88	5	0	0	3	5	9	100	5
F06.03	0	0	1	9	7	100	4	0	0	1	10	6	100	4
F06.04	1	1	4	4	7	88	5	0	2	2	5	8	88	5
F07.01	0	0	2	2	13	100	5	0	0	1	2	14	100	5
F07.02	0	0	5	5	7	100	5	0	0	2	5	10	100	5
F07.03	0	0	2	5	10	100	5	0	0	0	5	12	100	5
F07.04	0	0	4	6	7	100	5	0	0	1	5	11	100	5
F07.05	0	0	2	8	7	100	4	0	0	1	11	5	100	4
F07.06				1				0	0	2	9	6	100	4
F07.07					1			0	1	2	7	7	94	4
F08.01	0	0	0	7	10	100	5	0	0	0	4	13	100	5
F08.02	0	1	2	9	5	94	4	0	0	3	10	4	100	4
F08.03	0	0	0	8	9	100	5	0	0	0	7	10	100	5
F08.04	0	0	3	6	8	100	5	0	0	0	8	9	100	5
F08.05	0	0	3	8	6	100	4	0	0	0	12	5	100	4
F09.01	0	1	1	4	11	94	5	0	1	0	5	11	94	5
F09.02	0	1	1	6	9	94	5	0	0	1	6	10	100	5
F09.03	0	0	1	7	9	100	5	0	0	0	5	12	100	5
F09.04	0	0	1	7	9	100	5	0	0	0	4	13	100	5
F09.05	0	1	1	10	5	94	4	0	0	1	13	3	100	4
F09.06	0	0	5	7	5	100	4	0	0	4	10	3	100	4
F09.07	1	0	3	9	4	94	4	0	1	1	12	3	94	4
F09.08	0	1	5	4	7	94	5	0	1	4	4	8	94	5
F10.01	1	0	1	8	7	94	4	0	1	1	11	4	94	4
F10.02	0	1	2	10	4	94	4	0	0	3	12	2	100	4
F10.03	0	0	1	10	6	100	4	0	0	0	14	3	100	4
F10.04					1			0	2	0	10	5	88	4
F11.01	0	0	4	3	10	100	5	0	0	2	3	12	100	5
F11.02	0	0	5	5	7	100	5	0	0	1	7	9	100	5
F11.03	0	0	4	5	8	100	5	0	0	1	6	10	100	5
F11.04	0	0	4	6	7	100	5	0	0	1	9	7	100	4
F11.05	0	0	1	7	9	100	5	0	0	0	8	9	100	5
F11.06	0	1	4	5	7	94	5	0	1	0	9	7	94	4
F11.07	1	2	6	5	3	82	3	0	1	11	4	1	94	3
F11.08	0	1	6	5	5	94	3	0	0	9	6	2	100	3
F11.09	0	0	1	10	6	100	4	0	0	0	13	4	100	4
F11.10	0	0	3	5	9	100	5	0	0	1	5	11	100	5
F11.11	0	0	4	7	6	100	4	0	0	1	9	7	100	4
F11.12	0	0	3	5	9	100	5	0	0	0	4	13	100	5
F11.13	0	0	2	7	8	100	5	0	0	0	4	13	100	5

5.5.5 Statistical Measurement of Consensus

The level of consensus differs from one study to another, and there is no optimal consensus level (Ameyaw et al. 2016; Hallowell and Gambatese 2010). Ameyaw et al. (2016) list three methods, namely, absolute/ Standard deviation, Kendall's coefficient of concordance, and Chi-square ($\chi 2$) to measure level among the panel experts. The statistical measures of consensus are detailed hereafter.

5.5.5.1 Absolute Deviation and Standard Deviation

Absolute deviation and standard deviation are the most popular indicators employed in the literature (Hallowell and Gambatese 2010) to examine expert' consensus but without a minimum threshold. Some researchers accepted the standard deviation to the mean value ratio of 30% as the threshold for the difference in data. Other researchers use 5-10 % absolute variance about the median. Table 5.7shows the agreement based on the standard deviation to the mean percentage of 30%. The agreement is attended by all indicators except 5 indicators (F01.11, F01.12, F02.04, F06.04, and F11.07) in the first round, while agreement on all indicators is attended in the second round. The CCA group agreement is improved in the second round, as shown in Table 5.8.

Table 5.7: CCA indicators agreement based on mean and standard deviation percentage- Delphi rounds 1 & 2

	Round 1			Round 2		
Code	Mean	SD	% SD/Mean	Mean	SD	% SD/Mean
F01.01	4.59	0.618	13	4.77	0.479	10
F01.02	4.47	0.717	16	4.71	0.619	13
F01.03	4.59	0.618	13	4.65	0.619	13
F01.04	4.00	0.791	20	4.00	0.574	14
F01.05	4.65	0.493	11	4.77	0.447	9
F01.06	4.00	0.791	20	4.12	0.680	17
F01.07	4.12	0.697	17	4.18	0.574	14
F01.08	4.53	0.624	14	4.77	0.577	12
F01.09	4.12	0.781	19	4.12	0.619	15
F01.10	4.18	0.809	19	4.41	0.719	16
F01.11	3.77	1.200	32	4.24	1.047	25
F01.12	3.88	1.219	31	4.47	0.719	16
F01.13				4.06	0.784	19
F01.14				4.06	0.730	18
F03.15				4.35	0.497	11
F02.01	4.41	0.795	18	4.71	0.619	13
F02.02	4.35	0.606	14	4.29	0.577	13
F02.03	4.18	0.809	19	4.53	0.629	14
F02.04	3.53	1.125	32	4.00	0.957	24

Table 5.7: CCA indicators agreement based on mean and standard deviation percentage- Delphi rounds 1 & 2 (continued)

	Round 1			Round 2		
Code	**Mean**	**SD**	**% SD/Mean**	**Mean**	**SD**	**% SD/Mean**
F02.05	3.65	1.057	29	3.53	0.816	23
F02.06				3.77	0.663	18
F03.01	4.53	0.717	16	4.77	0.619	13
F03.02	4.29	0.772	18	4.53	0.727	16
F03.03	3.88	1.111	29	4.06	1.063	26
F03.04	3.88	0.857	22	3.82	0.806	21
F03.05	4.53	0.717	16	4.77	0.602	13
F03.06	4.29	0.470	11	4.29	0.447	10
F03.07	4.47	0.624	14	4.53	0.516	11
F03.08	4.47	0.624	14	4.71	0.500	11
F03.09	4.18	0.636	15	4.24	0.447	11
F03.10				4.35	0.975	22
F03.11				4.77	0.363	8
F04.01	4.47	0.624	14	4.59	0.632	14
F04.02	4.18	0.809	19	4.24	0.577	14
F04.03	4.47	0.514	11	4.41	0.512	12
F04.04	4.59	0.507	11	4.71	0.479	10
F04.05	4.47	0.624	14	4.71	0.619	13
F04.06	4.24	0.664	16	4.12	0.574	14
F04.07	4.41	0.507	11	4.29	0.479	11
F04.08	4.35	0.606	14	4.35	0.500	11
F04.09				4.35	0.514	12
F04.10				4.59	0.633	14
F05.01	4.53	0.717	16	4.77	0.577	12
F05.02	4.12	0.600	15	4.12	0.500	12
F05.03	4.12	0.781	19	4.06	0.680	17
F05.04	4.06	0.748	18	3.94	0.632	16
F05.05	3.82	0.883	23	4.00	0.632	16
F05.06	4.12	0.781	19	4.12	0.574	14
F05.07	4.06	0.659	16	4.06	0.443	11
F05.08	4.47	0.624	14	4.71	0.500	11
F05.09	4.00	0.866	22	4.24	0.403	10
F05.10	4.47	0.800	18	4.77	0.447	9
F06.01	4.29	1.047	24	4.65	0.727	16
F06.02	3.88	1.054	27	4.35	0.775	18
F06.03	4.35	0.606	14	4.29	0.577	13
F06.04	3.88	1.219	31	4.12	1.033	25
F07.01	4.65	0.702	15	4.77	0.577	12
F07.02	4.12	0.857	21	4.47	0.727	16
F07.03	4.47	0.717	16	4.71	0.479	10
F07.04	4.18	0.809	19	4.59	0.629	14
F07.05	4.29	0.686	16	4.24	0.577	14
F07.06				4.24	0.699	17
F07.07				4.18	0.917	22
F08.01	4.47	0.624	14	4.77	0.479	10
F08.02	4.06	0.827	20	4.06	0.680	17
F08.03	4.53	0.514	11	4.59	0.512	11
F08.04	4.29	0.772	18	4.53	0.516	11
F08.05	4.18	0.728	17	4.29	0.479	11
F09.01	4.35	0.931	21	4.53	0.816	18
F09.02	4.35	0.862	20	4.53	0.632	14
F09.03	4.47	0.624	14	4.71	0.479	10

Table 5.7: CCA Indicators agreement based on mean and standard deviation percentage- Delphi rounds 1 & 2 (continued)

	Round 1			Round 2		
Code	**Mean**	**SD**	**% SD/Mean**	**Mean**	**SD**	**% SD/Mean**
F09.04	4.47	0.624	14	4.77	0.447	9
F09.05	4.12	0.781	19	4.12	0.500	12
F09.06	4.00	0.791	20	3.94	0.680	17
F09.07	3.88	0.993	26	4.00	0.680	17
F09.08	4.00	1.000	25	4.12	0.998	24
F10.01	4.18	1.015	24	4.06	0.730	18
F10.02	4.00	0.791	20	3.94	0.574	15
F10.03	4.29	0.588	14	4.18	0.403	10
F10.04				4.06	0.917	23
F11.01	4.35	0.862	20	4.59	0.814	18
F11.02	4.12	0.857	21	4.47	0.619	14
F11.03	4.24	0.831	20	4.53	0.632	14
F11.04	4.18	0.809	19	4.35	0.619	14
F11.05	4.47	0.624	14	4.53	0.516	11
F11.06	4.06	0.966	24	4.29	0.775	18
F11.07	3.41	1.121	33	3.29	0.704	21
F11.08	3.82	0.951	25	3.59	0.793	22
F11.09	4.29	0.588	14	4.24	0.447	11
F11.10	4.35	0.786	18	4.59	0.632	14
F11.11	4.12	0.781	19	4.35	0.602	14
F11.12	4.35	0.786	18	4.77	0.447	9
F11.13	4.35	0.702	16	4.77	0.619	13

Table 5.8: CCA groups agreement based on mean and standard deviation percentage- Delphi rounds 1 & 2

Code	Round 1			Round 2		
	Mean	**SD**	**% SD/Mean**	**Mean**	**SD**	**% SD/Mean**
G01	4.71	0.588	12	4.82	0.447	9
G02	4.47	0.717	16	4.65	0.512	11
G03	4.41	0.507	11	4.24	0.447	11
G04	4.41	0.507	11	4.29	0.479	11
G05	4.59	0.507	11	4.82	0.447	9
G06	4.65	0.606	13	4.77	0.577	12
G07	4.59	0.507	11	4.65	0.500	11
G08	4.47	0.624	14	4.71	0.500	11
G09	4.29	0.772	18	4.65	0.516	11
G10	4.18	0.728	17	4.24	0.544	13
G12	4.47	0.717	16	4.65	0.500	11

5.5.5.2 Kendall's Coefficient of Concordance

Kendall's Coefficient of Concordance (W) is employed to examine the consensus level among the respondents' groups. It is suitable for ordinal data collected from the Likert scale (Cohen et al. 2007). The value suggests the level of agreement among the panelist by considering the differences between the mean ratings of the different variables (Hon et al. 2012). If the W value is one, this means a perfect consensus. In practice, the W value should be increased in succeeding rounds. According to Hon et al. (2012), the W range is .234 to 0.600 (Hon et al. 2012). Albert et al. (2017), recommend not using Kendall's W if the number of subjects is less than 7 and use Chi-Square analysis instead. For CCA indicators, the first-round show values of (W) are ranging from 0.17 to 0.36 while the second round shows improvement of values (range 0.26 to 0.49). The results of the second-round meet Hon's criteria, and therefore, one can consider as significant consensus improvement among experts. For CCA groups, the first round shows values of (W) are ranging from 0.100 to 0.38 while the second round shows improvement of values (range 0.24 to 0.67). The results of the second-round meet Hon's criteria, and therefore, one can consider as significant consensus among experts. details are illustrated in Table 5.9.

According to Patajoki (2013), public procurement is controlled by heavy legislation and regulations while the private sector is not ordered by the same legislation but aims profit. The flexibility offered to the private sector makes the expert's judgment slightly different while the rigidity in public procurement forces professionals to follow the rules and procedures in a systematic order. Also, in public procurement, the contract forms the relationship between the contracting parties but in the private sector, where flexibility is available to formulate the relationship within a contract (Carolina et al. 2012). This explains the variance in private experts' opinions when compared to public experts. Likewise, and within the study expert panel, out of 7 experts, 6 consultant professionals are more dealing with the private sector, and their opinion is slightly different. The contractor would prefer to follow systematic procedures, and this may explain their significant agreement level in comparison with the employer and consultant staff. Typically, the consultant is working very closely with the employer as a representative and their opinions are matching. This explains the similarity in consultant and employer agreement level. Except for consultant professional opinions, a similar conclusion is drawn to justify the agreement level of the CCA groups.

Table 5.9: Indicators test statistics for Delphi studies

	Group of Experts					
Test Statistics	**Overal l**	**Public**	**Privat e**	**Employe r**	**Consulta nt**	**Contracto r**
Indicators, Round 1						
Number of Experts (N)	17	6	11	4	7	6
Concordance Coefficient (W)	0.15	0.24	0.17	0.36	0.28	0.24
Chi-Square (χ^2)	213	117	155	118	158	118
Degrees of Freedom (df)	81	81	81	81	81	81
Asymp. Significant	0.000	0.006	0.000	0.004	0.000	0.005
Indicators, Round2						
Number of Experts (N)	17	6	11	4	7	6
Concordance Coefficient (W)	0.28	0.49	0.26	0.34	0.35	0.44
Chi-Square (χ^2)	443	269	260	124	226	245
Degrees of Freedom (df)	92	92	92	92	92	92
Asymp. Significant	0.000	0.000	0.000	0.014	0.000	0.000
Group, Round 1						
Number of Experts (N)	17	6	11	4	7	6
Concordance Coefficient (W)	0.10	0.23	0.10	0.38	0.23	0.19
Chi-Square (χ2)	17	14	10	15	16	12
Degrees of Freedom (df)	10	10	10	10	10	10
Asymp. Significant	0.069	0.179	0.400	0.122	0.088	0.309
Group, Round2						
Number of Experts (N)	17	6	11	4	7	6
Concordance Coefficient (W)	0.32	0.67	0.24	0.48	0.28	0.53
Chi-Square (χ2)	55	40	26	19	19	32
Degrees of Freedom (df)	10	10	10	10	10	10
Asymp. Significant	0.000	0.000	0.004	0.040	0.037	0.000

5.5.5.3 Chi-Square Analysis

Chi-square (χ2) is used to assess the consistency in the expert's ranking. χ2 is recommended for 7 or more evaluated variables. The Delphi panelist achieves the consensus level when the χ2 value exceeds the critical χ2, and the null hypothesis can be rejected (Albert et al. 2017; Hon et al. 2012). From statistics tables, critical Chi-square values are 18.307, 103.01, and 115.390 for degrees of freedom of 10, 81, and

92, respectively at 95 % confidence intervals (Montgomery and Runger 2011). For CCA indicators, Table 5.9 shows that all Chi-Square is higher than the critical values. therefore, there is an association that exists between the private and public experts, and between the employer, consultant, and contractor's experts at 0.05 significance level for both CCA indicators and CCA groups.

5.5.6 Group Analysis- Mean Scores Ranking

In the second round of the Delphi study, the mean scores are used to rate 93 CCA indicators for each sector, each respondent organization, and total sample frame as well.

Table 5.10 represents the mean scores among the experts' different groups. Although the rate is different between different groups, the test statistic does not illustrate significant differences.

Table 5.10: Mean scores among the groups of experts- round 2

Code	Overall		Public		Private		Employer		Consultant		Contractor	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
F01.01	4.76	1	5.000	1	4.640	17	4.750	9	4.710	8	4.830	4
F01.02	4.71	14	5.000	1	4.550	25	5.000	1	4.430	28	4.830	4
F01.03	4.65	22	4.500	33	4.730	7	4.500	29	4.710	8	4.670	20
F01.04	4.00	82	3.830	83	4.090	68	4.000	83	4.000	64	4.000	74
F01.05	4.76	1	4.830	6	4.730	7	4.500	29	5.000	1	4.670	20
F01.06	4.12	66	4.000	69	4.180	60	4.250	54	4.000	64	4.170	65
F01.07	4.18	63	4.170	56	4.180	60	4.500	29	4.140	55	4.000	74
F01.08	4.76	1	4.830	6	4.730	7	5.000	1	4.570	16	4.830	4
F01.09	4.12	66	4.000	69	4.180	60	4.000	83	4.290	41	4.000	74
F01.10	4.41	41	4.330	44	4.450	37	4.500	29	4.290	41	4.500	36
F01.11	4.24	56	4.500	33	4.090	68	4.250	54	4.000	64	4.500	36
F01.12	4.47	38	4.330	44	4.550	25	4.500	29	4.430	28	4.500	36
F01.13	4.06	74	4.000	69	4.090	68	3.750	88	4.000	64	4.330	51
F01.14	4.06	74	4.170	56	4.000	75	3.750	88	4.000	64	4.330	51
F01.15	4.35	43	4.170	56	4.450	37	4.000	83	4.570	16	4.330	51

Table 5.10: Mean scores among the groups of experts- round 2 (continued)

Code	Overall		Public		Private		Employer		Consultant		Contractor	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
F02.01	4.71	14	4.830	6	4.640	17	4.750	9	4.570	16	4.830	4
F02.02	4.29	50	4.170	56	4.360	48	4.750	9	4.290	41	4.000	74
F02.03	4.53	30	4.330	44	4.640	17	4.250	54	4.570	16	4.670	20
F02.04	4.00	82	4.330	44	3.820	88	4.250	54	3.570	88	4.330	51
F02.05	3.53	92	3.500	90	3.550	92	3.750	88	3.430	91	3.500	90
F02.06	3.76	90	3.330	92	4.000	75	3.750	88	3.860	74	3.670	89
F03.01	4.76	1	4.830	6	4.730	7	4.750	9	4.710	8	4.830	4
F03.02	4.53	30	4.500	33	4.550	25	5.000	1	4.430	28	4.330	51
F03.03	4.06	74	4.670	15	3.730	90	4.500	29	3.710	81	4.170	65
F03.04	3.82	89	3.830	83	3.820	88	4.000	83	4.000	64	3.500	90
F03.05	4.76	1	4.670	15	4.820	1	4.750	9	4.860	2	4.670	20
F03.06	4.29	50	4.170	56	4.360	48	4.250	54	4.140	55	4.500	36
F03.07	4.53	30	4.670	15	4.450	37	4.500	29	4.570	16	4.500	36
F03.08	4.71	14	4.670	15	4.730	7	5.000	1	4.570	16	4.670	20
F03.09	4.24	56	4.000	69	4.360	48	4.250	54	4.140	55	4.330	51
F03.10	4.35	43	4.830	6	4.090	68	4.250	54	4.000	64	4.830	4
F03.11	4.76	1	4.670	15	4.820	1	4.750	9	4.860	2	4.670	20
F04.01	4.59	24	4.500	33	4.640	17	4.750	9	4.430	28	4.670	20
F04.02	4.24	56	4.000	69	4.360	48	4.250	54	4.290	41	4.170	65
F04.03	4.41	41	4.170	56	4.550	25	4.500	29	4.430	28	4.330	51
F04.04	4.71	14	4.500	33	4.820	1	4.750	9	4.860	2	4.500	36
F04.05	4.71	14	4.670	15	4.730	7	5.000	1	4.710	8	4.500	36
F04.06	4.12	66	3.830	83	4.270	55	4.250	54	4.290	41	3.830	86
F04.07	4.29	50	4.000	69	4.450	37	4.500	29	4.430	28	4.000	74
F04.08	4.35	43	4.000	69	4.550	25	4.500	29	4.430	28	4.170	65
F04.09	4.35	43	4.330	44	4.360	48	4.250	54	4.290	41	4.500	36
F04.10	4.59	24	4.670	15	4.550	25	5.000	1	4.290	41	4.670	20
F05.01	4.76	1	5.000	1	4.640	17	4.750	9	4.570	16	5.000	1
F05.02	4.12	66	4.000	69	4.180	60	4.250	54	4.000	64	4.170	65
F05.03	4.06	74	4.170	56	4.000	75	4.250	54	3.710	81	4.330	51
F05.04	3.94	86	4.000	69	3.910	86	4.250	54	3.710	81	4.000	74
F05.05	4.00	82	4.000	69	4.000	75	4.250	54	3.710	81	4.170	65
F05.06	4.12	66	4.330	44	4.000	75	4.500	29	3.860	74	4.170	65
F05.07	4.06	74	4.000	69	4.090	68	4.250	54	4.000	64	4.000	74
F05.08	4.71	14	4.670	15	4.730	7	5.000	1	4.710	8	4.500	36
F05.09	4.24	56	4.170	56	4.270	55	4.250	54	4.140	55	4.330	51
F05.10	4.76	1	4.830	6	4.730	7	4.750	9	4.860	2	4.670	20
F06.01	4.65	22	5.000	1	4.450	37	4.750	9	4.290	41	5.000	1

Table 5.10: Mean scores among the groups of experts- round 2 (continued)

Code	Overall		Public		Private		Employer		Consultant		Contractor	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
F06.02	4.35	43	4.670	15	4.180	60	4.500	29	3.860	74	4.830	4
F06.03	4.29	50	4.500	33	4.180	60	4.500	29	4.000	64	4.500	36
F06.04	4.12	66	4.330	44	4.000	75	4.500	29	3.710	81	4.330	51
F07.01	4.76	1	5.000	1	4.640	17	4.750	9	4.570	16	5.000	1
F07.02	4.47	38	4.500	33	4.450	37	4.500	29	4.430	28	4.500	36
F07.03	4.71	14	4.830	6	4.640	17	4.750	9	4.710	8	4.670	20
F07.04	4.59	24	4.670	15	4.550	25	4.750	9	4.430	28	4.670	20
F07.05	4.24	56	4.170	56	4.270	55	4.250	54	4.290	41	4.170	65
F07.06	4.24	56	4.330	44	4.180	60	4.750	9	4.140	55	4.000	74
F07.07	4.18	63	4.500	33	4.000	75	4.500	29	3.860	74	4.330	51
F08.01	4.76	1	4.830	6	4.730	7	5.000	1	4.570	16	4.830	4
F08.02	4.06	74	4.000	69	4.090	68	4.500	29	3.860	74	4.000	74
F08.03	4.59	24	4.670	15	4.550	25	4.250	54	4.570	16	4.830	4
F08.04	4.53	30	4.330	44	4.640	17	4.500	29	4.570	16	4.500	36
F08.05	4.29	50	4.000	69	4.450	37	4.250	54	4.290	41	4.330	51
F09.01	4.53	30	4.830	6	4.360	48	4.750	9	4.140	55	4.830	4
F09.02	4.53	30	4.670	15	4.450	37	4.500	29	4.290	41	4.830	4
F09.03	4.71	14	4.670	15	4.730	7	4.750	9	4.710	8	4.670	20
F09.04	4.76	1	4.670	15	4.820	1	4.500	29	4.860	2	4.830	4
F09.05	4.12	66	3.830	83	4.270	55	4.250	54	4.140	55	4.000	74
F09.06	3.94	86	3.830	83	4.000	75	4.250	54	3.710	81	4.000	74
F09.07	4.00	82	3.830	83	4.090	68	4.500	29	3.860	74	3.830	86
F09.08	4.12	66	4.330	44	4.000	75	4.500	29	3.430	91	4.670	20
F10.01	4.06	74	4.170	56	4.000	75	4.250	54	3.710	81	4.330	51
F10.02	3.94	86	3.830	83	4.000	75	4.250	54	3.860	74	3.830	86
F10.03	4.18	63	4.170	56	4.180	60	4.250	54	4.140	55	4.170	65
F10.04	4.06	74	4.330	44	3.910	86	4.000	83	3.570	88	4.670	20
F11.01	4.59	24	4.670	15	4.550	25	4.750	9	4.290	41	4.830	4
F11.02	4.47	38	4.500	33	4.450	37	4.500	29	4.290	41	4.670	20
F11.03	4.53	30	4.500	33	4.550	25	4.500	29	4.570	16	4.500	36
F11.04	4.35	43	4.170	56	4.450	37	4.250	54	4.430	28	4.330	51
F11.05	4.53	30	4.500	33	4.550	25	4.250	54	4.430	28	4.830	4
F11.06	4.29	50	4.330	44	4.270	55	4.250	54	4.140	55	4.500	36
F11.07	3.29	93	3.170	93	3.360	93	3.500	93	3.140	93	3.330	93
F11.08	3.59	91	3.500	90	3.640	91	3.750	88	3.570	88	3.500	90
F11.09	4.24	56	4.000	69	4.360	48	4.250	54	4.430	28	4.000	74
F11.10	4.59	24	4.670	15	4.550	25	4.750	9	4.430	28	4.670	20
F11.11	4.35	43	4.170	56	4.450	37	4.250	54	4.290	41	4.500	36
F11.12	4.76	1	4.670	15	4.820	1	4.500	29	4.860	2	4.830	4
F11.13	4.76	1	4.670	15	4.820	1	4.750	9	4.710	8	4.830	4

5.5.7 Measurement of Importance and Agreement Strength

Although one cannot presume equal intervals among values, it could be argued that the intensity of feeling between two consecutive points (i.e., slightly important, and moderately important) is comparable to the feeling among other successive categories (i.e., moderately important, and very important) on the Likert scale (Cohen et al. 2007). This suggests establishing the scale intervals as: <1.5 is Not at all important; 1.51-2.5 is Slightly important; 2.51-3.5 is Moderately important; 3.51-4.5 is Very important; and > 4.5 is Extremely important.

The main use of the Inter-rater Agreement (IRA) method is to assess the strength of agreement. The IRA method is able to remove the effects of scale, sample size, number of raters as compared to other statistics techniques (Brown and Hauenstein 2005; Khan 2016). The $a_{wg(1)}$ estimates the agreement in terms of the ratio of an observed agreement to the maximum disagreement possible. Brown and Hauenstein (2005) Propose $a_{wg(1)}$ to represent the measure of agreement.

$$a_{wg(1)} = 1 - \frac{2xSD^2}{[(H+L)xM - M^2 - HxL]x\,k/(k-1)} \qquad (5.4)$$

Where:

SD	=	item standard deviation
H	=	highest possible rating (i.e., 5)
L	=	lowest possible rating (i.e., 1)
M	=	the observed mean of all respondents' responses for a single indicator
k	=	number of experts in the round

In the previous formula, the dominator represents the maximum possible variance. The subject means would fall between the minimum and maximum values, as shown in formula Equation (5.5) and Equation (5.6). Also, the minimum number of raters required is more than the number of response categories -1 (i.e., 4).

$$Mmin = \frac{L.(k-1)+H}{k} \tag{5.5}$$

$$Mmax = \frac{H(k-1)+L}{k} \tag{5.6}$$

The interpretation of the IRA estimates indicates perfect agreement when the value is equal to one and maximum disagreement when the value is equal to -1. The detailed meaning of IRA values is: 0.00–0.30 is a Lack of agreement; 0.31–0.50 is Weak agreement; 0.51–0.70 is Moderate agreement; 0.71–0.90 is Strong agreement; and 0.91–1.00 is Very strong agreement.

The IRA method is used to examine the strength of agreement in the second cycle and validate the other test statistics. $Mmin,$ and $Mmax$ for round 2 were calculated as 1.24 and 4.77 respectively for 17 respondents, and 1 to 5 scales. If the observed mean is greater than the maximum means, it represents a high degree of agreement in those CCA groups (Brown and Hauenstein 2005). Three CCA groups fall outside the defined range (i.e., G01, G05, and G06) due to extreme agreements.

The eleven groups (latent indicator) of CCA indicators are presented in Table 5.11. The mean scores of these groups ranged from 4.24 to 4.82. Also, 3 and 8 groups are ranked as 'Very important", 'Extremely important,' and no groups are ranked below 'Very important." Henceforward, it is concluded that all 11 groups have a significant contribution towards the CCA performance and are valid for further investigation through a questionnaire survey. Importantly, extremely important indicators (tasks) and groups should be handled carefully by the CCA team. The agreement level in the second round shows a moderate to a strong level of agreement. 8 and 3 CCA groups are ranked as 'Moderate agreement" and 'Strong agreement" respectively. The percentage of the agreement is representing 100 %.

Table 5.11: Inter-rater agreement analysis & importance level of groups- round 2

Code	Mean	SD	AWG (1)	Agreement		Importance	
				Change*	Level	Change*	Level
G01	4.82	0.390	0.58	+	M.A.	+	E.I.
G02	4.65	0.490	0.65	+	M.A.	+	E.I.
G03	4.24	0.440	0.85	+	S.A.	-	V.I.
G04	4.29	0.470	0.82	+	S.A.	-	V.I.
G05	4.82	0.390	0.58	-	M.A.	+	E.I.
G06	4.82	0.390	0.58	+	M.A.	+	E.I.
G07	4.65	0.490	0.65	-	M.A.	+	E.I.
G08	4.71	0.470	0.61	+	M.A.	+	E.I.
G09	4.65	0.490	0.65	+	M.A.	+	E.I.
G10	4.24	0.560	0.76	+	S.A.	+	V.I.
G11	4.65	0.490	0.65	+	M.A.	+	E.I.

Key:
(+) represents a positive change from Round 1 (-) Represents negative change from Round 1
LA = lack of agreement; WA = weak agreement; MA = moderate agreement; and SA = strong agreement
N.I.=Not at all important; S.I.=Slightly important; M. I= Moderately important; V. I=Very important, and E.I.=Extremely important

Table 5.12 lists the ranking and importance of CCA indicators and their respective groups for round two. The mean scores of these indicators are ranged from 3.29 to 4.76. Out of 93 indicators, 1, 55, and 37 indicators are ranked as “Moderately Important,” “Very Important,” and “Extremely Important” respectively. No indicators are ranked as either ‘Slightly important” or “Not at all important.” Henceforward, it is concluded that all 93 indicators have a significant contribution towards the CCA performance and are valid for further investigation through a questionnaire survey. The IRA values for all indicators in the second round are provided in Table 5.12. The agreement level in the second round shows a lack of agreement to a strong level of agreement. 5 indicators do not attend the agreement level while 13, 38, and 37 indicators are ranked as ‘Weak agreement”, ‘Moderate agreement,” and ‘Strong agreement” respectively. The percentage of the agreement after the second round represents 94.6 %. The results of IRA support the consensus reached through the simple mode score mean scores, concordance coefficient, and Chi-Square analysis, and the data are reliable for further analysis.

Table 5.12: Inter-rater agreement & importance level of indicators- round 2

Code	Mean	SD	AWG (1)	Agreement		Importance	
				Change*	Level	Change*	Level
F01.01	4.76	0.440	0.60	+	M.A.	+	E.I.
F01.02	4.71	0.590	0.39	-	W.A.	+	E.I.
F01.03	4.65	0.610	0.45	-	W.A.	+	E.I.
F01.04	4.00	0.500	0.84	+	S.A.		V.I.
F01.05	4.76	0.440	0.60	-	M.A.	+	E.I.
F01.06	4.12	0.600	0.75	+	S.A.	+	V.I.
F01.07	4.18	0.390	0.89	+	S.A.	+	V.I.
F01.08	4.76	0.560	0.35	-	W.A.	+	E.I.
F01.09	4.12	0.600	0.75	+	S.A.		V.I.
F01.10	4.41	0.710	0.53	+	M.A.	+	V.I.
F01.11	4.24	1.030	0.19	-	L.A.	+	V.I.
F01.12	4.47	0.620	0.61	+	M.A.	+	V.I.
F01.13	4.06	0.750	0.63		M.A.		V.I.
F01.14	4.06	0.660	0.72		S.A.		V.I.
F03.15	4.35	0.490	0.79		S.A.		V.I.
F02.01	4.71	0.470	0.61	+	M.A.	+	E.I.
F02.02	4.29	0.470	0.82	+	S.A.	-	V.I.
F02.03	4.53	0.510	0.71	+	S.A.	+	E.I.
F02.04	4.00	0.940	0.45	+	W.A.	+	V.I.
F02.05	3.53	0.800	0.68	+	M.A.	-	V.I.
F02.06	3.76	0.750	0.69		M.A.		V.I.
F03.01	4.76	0.440	0.60	+	M.A.	+	E.I.
F03.02	4.53	0.620	0.56	+	M.A.	+	E.I.
F03.03	4.06	1.030	0.31	+	W.A.	+	V.I.
F03.04	3.82	0.810	0.63	+	M.A.	-	V.I.
F03.05	4.76	0.440	0.60	+	M.A.	+	E.I.
F03.06	4.29	0.470	0.82		S.A.		V.I.
F03.07	4.53	0.510	0.71	+	S.A.	+	E.I.
F03.08	4.71	0.470	0.61	+	M.A.	+	E.I.
F03.09	4.24	0.440	0.85	+	S.A.	+	V.I.
F03.10	4.35	0.930	0.25		L.A.		V.I.
F03.11	4.76	0.440	0.60		M.A.		E.I.
F04.01	4.59	0.620	0.51	-	M.A.	+	E.I.
F04.02	4.24	0.560	0.76	+	S.A.	+	V.I.
F04.03	4.41	0.510	0.76	+	S.A.	-	V.I.
F04.04	4.71	0.470	0.61	-	M.A.	+	E.I.
F04.05	4.71	0.470	0.61	+	M.A.	+	E.I.
F04.06	4.12	0.490	0.84	+	S.A.	-	V.I.
F04.07	4.29	0.470	0.82	+	S.A.	-	V.I.
F04.08	4.35	0.490	0.79	+	S.A.		V.I.
F04.09	4.35	0.490	0.79		S.A.		V.I.
F04.10	4.59	0.620	0.51		M.A.		E.I.
F05.01	4.76	0.560	0.35	-	W.A.	+	E.I.
F05.02	4.12	0.490	0.84	+	S.A.		V.I.
F05.03	4.06	0.660	0.72	+	S.A.	-	V.I.
F05.04	3.94	0.560	0.81	+	S.A.	-	V.I.
F05.05	4.00	0.610	0.77	+	S.A.	+	V.I.

Table 5.12: Inter-rater agreement & importance level of indicators–round 2 (continued)

Code	Mean	SD	AWG (1)	Agreement		Importance	
				Change*	Level	Change*	Level
F05.06	4.12	0.600	0.75	+	S.A.		V.I.
F05.07	4.06	0.430	0.88	+	S.A.		V.I.
F05.08	4.71	0.470	0.61	+	M.A.	+	E.I.
F05.09	4.24	0.440	0.85	+	S.A.	+	V.I.
F05.10	4.76	0.440	0.60	+	M.A.	+	E.I.
F06.01	4.65	0.700	0.28	+	L.A.	+	E.I.
F06.02	4.35	0.790	0.46	+	W.A.	+	V.I.
F06.03	4.29	0.590	0.72	+	S.A.	-	V.I.
F06.04	4.12	1.050	0.24	+	L.A.	+	V.I.
F07.01	4.76	0.560	0.35	+	W.A.	+	E.I.
F07.02	4.47	0.720	0.47	-	W.A.	+	V.I.
F07.03	4.71	0.470	0.61	+	M.A.	+	E.I.
F07.04	4.59	0.620	0.51	-	M.A.	+	E.I.
F07.05	4.24	0.560	0.76	+	S.A.	-	V.I.
F07.06	4.24	0.660	0.67		M.A.		V.I.
F07.07	4.18	0.880	0.44		W.A.		V.I.
F08.01	4.76	0.440	0.60	-	M.A.	+	E.I.
F08.02	4.06	0.660	0.72	+	S.A.		V.I.
F08.03	4.59	0.510	0.67	-	M.A.	+	E.I.
F08.04	4.53	0.510	0.71	+	S.A.	+	E.I.
F08.05	4.29	0.470	0.82	+	S.A.	+	V.I.
F09.01	4.53	0.800	0.27	+	L.A.	+	E.I.
F09.02	4.53	0.620	0.56	+	M.A.	+	E.I.
F09.03	4.71	0.470	0.61	+	M.A.	+	E.I.
F09.04	4.76	0.440	0.60	-	M.A.	+	E.I.
F09.05	4.12	0.490	0.84	+	S.A.		V.I.
F09.06	3.94	0.660	0.74	+	S.A.	-	V.I.
F09.07	4.00	0.710	0.68	+	M.A.	+	V.I.
F09.08	4.12	0.990	0.33	-	W.A.	+	V.I.
F10.01	4.06	0.750	0.63	+	M.A.	-	V.I.
F10.02	3.94	0.560	0.81	+	S.A.	-	V.I.
F10.03	4.18	0.390	0.89	+	S.A.	-	V.I.
F10.04	4.06	0.900	0.47		W.A.		V.I.
F11.01	4.59	0.710	0.36	-	W.A.	+	E.I.
F11.02	4.47	0.620	0.61	+	M.A.	+	V.I.
F11.03	4.53	0.620	0.56	+	M.A.	+	E.I.
F11.04	4.35	0.610	0.68	+	M.A.	+	V.I.
F11.05	4.53	0.510	0.71	+	S.A.	+	E.I.
F11.06	4.29	0.770	0.52	+	M.A.	+	V.I.
F11.07	3.29	0.690	0.77	+	S.A.	-	M.I.
F11.08	3.59	0.710	0.74	+	S.A.	-	V.I.
F11.09	4.24	0.440	0.85	+	S.A.	-	V.I.
F11.10	4.59	0.620	0.51	+	M.A.	+	E.I.
F11.11	4.35	0.610	0.68	+	M.A.	+	V.I.
F11.12	4.76	0.440	0.60	+	M.A.	+	E.I.
F11.13	4.76	0.440	0.60	+	M.A.	+	E.I.

Key:
(+) represents a positive change from Round 1 (-) Represents negative change from Round 1
LA = lack of agreement; WA = weak agreement; MA = moderate agreement; and SA = strong agreement
N. I=Not at all important; S.I.=Slightly important; M. I= Moderately important; V. I=Very important; and E.I.=Extremely important

5.6 CCA FRAMEWORK

Based on the above, the Delphi study validates the proposed Construction Contract Administration Framework (CAPF). The core of the proposed framework is the operational activities/ tasks of the contract administration, and the shell is the project management process. As shown in Figure 5.3, CAPF is divided into three main components; (1) supporting function, (2) timeline function, and (3) core competency function that captures the full life cycle of the contract administration process. The supporting function includes team management, document and record management, and contract risk management. This function routinely serves the other eight processes. The timeline function includes governance and start-up management, contract execution (quality & acceptance management), and contract closeout management. This function represents the three groups of project management processes (i.e., planning, executing and closing) and is further supported by the groups of monitoring and control processes (the core competency function). The core competency function includes communication & relationship management, performance monitoring and reporting management, financial management, changes & changes control management and claims and disputes resolution management.

The timeline function receives and provides input from the core competency functions. There is an interaction between the different process groups and the overall construction administration function. Also, each process involves individual or teamwork effort and may occur in one or more project phases. In practice, the processes presented in Figure 5.3 overlapped and cannot be segregated from each other and thereby require integrated teamwork rather than individual effort. Figure 5.4 shows the final 93 indicators and 11 groups.

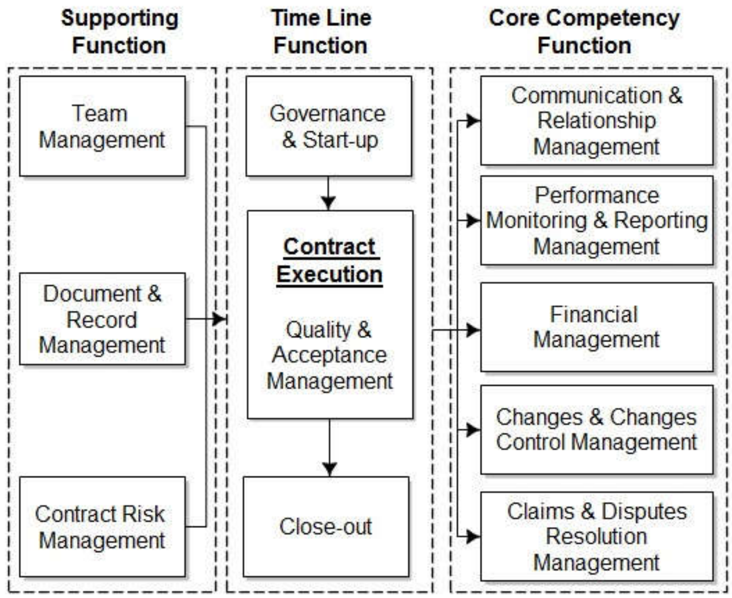


Figure 5.3: Contract administration performance framework (CAPF)

5.7 DISCUSSION OF DELPHI RESULTS

As the different methods give different figures for the agreement between experts, an attempt is made to compare the results from the different methods. Figure 5.5 shows the different agreement levels obtained from the Score percentage, Mode value, mean to standard deviation ration, and IRA Index. Notably, the scoring method and SDMR give almost similar results. In the same way, the mode score and IRA methods give almost similar results, too. It can be concluded that agreement significantly achieved for most of the indicators through the simple mode score, mean scores, coefficient of concordance, Chi-Square analysis, and IRA. As described, the data are reliable for further analysis.

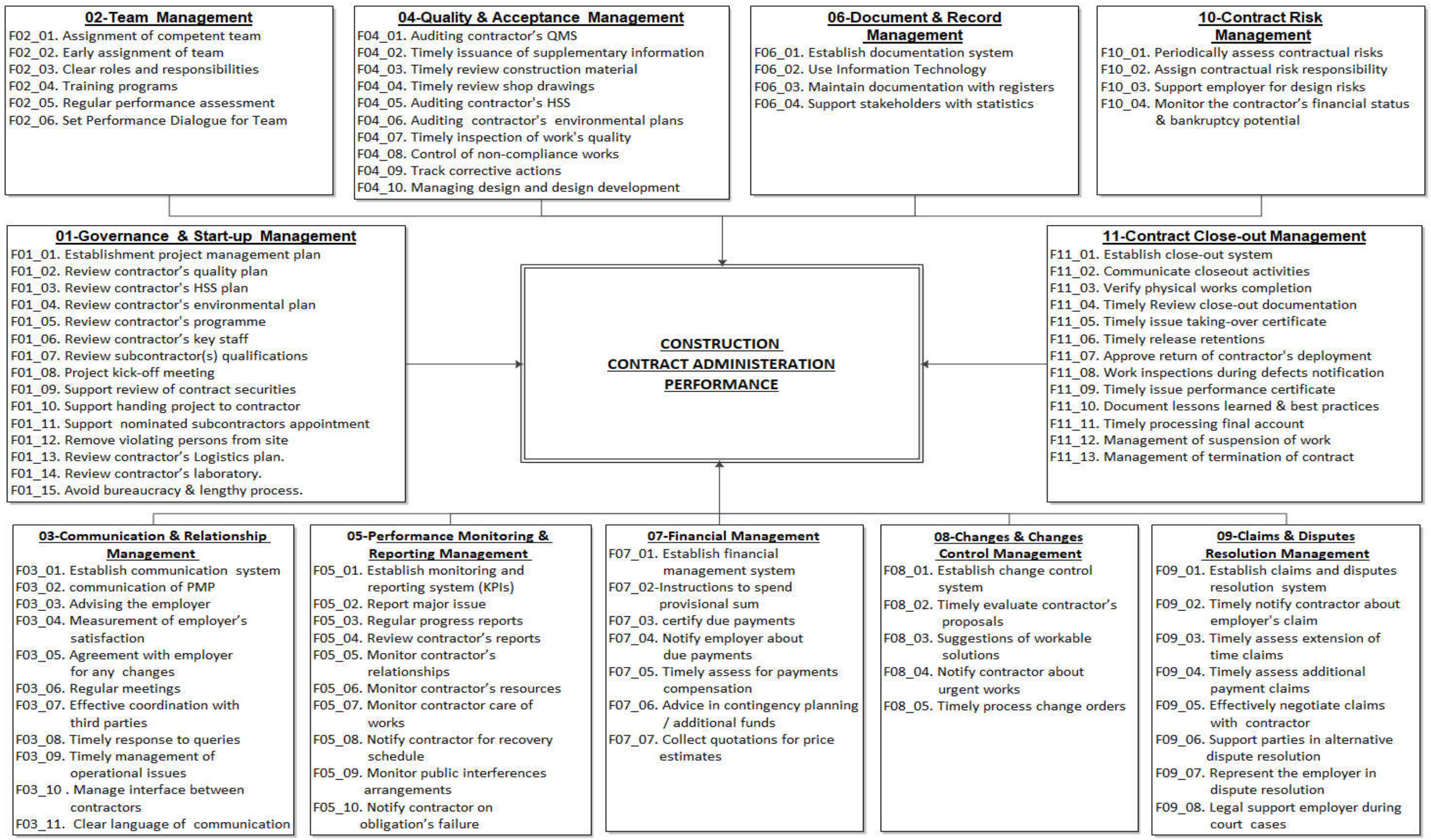


Figure 5.4: Indicators of construction contract administration framework

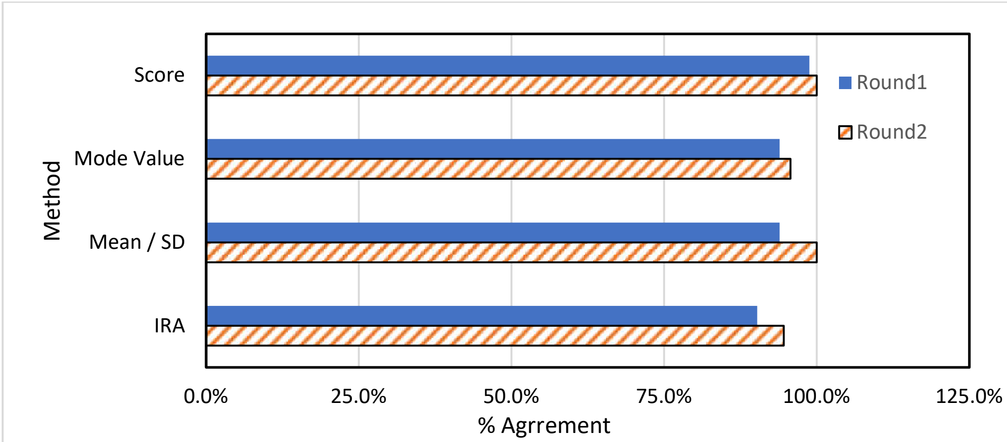
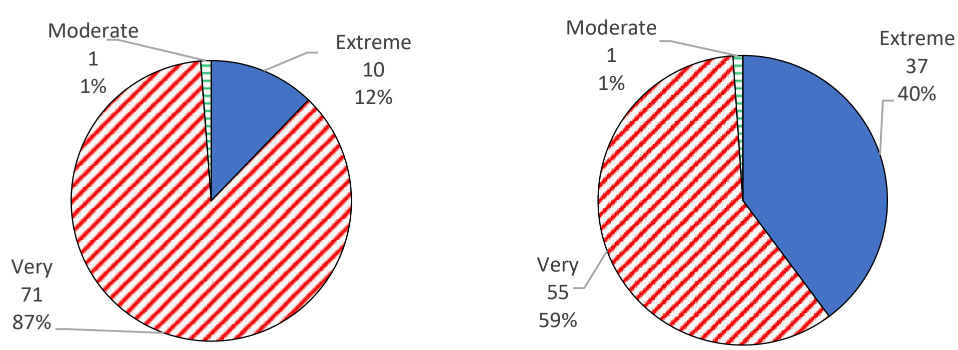


Figure 5.5: Compare the agreement level from different methods

The second round of the Delphi survey ranks 1 indicator as moderately important, 55 indicators as very important, and 37 indicators as extremely important, as shown in Figure 5.6. Therefore, a focus on these indicators would certainly help in reducing problems in CCA, and the CCA team is recommended to monitor the performance of those indicators to improve the CCA performance and decrease disputes that may be generated from the improper performance of these tasks. While the client and consultant should focus on monitoring the performance of the identified indicators, the contractor should assess the other stakeholders with cooperation and coordination.



(a) (b)

Figure 5.6: Importance level distribution: (a) round 1; and (b) round 2

5.8 CHAPTER SUMMARY

This chapter identifies the CCA indicators and discusses the data collection and analysis to achieve Objective 2. 82 factors contributing to construction CCA performance are collected from literature, 4 semi-structured interviews. Another 11 factors are added by the experts of the Delphi study. The core of the proposed framework is the operational activities/ tasks of the contract administration, and the shell is the project management process. The expert's panel is grouped into public and private sector experts. Also, they are grouped as an employer, consultant, and contractor groups. The data collected is analyzed by Spearman rank-order correlation, score percentage, mean to standard deviation ratio to take the decision to continue Delphi study after round two, or to continue. The factor ranking and consensus are examined through simple mode scoring, mean scoring, ranking, and Kendall's coefficient of concordance (W), and Chi-Square ($\chi 2$), The Delphi study results are followed by measuring the agreement strength through the IRA indicator.

A significant consensus is achieved after two rounds of Delphi study. The higher values of Cronbach alpha for both rounds describe the data reliability. The importance recognize by experts constitutes to focus on the identified factors to obtain a good performance of CCA.). The IRA varies from a weak level of agreement to a strong level agreement for each individual factor after the second round of the Delphi survey. The agreement level represents 94.6 of the proposed factors and 100 % of the proposed groups. The lowest rank obtained is moderately important, and most factors are ranked as very important and extremely important. The output of the Delphi study validates the identified factors and Framework. Therefore, the third objective is achieved.

CHAPTER 6 : FUZZY LOGIC AND STRUCTURAL EQUATION MODELING

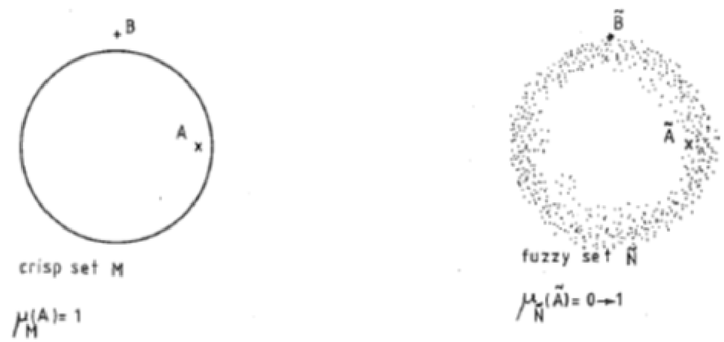
6.1 INTRODUCTION

During the last decades, several managerial tools have been developed from other industries to help the construction industry professionals to effectively plan and control their projects due to the presence of uncertainties and complexity (Seresht and Fayek 2015). This chapter introduces the important aspect of Fuzzy Set Theory, Fuzzy Logic, and the Structural Equation Modeling that shall be utilized for this study and required for the collection of data, preparation for analysis, and the establishment of the research model.

6.2 FUZZY LOGIC MODELS

In 1965, Fuzzy logic was developed by Zadeh to gives the human reasoning process a mathematical precision (Seresht and Fayek 2015). Fuzzy logic is a collection of mathematical principles for the illustration of information based on degrees of membership. Fuzzy logic is a technique for capturing vague conditions, incomplete, non-obtainable, subjective, and linguistically expressed data in a precise way (Seresht and Fayek ; Singhaputtangkul and Zhao 2016) to deal with ill-defined and complex situations in a decision-making problem (Baloi and Price 2003). The fuzzy logic allows users to assess subjective topics by expressing themselves linguistically (Poveda and Fayek 2009). Fuzzy logic is able to represent the concepts expressed in the natural language to meaningfully mathematical numbers (Ozdemir 2015).

A fuzzy set is an extension of the classical set theory. In the classical set theory, a set defined as a group of objects with a common property (Nguyen 1985). An element (X) is either belonging $(\mu M(x) = 1)$ to or not belonging$(\mu M(x) = 0)$ to the investigated set (of elements *M*), as represented by the membership function $\mu M(x)$. Graphically, the difference between the crisp (classical) and fuzzy concepts is illustrated in Figure 6.1.



(a) (b)

Figure 6.1: Set theory : (a) crisp set; and (b) fuzzy set (Nguyen, 1985)

The fuzzy set theory allows correlating an element partially to a set. Within the range over which the variable extents (so-called a universe of discourse X), a fuzzy set M is branded by a membership function μM(x). The membership function links each element x of the universe of discourse to the membership function number between 0 to 1 — also, the membership function representing the grade of membership of x in the fuzzy set. The membership grade represents the 'membership' of an element x to the set M. Contrary to the classical set theory, the fuzzy sets theory allows us to define membership values as real numbers between an interval of [0, 1] (Ross 2005).

Fuzzy logic-based models are ranged from simple to complex. It and can be broadly classified as simple, hybrid, and multi-criteria decision models. The simple models include fuzzy models, fuzzy Delphi, fuzzy regression, fuzzy grey prediction, fuzzy AHP, fuzzy ANP, fuzzy clustering. The hybrid models include neuro-fuzzy, adaptive, neuro-fuzzy inference system, fuzzy genetic algorithm, fuzzy expert system, neuro-fuzzy expert system, fuzzy DSS, fuzzy data envelopment analysis, neuro-fuzzy data envelopment analysis. The multicriteria decision models include fuzzy VIKOR, fuzzy TOPSIS, fuzzy support vector machine, fuzzy optimization (Suganthi et al. 2015).

A typical fuzzy rule-based system consists of four elements: fuzzifier, rule-based, inference engine, and defuzzifier (Lotfizadeh and Berkeley 2001). First, the fuzzifier directs the degree of membership of an input to a certain membership function. Secondly, the rule-base describes the relationships between the inputs and the output variables; subsequently, the output is established based on the degree of membership definite by the fuzzifier. Third, the inference engine generates consequent rules using membership functions. Finally, a defuzzifier converts fuzzy outputs into crisp values.

6.2.1 Fuzzy Set Theory and Fuzzy Logic in Construction

The fuzzy set theory has been increasingly utilized by numerous researchers in a variety of professional areas (Singhaputtangkul and Zhao 2016) and has been applied to successfully model several construction topics (Chan et al. 2009; Poveda and Fayek 2009). Fuzzy set researches cover quite a lot of disciplines and applications. Fuzzy Set is a powerful modeling technique that suited the construction industry because the construction industry is unique in characteristics and lack of historical data (Chan et al. 2009).

Since long time, fuzzy set theory has been used for construction management applications such as tender evaluation with multiple criteria and many decision making parties, bidding margin, evaluating alternative construction technology, project control, and scheduling, cash flow analysis, and the association between the final project outcomes and the behavior of the project managers publications (Ameyaw et al. 2016). Dainty et al. (2005) proposed a multidimensional model to predict the performance of project managers based on competency. Georgy et al. (2005) developed neuro-fuzzy models to predict the performance of engineers and design professionals. Kaka et al. (2008) correlated the performance of services and employees to the client satisfaction by the fuzzy logic approach. Chow and Ng (2007). Evaluated the engineering consultant performance by fuzzy gap analysis model. Li et al. (2007) suggested a fuzzy framework to evaluate a contractor's vague and subjective prequalification criteria. Another recent study carried out by Pawan and Lorterapong (2015) used a fuzzy set theory to model the fuzziness of the project time contingency and assess the influence of multiple risks on activity durations. Enormous authors carried similar studies in a different construction management area such as the Fuzzy risk assessment model in public-private partnership infrastructure projects (Mazher et al. 2018), a fuzzy consensus scheme integrated to mitigate design team groupthink and disagreements on the design of a building envelope (Singhaputtangkul and Zhao 2016). Shi et al. (2014) deployed the fuzzy logic theory combined with Data Envelopment Analysis to calculate the magnitude of delivery risk in a large construction program. Poveda and Fayek (2009) deployed the fuzzy logic approach in evaluating and predicting the performance of trades foremen using a seven-point linguistic scale. The model contained many factors categorized into six groups and was compared with a statistical-based mean evaluation to validate the results. The authors argued that fuzzy logic was able to model the performance evaluation uncertainty. Uncertainty in performance evaluation was referred to as the presence of numerous factors, the linguistic assessment nature, and the nonlinearity of relationships among the different factors.

Thus, fuzzy logic proved its acceptance among the construction industry researchers due to the vague, subjective and uncertain nature of many factors affecting the construction projects, lack of proper quantification of factors and ability to model the different relationships between the inputs and the outputs. As a result, the previous study demonstrated that a fuzzy approach is appropriate and can provide a useful technique for the construction industry. Therefore, the Fuzzy set theory was chosen for this study due to a lack of quantitative data on the subject, the presence of uncertainty and fuzziness associated with the importance of several indicators affecting the CCA performance, the necessity to use subjective judgments of the industry participants. As such, the Fuzzy Set theory is extended for evaluating the performance of CCA.

6.2.2 The Linguistic Variables and Study Questionnaire

The linguistic variable means linguistic expressions rather than numerical values (Ozdemir 2015) such as low, medium, or high within a fuzzy set. The selection of a certain fuzzy set is dependent on the problem context. Each linguistic variable can be converted into a linguistic value in which each value is expressed as a membership function. According to Singhaputtangkul and Zhao (2016), linguistic assessments used instead of numerical values in a situation where a large amount of information, subjective information, or incomplete knowledge exist. For this study, five linguistic variables were defined as 1) not at all important (NI); 2) slightly important (SI); 3) moderately important (MI); 4) very important (VI), and 5) extremely important (EI). The target respondents were requested to rate the impact of factors on CCA performance according to the linguistic scale. The questionnaire was sent online to construction professionals, and 366 response were collected.

6.2.3 Fuzzy Role-Based System

6.2.3.1 Fuzzy Membership Functions

Fuzzy membership functions identify the linguist variable. The membership function is expressed as a curve that defines how the value of a fuzzy variable is plotted to a degree of membership between 0 and 1 (Shi et al. 2014). Several ways, such as an expert judgment or historical data, were available to determine the numerical values of the membership functions (Seresht and Fayek 2015). Fuzzy sets can take various shapes, and the linear forms, such as the trapezoidal and triangular shapes, are used commonly used. A membership function can be established for each of these linguistic values using a particular shape on a specific range as fit for given conditions. According to (Rahim 2017), the triangular, trapezoid, and Gaussian membership functions have the same result, but the triangular membership function is easier than trapezoid and Gaussian. the three membership functions have the disadvantages and advantages depending on the case study conducted. In the fuzzy set, the triangular shapes were the mostly employed forms to quantify the qualitative information (Ozdemir 2010; Singhaputtangkul and Zhao 2016), as shown in Equation 6.1.

$$\mu M(x) = \begin{cases} 0\,, x < a \; or \; x > c \\ \frac{x-a}{b-a}\,, a \leq x \leq b \\ \frac{c-x}{x-b}\,, b < x \leq c \end{cases} \quad (6.1)$$

Where:

x = Element to be investigated

M = fuzzy numbers (a, b, c)

$\mu M(x)$ = linear membership function

Figure 6.2 represents a fuzzy set for a fuzzy variable, “Quality” that were grouped into three functions. When the quality variable is graded as 35 %, the associated linguistic variables (High, Medium, and Low) would have a membership value of (0, 0.75, 0.5), respectively. It means that the quality value is 0.75 membership to fuzzy set "Medium” and 0.5 membership to fuzzy set ‘low.’

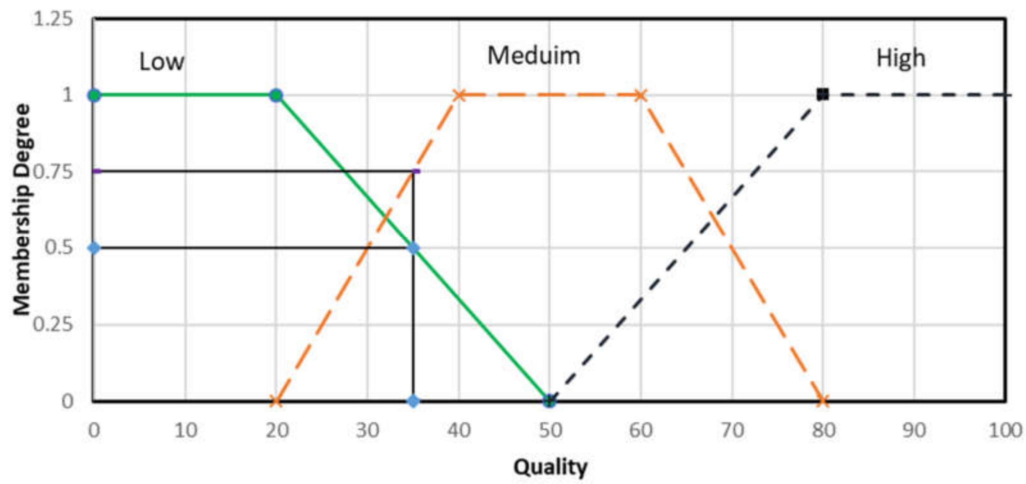


Figure 6.2: Example fuzzy membership function

6.2.3.2 *Fuzzy Rules*

Once the subjective variables have been defined with fuzzy membership functions, the relationships between these variables must be modeled using fuzzy logic techniques. Fuzzy logic techniques include two alternatives: 1) Fuzzy arithmetic and mathematical equations where historical data are available, 2) Fuzzy rule-based systems (i.e., expert judgments) where historical data are unavailable (Seresht and Fayek 2015). The fuzzy rules connect the input variables to output variables. It can be expressed as a conditional statement 'IF ... and … THEN ...' to describe the system response regarding linguistic words rather which is equivalent to the mathematical formulae. The 'IF' part represents the 'antecedent or circumstance' while the 'THEN' part represents the 'consequent or conclusion' of the rule. The antecedent proposition determination of how many rules are required to express a fuzzy system depends on the number of inputs variables, a number of outputs variables and the system anticipated behavior. There are several types of fuzzy rules that include Mamdani-Style, Confidence Degrees; Takagi-Surgeon, Gradual, Generalized, and Recurrent. Each rule is assessed to define the degree of rule fulfillment. Mamdani fuzzy rules were selected because it is widely accepted in literature and meets the human mind to represent relationships. The rules are formed in Equation 6.2 as:

$$Ri: IF\ (X\ is\ A_i)\ THEN\ (Y\ is\ B_j)\ for\ i=1, 2, \ldots, L;\ j=1, 2, N \quad (6.2)$$

Where:

Ri	=	Rule number *i*
X	=	Input (antecedent) fuzzy variable to be investigated
Ai	=	Subset corresponding to an antecedent linguistic constant (an element of)
L	=	Total number of elements in set *A*
Y	=	output fuzzy variable
Bj	=	Fuzzy subset corresponding to a consequent linguistic constant (one of *N* in set *B*)

The rules may be set as if the importance of an event is "X," then consequences of the event on the CCA performance is "X"

6.2.3.3 Aggregation and Defuzzification Methods

Aggregation means the combination of the consequents of each rule in a Mamdani fuzzy inference system in preparation for defuzzification. The outputs of a fuzzy rule-based system have irregularly shaped membership functions. Therefore, the results must be either defuzzified or approximated by a regular membership function for further calculations. Defuzzification is the process of producing a non-fuzzy number by converting the fuzzy memberships to a single crisp value (Seresht and Fayek 2015; Shi et al. 2014). The most common mathematical methods for the defuzzification process include the Center of Area method (also known as the center of gravity method or centroid method), the center of maxima method, largest of maxima, smallest of maxima, and the mean of maxima method. The center of the area is the most common method of defuzzification. It determines the centroid of an area under the membership function. The equation for the Centre of the area takes the membership value times each element divided by the sum of the values of membership. Middle of Maxima, Largest of Maxima, Smallest of Maxima methods take the range of elements with the largest membership value and determine the middle, largest, and smallest values for the three methods, respectively. These methods provide a rougher estimation of the defuzzified value than the center of the area method. The mean of maxima is like the above methods but slightly more refined. Unlike the Center of Area method, this method takes into account the values with maximum membership (Poveda and Fayek 2009). The defuzzification method of trapezoidal fuzzy numbers M (a, b, c, and d) can be defuzzified by a value (e) which represents the center of gravity of the trapezoidal shape (Shyi 1997) as depicted graphically in Figure 6.3 and as shown in Equation (6.3).

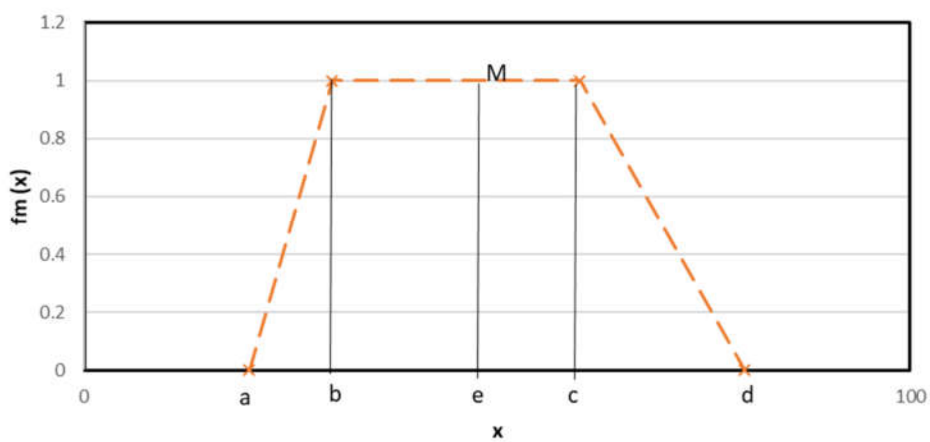


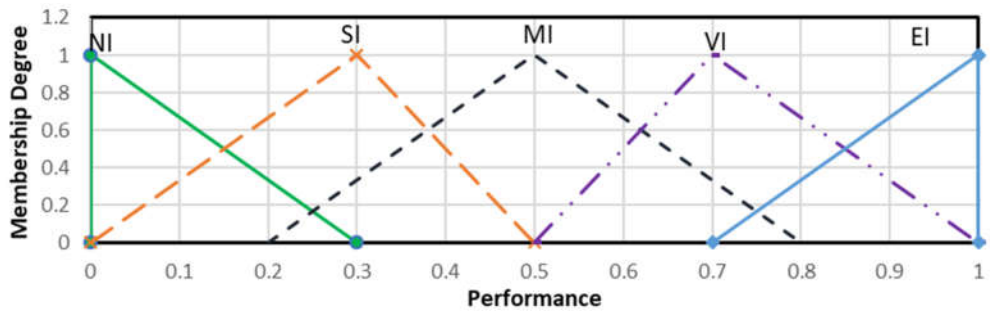
Figure 6.3: Trapezoidal fuzzy number M defuzzification

$$e = \frac{a + b + c + d}{4} \tag{6.3}$$

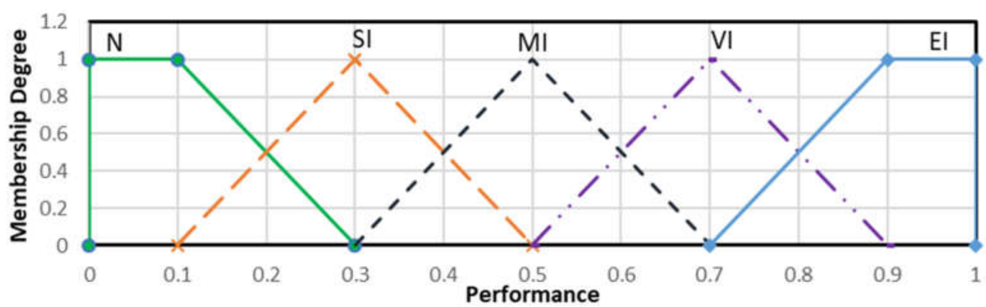
6.2.3.4 Linguistic Terms, Membership Functions, and Defuzzification

To avoid bias in selecting a certain fuzzy membership function, the researcher reviewed implementation of fuzzy membership function in construction management and found 3 references namely 1) triangular fuzzy membership function used by

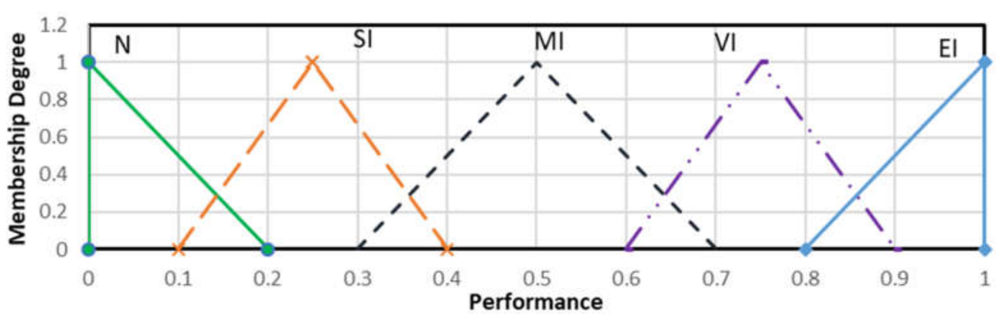
(Gunduz et al. 2017) to establish safety performance index for safety on construction sites(Figure 6.4a); 2) trapezoidal-triangular fuzzy membership function used by (Ozdemir 2010) to predict schedule delay in construction projects and by (Georgy et al. 2005) to Predict the engineering performance (Figure 6.4b); and 3) triangular fuzzy membership function used by (Nguyen et al. 2008) for Architect/Engineer team performance assessment (Figure 6.4c).



(a)



(b)



(c)

Figure 6.4: Different options of membership function: (a) Gunduz et al. (2017); (b) Ozdemir (2010); and (c) Nguyen et al. (2008)

Although one cannot presume equal intervals among values, it could be argued that the intensity of feeling between two consecutive points (i.e., slightly important, and moderately important) is comparable to the feeling among other successive categories (i.e., moderately important, and very important) on the Likert scale (Cohen et al. 2007). Based on this concept, the fuzzy membership function proposed (Gunduz et al. 2017) for safety performance index is selected for this study.

This study employed a methodology used by (Gunduz et al. 2017; Nguyen et al. 2008; Ozdemir 2015; Shyi 1997) to utilize the fuzzy set theory and get the associated crisp values from Likert scale linguistic terms: Not at all important (NI), Slightly important, (SI), Moderately important (MI), Very important (VI), and Extremely important (EI). By applying equation 6.3 for the proposed membership function and the associated fuzzy numbers, the defuzzified (crisp values), as shown in Table 6.1.

Table 6.1: Linguistic term, fuzzy number, and crisp value

SN	Linguistic Term	Fuzzy Number	Crisp Value
1	Not at all important (NI)	(0.0, 0.0, 0.0, 0.3)	0.075
2	Slightly important (SI)	(0.0, 0.3, 0.3, 0.5)	0.275
3	Moderately important (MI)	(0.2, 0.5, 0.5, 0.8)	0.500
4	Very important (VI)	(0.5, 0.7, 0.7, 1.0)	0.725
5	Extremely important (EI)	(0.7,1.0,1.0,1.0)	0.925

6.3 STRUCTURE EQUATION MODELING

Structural Equation Modeling (SEM)- also known as the analysis of covariance structures or causal modeling- is a general approach to data analysis(Arbuckle 2017). Bentley is the pioneer who introduced the implementation of the Structural Equation Modeling as a Multivariate Statistical Technique to estimate the constructs in psychological science in 1980. Since that date, structural equation modeling (SEM) has been used for social science, psychological science, project management, and construction-related researches for several years. The applications have been accelerating over time, more popular, and more manageable for users because of the available range of available software with a friendly graphic interface. The proper usage of the method shall give reasonable results in measurement, and the quality of results depends on the experience of the applicator (Jöreskog and Sörbom 1996; Xiong et al. 2015). According to Ozdemir (2015), SEM is more powerful than other multivariate analysis techniques to evaluate the latent factors as the method can:

1. allow studying unobservable and non-quantifiable variables using latent factors underlying the indicators;
2. provide adequate accuracy for hypothesis testing at the construct level;
3. examine the interrelationships between constructs;
4. perform simultaneously multiple regression equations analysis to explore a separate, but interdependent variables;
5. analyze a massive number of variables having different relationships with several complex models;
6. investigate direct and indirect causal effects and covariance among variables;
7. evaluate an unlimited number of hypothesis;
8. consider the impacts of ill-measured data through measurement errors of indicators;
9. assess hypotheses testing through a confirmatory approach in data analysis; and support validity/reliability tests with several fit indices.

The descriptive and exploratory nature of the other multivariable analysis techniques makes the SEM the most applicable method for model testing. Also, SEM carries out a factor analysis and path analysis at the same time; estimate causal associations amongst constructs and indicators simultaneously; perform comparisons between groups with a more holistic model than traditional statically analysis techniques (Xiong et al. 2015).

6.3.1 Structural Equation Modeling Basic Terms

Construct (also referred to as latent factors, theoretical variables, or factors) are the abstract concepts that a researcher defines to build a theory. It is measured by combining indicators into a relation (Cooper and Schindler 2014). Also, it is referred to as a set of procedures that are used to measure the abstract under observation.

Indicators (also referred to as measurable variables or manifest variables) are the researcher measures to capture the construct.

A hypothesis is a theoretical or empirically statement to explains the relationship between two or more variables (Cooper and Schindler 2014).

A theory is a set of interconnected hypotheses to explain a phenomenon of interest (Cooper and Schindler 2014). The theory is different from the model in the sense that the model empirically represents theory (Soysa 2017).

The Likert scale is an ordinal scale commonly used in the questionnaire survey to get the respondent rating to a given statement (Norman 2010). The Likert scale can be treated as an interval scale to measure a latent factor in the parametric statistical methods such as structural equation modeling (SEM) (Boone and Boone 2012; Norman 2010).

6.3.2 Overview of Structural Equation Modeling

SEM examines relations between two main types of variables called constructs and indicators. A structural equation model is a powerful tool for investigating the relationship and direction of effect between constructs. Construct is represented by an ellipse, an indicator is represented by a rectangle, the error term is represented by a circle and line arrow represents a causality. A two-way arrow between constructs examines the ability of the indicators to represent well the constructs through a Confirmatory Factor Analysis (i.e., Convergent Validity) or the relationship between constructs is different (i.e., Discriminant Validity). The SEM method contains two main modules: 1) a number of measurement models, and 2) a structural model. The simplest form of a measurement model contains a single construct; and a number of related indicators with the related errors in measurement. The structural model includes constructs and their interrelationships (Xiong et al. 2015).

Models are developed for one of two purposes: 1) to validate the framework of one or more constructs; 2) to stimulate the causal relation between constructs through Confirmatory Factor Analysis (CFA). Research design with SEM involves two types of studies 1) cross-sectional studies and 2) longitudinal studies. The majority of the previous researches use the cross-sectional (causal) research design, and very few use the longitudinal research design (Xiong et al. 2015). SEM cross-sectional study is focused on establishing observed and construct's a relationship at a specific time, and the longitudinal study deals with changes of the constructs with time. Dependent Variables (i.e., Endogenous Variables) and Independent Variables (i.e., Exogenous Variables) in regression models are the two classes of the constructs (Hair et al. 2012).

6.3.3 SEM Implementation in Construction

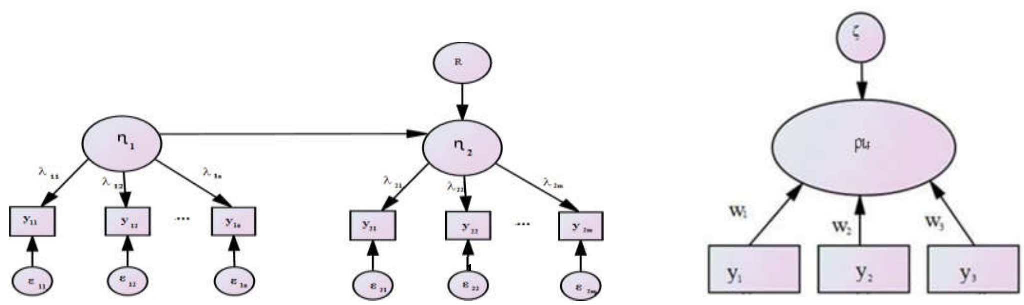
SEM has been widely used in construction management studies to identify the variables, the correlations among the variables, and the causal-path between the variables (Xiong et al. 2015). Xiong et al. (2015) carried out a review of applications of the structural equation modeling in construction researches between over the period 1998-2012 for the top construction research journals and found broad implementation, acceleration, and acceptance for SEM over time. The author supported SEM's future applications in construction with a guideline framework for proper implementation. Sarkar et al. (1998) introduced SEM in construction research and establishes a concept to measure the termination costs and collaborative behavioral processes strength through compatibility, role clarity, resource interdependence variety of global construction firms. Trust and commitment were used to manifest the bonding relation. Molenaar et al. (2000) performed one of the early implementations of SEM in the construction area. Molenaar illustrated the ability of structural equation model analysis to quantify factors affecting contract disputes between contractors and owners (disputes potential index) and clarified the causes of contract related construction problems. The study covered the relationship between disputes potential and several factors such as management ability, financial planning, allocation of risk, and definition of the project scope. SEM showed its strength to present the interaction of the variables over logistic regression modeling. Ozorhon (2007) used SEM to model the performance of international joint ventures (IJV) with Turkish construction companies. The research concluded that the agreement on the indicators and determinants does not exist for IJV and therefore established the interrelationships among the drivers of the IJV and its impact on the JV performance. Isa et al. (2015) used PLS-SEM to determine factors affecting the business performance of the Malaysian construction companies in the international markets. The measures were the profit targets, prestige, competitive advantages, effective use of resources, and business expansion. The constructs were country factors, market factors; organization factors; and project factors. The author concluded that strong and stable human relationships would enhance the firms' performance. Gunduz et al. (2017), used fuzzy SEM to empirically validate the theoretical model and develop a multidimensional safety performance model in construction sites. The data consist of a total of 168 variables in 16 factors collected from an extensive literature review. Gunduz concluded the ability of SEM to model the safety performance on construction sites. Shen et al. (2017), formulated a short structural equation model for causes of contractors' claims in EPC projects with three latent factors: 1) external risk, 2) client organizational behavior, and 3) project definitions in the contract . Abusafiya and Suliman (2017), and Memon and Rahman (2013) adopted structural equation modeling (SEM) approach to measure the impact of cost overrun factors on project cost in construction projects in Bahrain and concluded that contract administration and project management related factors are the highest impact factors causing cost overrun. Such studies were similar to Yap (2013) study of factors affecting the abandoned project. This study uses SEM to test and analyze interrelationships among constructs of CCA performance and associated indicators.

6.3.4 Modeling of Constructs

For testing hypotheses, the construct is modeled in a specific technique to allow mathematical and statistical operations (Hair et al. 2014). There are three ways to model the construct, namely: reflective construct, Formative Construct, and Higher-Order Constructs. Higher-Order Construct (so-called Hierarchical or second-order construct) is highly abstract concepts that require fewer constructs in a reflective or a formative model. The relationships between the indicators and the specific constructs drive the construct type.

6.3.4.1 Reflective and Formative Construct

Reflective construct means that the measures of a construct are a reflection of the construct on the indicator and are not elements that form the construct. Thus, the cause of the measures is their underlying construct, and when the construct varies, all its measures are expected to vary in the same way (Bollen 2002). Reflective indicators show a very high level of internal consistency among them. So, if indicators that must be set as formative are misclassified as reflective, then the researcher should demonstrate a high level of internal consistency (Park 2017). Figure 6.5a represents the graphical representation of the SEM reflective model. The search hypothesis is that the construct η1 explains/predicts the construct η2. The construct η1 is related to n number of indicators and the construct η2 related to m number indicators. The construct η2 has a residual error R. Equations 6.4 and 6.5 represent the relationship between the constructs and their associated indicators. The parameters (factor loadings) λ1i and λ2j represent the correlation between the indicators and their relevant constructs while terms ε1i and ε2j represent the error terms associated with each relation (Cooper and Schindler 2014). The first two equations express the measurement model which establish the relations between the constructs and indicators. The third equation represents the relation between the two constructs η1 and η2 (research hypothesis) and called the structure model among the constructs (Cooper and Schindler 2014). For ease of comparison, the parameters λ1i, λ2j, and κ should be in standardized scores.



(a) (b)

Figure 6.5: SEM model formulation: (a) reflective model; and (b) formative model

$$Y_{1i} = \lambda_{1i}.\eta_1 + \varepsilon_{1i} \text{ (i=1 to n)} \quad (6.4)$$

$$Y_{2j} = \lambda_{2j}.\eta_2 + \varepsilon_{2j} \text{ (j=1 to m)} \quad (6.5)$$

$$\eta_2 = k.\eta_1 + R \quad (6.6)$$

Formative constructs are modeled as the effect of its indicators. Alternatively, the formative construct is being formed by its indicators. The indicators are only partially mapped into its construct. The formative indicators move in the reverse direction and changes in the construct do not cause changes in the indicators (Roy et al. 2012). Figure 6.5b represents the graphical representation of the SEM formative model. The three formative indicators y_i forms the construct η_F with factor loading $w_i$and associate and disturbance term ξ. In Equation 6.7, when the disturbance error is equal to zero then construct is completely formed by its indicators.

$$\eta_F = \sum w_i . y_i + \xi_1 \quad \text{(i=1,2, 3 …)} \qquad 6.7)$$

Table 6.2 shows the main differences between the reflective and formative constructs.

Table 6.2Reflective versus formative constructs (Roy et al. 2012)

Reflective	Formative
Construct explains indicators	Construct is a combination of the indicators
The direction of causality is from constructs to indicators (indicators represent the consequences of the construct)	The direction of causality is from indicators to construct (indicators represent the causes of the construct)
Observed variables are correlated	Correlation among indicators are not required
Indicators are interchangeable (the removal of an item does not change the essential nature of the underlying construct)	Indicators are not interchangeable (omitting an indicator is omitting a part of the construct)
Changes in construct directly cause a change in assigned indicators in the same manner (If indicator change, the construct will not change)	Changes will not cause changes in the indicator) (i.e., If an indicator change, the construct will change)

6.3.5 SEM Techniques

There are two techniques for estimating the structural equation models. The first technique is the covariance-based SEM (CB-SEM) and the second technique is the partial least squares-based SEM (PLS-SEM) (Hair et al. 2012). This research is adopting CB-SEM due to the extensive application of the technique and many advances that lead to extend the method's capabilities. Advances include the ability to analyze complex and comprehensive problems and the ability to measure second and third-order constructs that are applicable to this research (Bohari 2017).

6.3.5.1 The Covariance Approach

The covariance approach (also known as Linear Structural Relations, Covariance Structure Analysis, Covariance Structure Modelling, Causal Modelling, Analysis of Moment Structures) is a general method for analysis of the covariance structure of measures to formulate the constructs. The covariance approach determines how well a researcher's hypothesized model is capable of repeating the covariance between the indicators through the estimated parameters of the specified model. The approach algorithm is iteratively minimizing the difference between the sample covariance matrix and the implied covariance matrix to estimates model parameters (Bollen and Hoyle 2012). The approach provides all the model parameters and overall goodness-of-fit tests simultaneously but requires a large sample size (n > 200), and normally distributed data (Soysa 2017). The violation of that requirement would result in the convergence of iterations and negative variances (Kline 2015).

6.3.5.2 The Partial Least Squares Approach

The Partial Least Squares Approach (also so-called variance-based SEM approach) is a robust technique for rendering statistical inferences for non-parametric assumptions of data (i.e., non-normally distributed data). By this technique, the path coefficients and other unknown parameters are estimated iteratively, block by block, until variance reduction is no longer possible using the ordinary least squares regression technique (Fornell & Bookstein, 1982). It is a limited-information estimation method and provides no global goodness-of-fit measure and the overall model quality is examined by evaluating a set of nonparametric evaluation criteria (Cooper and Schindler 2014). The PLS-SEM technique is useful for formative constructs; and small sample size, and non-normal data (Cooper and Schindler 2014).

6.3.6 SEM Software Packages

The essential SEM is established through several covariance-based software programs to support Confirmatory Factor Analysis and path analysis required for testing hypothesized structural equation models include LISERAL; AMOS; EQS; SAS CALIS, MPLUS, MX GRAPH, the RAMONA module of SYSTAT, the SEPATH module of STATISTICA; Smart-PLS; SEM in R; and Lavaan (R-Package). Each software pages have advantage and disadvantage. LISREL deals with very complicated situations such as nonlinear constraints. AMOS deals with incomplete data and possesses a user-friendly interface platform but unable to handle the input data with an only correlation matrix. EQS deals with non-normal data and data screening. According to Xiong et al. (2015), the most used software for SEM modeling was AMOS (55.4%) and then LISREL 31.3% while the rest of the models used other software. Base on the above, the structural equation model software selected for this study is AMOS 24.

6.3.6.1 IBM-AMOS SEM Software

AMOS, an abbreviation of Analysis of Moment Structures. It is a computer program utilized in structural equation modeling (SEM) with several statistical techniques such as path analysis, confirmatory factor analysis, causal modeling with latent factors, and even analysis of variance and multiple linear regression. The program is an easy-to-use for visual SEM graphical representation (Xiong et al. 2015). AMOS is the leader to enter problems by building a path diagram directly on the computer screen (Mueller and Hancock 2008). The model fit can be easily assessed, and users will be able to make modifications and print out a publication-quality graphic of the final mode (Arbuckle 2017). AMOS and MX were the first structural modeling programs to utilize the Maximum Likelihood approach to handling missing data. Also, Amos can handle non-normal data through the bootstrapping maximum likelihood method of estimation

6.3.6.2 Estimation Techniques in AMOS

Amos provides several methods for estimating structural equation models namely: 1) Maximum likelihood, 2) Unweighted least squares, 3) Generalized least squares, 4) Browne's asymptotically distribution-free criterion, 5) Scale-free least squares and 6) Bayesian estimation.

6.4 SEM MODEL DEVELOPMENT STEPS

SEM testes the relationship between constructs and indicators in which indicators are measurable items due to their objective facts, while constructs are measured by the indicators due to their abstract characteristics (Xiong et al. 2015). The Confirmatory Factor Analysis (CFA) and a second-order factor structural model would be employed to investigate the relationships among constructs of CAPM and evaluate the reliability and validity of the proposed assessment model.

6.4.1 Model Specification and Identification

The model specification sets a conceptual model comprising of the hypothesized relationships (theory) and establishing the associated equations. The model identification ensures that the specified model has a unique numerical solution (Ozdemir 2015). SEM modeling involved a two-model analysis, namely: the measurement model and the structural model.

6.4.2 Model Estimation

The model estimation means the selection of an appropriate estimation method to identify the model parameters (Ozdemir 2015). The choice of a certain method depends on the distribution of data, the size of the sample, and the type of data matrix (CB-SEM or PLS-SEM). The software packages contain several estimation methods such as maximum likelihood (ML), weighted least squares (WLS), generalized least squares (GLS), or Asymptotic distribution-free (ADF) and ordinary least squares (OLS) methods. ML assumes multivariate normality and cannot deal with multivariate nonnormality issues. If nonnormality exists, Byrne (2010) recommends assessing the multivariate outliers. Where removal of outliers doesn't improve the multivariate nonnormality, there are other three estimation methods to deal with nonnormally of indicators (Byrne 2010; Narayanan 2012) as follows :

1. Asymptotic Distribution-Free (ADF) estimation: ADF estimation method does not require any assumptions regarding normality but requires a large size sample (500 or greater than ten times the number of estimated parameters) and computationally expensive. Therefore, the technique is not applicable to several empirical studies.
2. Scaling procedure (Satorra and Bentler) estimation: This method applies corrections to standard errors of parameter and goodness of fit indices (Satorra and Bentler 2001). The scaling factor considers the amount of nonnormality in the data.
3. Bootstrapping techniques. It uses the original data as the parent data for repetitive replacement sampling. Bootstrapping is either naive or Bollen–Stine bootstrapping. The naive bootstrapping is used for standard computing errors of parameter estimates. Bollen and Stine bootstrapping transform the original data to ensure that the covariance structure is online with the null hypothesis and the values generated to reproduce the nonnormality and sampling variability without affecting the model misfit.

Due to data normality issues, the Bootstrapping Maximum likelihood estimation method is utilized in this study to measure the structural paths and factor loadings.

6.4.3 Model Evaluation

Upon selection of the appropriate estimation method, the CFA model should be evaluated for model fit, reliability, and validity before demonstrating the structural model. The reliability process comprises unidimensionality and individual reliability of indicators. The validity (so-called construct validity) process encompasses both convergent and discriminant validity.

6.4.4 Model Re-Specification

The model should be re-specified if the Modification Indices are greater than 10 (Bohari 2017).

6.5 CHAPTER SUMMARY

This chapter described the theoretical background of fuzzy set theory, selection of the fuzzy membership function and the associated linguistic terms, and defuzzification of the d linguistic terms into concrete numbers the crisp values used in this study to prepare the data collection for analysis by structural equation modeling.

Since SEM is the method of choice in behavioral sciences to examine the two key components of a theoretical model 1)the measurement model and 2) the structural model. the CB-SEM and PLS-SEM estimation techniques were reviewed to examine which of those techniques is more suitable for the researcher's study.

CHAPTER 7 : MODEL DEVELOPMENT AND ANALYSIS

7.1 INTRODUCTION

The research aims to develop a systematic Contract Administration Performance Model (CAPM) for general construction projects. This chapter represents the preparation of data for analysis, data demographics, data cleaning, analysis of questionnaire data, and how the proposed structured equation model fits the standard SEM criteria. The SEM examines the relationships between the constructs and their indicators, which would guide the CCA performance.

7.2 SAMPLE SIZE

There is no agreement on the desired sample size in SEM analysis (Bagozzi and Yi 2011). For factor analysis with a small number of items, Bagozzi and Yi (2011), argued that a sample size below 100 might be expressive, but a preferred a sample size above 200. Despite the sample size or sample size to free parameters or ratio, the author argues that distributional properties of the dataset are important than not sample size, and the ratio can go down to 2:1. For many indicators with large factor loadings, it revealed that the ratio of the size of the sample to the number of parameters might reach 5:1 under normal theory, and 10:1 for arbitrary distributions. To guarantee robust results, the structural equation modeling required a minimum of 5–10 cases per measure or size of a sample of 200 (Hair et al. 2014). According to Kline (2015), an acceptable size should contain 100 to 200 samples. Xiong et al. (2015) analyzed the sample size for 84 literature papers concerning SEM implantation in construction and stated that a sample size of less than 200 was used in 77.4% (65 of 84). Also, the sample size to free parameters ratio of less than 5 was 85.7% (72 of 84), and of less than

10 was 94.0% (79 of 84).

This study collected 366 replies with a response rate of more than 30 %. After removing outliers and non-serious responses, the sample size for this study was 336. Thus, it is considered within the acceptable range, and the result would be reasonably reliable.

7.3 RESPONDENTS' DEMOGRAPHIC CHARACTERISTICS

Reporting respondents 'demographic information is important to illustrate the reliability of the involved respondents, and its impact on the level of analysis is limited to group analysis of sectors and organizations. It is important to confirm that the collected responses were originated from a trusted source and ensure that the research findings represent a holistic view. The data validated for analysis collected from 336 participants during the period from August to November 2018. This section describes the characteristics of the respondents in ten areas as follows: 1)Number of years of work experience related to construction; 2) Registration status; 3)Training in contract or contract administration; 4) Certification in contract or contract administration; 5)Sector representing the respondent's major experience; 6)An organization representing the respondent's major experience; 7) Respondent's position; 8) Respondent's area(s) of expertise; 9) Type of project(s) reflects the respondent's experience; and 10) Respondent's familiarity with forms of contract.

7.3.1 Detailed Discussion of Respondents' Profiles

The summary of the respondents' profiles are shown in Table 7.1and details are discussed in the succeeding sections.

Table 7.1: Respondentts' Profile

Profile	Freq.	%	Profile	Freq.	%
Experience			**Position**		
<=l 5	25	7.4	Executive Manager	14	4.2
(6 - 10)	49	14.6	Department Manager	62	18.5
(11 - 15)	57	17.0	Project Manager	71	21.1
(16 - 20)	69	20.5	Senior Engineer or Architect	75	22.3
(21 - 25)	66	19.6	Quantity Surveyor	30	8.9
> 25	70	20.8	Engineer or Supervisor	73	21.7
			Others	11	3.3
Professional Registration	87	25.9	**Area of Expertise**		
Not Registered	249	74.1	Engineering & Design	69	
Registered			Project Management	130	
	155	46.1	Project Control	92	
Training in Contract	181	53.9	Site Execution	107	
Not Trained			Construction Supervision	161	
Trained	260	77.4	Quality control	95	
	76	22.6	Contract Admin./ Manage.	133	
Certificates in Contract			Other (please specify):	1	
Not Certified	187	55.7	**Type of Projects**		
Certified	125	37.2	Building Construction	297	
	24	7.1	Industrial facilities	55	
Sector			Infrastructure	80	
Private	164	48.8	Utilities	80	
Public	49	14.6	Other	5	
Public & Private	117	34.8	**Forms of Contract**		
	6	1.8	FIDIC	212	
Organization			JCT	27	
Consultant/ Designer			AIA	34	
Employer			NEC	45	
Contractor			National Condition	195	
Mixed			Other	6	

7.3.1.1 Experience Profile

The respondents' number of years is established to indicate the respondent's level of expertise and knowledge in the construction. The respondents have varying levels of experience of working in construction. The years of experience of the participants are less than five years 25 (7.4%), 6–10 years 49 (14.6 %), 11–15 years 57 (17%), 16–20 years 69 (20.5%), 21-25 years 66 (19.6%) and more than 25 years 70 (20.8%). Most of the respondents (78 %) have more than ten years of experience in construction and meaning that their response is based on a good level of experience.

7.3.1.2 Professional Registration Profile

Most respondents had a professional registration as either Authority registration, syndicate membership, chartered, professional engineer 249 (74.1%), while only 87 (25.9%) respondents were not registered. The results indicate a significant percentage of a registered professional, and therefore, their opinion would be reliable.

7.3.1.3 Training Profile

More than half of the respondents, 181 (53.9 %), acquired knowledge on contract and contract management training while only 155 (46.1 %) had no training. This result shows that a fair percentage of the respondents acquire knowledge on contract and contract administration and are aware and possess knowledge of the research area.

7.3.1.4 Certification Profile

Only 76 (22.6 %) respondents had a certificate in CCA, and the rest 260 (77.4%) are practitioners. As the industry include architects, engineers, quantity surveyors' managers, functional engineers and project managers, the percentage of construction professionals having a certificate in CCA represents a fair portion and is compensated by the participant's professional background, level of experience, involvement in construction projects, training, and registration. Therefore, their views represent the study context

7.3.1.5 Sector Profile

Among the respondents, private-sector workers represented 187 (55.7%), public sector works were 125 (37.2 %), and mixed sector experience was 24 (7.1 %). This would ensure that the respondents are scattered among the principal industry sectors, and their opinions will reflect the different perspectives.

7.3.1.6 Organization Profile

Respondents were associated with various organizations: consultants / Designer

164 (48.8 %), employer 49 (14.6%), contractors/ subcontractors 117 (34.8 %), and mixed employments 6 (1.8 %). The respondents are scattered among the main industry organization, and their opinions will reflect the different organizational opinions.

7.3.1.7 Position Profile

The professional background of the participants is executive managers 14 (4.2%), department manager 62 (18.5 %), project manager 71 (21.1 %), senior engineer or architect 75 (22.3%), quantity surveyor 30 % (8.9 %), engineer or supervisor 73 (21.7 %), and others 11(3.3%). It is worth to state that all respondents except the executive managers (95.8 %) are somewhat involved in contract administration. In the worst-case scenario, all respondents except the executive managers, department manager, and others (74.1 %) are deeply involved in CCA activities. As demonstrated, the collected responses were originated from a trusted source of different hats in construction. The respondents have a variety of backgrounds in construction.

7.3.1.8 Area of Expertise Profile

All respondents were involved in different construction activities. With respect the particular construction experience, the respondents have experience in engineering & design were 69, project management 130, project control (cost, planning, dc, risk, etc.) 92, site execution 107, construction supervision 161, quality control 95, contract management/ administration 133 and other 1. As demonstrated, the respondents' level of experience covers most of the construction domain. The findings demonstrate that the respondents were experienced in different construction activities.

7.3.1.9 Project Profile

Respondent's experience regarding the type of construction is building construction 297, industrial facilities 55, infrastructure 80, utilities 80, and other types 5. Therefore, the respondents' level of experience covers most of the construction project types.

7.3.1.10 Forms of Contract Profile

Concerning the forms of contract, the respondent's experience 212 in FIDIC, 27 in JCT, 34 in AIA, 45 in NEC, 195 in National Condition, and 6 in Others. As demonstrated, more than 60 % of the respondents had experience in international conditions of the contract. It is a good sign that the respondents' opinion is not based on only local conditions, but their knowledge covers the worldwide conditions, and therefore, the study can extend behind its geographical region.

7.3.1.11 Overall Respondents' Profile

Consequently, the study covers a wide range of construction professionals with adequate expertise and experience in construction, project management, and contract administration.

7.4 DATA TREATMENT

Data cleaning and preparation is essential to minimize the potential risk of data error and biased result. Before carrying out SEM analysis, the data were examined for unengaged responses, outliers, and data normality. SEM standard techniques require the data to have a normal distribution; otherwise, alternative techniques would be utilized (Byrne 2010; Hair et al. 2014). The design of the questionnaire did not allow any missing values by making all fields compulsory. Therefore, the respondents were only opted to either complete the full survey or quit. The frequency of the data set is shown in Appendix E, Table E.1

7.4.1 Data Screening for Careless Responses and Outliers

The respondent's input was screened against careless responses and outliers. The careless response was examined by the respondee response pattern for which a respondent may indicate the same response option for some consecutive items, while outliers may indicate observations that are different or dissimilar (Hair et al. 2014). Within this study, careless responses were measured through standard deviation and group rating in comparison to average factor ratings. 4 participants maintained the same answers (i.e., the standard deviation is zero). 16 participants had rated the group rating completely deviating from the average of the factor within the corresponding group. The "multivariate outlier detection" was measured by Mahalanobis distance using multiple regression with SPSS software. Mahalanobis distances express the squared distance- in standard units- of the vector of an observation from the vector of sample means for all variables (Hair et al. 2014). The probability of Mahalanobis distance was found below 0.001 for ten responses, and therefore, those responses were eliminated (Pamulu 2010) to lift only 336 out of 366 responses for further analysis.

7.4.2 Normality for Constructs and Indicators

Investigation of normality of data (as either univariate or multivariate normality), is critical before performing SEM analysis. Non-normal data may lead to inflating chi-square statistics, deflate the standard errors, and bias the coefficient significance, (Hair et al. 2014). Univariate normality defines the normality distribution of the individual variables. On the contrary, sample multivariate normality defines the joint distribution of all variables. However, issues in univariate normality affect the multivariate normality distribution.

7.4.2.1 Univariant Normality

Univariate normality of data is examined either graphically (Data histogram, box plot, and Q-Q plot) or numerically (skewness and kurtosis, Kolmogorov-Smirnov test, or Shapiro-Wilk normality test). Thus, the data collected was screened for the normality distribution using SPSS and AMOS. The univariant normality of data was examined by skewness and kurtosis as reported by AMOS for each indicator. According to Pallant (2011), the Skewness value represents the distribution's symmetry, while Kurtosis represents the distribution's peakedness (distribution's picks). Skewness and kurtosis values of zero represent perfectly normal data. Different authors consider a different range for the acceptable values of skewness and kurtosis to satisfy the normality assumptions. According to (Kline 2015), absolute values of the Skewness and Kurtosis indices of more than 3 and eight are considered as "severe" for SEM models. According to Xiong et al. (2015), absolute values of Skewness and Kurtosis more than extreme ones are an indication for non-normality. The study normality tests show that the absolute skewness values ranged from 0.230 to 1.016 for indicators F02.06 and F07.01, respectively. The absolute kurtosis values ranged from 0.011 to 0.864 for indicators F02.03 to F06.04. Both results are within Xiong et al. (2015) criteria. Appendix E, Table E.2 presents the normality test calculated for all indicators. and review of the kurtosis values reveals no item to be substantially kurtotic or skewed. According to Byrne (2010); Hair et al. (2014) the absolute critical ratio (c.r.) values of 1.96 or less indicate significant degrees of non-normality. Moderate kurtoses were observed for 20 Factors (i.e. F01.07, F01.08, F01.11, F02.05, F03.01, F03.04, F03.10, F04.06, F04.09, F05.02, F05.03, F05.07, F05.09, F06.04, F07.03, F07.06, F08.03, F09.02, F10.02, and F11.05).

Due to the doubt results from skewness and kurtosis tests, univariant normality of data was also examined by the Shapiro-Wilk normality test (Ws)of the SPSS. The Ws examines the correlation between the given data and ideal normal scores. A value near one means that data are more normally distributed, and the null hypothesis for normally distributed data is accepted. Moreover, the significance values (p-value) would be greater than a certain threshold (i.e., 0.05) for the data to be normal, as shown in Table

E.2. The output of the Ws test showed that the significant values (p-values) were less than 0.05 for all items and that there is evidence that the data deviates from normality (Shapiro and Wilk 1965; Zahoor et al. 2017).

7.4.2.2 Multivariate Normality

An important assumption related to applications of SEM is that the data are multivariate normal (Byrne 2010) . It is common in a Likert-scaled questionnaire that the majority of respondents selecting the same scale point as extremely peaked and lead to a multivariate positive kurtotic distribution (Byrne 2010). Maria's coefficient and its critical ratio are used to examine the multivariate kurtosis of the dataset. Dataset achieves the multivariate normally distributed assumption when the critical ratio (c.r.) is less than 1.96 at the 0.05 significance level. Thus, the coefficient of multivariate kurtosis is almost approaching zero. The large value of Maria's coefficient reflects significant positive kurtosis (Byrne 2010). In this dataset, the z-statistic (c.r.) of 50.08 is highly indicative of nonnormality in the dataset as shown in Table E.2.

7.4.2.3 Dealing with Non-normality

Most of the SEM software uses the maximum likelihood as the default estimation method. To deal with normally distributed multivariate data. If nonnormality exists, (Byrne 2010) recommends assessing the multivariate outliers. Where outliers removal doesn't improve the multivariate nonnormality, there are other three estimation methods to deal with nonnormally of indicators (Byrne 2010; Narayanan 2012): Asymptotic Distribution-Free (ADF) estimation, scaling procedure (Satorra and Bentler) estimation, and Bootstrapping techniques,

To deal with nonmoral data in Amos: 1)the variables should be checked against joint multivariate nonnormality; 2) the model fit would be judged by the corrected Bollen-Stine p-value; 3) bootstrap generates the standard errors, parameter estimates, and significance tests for the parameters, and the scale of latent factors set to 1.00 and not the corresponding factor's variance. If the factor's variance is set to 1.00, then the standard error of the bootstrapped estimates may be artificially inflated by changing the factor loadings of the bootstrap samples.

7.5 CONTRACT ADMINISTRATION PERFORMANCE MODEL

This study aims to develop a model for measuring contract administration performance (CAPM) and develop an overall performance index (CCAPI) in construction projects. Based on a comprehensive literature review, interview with construction professionals, and 2 rounds modified Delphi study, the proposed CAPF categorizes 93 CCA indicators affecting the contract administration into 11 constructs. To suggest the association between the indicators and first-order latent constructs, conformity factor analysis (CFA) will be conducted.

On the other hand, the CCAPI will be predicted as a second-order construct that links to the 11 first-order constructs through a structural model with 93 CCA indicators, (Figure 7.1). The causal directions point out from CCAPI to the other 11 constructs. The 11 constructs are: G01-project governance & start-up management with 15 indicators, G02-contract administration team management with 6 indicators, G03-communication & relationship management with 11 indicators, G04-quality & acceptance management with 10 indicators, G05-performance monitoring & reporting management with 10 indicators, G06-document & record management with 4 indicators, G07-financial management with 7 indicators, G08-changes & changes control management with 5 indicators, G09-claims & disputes resolution with 8 indicators, G10-contract risk management with 4 indicators, and G11-contract close-out management with 13 indicators. The higher level of implementation of the CCA indicators is anticipated to increase the satisfactory performance of the CCA. The hypotheses to test the CCAPI reflection by the first-order constructs are shown in Table 7.2.

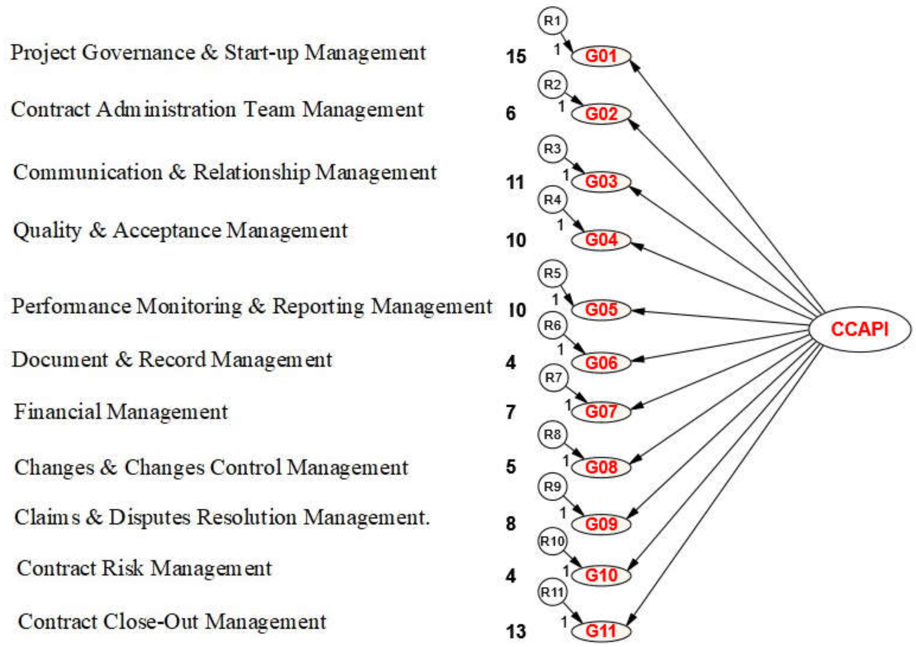


Figure 7.1: Construction contract administration model (CAPM)

Table 7.2: Research hypotheses

Hypothesis No.	Description
HO1	Project Governance & Start-up has a significant positive impact on the performance of CCA
HO2	Contract Administration Team Management has a significant positive impact on the performance of CCA
HO3	Communication & Relationship Management has a significant positive impact on the performance of CCA
HO4	Quality & Acceptance Management has a significant positive impact on the performance of CCA
HO5	Performance Monitoring & Reporting Management has a significant positive impact on the performance of CCA
HO6	Document & Record Management has a significant positive impact on the performance of CCA
HO7	Financial Management has a significant positive impact on the performance of CCA
HO8	Changes & Changes Control Management has a significant positive impact on the performance of CCA
HO9	Claims & Disputes Resolution Management has a significant positive impact on the performance of CCA
HO10	Contract Risk Management has a significant positive impact on the performance of CCA
HO11	Contract Close-Out Management has a significant positive impact on the performance of CCA
HO12	The 11 constructs are positively predicting the construction contract administration performance index at the project level.

7.6 CAPM MEASUREMENT MODEL

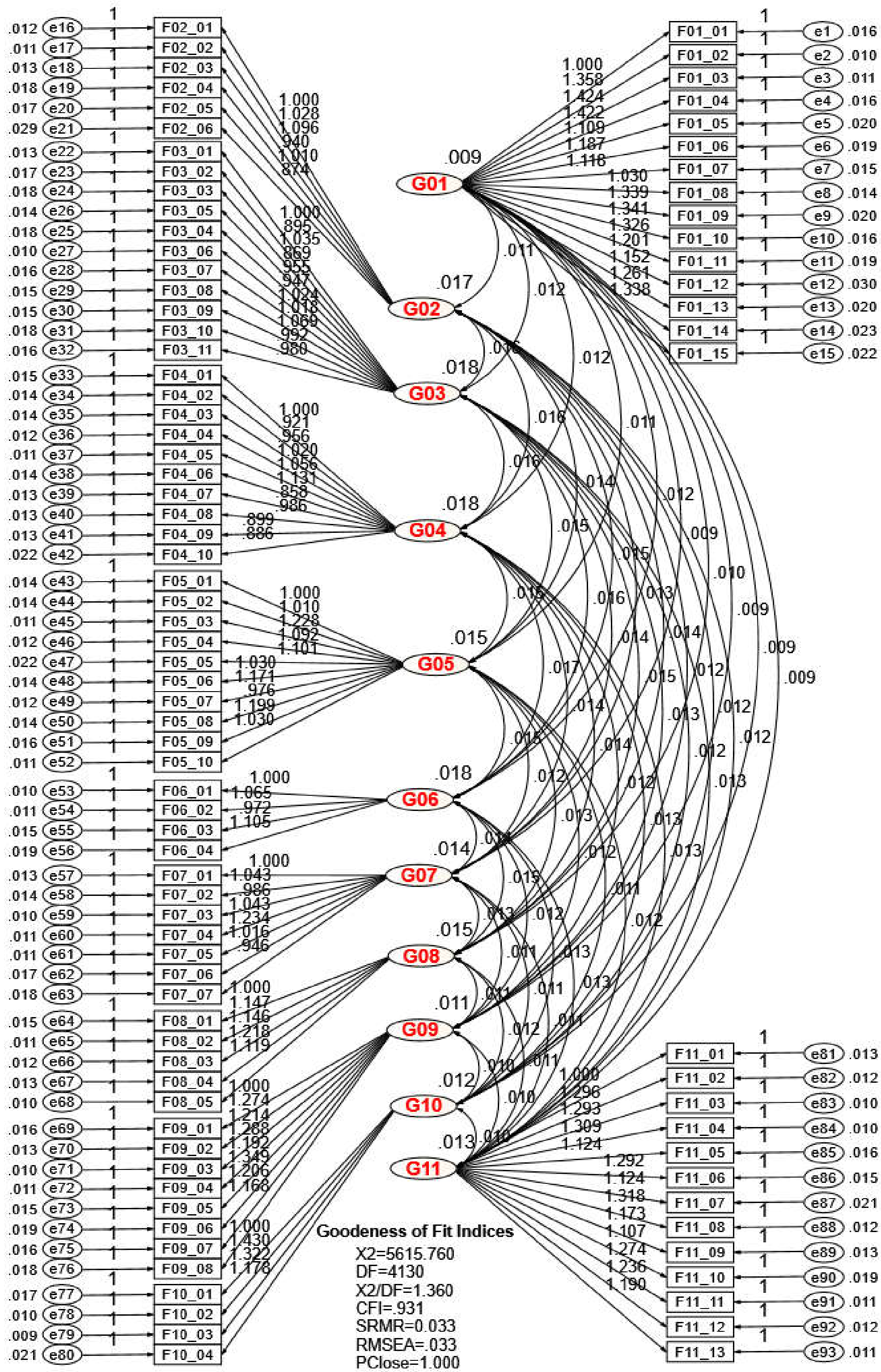
This section presents the outcome of the proposed measurement model includes the testing for unidimensional, validity, reliability, and evaluates a data set by confirming the underlying structure based on theoretical background. Due to the data normality issue, bootstrapping maximum likelihood estimation method is adopted, and the CFA follows the sequence.

1. Propose an initial model based on the underlying theory.
2. Check Model Fit.
    a. If satisfactory GOF indices obtained, then go to step 3
    b. If the model does not fit, then delete factor loading less than 0.4 (one item at a time) till model fit. If the model does not fit, then examine the Modification Indices that are greater than 15 and delete one of the redundant items,
3. Assessing the validity and reliability of a measurement model.
4. Report results.

Figure 7.2 and Figure 7.3 show the un-standardized and standardized estimates of the CFA result.

7.6.1 Measurement Model Goodness of Fit Indices

Goodness-of-fit (GOF) indices are essential for model improvement. Literature reveals the availability of several indices such as absolute fit, incremental fit, goodness-of-fit, badness-of-fit indices (Hair et al. 2014; Xiong et al. 2015) and no consensus on the best indicator. Hair et al. (2014) recommended using at least one index from each group. $\chi 2$, $\chi 2/df$, RMSEA, CFI, and NNF are regarded as absolute indices for evaluating the fit of a model to data (Bollen and Hoyle 2012; Hair et al. 2014). Likewise, chi-square plus RMSEA and CFI were proposed to assess the model fit (Hu and Bentler 1999). The following indices were employed to assess the model-fit for this study:



Common latent factor was hidden for clarity.

Figure 7.2: CAPM confirmatory factor analysis- unstandardized estimates

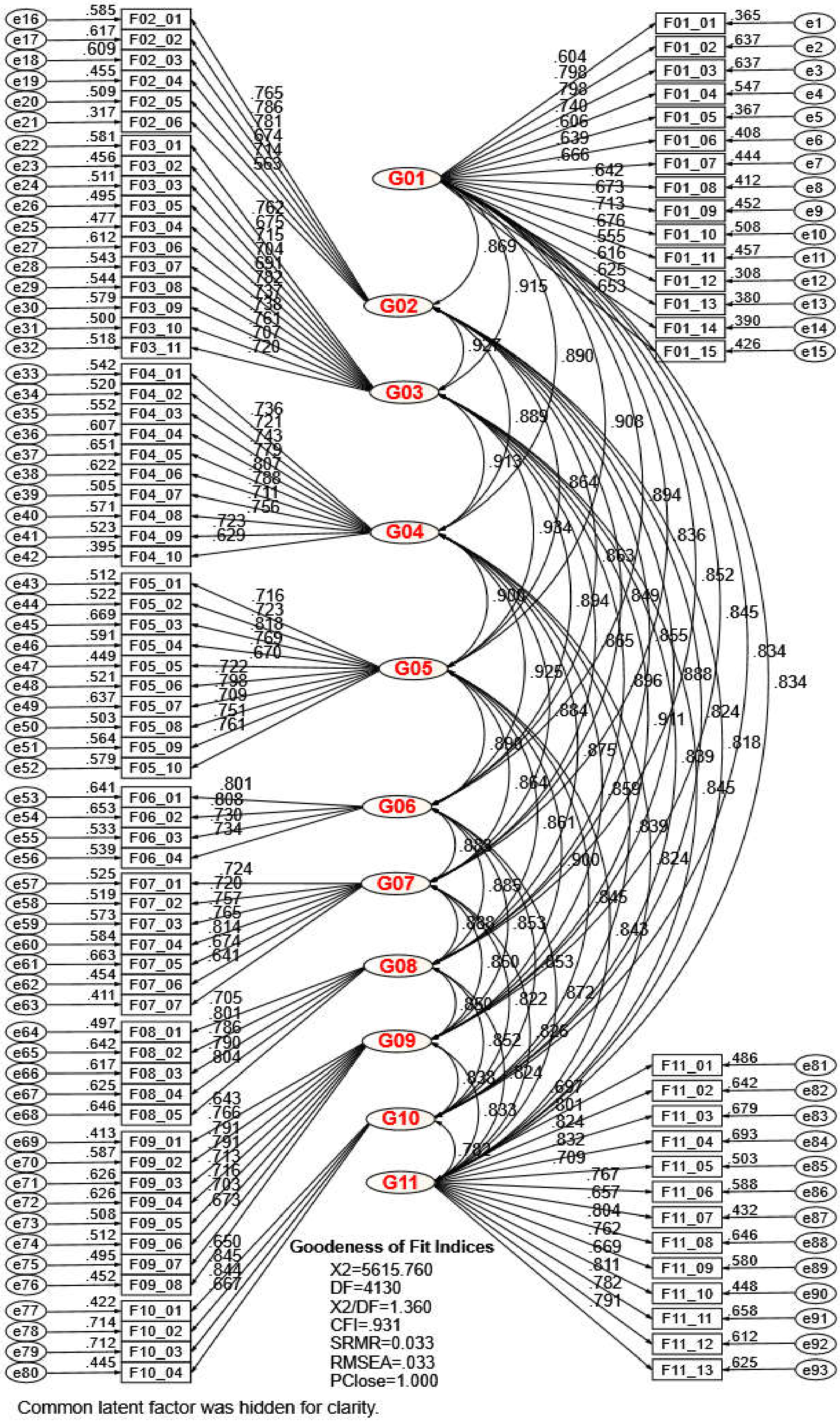


Figure 7.3: Confirmatory factor analysis for CCAP - standardized estimates

1. *Relative Chi-Square (χ2/df), also called parsimonious fit:* Contrary to the no-agreement on the proper overall goodness-of-fit index for evaluating a model, χ2 statistic considered as a fundamental measure. The χ2 statistics indicating the degree of discrepancy between the implied (fitted) and sample covariance matrices (Bagozzi and Yi 2011). A significant value of the χ2 test means that there is a substantial discrepancy between the model and data. It referred to as the badness of fit' measure (Kline 2015). Additional measures of fit are recommended since the chi-square test is increased as the sample size increase (Bagozzi and Yi 2011; Xiong et al. 2015). Adjusted Chi-square(χ2/df) helps to correct the bias introduced by the non-normal data distribution with a value from one to three (Hair et al. 2014; Xiong et al. 2015) for a preferred fit.
2. *Root Mean Squared Error of Approximation (RMSEA):* It represents the degree to which a lack of fit is due to misspecification of the model tested versus being due to sampling error. It measures how good the parameter estimates generated by the model fit the sample matrix (Byrne 2010). RMSEA is not sensitive to the sample size, and therefore, it is an adequate measure for small samples. It is a badness-of-fit index with an acceptable value ranges from 0.05 to 0.1 (Byrne 2010). However, an amount of less than 0.08 is considered a reasonable fit (Hair et al. 2014). Associated with RMSEA, PCLOSE test is a one-sided test examining the null hypothesis that the RMSEA value is 0.05. Thus, PCLOSE values more than 0.05, concludes that the model fit is close. The Standardized Root Mean Square Residual (SRMR) is another absolute measure of fit representing the average difference between the observed and predicted correlations. The perfect fit is attained for SRMR value of zero, and it has no penalty for model complexity. Hu and Bentler (1999)suggested a value below 0.08 for a good fit.

3. *Comparative Fit Index (CFI):* It is an incremental fit index that compares the hypothesized model with the independence (baseline) model to check if the model fits the sample data better than the independent model (model with uncorrelated variables). CFI values ranging from 0 to 1, with cut off value 0.92 for good model fit (Hair et al. 2014).

The measurement model result revealed that $\chi 2$/df value of 1.36 is below the threshold range between values of 1.0 and 3.0 suggested by (Hair et al. 2014). CFI is reported with a value of 0.931, which is above an acceptable fit of 0.90. SRMR=0.033(<.08), The RMSEA shows a value of 0.033, which is below 0.08 and PCLOSE =1.000 (>.05), as shown in

Table 7.3. Since the maximum likelihood assumes joint multivariate normality of the indicators, but the indicators of the data set are nonnormally distributed by testing the critical ratio (c.r.). The probability of the maximum likelihood chi-square test of model fit rejects the null hypothesis of overall model fit: chi-square = 5615.76 with 4130 degrees of freedom, p-value = 0.00. In this instance, the Bollen-Stine bootstrap will be able to correct the shortcoming of the maximum likelihood method in dealing with nonnormally distributed data. The Bollen-Stine p-value is one of the ways to adjust non-normality in the database to assess the overall model fit. Bootstrap has been requested for 2000 samples. The model fits better in 1551 bootstrapped samples and fits worse in 449 bootstrap samples. The null hypothesis is that the model is correct leads to a Bollen-Stine bootstrap p-value of 0.225. With a significance level of .05, the null hypothesis would not be rejected but would conclude that the model fits the data well. Further, the Bollen-Stine bootstrap chi-square is 5287.867 instead of 5615.76 suggested by maximum likelihood analysis.

Table 7.3: CFA Goodness of fit indices for the CAPM measurement model

Measure	Estimate	Threshold	Interpretation
CMIN	5615.76	--	--
DF	4130	--	--
CMIN/DF	1.36	1 to 3	Excellent
CFI	0.931	>0.95	Acceptable
SRMR	0.033	<0.08	Excellent
RMSEA	0.033	<0.06	Excellent
PCLOSE	1	>0.05	Excellent
p-value (ML)	0.0	>0.05	
p-value (Bollen-Stine)	0.225	>0.05	

*Criteria is adopted from (Hu and Bentler 1999)

7.6.2 Measurement Model Reliability

Reliability is the variance of true scores over the variance of the observed scores Reliably of test scores refer to the extent to which a set of scores indicate the true scores of the construct under observation. Reliability is a necessary, but not a sufficient condition for validity (Soysa 2017). The internal consistency reliability coefficient (*Cronbach's Alpha)* is the extent to which measures of a construct are internally consistent with similar results for the concept under observation. The reliability of the measurement model is examined by the internal consistency of constructs, which is further measured through individual item reliability and unidimensionality. Cronbach's Alpha greater than 0.7 will achieve satisfactory individual reliability (Hair et al. 2014).

The reliability of the measurement model is examined by the internal consistency of constructs, which is further measured through individual item reliability and unidimensionality.

7.6.2.1 Individual Item Reliability

The reliability coefficient (Cronbach's alpha (α)) of the SPSS package was utilized to assess the consistency of the entire scale with a cut off value 0.7 (Hair et al. 2014).

Table 7.4 and Table 7.5 show the results of the reliability analysis for all variables and constructs in this study. All values are more than 0.839. Therefore, the respondents' data are considered to be consistent and reliable for further analysis (Cohen et al. 2007; Zahoor et al. 2017), and the set of indicators represents a single construct. Also, the alpha value for the complete data set (0.988). It designates that the questionnaire scale has accomplished an acceptable internal consistency and reliability.

Table 7.4: Cronbach's Alpha values for constructs

Group	Cronbach's alpha values (Internal consistency)	No of Items
G01	0.921	15
G02	0.857	6
G03	0.924	11
G04	0.923	10
G05	0.924	10
G06	0.851	4
G07	0.884	5
G08	0.896	8
G09	0.896	8
G10	0.839	4
G11	0.947	13
Overall	0.988	93

7.6.2.2 Uni-dimensionality

Unidimensionality shows the degree to which indicators express only a single construct (Hair et al. 2014). The unidimensional assessment was performed through standardized factor loadings, the examination of a matrix of standardized residuals elements, and modification indices as detailed below:

1. Indicators with standardized factor loadings: Figure 7.3 shows that standardized factor loadings of the indicators are above the threshold of 0.5 (Hair et al. 2014) and are positive numbers. Thus, the CAPM measurement model has achieved this criterion of unidimensionality;

2. The elements of the matrix of standardized residuals contain a number of absolute values below 3 (Ozdemir 2015); and
3. Modification indices more than five might be a threat to unidimensional and greater than ten may require model improvement/ re-specification (Bohari 2017).

Table 7.5: Cronbach's Alpha values for indicators

Code	Cronbach's alpha	Item	Cronbach's alpha	Item	Cronbach's alpha
F01.01	0.919	F03.11	0.918	F07.07	0.879
F01.02	0.912	F04.01	0.914	F08.01	0.871
F01.03	0.912	F04.02	0.916	F08.02	0.855
F01.04	0.914	F04.03	0.914	F08.03	0.854
F01.05	0.918	F04.04	0.912	F08.04	0.862
F01.06	0.917	F04.05	0.911	F08.05	0.852
F01.07	0.916	F04.06	0.912	F09.01	0.892
F01.08	0.917	F04.07	0.916	F09.02	0.878
F01.09	0.916	F04.08	0.913	F09.03	0.878
F01.10	0.915	F04.09	0.915	F09.04	0.877
F01.11	0.916	F04.10	0.922	F09.05	0.883
F01.12	0.920	F05.01	0.918	F09.06	0.884
F01.13	0.917	F05.02	0.917	F09.07	0.885
F01.14	0.917	F05.03	0.911	F09.08	0.887
F01.15	0.917	F05.04	0.915	F10.01	0.822
F02.01	0.826	F05.05	0.921	F10.02	0.767
F02.02	0.821	F05.06	0.917	F10.03	0.773
F02.03	0.822	F05.07	0.912	F10.04	0.819
F02.04	0.838	F05.08	0.918	F11.01	0.945
F02.05	0.830	F05.09	0.916	F11.02	0.942
F02.06	0.861	F05.10	0.916	F11.03	0.941
F03.01	0.916	F06.01	0.813	F11.04	0.941
F03.02	0.919	F06.02	0.794	F11.05	0.944
F03.03	0.919	F06.03	0.812	F11.06	0.943
F03.04	0.918	F06.04	0.823	F11.07	0.946
F03.05	0.919	F07.01	0.871	F11.08	0.942
F03.06	0.915	F07.02	0.867	F11.09	0.942
F03.07	0.917	F07.03	0.864	F11.10	0.945
F03.08	0.917	F07.04	0.864	F11.11	0.941
F03.09	0.916	F07.05	0.857	F11.12	0.942
F03.10	0.917	F07.06	0.877	F11.13	0.942

7.6.3 Measurement Model Validity

The validity assessment shows how well the elements of the measurement system (e.g., the questionnaire items in a survey) measure what they are supposed to measure. Construct validity is defined as the extent to which the operationalization of a construct measured what it is supposed to measure (Cooper and Schindler 2014) and viewed as a broad concept that includes predictive validity and content validity (Kline 2015). Construct validity is essential for testing of the reliable model and development of the theory. Therefore, Construct validity covers both the agreement of indicators hypothesized to measure a construct and the dissimilarity between those indicators and indicators of different constructs (Xiong et al. 2015). Also, construct validity includes convergent validity and discriminant validity. Construct validity is examined by either Explanatory Factor Analysis (EFA) or Confirmatory Factor Analysis (CFA).

7.6.3.1 Convergent Validity

Convergent validity tests that all indicators within a construct are correlated only to this construct. Convergent validity is satisfactory if: 1) all factor loadings of a construct are greater than 0.5; otherwise, the indicator is considered for deletion (Xiong et al. 2015); 2) significance of regression weight is less than 0.05, (Khan 2016; Zahoor et al. 2017); 3) Average Variance Extracted (AVE) on the construct level is more than 0.5 (Hair et al. 2014; Khan 2016; Xiong et al. 2015); and 4) construct reliability (CR) is higher than 0.7 (Hair et al. 2014). According to Malhotra and Birks (2006), AVE is stricter than CR, and the researcher may conclude that the convergent validity of the construct is adequate by CR alone. AVE is a measure of the amount of variance that is captured by a construct to indicate convergence and is equal to the average of all squared factor loadings, as shown in Equation 7.1 (Hair et al. 2014). construct reliability (CR) represents the convergent validity and it is computed from the squared sum of factor loadings (Li) for each construct and the sum of the error variance terms for a construct (ei) as:

$$AVE = \frac{\sum_{i=1}^{n} L_i^2}{n} \tag{7.1}$$

$$CR = \frac{(\sum_{i=1}^{n} L_i)^2}{(\sum_{i=1}^{n} L_i)^2 + \sum_{i=1}^{n} e_i} \qquad (7.2)$$

Where:

Li = standardized factor loading

i = number of items

n = total no of items

e_i = error variance terms for a construct i

Figure 7.3 shows that all factor loadings are higher than 0.5, and the significance of regression weight is less than 0.05. Therefore, satisfactory convergent validity is attained (Khan 2016; Xiong et al. 2015). Also, the results revealed that the constructs have CR value more than 0.70 (range 0.841-0.948), the minimum of AVE value is 0.5150 (above 0.50) except for constructing G01.

Table 7.6 indicates the internal consistency of the construct and reliability of the model. Also, the Cronbach's alpha coefficient was above 0.70 and indicating good consistency. Both SFL, CR, and AVE values satisfy convergent validity criteria.

Table 7.6: Construct reliability of the latent factors

Group	**Composite Reliability (CR)**	**Average Variance Extracted (AVE)**
G01	0.924	0.449
G02	0.863	0.515
G03	0.925	0.529
G04	0.924	0.549
G05	0.925	0.555
G06	0.853	0.592
G07	0.888	0.533
G08	0.884	0.605
G09	0.899	0.527
G10	0.841	0.573
G11	0.948	0.584
OVERALL	0.924	

7.6.3.2 Discriminant Validity

Contrary to convergent validity, discriminant validity (DV)means that the different constructs' indicators are not correlated to the degree that they express the same object. There are several ways to test the discriminant validity: 1) the square root of each construct's AVE should be more significant than its highest correlation with other constructs; 2) AVE should be more than the average shared variance (ASV); 3) AVE of a particular construct should be greater than the highest squared correlation of that construct; 4) AVEs of any two constructs should be higher than the shared variance between the two constructs; 5) no cross-loading existed within the value of 0.2; 6) the correlation between exogenous constructs should be less than 0.85 (Khan 2016; Zahoor et al. 2017); and 7) the correlations among constructs differ significantly from unity or when the x2 difference test indicates that two constructs are not perfectly correlated (Ozdemir 2015; Steenkamp and Van 1991). According to (Xiong et al. 2015), 64.2% (34 of 53) literature articles had at least one construct's AVE less than 0.5, and 29.4% (5 of 17) have questionable discriminant validity. ASV is equal to the mean of the squared correlation values of a construct with all other constructs. MSV is to the maximum value of the squared correlations of a construct with all other constructs.

As shown in Table 7.7, the correlation between some exogenous constructs slightly exceeds 0.85 (Khan 2016; Zahoor et al. 2017) but still below 1 (Ozdemir 2015; Steenkamp and Van 1991). Thus, the discriminant validity is achieved because of none of the values in the factor correlation matrix approaching unity.

7.6.4 Measurement Model Re-Specification

In this study, a careful examination of the model indices revealed a significant correlation among the error variables. After correlating the error terms within the associated constructs, the model fit did not improve, and therefore the original model retained. To improve the model for discriminant validity, the author tries to remove the highly correlated indicators but, no significant improvement was achieved, and no improvement was attained in Cronbach Alpha. Hence, all indicators were incorporated again in the model, and no model re-specification would be required.

Table 7.7: Intercorrelations of latent factors

	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10	G11
G01	1										
G02	0.869	1									
G03	0.915	0.927	1								
G04	0.890	0.889	0.913	1							
G05	0.908	0.864	0.934	0.900	1						
G06	0.894	0.863	0.894	0.925	0.890	1					
G07	0.836	0.849	0.865	0.884	0.864	0.883	1				
G08	0.852	0.855	0.896	0.875	0.861	0.885	0.888	1			
G09	0.845	0.888	0.911	0.859	0.900	0.853	0.850	0.850	1		
G10	0.834	0.824	0.839	0.839	0.845	0.853	0.822	0.852	0.838	1	
G11	0.834	0.818	0.845	0.824	0.843	0.872	0.826	0.824	0.833	0.782	1

7.7 THE STRUCTURAL MODEL

As shown in Figure 7.4, and Figure 7.5, the correlations between constructs were replaced by hypothesizing causal relationships.

7.7.1 Structure Model Fit

The goodness of fit indices shows how to fit the items are in measuring their respective latent constructs. Figure 7.4, and Figure 7.5 revealed that $\chi 2/df$ value of 1.365 is below the threshold range between values of 1.0 and 3.0 suggested by (Hair et al. 2014). The p-value Bollen-Stine value of 0.206 is above 0.05. CFI is reported with a value of 0.930, which is above 0.90. SRMR=0.033(<.08), The RMSEA shows a value of 0.033, which is below 0.08 and PCLOSE=1.000(>.05. Thus, it concludes that the CFA model achieved the requirement of the goodness of fit recommended by (Hair et al. 2014; Hu and

Bentler 1999).

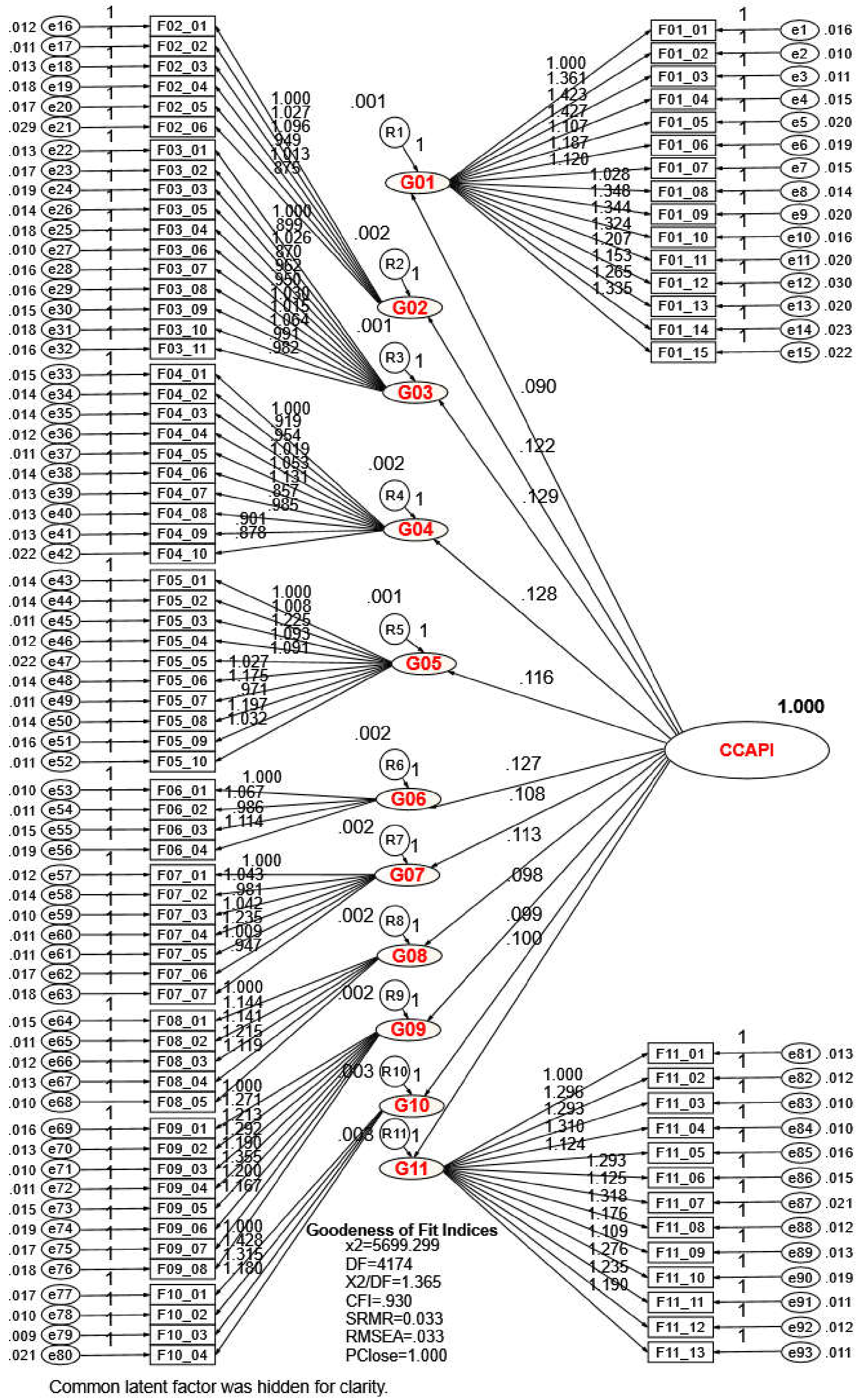


Figure 7.4: CAPM second-order factor structural model- restrained model

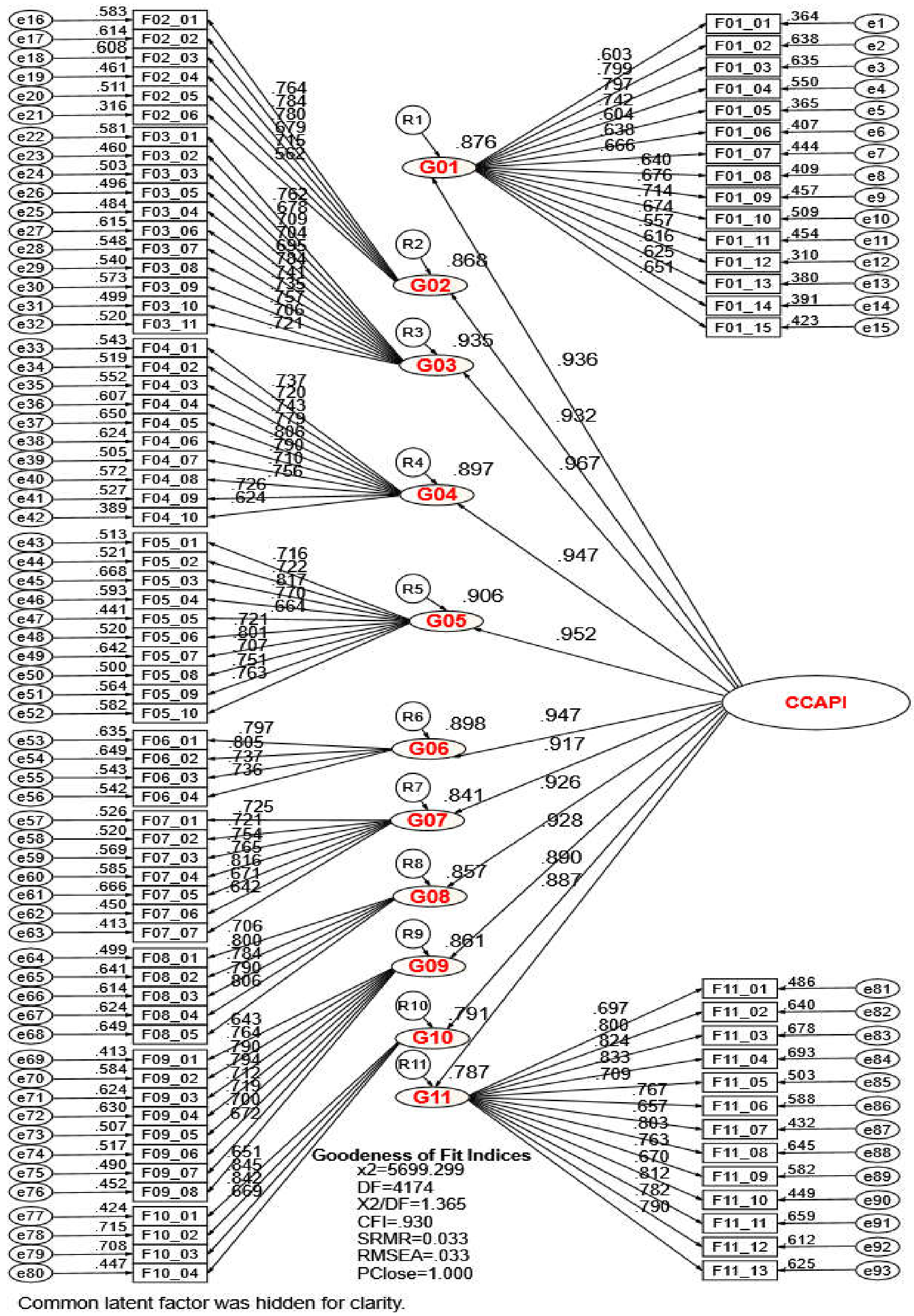


Figure 7.5: CAPM second-order factor structural model - standardized estimates

7.7.2 Structure Model Factor Loading

After examining the second-order SEM model, the fitness indices have achieved the required level. Thus, no item deletion and modification is needed. For the structure model, percent of variance explained (R^2) value is the most important output that reflects the strong relationship (correlation level of importance) among second-order constructs and the first-order constructs by the model. In multiple regression models, (R^2) is computed by pairwise correlations among all the variables (independent variables correlations with each other and dependent variable correlations).

Referring to Table 7.8 the standardized factor loading is higher than 0.5 (Xiong et al. 2015), the significance of regression weight is less than 0.05 (Khan 2016; Zahoor et al. 2017), and the minimum value of R2 is 0.787 which correlate the CCAPI to G011. Thus, the CCA performance is strongly associated with the 11 constructs, and the contributions of CAPM on its eleven sub-constructs are good. Concerning the factor loading, the results showed that CAPM loads well on its 11 first-order constructs. The standardized factor loading (SFL) of CAPM on elven constructs is greater than 0.7. Thus, a theory that the CCA Performance consists of eleven first-order constructs is well supported. As shown in Figure 7.4, all sub-constructs in the CAPM model are highly significant since their respective p-value is lower than 0.01. Further, the first order SFL is shown in Table 7.9 , and all values are greater than 0.50, which achieves convergence validity.

Table 7.8: Second-order factor for the formulation of CCAPI

First Order Factor	SFL	Standard Error	Critical Ratio (T-Value)	R2
G01	0.936	0.008	11.578	0.876
G02	0.932	0.008	15.167	0.868
G03	0.967	0.008	15.85	0.935
G04	0.947	0.009	14.878	0.897
G05	0.952	0.008	14.408	0.906
G06	0.947	0.008	16.323	0.898
G07	0.917	0.008	14.061	0.841
G08	0.926	0.008	13.704	0.857
G09	0.928	0.008	12.318	0.861
G10	0.89	0.008	11.994	0.791
G11	0.887	0.008	13.278	0.787

Table 7.9: Standard factor loadings of the indicators (indicators)

Code	Loading	Variable	Loading	Variable	Loading
F01.01	0.603	F03.11	0.721	F07.07	0.642
F01.02	0.799	F04.01	0.737	F08.01	0.706
F01.03	0.797	F04.02	0.72	F08.02	0.8
F01.04	0.742	F04.03	0.743	F08.03	0.784
F01.05	0.604	F04.04	0.779	F08.04	0.79
F01.06	0.638	F04.05	0.806	F08.05	0.806
F01.07	0.666	F04.06	0.79	F09.01	0.643
F01.08	0.64	F04.07	0.71	F09.02	0.764
F01.09	0.676	F04.08	0.756	F09.03	0.79
F01.10	0.714	F04.09	0.726	F09.04	0.794
F01.11	0.674	F04.10	0.624	F09.05	0.712
F01.12	0.557	F05.01	0.716	F09.06	0.719
F01.13	0.616	F05.02	0.722	F09.07	0.7
F01.14	0.625	F05.03	0.817	F09.08	0.672
F01.15	0.651	F05.04	0.77	F10.01	0.651
F02.01	0.764	F05.05	0.664	F10.02	0.845
F02.02	0.784	F05.06	0.721	F10.03	0.842
F02.03	0.78	F05.07	0.801	F10.04	0.669
F02.04	0.679	F05.08	0.707	F11.01	0.697
F02.05	0.715	F05.09	0.751	F11.02	0.8
F02.06	0.562	F05.10	0.763	F11.03	0.824
F03.01	0.762	F06.01	0.797	F11.04	0.833
F03.02	0.678	F06.02	0.805	F11.05	0.709
F03.03	0.709	F06.03	0.737	F11.06	0.767
F03.04	0.695	F06.04	0.736	F11.07	0.657
F03.05	0.704	F07.01	0.725	F11.08	0.803
F03.06	0.784	F07.02	0.721	F11.09	0.763
F03.07	0.741	F07.03	0.754	F11.10	0.67
F03.08	0.735	F07.04	0.765	F11.11	0.812
F03.09	0.757	F07.05	0.816	F11.12	0.782
F03.10	0.706	F07.06	0.671	F11.13	0.79

7.7.3 Cross Verification the Second-Order Factor Loading

During the questionnaire survey, participants were requested to rate the importance of each latent factor (11 Process group). The data is used to construct an alternative structural model to confirm the second-order factor loading of the primary model, as shown in Figure 7.6. excellent model fitness is attained for the alternative model. Also, the model shows similar factor loadings to the prime model, as shown in Table 7.10 The maximum difference between both models is of magnitude 6 %, therefore if the average factor load is considered then the maximum deviation from the prime model will be 3.3 %, which is negligible.

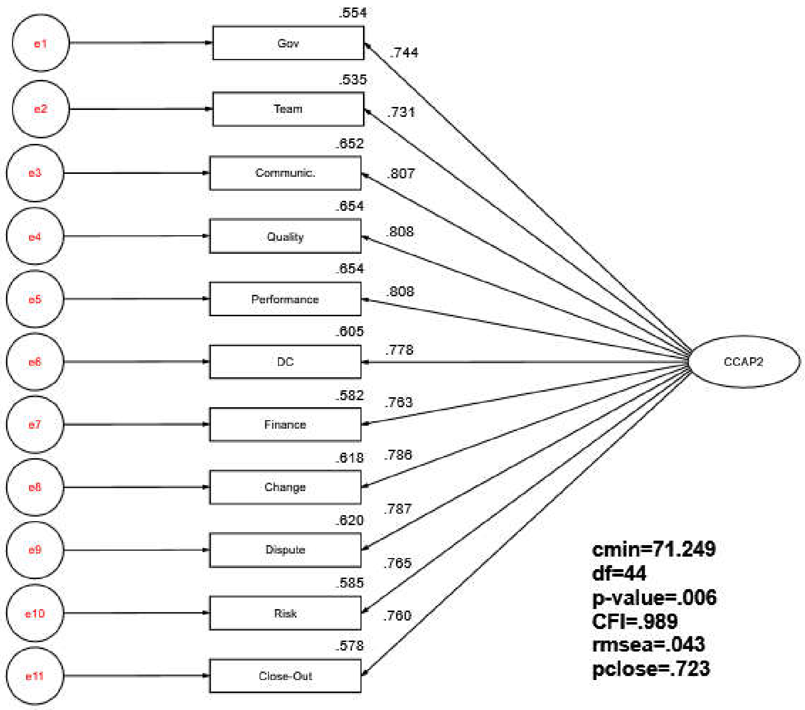


Figure 7.6: Alternative CAPM structural model - standardized estimates

7.7.4 Multigroup Model Comparison

During the questionnaire survey, the respondents identify their sector type and organization type. The χ^2 differences test is carried out to show if there are any differences between the response of different organization types and sector types on the path diagram (Gaskin and Lim 2018). The χ^2 differences test show that there is no model difference between the different organizations (Consultant and Employer groups versus the contractor group) and the sectors (Private and Public) as the P-value is greater than .05, as shown in Table 7.11 to

Table 7.15. This means a reduction in model fit due to either sector or organization with respect to measurement weights is not significant. Therefore, there is no significant difference between different groups and sectors.

Table 7.10: Factor loads and weights from the prime and alternative SEM models

Group	Prime Model		Alternative Model		% Error in Weight	Average Factor Weight
	Estimate	Weight	Estimate	Weight		
G01	0.936	0.0915	0.744	0.0872	4.7%	0.0894
G02	0.932	0.0911	0.731	0.0856	6.0%	0.08835
G03	0.967	0.0945	0.807	0.0945	0.0%	0.0945
G04	0.947	0.0926	0.808	0.0946	-2.2%	0.0936
G05	0.952	0.0931	0.808	0.0946	-1.6%	0.09385
G06	0.947	0.0926	0.778	0.0911	1.6%	0.09185
G07	0.917	0.0896	0.763	0.0894	0.2%	0.0895
G08	0.926	0.0905	0.786	0.0921	-1.8%	0.0913
G09	0.928	0.0907	0.787	0.0922	-1.7%	0.09145
G10	0.89	0.0870	0.765	0.0896	-3.0%	0.0883
G11	0.887	0.0867	0.76	0.089	-2.7%	0.08785

Table 7.11: The χ2 differences test for the different groups

Group	DF	CMIN	P	NFI Delta1	IFI Delta2	RFI rho1	TLI rho2
Organization Type	93	75.119	.913	.002	.003	-.002	-.003
Sector	93	80.508	.819	.003	.003	-.002	-.003

Table 7.12: The χ2 differences test for the organization type

Model	X2		DF
Unconstrained	13457.463		8348
Constrained	13465.282		8359
Difference	7.819		11
P-Value		0.729	

Table 7.13: The χ2 differences test for organization type- paths of constructs

Path Name	Employer Side Beta	Contractor Beta**	Difference in Betas	P-Value	Interpretation
CCAP → G01	0.943***	0.927***	0.016	0.555	There is no difference.
CCAP → G02	0.949***	0.913***	0.035	0.113	There is no difference.
CCAP → G03	0.966***	0.970***	-0.004	0.448	There is no difference.
CCAP → G04	0.956***	0.929***	0.027	0.531	There is no difference.
CCAP → G05	0.959***	0.942***	0.017	0.673	There is no difference.
CCAP → G06	0.954***	0.934***	0.021	0.361	There is no difference.
CCAP → G07	0.926***	0.907***	0.018	0.543	There is no difference.
CCAP → G08	0.916***	0.943***	-0.027	1	There is no difference.
CCAP → G09	0.922***	0.938***	-0.016	0.493	There is no difference.
CCAP → G10	0.886***	0.897***	-0.011	0.856	There is no difference.
CCAP → G11	0.880***	0.902***	-0.022	0.191	There is no difference.

Significance Indicators: † $p < 0.100$; * $p < 0.050$; ** $p < 0.010$; and *** $p < 0.001$

Table 7.14: The $\chi 2$ differences test for the sector type

	X2		DF
Unconstrained	13199.33		8348
Constrained	13210.26		8359
Difference	10.928		11
P-Value		0.449	

Table 7.15: The $\chi 2$ differences test for sector type- paths of constructs

Path Name	Private Beta	Public Beta	Difference in Betas	P-Value	Interpretation
CCAP → G01	0.928***	0.940***	-0.012	0.643	There is no difference.
CCAP → G02	0.949***	0.905***	0.044	0.017	The positive relationship between G02 and CCAP is stronger for Private.
CCAP → G03	0.963***	0.983***	-0.02	0.436	There is no difference.
CCAP → G04	0.941***	0.955***	-0.014	0.354	There is no difference.
CCAP → G05	0.950***	0.953***	-0.002	0.028	The positive relationship between G05 and CCAP is stronger for Public.
CCAP → G06	0.958***	0.948***	0.01	0.306	There is no difference.
CCAP → G07	0.902***	0.943***	-0.041	0.069	The positive relationship between G07 and CCAP is stronger for Public.
CCAP → G08	0.908***	0.945***	-0.036	0.171	There is no difference.
CCAP → G09	0.956***	0.921***	0.035	0.518	There is no difference.
CCAP → G10	0.852***	0.912***	-0.06	0.355	There is no difference.
CCAP → G11	0.897***	0.876***	0.021	0.04	The positive relationship between G11 and CCAP is stronger for Private.

Significance Indicators: † $p < 0.100$; * $p < 0.050$; ** $p < 0.010$; and *** $p < 0.001$

7.8 HYPOTHESIS TESTING

The hypothesis testing in the (SEM) examines the overall model fit and the significance of parameter estimate values, as well. The previous section discussed the final model fit, and this section would discuss the parameter estimates supporting the study hypotheses. The Contract Administration Performance Indicator (CCAPI) construct is a second-order construct with 11 first-order constructs. The causal directions point out from CCAPI to the other 11 constructs. The 11 constructs are measured using 93 indicators from the questionnaire. The results in Figure 7.4 showed that CCAPI - as a second-order construct, loads well on its 11 first-order constructs. Based on Table 7.16 The probability of getting a critical ratio as large as 11.578 to 16.323 in absolute value is less than 0.001. In other words, the regression weight for CCAPI in the prediction of G01 is significantly different from zero at the 0.001 level. The factor loading of CCAPI on G01 to G11 are 0.936, 0.932, 0.967, 0.947, 0.952, 0.947, 0.917, 0.926, 0.928, 0.89, and 0.887 respectively. Furthermore, the R2 for all sub-constructs are high (0.876, 0.869, 0.935, 0.897, 0.906, 0.899, 0.841, 0.857, 0.859, 0.790, and 0.787), which reflects the association between CCAPI on its 11 sub-constructs is well established.

Thus, the theory suggested that CCAPI is highly associated with G01 to G11 is well supported, as shown in Table 7.17.

Table 7.16: The regression path coefficient values for CAPM (unstandardized)

First Order Factor	Un-Standardized Estimate	Standard Error	Critical Ratio (T-Value)	P-Value	R2
G01<--- CCAPI	0.122	0.008	11.578	<.001	0.876
G02<--- CCAPI	0.129	0.008	15.167	<.001	0.868
G03<--- CCAPI	0.128	0.008	15.85	<.001	0.935
G04<--- CCAPI	0.116	0.009	14.878	<.001	0.897
G05<--- CCAPI	0.127	0.008	14.408	<.001	0.906
G06<--- CCAPI	0.108	0.008	16.323	<.001	0.898
G07<--- CCAPI	0.113	0.008	14.061	<.001	0.841
G08<--- CCAPI	0.098	0.008	13.704	<.001	0.857
G09<--- CCAPI	0.099	0.008	12.318	<.001	0.861
G10<--- CCAPI	0.100	0.008	11.994	<.001	0.791
G11<--- CCAPI	0.122	0.008	13.278	<.001	0.787

7.9 MODEL INTERNAL AND EXTERNAL VALIDITY

Validity can be extended behind the validity of a measurement system and the validity of the hypothesized relationships to contain internal validity and external validity (Soysa 2017). In quantitative research, the most common threats that are affecting the internal and external validity of the data collection and analysis are mortality (loss of subjects), location (the bias of results generated from the worksite environment), instrumentation, and instrument decay (changes in questionnaire items, scoring, and the bias of the data collector) (Zahoor et al. 2017). Several precautions to minimize internal validity threats and potential biases. This includes random sampling, a collection of data from different sectors, different organizations, different levels of experiences, professionals with different cultures.

Table 7.17: The hypothesis statement for every path and its conclusion

Hypothesis statement	Result
HO1: The Project Governance & Start-up has a significant positive impact on the performance of CCA	Supported
HO2: Contract Administration Team Management has a significant positive impact on the performance of CCA	Supported
HO3: Communication & Relationship Management has a significant positive impact on the performance of CCA	Supported
HO4: Quality & Acceptance Management has a significant positive impact on the performance of CCA	Supported
HO5: Performance Monitoring & Reporting Management has a significant positive impact on the performance of CCA	Supported
HO6: Document & Record Management has a significant positive impact on the performance of CCA	Supported
HO7: Financial Management has a significant positive impact on the performance of CCA	Supported
HO8: Changes & Changes Control Management has a significant positive impact on the performance of CCA	Supported
HO9: Claims & Disputes Resolution Management has a significant positive impact on the performance of CCA	Supported
HO10: Contract Risk Management has a significant positive impact on the performance of CCA	Supported
HO11: Contract Close-Out Management has a significant positive impact on the performance of CCA	Supported
HO12: the 11 latent factors are positively measuring the CCA performance of the construction.	Supported

In particular, internal validity that referring to whether the influence of the independent variables (indicators) or treatments caused the observed effects on the dependent variables (constructs) (Malhotra et al. 2012; Soysa 2017) and to the ability of a research instrument to measure what it is purported to measure (Cooper and Schindler 2014). According to Cooper and Schindler (2014), internal validity can be justified by content validity and construct validity. External validity refers to whether the study findings can be generalized (Malhotra et al. 2012).

As demonstrated through the literature review in Chapter 3, it has been well established that poor contract administrations have been caused by improper practices of the CCA tasks and on the other side, the effective and adequate performance was attended by the proper implementation. Therefore, a strong justification of the hypothesized causality would exist. The measurement model achieved the requirement of construct validity. The instrumentation threat was minimized through a well-designed questionnaire based on a comprehensive literature review, and the study of several tender requirements concerns CCA functions. Before release the final questionnaire, four structured interviews were conducted with construction expats to enhance the questionnaire quality, ensure content validity, and minimize instrument decay threats. The location-related threats were minimized by random sampling and spread the survey over many professionals. Since the researcher selected large representative samples, the study would be expected to be free from method bias, and the findings were not influenced by the actions of the researcher (Cooper and Schindler 2014). Finally, the data was examined and treated for outliers and nonserious responses to reduce data variability and biases. The content validity of the CCA was further accomplished through the pilot studies (modified Delhi study). Face validity was achieved because all the indicators in each construct are related to constructing abstract (Zahoor et al. 2017). The factors selected from several worldwide studies and not limited to a certain form of contract or region. For these reasons, the researcher argues that actions were taken to enhance the internal and external validity of the research findings.

Qatar's general conditions are almost similar to the FIDIC Red Book (Glover

2007). Regionally, the FIDIC Old Red Book-4th edition remains the contract of preference in the bulk of the Middle East projects includes Qatar (Glover 2007; Sadek 2016), and more than 50 percent of the middle east contract uses FIDIC standard forms. FIDIC red Book 1987 represents 28% of the standard forms adopted in the Middle East, while the New Red Book 1999 is the second with 24% adoption (Sadek and Kulatunga 2013). Internationally, the most commonly adopted form is the Red Book (Hillig et al. 2010; Shnookal and Charrett 2010). Therefore, this study focuses on the Design-Bid-Build Contract, and the research output would be applied internationally as well.

7.10 CHAPTER SUMMARY

This chapter conducted the SEM statistical analysis. Three hundred sixty-six questionnaires were received, and only 336 questionnaires were validated for analysis due to the presence of unengaged responses and outliers. The respondents' demographic was reported using descriptive analysis, including the respondent’s set of profiles and types of projects. The sample dataset violates the normality assumption, and techniques to deal with non-normal data were discussed. The Cronbach's alpha test was utilized to check the internal consistency and reliability of the variables, and the dataset was found reliable. CFA and SEM were carried out using AMOS version 24 and, the research hypotheses were tested, and the level of significance reported. The final model confirmed the model fit, reliability, and validity, and therefore, the data is consistent with the hypothesized model.

CHAPTER 8 : CAPM PERFORMANCE INDEX, MOBILE APP AND CASE STUDIES

8.1 INTRODUCTION

Chapter seven confirmed the model achieved goodness of fit indices, reliability, and validity, and therefore, the data is consistent with the hypothesized model. This chapter aimed to formulate a Construction Contract Administration Performance Index (CCAPI) based on the established standardized factor loading,

8.2 CONSTRUCTS RELATIVE WEIGHTS

This study implemented a methodology based on second-order Confirmatory Factor Analysis with different latent factors. The relative weight of a group is the standardized factor loadings of that group divided by the sum of all standardized factor loadings. (Gunduz et al. 2018; Yoo and Donthu 2001). Also, the calculation is based on the weighted sum of scores of the indicators represent an approximation of the score of their underlying construct (Bollen 2002). The weight of the indicator can be assigned based on the loading coefficients (Cha et al. 2018; Nguyen et al. 2013).

The formulas adopted to calculate CCA performance Index (CCAPI) are:

$$RFW1_i = SFL_i \,/\, \Sigma\,(SFL_i) \quad (8.1)$$

$$RFW2_i = RFW1_i \text{ or } NaN \quad (8.2)$$

$$RFW3_i = RFW2_i * \Sigma RFW1_i / \Sigma RFW2_i \quad (8.3)$$

$$FW_i = C_i * RFW3_i \quad (8.4)$$

$$RGW1_j = SFL_j / \Sigma SFL_j \quad (8.5)$$

$$RGW2_j = RGW1_j \quad (8.6)$$

$$RGW3_j = RGW2_j / \Sigma RGW2_j \quad (8.7)$$

$$FW2_i = C_i * RFW3_i * RGW3_J \quad (8.8)$$

$$P_j = \Sigma FW2_i \quad (8.9)$$

$$\% P_j = P_j / RGW3_j * 100 \quad (8.10)$$

Where:

SFL_i	=	Standardized factor loading of the indicator i (i=15,6,11,10,10,4,7,5,8,4,13) for groups j=1 to 11)
$RFW1_i$	=	Relative Factor Weight (Within Group) of the indicator
$RFW2_i$	=	Applicable Relative Factor Weight (Within Group) of the indicator (i.e., $RFW2_i = 0$ for not applicable indicator i);
$RFW3_i$	=	Updated Relative Factor Weight (Within Group) of the indicator i
C_i	=	conformity of indicator based on actual implementation (i.e. C_i=0 to 100 or NaN)
FW_i	=	Factor Weight (Within Group) each indicator i considering the variable availability and site observations
SFL_j	=	Standardized Factor loading of group j (j= 1 to 11)
$RGW1_j$	=	The relative weight of group j
$RGW2_j$	=	Applicable Weight of group j (i.e., $RGW2_j$ =0 if all indicators within group j are not applicable)
$RWG2_j$	=	Updated Weight of group j
$FW2_i$	=	Overall Final Factor Weight based on group availability and indicator availability
P_j	=	Group Performance
$\% P_j$	=	Group Performance Index

The calculated Relative Factor Weight of the indicator (RFW1) and Relative weight of group (RGW1) are shown in Table 8.1.

Table 8.1: Standardized factor loading of the second-order SEM model and relative weights of indicators and constructs.

Indicators									Latent Factors		
Code	SFLi[1]	RFW1i[2]	Code	SFLi[1]	RFW1i[2]	Code	SFLi[1]	RFW1i[2]	Code	SFLi[1]	RGW1i[2]
F01.01	0.603	0.0603	F04.01	0.737	0.0997	F08.01	0.706	0.1817	G01	0.936	0.0915
F01.02	0.799	0.0799	F04.02	0.720	0.0974	F08.02	0.800	0.2059	G02	0.932	0.0911
F01.03	0.797	0.0797	F04.03	0.743	0.1005	F08.03	0.784	0.2017	G03	0.967	0.0945
F01.04	0.742	0.0742	F04.04	0.779	0.1054	F08.04	0.790	0.2033	G04	0.947	0.0926
F01.05	0.604	0.0604	F04.05	0.806	0.1091	F08.05	0.806	0.2074	G05	0.952	0.0931
F01.06	0.638	0.0638	F04.06	0.790	0.1069	F09.01	0.643	0.1110	G06	0.947	0.0926
F01.07	0.666	0.0666	F04.07	0.710	0.0961	F09.02	0.764	0.1319	G07	0.917	0.0896
F01.08	0.640	0.0640	F04.08	0.756	0.1023	F09.03	0.790	0.1363	G08	0.926	0.0905
F01.09	0.676	0.0676	F04.09	0.726	0.0982	F09.04	0.794	0.1370	G09	0.928	0.0907
F01.10	0.714	0.0714	F04.10	0.624	0.0844	F09.05	0.712	0.1229	G10	0.890	0.0870
F01.11	0.674	0.0674	F05.01	0.716	0.0963	F09.06	0.719	0.1241	G11	0.887	0.0867
F01.12	0.557	0.0557	F05.02	0.722	0.0971	F09.07	0.700	0.1208			
F01.13	0.616	0.0616	F05.03	0.817	0.1099	F09.08	0.672	0.1160			
F01.14	0.625	0.0625	F05.04	0.770	0.1036	F10.01	0.651	0.2165			
F01.15	0.651	0.0651	F05.05	0.664	0.0893	F10.02	0.845	0.2810			
F02.01	0.764	0.1783	F05.06	0.721	0.0970	F10.03	0.842	0.2800			
F02.02	0.784	0.1830	F05.07	0.801	0.1078	F10.04	0.669	0.2225			
F02.03	0.780	0.1821	F05.08	0.707	0.0951	F11.01	0.697	0.0704			
F02.04	0.679	0.1585	F05.09	0.751	0.1010	F11.02	0.800	0.0808			
F02.05	0.715	0.1669	F05 10	0.763	0.1027	F11.03	0.824	0.0832			
F02.06	0.562	0.1312	F06.01	0.797	0.2592	F11.04	0.833	0.0841			
F03.01	0.762	0.0953	F06.02	0.805	0.2618	F11.05	0.709	0.0716			
F03.02	0.678	0.0848	F06.03	0.737	0.2397	F11.06	0.767	0.0774			
F03.03	0.709	0.0887	F06.04	0.736	0.2393	F11.07	0.657	0.0663			
F03.04	0.695	0.0870	F07.01	0.725	0.1423	F11.08	0.803	0.0811			
F03.05	0.704	0.0881	F07.02	0.721	0.1415	F11.09	0.763	0.0770			
F03.06	0.784	0.0981	F07.03	0.754	0.1480	F11.10	0.670	0.0676			
F03.07	0.741	0.0927	F07.04	0.765	0.1502	F11.11	0.812	0.0820			
F03.08	0.735	0.0920	F07.05	0.816	0.1602	F11.12	0.782	0.0789			
F03.09	0.757	0.0947	F07.06	0.671	0.1317	F11.13	0.790	0.0797			
F03.10	0.706	0.0883	F07.07	0.642	0.1260						
F03.11	0.721	0.0902									

SFLi= Standardized Factor Loading from SEM model, and RFW1i= Relative Factor/ Group Weight

8.3 CONSTRUCTION CONTRACT ADMINISTRATION PERFORMANCE INDEX (CCAPI)

The formula expressed Construction Contract Administration Performance

Index (CCAPI) calculation is shown in Equation 8.11.

$$CCAPI = \Sigma P_j \quad (8.11)$$

Where:

$CCAPI$ = Construction Contract Administration Performance Index

Pj = Group Performance as calculated by equation 8.1

The CCAPI represented the sum of the 11 process groups' performance indices. Table 8.2 explains sample calculations for the different formulas adopted to calculate CCAPI for process groups numbers G01 to G11 of project #1. Descriptions of the columns in Table 8.2 are explained as follows:

- Column code: In this table, indicators are listed in the ascending order according to the variable coding (column variable).
- Column Ci: represents the % of implementation (conformity of each variable on scale 0-100 (0 for major non-conformance, 100 for full conformance, and "NaN" for not applicable).
- Column SFLi: Standardized Factor Loadings of the indicators i based on SEM model output.
- Column RFW1i: Relative weight of the indicator i (example: RFW1F09.01= 0.643/ (0.643+0.764+0.790+0.794+0.712+0.719+0.700+0.672) = 0.1110 (Equation 8.1).
- Column RFW2i: Applicable relative weight of the indicator i (example: RFW2F09.01= 0.1110 and RFW2F09.08= NaN as per Equation 8.2).
- Column RFW3i: Updated relative weight of the indicator (example: RFW3F09.01= 0.1110 x 1.0 / (0.1110+ 0.1319 + 0.1363 + 0.1370 + 0.1229) = 0.1736 as per Equation 8.3). This updated weight takes into consideration non applicability of the last 3 variables within group 9.

- Column FWi: The Factor weight based on the site observations of each indicator (example: FWF09.01= 90 x 0.1736= 15.628 as per Equation 8.4).
- Column SFLj: Standardized Factor load of group j (latent factor) based on the SEM model.
- Column RGW1j demonstrated Relative weight of group j (example: RGW1G09 =0.9280/ (0.936+0.932+0.967+0.947+0.952+0.947+0.917+0.926+0.928+0.890+ 0.887) = 0.0907 as per Equation 8.5).
- Column RGW2j: Applicable relative weight of group j (example: RGW1G09= 0.0907 because all groups are implemented, If the group is not applicable, then RGW2j = NaN as per Equation 8.6).
- Column RGW3j: Updated relative weight of group j (example: RGW1G09= 0.0907 as per Equation 8.7).
- Column FW2i: final Factor Weight based on group availability and indicator availability (example: FW2F09.01= 90 x 0.1736 x 0.0907 = 1.4178 as per Equation 8.8). If the variable is not applicable, then FW2i= NaN.
- Column Pj: group performance (example: PG09=1.4178+ 1.6846+ 1.7419+ 1.7507+ 1.5699 = 8.17 as per Equation).
- Column % Pj: group performance index (example: %PG09= 8.17/0.0907 =90.0 % as per Equation 8.10).
- The last row represents the Construction Contract Administration Performance Index (CCAPI) (example CCAPI for project #1 = 7.94+ 7.48+8.73+ 8.80+ 8.62+ 8.56+ 8.16+ 8.33+ 8.17+ 4.78+ 7.50 = 87.0 % as per Equation 8.11).

From the SEM analysis, the relative group weights (contribution of each group to CCAPI at the ultimate compliance) of G01 to G11 were 0.0915, 0.0911, 0.0945, 0.0926, 0.0931, 0.0926, 0.0896, 0.0905, 0.0907, 0.0870, and 0.0867, respectively.

Therefore, the ultimate contributions of groups G1 to G11 to the construction contract administration performance are 9.15%, 9.11%, 9.45%, 9.26%, 9.31%, 9.26%, 8.96%, 9.05%, 9.07%, 8.7%, and 8.67% respectively. In the real-world, the implementation or degrees of conformance of each indicator are different and cannot exceed 100 %; therefore, the contribution of each construct (group) to the overall CCA performance will be less than its ultimate value. Within each construct, each indicator contributes to the CCA performance through the product of its ultimate relative weight (RFW3i) and the % of conformance/ compliance (% Ci). The performance of each construct (Pi) is the product of the summation of each indicator contribution within these groups (FW1i) and the construct ultimate relative weight (RGW3j). For example, the contribution of G09-Claims & Disputes Resolution is calculated as 0.0907 x (0.0158+0.0187+0.0194+0.0195+0.0174+0.0000+0.0000+0.0000) = 8.17. The summation of this Pi values will establish the overall CCA performance (CCAPI) while its ratio to the updated ultimate relative group weight (RGW3i) will provide its absolute percentage of performance. It worth to note that the relative weight of the G03-Communication & Relationship was 0.0945 and therefore ranked as the first construct affecting the construction contract administration performance followed by G05-Performance Monitoring & Reporting with a relative weight of 0.0931 as the second construct. A discussion of the relative weights is presented in Chapter 9.

8.4 INTRODUCE AN ALTERNATIVE SHORT MODEL

8.4.1 Short Model Formulation

To simplify the data entry, reduce time consumed to collect data, and speed up the evaluation of CCA performance in construction projects, a short model which included the top three most significant indicators in each process group considering their standardized factor loadings calculated previously is proposed. Contrary to the full model, which included 93 indicators affecting CCA performance, the short model includes only 33 indicators categorized into the same 11 process groups of the full model as listed in Table 8.3. The calculation concept of the short model is not differing from the full model. Both models were sharing the corresponding factor loadings and site evaluations of the indicators. Furthermore, Standardized Factor Loadings and Relative Factor Weights of the latent factors were not changed between models. The results of the full and short model results were different due to the difference in values of the updated relative factor and group weights of the indicators (RFW3i and RGW2j).

Table 8.2: Calculation of CCAPI for project# 1 by the full model

Code	C_i	SFL_i	$RFW1_i$	$RFW2_i$	$RFW3_i$	FW_i	SFLj	$RGW1_j$	$RGW2_j$	$RGW3_j$	$FW1_i$	$FW2_i$	P_j	% P_j
F01.01	85	0.603	0.0603	0.0603	0.0603	5.12	0.936	0.0915	0.0915	0.0915	0.0055	0.4689	7.94	86.8
F01.02	90	0.799	0.0799	0.0799	0.0799	7.19					0.0073	0.6579		
F01.03	90	0.797	0.0797	0.0797	0.0797	7.17					0.0073	0.6562		
F01.04	90	0.742	0.0742	0.0742	0.0742	6.68					0.0068	0.6109		
F01.05	80	0.604	0.0604	0.0604	0.0604	4.83					0.0055	0.4421		
F01.06	95	0.638	0.0638	0.0638	0.0638	6.06					0.0058	0.5545		
F01.07	90	0.666	0.0666	0.0666	0.0666	5.99					0.0061	0.5484		
F01.08	95	0.64	0.064	0.064	0.064	6.08					0.0059	0.5562		
F01.09	95	0.676	0.0676	0.0676	0.0676	6.42					0.0062	0.5875		
F01.10	85	0.714	0.0714	0.0714	0.0714	6.07					0.0065	0.5552		
F01.11	80	0.674	0.0674	0.0674	0.0674	5.39					0.0062	0.4933		
F01.12	50	0.557	0.0557	0.0557	0.0557	2.78					0.0051	0.2548		
F01.13	95	0.616	0.0616	0.0616	0.0616	5.85					0.0056	0.5354		
F01.14	95	0.625	0.0625	0.0625	0.0625	5.94					0.0057	0.5432		
F01.15	80	0.651	0.0651	0.0651	0.0651	5.21					0.006	0.4765		
F02.01	85	0.764	0.1783	0.1783	0.1783	15.16	0.932	0.0911	0.0911	0.0911	0.0162	1.3812	7.48	82
F02.02	85	0.784	0.183	0.183	0.183	15.56					0.0167	1.4173		
F02.03	90	0.78	0.1821	0.1821	0.1821	16.39					0.0166	1.493		
F02.04	70	0.679	0.1585	0.1585	0.1585	11.09					0.0144	1.0109		
F02.05	80	0.715	0.1669	0.1669	0.1669	13.35					0.0152	1.2165		
F02.06	80	0.562	0.1312	0.1312	0.1312	10.49					0.012	0.9562		
F03.01	80	0.762	0.0953	0.0953	0.0953	7.63	0.967	0.0945	0.0945	0.0945	0.009	0.7211	8.73	92.3
F03.02	80	0.678	0.0848	0.0848	0.0848	6.79					0.008	0.6416		
F03.03	95	0.709	0.0887	0.0887	0.0887	8.43					0.0084	0.7967		
F03.04	95	0.695	0.087	0.087	0.087	8.26					0.0082	0.781		
F03.05	95	0.704	0.0881	0.0881	0.0881	8.37					0.0083	0.7911		
F03.06	95	0.784	0.0981	0.0981	0.0981	9.32					0.0093	0.881		
F03.07	95	0.741	0.0927	0.0927	0.0927	8.81					0.0088	0.8327		

Table 8.2: Calculation of CCAPI for project# 1 by the full model (continued)

Code	C_i	SFL_i	$RFW1_i$	$RFW2_i$	$RFW3_i$	FW_i	$SFLj$	$RGW1_j$	$RGW2_j$	$RGW3_j$	$FW1_i$	$FW2_i$	P_j	% P_j
F03.08	95	0.735	0.092	0.092	0.092	8.74					0.0087	0.8259		
F03.09	95	0.757	0.0947	0.0947	0.0947	9					0.009	0.8507		
F03.10	95	0.706	0.0883	0.0883	0.0883	8.39					0.0084	0.7934		
F03.11	95	0.721	0.0902	0.0902	0.0902	8.57					0.0085	0.8102		
F04.01	95	0.737	0.0997	0.0997	0.0997	9.47	0.947	0.0926	0.0926	0.0926	0.0092	0.877	8.80	95
F04.02	95	0.72	0.0974	0.0974	0.0974	9.25					0.009	0.8568		
F04.03	95	0.743	0.1005	0.1005	0.1005	9.55					0.0093	0.8842		
F04.04	95	0.779	0.1054	0.1054	0.1054	10.01					0.0098	0.927		
F04.05	95	0.806	0.1091	0.1091	0.1091	10.36					0.0101	0.9591		
F04.06	95	0.79	0.1069	0.1069	0.1069	10.15					0.0099	0.9401		
F04.07	95	0.71	0.0961	0.0961	0.0961	9.13					0.0089	0.8449		
F04.08	95	0.756	0.1023	0.1023	0.1023	9.72					0.0095	0.8996		
F04.09	95	0.726	0.0982	0.0982	0.0982	9.33					0.0091	0.8639		
F04.10	95	0.624	0.0844	0.0844	0.0844	8.02					0.0078	0.7425		
F05.01	95	0.716	0.0963	0.0963	0.0963	9.15	0.952	0.0931	0.0931	0.0931	0.009	0.8518	8.62	92.6
F05.02	85	0.722	0.0971	0.0971	0.0971	8.26					0.009	0.7685		
F05.03	90	0.817	0.1099	0.1099	0.1099	9.89					0.0102	0.9208		
F05.04	95	0.77	0.1036	0.1036	0.1036	9.84					0.0096	0.916		
F05.05	85	0.664	0.0893	0.0893	0.0893	7.59					0.0083	0.7068		
F05.06	95	0.721	0.097	0.097	0.097	9.22					0.009	0.8577		
F05.07	95	0.801	0.1078	0.1078	0.1078	10.24					0.01	0.9529		
F05.08	95	0.707	0.0951	0.0951	0.0951	9.04					0.0089	0.8411		
F05.09	95	0.751	0.101	0.101	0.101	9.6					0.0094	0.8934		
F05 10	95	0.763	0.1027	0.1027	0.1027	9.75					0.0096	0.9077		
F06.01	95	0.797	0.2592	0.2592	0.2592	24.62	0.947	0.0926	0.0926	0.0926	0.024	2.2796	8.56	92.5
F06.02	90	0.805	0.2618	0.2618	0.2618	23.56					0.0242	2.1813		
F06.03	95	0.737	0.2397	0.2397	0.2397	22.77					0.0222	2.108		
F06.04	90	0.736	0.2393	0.2393	0.2393	21.54					0.0222	1.9943		
F07.01	95	0.725	0.1423	0.1423	0.1423	13.52	0.917	0.0896	0.0896	0.0896	0.0128	1.2121	8.16	91

Table 8.2: Calculation of CCAPI for project# 1 by the full model (continued)

Code	C_i	SFL_i	$RFW1_i$	$RFW2_i$	$RFW3_i$	FW_i	SFLj	$RGW1_j$	$RGW2_j$	$RGW3_j$	$FW1_i$	$FW2_i$	P_j	% P_j
F07.02	95	0.721	0.1415	0.1415	0.1415	13.45					0.0127	1.2054		
F07.03	95	0.754	0.148	0.148	0.148	14.06					0.0133	1.2606		
F07.04	95	0.765	0.1502	0.1502	0.1502	14.27					0.0135	1.279		
F07.05	70	0.816	0.1602	0.1602	0.1602	11.21					0.0144	1.0052		
F07.06	95	0.671	0.1317	0.1317	0.1317	12.51					0.0118	1.1218		
F07.07	95	0.642	0.126	0.126	0.126	11.97					0.0113	1.0733		
F08.01	95	0.706	0.1817	0.1817	0.1817	17.26	0.926	0.0905	0.0905	0.0905	0.0164	1.5624	8.33	92
F08.02	95	0.8	0.2059	0.2059	0.2059	19.56					0.0186	1.7705		
F08.03	80	0.784	0.2017	0.2017	0.2017	16.14					0.0183	1.4611		
F08.04	95	0.79	0.2033	0.2033	0.2033	19.31					0.0184	1.7483		
F08.05	95	0.806	0.2074	0.2074	0.2074	19.7					0.0188	1.7837		
F09.01	90	0.643	0.111	0.111	0.1736	15.63	0.928	0.0907	0.0907	0.0907	0.0158	1.4178	8.17	90
F09.02	90	0.764	0.1319	0.1319	0.2063	18.57					0.0187	1.6846		
F09.03	90	0.79	0.1363	0.1363	0.2133	19.2					0.0194	1.7419		
F09.04	90	0.794	0.137	0.137	0.2144	19.3					0.0195	1.7507		
F09.05	90	0.712	0.1229	0.1229	0.1923	17.3					0.0174	1.5699		
F09.06	NaN	0.719	0.1241	0	0	NaN					0	NaN		
F09.07	NaN	0.7	0.1208	0	0	NaN					0	NaN		
F09.08	NaN	0.672	0.116	0	0	NaN					0	NaN		
F10.01	60	0.651	0.2165	0.2165	0.2165	12.99	0.89	0.087	0.087	0.087	0.0188	1.1302	4.78	55
F10.02	60	0.845	0.281	0.281	0.281	16.86					0.0245	1.467		
F10.03	50	0.842	0.28	0.28	0.28	14					0.0244	1.2182		
F10.04	50	0.669	0.2225	0.2225	0.2225	11.12					0.0194	0.9679		
F11.01	95	0.697	0.0704	0.0704	0.0836	7.94	0.887	0.0867	0.0867	0.0867	0.0073	0.6889	7.50	86.5
F11.02	90	0.8	0.0808	0.0808	0.096	8.64					0.0083	0.7491		
F11.03	90	0.824	0.0832	0.0832	0.0989	8.9					0.0086	0.7715		
F11.04	90	0.833	0.0841	0.0841	0.0999	8.99					0.0087	0.78		
F11.05	90	0.709	0.0716	0.0716	0.0851	7.66					0.0074	0.6639		

Table 8.2: Calculation of CCAPI for project# 1 by the full model (continued)

Code	C_i	SFL_i	$RFW1_i$	$RFW2_i$	$RFW3_i$	FW_i	SFLj	$RGW1_j$	$RGW2_j$	$RGW3_j$	$FW1_i$	$FW2_i$	P_j	% P_j
F11.06	85	0.767	0.0774	0.0774	0.092	7.82					0.008	0.6783		
F11.07	80	0.657	0.0663	0.0663	0.0788	6.31					0.0068	0.5468		
F11.08	80	0.803	0.0811	0.0811	0.0963	7.71					0.0084	0.6683		
F11.09	80	0.763	0.077	0.077	0.0915	7.32					0.0079	0.635		
F11.10	80	0.67	0.0676	0.0676	0.0804	6.43					0.007	0.5576		
F11.11	90	0.812	0.082	0.082	0.0974	8.77					0.0084	0.7603		
F11.12	NaN	0.782	0.0789	0	0	NaN					0	NaN		
F11.13	NaN	0.79	0.0797	0	0	NaN					0	NaN		
Construction Contract Administration Performance Index (CCAPI)													**87 %**	

Table 8.3: Calculation of CCAPI for project# 1 by the short model

Code	C_i	SFL_i	$RFW1_i$	$RFW2_i$	$RFW3_i$	FW_i	SFLj	$RGW1_j$	$RGW2_j$	$RGW3_j$	$FW1_i$	$FW2_i$	P_j	% P_j
F01.02	90	0.7990	0.3417	0.3417	0.3417	30.76	0.9360	0.0915	0.0915	0.0915	0.0313	2.8144	8.2	90.0
F01.03	90	0.7970	0.3409	0.3409	0.3409	30.68					0.0312	2.8074		
F01.04	90	0.7420	0.3174	0.3174	0.3174	28.56					0.0290	2.6136		
F02.01	85	0.7640	0.3282	0.3282	0.3282	27.90	0.9320	0.0911	0.0911	0.0911	0.0299	2.5416	7.9	86.7
F02.02	85	0.7840	0.3368	0.3368	0.3368	28.63					0.0307	2.6082		
F02.03	90	0.7800	0.3351	0.3351	0.3351	30.15					0.0305	2.7475		
F03.01	80	0.7620	0.3309	0.3309	0.3309	26.47	0.9670	0.0945	0.0945	0.0945	0.0313	2.5023	8.5	90.0
F03.06	95	0.7840	0.3404	0.3404	0.3404	32.34					0.0322	3.0573		
F03.09	95	0.7570	0.3287	0.3287	0.3287	31.23					0.0311	2.9520		
F04.04	95	0.7790	0.3280	0.3280	0.3280	31.16	0.9470	0.0926	0.0926	0.0926	0.0304	2.8848	8.8	95.0
F04.05	95	0.8060	0.3394	0.3394	0.3394	32.24					0.0314	2.9848		
F04.06	95	0.7900	0.3326	0.3326	0.3326	31.60					0.0308	2.9255		

Table 8.3: Calculation of CCAPI for project# 1 by the short model (continued)

Code	C_i	SFL_i	$RFW1_i$	$RFW2_i$	$RFW3_i$	FW_i	SFLj	$RGW1_j$	$RGW2_j$	$RGW3_j$	$FW1_i$	$FW2_i$	P_j	% P_j
F05.03	90	0.8170	0.3421	0.3421	0.3421	30.79	0.9520	0.0931	0.0931	0.0931	0.0318	2.8657	8.7	93.3
F05.04	95	0.7700	0.3224	0.3224	0.3224	30.63					0.0300	2.8509		
F05.07	95	0.8010	0.3354	0.3354	0.3354	31.87					0.0312	2.9657		
F06.01	95	0.7970	0.3407	0.3407	0.3407	32.37	0.9470	0.0926	0.0926	0.0926	0.0315	2.9969	8.6	93.3
F06.02	90	0.8050	0.3442	0.3442	0.3442	30.97					0.0319	2.8676		
F06.03	95	0.7370	0.3151	0.3151	0.3151	29.93					0.0292	2.7713		
F07.03	95	0.7540	0.3229	0.3229	0.3229	30.68	0.9170	0.0896	0.0896	0.0896	0.0289	2.7501	7.7	86.3
F07.04	95	0.7650	0.3276	0.3276	0.3276	31.12					0.0294	2.7902		
F07.05	70	0.8160	0.3495	0.3495	0.3495	24.46					0.0313	2.1930		
F08.02	95	0.8000	0.3339	0.3339	0.3339	31.72	0.9260	0.0905	0.0905	0.0905	0.0302	2.8715	8.6	95.0
F08.04	95	0.7900	0.3297	0.3297	0.3297	31.32					0.0298	2.8356		
F08.05	95	0.8060	0.3364	0.3364	0.3364	31.96					0.0305	2.8930		
F09.02	90	0.7640	0.3254	0.3254	0.3254	29.28	0.9280	0.0907	0.0907	0.0907	0.0295	2.6568	8.2	90.0
F09.03	90	0.7900	0.3365	0.3365	0.3365	30.28					0.0305	2.7472		
F09.04	90	0.7940	0.3382	0.3382	0.3382	30.43					0.0307	2.7611		
F10.02	60	0.8450	0.3587	0.3587	0.3587	21.52	0.8900	0.0870	0.0870	0.0870	0.0312	1.8724	4.7	53.6
F10.03	50	0.8420	0.3574	0.3574	0.3574	17.87					0.0311	1.5548		
F10.04	50	0.6690	0.2840	0.2840	0.2840	14.20					0.0247	1.2353		
F11.03	90	0.8240	0.3337	0.3337	0.3337	30.04	0.8870	0.0867	0.0867	0.0867	0.0289	2.6046	7.8	90.0
F11.04	90	0.8330	0.3374	0.3374	0.3374	30.36					0.0293	2.6330		
F11.11	90	0.8120	0.3289	0.3289	0.3289	29.60					0.0285	2.5667		
Construction Contract Administration Performance Index (CCAPI)													**87.7 %**	

8.5 MOBILE APPLICATIONS

8.5.1 Mobile Solutions

Mobile applications are generally classified as either native mobile, mobile web, and hybrid mobile solutions (Griffith 2017; Gunduz et al. 2018). The native solution is consisting of developing a separate application for each platform (i.e., java for android, Objective-C or Swift for iOS and Visual C#, C++, or XAML for Windows platforms (Griffith 2017; Latif et al. 2016).

The mobile-web solution is web server-side application by using web browsers with Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), and JavaScript codes. The application is implemented as an optimized website for mobile considering different screen sizes and their usage philosophy. These approaches do not require application updates but cannot reach the native functions of the device (i.e., notifications system, Cameras, GPS) and required URL access (Griffith 2017; Latif et al. 2016). The hybrid solution combines the web technologies and native functionalities in one application in which the application executed through the browser engine. In other words, the hybrid solution is to use a chromeless web browser to run the web application (Griffith 2017). The hybrid application developers use the application stores to distribute their applications, and the native features are available through an abstract layer. Compared to native apps, it is performance is slower (Latif et al. 2016).

8.5.2 Cross-Platform Software Development Kits (SDKs)

At present, the use of smartphone technologies is growing at an accelerated rate, and companies recognized the need to develop business applications using smartphone access (Latif et al. 2016). Cross-platform is a single Software Development Kit (SDK) tool that allows developers to develop applications that can run under different mobile platforms (iOS, Android, etc.…) and maintain the application performance the same as the native application (Latif et al. 2016). Through the cross-platform, development time and associated costs are reduced since the code is written with one environment to keep the applications deployed in many operating systems and target multiple devices. Cross compilers transform these codes into a native code compatible with the device platform. Therefore, the deployment of a cross-platform environment makes the development of the mobile applications easier in coding and more efficient in development.

The most popular five mobile application development frameworks are as follows: a) Ionic, b) React Native, c) Xamarin, d) PhoneGap, e) and Flutter. Ionic is a client-side framework that supports in building hybrid solutions with a combination of HTML, CSS3, and JavaScript at cost-free. It functions better with the Angular, PhoneGap, and Cordova plugins (Latif et al. 2016). React Native is another popular open-source, cross-platform framework by Facebook for developing native apps for iOS and Android platforms. Xamarin is introduced for developing apps for Android, iOS, and Windows using C# or Ruby coding. Microsoft made a free package offered for starters with app store delivery capabilities and the ability to run several tests for any devices. PhoneGap is an open-source platform by Adobe that allows designing apps for iPhone, Android, Windows, and BlackBerry. PhoneGap performs best for mobile applications that do not depend on the device's native features and does not require for graphics-intensive apps. Flutter is open-source Google's mobile User Interface framework to help developers to test easily and build quickly hybrid applications for mobile, web, and desktop from a single codebase under iOS and Android apps. Max Lynch, Ben Sperry develop Ionic, and Adam Bradley in 2013 as an Open Source, and front-end HTML5 Cellular Application Development Framework assembled on top of AngularJS and Cordova for building hybrid mobile applications

(Griffith 2017). It is considered as "Bootstrap for Native," with the ability to support a wide-ranging of standard native mobile components, smooth animations, and attractive design.

The Ionic key features are (1) Ionic is using AngularJS Model View Controller architecture for constructing rich applications optimized for mobile devices, (2) Ionic is using CSS styling components to offer most of the elements needed by mobile apps. (3) Ionic is using the JavaScript components to extend HTML and CSS elements with JavaScript functionalities. (4) Apache Cordova plugins offer Application Programming Interface (API) required for using native functions of the device with JavaScript code. (5) Ionic command-line interface or Command Language Interpreter (CLI), the NodeJS utility-driven with commands for imitating, constructing, running, and emulating Ionic applications. (6) Ionic View platform for uploading, sharing, and testing the app on native devices (TutorialsPoint 2019).

The main advantages of Ionic are related to (1) use for hybrid applications development which can package the mobile application for Android, IOS, Windows Phone and Firefox OS by single source code, (2) presence of pre-generated application setup layouts for easy start, (3) build applications in a very clean and modular way (4) Both Ionic and Google Developers Team support improvement of the Ionic framework by regular updates (TutorialsPoint 2019).

On the other side, the critical limitations of the Ionic framework are (1) tricky testing under web browser (2) hard to combine different native functionalities (3) slower hybrid applications compared with the native ones. In our case, The CAPM does not need either different native features or high-speed computation algorithms. Therefore, IONIC limitations are not an issue (TutorialsPoint 2019). The last product release is (Ionic CLI 4.12.0) supports Android 4.1, iOS 9, Windows 10 apps, and

BlackBerry 10 apps and up (Griffith 2017).

The typical architecture of Ionic's applications includes five primary elements, namely, (1) modules that outline a use into organized blocks of functionality by packaging components, directives, and services. (2) Components are the basic building block to construct elements and logic on the page for the user interface. (3) Templates are used to define a component view. Although a template appears like typical HTML pages, it may contain non-regular HTML components (tags) to improve HTML markup capabilities. (4) Services that provide values, functions, or features needed to access remote (backend API's) data. A service is a class that has a narrow and well-defined scope. (5) external resources, which will empower the application to externally interact with other resources.

In this study, the Ionic side menu project is developed to develop a hybrid mobile application called CAPM. The mobile app is available to run under the Android platform at the below link.

https://drive.google.com/open?id=1sQGuzdzZ0Oh_cui4t07mOmukftJ9Ku5j

8.5.3 CAPM Application

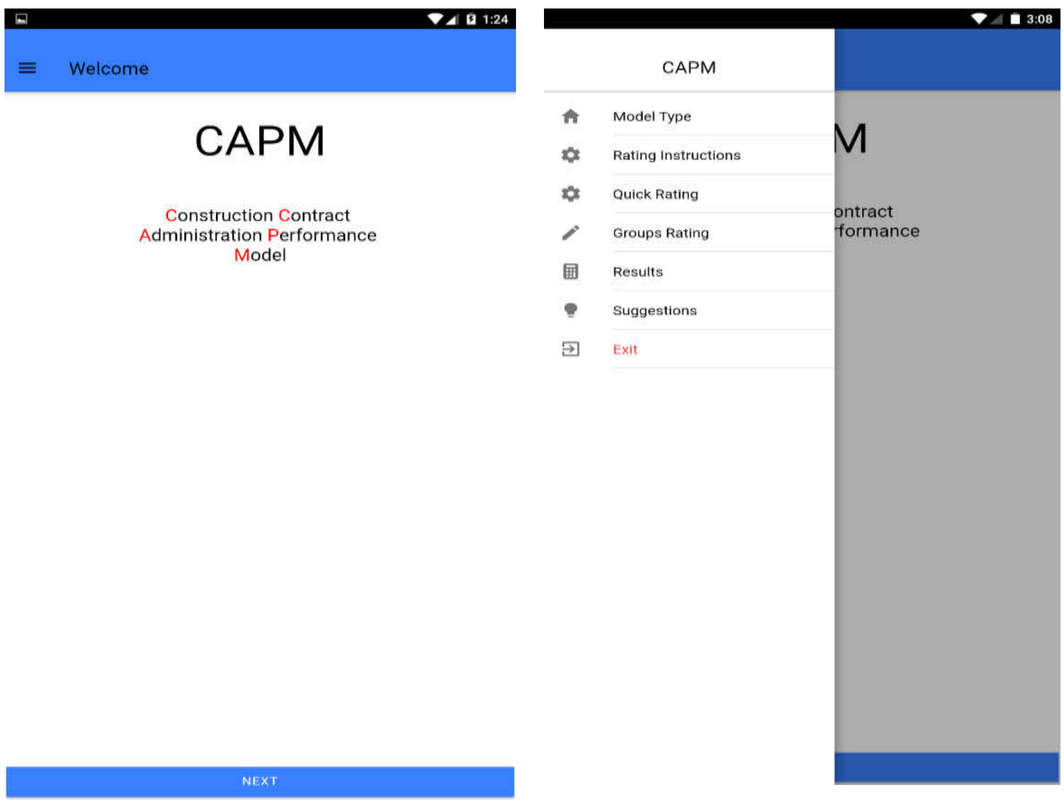
The development of (CAPM) application for web and mobile devices application was briefly explained as follows. The CAPM mobile application general flow contains three main parts, namely: (1) introduction& instruction (2) input screens, and (3) output screens, as shown in Figure 8.1 to Figure 8.5. The screenshots within those figures represent the input and output screens for project #1 by using the short model and 77 % benchmark value.

8.5.3.1 Introduction and Instructions Screens

The introduction & instruction part contains three screens. The CAPM starts with an introductory page, contains the program name "Contract Administration

Performance Model," as shown in Figure 8.1a. Also, CAPM is coded with side menu to enable quick access to the model type, rating instructions, quick rating, group rating, results at any time, or to exit the app (Figure 8.1b).

After clicking the next button, CAPM welcome screen with the title "Welcome to CAPM" opens. This page contains descriptions of the model and 2 radio buttons for selecting between short and full models, as shown in Figure 8.2a. This screen is displayed with the below explanations' paragraphs:



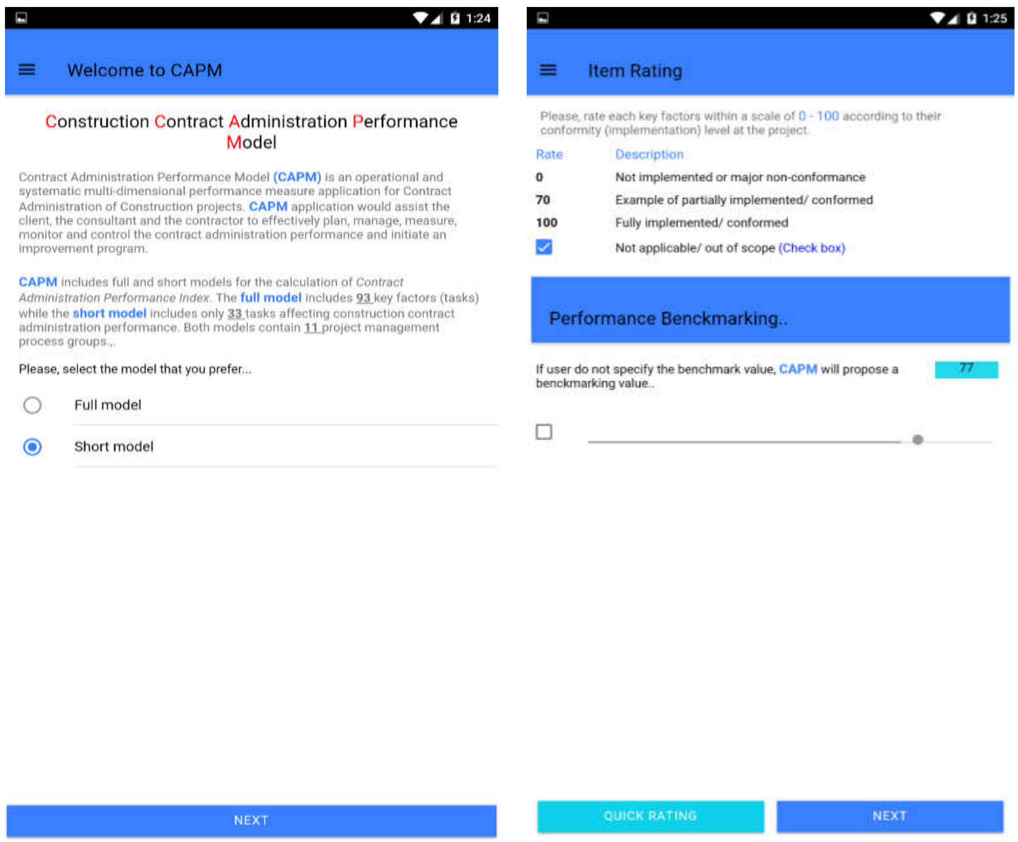
(a) (b)

Figure 8.1: CAPM user interface: (a) welcome screen; and (b) side menu

" Contract Administration Performance Model (CAPM) is an operational and systematic multi-dimensional performance measure application for Contract Administration of Construction projects. CAPM application would assist the client, the consultant, and the contractor to effectively

plan, manage, measure, monitor, and control the contract administration performance and initiate an improvement program".

CAPM includes full and short models for the calculation of the Contract Administration Performance Index. The full model includes 93 indicators (tasks), while the short model includes only 33 tasks affecting construction contract administration performance. Both models contain 11 project management processes, groups." Please, select the model that you prefer. "



(a) (b)

Figure 8.2: CAPM application user interface: (a) introduction and model type screen; and (b) item rating instructions screen

Users can select the model type (either full or short) and press the next button to go to the "Item Rating" screen. Figure 8.2b. should this screen, which contains instructions to rate items. The "Item Rating" screen displays the explanations' paragraph below:

"Please, rate each indicator within a scale of 0 - 100 according to their conformity (implementation) level at the project."

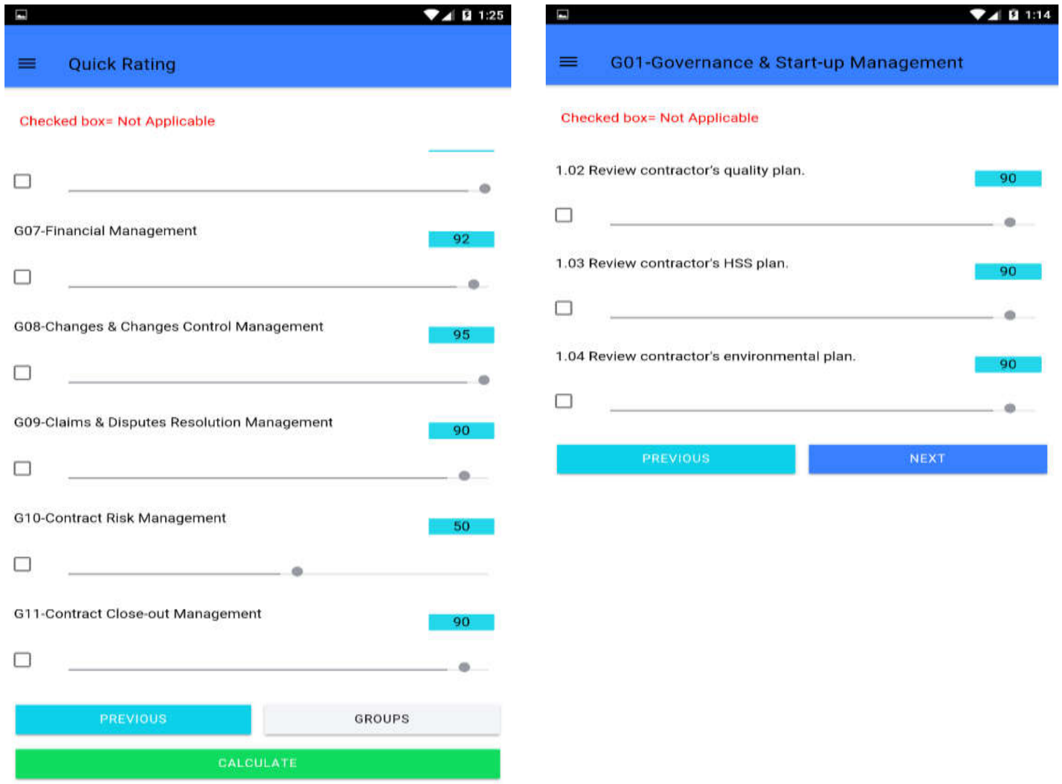
Rate	*Description*
0	*Not implemented or major non-conformance*
70	*Example of partially implemented/ conformed*
100	*Fully implemented/ conformed*
Checkbox	*Not applicable/ out of scope*

In Addition to the item rating instructions, this screen contains an optional benchmark value from 1 to 100. If the user does not specify the benchmark value, CAPM will propose CCAPI value as a benchmark. The CAPM uses the benchmark value as a reference to establish below-average performance for groups and indicators.

8.5.3.2 Input Screens

At the bottom of the "Item Rating" screen, the user has two options: 1) "QUICK RATING" to open a quick rating screen; and 2) press "NEXT "to open the first Indicators rating screen. The selection of the first option opens the "Quick Rating" screen (Figure 8.3a) to enter the average performance for each process group. This value is set as average values for all indicators within the same group. After that, the user has another two options, either to start the calculation and then present the CCA performance based on average entered values or re-rate the Key performance for each individual indicator. The selection of the second option opens the "01 Governance and start-up Management "screen and starts rating of the 93 indicators of the full model or the 33 indicators of the short model for the eleven groups (Figure 8.3b).

The "G01 Governance and start-up Management "screen is followed by another 10 input screens which ended by "G11 Contract Close-out Management". Each screen contains a "previous" button to return back to the previous screen or "NEXT" button to go to the next process group screen. The last input screen, "Contract Close-out Management," contains a "Calculate" button to present the output screens. The default value for all input screens is 50 %.

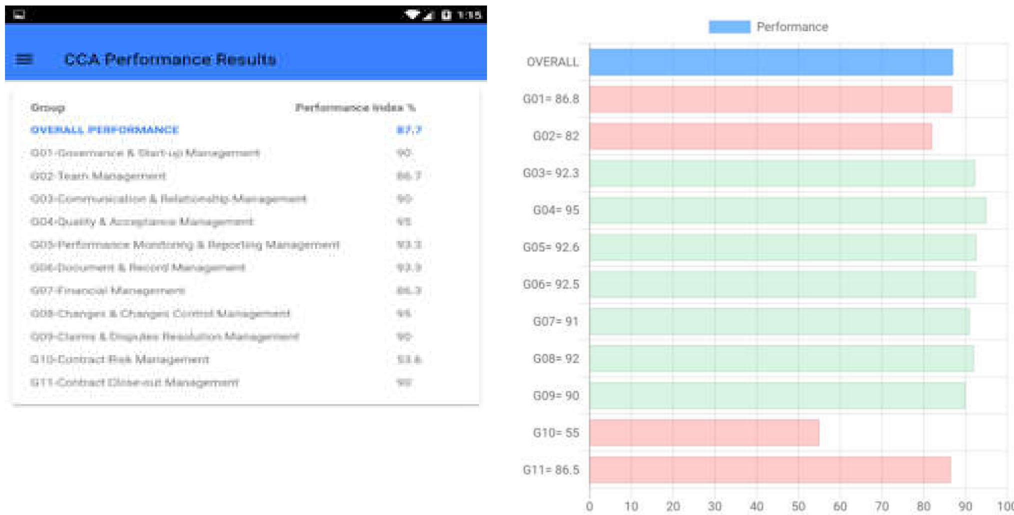


(a) (b)

Figure 8.3: CAPM application user interface: (a) quick rating screen input screens; and (b) sample process group input screen for short mode

8.5.3.3 Output Screens

When all data are entered, and the user presses the calculation button, the results tabs will be displayed on the screen as a summary table for the process group performance and CCAPI (Figure 8.4a), bar chart (Figure 8.4b), radar chart with benchmarked value(Figure 8.5a), pie chart, full list of factors and their rating, not applicable item (Figure 8.5c), and below-average list of elements as compared with the benchmarking value (Figure 8.5d). When the previous button is clicked, the program returns to the previous screen and maintain the saved values of data. There is no expiration period for the CAPM application, and it is always starting from default values (50 % indicators).



(a) (b)

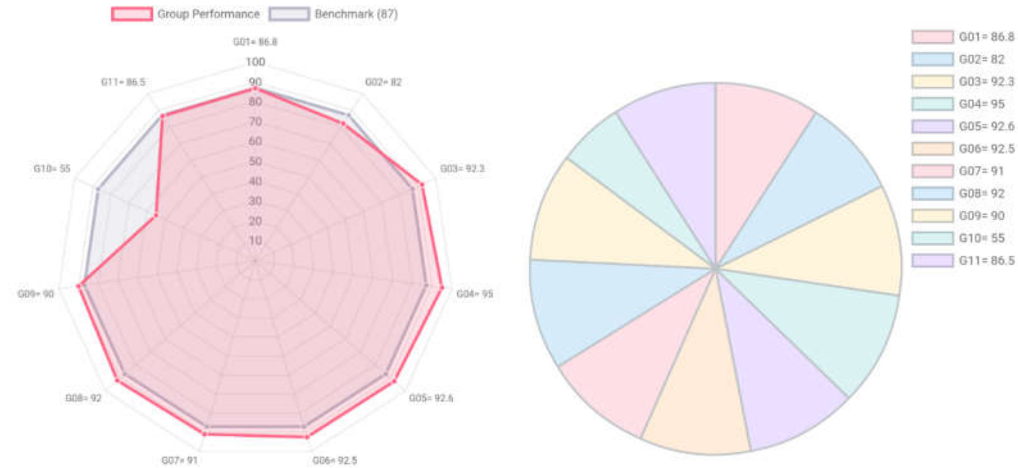
Figure 8.4: CAPM application user interface: (a) CCAPI table; and (b)bar chart

8.5.3.4 Side Menu

When the side menu is clicked, CAPM opens side Menu which contains welcome, item rating, quick rating screen, group ratings, results, and exit menus.

8.6 PRACTICAL IMPLEMENTATION OF CAPM IN PROJECTS

Depending on the way of implementation, the industry professionals can decrease the CCA issues in several ways and may gain several benefits from using the proposed model. CAPM could be used as a qualitative and quantitative tool. As a qualitative tool, the team could use the proposed model as a guideline to establish all components of the CCA management system. Secondly, the auditors of the management system would be able to use identified factors as an audit checklist for service compliance, either in longitudinal or cross auditing processes. Thirdly, the CAPM could be used as a continual improvement vehicle and an early warning sign by focusing on underperformed processes and initiating an improvement project if necessary.



(a) (b)

Not Implemented Factors	Conformity %
9.06 Support parties in alternative dispute resolution.	NA
9.07 Represent the employer in dispute resolution.	NA
9.08 Legal support employer during court cases.	NA
11.12 Proper management of suspension of work.	NA
11.13 Proper management of termination of contract.	NA

(c)

Below Average Factors	Conformity %
1.01 Establishment project management plan.	85
1.05 Review contractor's programme.	80
1.10 Support handing project to contractor.	85
1.11 Support nominated subcontractors appointment.	80
1.12 Remove violating persons from site.	50
1.15 Avoid bureaucracy & lengthy process.	80
2.01 Assignment of competent team.	85
2.02 Early assignment of team.	85
2.04 Training programs.	70
2.05 Regular performance assessment.	80
2.06 Set Performance Dialogue for Team.	80
3.01 Establish communication system .	80
3.02 Communication of PMP.	80
5.02 Report major issue.	85
5.05 Monitor contractor's relationships.	85
7.05 Timely assess for payments compensation.	70
8.03 Suggestions of workable solutions.	80
10.01 Periodically assess contractual risks.	60
10.02 Assign contractual risk responsibility.	60
10.03 Support employer for design risks.	50
10.04 Monitor the contractor's financial status & bankruptcy potential.	50

(d)

Figure 8.5: User interface: (a) radar chart; (b) pie chart; c) not applicaple; and (d) below average

CAPM may be used as a measurement tool to capture the overall performance of CCA activities for running and completed projects. The second way is to benchmark the CCA service within the same organization and/or to compare the service level among different organizations. The third way is to capture the performance level of individuals by rating the performance of indicators assigned to each staff member.

The CAPM was employed to assess the CCA performance in 13 international construction projects. The assessment forms were completed by the CCA experts (minimum 15 years of experience in contract administration) according to a scale between 0 to 100. Where the variable is not implemented, assessment is recorded as "NaN." CAPM was used to calculate the process group performance and the overall CCAPI for the 13 projects for short and full models, and the results were represented by Excel charts.

8.6.1 CAPM Rating Guidelines

In procurement, contract administration practice is undertaken to accomplish the objectives and goals expressed in the contract. The operational performance involves the record of non-financial outcomes to quantify effectively and efficiently the planned goals through specific activities or work within a given period (Joyce 2014). According to Pollaphat and Zijin (2007), the performance evaluation criteria were timeliness, quality, effectiveness, control, reliability, added value, responsiveness, and satisfaction. Likewise, Joyce (2014) argued that the operational performance of CCA services could be measured successfully by means of suitable key performance indicators linked with performance criteria such as efficiency, quality, flexibility, speed, compliance, relationship, defects rates, customer satisfaction and cycle time (Joyce 2014). For example, certification of due payments (F07.03) can be measured in terms of review time, and accuracy. The review time criteria can be used as a time indicator (payment review time indicator = (1- the average time for delayed reviews exceed stipulated time/ stipulated time) x100). Also, the time indicator can be expressed as the time limit set in a contract divided by average actual review time with the maximum value of one. The accuracy of payment can be represented as value of return of payment due to incorrect or missing information (payment return indicator =(1- value of cases of payment return / total value of payments), and the contractor's complaints can be represented with respect to the payment review process (payment complaints indicator =(1- number of contractor's complaints on payment/ total number of payments). Similarly, the indicator reviews of shop drawings (F04.04) can be measured by averaging the performance indicators related to review time, review accuracy, ability to detect defects in drawings, and flexibilities to set review priorities, and contractors complain about overdue review time. Another example is a measurement of assignment of technically competent CCA team (F02.01). It can be measured in terms of compliance of the actual staff qualification against professional service agreement requirement and the client's prior approval for staff assignment. Averaging the stated indicators for each indicator are helpful in establishing the relationship among contract administration indicators (practice) and the operational performance. A simplified rating guideline for CAPM is shown in appendix G.

8.6.2 Profile of Projects

Out of the 13 projects, 6 projects were public projects, and 7 projects were private projects. 10 projects represent building type construction (i.e., mega administration building, educational and health facilities, malls and central markets, tower, villa compounds, and apartment buildings). The remaining 3 projects represented 2 infrastructures (drainage network) projects and one industrial facility (warehouses). The construction contract values ranged between 1000 to 4 million USD. 3 projects were completely completed, 3 projects passed testing on completion, and the remaining 7 projects were under construction at the time of testing. Table 8.4: Profile of projects shows the profile of the 13 pilot projects. Further, the 13 projects are supervised by Grade "A" consultants and contractors with a certified quality management system to ensure the availability of records and process necessary to measure the CCA performance.

Table 8.4: Profile of projects 1 to 13

Project	Sector	Type	Project Value (US Million)
#1	Public	Building	490
#2	Public	Building	232
#3	Public	Building	100
#4	Public	Infrastructure	60
#5	Public	Industrial facilities	38
#6	Private	Building	14
#7	Private	Building	1000
#8	Private	Building	92
#9	Private	Building	75
#10	Private	Building	32
#11	Private	Building	28
#12	Private	Building	15
#13	Private	Infrastructure	4

In the bulk of the Middle East projects, including Qatar, the FIDIC Red Book remains the contract of preference (Glover 2007; Sadek 2016). Internationally, the red book is the most commonly adopted form (Hillig et al. 2010; Shnookal and Charrett 2010). The literature demonstrates that there is not much difference between the general conditions of contracts in Qatar and the FIDIC Red book. Therefore, the implementation of the research output through the Qatari projects validates the model for other international projects as well.

Based on the detailed calculation illustrated in the previous sections, the Construction Contract Administration Performance Index (CCAPI) for 13 projects are presented in Table 8.5.

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Table 8.5: Full model calculated CCAPI- projects 1 to 13

Group	Project												
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
G01	86.8	93.9	68.0	90.1	86.4	82.3	94.3	84.5	79.6	73.2	76.9	51.4	92.1
G02	82.0	67.3	73.8	91.3	89.9	84.2	70.4	84.2	43.9	74.2	76.3	63.4	86.9
G03	92.3	62.3	85.3	79.9	75.5	97.5	91.0	97.7	71.2	61.2	56.9	71.1	73.4
G04	95.0	67.2	82.7	78.5	75.5	76.4	88.4	88.1	59.1	61.2	45.5	65.5	82.7
G05	92.6	58.5	80.2	100.0	100.0	86.2	79.2	91.1	64.4	70.9	39.6	63.4	61.0
G06	92.5	69.9	81.3	94.0	100.0	72.1	100.0	96.1	61.3	86.1	52.6	82.5	63.0
G07	91.0	61.1	78.9	100.0	85.8	97.4	100.0	95.6	54.2	87.3	65.3	63.0	100.0
G08	92.0	64.9	78.1	100.0	100.0	100.0	93.9	100.0	85.3	79.7	66.6	81.0	100.0
G09	90.0	70.2	86.1		87.6	86.5	87.9	100.0	80.5	87.5	75.0	74.5	100.0
G10	55.0	58.3	65.0	100.0	72.0	0.0	63.6	0.0	38.9	57.2	38.9	57.6	
G11	86.5		67.8		85.1	91.3	83.0	43.4		71.3	61.6	64.3	90.4
CCAPI	87.0	67.4	77.1	92.5	87.1	79.7	86.6	80.6	64.0	73.6	59.6	67.1	84.7

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8.6.2.1 Project # 1

The CCAPI for project #1 is calculated as 87.0 %. The results obtained by calculating the performance level of each process group are quite revealing that the best performance is related to G04-Quality & Acceptance (GPI= 95 %) while the worst implemented process group is G10-Contract Risk Management (GPI = 55% %). Except for the risk management, no significant differences are observed between groups.

8.6.2.2 Project # 2

For project #2, CCAPI is calculated as 67.4 %. The best performance is related to G01-Project governance and start-up (GPI= 93.9 %), while the worst performance is related to G10-Contract Risk Management (GPI= 58.3 %). Except for the first group, no significant differences between the different groups are identified.

8.6.2.3 Project # 3

For project #3, CCAPI is calculated as 77.0 % and the best performances are related to G09-Claims & Disputes Resolution and G03-Communication & Relationship with GPIs of 86.1 % and 85.3 %, respectively. On the contrary, the worst groups are G10-Contract Risk Management and G01-Project Governance & Start-up with GPIs of 65.0 %, and 67 %, respectively. Minor differences between groups are observed.

8.6.2.4 Project # 4

For project #4, CCAPI is calculated as 92.5 %. The best groups are G05-Monitoring & Reporting, G07-Financial Management, G08-Changes & Changes Control, and G10-Contract Risk Management with ultimate GPIs of 100 %. The lowest group is G04-Quality & Acceptance (GPI=78.5%).

8.6.2.5 Project # 5

For project #5, CCAPI is calculated as 87.1 and the best groups are G05-Monitoring & Reporting, G06-Document & Record, and G08-Changes & Changes Control with ultimate GPIs of 100 %. The lowest groups are G03-Communication & Relationship, G04-Quality & Acceptance, and G10-Contract Risk Management with GPIs of range 75.5 to 72.0 %.

8.6.2.6 Project # 6

The CCAPI for project #6 is calculated as 79.7 %. The best group is G08-Changes & Changes Control (GPI=100 %). The lowest implemented process groups are G10-Contract Risk management and G06-Document & Record with GPIs of zero, and 72.1 %, respectively.

8.6.2.7 Project # 7

For project #7, CCAPI is calculated as 86.6 %, and the best groups are G06-Document & Record, and G07-Financial Management, with 100 % GPIs while the lowest implemented process group is G02-CA Team Management, with GPI of 70.4 %.

8.6.2.8 Project # 8

For project #8, CCAPI is calculated as 80.6 %, and the best groups are G08-Changes & Changes Control, and G09-Claims & Disputes Resolution with 100 % ultimate performance. The lowest implemented process group is G10-Contract Risk Management with GPI of zero and then G11-Contract Close-Out, with only 43.4 %

performance level.

8.6.2.9 Project # 9

For project #9, CCAPI is calculated as 64.0 %. The best groups are G08-Changes & Changes Control and G09-Claims & Disputes Resolution with 85.3 % GPIs. The lowest implemented group is G10-Contract Risk Management with only GPIs of 38.9 % performance.

8.6.2.10 Project # 10

For project #10, CCAPI is calculated as 73.6 %, and the best group is G09-Claims & Disputes Resolution with GPI of 87.5 % and then is followed by G07-Financial Management with GPIs of 87.3 %.

8.6.2.11 Project # 11

For project #11, CCAPI is calculated as 59.6 %. The best-implemented groups are G01-Project Governance & Start-up, G02-CA Team Management, and G09-Claims & Disputes Resolution (GPIs = 6.9 to 75 %). The lowest group is G10-Contract Risk Management, with only 38.9 % GPI.

8.6.2.12 Project # 12

The CCAPI for project #12 is calculated as 67.1 %. The best- group is G06-Document & Record with (GPI=82.5 %) and then is followed by the G08-Changes & Changes Control (GPI =81.0 %). The lowest group is G10-Contract Risk Management, with only 57.6 % performance level.

8.6.2.13 Project # 13

Finally, the CCAPI for project #13 is calculated as 84.7 %. The best groups are G07-Financial Management, G08-Changes & Changes Control, and G09-Claims & Disputes Resolution with an ultimate GPI of 100 %. The lowest groups are G05-Monitoring & Reporting and G06-Document & Record (GPIs= 61.1 % and 63.0 %, respectively). Contract risk management is not part of the CCA organization scope and managed by the Employer.

8.7 PERFORMANCE BENCHMARKING ACCORDING TO CCAPI

8.7.1 Full model

The results of full model performance indices for the 11 process groups of the 13 projects and average performance indices are shown in Table 8.6. The result shows the highest calculated CCA performance index as 92.5 % for project #4, while the lowest calculated CCA performance index is calculated as 59.6 % for project #11. The overall CCAPI for projects #1, 4 to 8, and 13 exceeded the benchmarking value. The CCAPI of projects # 3 and 10 slightly dropped below the benchmarked value while CCAPI of projects #2, 9, 11, and 12 were significantly away from the benchmarking value. Therefore, the management of the last-mentioned 4 projects should focus on improving the overall performance of their process groups to enhance their performance indices. Also, the significant differences between the CCA performance necessitated the need to identify the performance of the project team across the different groups. it worth not note that 4 process groups, namely: project governance & start-up (G01), communication & relationship (G03), document & record (G06), and financial management (G07) demonstrate a performance index was slightly above the benchmarking value. Changes & changes control (G08) represented the highest process group performance (average value 87.8%) and followed by G09, claims & disputes resolution with an average value of 85.5%. On the negative side, 4 process groups (contract administration team management (G02), quality & acceptance (G04), performance monitoring & reporting (G05), and contract close-out management (G11) were slightly below the benchmarking value but within a difference of 5%. Contract risk management (G10) represented the lowest process group performance (average value 50.5 %) among the other process groups, and therefore, it could be argued that there would be an urgent need to re-structure this process and initiate an urgent continual improvement program for risk management. Also, the low performance of risk management was concluded by (Surajbali 2016).

Table 8.6: Full model benchmarking values-projects 1 to 13

Group	Project													
	#1	**#2**	**#3**	**#4**	**#5**	**#6**	**#7**	**#8**	**#9**	**#10**	**#11**	**#12**	**#13**	**Avg.**
G01	86.8	93.9	68.0	90.1	86.4	82.3	94.3	84.5	79.6	73.2	76.9	51.4	92.1	81.5
G02	82.0	67.3	73.8	91.3	89.9	84.2	70.4	84.2	43.9	74.2	76.3	63.4	86.9	76.0
G03	92.3	62.3	85.3	79.9	75.5	97.5	91.0	97.7	71.2	61.2	56.9	71.1	73.4	78.1
G04	95.0	67.2	82.7	78.5	75.5	76.4	88.4	88.1	59.1	61.2	45.5	65.5	82.7	74.3
G05	92.6	58.5	80.2	100.0	100.0	86.2	79.2	91.1	64.4	70.9	39.6	63.4	61.0	75.9
G06	92.5	69.9	81.3	94.0	100.0	72.1	100.0	96.1	61.3	86.1	52.6	82.5	63.0	80.9
G07	91.0	61.1	78.9	100.0	85.8	97.4	100.0	95.6	54.2	87.3	65.3	63.0	100.0	83.1
G08	92.0	64.9	78.1	100.0	100.0	100.0	93.9	100.0	85.3	79.7	66.6	81.0	100.0	87.8
G09	90.0	70.2	86.1		87.6	86.5	87.9	100.0	80.5	87.5	75.0	74.5	100.0	85.5
G10	55.0	58.3	65.0	100.0	72.0	0.0	63.6	0.0	38.9	57.2	38.9	57.6		50.5
G11	86.5		67.8		85.1	91.3	83.0	43.4		71.3	61.6	64.3	90.4	74.5
CCAPI	87.0	67.4	77.1	92.5	87.1	79.7	86.6	80.6	64.0	73.6	59.6	67.1	84.7	77.5
	CCAPI Public= 82.4							CCAPI Private = 74.5						

The overall CCAPI of the 13 projects are demonstrated in Figure 8.6. As previously demonstrated, the CCAPI of project #11 (59.6%) represents the lowest calculated index among the other projects and thus suggests further analysis of indicators and the associated process groups of this project. Figure 8.7 shows the different performance levels of the process groups of projects #11. In ascending order, the contract risk management (G10), performance monitoring & reporting (G05), quality & acceptance (G04), document & record (G06), and communication & relationship (G03) have very low-performance levels. Thus, the overall low performance of project #11 is affected by those processes' performance. In the first instance, any improvement efforts should direct to those process groups and then will direct to the other groups

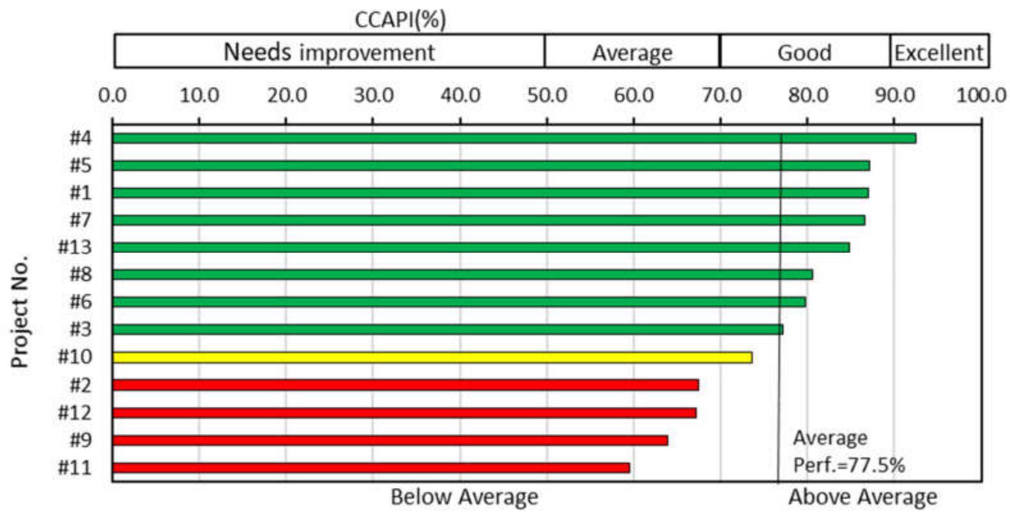

Figure 8.6: Calculated CCAPI for projects # 1 to 13

Figure 8.7: Calculated performance indices for project #11

8.8 DEGREE OF IMPLEMENTATION OF INDICATORS

Table 8.7 highlights the highly implemented indicators with a degree of implementation greater than 90 % in descending order according to their degree of implementation. The highest implemented variable among all other variables was "F03.11-Strict compliance with the language of communication as stipulated in the contract" with a 95% degree of implantation. The next highly implemented variables were “F01.08-Conducting project kick-off meeting to discuss contract with related parties”, “F03.05-Agreement between Employer and CCA team for any requested changes on scope, time or cost”, “F11.05-Timely issuance of taking-over certificate(s) with associated snags” and “F11.11-Proper processing Contractor's final account in accordance with the contract provision” with 94% degree of implantation.

Table 8.7: The highly implemented indicators- projects 1 to 13

Code	Indicator	Rank	Implementation		
			Min	Max	Mean
F03.11	Strict compliance with the language of communication as stipulated in the contract.	58	70	100	95
F01.08	Conducting a project kick-off meeting to discuss the contract with related parties.	85	70	100	94
F03.05	Agreement between Employer and CCA team for any requested changes on scope, time, or cost.	61	70	100	94
F11.05	Timely issuance of taking-over certificate(s) with associated snags.	79	80	100	94
F11.11	Proper processing Contractor's final account in accordance with the contract provision.	70	85	100	94
F01.05	Reviewing the Contractor's baseline programme.	91	75	100	93
F01.09	Supporting the Employer in reviewing contract securities (bonds and insurances).	79	70	100	93
F01.10	Supporting the Employer in handing over the project to the Contractor.	78	50	100	93
F07.03	Fair, reasonable, and equitable certification of due payments to the Contractor.	21	50	100	93
F09.07	Representing the Employer in alternative dispute resolution proceedings.	32	80	100	93
F01.02	Reviewing the Contractor’s project quality plan (PQP).	66	50	100	92
F01.06	Reviewing the Contractor’s proposed key staff.	87	70	100	92
F07.07	Collecting quotations for price estimates and Contractor’s price negotiations in respect of additional works / variations.	29	75	100	92
F08.02	Prompt evaluation of Contractor’s proposals for changes inclusive value engineering.	10	50	100	92
F01.07	Reviewing the proposed subcontractor(s) qualifications.	82	75	100	91
F01.03	Reviewing the Contractor's health, safety, and security plan.	66	30	100	90
F01.14	Reviewing Contractor’s proposed laboratory.	89	40	100	90
F02.05	Regular assessment of CCA team performance taking due note of any Employer or Contractor feedback/comments.	17	75	100	90
F08.05	Proper processing of the change orders on approved change requests.	8	50	100	90

Another key thing to mention was the indicators “F11.12-Proper management of suspension of the work process in compliance with the contract administrative procedures” and “F11.13-Proper management of termination of contract process in compliance with the contract administrative procedures” were fully implemented in one project only and therefore are excluded from the list. Table 8.8 points the 15 lowest implemented indicators with a degree of implementation less than 60 % in ascending order according to their degree of implementation. The lowest implemented variable among all other variables was “F11.10-Documenting lessons learned and best practices” with a 34 % degree of implantation. This variable was followed by “F10.04-Monitoring the Contractor’s financial status and bankruptcy potential”, “F05.05-Monitoring of Contractor’s relationship with Subcontractors”, “F11.07-Timely approving return of deployment of the Contractor’s resources upon Contractor’s request”, and “F04.01-Systematic auditing of the Contractor's implementation of quality management system’ with 35, 37, 45, and 46 % degrees of implementation respectively. One of the main observations was that all variables (4 variables) of the G10- contract risk management construct were listed as “Not-At-All Implemented” in some projects. Consequently, the low implementation of those variables supported the low performance of the contract risk management within the studied projects. Not to say that the low performance of those 13 variables may be referred to as not implementing those factors in several projects and/ or to the low degree of implementation. As those factors were affecting the overall performance of the construction contract administrations, the management of the project would draw some attention to increase the level of performance of these variables throughout an improvement program, structured procedures, training, and awareness.

Table 8.8: The lowest implemented indicators- projects 1 to 13

Code	Indicator	Rank	Implementation		
			Min	Max	Mean
F11.10	Documenting lessons learned and best practices.	85	0	80	34
F10.04	Monitoring the Contractor’s financial status and bankruptcy potential.	7	0	100	35
F05.05	Monitoring of Contractor’s relationship with Subcontractors.	61	0	100	37
F11.07	Timely approving return of deployment of the Contractor’s resources upon the Contractor’s request.	87	0	100	45
F04.01	Systematic auditing of the Contractor's implementation of a quality management system.	46	0	95	46
F01.04	Reviewing the Contractor's environmental management plan.	74	0	100	47
F02.04	Establishing training, and development programs for CCA team.	18	0	100	47
F03.04	Measuring the Employer’s satisfaction during the contract lifespan.	63	0	100	47
F10.03	Supporting the Employer for the risks associated with design review findings.	2	0	100	48
F09.08	Legal support to the Employer during court cases.	33	0	100	50
F04.06	Systematic auditing of the Contractor's compliance with environmental requirements.	38	0	100	54
F03.02	Communicating the PMP requirements to all involved parties.	64	0	100	56
F05.09	Monitoring of Contractor’s arrangements to minimize public interference.	43	0	100	56
F10.01	Periodically assessing the contractual risks with the help of the Contractor.	8	0	100	58
F10.02	Assignment of responsibility to the relevant party for each contractual risk expressed as a Responsibility Matrix.	1	0	100	58

Figure 8.8 shows the frequency of not at all implemented variables through the studied projects. Table 8.9 lists the frequency of the 15 top not-implemented variables in the studied projects. This an indication that such variables are either not implemented due to the exclusion of those services from the project scope or the project did not reach the stage of implanting those variables. The researcher made no effort to investigate the reason.

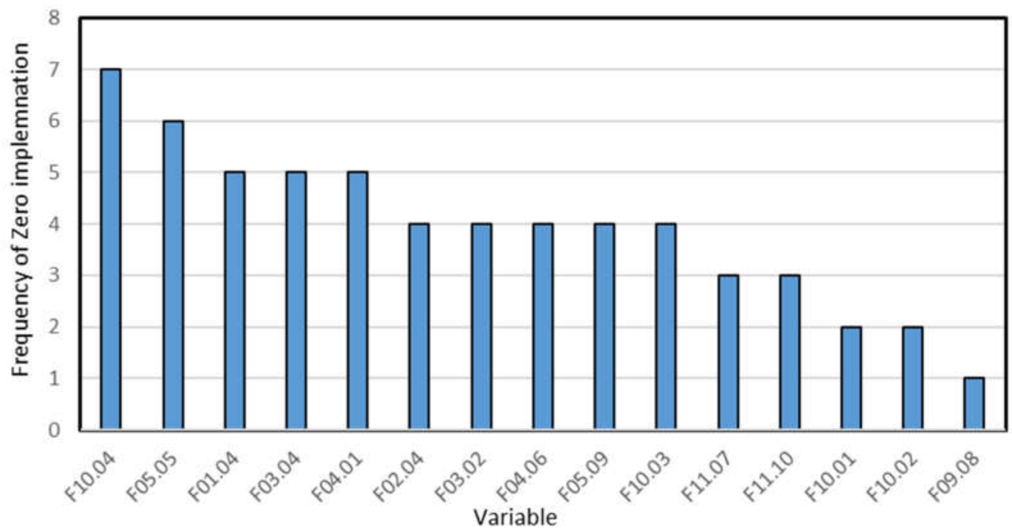

Figure 8.8: Frequency of “ Not-At-All Implemented” indicators- projects 1 to 13

Table 8.9: Frequency of “Not-applicable” indicators- Projects 1 to 13

Code	Indicator	Frequency
F09.08	Legal support to the Employer during court cases.	11
F09.07	Representing the Employer in alternative dispute resolution proceedings.	10
F09.06	Supporting the contracting parties to select alternative dispute resolution methods if not already set out in the contract.	8
F01.11	Supporting the Employer in appointing nominated subcontractor(s).	7
F11.07	Timely approving return of deployment of the Contractor’s resources upon the Contractor’s request.	7
F11.08	Periodic inspections of the works during the defect’s notification period.	7
F11.09	Proper issuance of performance certificate when the Contractor’s maintenance obligations are fulfilled in accordance with timelines as set out in the contract.	7
F11.10	Documenting lessons learned and best practices.	7
F11.11	Proper processing Contractor's final account in accordance with the contract provision.	7
F07.02	Proper issuance of instructions to spend provisional sum items.	6
F11.05	Timely issuance of taking-over certificate(s) with associated snags.	6
F11.06	Proper release of the due retention monies upon releasing relevant certificates.	6
F04.10	Managing design and design development during construction.	5

8.9 SHORT MODEL IMPLEMENTATION

8.9.1 The Short Model

Table 8.10 shows the short model performance indices for the 11 process groups for 13 projects and average performance indices as well. The result showed that the highest calculated CCA performance index was 92.4 % for project #4, while the lowest calculated CCA performance index was calculated as 61.6% for project #11.

Table 8.10: Calculation of short model CCAPI for each process group

Group	Project													
	#1	**#2**	**#3**	**#4**	**#5**	**#6**	**#7**	**#8**	**#9**	**#10**	**#11**	**#12**	**#13**	**Avg**
G01	90.0	84.1	80.0	84.1	73.4	68.3	100.0	68.3	83.5	68.3	68.3	35.9	68.2	74.8
G02	86.7	75.0	76.6	90.0	89.9	100.0	80.0	100.0	50.0	76.6	83.4	63.4	100.0	82.4
G03	90.0	75.0	81.6	83.6	96.7	96.7	91.7	96.7	75.0	73.3	66.5	76.8	66.8	82.3
G04	95.0	66.4	78.3	75.0	70.0	66.7	96.7	100.0	50.1	34.8	43.3	50.0	58.5	68.1
G05	93.3	66.6	80.1	100.0	100.0	100.0	91.6	100.0	71.7	63.3	50.0	70.0	100.0	83.6
G06	93.3	69.9	80.1	100.0	100.0	94.8	100.0	94.8	64.8	84.9	53.4	83.3	82.8	84.8
G07	86.3	58.5	75.0	100.0	100.0	100.0	100.0	100.0	58.5	90.0	66.1	61.5	100.0	84.3
G08	95.0	66.8	81.6	100.0	100.0	100.0	93.4	100.0	90.1	73.3	73.3	81.7	100.0	88.9
G09	90.0	75.0	86.7		100.0	75.0	83.3	100.0	83.7	86.7	75.0	85.0	100.0	86.7
G10	53.6	53.7	65.0	100.0	64.3	0.0	59.1	0.0	35.8	56.4	35.8	51.4		47.9
G11	90.0		70.0		98.3	92.5	80.0	44.8		83.3	62.4	79.9	100.0	80.1
CCAPI	87.7	69.2	77.8	92.4	90.3	81.6	88.9	82.8	66.5	71.8	61.6	67.2	87.4	78.9

8.9.2 Compare Full and Short Model Results

The percentage of error (deviation) of the results was calculated as the difference between CCAPI of the short and full model, respectively divided by the full model CCAPI (Gunduz et al. 2018), as shown in equation 8.12.

$$\%\,Dev = \frac{CCAPI_S - CCAPI_F}{CCAPI_F}\,x\,100 \qquad (8.12)$$

Where:

$CCAPI_S$ = Construction Contract Administration Performance Index for the short model

$CCAPI_F$ = Construction Contract Administration Performance Index for the full model

For example, % CCAPI Error for project #1 by short model = (87.7% - 87.0%) / 87.0 %) =0.8 %. As shown in

Table 8.11, the average error value was calculated as 1.8 % while the maximum error value was 3.90 % for project #9.

Table 8.11: Comparison between full the short models for projects 1 to 13

Project	Full Model Result % (1)	Short Model Result % (2)	Deviation % % Error= [(2)-(1)]/ (1)
#1	87.0	87.7	0.8%
#2	67.4	69.2	2.7%
#3	77.1	77.8	0.9%
#4	92.5	92.4	-0.1%
#5	87.1	90.3	3.6%
#6	79.7	81.6	2.3%
#7	86.6	88.9	2.6%
#8	80.6	82.8	2.7%
#9	64.0	66.5	3.9%
#10	73.6	71.8	-2.4%
#11	59.6	61.6	3.5%
#12	67.1	67.2	0.1%
#13	84.7	87.4	3.1%
Average	77.5	78.9	1.8%

This indicates that within the studied projects, the short model can capture the overall CCA performance with reasonable accuracy. Thus, it would recommend using the short model to capture the overall CCA performance where the performance of the indicator within each process group is almost consistent across the group. In case of great differences between the indicators within the same group, the full model would be more appropriate to capture the CCAPI.

8.10 CHAPTER SUMMARY

Chapter 8 described the formulation of a Construction Contract Administration Performance Index (CCAPI), the CAPM mobile application, and practical implementation of the proposed Model. The method of calculating the relative weights of indicators, first-order constructs, and the formulation of the CCAPI were described in the first section of this chapter with a complete solved example for both full and short models. Background of the mobile application in terms of different solutions types and the common cross-platform software development kits (SDK) and the cross-platform selected for this study (IONIC platform overview) were briefly described. The user interfaces for the CAPM mobile application, including introduction and instructions screens, input screens. output screens and side menu were presented by the middle of this chapter along with screenshots. In order to demonstrate the proposed model capability to capture construction contract administration performance, the model implementation in 13 running and completed construction projects was demonstrated, and the benchmark value CCAPI was established. The results reveal that CAPM could capture the different performance levels of CCA in construction projects. In terms of actual operational performance, this chapter highlighted and itemized the operational performance greater than 90 %, and the frequently not applicable (NaN) variables. Also, the capability of the proposed short model to capture CCAPIs for the 13 projects and the percentage of short model error (expressed as the difference between CCAPI of the short and full model respectively divided by the full model) were examined by the end of this chapter. The results of implementing the short model 13 construction projects revealed that the maximum absolute deviation was 3.9 %, while the average absolute deviation was only 1.8 %. This concluded that the short model could capture the overall CCA performance with reasonable accuracy for consistent operations.

As demonstrated, CAPM helps to ensure that the administration of the contract delivers the planned project outcomes and the procurement objectives. The different ways of using CAPF will provide a reliable tool that will help increase operational efficiency and effectiveness, minimize contractual problems, improve project control and trace staff performance at the successive stages of post awarding phase through improved compliance, awareness, visibility, monitoring and control over the contract administration activities. Therefore, the attention of the management on these factors would reduce problems in CCA and decrease disputes that may be generated from the improper performance of those factors.

CHAPTER 9 : DISCUSSION OF RESULTS

9.1 INTRODUCTION

This chapter aimed to discuss the research findings for the indicators affecting construction contract administration (indicator) and its associated process groups (constructs) and then correlate the findings of this study to previous works for evaluating the Construction Contract Administration Performance, if available.

9.2 DISCUSSION OF RESULTS

9.2.1 Components of The Performance Index (CCAPI)

The main finding of this study was that the construction contract administration could be represented by a single index "Construction Contract Administration Performance Index (CCAPI). CCAPI contains 11 constructs representing the project management process groups, as listed in Table 9.1.

The relative weight of the G03-Communication & Relationship was 0.0945 and, therefore, ranked as the first construct affecting the construction contract administration performance followed by G05-Performance Monitoring & Reporting with a relative weight of 0.0931 as the second construct. The two constructs G04-Quality & Acceptance and G06-Document & Record were ranked as the third construct affecting CCA performance with a relative weight of 0.0926. The fourth to elevenths constructs were G01-Project Governance & Start-up, G02-CA Team Management, G09-Claims & Disputes Resolution, G08-Changes & Changes Control, G07-Financial Management, G10-Contract Risk Management, and G11-Contract Close-Out Management with relative weights 0.0915, 0.0911, 0.0907, 0.0905, 0.0896, 0.087, and 0.0867 respectively.

Table 9.1: Relative weights and deviations of constructs from the average value

Code	Construct	Relative weight	% Division	Rank
G03	Communication & Relationship	0.0945	4.0%	1
G05	Performance Monitoring & Reporting	0.0931	2.4%	2
G04	Quality & Acceptance	0.0926	1.9%	3
G06	Document & Record	0.0926	1.9%	3
G01	Project Governance & Start-up	0.0915	0.7%	5
G02	CA Team Management	0.0911	0.2%	6
G09	Claims & Disputes Resolution	0.0907	-0.2%	7
G08	Changes & Changes Control	0.0905	-0.4%	8
G07	Financial Management	0.0896	-1.4%	9
G10	Contract Risk Management	0.0870	-4.3%	10
G11	Contract Close-Out Management	0.0867	-4.6%	11

% Division=100x (Relative Weight- Average Weight) / Average Weight

It worth noting that the absolute maximum division of the relative weight of constructs from the mean weight (considering equal weight for all factor) was 4.6%, as shown in Figure 9.1. Thus, all factors are important and contributing to construction contract administration performance.

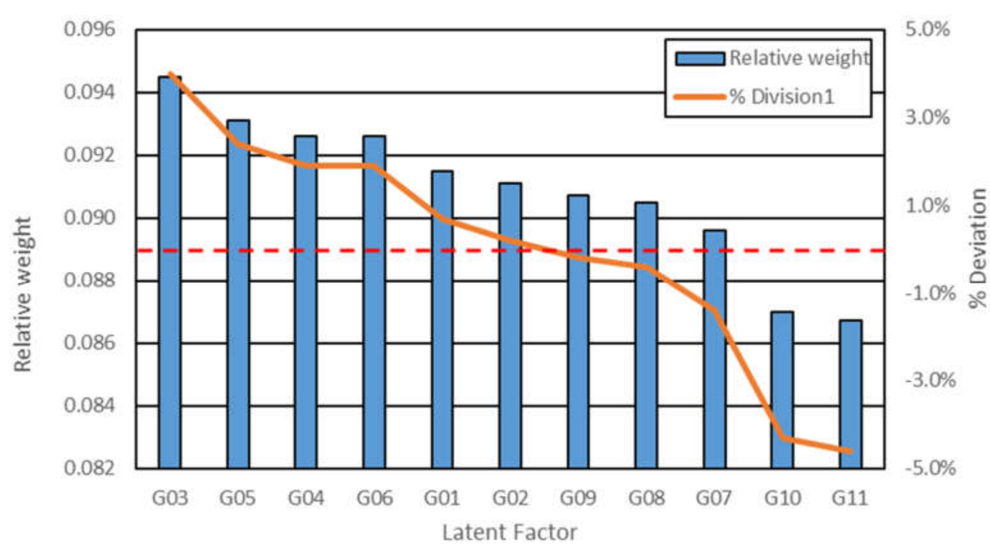

Figure 9.1: Constructs relative weights and deviations from the average value

9.2.2 Ranking of the Constructs and Indicators

Each construct involved a set of indicators. The summation of the product of each relative weight of the construct by the variable relative weight would indicate the relative contribution of each variable. The relative contribution of the indicator to CCAPI was calculated according to the formula presented in Chapter 8. Hereinafter is a sample calculation assuming all indicators are applicable:

$$FW1i = RFW1i * \ RGW1j \tag{9.1}$$

Where:

$FW1i$	=	Factor Weighted contribution of the indicator i to the CCAPI without considering its conformance on site
$RFW1i$	=	The relative weight of the indicator i within a construct J (refer to factor analysis results of Chapter 8, Equation 8.1
$RGW1j$	=	Relative Weight of construct j in contribution to CCAPI performance, considering its applicability (Chapter 8, Equation 8.5)

Based on the research questionnaire, the Factor Weight (FW) results would reveal the relative impact of CCA indicators and constructs on the contract administration performance. It is essential to mention that the FW represents the weight in which each factor and group shall contribute to the overall CCA performance. Despite the importance order of the indicators and constructs, all the factors identified within the study significantly contribute to the overall performance of the contract administration process. Negligence of any item may cause misconduct of an obligatory work, and therefore, no single item can be ignored or excluded.

9.2.3 Discussion of Indicators within Constructs

9.2.3.1 G01-Project Governance and Start-Up

G01-Project Governance & Start-up was ranked as 5th construct with a relative weight value of 0.0915. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.2 in descending orders. At this group levels, the most important indicators were 'F01.02-Reviewing the Contractor’s project quality plan (PQP) ' and 'F01.03-Reviewing the Contractor's health, safety, and security plan’ with the highest relative effect value of 0.0073 among the other factors and overall ranking of 66. The observed factor 'F01.04-Reviewing the Contractor's environmental management plan' was ranked as the third important indicator with a relative effect value of 0.0068 and an overall ranking value of 74.

Project governance guides the management activities to the strategic and operational goals. It establishes an overall view of how the project should be executed in light of the relationship among the stakeholders (PMI 2016). The factors established for the governance and start-up process group give the capability of the contract administrator to apply the administrative procedures and principles set out in the contract (Cunningham 2016) to have control over the project. The significant importance of the governance and start-up process group is related to three main objectives: (1) setting out the strategic project issues in the early stages; (2) taking the first steps for managing the project; and (3) taking corrective and preventive measures. The strategic issues include the establishment of a project management plan, review of contractors’ systems and plans (project quality plan, health, safety, and security plan, environmental management plan, baseline program, key staff, subcontractor’s qualifications, logistic plans and approve laboratory). The first steps of starting the post-awarding phase of the project include receiving the contractor’s bonds and insurances, organizing a kick-off meeting, distributing contract documents, and enabling the contractor’s possession of the site, as well as the appointment of nominated sub-contractors. The corrective and preventive actions include setting out ground rules to remove violating persons and provide a flexible system to avoid the lengthy process. It is worth stating that, without proper governance and start-up, the project will lack the establishment of the system and overall planning, which will have a direct effect on all other contract administration groups.

Table 9.2: Relative effects and ranking of the indicators of "G01-Project Governance & Start-up" construct on CCAPI

Code	**Indicator**	**RFW1i**	**FW1i**	**Group Rank**	**Overall Rank**
F01.02	Reviewing the Contractor's project quality plan (PQP)	0.0799	0.0073	1	66
F01.03	Reviewing the Contractor's health, safety, and security plan	0.0797	0.0073	1	66
F01.04	Reviewing the Contractor's environmental management plan	0.0742	0.0068	3	74
F01.10	Supporting the Employer in handing over the project to the Contractor	0.0714	0.0065	4	78
F01.09	Supporting the Employer in reviewing contract securities (bonds and insurances)	0.0676	0.0062	5	79
F01.11	Supporting the Employer in appointing nominated subcontractor(s)	0.0674	0.0062	5	79
F01.07	Reviewing the proposed subcontractor(s) qualifications	0.0666	0.0061	7	82
F01.15	Avoiding bureaucracy and lengthy process	0.0651	0.0060	8	84
F01.08	Conducting a project kick-off meeting to discuss the contract with related parties	0.0640	0.0059	9	85
F01.06	Reviewing the Contractor's proposed key staff	0.0638	0.0058	10	87
F01.14	Reviewing Contractor's proposed laboratory	0.0625	0.0057	11	89
F01.13	Reviewing the Contractor's logistics plan	0.0616	0.0056	12	90
F01.01	Establishing an overall project management plan (PMP)	0.0603	0.0055	13	91
F01.05	Reviewing the Contractor's baseline program	0.0604	0.0055	13	91
F01.12	Removal of any personnel intentionally violating the project requirements	0.0557	0.0051	15	93

RFW1i = Relative Weight, and FW1i= Relative effect

9.2.3.2 G02-CA Team Management

The rank of G02-CCA Team Management was the 6th construct with a relative weight value of 0.0911. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.3in ascending orders.

At this group level, the most important indicator was 'F02.03-Clear identification of individual roles and responsibilities within the CCA team ' with the highest relative effect value of 0.0166 among the other factors and overall ranking of 14. The second important indicator was 'F02.01-Assignment of technically competent, qualified, and experienced CCA team ' with relative effect value of 0.0162 and overall ranking value of 16 whereas 'F02.05-Regular assessment of CCA team performance taking due note of any Employer or Contractor feedback/comments' was ranked as the third important indicator with relative effect value of 0.0152 and overall ranking value of 17. The literature revealed problems in CCA function due to, shortage of CCA team, team late assignment, competency and qualification (Abusafiya and Suliman 2017; Alzara et al. 2016; Callahan 2010; Kerzner 2013; Memon and Rahman 2013; Pooworakulchai et al. 2017; Ssegawa-Kaggwa 2008; Yap 2013).

Table 9.3: Relative effects and ranking of the indicators of “G02-CA Team Management” construct on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F02.02	Early assignment of CCA team including all relevant disciplines	0.1830	0.0167	1	13
F02.03	Clear identification of individual roles and responsibilities within the CCA team	0.1821	0.0166	2	14
F02.01	Assignment of technically competent, qualified, and experienced CCA team	0.1783	0.0162	3	16
F02.05	Regular assessment of CCA team performance taking due note of any Employer or Contractor feedback / comments	0.1669	0.0152	4	17
F02.04	Establishing training, and development programs for CCA team	0.1585	0.0144	5	18
F02.06	Setting out performance dialogue for CCA team	0.1312	0.0120	6	26

RFW1i = Relative Weight, and FW1i= Relative effect

9.2.3.3 G03-Communication & Relationship

G03-Communication & Relationship was ranked as 1st construct with a relative weight value of 0.0945. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.4 in ascending orders. At this group level, the most important indicator was 'F03.06-Regular meetings with Employer and Contractor' with the highest relative effect value of 0.0093 among the other factors and overall ranking of 44. The second important indicator was 'F03.01-Establishing a communication management system ' and 'F03.09-Effective management of operational issues at field level between the contractor and CCA team' with relative effect value of 0.009 and overall ranking value of 48. The Communication & Relationship aims to maintain a good business relationship between the CCA team and the contractor to produce the services in accordance with the terms of the contract.

Table 9.4: Relative effects and ranking of the indicators of "G03-Communication & Relationship" construct on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F03.06	Regular meetings with Employer and Contractor	0.0981	0.0093	1	44
F03.01	Establishing a communication management system	0.0953	0.0090	2	48
F03.09	Effective management of operational issues at field level between the contractor and CCA team	0.0947	0.0090	2	48
F03.07	Effective coordination with third parties	0.0927	0.0088	4	56
F03.08	The prompt and accurate response to the Contractor's queries in compliance with the contract procedures	0.0920	0.0087	5	57
F03.11	Strict compliance with the language of communication as stipulated in the contract	0.0902	0.0085	6	58
F03.03	Advising the Employer on its functions	0.0887	0.0084	7	59
F03.10	Effective management of interface among Contractors	0.0883	0.0084	7	59
F03.05	Agreement between Employer and CCA team for any requested changes on scope, time or cost	0.0881	0.0083	9	61
F03.04	Measuring the Employer's satisfaction during the contract lifespan	0.0870	0.0082	10	63
F03.02	Communicating the PMP requirements to all involved parties	0.0848	0.0080	11	64

RFW1i = Relative Weight, and FW1i= Relative effect

Effective communication and a good relationship are some of the greatest concerns in construction management which support the successful completion of the project. Each party must hold the other party informed of and involved in progress, issues, problems, and available solutions. The literature showed similar importance levels and revealed that the contracting parties should use effective communication to successfully deliver timely projects and within budget (Barakat et al. 2018; Joyce 2014; Oluka and Basheka 2014; Solis 2016). Effective communication supported by a feedback protocol is vital to addressing issues and better understanding among contracting parties.

9.2.3.4 G04-Quality & Acceptance

G04-Quality & Acceptance was ranked as 3rd construct with a relative weight value of 0.0926. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.5in ascending orders.

At this group level, the most important indicator was 'F04.05-Systematic auditing the Contractor's compliance with health, safety, and security requirements on site' with the highest relative effect value of 0.0101 among the other factors and overall ranking of 35. The second important indicator was 'F04.06-Systematic auditing of the Contractor's compliance with environmental requirements ' with relative effect value of 0.0099 and overall ranking value of 38 whereas 'F04.04-Timely reviewing the shop drawings taking due cognizance the review cycles' was ranked as the third important indicator with relative effect value of 0.0098 and overall ranking value of 39. During the execution of the contract, inspections and audits are required by the Employer to ensure quality and verify compliance of the final product. Compliance and routine monitoring enable early corrective actions. It covers the control and analysis of non-conforming works.

Table 9.5: Relative effects and ranking of the indicators of the "G04-Quality & Acceptance" construct on CCAPI.

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F04.05	Systematic auditing the Contractor's compliance with health, safety, and security requirements on site	0.1091	0.0101	1	35
F04.06	Systematic auditing of the Contractor's compliance with environmental requirements	0.1069	0.0099	2	38
F04.04	Timely reviewing the shop drawings taking due cognizance the review cycles	0.1054	0.0098	3	39
F04.08	Devised system of controlling rejected / non-compliant works	0.1023	0.0095	4	42
F04.03	Timely reviewing the construction material prior to use by the contractor taking due cognizance of the review cycles	0.1005	0.0093	5	44
F04.01	Systematic auditing of the Contractor's implementation of a quality management system	0.0997	0.0092	6	46
F04.09	Devised system for regular tracking of corrective actions	0.0982	0.0091	7	47
F04.02	Prompt issuance of any further supplementary information to the contractor	0.0974	0.0090	8	48
F04.07	Systematic inspection of the quality of work items on site	0.0961	0.0089	9	54
F04.10	Managing design and design development during construction	0.0844	0.0078	10	65

RFW1i = Relative Weight, and FW1i= Relative effect

9.2.3.5 G05-Performance Monitoring & Reporting

G05-Performance Monitoring & Reporting was ranked as 2nd construct with a relative weight value of 0. 0931. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.6 in ascending orders. At this group level, the most important indicator was 'F05.03-Regular progress reports to the Employer' with the highest relative effect value of 0.0102 among the other factors and overall ranking of 34. The second important indicator was 'F05.07-Monitoring the contractor care of the works including Employer's provided properties' with relative effect value of 0.01 and overall ranking value of 37 whereas 'F05.04-Reviewing the Contractor's reports ' and 'F05.10- Notifying the contractor on failure to carry out any contractual obligation ' were ranked as the third important indicator with relative effect value of 0.0096 and overall ranking value of 40. Performance monitoring and reporting are the primary responsibilities of the contract administrator. Performance monitoring is a structured review and monitoring of the contractor's progress to deliver project scope and quality within cost and schedule constraints (Treasury 2017). Simply, the contract administrator is to make sure that the performance of the contractor agrees with the contract, and the employer is aware of all issues. The group is important because it provides a way to ensure that the procurement objectives are being met (Bartsiotas 2014; Hidaka and Owen 2015; Joyce 2014). It covers performance management activities such as the early establishment of realistic key performance indicators (KPIs), measurement of customer satisfaction, reports of issues, routine reports to the employer, monitoring of the arrangements to minimize public interference, monitoring protection for the employer's properties and sending notifications to the contractor. The contract administrator follows up the contractor's program and updates, monitors the contractor's resources, and issues notifications to the contractor on failures. The significance important of this process group is related to 1) keeping the contractor's accountability for deliverables; 2) generating key input for payment, and 3) highlighting areas for essential corrective action. Project progress monitoring is associated with the project start to ensure that activities are timely performed, and payments are correctly evaluated. The findings of monitoring will develop a lot of information which will be analyzed then communicated through an approved reporting system to the appropriate party for further action. The common practice to include status, progress, issues, recommendations, variance analysis, and established remedies in the report.

Table 9.6: Relative effects and ranking of the indicators of "G05-Performance Monitoring & Reporting" construct on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F05.03	Regular progress reports to the Employer	0.1099	0.0102	1	34
F05.07	Monitoring the contractor care of the works including Employer's provided properties	0.1078	0.0100	2	37
F05.04	Reviewing the Contractor's reports	0.1036	0.0096	3	40
F05 10	Notifying the contractor on failure to carry out any contractual obligation	0.1027	0.0096	3	40
F05.09	Monitoring of Contractor's arrangements to minimize public interference	0.1010	0.0094	5	43
F05.01	Establishment of a monitoring and reporting system inclusive key performance indicators	0.0963	0.0090	6	48
F05.02	Issuing separate reports for major issues to keep the Employer informed	0.0971	0.0090	6	48
F05.06	Monitoring of the Contractor's suitability and adequacy of resources including equipment, materials, and personnel	0.0970	0.0090	6	48
F05.08	Timely notification of the contractor for recovery schedule when progress is slow in relation to the approved program	0.0951	0.0089	9	54
F05.05	Monitoring of Contractor's relationship with Subcontractors	0.0893	0.0083	10	61

RFW1i = Relative Weight, and FW1i= Relative effect

9.2.3.6 G06-Document & Record

G06-Document & Record was ranked as 3rd construct with a relative weight value of 0.0926. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.7in ascending orders. At this group level, the most important indicator was 'F06.02-Using information communication technology (ICT) in administering the contract ' with the highest relative effect value of 0.0242 among the other factors and overall ranking of 3. The second important indicator was 'F06.01-Establishing a document management system' with relative effect value of 0.024 and overall ranking value of 4 whereas 'F06.03-Maintaining updated project documentation with registers' and 'F06.04-Supporting the project stakeholders with regular statistics' was ranked as the least important indicator with relative effect value of 0.0222 and overall ranking value of 5.

Table 9.7: Relative effects and ranking of the indicators of "G06-Document & Record" construct on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F06.02	Using information communication technology (ICT) in administering the contract	0.2618	0.0242	1	3
F06.01	Establishing a document management system	0.2592	0.0240	2	4
F06.03	Maintaining updated project documentation with registers	0.2397	0.0222	3	5
F06.04	Supporting the project stakeholders with regular statistics	0.2393	0.0222	3	5
F06.02	Using information communication technology (ICT) in administering the contract	0.2618	0.0242	1	3
F06.01	Establishing a document management system	0.2592	0.0240	2	4
F06.03	Maintaining updated project documentation with registers	0.2397	0.0222	3	5
F06.04	Supporting the project stakeholders with regular statistics	0.2393	0.0222	3	5

RFW1i = Relative Weight, and FW1i= Relative effect

A proper documentation and recording system is the formal tool to maintain the parties' obligations, substantiate claims, and support compliance with contract provisions (Bartsiotas 2014; Joyce 2014; Okere 2012; Treasury 2017). The system includes- but not limited to contract document and amendments; quality records (material and vendor submittals, shop drawings, approvals, and inspection requests); site records (daily reports, site diary, and safety reports); reports (progress, and status) completion records (as-built drawings, completion certificates, final account, and snags); contractual notifications (claims, notifications, and evaluations) financial records (payment certificates, and variations); meetings; and other correspondences. Project records are vital for substantiating any claims/issues, dispute resolution process, or court actions (Treasury 2017). They also provide dynamic and objective evidence of complying with the contract requirement and execution of the contract. Effective use of information technology in contract administration will reduce the waste of time due to transfer and paper works in addition to real-time tracking (Kerzner 2013).

9.2.3.7 G07-Financial Management

G07-Financial Management was ranked as 9th construct with a relative weight value of 0.0896. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.8 in ascending orders. At this group level, the most important indicator was 'F07.05-Assessment of the Contractor’s compensation for delayed payments cases in compliance with any contractual provision ' with the highest relative effect value of 0.0144 among the other factors and overall ranking of 18. The second important indicator was 'F07.04-Timely notifying the Employer about the Contractor’s due payments timelines & financial status ' with relative effect value of 0.0135 and overall ranking value of 20 whereas 'F07.03-Fair, reasonable and equitable certification of due payments to the contractor ' were ranked as the third important indicator with relative effect value of 0.0133 and overall ranking value of 21.

Table 9.8: Relative effects and ranking of the indicators of “G07-Financial Management” construct on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F07.05	Assessment of the Contractor’s compensation for delayed payments cases in compliance with any contractual provision	0.1602	0.0144	1	18
F07.04	Timely notifying the Employer about the Contractor’s due payments timelines & financial status	0.1502	0.0135	2	20
F07.03	Fair, reasonable and equitable certification of due payments to the contractor	0.1480	0.0133	3	21
F07.01	Establishment of a financial management system	0.1423	0.0128	4	22
F07.02	Proper issuance of instructions to spend provisional sum items	0.1415	0.0127	5	23
F07.06	Advising the Employer in contingency planning/ additional funds	0.1317	0.0118	6	28
F07.07	Collecting quotations for price estimates and Contractor’s price negotiations in respect of additional works / variations	0.1260	0.0113	7	29

RFW1i = Relative Weight, and FW1i= Relative effect

The importance of this group is related to its importance in maintaining the contractor's due payment without delay (Alzara et al. 2016) to support the contractor's cash flow. Independent financial monitoring by the CCA team is important to speed up and justify the payment process. Payments spread throughout the course of the contract and are made to the contractor over the course of work being completed, material received on-site, or release of retained money.

9.2.3.8 G08-Changes & Changes Control

G08-Changes & Changes Control was ranked as 8^{th} construct with a relative weight value of 0.0905. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.9 in ascending orders.

Table 9.9: Relative effects and ranking of the indicators of "G08-Changes & Changes Control" construct on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F08.05	Proper processing of the change orders on approved change requests	0.2074	0.0188	1	8
F08.02	Prompt evaluation of Contractor's proposals for changes inclusive value engineering	0.2059	0.0186	2	10
F08.04	Properly notifying the contractor about urgent works required for the safety of the works	0.2033	0.0184	3	11
F08.03	Proposing financially viable solutions to avoid a budget increase to the Employer due to changes requests	0.2017	0.0183	4	12
F08.01	Establishment of a change control system	0.1817	0.0164	5	15

RFW1i = Relative Weight, and FW1i= Relative effect

At this group level, the most important indicator was 'F08.05-Proper processing of the change orders on approved change requests ' with the highest relative effect value of 0.0188 among the other factors and overall ranking of 8. The second important indicator was 'F08.02-Prompt evaluation of Contractor's proposals for changes inclusive value engineering ' with relative effect value of 0.0186 and overall ranking value of 10 whereas 'F08.04-Properly notifying the contractor about urgent works required for the safety of the works' was ranked as the third important indicator with relative effect value of 0.0184 and overall ranking value of 11.

Changes in a construction contract are common, and the contract should be dynamically covering changes in the original plans as the project progress. Literature reveals the importance of implementing proper change control management within the contract administration system (Alzara et al. 2016; Islam et al. 2019). Furthermore, the Contract Administrator is not authorized to approving the contractor’s proposal for changes, amending the contract, or giving commitments for changes or relieve any contractual obligations (Murdoch and Hughes 2008; Treasury 2017) without the employer's consent. Control of changes will ensure an effective balance between compliance, owner's requirement, and maintaining the project budget. In other words, change control is crucial to achieving some improvement and correct errors. Contract modifications are changes that are made after signing the contract. Modification or changes are either bilateral modifications signed by both parties or unilateral modifications signed only by the Employer such as administrative changes; changes authorized other than change clauses, and termination of notices (Hidaka and Owen 2015). Therefore, effective management and control of contract is an essential part of the contract administration process. Effectively change controls include a formal process for making changes within or outside the contract and identifying the authorized persons to approve changes. And it requires establishing procedures for recognizing and valuing changes.

9.2.3.9 G09-Claims & Disputes Resolution

Further to several prominent dispute and conflict cases in the construction industry, the rank of G09-Claims & Disputes Resolution was the 7th construct with a relative weight value of 0.0907. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.10 in ascending orders.

At this group levels, the most important indicators were 'F09.03-Proper assessment of Contractor's entitlement for extension of time for completion within timelines as set out in the contract' and 'F09.04-Proper assessment of Contractor's entitlement for additional payment' with the highest relative effect value of 0.0124 among the other factors and overall ranking of 24. The indicator 'F09.02-Notifying the contractor about the Employer's rights to claim' was ranked as the third important indicator with a relative effect value of 0.012 and an overall ranking value of 26.

Table 9.10: Relative effects and ranking of the indicators of “G09-Claims & Disputes Resolution” construct on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F09.03	Proper assessment of Contractor's entitlement for extension of time for completion within timelines as set out in the contract	0.1363	0.0124	1	24
F09.04	Proper assessment of Contractor's entitlement for additional payment	0.1370	0.0124	1	24
F09.02	Notifying the contractor about the Employer's rights to claim	0.1319	0.0120	3	26
F09.06	Supporting the contracting parties to select alternative dispute resolution methods if not already set out in the contract	0.1241	0.0113	4	29
F09.05	Effectively negotiating claims between the contractor and the Employer	0.1229	0.0111	5	31
F09.07	Representing the Employer in alternative dispute resolution proceedings	0.1208	0.0110	6	32
F09.08	Legal support to the Employer during court cases	0.1160	0.0105	7	33
F09.01	Establishment of a claims and disputes resolution system if not already set out in the contract	0.1110	0.0101	8	35

RFW1i = Relative Weight, and FW1i= Relative effect

In construction contracts, disputes are inevitable and are real facts that cannot be avoided or denied. literature and statistics consider that the contract administration process as one of the major sources of the construction disputes (Arcadis 2018; El-adaway et al. 2018), and proper management of this process is critical in reducing disputes (Abotaleb and El-adaway 2017). The effective administration of claims and disputes will allow resolving timely and fairly any conflict and avoid the costly and time-consuming litigation process.

9.2.3.10 G10-Contract Risk Management

The ranks of G10-Contract Risk Management was the 10th construct with a relative weight value of 0.087. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.11 in ascending orders.

Table 9.11: Relative effects and ranking of the indicators of “G10-Contract Risk Management” construct on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F10.02	Assignment of responsibility to the relevant party for each contractual risk expressed as a Responsibility Matrix	0.2810	0.0245	1	1
F10.03	Supporting the Employer for the risks associated with design review findings	0.2800	0.0244	2	2
F10.04	Monitoring the Contractor’s financial status and bankruptcy potential	0.2225	0.0194	3	7
F10.01	Periodically assessing the contractual risks with help of the contractor	0.2165	0.0188	4	8

RFW1i = Relative Weight, and FW1i= Relative effect

At this group level, the most important indicator was 'F10.02-Assignment of responsibility to the relevant party for each contractual risk expressed as a Responsibility Matrix ' with the highest relative effect value of 0.0245 among the other factors and overall ranking of 1. The second important indicator was 'F10.03-Supporting the Employer for the risks associated with design review findings ' with relative effect value of 0.0244 and overall ranking value of 2 whereas 'F10.04-Monitoring the Contractor’s financial status and bankruptcy potential ' was ranked as the third important indicator with relative effect value of 0.0194 and overall ranking value of 7. The involvement of a large number of stakeholders would develop substantial risks in construction projects (El-Sayegh and Mansour 2015). Early risk identification assigns responsibilities and developing strategies to deal with risk, reduce its impact, and are key to effective risk management. The literature revealed that risk management is necessary for the efficient planning and realization of construction projects (Dziadosz and Rejment 2015). Contractual and legal risks such as delay in payments, poorly customized contract forms, inadequate administration of claims, third-party liabilities, and contract document conflicts are frequently seen in construction (El-Sayegh and Mansour 2015). Although the risk management includes main activities such as risk identification, analysis, response planning, and monitoring, the industry has yet established a systematic framework for the application of risk management in managing a contract (Serpell et al. 2015).

9.2.3.11 G11- Contract Close-out Management

G11-Contract Close-Out Management was ranked as 11th construct with a relative weight value of 0.0867. The rankings of components (indicators) of this construct according to their relative effects to CCAPI is shown in Table 9.12 in ascending orders. At this group level, the most important indicator was 'F11.04-Proper review of Contractor's close-out documentation' with the highest relative effect value of 0.0073 among the other factors and overall ranking of 66. The second important indicator was 'F11.03-Proper verification of physical works completion ' with relative effect value of 0.0072 and overall ranking value of 69 whereas 'F11.11-Proper processing Contractor's final account in accordance with the contract provision ' was ranked as the third important indicator with relative effect value of 0.0071 and overall ranking value of 70.

Table 9.12: Relative effects and ranking of the indicators of "G11-Contract Close-Out Management" construct on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F11.04	Proper review of Contractor's close-out documentation	0.0841	0.0073	1	66
F11.03	Proper verification of physical works completion	0.0832	0.0072	2	69
F11.11	Proper processing Contractor's final account in accordance with the contract provision	0.0820	0.0071	3	70
F11.02	Communicating closeout activities to all stakeholders	0.0808	0.0070	4	71
F11.08	Periodic inspections of the works during defects notification period	0.0811	0.0070	4	71
F11.13	Proper management of termination of the contract process in compliance with the contract administrative procedures	0.0797	0.0069	6	73
F11.12	Proper management of suspension of the work process in compliance with the contract administrative procedures	0.0789	0.0068	7	74
F11.06	Proper release of the due retention monies upon releasing relevant certificate	.0774	0.0067	8	76
F11.09	Proper issuance of performance certificate when the Contractor's maintenance obligations are fulfilled in accordance with timelines as set out in the contract	.0770	0.0067	8	76
F11.05	Timely issuance of taking-over certificate(s) with associated snags	.0716	0.0062	10	79
F11.01	Establishment of a close-out system	.0704	0.0061	11	82
F11.10	Documenting lessons learned and best practices	.0676	0.0059	12	85
F11.07	Timely approving return of deployment of the Contractor's resources upon Contractor's request	.0663	0.0058	13	87

RFW1i = Relative Weight, and FW1i= Relative effect

Contract closeout is the last part of the post-award phase and contains several activities or tasks, which should be handled by the contract administration team. Successful Completion contract is ended by completion certificates when services have been received, the contractor performed his obligations, and all significant issues have been addressed. and the employer accepted deliverables and pay for it, and maintenance certificates issued, and contractor's received his final account (Hidaka and Owen 2015). Also, the contract is ended by either mutual agreement or breach. Unsuccessful projects are often ended by termination. Terminations are classified as a termination for convenience by the Employer or terminated for default of the contractor. The Employer pays for satisfactory performance.

9.2.4 Discussion of Indicators According to Relative Effects

The 33 highest ranked indicators are shown in Table 9.13 in ascending order according to their ranking or descending order according to their overall relative effect on CCAPI. The first ranking factor was "Assignment of responsibility to the relevant party for each contractual risk expressed as a Responsibility Matrix" with a relative effect value of 0.0245 to avoid unclear risk allocation (Yap 2013). It and was followed by "Supporting the Employer for the risks associated with design review findings" with a relative effect value of 0.0244. Rework due to design errors have been extensively reported due to errors/ omissions in drawings, specifications, or bill of quantities (Alzara et al. 2016). The third important indicator was "F06.02-Establishing a document management system," with a relative effect value of 0.0242. the indicators "F06.01-Maintaining updated project documentation with registers" and "F06.03Supporting the project stakeholders with regular statistics" were the 4th and 5th important factors according to their relative effect. It worth noting that where the construct has a smaller number of indicators, indicators of this construct would have more contribution to the CCAPI. It referred to the fact that almost the construct contributions were almost similar, and therefore, where its relative weight was distributed over a small number of indicators, it would be highly contributing (i.e., have more relative effect). Based on this observation, 8 out of the 10 top observed factors were associated with the process groups "G10-Contract Risk Management" and "G06-Document & Record". Both constructs have only 4 indicators. The results indicate that the indicators affecting contract administration have different levels of significance. The team leader of the contract administration has prime tasks to focus on planning and system establishment and leave the administration of day-to-day activities to other CCA team. The team needs to focus on the most significant factors as they affect the overall performance of the CCA and the project as well. Poor contract administration would be eliminated by the proper and effective implementation of each process group through a competent team working towards achieving the project objectives.

Table 9.13: Relative effects and ranking of the highest 33 indicators on CCAPI

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F10.02	Assignment of responsibility to the relevant party for each contractual risk expressed as a Responsibility Matrix	0.2810	0.0245	1	1
F10.03	Supporting the Employer for the risks associated with design review findings	0.2800	0.0244	2	2
F06.02	Using information communication technology (ICT) in administering the contract	0.2618	0.0242	1	3
F06.01	Establishing a document management system	0.2592	0.0240	2	4
F06.03	Maintaining updated project documentation with registers	0.2397	0.0222	3	5
F06.04	Supporting the project stakeholders with regular statistics	0.2393	0.0222	3	5
F10.04	Monitoring the Contractor's financial status and bankruptcy potential	0.2225	0.0194	3	7
F08.05	Proper processing of the change orders on approved change requests	0.2074	0.0188	1	8
F10.01	Periodically assessing the contractual risks with help of the contractor	0.2165	0.0188	4	8
F08.02	Prompt evaluation of Contractor's proposals for changes inclusive value engineering	0.2059	0.0186	2	10
F08.04	Properly notifying the contractor about urgent works required for the safety of the works	0.2033	0.0184	3	11
F08.03	Proposing financially viable solutions to avoid a budget increase to the Employer due to changes requests	0.2017	0.0183	4	12
F02.02	Early assignment of CCA team including all relevant disciplines	0.1830	0.0167	1	13
F02.03	Clear identification of individual roles and responsibilities within the CCA team	0.1821	0.0166	2	14
F08.01	Establishment of a change control system	0.1817	0.0164	5	15
F02.01	Assignment of technically competent, qualified, and experienced CCA team	0.1783	0.0162	3	16

Table 9.13: Relative effects and ranking of the highest 33 indicators on CCAPI (continued)

Code	Indicator	RFW1i	FW1i	Group Rank	Overall Rank
F02.05	Regular assessment of CCA team performance taking due note of any Employer or Contractor feedback / comments	0.1669	0.0152	4	17
F02.04	Establishing training, and development programs for CCA team	0.1585	0.0144	5	18
F07.05	Assessment of the Contractor's compensation for delayed payments cases in compliance with any contractual provision	0.1602	0.0144	1	18
F07.04	Timely notifying the Employer about the Contractor's due payments timelines & financial status	0.1502	0.0135	2	20
F07.03	Fair, reasonable and equitable certification of due payments to the contractor	0.1480	0.0133	3	21
F07.01	Establishment of a financial management system	0.1423	0.0128	4	22
F07.02	Proper issuance of instructions to spend provisional sum items	0.1415	0.0127	5	23
F09.03	Proper assessment of Contractor's entitlement for extension of time for completion within timelines as set out in the contract	0.1363	0.0124	1	24
F09.04	Proper assessment of Contractor's entitlement for additional payment	0.1370	0.0124	1	24
F02.06	Setting out performance dialogue for CCA team	0.1312	0.0120	6	26
F09.02	Notifying the contractor about the Employer's rights to claim	0.1319	0.0120	3	26
F07.06	Advising the Employer in contingency planning/ additional funds	0.1317	0.0118	6	28
F07.07	Collecting quotations for price estimates and Contractor's price negotiations in respect of additional works / variations	0.1260	0.0113	7	29
F09.06	Supporting the contracting parties to select alternative dispute resolution methods if not already set out in the contract	0.1241	0.0113	4	29

RFW1i = Relative Weight, and FW1i= Relative effect

9.3 CHAPTER SUMMARY

The findings of 93 indicators and 11 constructs impacting CCA performance were discussed in this chapter. Also, the ranking and the relative weight (contribution) of the constructs and the ranking and the relative effect (contribution) of the indicators were also established. Further, the highest 30 indicators affecting the "CCA performance were stated. Those top indicators will be used to establish recommendations to the CCA team and industry professionals in the next chapter.

CHAPTER 10 : SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

10.1 INTRODUCTION

The focus of this study is the development of a systematic multidimensional construction contract administration performance at the project level. This study significantly contributes to the construction management body of knowledge by introducing and developing a Construction Contract Administration Performance framework (CAPF), model (CAPM) and index (CCAPI) based on a theoretical validated framework and empirically validated model to improve the contract administration performance.

The research was based on the data obtained from literature, semi-structured interviews with 4 industry professionals, Delphi technique involving 17 construction experts, online questionnaire survey involving 366 international construction professionals. On-line surveys were addressed to the executive manager, department manager, senior engineer or architect, quantity surveyor, project manager, and engineer/ supervisor in public and private sectors. The study reflected the perspectives of employer, consultant, and contractor who work in building construction, industrial facilities, infrastructure, and utilities.

10.2 OBJECTIVES AND OUTCOMES

Today's construction projects are becoming more sophisticated, large-scale, and risky. This means that an effective contract administration needs to be implemented in construction projects as CCA plays a vital role in construction as it contributes to project success or failure. Poor contract administration is considered to be a serious problem in the construction industry and is a significant cause of inefficient construction process, delays, reworks, unnecessary variations, poor communication among team players, conflicts and disputes for both employer and contractors. Poor construction contract administration may refer to poor planning (Alzara et al. 2016; Memon and Rahman 2013), poor communication and coordination (Surajbali 2016), lack of systems (Surajbali 2016) misunderstanding of processes (Surajbali 2016), lack of skilled personnel (Ahmed 2015), unclear roles (Surajbali 2016), and lack of training (Ahmed 2015; Surajbali 2016) and lack of performance measurement (Surajbali 2016). Yet CCA team need more trainings on better practices (Ahmed 2015; Bartsiotas 2014; Kayastha 2014; Niraula et al. 2008; Surajbali 2016), to act responsively (Ssegawa-Kaggwa 2008) with sufficient level of competency (Puil and Weele 2014; Surajbali 2016) and to efficiently monitor the contract (Surajbali 2016) to make efficient decisions (Puil and Weele 2014). Poor contract administration could be avoided or minimized when their causes are clearly identified and countered by systematic operational indicators and well recognized best practices that would satisfy the contractual obligations of the CCA team. The capability to manage and administer contracts could be measured by a maturity assessment tool (Garrett and Rendon 2005). Also, literature confirmed the significant contribution of operational performance to contract management/administration practices (Joyce 2014).

This study mainly examined the relationships between indicators affecting CCA performance (indicators) and the associated project management process groups (constructs) at the project level in order to establish a validated multidimensional construction contract administration performance framework, model and index. The validated model was then used to establish a Construction Contract Administration Performance Index (CCAPI) and a mobile app to assessing the performance of contract administration with the same name of the model (i.e., CAPM).

An exploratory sequential and sequential mixed research approach was implemented to achieve the objectives of this study, consisting of a mix of qualitative and quantitative techniques. The qualitative technique aimed to produce a list of CCA indicators that affect the performance of the contract administration processes through literature review, interviews, and further to validate/update this list by expert opinion (Delphi technique). The quantitative techniques aimed to implement a reliable statistical analysis tool (Fuzzy-SEM) to capture the association between the proposed indicator and the constructs and then to arrive at a single CCA performance indicator (CCAPI).

Based on the above aim, 8 objectives were first set and then achieved, as demonstrated in the previous chapters and as summarized hereafter.

1. Objective 1" Examine the CCA environment, practices, and current performance": through a comprehensive literature review of the construction industry stakeholders; project life cycle; definition and legal aspect of the construction contract; the different types of the project delivery methods; the different types international standard forms of contract; the key performance indicators; and the success criteria for construction projects were identified in Chapters 2.
2. Objective 2" Identify the indicators contributing to contract administration performance": through a comprehensive literature review covered the difference between contract management and contract administration, scope and needs; challenges and issues, poor and effective practices; critical success factor of contract administration. ; the roles, responsibilities, and limitations of the contract administrator under the different forms of contract; and the available contract administration key activities, models' frameworks. A detailed literature review, semi-structured interviews with 4 construction professionals, and preliminary questionnaire design led to

identifying 82 indicators (indicators) and 11 project management process groups (constructs) affecting CCA performance, as presented in chapter 3. Chapter 3 ended with a proposal for development of a preliminary CCA model which includes 11 project management process groups namely: governance, documentation & planning, human resources & capacity building; communication/relationship management; quality, acceptance & daily operations; performance monitoring & reporting; record & data management; payment & financial management; change & variation management; claims, disputes resolution & handling problems; risk management; and contract close-out.

3. Objective 3" Determine and cross-validate the CCA indicators that can significantly affect CCA performance": A preliminary questionnaire and two-round Delphi study to rank the 82 indicators in addition to an additional 11 factors identified by Delphi experts. The experts' panel was grouped by such variables as sectors (public and private) and organizations (Employer, consultant, and Contractor). The normality and reliability of the collected data were tested by corresponding statistical tests. The collected data were analyzed by means of Spearman rank-order correlation, mode score, mode value, and SDMR to take a go/no-go decision after the second round. The Delphi study was followed by the measurement of the strength of agreement through IRA analysis, as presented in chapter 5. The IRA varies from weak to strong level agreement for each individual subject. The agreement level represents 94.6 of the proposed indicators and 100 % of the proposed project management groups. Therefore, a significant consensus was achieved, and experts recognized the importance of the identified indicators for the overall project performance. Thus, the Delphi study confirmed the expert agreement of the importance of the proposed factors and further introduced 11 new indicators factors.

4. Objective 4" Examine the causal relationship between CCA indicators and constructs to set theory for measuring the performance of contract administration": The research hypotheses formed in Chapter 4 and the output of Chapter 5 led to establishing the final model. The issue of identifying the importance of CCA indicators is somewhat subjective, and CCA is bounded by ambiguities and uncertainties, therefor the data collection took the form of linguistic terms. As Such, the importance of the indicators affecting CCA presented in five linguistic terms (not at all important; slightly important; moderately important; very important; and extremely important). By using the fuzzy membership functions of the fuzzy set theory, the linguistic terms were defuzzified into tangible numbers (crisp values), as presented in Chapter 6. Also, chapter 6 explained the theoretical back group of the structural equation modeling as a multivariate analysis technique that would be used for validating the proposed model and hypotheses. A final online questionnaire was established, and self-administrated and full data were collected from 366 respondents to represent the rating of the importance of the 93 indicators affecting CCA performance". The first part of the questionnaire includes introductory information about the research and then followed by some questions regarding the respondents' profiles. The respondent demographic was reported using descriptive analysis, including the respondent's set of profiles and types of projects in the first part of Chapter 7. After explaining the profile of respondents, a preliminary analysis to prepare data for the SEM statistical analysis technique was conducted using AMOS V 24. 366 questionnaires were received, and only 336 questionnaires were validated for analysis due to the presence of non-serious responses and outliers. The sample dataset violates the normality assumption, and techniques to deal with non-normal data were discussed. The Cronbach's alpha test was utilized to check the

internal consistency and reliability of the variables, and the dataset was found reliable. The first-order Confirmatory Factor Analysis and second-order structural model were carried. Data deviated from normality, and the Maximum Likelihood Bootstrapping was used for model estimation. The research hypotheses were tested using the structural model (Relation among first order and second-order latent factors) of the SEM, and the level of significance reported. The SEM analysis confirmed that the Construction Contract Administration Performance Index (CCAPI) is reflected by the proposed 11 constructs as detailed in Chapter 7. It is worth noting that the contract administration full model requires the collection of data throughout the whole projects and therefore considered as a time-consuming assessment, and lengthy mode, and sometimes subjective. A short model was developed based on the 3 highest standardized factor loadings of the indicators for each construct (total of 33 indicators in 11 constructs). The short model requires consistent performance across indicators.

5. Objective 5" Establish quantified overall Construction Contract administration performance indicator (CCAPI)": CCAPI was adopted using the product of Relative Factor Weight and Relative Group Weight in order to arrive at the relative effect (contribution) of each indicator on CCAPI. The applicable relative weights were calculated from the standardized factor loading of the second-order structural model of the SEM. The product of the relative effect and site evaluations for the indicators within each group was used to calculate the weighted mean of this variable. The summation of the weighted mean within each construct group was used to calculate construct contribution and then aggregated to CCAPI. The first part of Chapter 8 explains the detailed methodology to formulate CCAPI.

6. Objective 6 "Mobile App assessment tool- CAPM": Driven by the fact that smartphones are available everywhere, and construction firms take several steps to shift to smartphones and web applications instead of the conventional desktop software packages. This study developed a hybrid mobile app to assess construction contract administration performance based on the CAPM model and with the same name. The middle part of Chapter 8 described the mobile app development using a cross-platform called Ionic V4. The CAPM features, introduction and instruction screens, input screens, and output screens were pointed out.
7. Objective 7 "Examine the proposed model through a pilot project": 13 ongoing and completed construction projects were selected to examine the proposed model, its ability to distinguish the performance level of the contract administration (CCAPI) and benchmark the CCAPI among the 13 projects. The degree of conformity of the 93 indicators was evaluated by CCA experts on a 1 to 100 scale to reflected zero conformance to full conformance of the indicators. Any not applicable variables (NaN) was recorded, and the model excluded it from the calculation and re-distribute its weight to other variables within the same construct. For the sake of replication of the calculation protocol/method, the full calculations of CCAPI for project #1 were systematically illustrated. The construct performance indicator (process group indicator) and the overall Construction Contract Administration Performance Index (CCAPI) were presented and discussed in detail for the 13 projects, and then CCAPI was benchmarked. On the other, the short model was also examined in the 13 projects, and the percentage of error (deviation) of the short model was expressed as the deviation of the short model from the full model.
8. Objective 8 "Proposing strategies to enhance the administrative practices/ performance": Based on the method of formulating CCAPI and establishment of

indicators and constructs contribution to construction contract administration performance, detailed discussion of the rating and relative effect (contribution) of the 11 constructs and the top 3 to 5 factors of each construct on CCAPI were discussed in Chapter 9. Also, Chapter 8 discussed the current status of implementing the 93 factors within the 13 pilot projects. The top 33 indicators affecting CCA performance were discussed, and recommendations to the construction industry to improve the construction contract administration performance -in terms of best practices were outlined in the last part of Chapter 10.

As detailed above, the objectives of this study were achieved by serval techniques, and the outcome of the study subject may support the construction professionals to improve their current practices regarding construction contract administration.

10.3 RECOMMENDATIONS FOR CONSTRUCTION PROFESSIONALS

The traditional view of construction contract administration as releasing payment, make a determination or contractual letters is not favoring the construction industry, the contract and contract administration should be viewed as a proper tool supporting the project management. Construction According to the outcome of this study, the following recommendations are offered to improve the construction contract administration performance of projects.

10.3.1 Recommendations to CCA Team and Consultants

The ultimate recommendation to CCA tram is to administrate the 11 process groups equally but with some focus on communications & relationship; performance monitoring & control; and quality groups. Based on the analysis of the importance of each variable and identification of the 30 top indicators affecting CCA performance, the following recommendations were established.

1. Responsibility Matrix should be established in order to assign responsibility to each identified contractual risk to its relevant party. This would maintain the risk owner aware and reliable for his/her risk.
2. Design review should be carried out at the early stage of the project by the CCA concerned team. This would minimize the risk of changes due to design errors or improper design at later stages.
3. Using Information Communication Technology (ICT) in administering the contract would improve project communications and reduce the time of transmitting the engineering documents and records.
4. Establishing a reliable document management system would support the smooth administration of the project by keeping the CCA team well informed about the system documentation and requirement.
5. Maintaining updated project documentation with registers would support all parties with factual records that are required to reserve rights.
6. Supporting the project stakeholders with regular statistics and dashboards would capture the overall view of the project and support decision making.
7. The Contractor's financial status and bankruptcy potential should be monitored regularly to avoid project delays or at the worst stop.
8. Approved change requests should be properly followed by change order or variation order in order to maintain the contractor's contractual entitlement under the contract. The CCA team should carefully understand the conditions related to change orders.
9. To improve the risk assessment process, the contractual risk should be periodically and jointly assessed with the help of the Contractor. This will grant that the

contractor is aware of his own contractual risks, shoulder this risk, and provide his/her input.

10. The Contractor's proposals for changes- inclusive value engineering- should be promptly evaluated. Several proposals can reduce the risks of delays, reduce construction and life cycle costs, increase efficiency, and may add value to the Employer.
11. The Contractor should be immediately notified about urgent works required for the safety of the works to reduce the Significant Injury Frequency Rate (SIFR) and site accident.
12. As the Employer agent, the Employer's change requested should be technically studied, and the CCA team should study several financially viable solutions and provide alternatives to the Employer. This would minimize the cost of changes or add the benefit of the Employer.
13. All necessary CCA team should be early assigned to the project. The early assignment would provide enough time to study the project and prompt response to all Contractors' early submissions and control the project execution from the commencement.
14. Each CCA team member should have clear roles and responsibilities. This would develop accountability for each individual act and making sure the team members understand their obligations. Developing an overall Responsibility Assignment Matrix would capture the overall project tasks.
15. The CCA should have a system in place for changes and changes control. The system should include change process, and authorities to process / approved changes

16. The CCA team members should be technically competent, qualified, and experienced to cover the project administrative needs and to avoid underperformance and wrong interpretation of the contract. Competency and experience can be improved with structured training programs. The abilities of the team would enhance the CCA function and maintain a good performance standard (Ahmed 2015).
17. The CCA organization should regularly assess the team performance and taking due note of any Employer or Contractor feedback/comments. The Employer and the contractor's feedback are crucial to discover the team weakness and work towards improving it.
18. At the project level, the CCA organization should establish a structured training and development programs for the CCA team covering the all necessary technical and contractual (especially contract law, regulations and contract administration process areas) aspect of the project.
19. The CCA team should monitor the timely release of the Contractor’s certified payment and notify the Employer regarding the due dates. One of the best practices is to forecast the cash flow needs on a regular basis and inform the Employer’s representative regarding the due payment through letters, Emails, or during regular meetings.
20. As the third party, the CCA team should - imperially and fairly -assess the Contractor’s compensation for any delayed payments in compliance with any contractual provision. Also, the team should bring the Employer’s attention to the consequences of delayed payment consequences.
21. The CCA should fairly, reasonably, and equitably evaluate the Contractor’s payment certification without unjustified deductions.

22. The CCA should have a system for the financial management of the contract. The system should include the payment process and authorities to process / approved the payment.
23. The CCA should have a system in place for the proper issuance of instructions to spend provisional sum items upon the Employers request.
24. The CCA team should properly assess the Contractor's entitlement for extension of time (EOT)for completion within timelines as set out in the contract. EOT workshops, negotiations, and presentations are one of the best practices that would speed up the assessment process and secure parties' mutual agreement for entitlement.
25. The CCA team should assess the Contractor's entitlement for additional payment within timelines as set out in the contract. Regardless of the root cause of additional payment, a fair and reasonable assessment would support both contracting parties to continue the project and minimize disputes.
26. The CCA team members should be aware of their performance through CCA management. Identifying and communicating the low-performance areas to the team is the first step to improve the performance.
27. As an Employer's agent, where notifications are required under the contract, the CCA should promptly notify the contractor about the individual cases of the Employer's rights to claim. This would reserve the Employer's rights under the contract and avoid repeating by the contractor.
28. In advance, the CCA should advise the Employer regarding any additional funds that may be required for the project due to price escalation, potential changes, changes in design, change requests, potential claims, or any other reasons. This would keep the Employer informed about any future financial arrangement

required. One of the best practices is to report financial risk in a separate commercial report to the employer.

29. The CCA team should have a sound price estimates system for any new items, system, or equipment. The CCA team should have the market knowledge and forecasting capability (Ahmed 2015). One of the best practices is to collect three quotations for any new items/ scope. This quotation represents the current market rates and shall facilitate the negotiation process with the Contractor.
30. Sometimes, the form of contract does not specify or propose an alternative dispute resolution method and refers to the local court in case of disputes. In such cases, the CCA team could proactively propose an alternative dispute resolution method such as amicable settlement, mediation, or arbitration.

To conclude, it is important for project success in utilizing the recommendations of this study as best practices, where applicable. Those recommendations are not intended to guide how to do tasks but outline what should be done, and the list is not exhaustive. Construction practitioners should determine the best way to carry out such tasks for their specific projects with the available resources and tools. Also, it is not essential to apply all recommendations to all projects, but it is expected that the current CCA practices can be improved if these recommendations and the overall model are adopted in a systematic and structured way.

Also, the results revealed that Documenting lessons learned, monitoring the Contractor’s financial status, monitoring of Contractor’s relationship with Subcontractors; timely approving return of deployment; systematic auditing of the Contractor's implementation of quality management system; and reviewing the Contractor's environmental management plan are not standard practices within the case studies projects.

10.3.2 Recommendations to Employers

CCA team is either the Employer's agent or third party is working towards achieving the Employer's objectives to complete a successful project. Therefore, the following basic recommendations were drawn to the Employer to support the CCA team to achieve their functions.

1. The Employer should make quick decisions to complete the project as planned without disruptions.
2. The Employer should demand design changes at the early stage of the project and to the extent that minimal adverse effects may occur.
3. The Employer should avoid delays in handing over the construction site to the contractor, approving the design, and releasing progress payments to avoid overall delay.
4. The Employer should be fairly accepting of the CCA assessment if it is supported by the contract provision and is fairly and impartially performed. The Employer's attempts to influence CCA fair assessment will end up with the Contractor's dispute and mistrust between parties.

Finally, the CAPM model is a good tool for the Employer to assess and track the CCA team performance and give instruction to correct the underperformed areas.

10.3.3 Recommendations to Contractors

CCA team is looking to achieve the project objectives in terms of time quality, scope. therefore, to avoid problems with the CCA team, the following basic recommendations are drawn to the main contractor to maintain a good relationship with the CCA team.

1. The contractor should be well equipped with experienced staff. Inadequate contractor's experienced staff would not be able to plan and manage projects and would have several communication failures with the CCA team.
2. The contractor should give more consideration to effective planning because the only well-planned project could be well executed.
3. The Contractor should carefully select capable and reliable subcontractors to reduce the risk of inferred quality and delays.
4. The quality of works and use of skilled workers would reduce the inspection time, improved safety of works, and reduce repeated rejection of works by the CCA team.

Finally, the CAPM model is a good tool for the contractor to track the CCA team performance and report immediately to CCA team management and/or the employer any issues.

10.3.4 Recommendations to All Parties

With the presence of several stakeholders in construction, timely, and effective communication and coordination among parties are critical success factors. To avoid misunderstandings, parties should establish proper communication channels and trust. Also, cooperation would be a vehicle to handle the problem without compromising the project goal. Maintaining ethical practice in procurement is very important as well (Ahmed 2015). Agreement of parties on effective procedures and controls in accordance with the relevant procedures of the contract would support project success.

10.4 CONCLUSION

This study implemented a new approach in establishing a systematic and operational multi-dimensional construction contract administration framework, model and provided CAPM as an assessment tool to abstract the Construction Contract

Administration Performance Index at the project level with 93 indicators affecting CCA performance in 11 project management process groups.

The model was developed on the basis of comprehensive literature review; semi-structured interviews with 4 construction professionals; and seeking 17 construction expert consent on the importance of the proposed variables and suggestions to recommend new factors (2 rounds modified Delphi study). A total of 93 key activities were developed for the main tasks affecting construction contract administration performance on 11 process groups namely: G01- Project Governance & Start-up; G02- CA Team Management; G03- Communication & Relationship; G04- Quality & Acceptance; G05- Performance Monitoring & Reporting; G06- Document & Record; G07- Financial Management; G08- Changes & Changes Control; G09- Claims & Disputes Resolution; G10- Contract Risk Management; and G11- Contract Close-Out. The CAPM combines the global view of CCA activities, the worldwide best practices, the success factors, the operational procedures, the provisions of the professional service agreements, and the conditions of contract in one database. Through different consensus measures, the worst-case scenario of the mode score, mode value, and SDMR were conducted to check the overall agreement on Delphi rounds. The mean value and IRA analyses were applied to quantify the significance and strength of the agreement of the identified indicators on project performance. As a result, experts agreed on the importance of the proposed factor. Further, experts agreed variables are subject to importance rating through an online questionnaire using 5 linguistic terms (Not at all important to extremely important). Full data collected from 366 respondents and then screened to exclude unengaged responses and outliers. The response ratings were defuzzified crisp values. The research data (crisp values) used to establish the contract administration performance model using first and second-order

Confirmatory Factor Analysis and structural model of the structural equation. The outcomes of the SEM analysis confirmed the validity of the proposed CAPM model (full model with 93 variables). The 3 top standardized factors loading of the indicator of each construct was used to form an alternative short model. A Construction Contract Administration Performance Index (CCAPI) was formulated using a weighted aggregation technique of the applicable relative factor weight and relative group weight obtained from SEM analysis in terms of standardized factor loadings. A hybrid mobile app (Called CAPM) was developed using IONIC V5 cross-platform. CAPM contains 3 introduction and instruction screens, 12 input screens, and 7 output screens. Optionally, the application may run in a prime full model mode with 93 key input factors sorted in 11 process groups affecting the contract administration performance or an alternative short model mode with only 33 key input factors to save the data gathering and entry time. The data are simply entered through sliding bars, and the output is represented by the performance indices table, bar, radar, and pie charts. The end-user may decide to enter a certain benchmark value or let the application base the performance benchmark on the overall performance level. A brief of using the CAPM mobile app was demonstrated. For any type of construction project at any stage of the post-award phase, CAPM could be used as a tool to assess the contract administration performance by rating the degree of implementation/ conformance of the applicable indicators on 0 to 100 scale. The model's output quantifies the level of performance in 11 CCA process groups and the overall performance as well. Thus, the CCA organization will be able to identify the performance level for each process group, benchmark the whole performance level, and capture the CCA staff performance. Furthermore, comparing the performance level for the individual process groups will lead to identify the strength and weaknesses of CCA implementations and initiate an improvement program for low performed areas. The proposed model was practically implemented in 13 construction projects, and the ability of CAPM to capture the performance levels of different projects was demonstrated.

At the process group level and from the outcome of the analysis and key findings of this research, the authors would draw the attention of the contract administration team to the ranking of the constructs. The study showed that G03-communication & relationship was ranked as 1^{st} construct with a relative weight value of 0.0945. G05-Performance monitoring & reporting was ranked as 2^{nd} construct with a relative weight value of 0.0931. G04-Quality & acceptance and G06-Document & record were ranked as 3 constructs with a relative weight value of 0.0926. Therefore, these 4 constructs are being the most significant process groups affecting CCA performance. On the contrary, G11-Contract Close-Out Management was ranked as the least significant construct with a relative weight value of 0.0867 and then followed by G10-Contract Risk Management with a relative weight value of 0.087. To avoid any doubt, the deviation from the average relative weights of the different constructs are within 5 %, and therefore, all constructs are considered significant and contribute to the CCA analysis.

At the indicators level, the study recommended that management should focus on activities such as F10.02-Assignment of contractual risk responsibility, F10.03-Providing support to the Employer for design risks, F06.01-Establishing a document management system, F06.03-Maintaining updated project documentation with registers, F06.04-Supporting the project stakeholders with regular statistics, F10.04-Monitoring the Contractor's financial status and bankruptcy potential, F08.05-Proper processing of the change orders on approved change requests, F10.01-Periodically assessing the contractual risks with help of the contractor and F08.02-Prompt evaluation of Contractor's proposals for changes inclusive value engineering as the most significant variables (indicators) affecting CCA performance.

The results of implementing the CAPM in 13 construction projects revealed that the maximum absolute deviation of the short model was only 3.9 %, while the average deviation was only 1.8 %. This indicates that the short model can capture the overall CCA performance with reasonable accuracy.

The study has developed a set of 30 recommendations to improving the practice of 30 top key CCA tasks carried out by CCA and short recommendations to the employer and the contractor to cooperate and coordinate closely with CCA.

This study contributes to the knowledge of construction management in three main aspects. Firstly, the research highlighted the underlying factors contributing to contract administration performance in construction projects by introducing the global view of a systematic, operational, and multi-dimensional model. Secondly, the reliable analytical tool implemented within this study would be able to abstract CCA performance by a single indicator. To the researcher's best of knowledge, this is the first multi-definitional fuzzy-SEM model that supports the contracting parties to assess the construction contract administration performance. Thirdly, the detailed methodology implemented to explore the importance of indicators through different consensus measures could be used to explore the important factors in other research areas.

In practice, The CAPM can be used as a qualitative tool or guideline for the establishment of CCA management system, audit checklist for service compliance, and a vehicle to initiate an improvement project to enhance the low performed areas within the CCA process groups. Also, CAPM can be used quantitively as a performance measurement tool in order to capture the overall service performance and capture the performance level of individuals. CAPM will provide a reliable tool that will help to increase operational efficiency and effectiveness, minimize contractual problems, improve project control and trace staff performance at the successive stages of the post-awarding phase through improved compliance, awareness, visibility, monitoring and control over the contract administration activities. Therefore, management control of these activities would reduce problems in CCA and decrease disputes that may be generated from the improper performance of those activities. Furthermore, the outcomes of the proposed assessment model could benefit the CCA firm, the employer, and the contractor involved in multiple projects to be able to compare and benchmark the CCA performance of different projects and to be able increasing the likelihood of implementing a proper contract administration procedure in their projects. Implementing those factors are appropriate given that those factors cover the basic construction contract administration activities for most typical construction projects, and the applicability of those factors has been recognized by industry professionals.

Monitoring the contract administration tasks through a systematic and measurable way will allow focusing on specific outcomes, directing resources properly, improving control, increasing staff accountability, providing performance information, and feedbacks.

Finally, contract administration increases the potential for successful project completion. This can be achieved by effective and systematic contract administration procedures.

10.5 LIMITATION AND FUTURE RESEARCH

Some limitations have been identified in this study. First, the identified factors are extracted from the post-awarding phase of design-bid-build contracts (conventional forms of contract). Second, the practical implementation of the model was adopted in only 13 construction projects, and the benchmarked values were derived from those limited projects. Third, full validation has not yet been possible. This would be possible after a clear definition of the rubric for scoring each factor.

Future researches may include:

1. Model Elements: The model may be modified for non-standard forms of contracts. Also, future studies would focus on different phases of the project and different contract types such as design-build, and public-private partnerships, etc.
2. CCAPI formulation: Academia may be able to use the proposed framework as a baseline for further researches to quantify the overall performance of the CCA using other precise analytical tools and techniques (Adaptive Neuro-Fuzzy Inference System (ANFIS), Fuzzy NeuroNetwork (FNN), Fuzzy Analytic Hierarchy Process (FAHP), Artificial Neural Networks (ANN)). Also, different membership functions can be investigated.
3. Software development: A web enterprise version can be developed to measure the CCA performance, benchmark the CCA performance, or develop running charts for CCA performance.
4. Although the study provided very basic guidelines for item rating, future studies may develop detailed performance matrices and KPIs to measure the degree of implementation /conformance of CCA activities in either scale between 0 and 100 or 5 points Likert scale (very poor, poor, average, good, and excellent). A clear guide on how to objectively score factors could be developed. This way, a systematic process/rubric for the scoring could be developed, and calibration between different assessors would be established. This will ensure consistency amongst the raters, improve the results' quality among different projects.

5. Nation-wide performance measurement program to identify CCA strength and weakness areas for the sake of changing the current practices, re-structure contract risk, or change legal framework.

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APPENDIX A: **CCA CHALLENGES & ISSUES**

Table A.1: CCA challenges & issues

SN	Factor	Authors
1	Overall procurement strategy & practices	Akoa (2011); Ernest (2013); Oluka and Basheka (2014)
2	Form of contract selection	Baloi and Price (2003); Ting and Whyte (2009)
3	General conditions of contract selection	Ting (2013); Sadek (2016); Ssegawa-Kaggwa (2008)
4	In-appropriate contract type	Akoa (2011); Al Hammadi (2009) ; Alzara et al. (2016); Yap (2013); Ntiyakunze (2011); Nyarko (2014); Obaju (2012); Shen et al. (2017); Ting (2013)
5	Contractor selection	Akoa (2011); (Pooworakulchai et al. 2017)
6	Weak legal framework to blacklist inefficient firms	Oluka and Basheka (2014); Surajbali (2016)
7	Separate design and construction phases	Sebastian and Davison (2011)
8	Growing project complexity	Sweis et al. (2014); Sebastian and Davison (2011)
9	Transparency	Ahmed (2015)
10	Administration budget allocation / constraints	Ahmed (2015); Kerzner (2013); Surajbali (2016); Sertyesilisik (2010); Ting (2013)
11	employers' priorities and expectations	Alzara et al. (2016); Kerzner (2013); Ntiyakunze (2011); Nyarko (2014); Sebastian and Davison (2011)
12	Project objectives	Alzara et al. (2016); Kerzner (2013); Ntiyakunze (2011); Nyarko (2014); Sebastian and Davison (2011)
13	Timeline constraints	Kerzner (2013); Rendon (2010); Joyce (2014)
14	Time to appoint a contract administrator	Baloi and Price (2003); Ting (2013); Kayastha (2014)
15	Low consultancy fee	Ntiyakunze (2011); Nyarko (2014)
16	Intervention of employer to change standard conditions / Inference in operations	Al Hammadi (2009) ; Alzara et al. (2016); Callahan (2010); Kerzner (2013); Klee et al. (2015); Obaju (2012); Sweis et al. (2014)
17	Unrealistic contract duration imposed by employer (project or Tender duration)	Akoa (2011); Al Hammadi (2009); Alzara et al. (2016); Baloi and Price (2003); Nyarko (2014); Ntiyakunze (2011)
18	Public interruption	Yap (2013); Kerzner (2013); Nyarko (2014)
19	Inexperienced employee	Yap (2013); Kerzner (2013)
20	Incompetent consultants	Akoa (2011); Yap (2013); Sweis et al. (2014)
21	Faulty tender process / information	Ernest (2013); Yap (2013); Kerzner (2013)
22	Site acquisition problems	Yap (2013)

Table A.1: CCA challenges & issues (continued)

SN	Factor	Authors
23	Mistakes by employer	Klee et al. (2015)
24	Pressure from the higher authority to award the contract to a specific contractor and Coercions	Ahmed (2015); Obaju (2012)
25	Low legal protection for project staff	Ahmed (2015)
26	Flexibility with regulations is too burdensome	Oluka and Basheka (2014)
27	Deficiencies in contacts	Sertyesilisik (2010); Abedi et al. (2011)
28	Unbalance modification in standard forms	Sertyesilisik (2010)
29	Difficult terms	Bent and Thumann (1994)
30	Unclear scopes / Mistakes in scope	Alzara et al. (2016); Davison et al. (2012); Joyce (2014); Henriod and Le Masurier (2002); Yap (2013); Obaju (2012); (Pooworakulchai et al. 2017); Shen et al. (2017); Ting and Whyte (2009)
31	Design issues/ Incomplete design/ documentation/ lack of adequate design	Abedi et al. (2011); Abusafiya and Suliman (2017); Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Callahan (2010); Henriod and Le Masurier (2002); Ernest (2013); Yap (2013); Kerzner (2013); Memon and Rahman (2013); Nyarko (2014); Obaju (2012); (Pooworakulchai et al. 2017); Salwa (2017); Sertyesilisik (2007)
32	Issue further drawings/ Information to the contractor	Al Hammadi (2009) ; Callahan (2010); Cunningham (2016); Obaju (2012); Sertyesilisik (2007)
33	Unclear documents/ ambiguities/ Internally conflicting documents /Incorrect details (contract/drawings/specifications) / Consistency/ Multiple meanings between specification and drawings	Abotaleb and El-adaway (2017); Akoa (2011); Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Alaghbari et al. (2007); Alzara et al. (2016); ; Henriod and Le Masurier (2002); Kerzner (2013); Ntiyakunze (2011); Nyarko (2014); Obaju (2012);Salwa (2017); Sertyesilisik (2007); Ssegawa-Kaggwa (2008); Sweis et al. (2014); Ting (2013); Ting and Whyte (2009)
34	Poor documentation systems	Kerzner (2013); Henriod and Le Masurier (2002)
35	Specification changes	Al Hammadi (2009) ; Alaghbari et al. (2007); Alzara et al. (2016); Okere (2012)
36	Errors or omissions in drawings or specifications or in bill of quantities	Abotaleb and El-adaway (2017); Abusafiya and Suliman (2017); Al Hammadi (2009); Alzara et al. (2016); Callahan (2010); Henriod and Le Masurier (2002); Memon and Rahman (2013); Ntiyakunze (2011); Nyarko (2014); Obaju (2012); Oluka and Basheka (2014); Sertyesilisik (2007); Shen et al. (2017); Surajbali (2016); Sweis et al. (2014)
37	Target high-quality requirement / perfection	Kerzner (2013); Okere (2012)
38	Improper address of statutory or requirement	Bent and Thumann (1994)
39	Inadequate management skills	Ahmed (2015); Alzara et al. (2016); Kerzner (2013); Oluka and Basheka (2014)

Table A.1: CCA challenges & issues (continued)

SN	Factor	Authors
40	Insufficient number of staff/workers	Abusafiya and Suliman (2017); Al Hammadi (2009) ; Alaghbari et al. (2007); Alzara et al. (2016); Callahan (2010); Kerzner (2013); Memon and Rahman (2013); (Pooworakulchai et al. 2017); Ssegawa-Kaggwa (2008); Yusuwan and Adnan (2013)
41	Structured and organized roles and responsibilities	Baloi and Price (2003); Yap (2013); Kerzner (2013); (Pooworakulchai et al. 2017); Surajbali (2016); Puil and Weele (2014)
42	Workloads	Abusafiya and Suliman (2017); Alzara et al. (2016); Kerzner (2013); Ssegawa-Kaggwa (2008); Ting (2013); Yusuwan and Adnan (2013);
43	Lack of understanding (i.e. project management, procurement processes; of Basic Construction Law Concepts, interpretation of documents and drawings)	Ahmed (2015); Baloi and Price (2003); Henriod and Le Masurier (2002); Rendon (2010); Sertyesilisik (2007); Yusuwan and Adnan (2013)
44	Request additional tasks	Pooworakulchai et al. (2017)
45	Personality & team conflicts	Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Alzara et al. (2016); Callahan (2010); Davison et al. (2012); Haidar (2011); Kerzner (2013); Ntiyakunze (2011); Ting (2013)
46	Awareness of contract provisions	Kasiem (2008)
47	Contract administrator experience & attitude	Ahmed (2015); Baloi and Price (2003); Kerzner (2013); Rendon (2010)
48	Understand, comply with & respect contract	Harris (2013); Ernest (2013); Okere (2012)
49	Contractor-employer relations	Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012)
50	Incompatible parties / Cultural differences/ Language difference	Abusafiya and Suliman (2017); Al Hammadi (2009) ; Alzara et al. (2016); Bent and Thumann (1994); Yap (2013); Ntiyakunze (2011); Nyarko (2014); Sertyesilisik (2007); Ting (2013)
51	Arrogance, condescension or intransigence by consultant/ employer	Henriod and Le Masurier (2002)
52	Misuse of employer authority/ document	Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Obaju (2012); Surajbali (2016)
53	Adversarial industry culture & Structure	Ntiyakunze (2011); Nyarko (2014); Ssegawa-Kaggwa (2008)
54	Working norms	Ntiyakunze (2011); Nyarko (2014)
55	Lack of cooperation	Al Hammadi (2009) ; Alzara et al. (2016); Yap (2013); Klee et al. (2015); Salwa (2017); Rendon (2010); Joyce (2014)
56	Misinterpretation of contract information	Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Ntiyakunze (2011); Nyarko (2014); Obaju (2012); Park and Kim (2018); Sertyesilisik (2007)

Table A.1: CCA challenges & issues (continued)

SN	Factor	Authors
57	Inflexibility & Attitude	Alzara et al. (2016); Rendon (2010); Joyce (2014); Yusuwan and Adnan (2013)
58	A lack of Understanding by Certifiers as to their true Functions and Obligations	Henriod and Le Masurier (2002)
59	Corruption	Ahmed (2015); Henriod and Le Masurier (2002); Joyce (2014); Kasiem (2008); Oluka and Basheka (2014); Rendon (2010)
60	Constraints on the activities of design consultants and certifiers through attempted cost savings	Henriod and Le Masurier (2002)
61	Qualification, skills, experience & adequate resources	Abusafiya and Suliman (2017); Ahmed (2015); Akoa (2011); Al Hammadi (2009); Alaghbari et al. (2007); Alzara et al. (2016); Baloi and Price (2003); Henriod and Le Masurier (2002); Yap (2013); Kerzner (2013); Memon and Rahman (2013); Ntiyakunze (2011); Nyarko (2014); Ssegawa-Kaggwa (2008); Ting (2013); Yusuwan and Adnan (2013)
62	Training of the staff with relevant knowledge	Ahmed (2015); Alaghbari et al. (2007); Alzara et al. (2016); Baloi and Price (2003); ; Ernest (2013); Ntiyakunze (2011); Nyarko (2014); Sertyesilisik (2007); Puil and Weele (2014)
63	Negligence	Akoa (2011); Ntiyakunze (2011); Nyarko (2014); Ting (2013)
64	Differences in evaluation methods	Akoa (2011); Nyarko (2014); Ssegawa-Kaggwa (2008)
65	Bad faith by the employer	Klee et al. (2015)
66	Lack of incentives for the procurement professionals	Ahmed (2015); Alzara et al. (2016); Abusafiya and Suliman (2017); Al Hammadi (2009) ; Baloi and Price (2003); Callahan (2010); Doloi (2013); Yap (2013); Kerzner (2013); Memon and Rahman (2013); Sertyesilisik (2007); Surajbali (2016); Puil and Weele (2014)
67	Poor contract management/ process integrity	Baloi and Price (2003); Oluka and Basheka (2014); Ssegawa-Kaggwa (2008)
68	Poor planning	Abusafiya and Suliman (2017); Al Hammadi (2009) ; Alzara et al. (2016); Callahan (2010); Yap (2013); Kerzner (2013); Memon and Rahman (2013);Pooworakulchai et al. (2017); Rendon (2010)
69	Project control problems	Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Al Hammadi (2009); Yap (2013)
70	Coordination & coordinating ability of consultant/administrator with employer's representatives	Abusafiya and Suliman (2017); Al Hammadi (2009); Alaghbari et al. (2007); Alzara et al. (2016); Baloi and Price (2003); Bent and Thumann (1994); Callahan (2010); Memon and Rahman (2013); Sertyesilisik (2007); Sweis et al. (2014); Ting (2013)
71	Poor administration & Bureaucratic procedure	Abotaleb and El-adaway (2017); Al Hammadi (2009) ; Al Jurf and Beheiry (2012); Alzara et al. (2016); Arcadis (2017); Callahan (2010); Doloi (2013); Ernest (2013); Yap (2013); Kasiem (2008); Kerzner (2013); Yap (2013); Kim (2015); Ntiyakunze (2011); Nyarko (2014)

Table A.1: CCA challenges & issues (continued)

SN	Factor	Authors
72	Monitoring and feedback process	Abusafiya and Suliman (2017); Akoa (2011); Al Hammadi (2009) ; Baloi and Price (2003); Ernest (2013); Yap (2013); Kerzner (2013); Kim (2015); Memon and Rahman (2013); Ntiyakunze (2011); Nyarko (2014); Oluka and Basheka (2014); Surajbali (2016)
73	Delay in passion to site	Akoa (2011) ; Al Hammadi (2009) ; Alzara et al. (2016); Callahan (2010); Obaju (2012); Salwa (2017); Sertyesilisik (2010)
74	Delays in site preparation	Sweis et al. (2014)
75	Work suspension by the employer	Al Hammadi (2009); Alzara et al. (2016); Callahan (2010); Salwa (2017); Sweis et al. (2014)
76	Inadequate supervision	Abusafiya and Suliman (2017); Alzara et al. (2016); Henriod and Le Masurier (2002); Memon and Rahman (2013); Ssegawa-Kaggwa (2008); Surajbali (2016); Ting (2013)
77	Financial constraints, difficulties, resources	Ting (2013); Okere (2012); Yap (2013)
78	Shortage of integration	Sebastian and Davison (2011)
79	Shortage of effective communication/ Non-adherence of communication procedures set, Ineffective means of communication and Lack of communication procedures	Abedi et al. (2011); Abusafiya and Suliman (2017); Akoa (2011); Al Hammadi (2009) ; Alzara et al. (2016); Bent and Thumann (1994); Ernest (2013); Henriod and Le Masurier (2002); Yap (2013); Kerzner (2013); Kim (2015); Memon and Rahman (2013); Ntiyakunze (2011); Nyarko (2014); Sebastian and Davison (2011); Sertyesilisik (2010); Surajbali (2016); Ting (2013)
80	The poor relationship among project team	Yap (2013); Oluka and Basheka (2014)
81	Deliberate blockage of information flow	Abusafiya and Suliman (2017); Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Memon and Rahman (2013); Ntiyakunze (2011); Nyarko (2014)
82	The speed of decision making	Abusafiya and Suliman (2017); Ahmed (2015); Al Hammadi (2009); Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Alaghbari et al. (2007); Alzara et al. (2016); Baloi and Price (2003); Kayastha (2014); Kerzner (2013); Memon and Rahman (2013); (Pooworakulchai et al. 2017); Sweis et al. (2014); Puil and Weele (2014)
83	Poor change management	Al Hammadi (2009) ; Alzara et al. (2016); Kerzner (2013); Park and Kim (2018)
84	Change order	Abedi et al. (2011);Al Jurf and Beheiry (2012); Baloi and Price (2003); Callahan (2010); Davison et al. (2012); Haidar (2011); Yap (2013); Nyarko (2014); Ntiyakunze (2011); Pooworakulchai et al. (2017); Sertyesilisik (2007); Shen et al. (2017); Sweis et al. (2014); Ting (2013)

Table A.1: CCA challenges & issues (continued)

SN	Factor	Authors
85	Design Changes	Abedi et al. (2011); Abusafiya and Suliman (2017); Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Baloi and Price (2003); Memon and Rahman (2013); Ntiyakunze (2011); Nyarko (2014); Obaju (2012); Sertyesilisik (2007)
86	Frequency & excessive use of variations and unnecessary changes	Abotaleb and El-adaway (2017); Alzara et al. (2016); Arcadis (2017); Ayarkwa et al. (2014); Baloi and Price (2003); Farooqui et al. (2014); Love et al. (2007); Nyarko (2014); Okere (2012); Salwa (2017); Sweis et al. (2014)
87	Budget changes / Cash flow changes	Abusafiya and Suliman (2017); Ahmed (2015); Al Hammadi (2009); Alzara et al. (2016); Baloi and Price (2003); Sertyesilisik (2010)
88	Late issue of instructions	Alaghbari et al. (2007); Cunningham (2016); Obaju (2012); Salwa (2017)
89	Change of materials requirement	Okere (2012);
90	Statutory amendments	Rendon (2010); Joyce (2014)
91	Delay	Abusafiya and Suliman (2017); Al Hammadi (2009) ; Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Alaghbari et al. (2007); Alzara et al. (2016); Ayarkwa et al. (2014); Callahan (2010); Davison et al. (2012); Haidar (2011); Maki (2016); Memon and Rahman (2013); Obaju (2012); Salama et al. (2008); Sertyesilisik (2007); Surajbali (2016)
92	Slow response to contractor inquiries by the consultant	Al Hammadi (2009) ; Kerzner (2013); Sweis et al. (2014); Ting (2013)
93	Approvals delays	Abusafiya and Suliman (2017); Akoa (2011); Al Hammadi (2009); Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Alzara et al. (2016); Memon and Rahman (2013); Nyarko (2014); Salwa (2017); Sertyesilisik (2007); Sweis et al. (2014)
94	Construction techniques	Pooworakulchai et al. (2017)
95	Disputes	Abotaleb and El-adaway (2017); Abedi et al. (2011); Akoa (2011); Alzara et al. (2016); Ayarkwa et al. (2014); Jarkas and Mubarak (2016); Arcadis (2017); Davison et al. (2012); Haidar (2011); Yap (2013); Farooqui et al. (2014); Love et al. (2007); Obaju (2012); Oluka and Basheka (2014); Sertyesilisik (2007)
96	Poor estimations and cash flow projections.	Abusafiya and Suliman (2017); Ahmed (2015); Akoa (2011); Al Hammadi (2009) ; Alzara et al. (2016); Callahan (2010); Henriod and Le Masurier (2002); Yap (2013); Memon and Rahman (2013); Ntiyakunze (2011); Nyarko (2014)
97	Progress rate	Sertyesilisik (2010)
98	Tracking global contracts	Rendon (2010); Joyce (2014)

Table A.1: CCA challenges & issues (continued)

SN	Factor	Authors
99	Identify contract activities	Ting (2013)
100	Contract administration manual & procedures	Al Hammadi (2009); Oluka and Basheka (2014); Yusuwan and Adnan (2013)
101	Control and status meetings	Alzara et al. (2016); Baloi and Price (2003)
102	Insufficient attention paid to programming and scheduling	Akoa (2011); Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Alzara et al. (2016); Henriod and Le Masurier (2002); Yap (2013); Obaju (2012)
103	Constructors' faults/ defects	(Abedi et al. 2011); Abusafiya and Suliman (2017); Alaghbari et al. (2007); Callahan (2010); ; Memon and Rahman (2013); (Pooworakulchai et al. 2017); Salwa (2017)
104	Definition of acceptance	Davison et al. (2012); Haidar (2011)
105	The slow response towards inspection and testing of completed projects	Akoa (2011); Al Hammadi (2009); Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Alzara et al. (2016); Callahan (2010); Salwa (2017); Sweis et al. (2014)
106	Poor quality	Al Hammadi (2009) ; Alzara et al. (2016); Yap (2013); Kerzner (2013); Ntiyakunze (2011); Nyarko (2014)
107	Incompetent contractor/ Subcontractor's performance	Abusafiya and Suliman (2017); Al Hammadi (2009) ; Alzara et al. (2016); Davison et al. (2012); Haidar (2011); Yap (2013); Kerzner (2013); Kim (2015); Memon and Rahman (2013)
108	Rework due to design errors/others	Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Alzara et al. (2016); Sertyesilisik (2007)
109	Improper/ defective material, workmanship or execution	Sertyesilisik (2010)
110	Care of execution of work	Sertyesilisik (2010)
111	Cost overrun	Abusafiya and Suliman (2017); Adindu and Oyoh (2011); Akoa (2011); Alzara et al. (2016); Awwad et al. (2016); Farooqui et al. (2014); Memon and Rahman (2013); Nyarko (2014); Ntiyakunze (2011); Obaju (2012); Oluka and Basheka (2014); Surajbali (2016); Salwa (2017)
112	Profit margins	Abotaleb and El-adaway (2017); Arcadis (2017); Ayarkwa et al. (2014); Farooqui et al. (2014); Love et al. (2007); Okere (2012); Nyarko (2014); Ntiyakunze (2011)
114	Tendency of contractor claiming high prices / Excessive claims made by the contractor	Ntiyakunze (2011); Nyarko (2014)
115	Poor safety management on site	Callahan (2010); Yap (2013)
116	Poor submission by the contractor	Yusuwan and Adnan (2013)
117	Late submission	Yusuwan and Adnan (2013)

Table A.1: CCA challenges & issues (continued)

SN	Factor	Authors
118	Collection of relevant facts	Yusuwan and Adnan (2013)
119	Claims in general	Abusafiya and Suliman (2017); Akoa (2011); Ayarkwa et al. (2014); Memon and Rahman (2013); Nyarko (2014); Sertyesilisik (2007); Sweis et al. (2014); Ting (2013)
120	Lack of effectiveness of the claim procedure	Al Hammadi (2009); Alzara et al. (2016); Klee et al. (2015); Obaju (2012); Sertyesilisik (2007); Sweis et al. (2014)
121	Insufficient use ICT	Rendon (2010); Joyce (2014)
122	Poor record keeping	Ahmed (2015); Kerzner (2013)
123	Data management	Rendon (2010); Joyce (2014); Yusuwan and Adnan (2013)
124	Inadequate contract provisions for enforcement/procedures of timely payments	Nyarko (2014)
125	Delayed payments/ lead time	Abotaleb and El-adaway (2017); Abusafiya and Suliman (2017); Ahmed (2015); Al Hammadi (2009); Al Jurf and Beheiry (2010); Al Jurf and Beheiry (2012); Alzara et al. (2016); Callahan (2010); Ernest (2013); Yap (2013); Memon and Rahman (2013); Ntiyakunze (2011); Nyarko (2014); Obaju (2012); Salwa (2017); Sertyesilisik (2007); Shen et al. (2017); Ssegawa-Kaggwa (2008); Sweis et al. (2014); Ting (2013); Puil and Weele (2014)
126	Pay due amount	Cunningham (2016); Abotaleb and El-adaway (2017)
127	Bureaucratic/ Improper payment procedures	Abotaleb and El-adaway (2017); Akoa (2011); Ernest (2013); Nyarko (2014); Okere (2012); Rendon (2010)
128	Funding Terms which can strain or jeopardize the certification process	Henriod and Le Masurier (2002)
129	Unavailable funds	Nyarko (2014); Okere (2012); Sertyesilisik (2007); Surajbali (2016); Sweis et al. (2014)
130	Valuation of final account	Abotaleb and El-adaway (2017)
131	The late release of retention money	Abotaleb and El-adaway (2017); Obaju (2012)
132	Withholding/cutting payments without a contractual basis	Abotaleb and El-adaway (2017)
133	Payment of variations	Abotaleb and El-adaway (2017); Alzara et al. (2016)
134	Uncertainty in construction	Sebastian and Davison (2011)
135	Changeable environment	Sebastian and Davison (2011)

Table A.1: CCA challenges & issues (continued)

SN	Factor	Authors
136	Economic changes and Unforeseen bad economic conditions	Abusafiya and Suliman (2017); Ahmed (2015); Akoa (2011); Al Hammadi (2009) ; Alzara et al. (2016); Yap (2013); Memon and Rahman (2013); Obaju (2012); Sebastian and Davison (2011)
137	Increased cost	Davison et al. (2012); Haidar (2011)
138	High risk of failure	Davison et al. (2012); Haidar (2011)
139	Unclear risk allocation	Yap (2013); Ntiyakunze (2011); Nyarko (2014); Sertyesilisik (2007); Shen et al. (2017)
140	Unforeseen, Site & weather conditions, problems (soil investigation)	(Abedi et al. 2011); Abusafiya and Suliman (2017); Ahmed (2015); Akoa (2011); Al Hammadi (2009) ; Alaghbari et al. (2007); Callahan (2010); Henriod and Le Masurier (2002); Yap (2013); Ntiyakunze (2011); Nyarko (2014); Obaju (2012); Salwa (2017); Shen et al. (2017)
141	Lack permit & information from regulatory authorities	Akoa (2011); Al Hammadi (2009) ; Alaghbari et al. (2007); Alzara et al. (2016); Callahan (2010); Ntiyakunze (2011); Nyarko (2014); Salwa (2017)
142	Insufficient project feasibility studies	Yap (2013)
143	Fraudulent practices and briberies/ Unfair practices of the contract Administrator	Abusafiya and Suliman (2017); Ahmed (2015); Akoa (2011); Alzara et al. (2016); Henriod and Le Masurier (2002); Yap (2013); Surajbali (2016); Puil and Weele (2014)
144	Litigation	Yap (2013); Surajbali (2016)
145	Unfavorable government policy	Abusafiya and Suliman (2017); Callahan (2010); Yap (2013); Kerzner (2013)
146	Too many participants involved	Akoa (2011); Al Hammadi (2009) ; Alzara et al. (2016); Yap (2013); Kerzner (2013); Ting (2013)
147	Adverse weather or acts of God	Yap (2013)
148	Political pressure	Abusafiya and Suliman (2017); Ahmed (2015); Akoa (2011); Kerzner (2013); Kim (2015); Oluka and Basheka (2014); Shen et al. (2017); Puil and Weele (2014)
149	Strike/ blockage/ delays in port	Ahmed (2015)
150	Compliance with regulations, and statuses	Al Hammadi (2009); Alaghbari et al. (2007); Oluka and Basheka (2014)
151	Material/ equipment procurement, availability	Abusafiya and Suliman (2017); Ahmed (2015); Akoa (2011); Al Hammadi (2009) ; Alaghbari et al. (2007); Alzara et al. (2016); Callahan (2010); ; Yap (2013); Oluka and Basheka (2014)
152	Contract completion date (definition, adjustment provisions; achievement)	Akoa (2011); Alzara et al. (2016); Obaju (2012); Sertyesilisik (2007)
153	Productivity rate	Abusafiya and Suliman (2017); Alaghbari et al. (2007); Alzara et al. (2016); Memon and Rahman (2013); Sertyesilisik (2007)
154	Verbal instructions in written	Obaju (2012)

APPENDIX B: **DELPHI STUDY- FIRST ROUND QUESTIONNAIRE**

Email to Participant

Subject: Invitation to Participate in a Process- Post-award Construction Contract Administration

It is our honor to invite you to participate in one of the validation phases of our ongoing research titled "***Post-award Construction Contract Administration Performance Measures in Construction Projects***." Your responses and information collected in this study will be treated **confidentially**. In this Phase, the researcher uses the "Delphi technique" to obtain a consistent consensus of qualified and carefully selected experts as follows:

- **Participants Round I:** This starts with a preliminary questionnaire where participants are requested to edit, rate, give feedback on, and comment upon the applicability and implementation of the questions/ factors listed. Summary statistics will be calculated from this round.
- **Participants Round II:** Comments, if any, from the previous round along with the summary statistics will be provided, and participants are requested to review their previous response and modify as appropriate.
- **Participants Round III:** Rounds will continue till consensus is obtained, or there is no improvement in response.

As a practitioner who possesses extensive experience in construction and contract administration, you are an ideal expert to communicate with us your important opinions and ideas. For round 1:

1. Please rate each item on the scale provided based on your own opinion.
2. Kindly explain, and comment on your answers, as appropriate.
3. Kindly add a very important factor or group which we may have missed.
4. Kindly return your response **within two weeks**.

APPENDIX C: **DELPHI STUDY- SECOND ROUND QUESTIONNAIRE**

Subject: Post-award Construction Contract Administration- Participant Second Round

It is our honor to invite you to participate in one of the validation phases of our ongoing research titled "***Post-award Contract Administration Performance Measures in Construction Projects***." Your responses and information collected in this study will be treated **confidentially**. In this Phase, the researcher uses the "Delphi technique" to obtain a consistent consensus of qualified and carefully selected experts as follows:

1. **Participants Round I:** This starts with a preliminary questionnaire where participants are requested to edit, rate, give feedback on, and comment upon the applicability and implementation of the questions/ factors listed. Summary statistics will be calculated from this round.
2. **Participants Round II:** Comments, if any, from the previous round along with the summary statistics will be provided, and participants are requested to review their previous response and modify as appropriate.
3. **Participants Round III:** Rounds will continue till consensus is obtained, or there is no improvement in response.

As a practitioner who possesses extensive experience in construction and contract administration, you are an ideal expert to communicate with us your important opinions and ideas. For round 2:

1. Please read the summary feedback collected from all participants in the previous round (**in below**).
2. Please compare your previous response with the other expert's overall mean and re-rate each item in **Column E** "Current Round Importance on Performance" on the scale provided. You are free to change your previous response or revise it based on your own opinion.
3. 11 new factors are identified from the previous round, and you are kindly requested to rate it.
4. Kindly explain, defend, and comment on your answers as appropriate.
5. Kindly return your response **within 2 weeks**.

Hesham Ahmed
Engineering Management Program
College of Engineering, Qatar University

Part-2: Construction Contract Administration Performance Model

Dear Participant;

11 categories and **93** factors that affect contract administration performance are listed below. Please, select the suitable **Importance Level** on "**Post-award Construction Contract Administration (CCA) Performance.**"

Importance of event
1 = Not at all important
2 = Slightly important
3 = Moderately important
4 = Very important
5= Extremely important

Example*: "Project management plan established by the contract administration team" has a very significant impact on the overall contract administration functions. Therefore, the project management plan is* ***extremely important*** *(value:****5****) on contract administration performance.*

NOTE1: We have added 3 blank rows under each group for you to add a very important Factor which we may have missed.

NOTE2: ***All factors*** *within the context of this survey are carried out by* ***CCA team members.***

Group 1: Project Governance and Start-up

This group covers the governance of the project, review the contractor's systems and other activities related to starting up a contract.

Sn	Factor & Feedback	A	B	C	Comments
1	Establishment of an overall project management plan (PMP). *(Clear objective /This is one of the most important functions)*	5			
2	Review of the contractor's quality management plan. *(This must be in line with the CCA quality plan of the project)*	5			
3	Review of contractor's health, safety, and security plan.	5			
4	Review of contractor's environmental management plan.	4			
5	Review of the contractor's baseline programme.	5			
6	Review of the contractor's proposed key staff. *(Technically accepted contactor supposed to have qualified staff)*	4			
7	Review of the proposed subcontractor(s) qualifications.	4			
8	Project kick-off meeting to discuss the contract with related parties. (A mandatory item)	5			
9	Support the employer in the review of contract securities (bonds and insurances).	4			

Sn	Factor & Feedback	A	B	C	Comments
10	Support the employer in handing over the project to the contractor. (A mandatory item / It depends on the client's requirements)	5			
11	Support the employer in appointing nominated subcontractor(s). *(Vendor list is provided by various consultants, nominated subcontractors are upon the instructions of the client in rare cases)*	5			
12	Removal of any personnel intentionally violating the project requirements. *(Since its intentionally, he should be removed from the site but if violation due to unawareness, training, and development should be in place)*	5			
13	Review the contractor's Logistics plan. *(NEW)*	--			
14	Review the contractor's proposed laboratory. *(NEW)*	--			
15	Avoid bureaucracy and lengthy process. *(NEW)*	--			

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance

Group 02: Contract Administration Team Management

This group covers the formation of the contract administration team, assignment of roles & responsibilities, staff evaluation, and training.

Sn	Factor & Feedback	A	B	C	Comments
1	Assignment of technically competent CCA team. *(To ensure effectiveness and reduce or avoid any potential dispute)*	5			
2	Early assignment of the CCA team, including all relevant disciplines. *(Mandatory to ensure the effectiveness and reduce or avoid any potential dispute)*	4			
3	Clear identification of roles and responsibilities within the CCA team. *(Mandatory to ensure the effectiveness and reduce or avoid any potential dispute/ clearly defined roles are important for effective operation)*	5			
4	Training programs for the CCA team. (Assigned staff deems qualified without training / Training is required, but it's not mandatory/ Qualified team should have previous training records)	4			
5	Regular assessment of CCA team performance. *(Less important for skilled, experienced and training people/ Set KPIs for CCA Team)*	3			
6	Set Performance Dialogue for CCA Team. *(NEW)*	--			
7					
8					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance

Group 3: Communication & Relationship Management

This group covers establishment communication systems, regular communications, ways of maintaining good relationships, and coordination.

Sn	Factor & Feedback	A	B	C	Comments
1	Establishment of a communication management system. *(Clear communication reduces the time for decision making/ mandatory item / Necessary for clear & effective management)*	5			
2	Effective communication of PMP requirements to all involved parties.	5			
3	Advising the employer on its functions. *(Client normally aware of its roles: The employer should be aware of its functions)*	5			
4	Measurement of employer's satisfaction during the contract lifespan.	3			
5	Agreement between employer and CCA team for any requested changes on scope, time, or cost. *(A mandatory item/ to ensure timely completion within budget)*	5			
6	Regular meetings with employers and contractors to address issues and assign actions.	4			
7	Effective coordination with third parties. (*third parties' performance & approvals)*	5			
8	Timely response to the contractor's queries. *(A mandatory item)*	5			
9	Timely management of operational issues at field level between the contractor and CCA team. *(site coordination / critical to avoid any hindrance to the works)*	4			
10	The managing interface between contractors. *(New)*	--			
11	Clear language of communication *(NEW, stipulated in the contract).*	--			
12					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance.

Group 04: Quality & Acceptance Management

This group covers inspections, acceptance, and auditing of the contractor's works in addition to compliance with HSE and environmental requirements.

Sn	Factor & Feedback	A	B	C	Comments
1	Auditing the contractor's implementation of the quality management system. *(A mandatory item to be in line with project quality plan)*	5			
2	Timely issuance of any further supplementary information to the contractor. *(Ensure all design drawings are in place with minimum changes in the implementation / The information should be completed from the beginning of the project)*	4			

Sn	Factor & Feedback	A	B	C	Comments
3	Timely review of construction material prior to use by the contractor. *(Approval must be timely)*	4			
4	Timely review of shop drawings.	5			
5	Auditing the contractor's compliance with health, safety, and security requirements on site.	5			
6	Auditing of the contractor's compliance with environmental requirements.	4			
7	Timely inspection of the quality of work items on site. *(Effective supervision only effective when the project is handover to the employer timely)*	4			
8	Control of non-compliance works. *(A mandatory item)*	4			
9	Track corrective actions. *(NEW)*	--			
10	Managing design and design development during construction. *(New, A mandatory item)*	--			
11					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance

Group 5: Performance Monitoring & Reporting Management

This group covers CCA team reports to the employer, monitoring the contractor's indicators affecting the project performance and associated notifications to the contractor.

Sn	Factor & Feedback	A	B	C	Comments
1	Establishment of monitoring and reporting system inclusive key performance indicators. *(A mandatory item)*	5			
2	Separate reports for a major issue to keep the employer informed.	4			
3	Regular progress reports to the employer.	4			
4	Review of the contractor's reports.	4			
5	Monitoring of contractor's relationship with subcontractors. *(Maybe shifted to risk / late payment from contractor to subcontractors on time/ It is contractor obligation)*	4			
6	Monitoring of the contractor's resources, including equipment, materials, and personnel.	4			
7	Monitoring the contractor's care of the works includes the employer's provided properties.	4			
8	Notifications to the contractor for a recovery schedule when progress is slow in relation to the approved programme.	5			
9	Monitoring of contractor's arrangements to minimize public interferences.	4			
10	Notification to the contractor on failure to carry out any contractual obligation.	5			
11					
12					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance

Group 06: Document & Record Management

This group covers the critical issues with respect to document management and record-keeping system.

Sn	Factor & Feedback	A	B	C	Comments
1	Establishment of the document management system. *(A mandatory item)*	5			
2	Use of information communication technology (ICT) in administering the contract. *(Proper system is required but not so critical, some projects can be managed by a paper-based system)*	5			
3	Maintaining updated project documentation with registers. *(Recordkeeping are extremely important in disputes and claims)*	4			
4	Support project stakeholders with statistics. *(No always required)*	5			
5					
6					
7					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance.

Group 7: Financial Management

This group covers financial management and payment certification.

Sn	Factor & Feedback	A	B	C	Comments
1	Establishment of a financial management system. *(A mandatory item/ To ensure the budgeted monitoring & control)*	5			
2	Timely issuance of instructions to spend provisional sum items. *(It is more client function)*	5			
3	Timely certification of due payments. *(To manage according to the contract conditions. /Many projects suffer due to late payments)*	5			
4	Timely notification of the employer about the contractor's payments timeline & financial Status. *(Financial management is the most important function / A lot of projects suspended because of insufficient fund or poor financial management)*	5			
5	Timely assessment of the contractor's compensation for delayed payment cases.	4			
6	Advice the Employer in contingency planning/ additional funds. *(New)*	--			
7	Collect quotations for price estimates and contractor's price negotiations. *(New)*	--			
8					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance.

Group 08: Changes & Changes Control Management

This group covers the change control system and change orders.

Sn	Factor & Feedback	A	B	C	Comments
1	Establishment of a change control system. *(A mandatory item)*	5			
2	Timely evaluation of contractor's proposals for changes in inclusive value engineering.	4			
3	Suggestions for workable solutions to avoid budget increase to the employer. *(Extremely important in limited budget projects)*	5			
4	Properly notification to the contractor about urgent works required for the safety of the Works. *(A mandatory item)*	5			
5	Timely processing of change orders on change requests.	4			
6					
7					
8					

*Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Cu*rrent Round Importance on Performance.

Group 09: Claims & Disputes Resolution Management

This group covers the assessment of the contractor's claims, minimizes disputes, protects the employer's rights, and the CCA team support to the employer in legal cases.

Sn	Factor & Feedback	A	B	C	Comments
1	Establishment of a claims and dispute resolution system. *(A mandatory item/Normally covered in the Contract procedures)*	5			
2	Timely notification of the contractor about the employer's rights to claim. *(Only important when the notification is required)*	5			
3	Timely assessment of the contractor's entitlement for extension of time for completion. *(Contractual requirements)*	5			
4	Timely assessment of the contractor's entitlement for additional payment. *(Contractual requirements)*	5			
5	Effective negotiating of claims between the contractor and the employer.	4			
6	Support the contracting parties to select alternative dispute resolution methods.	4			
7	Represent the employer in alternative dispute resolution proceedings. *(A mandatory item / Employer may select other bodies to represent him/ Not required in many cases)*	4			
8	Legal support to the employer during court cases. *(Important but not so much/legal support is under the purview lawyer during litigation /Not required in many cases)*	5			
9					

Sn	Factor & Feedback	A	B	C	Comments
10					
11					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance

Group 10: Contract Risk Management

This group covers the identification of contractual risks and deals with risk events.

Sn	Factor & Feedback	A	B	C	Comments
1	Periodically assessing the contractual risks with the help of the contractor. *(Contract Risk Management is incomplete, can't see "Establish" or "Risk identification." How we can assess without establishing! Maybe re-ordering: Establish, assess, report, support, rebuild)*	4			
2	Assignment of responsibility to the relevant party for each contractual risk.	4			
3	Support employer for the risks associated with design review findings.	4			
4	Monitor the contractor's financial status and bankruptcy potential. *(New)*	--			
5					
6					
7					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance

Group 11: Contract close-out Management

This group covers the close-out process to ensure proper administrative and contractual close out of the contract. It includes unusual scenarios such as suspension and termination of the contract.

Sn	Factor & Feedback	A	B	C	Comments
1	Establishment of a close-out system. *(A mandatory item)*	5			
2	Communication of closeout activities to all stakeholders.	5			
3	Verification of physical works completion.	5			
4	Timely review of contractor's close-out documentation. *(Timely manner)*	5			
5	Timely issuance of taking-over certificate(s) with associated snags.	5			
6	Timely release of the retention upon releasing relevant certificate. *(Contractual requirements)*	5			
7	Timely approval of the return of deployment of the contractor's resources. *(Not required in many cases)*	3			

Sn	Factor & Feedback	A	B	C	Comments
8	Periodic inspections of the works during the defects notification period.	3			
9	Timely issuance of performance certificate when the contractor's obligations are fulfilled. *(Contractual requirements)*	4			
10	Documentation of lessons learned and best practices. *(A mandatory item/ Post-mortem is important for forensic analysis of the success of every project/ No effect to the Contract)*	5			
11	Timely processing contractor's final account. *(Contractual requirements)*	4			
12	Timely management of suspension of the work process. *(A mandatory item)*	5			
13	Timely management of termination of the contract process. *(A mandatory item)*	5			
14					
15					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance.

Overall Groups

Sn	Factor & Feedback	A	B	C	Comments
1	Project Governance & Start-up. *(A mandatory item)*	5			
2	Contract Administration Team Management	5			
3	Communication & Relationship Management	4			
4	Quality & Acceptance Management	4			
5	Performance Monitoring & Reporting Management. *(A mandatory item)*	5			
6	Document & Record Management. *(A mandatory item)*	5			
7	Financial Management	5			
8	Changes & Changes Control Management	5			
9	Claims & Disputes Resolution Management. *(Proper administration can lead to avoid disputes)*	5			
10	Contract Risk Management	4			
11	Contract Close-Out Management. *(A mandatory item)*	5			
12					
13					
14					

Note: A= Other Experts Rating (Mode); B= Your Previous Round Rating; and C= Current Round Importance on Performance.
If you believe that we missed an important group, please list your suggestion for an additional group and the important tasks below.

Group12:

Sn	Factor	Importance On Performance	Comments
1			
2			
3			
4			
5			

Group13:

Sn	Factor	Importance On Performance	Comments
1			
2			
3			
4			
5			

Group14:

Sn	Factor	Importance On Performance	Comments
1			
2			
3			
4			
5			

APPENDIX D: **FINAL ON-LINE QUESTIONNAIRE**

Post-Award Construction Contract Administration Performance Measures

* Required

This questionnaire has been prepared in the scope of an ongoing research study "Post-award Construction Contract Administration Performance Measures in Design-Bid-Build Projects "in the Department of Engineering Management at Qatar University. All collected information will absolutely be kept **confidential**. Thanks for your kind support.

Best Regards,

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Advisor: **Prof. Murat Gunduz**

Construction Contract Administration (CCA) is a set of activities related to management of the contract during the construction phase by a third party leading position (Contract Administrator) and CCA team assigned by the employer to ensure each parties obligation are being met under the contract, fairly and impartially. The CCA team are either in-house employees of the employer or external party such as lead consultant, design consultant, supervision consultant, project architect, and/or project management organization.

Part-1: General Information

Dear Participant;

This part consists of questions regarding you and your organization. Please select the suitable choices and fill in the blanks in the table below cells.

1. **1. Your total number of years of work experience in construction?** *

   Mark only one oval.

   - Less than or equal 5
   - (6 - 10)
   - (11 - 15)
   - (16 - 20)
   - (21 - 25)
   - More than 25

2. **2. Are you a registered professional (Authority registration, Syndicate Membership, Chartered, PE …)?** *

   Mark only one oval.

   - Yes
   - No

3. **3. Have you had special training in contract or contract administration?** *

Mark only one oval.

- Yes
- No

4. **4. Have you had certificate in contract or contract administration?** *

Mark only one oval.

- Yes
- No

5. **5. Which sector can represent your major experience?** *

Mark only one oval.

- Public
- Private
- Other: ____________________

6. **6. Which organization can represent your major experience?** *

Mark only one oval.

- Employer
- Consultant/ Designer
- Contractor
- Other: ____________________

7. **7. What is your position at your company?** *

Mark only one oval.

- Executive Manager
- Department Manager
- Project Manager
- Senior Engineer or Architect
- Quantity Surveyor
- Engineer or Supervisor
- Other: ____________________

8. **8. What are your area(s) of expertise?** *

Check all that apply.

- [ ] Engineering & Design
- [ ] Project Management
- [ ] Project Control (Cost, Planning, DC, Risk,..)
- [ ] Site Execution
- [ ] Construction Supervision
- [ ] Quality control
- [ ] Contract Management/ Admin
- [ ] Other: ____________________

9. **9. Which type of project(s) reflects your experience?** *
Check all that apply.

- [ ] Building Construction
- [ ] Infrastructure (Roads, Bridges, Railways …)
- [ ] Utilities (Water, Electricity, Sewage)
- [ ] Industrial facilities
- [ ] Other: ____________________

10. **10. Which form of contract you are familiar with?** *
Check all that apply.

- [ ] FIDIC
- [ ] JCT
- [ ] NEC
- [ ] AIA
- [ ] National Conditions
- [ ] Other: ____________________

Skip to "Part-2: Construction Contract Administration Performance Model."

Part-2: Construction Contract Administration Performance Model

Dear Participant;

11 categories and 93 factors that affect contract administration performance are listed below. All factors within the context of this survey are carried out by CCA team members. Please, select the suitable expression next to each variable taking into consideration its **Importance Level** on Contract Administration Performance.

As an example: "Project management plan established by the contract administration team" has very high impact on the overall contract administration performance. Therefore, project management plan is **extremely important** on the contract administration performance.

What's the importance of the following Factors on Contract Administration Performance?

Group 1: Project Governance and Start-up

11. **1.01 Establishment of an overall project management plan (PMP).** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

12. **1.02 Reviewing the contractor's project quality plan (PQP).** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

13. **1.03 Reviewing the contractor's health, safety and security plan.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

14. **1.04 Reviewing the contractor's environmental management plan.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

15. **1.05 Reviewing the contractor's baseline programme.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

16. **1.06 Reviewing the contractor's proposed key staff.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

17. **1.07 Reviewing the proposed subcontractor(s) qualifications.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

18. **1.08 Conducting project kick-off meeting to discuss contract with related parties.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

19. **1.09 Supporting the employer in reviewing contract securities (bonds and insurances).** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

20. **1.10 Supporting the employer in handing over project to the contractor.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

21. **1.11 Supporting the employer in appointing nominated subcontractor(s).** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

22. **1.12 Removal of any personnel intentionally violating the project requirements.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

23. **1.13 Reviewing the contractor's logistics plan.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

24. **1.14 Reviewing contractor's proposed laboratory.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

25. **1.15 Avoiding bureaucracy and lengthy process.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Group 02: Contract Administration Team Management

26. **2.01 Assignment of technically competent, qualified, and experienced CCA team.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

27. **2.02 Early assignment of CCA team including all relevant disciplines.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

28. **2.03 Clear identification of individual roles and responsibilities within the CCA team.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

29. **2.04 Establishing training, and development programs for CCA team.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

30. **2.05 Regular assessment of CCA team performance taking due note of any employer or contractor feedback / comments.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

31. **2.06 Setting out performance dialogue for CCA team.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

Group 03: Communication & Relationship Management

32. **3.01 Establishing a communication management system.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

33. **3.02 Communicating the PMP requirements to all involved parties.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

34. **3.03 Advising the employer on its functions.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

35. **3.04 Measuring the employer's satisfaction during the contract lifespan.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

36. **3.05 Agreement between employer and CCA team for any requested changes on scope, time, or cost.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

37. **3.06 Regular meetings with employer and contractor.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

38. **3.07 Effective coordination with third parties.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

39. **3.08 Prompt and accurate response to the contractor's queries in compliance with the contract procedures.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

40. **3.09 Effective management of operational issues at field level between the contractor and CCA team.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

41. **3.10 Effective management of interface among contractors.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

42. **3.11 Strict compliance with the language of communication as stipulated in the contract.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Group 04: Quality & Acceptance Management

43. **4.01 Systematic auditing of the contractor's implementation of quality management system.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

44. **4.02 Prompt issuance of any further supplementary information to the contractor.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

45. **4.03 Timely reviewing the construction material prior to use by the contractor taking due cognizance of the review cycles.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

46. **4.04 Timely reviewing the shop drawings taking due cognizance the review cycles.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

47. **4.05 Systematic auditing the contractor's compliance with health, safety, and security requirements on site.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

48. **4.06 Systematic auditing of the contractor's compliance with environmental requirements.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

49. **4.07 Systematic inspection of quality of work items on site.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

50. **4.08 Devised system of controlling rejected / non-compliant works.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

51. **4.09 Devised system for regular tracking of corrective actions.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

52. **4.10 Managing design and design development during construction.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Group 05: Performance Monitoring & Reporting Management

53. **5.01 Establishment of a monitoring and reporting system inclusive key performance indicators.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

54. **5.02 Issuing separate reports for major issues to keep the employer informed.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

55. **5.03 Regular progress reports to the employer.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

56. **5.04 Reviewing the contractor's reports.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

57. **5.05 Monitoring of contractor's relationship with subcontractors.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

58. **5.06 Monitoring of the contractor's suitability and adequacy of resources including equipment, materials, and personnel.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

59. **5.07 Monitoring the contractor care of the works including employer's provided properties.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

60. **5.08 Timely notification of the contractor for recovery schedule when progress is slow in relation to the approved programme.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	⬭	⬭	⬭	⬭	⬭

61. **5.09 Monitoring of contractor's arrangements to minimize public interference.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

62. **5.10 Notifying the contractor on failure to carry out any contractual obligation.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Group 06: Document & Record Management

63. **6.01 Establishing a document management system.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

64. **6.02 Using information communication technology (ICT) in administering the contract.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

65. **6.03 Maintaining updated project documentation with registers.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

66. **6.04 Supporting the project stakeholders with regular statistics.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Group 07: Financial Management

67. **7.01 Establishment of a financial management system.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

68. **7.02 Proper issuance of instructions to spend provisional sum items.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

69. **7.03 Fair, reasonable and equitable certification of due payments to the contractor.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

70. **7.04 Timely notifying the employer about the contractor's due payments timelines & financial status.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

71. **7.05 Assessment of the contractor's compensation for delayed payments cases in compliance with any contractual provision.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

72. **7.06 Advising the employer in contingency planning/ additional funds.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

73. **7.07 Collecting quotations for price estimates and contractor's price negotiations in respect of additional works / variations.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Group 08: Change & Changes Control Management

74. **8.01 Establishment of a change control system.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

75. **8.02 Prompt evaluation of contractor's proposals for changes inclusive value engineering.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

76. **8.03 Proposing financially viable solutions to avoid budget increase to the employer due to changes requests.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

77. **8.04 Properly notifying the contractor about urgent works required for the safety of the works.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

78. **8.05 Proper processing of the change orders on approved change requests.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Group 09: Claims & Disputes Resolution Management

79. **9.01 Establishment of a claims and disputes resolution system if not already set out in the contract.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

80. **9.02 Notifying the contractor about the employer's rights to claim.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

81. **9.03 Proper assessment of contractor's entitlement for extension of time for completion within timelines as set out in the contract.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

82. **9.04 Proper assessment of contractor's entitlement for additional payment.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

83. **9.05 Effectively negotiating claims between the contractor and the employer.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

84. **9.06 Supporting the contracting parties to select alternative dispute resolution methods if not already set out in the contract.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

85. **9.07 Representing the employer in alternative dispute resolution proceedings.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

86. **9.08 Legal support to the employer during court cases.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Group 10: Contract Risk Management

87. **10.01 Periodically assessing the contractual risks with help of the contractor.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

88. **10.02 Assignment of responsibility to the relevant party for each contractual risk expressed as a Responsibility Matrix.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

89. **10.03 Supporting the employer for the risks associated with design review findings.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

90. **10.04 Monitoring the contractor's financial status and bankruptcy potential.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Group 11: Contract Close-Out Management

91. **11.01 Establishment of a close-out system.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

92. **11.02 Communicating closeout activities to all stakeholders.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

93. **11.03 Proper verification of physical works completion.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

94. **11.04 Proper review of contractor's close-out documentation.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

95. **11.05 Timely issuance of taking-over certificate(s) with associated snags.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

96. **11.06 Proper release of the due retention monies upon releasing relevant certificate.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

97. **11.07 Timely approving return of deployment of the contractor's resources upon contractor's request.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

98. **11.08 Periodic inspections of the works during defects notification period.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

99. **11.09 Proper issuance of performance certificate when the contractor's maintenance obligations are fulfilled in accordance with timelines as set out in the contract.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

100. **11.10 Documenting lessons learned and best practices.** *
Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

101. **11.11 Proper processing contractor's final account in accordance with the contract provision.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

102. **11.12 Proper management of suspension of work process in compliance with the contract administrative procedures.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

103. **11.13 Proper management of termination of contract process in compliance with the contract administrative procedures.** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
.	◯	◯	◯	◯	◯

Construction Contract Administration Groups

104. **What's the importance of the following Groups on Contract Administration Performance?** *

Mark only one oval per row.

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
G01- Project Governance & Start-up	◯	◯	◯	◯	◯
G02- Contract Administration Team Management	◯	◯	◯	◯	◯
G03- Communication & Relationship Management	◯	◯	◯	◯	◯
G04- Quality & Acceptance Management	◯	◯	◯	◯	◯
G05- Performance Monitoring & Reporting Management	◯	◯	◯	◯	◯
G06- Document & Record Management	◯	◯	◯	◯	◯
G07- Financial Management	◯	◯	◯	◯	◯
G08- Change & Changes Control Management	◯	◯	◯	◯	◯
G09- Claims & Disputes Resolution Management	◯	◯	◯	◯	◯
G10- Contract Risk Management	◯	◯	◯	◯	◯
G11- Contract Close-Out Management	◯	◯	◯	◯	◯

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APPENDIX E: **QUESTIONNAIRE DATA**

Table E.1: Questionaire data frequencies

Code	NI	SI	MI	VI	EI	Code	NI	SI	MI	VI	EI
F01.01		6	43	133	154	F06.01		9	50	133	144
F01.02		6	61	146	123	F06.02		17	84	153	82
F01.03		7	68	130	131	F06.03		14	73	140	109
F01.04	2	21	102	147	64	F06.04		43	102	126	65
F01.05	1	11	65	146	113	F07.01		5	46	109	176
F01.06		19	71	159	87	F07.02		11	80	156	89
F01.07		6	90	161	79	F07.03		1	56	143	136
F01.08		1	66	152	117	F07.04		6	66	161	103
F01.09	1	21	77	138	99	F07.05		18	72	158	88
F01.10	1	13	83	142	97	F07.06		9	85	131	111
F01.11		28	103	139	66	F07.07		14	79	157	86
F01.12	11	19	103	134	69	F08.01		7	61	116	152
F01.13	2	25	125	141	43	F08.02		13	76	152	95
F01.14	3	38	108	142	45	F08.03		10	76	131	119
F01.15	2	25	89	135	85	F08.04		17	69	127	123
F02.01		12	61	152	111	F08.05		8	73	146	109
F02.02		15	67	165	89	F09.01		4	55	119	158
F02.03	1	21	69	158	87	F09.02	2	10	63	155	106
F02.04	3	24	116	146	47	F09.03	1	3	65	153	114
F02.05		31	111	141	53	F09.04		11	65	151	109
F02.06	10	47	135	111	33	F09.05	1	13	76	156	90
F03.01	1	10	49	128	148	F09.06	3	27	107	129	70
F03.02	1	17	77	164	77	F09.07	2	20	114	146	54
F03.03	4	16	90	138	88	F09.08	1	19	103	144	69
F03.04	1	15	103	133	84	F10.01	1	9	70	154	102
F03.05		8	45	131	152	F10.02		20	87	135	94
F03.06		10	64	174	88	F10.03	1	11	77	154	93
F03.07	1	19	86	146	84	F10.04	2	27	92	138	77
F03.08	1	16	64	142	113	F11.01		5	54	139	138
F03.09	2	19	84	148	83	F11.02		18	70	148	100
F03.10		23	94	141	78	F11.03		11	73	138	114
F03.11	1	16	99	143	77	F11.04		15	70	152	99
F04.01		15	73	133	115	F11.05		10	84	132	110
F04.02		15	83	161	77	F11.06	2	17	90	137	90
F04.03		10	62	135	129	F11.07	3	37	112	141	43
F04.04	1	11	62	142	120	F11.08	1	19	92	146	78
F04.05		10	68	129	129	F11.09		13	85	154	84
F04.06		27	79	140	90	F11.10	2	14	104	133	83
F04.07		8	59	158	111	F11.11	1	11	87	147	90
F04.08		14	81	150	91	F11.12	1	11	77	145	102
F04.09		9	86	155	86	F11.13	1	9	67	159	100
F04.10		18	71	123	124	G01		6	38	158	134
F05.01		7	65	134	130	G02		6	52	182	96
F05.02		8	81	147	100	G03		5	38	161	132
F05.03		21	95	147	73	G04		4	37	146	149
F05.04		18	98	160	60	G05		3	45	159	129
F05.05	6	41	114	135	40	G06		6	49	144	137
F05.06		14	72	158	92	G07		4	29	149	154
F05.07		21	108	147	60	G08		2	32	131	171
F05.08		7	62	141	126	G09		3	39	162	132
F05.09	1	31	110	131	63	G10		3	51	148	134
F05.10		5	58	131	142	G11		3	43	156	134

NI= Not all-important; SI= Slightly important; MI= Moderately important; VI= Very important; EI= Extremely important

Table E.2: Examine of normality of indicators by of the Skewness, Kurtosis values, and Shapiro-Wilk

Code	skew and kurtosis				Shapiro-Wilk	
	skew	c.r.	kurtosis	c.r.	Statistic	p-value
F01.01	-0.929	-6.952	0.33	1.234	0.779	0.000
F01.02	-0.623	-4.661	-0.291	-1.088	0.816	0.000
F01.03	-0.619	-4.631	-0.486	-1.818	0.816	0.000
F01.04	-0.413	-3.093	-0.241	-0.901	0.868	0.000
F01.05	-0.725	-5.426	0.116	0.435	0.831	0.000
F01.06	-0.599	-4.485	-0.182	-0.679	0.843	0.000
F01.07	-0.265	-1.984	-0.615	-2.3	0.837	0.000
F01.08	-0.397	-2.968	-0.828	-3.097	0.807	0.000
F01.09	-0.602	-4.508	-0.3	-1.124	0.852	0.000
F01.10	-0.529	-3.957	-0.277	-1.038	0.850	0.000
F01.11	-0.297	-2.224	-0.659	-2.467	0.868	0.000
F01.12	-0.646	-4.834	0.204	0.763	0.871	0.000
F01.13	-0.252	-1.889	-0.286	-1.068	0.870	0.000
F01.14	-0.363	-2.713	-0.421	-1.576	0.879	0.000
F01.15	-0.506	-3.786	-0.385	-1.442	0.867	0.000
F02.01	-0.687	-5.143	-0.056	-0.209	0.826	0.000
F02.02	-0.62	-4.64	-0.043	-0.16	0.836	0.000
F02.03	-0.678	-5.074	0.011	0.04	0.846	0.000
F02.04	-0.366	-2.741	-0.143	-0.536	0.870	0.000
F02.05	-0.242	-1.809	-0.636	-2.381	0.869	0.000
F02.06	-0.23	-1.718	-0.348	-1.304	0.895	0.000
F03.01	-1.006	-7.529	0.608	2.275	0.792	0.000
F03.02	-0.597	-4.47	0.034	0.129	0.848	0.000
F03.03	-0.605	-4.526	0.032	0.121	0.860	0.000
F03.04	-0.335	-2.503	-0.55	-2.059	0.861	0.000
F03.05	-0.946	-7.082	0.343	1.282	0.783	0.000
F03.06	-0.588	-4.399	0.056	0.21	0.827	0.000
F03.07	-0.505	-3.781	-0.303	-1.132	0.859	0.000
F03.08	-0.757	-5.662	0.054	0.204	0.834	0.000
F03.09	-0.575	-4.3	-0.101	-0.379	0.859	0.000
F03.10	-0.378	-2.828	-0.602	-2.253	0.862	0.000
F03.11	-0.374	-2.799	-0.414	-1.549	0.862	0.000
F04.01	-0.606	-4.533	-0.427	-1.598	0.836	0.000
F04.02	-0.457	-3.418	-0.313	-1.172	0.848	0.000
F04.03	-0.711	-5.317	-0.215	-0.806	0.817	0.000
F04.04	-0.774	-5.79	0.169	0.633	0.825	0.000
F04.05	-0.655	-4.902	-0.396	-1.483	0.820	0.000
F04.06	-0.521	-3.902	-0.528	-1.977	0.855	0.000
F04.07	-0.643	-4.808	-0.06	-0.223	0.821	0.000
F04.08	-0.476	-3.56	-0.422	-1.579	0.847	0.000
F04.09	-0.365	-2.733	-0.527	-1.971	0.843	0.000
F04.10	-0.661	-4.946	-0.445	-1.665	0.830	0.000
F05.01	-0.64	-4.79	-0.397	-1.484	0.815	0.000
F05.02	-0.42	-3.143	-0.581	-2.174	0.838	0.000
F05.03	-0.368	-2.751	-0.541	-2.025	0.861	0.000

Table E.2: Examine of normality of indicators by of the Skewness, Kurtosis values, and Shapiro-Wilk (continued)

Code	skew and kurtosis				Shapiro-Wilk	
	skew	c.r.	kurtosis	c.r.	Statistic	p-value
F05.04	-0.346	-2.588	-0.401	-1.501	0.854	0.000
F05.05	-0.369	-2.763	-0.353	-1.32	0.886	0.000
F05.06	-0.564	-4.221	-0.211	-0.789	0.840	0.000
F05.07	-0.257	-1.927	-0.566	-2.118	0.862	0.000
F05.08	-0.649	-4.857	-0.289	-1.081	0.816	0.000
F05.09	-0.267	-1.996	-0.633	-2.37	0.878	0.000
F05.10	-0.71	-5.314	-0.319	-1.195	0.800	0.000
F06.01	-0.875	-6.546	0.158	0.593	0.796	0.000
F06.02	-0.46	-3.44	-0.404	-1.512	0.852	0.000
F06.03	-0.584	-4.373	-0.385	-1.442	0.838	0.000
F06.04	-0.246	-1.841	-0.864	-3.232	0.875	0.000
F07.01	-1.016	-7.602	0.211	0.79	0.754	0.000
F07.02	-0.452	-3.382	-0.394	-1.474	0.843	0.000
F07.03	-0.548	-4.103	-0.681	-2.549	0.794	0.000
F07.04	-0.512	-3.831	-0.298	-1.115	0.825	0.000
F07.05	-0.586	-4.384	-0.203	-0.758	0.843	0.000
F07.06	-0.432	-3.23	-0.728	-2.722	0.836	0.000
F07.07	-0.49	-3.668	-0.323	-1.21	0.845	0.000
F08.01	-0.778	-5.825	-0.315	-1.179	0.793	0.000
F08.02	-0.52	-3.892	-0.344	-1.289	0.842	0.000
F08.03	-0.548	-4.098	-0.557	-2.086	0.830	0.000
F08.04	-0.675	-5.051	-0.38	-1.421	0.830	0.000
F08.05	-0.513	-3.842	-0.462	-1.73	0.831	0.000
F09.01	-0.797	-5.963	-0.294	-1.101	0.781	0.000
F09.02	-0.801	-5.991	0.545	2.041	0.829	0.000
F09.03	-0.609	-4.554	0.043	0.16	0.818	0.000
F09.04	-0.631	-4.724	-0.176	-0.658	0.830	0.000
F09.05	-0.591	-4.423	-0.021	-0.077	0.846	0.000
F09.06	-0.369	-2.759	-0.437	-1.636	0.879	0.000
F09.07	-0.324	-2.425	-0.235	-0.878	0.867	0.000
F09.08	-0.346	-2.592	-0.42	-1.572	0.866	0.000
F10.01	-0.634	-4.742	0.069	0.258	0.835	0.000
F10.02	-0.45	-3.369	-0.604	-2.26	0.855	0.000
F10.03	-0.57	-4.266	-0.058	-0.216	0.844	0.000
F10.04	-0.472	-3.528	-0.402	-1.502	0.871	0.000
F11.01	-0.721	-5.398	-0.179	-0.671	0.801	0.000
F11.02	-0.618	-4.623	-0.264	-0.989	0.841	0.000
F11.03	-0.57	-4.268	-0.437	-1.635	0.833	0.000
F11.04	-0.601	-4.497	-0.228	-0.854	0.839	0.000
F11.05	-0.449	-3.363	-0.681	-2.548	0.838	0.000
F11.06	-0.518	-3.873	-0.256	-0.956	0.860	0.000
F11.07	-0.343	-2.57	-0.399	-1.494	0.879	0.000
F11.08	-0.447	-3.345	-0.35	-1.308	0.862	0.000
F11.09	-0.422	-3.16	-0.438	-1.638	0.848	0.000
F11.10	-0.379	-2.835	-0.375	-1.402	0.861	0.000
F11.11	-0.47	-3.515	-0.278	-1.041	0.850	0.000
F11.12	-0.583	-4.362	-0.154	-0.575	0.843	0.000
F11.13	-0.66	-4.94	0.192	0.717	0.833	0.000
	Multivariate		726.386	50.08		

APPENDIX F: **PROJECT 1 TO 13 CAPM RATING**

Table F.1: Data collection for project 1 to 13

Code	Project #												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
F01.01	85	100	75	75	50	100	95	100	80	90	0	0	100
F01.02	90	100	80	100	50	100	100	100	100	100	100	75	80
F01.03	90	100	80	100	100	100	100	100	75	100	100	30	50
F01.04	90	50	80	50	70	0	100	0	75	0	0	0	75
F01.05	80	100	75	100	NaN	100	100	100	100	90	100	75	100
F01.06	95	100	60	90	80	100	100	100	100	80	100	70	100
F01.07	90	100	75	90	80	100	100	100	80	80	100	75	100
F01.08	95	100	75	100	100	100	100	100	100	70	100	75	100
F01.09	95	100	75	100	100	100	100	100	100	70	100	75	100
F01.10	85	100	100	100	100	100	100	100	100	80	100	50	100
F01.11	80	NaN	0	NaN	NA	NA	75	NaN	NaN	90	NaN	50	100
F01.12	50	100	75	NaN	100	NA	50	NaN	100	50	100	50	NaN
F01.13	95	100	75	75	100	0	100	0	0	80	0	50	100
F01.14	95	100	75	100	100	100	100	100	100	40	100	70	100
F01.15	80	70	0	NaN	100	70	85	100	0	NA	70	30	100
F02.01	85	75	80	90	100	100	80	100	50	80	75	50	100
F02.02	85	75	75	90	100	100	80	100	50	80	100	70	100
F02.03	90	75	75	90	70	100	80	100	50	70	75	70	100
F02.04	70	0	70	100	NA	0	25	0	0	80	75	NaN	100
F02.05	80	100	75	100	NA	100	75	100	100	80	75	NaN	100
F02.06	80	75	65	75	NA	100	80	100	0	50	50	NaN	0
F03.01	80	75	90	100	100	90	85	90	80	80	100	75	75
F03.02	80	0	90	75	0	100	80	100	0	50	0	70	75
F03.03	95	75	85	100	0	100	90	100	80	80	50	70	80
F03.04	95	0	90	50	50	85	100	85	0	0	0	50	0
F03.05	95	100	90	100	100	100	90	100	100	70	100	80	75
F03.06	95	75	75	100	100	100	100	100	70	70	50	85	75
F03.07	95	100	90	75	100	100	95	100	100	0	40	70	100
F03.08	95	75	80	100	80	100	85	100	100	90	80	70	100
F03.09	95	75	80	50	90	100	90	100	75	70	50	70	50
F03.10	95	0	85	25	100	NA	85	100	70	70	50	70	100
F03.11	95	100	85	100	100	100	100	100	100	90	100	70	75
F04.01	95	75	80	75	50	0	70	0	0	0	0	75	75
F04.02	95	75	90	75	50	100	70	100	70	60	0	75	100
F04.03	95	100	85	75	50	100	90	100	100	70	80	80	100
F04.04	95	100	75	NaN	70	100	90	100	75	70	70	50	50
F04.05	95	50	75	75	70	100	100	100	75	NA	60	50	75
F04.06	95	50	85	75	70	0	100	100	0	0	0	50	50
F04.07	95	50	90	NaN	100	90	95	90	70	90	80	80	100
F04.08	95	50	90	NaN	100	100	95	100	65	90	60	75	100
F04.09	95	70	75	NaN	100	100	90	100	70	90	60	50	100
F04.10	95	50	NaN	100	100	NA	80	NaN	70	90	NaN	75	NaN
F05.01	95	75	70	100	100	50	85	100	50	50	0	75	50
F05.02	85	75	75	100	100	100	90	100	80	50	50	70	75
F05.03	90	75	85	100	100	100	100	100	75	50	50	70	100
F05.04	95	75	75	100	100	100	100	100	70	60	50	70	100
F05.05	85	0	70	NaN	100	0	50	0	0	70	0	70	0

Table F.1: Project 1 to 13 collected data (continued)

Code	Project												
	1	2	3	4	5	6	7	8	9	10	11	12	13
F05.06	95	75	80	100	100	100	75	100	70	80	50	70	50
F05.07	95	50	80	NaN	100	100	75	100	70	80	50	70	100
F05.08	95	80	90	NaN	100	100	50	100	70	90	70	70	50
F05.09	95	0	90	NaN	NaN	100	70	100	70	90	0	0	0
F05 10	95	75	85	100	100	100	90	100	80	90	70	70	70
F06.01	95	90	85	100	100	100	100	100	75	85	60	85	100
F06.02	90	50	80	100	100	85	100	85	50	80	50	80	50
F06.03	95	70	75	100	100	100	100	100	70	90	50	85	100
F06.04	90	70	85	75	100	0	100	100	50	90	50	80	0
F07.01	95	75	80	100	100	100	100	NaN	50	80	0	50	100
F07.02	95	100	75	NaN	0	NA	100	NaN	NaN	90	NaN	50	NaN
F07.03	95	100	75	100	100	100	100	100	100	90	100	50	100
F07.04	95	0	75	NaN	100	100	100	NaN	0	90	50	85	100
F07.05	70	75	NaN	NaN	100	100	100	100	75	90	50	50	NaN
F07.06	95	0	80	100	100	NA	100	NaN	0	80	100	80	100
F07.07	95	75	90	NaN	100	85	100	85	100	90	100	80	100
F08.01	95	75	75	100	100	100	100	100	75	90	40	80	100
F08.02	95	50	85	100	100	100	100	100	100	80	100	80	100
F08.03	80	50	70	100	100	100	90	100	80	90	70	80	100
F08.04	95	50	90	100	100	100	80	100	70	70	70	80	100
F08.05	95	100	70	100	100	100	100	100	100	70	50	85	100
F09.01	90	75	85	NaN	100	100	100	100	75	85	75	85	100
F09.02	90	75	80	NaN	100	NA	90	NaN	50	80	75	85	100
F09.03	90	75	90	NaN	100	75	80	100	100	90	75	85	100
F09.04	90	75	90	NaN	100	75	80	100	100	90	75	85	100
F09.05	90	50	85	NaN	100	100	90	100	75	90	75	85	100
F09.06	NaN	NaN	NaN	NaN	0	NA	90	NaN	NaN	90	75	85	NaN
F09.07	NaN	NaN	NaN	NaN	100	NA	NaN	100	NaN	NaN	NaN	80	NaN
F09.08	NaN	NaN	NaN	NaN	100	NA	NaN	NaN	NaN	NaN	NaN	0	NaN
F10.01	60	75	65	NaN	100	0	80	0	50	60	50	80	NaN
F10.02	60	75	65	NaN	100	0	80	0	50	60	50	80	NaN
F10.03	50	75	65	100	0	0	85	0	50	50	50	0	NaN
F10.04	50	0	65	100	100	0	0	0	0	60	0	80	NaN
F11.02	90	NaN	70	NaN	100	90	80	0	NaN	90	50	80	100
F11.03	90	NaN	70	NaN	95	95	80	90	NaN	80	75	60	100
F11.04	90	NaN	70	NaN	100	90	75	0	NaN	80	50	80	100
F11.05	90	NaN	NaN	NaN	100	NA	100	NaN	NaN	80	100	90	100
F11.06	85	NaN	NaN	NaN	0	NA	90	NaN	NaN	80	100	50	100
F11.07	80	NaN	NaN	NaN	100	NA	90	NaN	NaN	0	0	0	NaN
F11.08	80	NaN	NaN	NaN	100	NA	80	NaN	NaN	60	NaN	50	100
F11.09	80	NaN	NaN	NaN	100	NA	75	NaN	NaN	80	NaN	100	100
F11.10	80	NaN	NaN	NaN	0	NA	75	NaN	NaN	50	NaN	0	0
F11.11	90	NaN	NaN	NaN	100	NA	85	NaN	NaN	90	NaN	100	100
F11.12	NaN	NaN	NaN	NaN	100	NA	NaN	NaN	NaN	NaN	NaN	NaN	NaN
F11.13	NaN	NaN	NaN	NaN	100	NA	NaN	NaN	NaN	NaN	NaN	NaN	NaN

APPENDIX G: **CAPM RATING GUIDELINES**

Time Performance Measure (TP_i) is referred to as the average time for delayed tasks (T_d) versus the time frame as stipulated in the contract or the agreed time frame to carry out this task (T_c) for variable i.

$$TP_i = \left[1 - \frac{T_d - T_c}{T_c}\right] x100, 100 \leq TP_i \leq 0 \quad \text{(G.1)}$$

Compliance Performance Measure $* CP_i$) is referred to the number of tasks property performed (N_a) versus the total number of tasks (N_t) of a variable i.

$$CP_i = \left[\frac{N_a}{N_t}\right] x100, 100 \leq CP_i \leq 0 \quad \text{(G.2)}$$

Also, Compliance performance (CP_i) is referred to the number of tasks improperly performed (N_i) due to CCA culpability versus the total number of tasks (N_t) of a variable *i*.

$$CP'_i = \left[1 - \frac{N_i}{N_t}\right] x100, 100 \leq CP_i \leq 0 \quad \text{(G.3)}$$

Customer Satisfaction Measure (CS_i) is referred to as the employers rating for CCA services (R_e) versus maximum score rating (R_{max}) of a variable *i*.

$$CS_i = \left[\frac{R_e}{R_{max}}\right] x100, 100 \leq CS_i \leq 0 \quad \text{(G.4)}$$

Value (Cost) Performance Measure (VP_i) is referred to as the value of tasks property performed (V_a) versus the total value of tasks (V_t) of a variable *i*.

$$VP_i = \left[\frac{V_a}{V_t}\right] x100, 100 \leq VP_i \leq 0 \quad \text{(G.5)}$$

Also, value performance is referred to as the value of tasks improperly performed (V_i) due to CCA culpability versus total value of tasks (V_t) of a variable i.

$$VP'_i = \left[1 - \frac{V_i}{V_t}\right] x100, 100 \leq CP_i \leq 0 \quad \text{(G.6)}$$

Table G.1: Rating guidelines for CAPM

Code	Indicator	Measure	Rating (100-0)
F01.01	Establishing an overall project management plan (PMP).	Approved PMP Approved with comments PMP exist but no approval No PMP	100 55-95 50 0
F01.02	Reviewing the contractor's project quality plan (PQP).	Average time for delayed review versus time frame stipulated No of on-time review versus total number review	TP_i CP_i
F01.03	Reviewing the contractor's health, safety, and security plan (HSSP).	Average time for delayed review versus time frame stipulated No of on-time review versus total number review	TP_i CP_i
F01.04	Reviewing the contractor's environmental management plan (EMP).	Average time for delayed review versus time frame stipulated No of on-time review versus total number review	TP_i CP_i
F01.05	Reviewing the contractor's baseline programme (BL).	Average time for delayed review versus time frame stipulated No of on-time review versus total number review	TP_i CP_i
F01.06	Reviewing the contractor's proposed key staff.	Average time for delayed review versus time frame stipulated No of on-time review versus total number review	TP_i CP_i
F01.07	Reviewing the proposed subcontractor(s) qualifications.	Average time for delayed review versus time frame stipulated No of on-time review versus total number review	TP_i CP_i
F01.08	Conducting project kick-off meetings to discuss contract with related parties.	Complete Kick of Meeting address all construction contract requirement for project start Incomplete Kick-off meeting No Record	100 50-95 0
F01.09	Supporting the employer in reviewing contract securities (bonds and insurances).	No of appropriately approved securities versus total number of contract securities Note: Absolute contract securities and where CCA tram failed to notify contractor are considered un-appropriately	CP_i
F01.10	Supporting the employer in handing over the project to the contractor.	Hand over the site on time 7 days delay 14 Days delay More than 14 days Delay	100 75 50 0
F01.11	Supporting the employer in appointing nominated subcontractor(s).	Nominate sub-contractor on time 7 days delay 14 Days delay More than 14 days Delay	100 75 50 0
F01.12	Removal of any personnel intentionally violating the project requirements.	Fully Implemented Partially Implemented Not Implemented at all	100 50-95 0

Table F.1: Rating guidelines for CAPM (continued)

Code	Indicator	Measure	Rating (100-0)
F01.13	Reviewing the contractor's logistics plan (CLP).	Average time for delayed review versus time frame stipulated	TP_i
		No of on-time review versus total number review	CP_i
F01.14	Reviewing contractor's proposed laboratory (LAB).	Average time for delayed review versus time frame stipulated	TP_i
		No of on-time review versus total number review	CP_i
F01.15	Avoiding bureaucracy and lengthy process.	Approved lean and value-added processes	100
		Approved process without value	50
		Too lengthy process	0
F02.01	Assignment of technically competent, qualified, and experienced CCA team.	No of approved functional CCA team by the Employer versus total number to functional team CCA	CP_i
F02.02	Early assignment of the CCA team, including all relevant disciplines.	No of on-time assigned functional CCA team assignment versus total number of CCA functional team shown in the staffing plan	CP_i
F02.03	Clear identification of individual roles and responsibilities within the CCA team.	No of available job descriptions for functional team versus total number to CCA functional team	CP_i
F02.04	Establishing training and development programs for the CCA team.	Approved Comprehensive training program available and implemented	100
		Partially implemented training Program	5-95
		No training program	0
F02.05	Regular assessment of CCA team performance taking due note of any employer or contractor feedback/comments.	CCA organization perform regular performance assessment for the project team	100
		Irregular performance assessment	50
		No assessment	0
F02.06	Setting outperformance dialogue for the CCA team.	Performance communicated to the team and action plan available	100
		Performance communicated to the team and no action plan available	50
		No dialogue Available	0
F03.01	Establishing a communication management system (CMS).	Approved CMS	100
		Approved with comments	75-95
		CMS exists but no approval	50
		No CMS	0
F03.02	Communicating the PMP requirements to all involved parties.	Number of functional staff fully aware about PMP versus total number of CCA functional Team	CP_i
F03.03	Advising the employer on its functions.	Number of letters issued to advise Employer about his obligations versus the contractor's claim due to the Employer's failure Note: 100, if there are no claims	CP_i
F03.04	Measuring the employer's satisfaction during the contract lifespan.	Employers' rating for CCA services versus maximum score rating Note: 0 if no records	CS_i
F03.05	Agreement between employer and CCA team for any requested changes on scope, time, or cost.	No of approved change requests versus Total number of change requests Note: 0 if no records	CP_i

Table F.1: Rating guidelines for CAPM (continued)

Code	Indicator	Measure	Rating (100-0)
F03.06	Regular meetings with employers and contractors.	Regular Meeting Irregular meetings No meetings	100 50 0
F03.07	Effective coordination with third parties.	Number of records of coordinating with the third party versus the contractor's notification/ claim for failure to coordinate Note: 100 if no notifications/ Claims	CP_i
F03.08	Prompt and accurate response to the contractor's queries in compliance with the contract procedures.	Average time for delayed response versus time frame stipulated Number of on-time responses versus total number responses	TP_i CP_i
F03.09	Effective management of operational issues at field level between the contractor and CCA team.	No operational issues solved promptly versus the total number of issues raised Note: 100 if no issues	CP_i
F03.10	Effective management of interface among contractors.	Number of interface issues solved promptly versus total number interface of issues raise Note: 100 if no issues	CP_i
F03.11	Strict compliance with the language of communication as stipulated in the contract.	Project records comply with the contract language Full comply Partial comply Not comply	 100 50 0
F04.01	Systematic auditing of the contractor's implementation of quality management system.	Number of actual audits done versus no of planned audit as per construction contract Note: 0 if no records	CP_i
F04.02	Prompt issuance of any further supplementary information to the contractor.	Average time for delayed information versus time frame stipulated Number of issued supplementary information versus no of notifications regarding missing info. Note: 1000 if no records	TP_i CP_i
F04.03	Timely reviewing the construction material (MAT) prior to use by the contractor taking due cognizance of the review cycles.	Average time for delayed reviews versus time frame stipulated Number of on-time reviewed MAT versus total Number of material submittals	TP_i CP_i
F04.04	Timely reviewing the shop drawings (SD) taking due cognizance of the review cycles.	Average time for delayed reviews versus time frame stipulated Number of on-time reviewed SD versus total Number of SD submittals	TP_i CP_i
F04.05	Systematic auditing the contractor's compliance with health, safety, and security requirements on site.	Number of actual audits done versus no of planned audit as per construction contract 0 if no records	CP_i
F04.06	Systematic auditing of the contractor's compliance with environmental requirements.	Number of actual audits done versus no of planned audit as per construction contract 0 if no records	CP_i
F04.07	Systematic inspection of the quality of work items on site.	Average time for delayed inspections versus time frame stipulated Number of on-time inspections versus total Number of inspections	TP_i CP_i

Table F.1: Rating guidelines for CAPM (continued)

Code	Indicator	Measure	Rating (100-0)
F04.08	Devised system of controlling rejected / non-compliant works (NCR).	Number of on-time NCRs closed versus number of NCRs due for closings	CP_i
F04.09	Devised system for regular tracking of corrective actions (CAR).	Number of on-time CARs closed versus number of CARs due for closings	CP_i
F04.10	Managing design and design development during construction.	Average time for delayed review versus time frame stipulated	TP_i
		Number of on-time review versus the total number of inspections	CP_i
F05.01	Establishment of a monitoring and reporting system (MRS) inclusive key performance indicators.	Approved MRS	100
		Approved with comments	55-95
		MRS exist but no approval	50
		No MRS	0
F05.02	Issuing separate reports for major issues to keep the employer informed.	Number of issues addressed to the Employer (Ia) versus total no of project issues Note: 100 if no issues	CP_i
F05.03	Regular progress reports to the employer.	Regular reports	100
		Irregular reports	50-95
		No reports	0
F05.04	Reviewing the contractor's reports.	Regular review	100
		Irregular review	50-95
		No review	0
F05.05	Monitoring of contractor's relationship with subcontractors.	Regular monitoring	100
		Irregular monitoring	50-95
		No monitoring	0
F05.06	Monitoring of the contractor's suitability and adequacy of resources, including equipment, materials, and personnel.	Number of on-time daily reports issued versus total number of reports as per contract	CP_i
F05.07	Monitoring the contractor care of the works, including the employer's provided properties.	Number of cases contractor's damage the Employer properties without proper notification by CCA	
		O case	100
		1-2 case	50
		>2 case	0
F05.08	Timely notification of the contractor for a recovery schedule when progress is slow in relation to the approved programme.	Total number of notifications issued versus total cases recovery plan is required	CP_i
F05.09	Monitoring of contractor's arrangements to minimize public interference.	Total number of closing of public complaints versus total number of publics complains	CP_i
F05 10	Notifying the contractor on failure to carry out any contractual obligation.	Total Number of notifications issued versus of total number notifications observed by the Employer	CP_i
F06.01	Establishing a document management system (DMS).	Approved DMS	100
		Approved with comments	55-95
		DMS exist but no approval	50
		No DMS	0
F06.02	Using information communication technology (ICT) in administering the contract.	Full utilized ICT	100
		Partially utilized	50-95
		Not utilized	0

Table F.1: Rating guidelines for CAPM (continued)

Code	Indicator	Measure	Rating (100-0)
F06.03	Maintaining updated project documentation with registers.	Up to date registers	100
		Partially updated register	50-95
		No Registers	0
F06.04	Supporting the project stakeholders with regular statistics.	Dully updated dashboards and statistics for Engineering submission, payments, engineering documents, progress, and safety)	100
		Partially statistics	50-95
		No statistics	0
F07.01	Establishment of a financial management system (FMS).	Approved FMS	100
		Approved with comments	55-95
		FMS exists but no approval	50
		No DMS	0
F07.02	Proper issuance of instructions to spend provisional sum items.	Average time for delayed instructions versus time frame stipulated by the employer	TP_i
		Value of on-time issued instructions versus Employers requested instructions. Note: 100 if no records	VP_i
F07.03	Fair, reasonable, and equitable certification of due payments to the contractor.	Average time for delayed reviews versus time frame stipulated	TP_i
		Value of on-time correctly issued from first time versus total value of payments	VP_i
F07.04	Timely notifying the employer about the contractor's due payment timelines & financial status.	Number of on-time issued notification to Employer versus number of delayed of payments	CP_i
		Value on-time issued a notification to Employer versus Values of delayed of payments	VP_i
F07.05	Assessment of the contractor's compensation for delayed payment cases in compliance with any contractual provision.	Number of recommendations for payment compensation versus number of delayed payments	CP_i
		Value of recommendations for payment compensation versus value of delayed payments	VP_i
F07.06	Advising the employer in contingency planning/ additional funds.	Regular commercial reports	100
		Irregular commercial reports	50-95
		Not commercial reports	0
F07.07	Collecting quotations for price estimates and contractor's price negotiations in respect of additional works/variations.	Number of cost estimates reports supported with quotations for new item or cost breakdown versus total number of cost estimate reports	CP_i
		Value of Cost Estimates reports versus Values of variations Note: 100 if no new items exist	VP_i
F08.01	Establishment of a change control system (CCS).	Approved CCS	100
		Approved with comments	55-95
		CCS exists but no approval	50
		No CCS	0
F08.02	Prompt evaluation of contractor's proposals for changes in inclusive value engineering.	Average time for delayed reviews versus time frame stipulated by the contract	TP_i
		Number of on-time reviews versus total number of contractor's proposals Note: 0 if no records	CP_i

Table F.1: Rating guidelines for CAPM (continued)

Code	Indicator	Measure	Rating (100-0)
F08.03	Proposing financially viable solutions to avoid budget increase to the employer due to changes requests.	No of CCA team alternative proposal versus total no of changes requests No of Employers complaints due to ineffective solutions versus total number of changes	CP_i
F08.04	Properly notifying the contractor about urgent works required for the safety of the works.	Fully implemented Partially Implemented No records	100 50-95 0
F08.05	Proper processing of the change orders on approved change requests.	Number of variations returned for correction versus total number of variations Value of variations returned for correction versus total value of variations	CP_i VP_i
F09.01	Establishment of a claims and dispute resolution system (CDS) if not already set out in the contract.	Approved CDS Approved with comments CDS exist but no approval No CDS	100 55-95 50 0
F09.02	Notifying the contractor about the employer's rights to claim.	Value of Employer's claims not granted due to CCA team culpability versus total value of Employer's claims	VP'_i
F09.03	Proper assessment of contractor's entitlement for extension of time for completion within timelines as set out in the contract.	Number of days granted due to CCA team culpability versus the total number of extended days	CP'_i
F09.04	Proper assessment of contractor's entitlement for additional payment.	Number of cases of improper assessment due to CCA team culpability versus total number of assessments	CP'_i
F09.05	Effectively negotiating claims between the contractor and the employer.	Number of settled claims versus the total number of claims Value of settled claims versus total value of claims	CP_i VP_i
F09.06	Supporting the contracting parties to select alternative dispute resolution methods if not already set	Fully implemented Partially Implemented No records	100 50-95 0
F09.07	Representing the employer in alternative dispute resolution proceedings.	Fully implemented, if required Partially Implemented No records	100 50-95 0
F09.08	Legal support to the employer during court cases.	Value of legal cases lost due to CCA team culpability versus total contractor's claim	VP'_i
F10.01	Periodically assessing the contractual risks with help of the contractor.	Regular & comprehensive risk assessment records Irregular risk assessment records No risk records	100 50-95 0
F10.02	Assignment of responsibility to the relevant party for each contractual risk expressed as a Responsibility Matrix.	Comprehensive risk responsibility matrix Basic risk responsibility matrix No risk responsibility matrix	100 50-95 0
F10.03	Supporting the employer for the risks associated with design review findings.	Comprehensive design review report at the beginning of the project Late issued a Design review report No design review report	100 50-95 0

Table F.1: Rating guidelines for CAPM (continued)

Code	Indicator	Measure	Rating (100-0)
F10.04	Monitoring the contractor’s financial status and bankruptcy potential.	Up to date yearly submission of Contractor’s financial statement No submission	100 0
F11.01	Establishment of a close-out system (COS).	Approved COS Approved with comments COS exist but no approval No COS	100 55-95 50 0
F11.02	Communicating closeout activities to all stakeholders.	Involving all key stakeholders in close-out Partially involve key stakeholders No records	100 50-95 0
F11.03	Proper verification of physical works completion.	Fully implemented testing and commissioning plan Partially implemented No records	100 50-95 0
F11.04	Proper review of contractor's close-out documentation.	Fully reviewed document (operation and maintenance manuals, as-built drawings, warranties…etc.) Partially reviewed No record	100 50-95 0
F11.05	Timely issuance of taking-over certificate(s) with associated snags.	Average time for delayed certificates versus time frame stipulated by the contract Number of on-time issued certificates versus total number of issued certificates	TP_i CP_i
F11.06	Proper release of the due retention monies upon releasing relevant certificates.	Average time for delayed retention versus time frame stipulated by the contract Value of on-time certified retentions versus total value of retentions	TP_i VP_i
F11.07	Timely approving return of deployment of the contractor’s resources upon contractor’s request.	Average time for delayed requests versus time frame requested by the contractor	TP_i
F11.08	Periodic inspections of the works during defects notification period.	Number of visits carried out versus number of visits required by contract	CP_i
F11.09	Proper issuance of performance certificate when the contractor’s maintenance obligations are fulfilled	Average time for delayed certificates versus time frame stipulated by the contract Value of on-time certified certificates versus total value of retentions	TP_i VP_i
F11.10	Documenting lessons learned and best practices.	Fully implemented Partially implemented No records	100 50-95 0
F11.11	Proper processing contractor's final account in accordance with the contract provision.	Average time for delayed reviews versus time frame requested by the contract	TP_i
F11.12	Proper management of suspension of work process in compliance with the contract administration procedures.	Fully implemented Partially implemented No records	100 50-95 0
F11.13	Proper management of termination of the contract process in compliance with the CCA procedures.	Fully implemented Partially implemented No records	100 50-95 0