QATAR UNIVERSITY

COLLEGE OF ENGINEERING

CONSTRUCTION PROJECTS DELAY MITIGATION FRAMEWORK USING BALANCED SCORECARD AND QUALITY FUNCTION DEPLOYMENT

BY

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ABSTRACT

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Delays in many projects mostly occur in the construction phase which may have a consequent impact on the project's overall performance in areas such as profitability, quality, and safety. This project demonstrates the importance of applying proper management tools to overcome delays in the construction industry. Its aim is to propose a framework which can be implemented to effectively manage construction projects, and hence, mitigate delays. A literature review was conducted to identify the critical factors that would assist in overcoming or mitigating delays. Two management tools were used which are the balanced score card (BSC) and quality function deployment (QFD) to construct the framework. These tools were used to design a survey questionnaire to develop a matrix for analysing the best methods for mitigating delays based on the different BSC perspectives. Findings of this study indicate that the most important factors that influence the achievement of the project's financial goals primarily belong to client-related factors, followed by contractor and project management team-related factors. The proposed integrated BSC and QFD framework can therefore serve as a systematic and structural approach for ranking the critical enabling factors of delay mitigation based on the severity of their impact to the project's financial success, thereby helping construction industry professionals prioritize goals and mitigate delays more effectively.

Keywords: *Construction Management, Construction Project Delay Mitigation, Balanced Score Card, Quality Function Deployment, Integrated BSC and QFD Framework*

DEDICATION

I would like to dedicate my work, a labor of love, to my parents who are my best teachers. This is also dedicated to my lovely wife who prays unceasingly for me. I also dedicate this to my family and friends who served as my inspiration during the preparation of this project.

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Chapter 1 : Introduction

1.1. Background

The construction industry is considered to be a key contributor to global economic growth (Zidane and Andersen 2018b). It is through the construction industry that society is able to achieve "its goals of urban and rural development" (Ali and Wali 2019). Because of the forward and backward linkages that it has developed with other industries, the construction industry plays a pivotal role in the provision of the requisite infrastructure in improving the quality of life (Durdyev et al. 2017). In addition, its contribution to the global economy cannot be undermined, as it represented around thirteen percent of the global gross domestic product (GDP) in 2013 alone (Schilling 2013). According to the Global Construction Outlook to 2023 - Q3 2019 Update, "the pace of global construction output growth is expected" to increase to up to 3.5 percent in 2020" (Research and Markets 2019).

However, since the construction process is in itself shaped by unpredictable events such as changing weather conditions and a diverse range of internal and external factors such as client/contractor-related delay causes, and regulatory instruments and political climate, respectively, construction project delays have become commonplace. The term 'delay' has been referred to as an action "to make something happen later than expected; to cause something to be performed later than planned; or to not act timely. It is what is being delayed that determines if a project or some other deadline, such as a milestone, will be completed late" (Zidane and Andersen 2018b).Within the context of the construction industry, construction delay has been defined as the inability to achieve "desired project duration upon contract agreement" (Gunduz et al. 2016, Gunduz and AbuHassan 2016). In other words, construction delay pertains to the "the delay in time either beyond the agreed contract deadline or beyond the date the parties have agreed upon for the delivery of a project" (Larsen et al. 2015).

Indeed, the universality and ubiquity of construction delays have been highlighted in construction management literature (Arditi et al. 1995, Larsen et al. 2015, Durdyev et al. 2017, Zidane and Andersen 2018b). Despite the advent of technology and the availability of project management and engineering techniques, delays continue to be pervasive and problematical. Construction delay causes have also been found to be highly variable and country specific (Venkatesh and Venkatesan 2017). Similarly, in the case of Qatar, delays in construction have been experienced across the construction projects.

Since the last three decades, the extent of delays in construction projects has been documented to vary in different countries around the world. For instance, in a study conducted by Semple et al. (1994), it was found that in Canada, construction project delays go beyond the original contract duration by 100 percent. In Turkey, utility projects suffered 34.6 percent delay in contractors' projects and 43.6 percent delay in public projects, respectively (Arditi et al. 1995). In the US, 150 highway construction projects suffered time overruns of an average of 272 days or 25 percent of contract duration (Ellis and Thomas 2003). In the UAE, out of 450 residential building construction projects, 56 percent of the projects were subjected to delays (Kouski et al. 2005).

In many countries, it has been documented that the average schedule overrun was 42.7 percent for mixed construction projects (Ansar et al. 2016). Most recently, it has been found that the average time overrun in public university buildings in Ghana was 62.7 percent (Olatunde and Alao 2017).

In the same manner, the outcomes of construction delays are wide ranging often in the form of time and cost overruns, disputes, arbitrations, litigations, and finally, project abandonment (Prasad et al. 2019). The added financial costs due to construction delays are staggering as well. For instance, the global average of construction disputes has been valued at forty-six million US dollars for the year 2016 alone (Arcadis 2016). It has been documented that construction disputes are often caused by delays (Semple et al. 1994, Ijaola and Iyagba 2012, Kikwasi 2012, Sambasivan et al. 2017). In like manner, findings of studies carried out in South Africa, Nigeria, and Ghana indicate that most building projects were not completed on time; and that in Sub-Saharan Africa, construction delays result in an excess of one hundred percent of the anticipated project cost (Jongo et al. 2019). Similarly, around seventy percent of construction projects in Dubai suffer delays (Maceda 2016, Johnson and Babu 2018) and that “the Chartered Institute of Building (CIOB) identified Dubai metro as the third most troublesome project with 5 years delay and 85% increase in cost from the estimated schedule” (Johnson and Babu 2018).

As evidenced by the above discussion, construction delays often result in cost overruns.

1.2 Project Aim and Objectives

Despite the richness of available literature relevant to the types and outcomes of construction delays, there is a need in studies that are relevant to the measures for mitigating delays. Furthermore, although the prescribed measures are extensive, they are nevertheless, generic, broad, and fragmented (Mezher and Tawil 1998, Faridi and El-Sayegh 2006, Ng 2007, Olawale and Sun 2010). Thus, there is an apparent need for contributions that can offer more systematic and holistic approaches for mitigating construction delays. Moreover, Dolage and Pathmarajah elucidate that “majority of project delays occur during the construction phase, where many unforeseen factors are always involved” (Jongo et al. 2019). Thus, this project hopes to close the gaps in existing construction management literature by seeking to achieve the following project aim and objectives:

This project primarily aims to develop a combined Balanced Scorecard (BSC) and Quality Function Deployment (QFD) framework for mitigating construction delays during the planning and execution stages of the project. To achieve this aim, the following project objectives have been set:

- To apply the BSC approach in mitigating construction project delays.
- To identify the financial perspective relevant to construction delays.
- To apply the QFD approach in mitigating construction project delays.
- To identify the important factors that strongly influence the financial perspective in mitigating construction project delays with the use of an integrated BSC and QFD approach. The combination of QFD and BSC is envisaged to provide a long-term strategy for the construction industry to mitigate delays.

Within the context of delay analysis, QFD can effectively deploy desirable project attributes. Moreover, QFD serves as a matrix that focuses on the objectives of the enablers of delay mitigation and the financial objectives. Thus, it serves as a ranking mechanism that can be useful in prioritizing client, contractor and project management team, and innovation and learning goals relevant to the achievement of financial objectives. Therefore, QFD can assist construction industry practitioners in ranking the enablers of delay mitigation based on the strength of their influence on the achievement of financial goals. Similarly, the BSC enables the connection of the enablers of delay mitigation and the financial goals in a causal chain in order to come up with desired outcomes. Thus, BSC can help examine the relationships between the critical success factors (i.e. enablers of delay mitigation) and the financial thrusts of construction projects.

The combined QFD and BSC framework can serve as a systematic approach for measuring the strength of influence of the enablers of delay mitigation on financial goals. Therefore, the proposed framework is a valuable tool for the construction industry in mitigating delays. It can help construction industry practitioners prioritize mitigation measures based on how strong they affect the financial goals. Finally, the proposed framework can be considered a novel tool in the field of construction delay mitigation since this is the first integrated BSC and QFD framework that is relevant to construction delay mitigation literature.

Chapter 2 : Literature Review

2.1 Introduction

Construction projects delays, being a global phenomenon, is not something new. Despite the rapid technological advancement and utility of project management techniques, construction project delays remain pervasive. Extant construction management literature highlights the ubiquity and pervasiveness of construction delays. Therefore, it is imperative to understand the causes and types of construction project delays, as well as their impact and how to mitigate them. Thus, this chapter will present the results of the literature review relevant to the aforementioned issues. The structure of this chapter is as follows: First, the results of the literature review on the causes of construction project delays are presented. This is followed by the results of the review related to the types of construction project delays. Next, literature review results on the impacts of construction project delays are discussed. Then, the results of the review relevant to the different mitigation measures for construction project delays are presented. Finally, a summary of the key findings from the review is presented, including a brief discussion of the gaps in literature.

2.2 Causes of Construction Project Delays

2.2.1 Top ten causes of project delays.

Zidane and Andersen (2018b) identified the top ten universal delay factors in construction projects based on a systematic review of 105 studies from 46 countries. Findings of the systematic review indicate that the top ten universal or worldwide delay factors are as follows: (1) design changes during construction /change orders, (2) delays in contractor's payments, (3) poor planning and scheduling, (4) poor site management and supervision, (5) incomplete or improper design, (6) inadequate contractor experience/building methods and approaches, (7) contractor's financial difficulties, (8) sponsor/owner/client's financial difficulties, (9) shortage in resources such as human resources, machinery, equipment, and (10) poor labour productivity. In a broader perspective, the aforementioned delay factors can be grouped into two general types of delay causes: contractor-related causes and client/owner-related causes. Table 2.1 below presents the top ten universal delay factors by Zidane and Andersen (2018b).

Table 2.1 Top Ten Delay Factors and Their Respective Categories

Source	Top Ten Universal Delay Factors	General Category of Delay Causes
Zidane and Andersen (2018b)	1. Design changes during construction /change orders	Owner/client-related
	2. Delays in contractor's payments	Owner/client-related
	3. Poor planning and scheduling	Contractor-related
	4. Poor site management and supervision	Contractor-related
	5. Incomplete or improper design	Contractor-related
	6. Inadequate contractor experience/building methods and approaches	Contractor-related
	7. Contractor's financial difficulties	Contractor-related
	8. Sponsor/owner/client's financial difficulties	Owner/client-related
	9. Shortage in resources such as human resources, machinery, equipment	Contractor-related

2.2.2. Disparity in the causes of construction project delays between developing and developed countries.

Despite the seeming universal nature of construction project delay causes, results of the review related to delay causes of construction projects in developing countries have been found to be different than those in developed countries (Prasad et al. 2019). In developing countries such as Jordan (Odeh and Battaineh 2002), Ghana (Frimpong et al. 2003), Malaysia (Alaghbari 2007), Hongkong (Lo et al. 2006), and Thailand (Toor and Ogunlana 2008), delay causes include contractor issues such as ineffective planning and project scheduling, inadequate experience, poor site management, and shortage of laborers. In addition, construction delays were also caused by the owner's interference, issues in monthly payments, slow and lackluster instruction by the consultant, and material procurement. On the other hand, in developed countries such as the US (Ahmed et al. 2003), Australia (Wong and Vimonsatit 2012), UK (Shebob et al. 2012), and Singapore (Hwang et al. 2013), construction delays were found to have been caused by errors in construction work, lack of a needs- identification process, subcontractor problems, change order, changes in drawings, skill and labor shortages, extreme weather conditions, changes in the prices of materials, incomplete documents, approval of building permits, and incomplete inspections. Thus, in developing countries, construction delay causes are mostly comprised by internal factors such as the contractor's or clients' financial issues, problems with cash flow, payment delays by owner, and client's change orders (Islam and Trigunarsyah 2017). In contrast, in developed countries, construction delay causes are mostly comprised by external factors such as prices of materials, building permits, labour supply, and the weather. This claim has been supported by Ogunlana et al. (1996) who emphasized that the disparity is caused by the special constraints with which contractors and clients in developing countries had to overcome (Prasad et al. 2019). Such constraints, however, do not pose as serious impediments in developed countries. Table 2.2 below presents the comparison of delay causes between developing and developed countries.

Table 2.2 Comparison of Delay Causes between Developing and Developed Economies

Sources	Country	Type of Economies	Delay Causes	General Type of Delay Causes
Odeh & Battaineh (2002)	Jordan	Developing	Contractor issues (ineffective planning and project scheduling, inadequate experience, poor site management, and shortage of laborers); Owner's interference, issues in monthly payments, slow and lackluster instruction by consultant, and material procurement.	Internal causes
Frimpong et al. (2003)	Ghana			
Alaghbari et al. (2007)	Malaysia			
Lo, Fung, & Tung (2006)	Hongkong			
Toor and Ogunlana (2008)	Thailand			
Gonduz et al. (2013)	Turkey			
Ahmed et al. (2003)	US	Developed	Extreme weather conditions, changes in the prices of materials, incomplete documents, approval of building permits, and incomplete inspections	External causes
Wong and Vimonsatit (2012)	Australia			
Shebob et al. (2012)	UK			
Hwang et al. (2013)	Singapore			

2.2.3 Recent studies that explored the causes of construction project delays.

There were several more recent studies which looked at the causes of construction project delays. These studies were carried out from 2015 onwards.

Larsen et al. (2015) identified the factors affecting schedule delay, cost overrun, and quality level in public construction projects in Denmark using a survey questionnaire comprised by 26 factors which were previously identified through interviews and which were subsequently completed by 56 publicly- employed project managers. Findings from the study revealed that aside from unsettled or lack of project funding, external delay factors were also responsible for construction project delays in Denmark. These external delay factors include the following: “delays or long process times by other public authorities, unpredictable soil conditions, state of the market conditions, unpredictable project conditions and finally unpredictable weather conditions” (Larsen et al. 2015). Therefore, when compared to the trend shown in Table 2.2 above, findings from this study buttress prior literature findings regarding the general type of delay causes in developed countries, which are mostly external in nature.

Gunduz and AbuHassan (2016) used a survey questionnaire completed by 179 respondents, and Relative Importance Index (RII) in identifying key delay factors affecting construction projects in Qatar. Their findings indicate that the top five delay causes in Qatar’s construction industry are as follows: (1) owner-related delay factor (delay in decision-making), (2) contractor-related delay factor (poor site management and supervision), (3) material-related delay factor (shortage of construction materials), (4) owner-related delay factor (changes to the project), and (5) labour-related delay factor (shortage of laborers). Since most of the causes were internal in nature, their findings support the general trend shown in Table 2.2.

Durdyev et al. (2017) identified the causes of delay in residential construction projects in Cambodia using a survey questionnaire completed by 48 project consultants and contractors. Findings of their study indicate that the delay causes are a combination of both internal and external factors. External factors include accidents arising from the effect of rain on construction activities, poor site safety, price fluctuations, breakdowns of construction plant and equipment, poor ground conditions, and delays in obtaining building permits. On the other hand, internal causes include unrealistic project scheduling, delays by subcontractor, poor communication and coordination, and poor site management, amongst many others. These findings do not support the general trend of delay causes as shown in Table 2.2 above since Cambodia is a developing country.

Zidane and Andersen (2018a) used survey questionnaires completed by 202 engineers in identifying the top ten delay factors in major Norwegian construction projects which include the following: (1) poor planning and scheduling, (2) slow decision making, (3) internal administrative procedures and bureaucracy within project organisations, (4) shortage in resources such as human resources, machinery, equipment, (5) poor coordination and communication between parties, (6) slow quality inspection process of the completed work, (7) design changes during construction/change orders, (8) owner's lack of commitment and clear demands, (9) office issues, and (10) late/slow/incomplete/improper design. These findings do not support the general trend shown in Table 2.2 above since these are all internal factors, and Norway is a developed country.

Another relevant study by Prasad et al. (2019) investigated the causes of delay in India by project sector using a survey questionnaire completed by 200 major clients, consultants, and contractors. Their findings suggest that financial-related factors were the most important causes in Indian projects. In particular, the highly ranked causes include the following: financial difficulties faced by contractors, owner's delayed payments for extra work, owner's variation orders, changes in design and changes in scope during construction, claims settlement delays, and contractor's late payment to suppliers and subcontractors. Since the aforementioned causes are internal in nature, that is, they originate from contractors and owners, these findings support the claims made by Islam and Trigunarsyah (2017) who explained that delay causes in developing countries are mostly internal in nature and also support the findings in Table 2.2 above.

Table 2.3 Results of Review of Literature on Delay Causes

Source	Country	Type of Economy	Key Findings
Larsen et al. (2015)	Denmark	Developed	Delay causes are mostly external in nature. Support the trend in Table 2.2.
Gunduz and AbuHassan (2016)	Qatar	Developing	Delay causes are internal in nature. Support the trend in Table 2.2.
Durdyev et al. (2017)	Cambodia	Developing	Delay causes are a combination of both internal and external factors. Do not fully support the trend in Table 2.2.
Zidane and Andersen (2018a)	Norway	Developed	Delay causes are internal in nature. Do not support the trend in Table 2.2.
Prasad et al. (2019)	India	Developing	Delay causes are internal in nature. Support the trend in Table 2.2.

2.2.4 Key findings of the review on delay causes.

Findings from this review suggest that results of the review of literature prior to 2015 highlight the presence of a set of universal delay factors in construction projects, as well as the disparity of delay causes between developing and developed economies. In particular, delay causes in developing countries are largely internal in nature: they arose from contractor and owner/client factors such as those contained in Table 2.2. On the other hand, delay causes in developing countries are largely external in nature: they arose from causes outside of contractor and owner/client factors such as those italicized and also shown in Table 2.2. As Prasad et al. (2019) explained, the disparity of delay causes between developing and developed countries is attributable to the constraints faced by contractors and clients alike in terms of the availability of financial resources. Similarly, Venkatesh and Venkatesan (2017) observed such disparity in delay causes between the two different types of economy and aptly put forward the results of their analysis as follows: "The criticality of delay causes in developing countries as against developed countries is a reflection of the financial status / fund availability with implementation agencies as well as the contractors in developed countries as against those in the developing countries." While findings from this review support the views of Prasad et al. (2019) and Venkatesh and Venkatesan (2017), they also suggest that despite the differences of delay causes between developing countries and developed countries, they also share common delay causes such as shortage of laborers, owner's interference in terms of change orders and changes in drawings, and issues with material procurement. In addition, findings from this review suggest that findings from literature those studies undertaken from 2015 onwards, do not fully support the disparity in delay causes between developing and developed economies. This subsequently indicates that delay factors can vary from country to country and can be influenced by the respondents' perspectives, by the way the delay factors are categorized into groups, and the type of construction projects under study. Finally, knowledge of the causes of delay eventually ushers in the necessity of understanding the types of construction project delay whose literature review findings will be discussed in the succeeding section.

2.3 Types of Construction Project Delays

One of the seminal works on the different types of construction delays was done by Kraiem and Diekmann (1987) who designed a tool to help in the analysis of delay claims and explained that there are four types of delays, namely: compensable, non-excusable, excusable, and concurrent delay. Kraiem and Diekmann (1987) further explained that compensable delays are those delays caused by the owner or client; non-excusable delays are those caused by the contractor; excusable delays are those caused by acts of God or a third party, and concurrent delays are those caused by a combination of two or more types of delays happening concurrently.

Bramble and Callahan (2000) refined Kraiem and Diekmann's (1987) classification of the types of delay and proposed the following: (1) excusable, (2) non-excusable, and (3) concurrent delays. According to Bramble and Callahan (2000), excusable delays can be further categorized into either compensable or non-compensable delays, whereby the contractor can ask for an extension of the deadline due to fortuitous events or reasons beyond the contractor's control. On the other hand, non-excusable delays are those arising from the contractor's negligence wherein they are not entitled to any compensation. Lastly, concurrent delays are those involving a combination of two or more excusable delays and a non-excusable delay, in which case, the contractor is entitled only to a partial compensation.

In a more recent publication, Trauner Jr. et al. (2009) enumerated the following types of construction delays, which are further refinements of the previous classifications put forth by Kraiem and Diekmann (1987) and Bramble and Callahan (2000): (1) critical or non-critical, (2) excusable or non-excusable, (3) compensable and non-compensable, and (4) concurrent or non-concurrent. Trauner Jr. et al. (2009) further explained the different types of delays in the following manner:

1. Critical delays are those that affect the project completion or a milestone date. On the other hand, delays that do not affect the project completion or a milestone date are categorized as non-critical delays. Trauner Jr. et al. (2009) further explained that the critical delay concept arose from the critical path method (CPM) scheduling which presupposes that "all projects, regardless of the type of schedule, have 'critical' activities. If these activities are delayed, the project completion date or a milestone date will be delayed." As to the determination of which particular activities control the

project completion date, Trauner Jr. et al. (2009) elucidated that they are dependent on the following variables: the project itself, the plan and schedule of the contractor, the contractor's requirements for phasing and sequence, and the project's physical constraints.

2. Excusable delays arise from fortuitous or unforeseeable delay which are beyond the contractor's control. On the other hand, a non-excusable delay arises from events that are within the control of the contractor.

3. A compensable delay is a type of delay wherein the contractor is entitled to an extension of the deadline and to additional compensation. However, since only excusable delays are compensable, a non-compensable delay is where the contractor is not entitled to additional compensation despite the occurrence of an excusable delay.

4. Concurrent delays are those that are distinct from the critical path, but which occur at the same time. On the other hand, non-concurrent delays are those that do not occur at the same time. Figure 2.1 below illustrates the types of delays based on Trauner Jr. et al.'s (2009) classification.

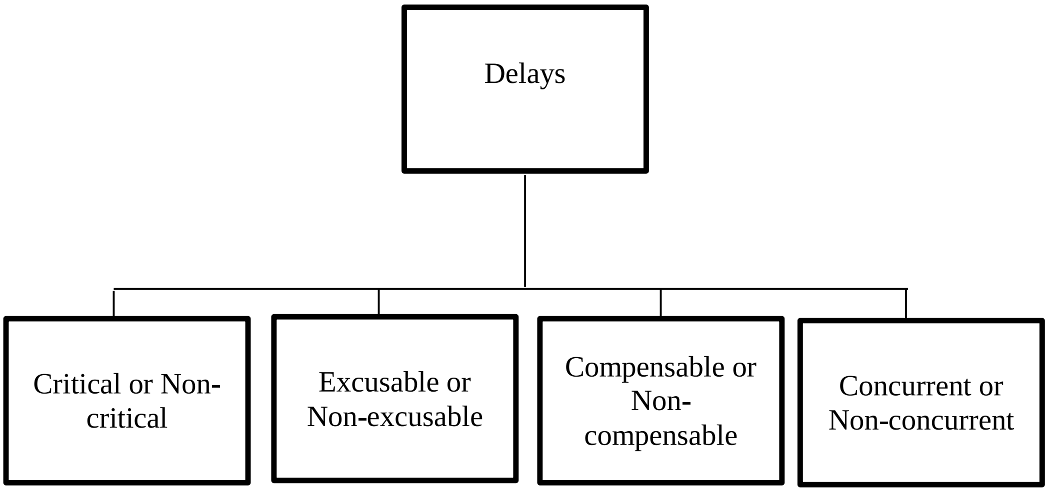

Figure 2.1 Types of Delays According to Trauner Jr. et al. (2009)

Based on the classification of the types of delay, a flow diagram summary of the delay categories was developed by Industrial Audit.com (Undated) (see Figure 2.2. below) to aid in capturing, categorizing, and analyzing delays.

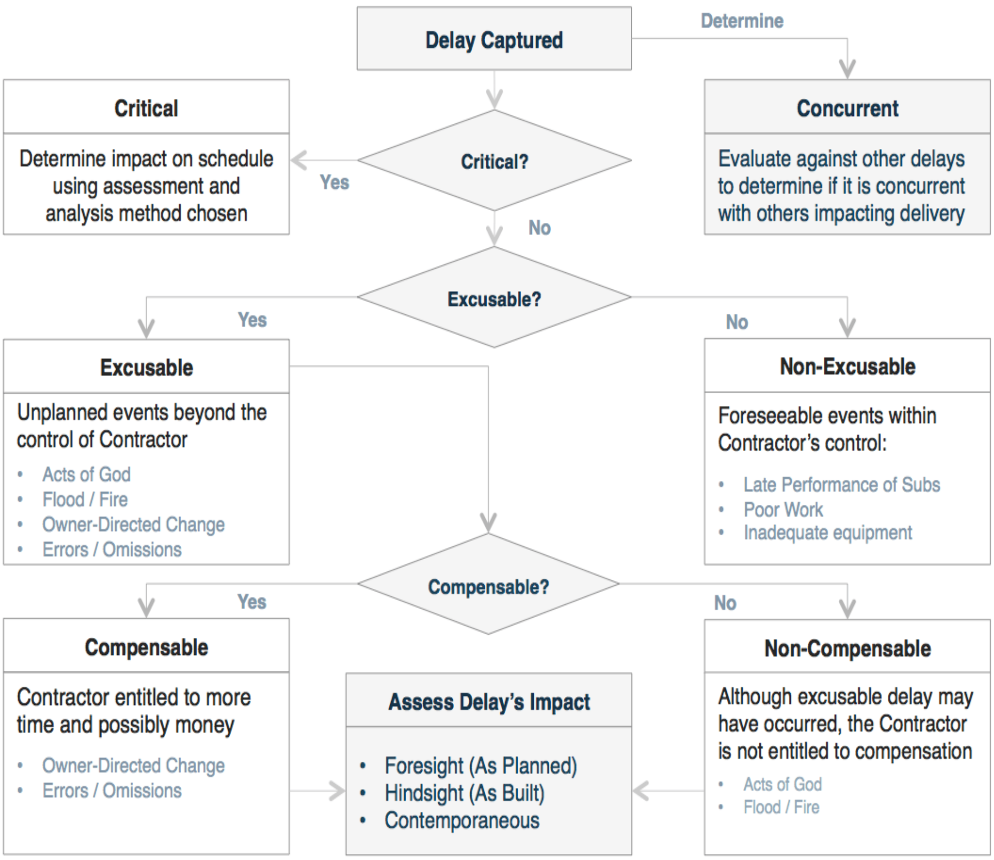

Figure 2.2 Flow Diagram Summary of the Different Delay Categories (Industrial Audit.com)

Gluzak and Lesniak (2015) categorized the types of construction project delays into two, namely: justified and unjustified. The authors claimed that justified delays occur as a result of the client's or owner's fault and thus, the contractor is entitled to compensation. An example of a justified delay is when the owner or client changed the design documentation. Gluzak and Lesniak (2015) added that "the investor's interference in the competences of the contractor, modifications of earlier findings and a long decision-making process are further reasons leading to possible delays." On the other hand, examples of unjustified delays include contractor-dependent factors that are "associated primarily with the availability of resources, proper organization, supervision and experience" (Gluzak and Lesniak 2015). Table 2.4 below presents the results of the review related to the types of delay.

Table 2.4 Results of the Literature Review of the Types of Delay

Source	Types of Construction Project Delays	Basis of Classification
Kraiem and Diekmann (1987)	Compensable, non-excusable, excusable, and concurrent delay.	Cause(s) of delay
Bramble and Callahan (2000)	excusable, non-excusable, and concurrent delays	
Trauner Jr. et al. (2009)	Critical or non-critical, excusable or non-excusable, compensable and non-compensable, and concurrent or non-concurrent.	
Gluzak and Lesniak (2015)	justified and unjustified	

Despite the variance in the typology of delays found in literature, all of the categories were based on construction delay causes, thereby suggesting the inextricable link between the causes of delay and the types of delay. Therefore, the importance of identifying the causes of delay in the determination of the types of delay is paramount. Finally, after reviewing the types of delay found in the literature, it is but logical to undertake a review of literature related to the impact of delays, the results of which are discussed in the next section.

2.4 Impacts of Construction Project Delays

2.4.1 Predominance of time and cost overruns as outcomes of construction delays in prior literature (1995-2013)

There is a significant body of literature that deals with the impacts of construction project delays in different countries around the world (Alaghbari et al. 2007, Alinaitwe et al. 2013). The seminal work of Assaf et al. (1995) used descriptive statistics in identifying cause and effect factors in the Saudi Arabian construction industry. Findings of their study suggest that the following delay causes resulted in time and cost overruns: owner/client factors, materials procurement and availability, contractual relationships, changes, scheduling and controlling, and government relations. Indeed, prior literature highlights the pervasiveness of time and cost overruns as the resulting impacts from construction project delay in various countries. For instance, Nguyen et al. (2004) used exploratory factor analysis and rank correlation in identifying cause and effect factors in the Vietnamese construction industry and found that environment, as well as owner/client and contractor-related factors resulted in time and cost overruns. Similar findings were obtained by Assaf and Al-Hejji (2006) who used descriptive statistics and rank correlation in examining the delay cause and effect factors in large building construction projects in Saudi Arabia. In addition, with the use of descriptive statistics and one-sample t-test, Aibinu, and Odeyinka (2006) found that in the Nigerian construction industry, labour shortage and contractor-related delay causes such as financial issues, poor site management , and defective workmanship resulted to time and cost-overruns, dispute, arbitration, litigation, and finally, to abandonment. Identical results were obtained by Sambasivan and Soon (2007) who used descriptive statistics and correlation in examining the delay cause and effect factors in the Malaysian construction industry. In particular, they found that owner/client and contractor -related delay causes in addition to contract and contractual relationship issues led to time and cost-overruns, dispute, arbitration, litigation, and abandonment. To identify delay cause and effect in the building construction sector in Egypt, Abd El-Razek et al. (2008) used descriptive statistics and rank correlation. They found that external causes such as environmental conditions, approval processes, material procurement and availability; as well as contractor issues such as financing concerns and site management resulted in delays. Yang et al. (2010) used descriptive statistics and Structural Equation Modelling (SEM) in examining private participating public construction works under the build-operate-transfer model in Taiwan and found that external causes such as regulatory instruments, transfer mechanisms, political stability, administrative procedures, as well as owner/client-related factors such as design and plan changes resulted in delays. Kasimu and Abubakar (2012) used descriptive statistics in evaluating the impacts of delay causes in the Nigerian construction industry. Findings of their study suggest that the impacts of contractor-related delay factors such as financial difficulties, ineffective project management practices, poor communication, and shortage in laborers, were time and cost overruns, in addition to being blacklisted by regulatory authorities, and client's loss of confidence. Kikwasi (2012) used descriptive statistics in examining the causes and effects of delays and disruptions in construction projects in Tanzania and found that internal causes such as owner-related delay factors (design changes, payment delays to contractors, and information delays), contractor-related delay factors (ineffective or poor project management and financial/funding problems) and disputes between owner and contractor regarding compensation have led to time and cost overruns, in addition to disputes. Ijaola and Iyagba (2012) used descriptive statistics and Relative Importance Index in comparing change order in construction projects in Nigeria and Oman, vis- à-vis the causes, effect, benefits and remedies. They found that delay causes were client's change order issues arising from additional works and design changes which subsequently resulted in claims and disputes in Nigeria and delays and cost overruns in Oman. Alinaitwe et al. (2013) used descriptive statistics and rank correlation in identifying delay causes and effects in Uganda. Findings of their study indicate that external causes and client and contractor-related causes resulted in time and cost overruns.

Table 2.5 Summary of Results of the Review on the Impacts of Delay found in Prior Literature (1995-2013)

Source	**Country**	**Research Technique Used**	**Causes**	**Impacts**
Assaf et al. (1995)	Saudi Arabia	Descriptive statistics	Owner/client factors, materials procurement and availability, contractual relationships, changes, scheduling and controlling, and government relations	Time and cost overruns
Nguyen et al. (2004)	Vietnam	Exploratory factor analysis and rank correlation	Environment, owner/client and contractor-related factors	Time and cost overruns
Assaf and Al-Hejji (2006)	Saudi Arabia	Descriptive statistics and rank correlation	Environment, owner/client and contractor-related factors	Time and cost overruns
Aibinu and Odeyinka (2006)	Nigeria	Descriptive statistics and one-sample t-test	Labour shortage and contractor-related delay causes such as financial issues, poor site management, and defective workmanship	Time and cost-overruns, dispute, arbitration, litigation, abandonment
Sambasivan and Soon (2007)	Malaysia	Descriptive statistics and correlation	Owner/client and contractor -related delay causes, and contract and contractual relationship issues	Time and cost-overruns, dispute, arbitration, litigation, abandonment
Abd El-Razek et al. (2008)	Egypt	Descriptive statistics and rank correlation	External causes (environmental conditions, approval processes, material procurement and availability) and contractor issues (financing concerns and site management)	Delays

Table 2.5 (continued) Summary of Results of the Review on the Impacts of Delay found in Prior Literature (1995-2013)

Source	Country	Research Technique Used	Causes	Impacts
Yang et al.(2010)	Taiwan	Descriptive statistics and Structural Equation Modelling (SEM)	External causes such as regulatory instruments, transfer mechanisms, political stability, administrative procedures, and owner/client-related factors such as design and plan changes	Delays
Kasimu and Abubakar (2012)	Nigeria	Descriptive statistics	Contractor-related delay factors such as financial difficulties, ineffective project management practices, poor communication, and shortage in laborers	Time and cost overruns, being blacklisted by regulatory authorities, and client's loss of confidence
Kikwasi (2012)	Tanzania	Descriptive statistics	Owner-related delay factors (design changes, payment delays to contractors, and information delays), contractor-related delay factors (ineffective or poor project management and financial/funding problems), disputes between owner and contractor	Time and cost overruns disputes
Ijaola and Iyagba (2012)	Nigeria and Oman	Descriptive statistics and Relative Importance Index	Client's change order issues arising from additional works and design changes	Claims and disputes in Nigeria, and delays and cost overruns in Oman
Alinaitwe et al.(2013)	Uganda	Descriptive statistics and rank correlation	External causes and client and contractor-related causes	Time and cost-overruns

Review of prior literature from 1995 to 2013 (see Table 2.5) suggest that time and cost overruns were the most common effects of construction project delays in different countries around the world (Assaf et al. 1995, Nguyen et al. 2004, Assaf and Al-Hejji 2006, Aibinu and Odeyinka 2006, Sambasivan and Soon 2007, Alinaitwe et al. 2013). These impacts occurred as a result of internal causes: both owner/client and contractor-related delay factors which include contractual relationships, changes, scheduling and controlling, financial issues, poor site management, and defective workmanship, amongst many others. Only two studies, those conducted by Abd El-Razek et al. (2008) and Yang et al. (2010) concluded that delays occurred as a result of external causes such as environmental conditions, approval processes, material procurement and availability, regulatory instruments, and political stability. These findings suggest that internal delay factors often result in time and cost overruns, while external causes often lead to delays only. Such observation is attributable to the fact that internal factors constitute critical and non-excusable delays.

2.4.2 Recent studies on the impacts of construction project delays.

There were several studies from literature which explored the impacts of construction project delays. These studies were carried out from 2015 onwards.

Amoatey et al. (2015) assessed the causes and effects of delays in public sector housing projects in Ghana using descriptive statistics. They found that time and cost-overruns, litigation, work stoppage and client's lack of desire to continue the project, and arbitration were the effects of various delay causes such as "delay in payment to contractor/supplier, inflation/price fluctuation, price increases in materials, inadequate funds from sponsors/clients, variation orders and poor financial/capital market" (Amoatey et al. 2015).

Gajare et al. (2015) examined the causes and impacts of delays in the Indian construction industry using survey questionnaires which were subsequently analyzed to obtain the frequency index, importance index, and severity index. Findings of their study indicate that contractor's inadequate experience and poor planning and site management, shortage in materials and labour supply, and lack of communication between parties resulted in time and cost overruns.

Hisham and Yahya (2016) used survey questionnaires which were later analyzed using Relative Importance Index (RII) to identify the causes of delays and the effects of delays in the Malaysian construction industry. Findings of their study indicate that time and cost overruns were the major impacts of construction delays that consisting of subcontractor and contractor-related delay factors.

Sambasivan et al. (2017) used descriptive statistics and Structural Equation Modelling (SEM) to identify the impacts of delay causes in the Tanzanian construction industry. Findings of their study suggest that client and contractor-related delay factors resulted in cost overruns, disputes, arbitrations, litigations, and abandonment.

Reshma and Robin (2018) investigated the causes of construction delays and cost overruns in the UAE construction sector using a mixed-methods approach. Findings of their study suggest that the following top five delay factors resulted in time overruns: "design variation from client and consultant, unrealistic schedules and completion dates projected by clients, delay in obtaining government permits and approvals, inaccurate time estimation by the consultants and change orders from clients" (Reshma and Robin 2018). On the other hand, the following top five delay factors resulted in cost overruns: "design variation, poor cost estimation, delay in client's decision-making process, financial constraints of client and inappropriate procurement method" (Reshma and Robin 2018).

Rashid (2020) explored the causes and impacts of delays on construction projects in Pakistan using primary data collected through questionnaire from 172 construction industry professionals. Multiple regression was used in the data analysis whose results indicate that the causes of delays which were largely contractor, client, consultant, material and equipment-related, resulted in project time overrun, cost overrun, project abandonment, and litigation.

Samsudin et al. (2020) studied the relationship between contractor inexperience and ineffective communication, which had been previously identified as delay factors, and building project performance. They used a survey questionnaire which were distributed to 89 construction companies in Kuantan, Malaysia. Using the PLS-SEM technique in the data analysis, the researchers concluded that the identified delay factors resulted in poor building project performance such as time overruns.

Table 2.6 below presents a summary of the results of the review of literature on the effects of delays.

Table 2.6 Results of Review of literature on Impacts of Construction Project Delays (2015-2020)

Source	Country	Research techniques	Causes	Effects
Amoatey et al. (2015)	Ghana	Descriptive statistics	Delay in payment to contractor/supplier, inflation/price fluctuation, price increases in materials, inadequate funds sponsors/clients, variation orders and poor financial/capital market	Time and cost-overruns, litigation, work stoppage and client's lack of desire to continue the project, and arbitration
Gajare et al. (2015)	India	Descriptive statistics, frequency index, importance index, and severity index	Contractor's inadequate experience and poor planning and site management, shortage in materials and labour supply, and lack of communication between parties	Time and cost-overruns
Hisham and Yahya (2016)	Malaysia	Descriptive statistics and Relative Importance Index (RII)	Subcontractor and contractor-related delay factors.	Time and cost-overruns
Sambasivan et al. (2017)	Tanzania	Descriptive statistics and Structural Equation Modelling (SEM	Client and contractor-related delay factors	Cost overruns, disputes, arbitrations, litigations, and abandonment.
Reshma and Robin (2018)	UAE	Mixed-methods approach	Clients' and consultants' design changes, unrealistic schedules and completion dates by clients, bureaucratic red tape	Time overruns
			Design changes, poor cost projection, slow decision-making process of clients, Client's financial issues, and unsuitable procurement method	Cost overruns
Rashid (2020)	Pakistan	Multiple regression	Contractor, client, consultant, material and equipment-related delay factors	Project time overrun, cost overrun, project abandonment, and litigation.

2.4.3 Key findings on the impacts of construction project delays.

Sunjka and Jacob (2013) explained that a schedule or time overrun occurs if the project completion time, as stipulated in the contract, is exceeded. On the other hand, cost overruns occur when the construction project is completed at a higher cost compared to the original budgetary allocation. Results of this review indicate that time and cost overruns are the top two most common and pervasive effects of construction project delays. Such pervasiveness is evidenced by the homogeneity of the findings of studies that explored the effects of delays as shown in Tables 2.5 (results of the review of prior literature) and 2.6 (results of the review of literature). These finding support the claims of Kaliba et al. (2009) who elucidated that time and cost overruns are the most common outcomes of construction project delays.

In addition, with the exception of three studies (Assaf et al. 1995, Kasimu and Abubakar 2012, Kikwasi 2012), all other studies used another statistical technique in addition to descriptive statistics. The usefulness of applying a combination of statistical techniques has been highlighted by Sambasivan et al. (2015) who recommended the use of a combination of statistical approaches in exploring the complete relationships between the causes and effects of delays. Overall, the mutual inclusivity of delay causes, and their corresponding effects have been illustrated in all of the studies reviewed. There is no singular study which identified the effects of delay without first examining the causes. Finally, the following section presents the results of the literature review on the mitigation of impacts of construction project delays.

2.5 Mitigation Measures for Construction Project Delays

2.5.1 Mitigation measures for construction project delays in prior literature (1998-2011).

Prior literature is replete with practical approaches for mitigating construction project delays. For instance, Mezher and Tawil (1998) recommended using management techniques and improving communication amongst clients, consultants, and contractors after finding out that the causes of delays in the Lebanese construction industry were the importance placed by clients on financial concerns, by consultants on project management issues, and by contactors on contractual relationships. Love et al. (2000) used a system dynamics model for mitigating the effects of overtime work on project cost and quality. They recommended the application of the combination of 50 percent overtime work and 30 percent additional resources for mitigating construction project delays. They also recommended the calculation of accurate initial project estimates at the project's planning stage. Abdul-Rahman et al. (2006) recommended the following measures for mitigating construction delays not only in the Malaysian context, but globally as well: (1) involvement of capable and experienced construction managers, highly-skilled laborers, and an independent supervising engineer for project monitoring, (2) use of up-to-date technology, (3) accurate initial time and cost estimates, (4) undertaking pre-construction planning of project activities and resource requirements, (5) allocation of sufficient resources at the design phase of the project, (6) use of effective planning strategies, (7) timely delivery of materials, (8) stockholder's strong commitment, (8) holding of regular meetings, (9) using a more effective contract award procedure to ensure the selection of more capable contractors, and (10) employment of a systematic control mechanism. Faridi and El-Sayegh (2006) recommended the improvement of planning and control processes in mitigating construction project delays in the UAE. Ng (2007) recommended the use of accurate initial project estimates and implementation of a systematic control mechanism in mitigating delays in the Malaysian housing construction sector, which were also part of Abdul-Rahman et al.'s (2006) recommendations. Olawale and Sun (2010) recommended the use of a systematic control mechanism and a more effective contract award procedure to ensure the participation of capable and experienced contractors, and the holding of regular meetings to monitor the progress to mitigate construction project delays in general. Abedi et al. (2011) proposed the use of 30 mitigation measures for construction delays in a world-wide setting which include the following amongst many others : calculation of accurate initial cost estimates, allocation of sufficient time and resources at the design phase of the project, holding of regular meetings, use of up-to-date technology, using effective strategic planning initiatives, hiring a capable project manager, a reliable contractor, a competent consultant for the project, as well as an independent project engineer for progress monitoring. These measures are the same as those recommended by Abdul-Rahman et al. (2006).

Table 2.7 Results of the Review of Prior Literature on Mitigation Measures for Construction Project Delays

Source	**Mitigation Measures**	**Evaluation of the Proposed Measures**
Mezher and Tawil (1998)	Use of management techniques and improving communication amongst clients, consultants, and contractors	Broad and generic
Love et al. (2000)	Application of the combination of 50 percent overtime work and 30 percent additional resources	Cannot be used to mitigate external delay causes/excusable delays
Abdul-Rahman et al. (2006)	(1) involvement of capable and experienced construction managers, highly-skilled laborers, and an independent supervising engineer for project monitoring, (2) use of up-to-date technology, (3) accurate initial time and cost estimates, (4) undertaking pre-construction planning of project activities and resource requirements, (5) allocation of sufficient resources at the design phase of the project, (6) use of effective planning strategies, (7) timely delivery of materials, (8) stockholder's strong commitment, (8) holding of regular meetings, (9) using a more effective contract award procedure to ensure the selection of more capable contractors, and (10) employment of a systematic control mechanism	Exhaustive list of mitigation measures that covers entire project lifecycle.
Faridi and El-Sayegh (2006)	Improving planning and control processes	Broad and generic; same as Rahman et al.'s (2006) proposed mitigation measures
Ng (2007)	Use of accurate initial project estimates and implementation of a systematic control mechanism	Broad and generic; same as Rahman et al.'s (2006) proposed mitigation measures
Olawale and Sun (2010)	Use of a systematic control mechanism and a more effective contract award procedure to ensure the participation of capable and experienced contractors, holding of regular meetings to monitor the progress	Broad and generic measures; same as Rahman et al.'s (2006) proposed mitigation measures
Abedi et al. (2011)	30 mitigation measures which include the following amongst many others: calculation of accurate initial cost estimates, allocation of sufficient time and resources at the design phase of the project, holding of regular meetings, use of up-to-date technology, using effective strategic planning initiatives, hiring a capable project manager, a reliable contractor, a competent consultant for the project, as well as an independent project engineer for progress monitoring.	Although the list is exhaustive, most of the mitigation measures are a regurgitation of Abdul-Rahman et al.'s (2006) proposed mitigation measures

2.5.2 Mitigation measures for construction project delays in literature (2015-2020).

Chai et al. (2015) used a Structural Equation Modelling (SEM) approach to evaluate the delay mitigation measures in the Malaysian housing industry. They extracted 17 mitigation criteria through principal component analysis. Those criteria were subsequently grouped into predictive, preventive, and organizational or corrective measures. Predictive measures are used in "forecasting probabilities and trends that develop dummy delays to avoid delays on critical path activities," while preventive measures are the "precautionary measures that are prepared as a defense against inhibiting factors" and are used during the project's planning stage; and corrective measures are used in mitigating the impacts of the controlling factors by serving as a remedy (Chai et al. 2015). Findings of their study indicate that preventive measures are the most effective mitigating measures for delays in the housing industry.

Asim et al. (2017) developed a model that incorporates lean principles for mitigating delays in real estate construction. The model enables the identification of the liability for delays for the resolution of dispute claims and promotes the use of lean principles in order to eliminate the possibility of encountering the same types of delays in the future.

Zidane and Andersen (2018a) identified the key delay issues in major Norwegian construction projects and their corresponding mitigation measures, using an exhaustive literature review, survey questionnaires, and unstructured interviews. They came up with mitigation measures which were tailored for the specific delay causes in the Norwegian construction industry. These mitigation measures include the following: use of virtual modelling, anchoring major decisions in advance of engineering, simplification of administrative procedures, improving resource allocation, improving inter-disciplinary coordination, and executing projects as turnkey contracts.

Prasad et al. (2019) used semi-structured in-depth interviews with senior construction industry professionals in India to develop a comprehensive set of mitigation measures which were grouped into the following 5 categories: mitigation measures for delay in claims settlement, mitigation measures for contractor's financial issues, mitigation measures delay in settlement of variations in changes in scope, mitigation measures for late payment to suppliers and subcontractors, and mitigation measures for changes in design. They recommended the aforementioned mitigation measures for construction project delays not only for India, but for all countries around the world.

Shengea et al. (2020) identified and ranked the critical factors that influence delays in construction of hydropower projects in India using the results of the literature review and interviews to inform the survey questionnaire, and ranking techniques such as Importance Index and Fuzzy Risk Assessment to rank the critical factors based on the severity of their impact to project success. Findings of their study highlighted the usefulness of the Importance Index and Fuzzy Risk Assessment in the ranking of delay factors. Furthermore, Shengea et al. (2020) recommended the following measures for mitigating delays in hydropower construction projects particularly in India: investing sufficient time and money in projects, having a well-defined risk- sharing agreement, encouraging "strong coordination within the project groups and various interfaces, and avoiding delay in deciding contractor clams," and contractors adopting quicker construction techniques and avoiding the use of outdated construction equipment.

Table 2.8 Results of the Review of literature on Mitigation Measures for Construction Project Delays

Source	**Mitigation Measures**	**Evaluation of the Mitigation Measures**
Chai et al. (2015)	Predictive, preventive, and organizational or corrective measures	Exhaustive list of mitigation measures that covers entire project lifecycle.
Asim et al. (2017)	Model was developed to enable the identification of the liability for delays for the resolution of dispute claims	Specific to India's real estate sector; limited to dispute resolution
Zidane and Andersen (2018)	Use of virtual modelling, anchoring major decisions in advance of engineering, simplification of administrative procedures, improving resource allocation, improving inter-disciplinary coordination, and executing projects as turnkey contracts.	Broad and generic
Prasad et al. (2019)	Mitigation measures for delay in claims settlement, mitigation measures for contractor's financial issues, mitigation measures delay in settlement of variations in changes in scope, mitigation measures for late payment to suppliers and subcontractors, and mitigation measures for changes in design.	Exhaustive list of measures that covers entire project lifecycle. Can be used as a checklist for mitigating effects of construction delays.
Shengea et al. (2020)	Investing sufficient time and money in projects, having a well-defined risk- sharing agreement, encouraging "strong coordination within the project groups and various interfaces, and avoiding delay in deciding contractor clams," and contractors adopting quicker construction techniques and avoiding the use of outdated construction equipment.	Specific to hydropower construction projects in India

2.5.3 Key findings on the mitigation measures for construction project delays.

There are only a handful of prior studies that offer suggestions for resolving problems arising from construction project delays. In addition, most of these measures are broad and generic (Mezher and Tawil 1998, Faridi and El-Sayegh 2006, Ng 2007, Olawale and Sun 2010). Amongst the studies reviewed, only Abdul-Rahman et al. (2006) were able to come up with an exhaustive list of mitigation measures that covers the project's lifecycle. Similarly, there is a dearth in studies in literature that contains systematic approaches for mitigating construction project delays. Only Chai et al. (2015) and Prasad et al. (2019) were able to come up with an exhaustive list of mitigation measures that can be used as a checklist by construction professionals for addressing a wide range of delay issues. This observation is aligned with the claim of Prasad et al. (2019) which highlights the lack of depth and specifics of mitigation measures found in prior literature.

Finally, findings from the literature review will be used to form the objectives of the different balanced scorecard (BSC) perspectives for mitigating delays. Table 2.9 shows the objectives of these perspectives and their respective sources.

Table 2.9 Objectives of the BSC Perspectives and the Respective References

	Objective	References
Financial Perspective	Complete the project within the allocated budget	Amoatey et al.(2015), Gajare, et al. (2015), Hisham and Yahya (2016), Reshma and Robin (2018)
	Avoid penalties and liquidated damages	Aibinu and Odeyinka (2006), Sambasivan and Soon (2007)
	Enhance reputation and hence gain more business opportunities	Kasimu and Abubakar (2012)
	Decrease overhead and operational costs	Alinaitwe et al. (2013)
	Achieve early revenue and capital cost recovery	Abdul-Rahman et al. (2006)
	Eliminate any additional cost due to late delivery of material and equipment	Abd El-Razek et al. (2008), Zidane and Andersen (2018b)
	Reduce cost due to rework	Abdul-Rahman et al. (2006), Abedi et al. (2011)
Client Perspective	Ensure timely completion of design to avoid or minimize any changes during execution	Yang et al. (2010), Ijaola and Iyagba (2012), Kikwasi (2012), Reshma and Robin 2018), Zidane and Andersen, (2018b)
	Perform adequate project planning and scheduling	Abedi et al. (2011)
	Ensure comprehensive project control and monitoring systems for schedule, cost control and change order tracking	Abdul-Rahman et al. (2006), Prasad et al. (2019)
	Expedite decision making process	Prasad et al. (2019)
	Put in place comprehensive contract document	Olawale and Sun (2010)
	Promptly coordinate interface between client, project stakeholders, and contractor	Abdul-Rahman et al. (2006)
	Prepare comprehensive tender document and process	Abdul-Rahman et al. (2006)
	Ensure selection of the optimum bidder not only the lowest bidder	Chai et al. (2015)
	Timely progress payments to the contractor	Abdul-Rahman et al. (2006)
	Include pre-approved vendor and subcontractor list in the contract to expedite material submittals and pre-qualifications	Chai et al.(2015)
	Organize frequent internal project progress meeting	Abedi et al. (2011)
	Enforce delay penalties and early completion incentive clauses	Chai et al. (2015)
	Ensure robust QHSE management system and practises are in place	Abdul-Rahman et al. (2006)
	Ensure quick access for contractors and subcontractors to site	Abedi et al. (2011)
	Perform necessary soil investigation in advance	Abdul-Rahman et al. (2006)
Contractor and Project Mgt. Team Perspective	Effectively Plan, manage and supervise site construction activities	Alaghbari et al. (2007), Gonduz et al. (2013)
	Hire competent personnel for the project	Abdul-Rahman et al. (2006), Abedi et al. (2011)
	Select the optimum subcontractors and suppliers	Abdul-Rahman et al. (2006), Abedi et al. (2011)
	Ensure all submitted technical information is accurate for commencement of the work	Abdul-Rahman et al. (2006)
	Ensure timely payment to subcontractors and suppliers	Abdul-Rahman et al. (2006), Abedi et al. (2011)
	Put in place appropriate material management strategy	Zidane and Andersen (2018a), Prasad et al. (2019)
	Allocate sufficient manpower for the project	Abdul-Rahman et al. (2006)

Table 2.9 (continued) Objectives of the BSC Perspectives and the Respective References

	Objective	References
Contractor and Project Mgt. Team Perspective	Put in place appropriate plant and equipment management strategy	Abedi et al. (2011)
	Ensure sufficient funding is in place at different milestone of the project	Abdul-Rahman et al. (2006), Abedi et al. (2011)
	Put in place comprehensive risk management plan	Zidane and Andersen (2018a)
	Organize frequent project progress meeting between all project parties	Abdul-Rahman et al. (2006), Abedi et al. (2011)
	Ensure quick site mobilization process	Abdul-Rahman et al. (2006), Abedi et al. (2011)
	Motivate labors through incentive programs, good standard accommodation camp, and recreation facilities	Prasad et al. (2019), Abdul-Rahman et al. (2006)
	Consider impact of seasonal weather conditions on performance and plan site activities accordingly	Hwang et al. (2013)
Innovation and Learning Perspective	Put in place knowledge management system to utilize previous project experience as applicable	Chai et al. (2015)
	Allow open communication and feedback approach between all parties	Mezher and Tawil (1998)
	Utilize electronic systems to track schedule and cost	Olawale and Sun (2010)
	Provide training for project team to continuously upgrade their knowledge and to upskill labour.	Chai et al. (2015)
	Increase productivity by using latest technology of construction tools and equipment as required	Zidane and Andersen (2018a)
	Utilize electronic documentation systems review, approve documents and track document flow	Zidane and Andersen (2018a)
	Resequencing work activities wherever possible without increasing resources	Abdul-Rahman et al. (2006)

2.6 Summary of Key Findings

Firstly, results of the literature review on causes of construction project delays highlight the variability of delay causes. Although most delay issues in developing countries are attributable to internal causes and those in developed countries are mostly due to external causes, literature blurs such distinction. Indeed, results of the review of literature underscores the country-to-country variability of delay causes.

Secondly, results of the review on the types of project delays highlight the variance in the typology and categorization of the types of delay. Moreover, results of the review emphasize the association between the causes of delay and the types of delay, thereby implying the prerequisite for understanding the former in order to determine the latter. Thirdly, results of the review on the impacts of construction project delays highlight the predominance and pervasiveness of time and cost overruns.

All reviewed studies identified time and cost overruns as the most common and most critical effects of delays. Finally, unlike the topics of project delay causes and impacts which are replete with studies, there is a dearth in studies relevant to mitigation measures for delays. In addition, most of the mitigation measures found in literature were generic, piecemeal, and lacking in depth. Thus, there is a need for studies which can offer more holistic and systematic approaches for mitigating construction project delays. This study is thus, envisaged to close such gaps in literature.

Chapter 3 : Methodology

3.1 Introduction

The different negative impacts of construction delays have been documented in literature. These impacts range from simple delays to time and cost overruns, to disputes, to arbitration, to litigation, and finally, to project abandonment (Aibinu and Odeyinka 2006, Sambasivan and Soon 2007, Kasimu and Abubakar 2012). These delay outcomes are detrimental to the brand image and reputation of construction firms who run the risk of being blacklisted by regulatory authorities and losing client confidence. Thus, the current study aims to develop a framework based on an integrated Balanced Scorecard (BSC) and Quality Function Deployment (QFD) approach that can guide construction firms in mitigating construction delays. This chapter will discuss the methodology used in order to achieve the aforementioned aim. The structure of this chapter is as follows: First, it will present a brief discussion of the BSC and its implementation in the construction industry. This is followed by a discussion of the QFD and its application in the construction industry. Then, a succinct discussion of the application of an integrated BSC and QFD approach will be presented. The rest of the sections will explore on the methodology of the current research and will encompass the following: conceptual framework, research philosophy, research approach, research design, research strategy, research procedures, and ethical considerations. Finally, a succinct summary of the chapter will be presented.

3.2 The BSC Approach

The BSC has been described as “a customer-based planning and process-improvement system” whose aim is to focus and drive the change process. The BSC “translates strategy into an integrated set of financial and nonfinancial measures that communicates the organizational strategy to employees and provides them with feedback on which they can take action to achieve their objectives" (Pineno 2004). The BSC was introduced in the early 1990s by Kaplan and Norton as a unifying tool that promotes the use "of non-financial information in the performance evaluation of business units" (Abdel-Kader et al. 2011). Whilst the nucleus of traditional accounting methods is solely financial measures, the BSC, on the other hand, "includes both objective and subjective measures addressing four major areas: Financial Perspective, Customer Perspective, Internal Business Process, and Learning Process and Growth Perspective" (Pineno 2004). The aforementioned measures connect the organization's vision and strategy which are subsequently expressed in the form of aims that measure the realization of the strategy (Michalska 2005). Thus, a single BSC report typically includes a summary the following: financial and non-financial measures, short-term and long-term performance, and outcome diagram and leading measures (Abdel-Kader et al. 2011). The success of the BSC is heavily hinged on the manner by which it connects the four areas in a causal chain in order to generate the desired outcomes (Chen et al. 2011).

Figure 3.1 below is a diagram of Rockwater's BSC. Rockwater is "a wholly-owned subsidiary of Brown & Root/Halliburton," which is a renowned leader in the *engineering and construction industry* (Kaplan and Norton 1993). As shown in Figure 3.1, Rockwater's BSC has four sets of performance measures which were grouped into four categories, namely:

Financial perspective. The financial component includes the following five measures: return- on -capital-employed and cash flow, which "reflected preferences for short-term results", and forecast reliability which represents "the corporate parent's desire to reduce the historical uncertainty caused by unexpected variations in performance" (Kaplan and Norton 1993). These three measures are considered to be important to shareholders. In addition, project profitability measures were included to make the project as “the basic unit of planning and control,” and sales backlog enables the reduction of performance uncertainty (Kaplan and Norton 1993).

Customer perspective. Customer perspective includes the following measures: pricing index, customer ranking survey, and satisfaction index and market share.

Internal business perspective. This perspective includes measures for each business-process phase, namely: “the number of hours spent with prospects; tender/bid success rate; project performance effectiveness/index, safety/loss control, rework; and length of project closeout cycle” (Kaplan and Norton 1993).

Innovation and learning perspective. “Intended to drive improvement in financial, customer, and internal process performance.” This perspective includes the following measures: percent revenue from new services, rate of improvement success, staff attitude survey, number of employee suggestions, and revenue per employee (Kaplan and Norton 1993).

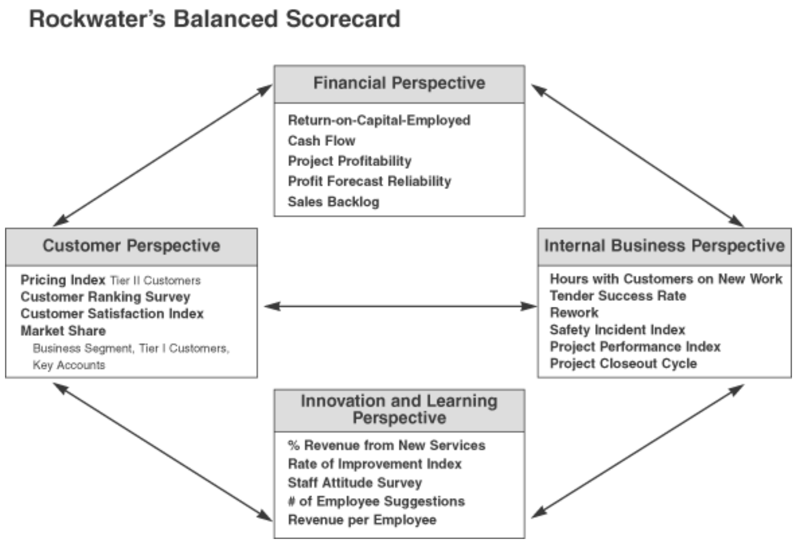

Figure 3.1 Rockwater’s BSC Kaplan & Norton (1993)

The financial perspective considers how the company appears to shareholders; the customer perspective identifies how customers view the company; the internal perspective identifies what it is that the company must excel at; and the innovation and learning perspective determines if the company can "continue to improve and develop value" (Kippenberger 1996). The suggested advantages of the BSC are as follows: it enables managers to look at the company's performance in many areas concurrently; it helps managers focus on the critical indicators; it consolidates a diverse range of indicators into one report; it prevents sub-optimization; it enables managers to determine if "changes in one area are at the expense of another" (Kippenberger 1996). Furthermore, several authors have considered the balanced scorecard as an "appropriate tool for introducing a complex system of measuring innovation performance for an entire company" (Zizlavsky 2016).

3.2.1 Application of the BSC in the Construction Industry

The literature is replete with the use of BSC in various activity sectors (Rantanen et al. 2007, Hoque 2014). For instance, the BSC has been found to be useful in evaluating the performance of local governments (Hoque and Adam 2011), manufacturing firms (Hoque 2005), financial institutions and insurance companies (Kaplan and Norton 1996), and healthcare centres (Stewart and Bestor 2000). With regards to the BSC's use in the construction industry, several authors have underscored its applicability such as Kagioglou et al. (2001), Chan and Chan (2004), Bassioni et al. (2005), Robinson et al. (2005), and Lin and Shen (2007). According to Robinson et al. (2005), the BSC includes a range of leading and lagging indicators and is considered to be more extensive than the European Foundation for Quality Management (EFQM) excellence framework. Chan (2009) used the BSC to examine the relationships between the critical success factors and the strategic thrusts in the master plan of the Malaysian construction industry for 2006-2015. Chan (2009) found that the BSC was useful in revealing that the eight critical success factors and seven strategic thrusts of the master plan cover all four perspectives, and in subsequently developing thirty-four performance measures for evaluating the outcomes of the strategic thrusts.

However, various authors have also highlighted the weaknesses of using the BSC alone in measuring the performance of construction companies. For instance, Andersen et al. (2000), Kanji and Moura (2001), and Chiang and Lin (2009) have considered the BSC as lacking in the ability to facilitate interaction between top executives and employees due to its top-down approach, thereby rendering it useless for benchmarking construction activities and in promoting industry best practices. Furthermore, Francioli and Cinquini (2014) have highlighted the ambiguity of the relationships between and within the four BSC perspectives. Such ambiguity had already been pointed out earlier by Koo (1997, 1998) who argued that Kaplan and Norton's (1996) proposal to use "correlation analysis to establish the hypothesis of causal linkages among various measures" is counterintuitive since a "high correlation does not imply causal relationship" and that "the reverse is however true i.e. having a causal relationship implies a high correlation relationship." Koo (1998) further noted the lack of "a systematic and structural approach to quantify the strengths of association among the various BSC measures." To overcome the aforementioned weaknesses of the BSC, Koo (1998) recommended combining the BSC with another tool such as the QFD. Koo's (1998) recommendation was later buttressed by Price (2003) who argued that to enhance continuous improvement, BSC should be integrated with another tool such as the business excellence model (BEM) into strategic management processes.

Such suggestions by Koo (1997, 1998) and Price (2003) had been the basis of the studies conducted by Luu et al. (2008) and Oyewobi et al. (2015) who fortified the strengths of the BSC by combining it with another performance measurement tool. For instance, Luu et al. (2008) proposed and tested an integrated model of the BSC and the strengths, weaknesses, opportunities, and threats (SWOT) matrix in evaluating the strategic performance of large construction companies in Vietnam. Findings of their study indicate that their integrated model generated eleven effective solutions that could be grouped into the following four categories, namely: (1) innovating organizational structure; (2) effectively managing processes at construction sites; (3) stepping up cost control; and (4) improving equipment management" (Luu et al. 2008).

Similarly, Oyewobi et al. (2015) proposed an integrated model for measuring the performance of construction companies by assessing the strengths and weaknesses of the BSC and BEM. Findings of their study suggest the usefulness of an integrated BSC and BEM model in helping construction companies perform "regular health checks of all business process" and help link "organisational activities with strategic primacy" (Oyewobi et al. 2015). In particular, the integrated BSC and BEM model complements both approaches and thus, affords a better way of evaluating the performance of construction companies (Oyewobi et al. 2015).

Although the BSC has been integrated with other tools such as the SWOT matrix (Luu et al. 2008) and the BEM (Oyewobi et al. 2015) in measuring the general or overall performance of construction companies, there is a dearth in studies that delve on the combination of the BSC with other performance measurement tools to come up with a framework for measuring the performance of construction companies in mitigating delays, despite the highlighted negative outcomes of construction delays in the literature. Thus, the succeeding sections will explore the suitability of another performance measurement tool, the QFD or House of Quality (HOQ) in strengthening the BSC approach to subsequently explore the possibility of developing a more integrated and holistic performance measurement framework for mitigating the impacts of construction delays.

3.3 The QFD Approach

QFD has been defined as "a system for translating consumer requirements into appropriate company requirements at every stage, from research, through product design and development, to manufacture, distribution, installation and marketing, sales and services" (Koo 1998). It was introduced at Mitsubishi's Kobe shipyard in 1972 (Koo 1998). Alsyouf et al. (2011) explained that QFD involves the deployment of product or service attributes "desired by the customer throughout all the appropriate functional components of an organization." QFD is useful in translating customer needs into the attributes of engineering design "through the integration of designing, marketing, manufacturing" and other related organisational functions (Alsyouf et al. 2011). In addition, it serves as a "powerful tool that ensures proper communication between the client and the design team" (Chao and Ishii 2004).

The QFD uses the house of quality (HOQ) matrix in its methodology. The main focus of the HOQ rests on the WHATs or the identified customer needs, and the HOWs or the engineering attributes (Alsyouf et al. 2011). Figure 3.2 below shows the components of the HOQ.

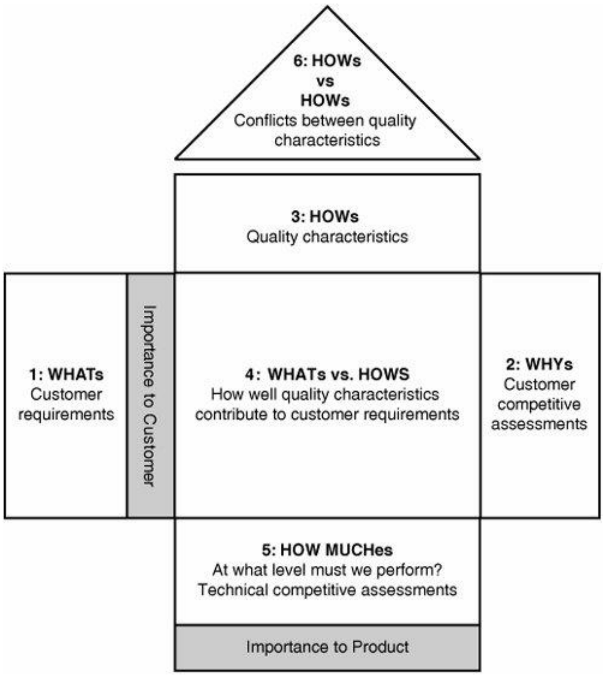

Figure 3.2 The Components of the House of Quality

3.3.1 Applications of QFD in the Construction Industry

Compared to the use of the BSC in the construction industry, there are more studies found in literature that focus on the application of the QFD within the context of construction management. For instance, Artidi and Lee (2003) used the QFD in developing a performance measurement tool to evaluate the corporate service quality of a design-build (D/B) firm. Results of the survey administered to construction workers were used to rank the service quality factors relative to the client's needs and expectations, while results of the survey administered to by D/B executives were used to rank the components of quality management systems in place. Then, a professional quality system assessor integrated all the attributes of the relationships between service quality factors and quality system requirements into one measurement system. Artidi and Lee (2003) maintained that QFD can be considered as a ranking mechanism that can be used in choosing D/B firms. In the same manner, Ahmed et al. (2009) examined the applicability of the QFD during the planning process of civil engineering capital projects. Their findings suggest that QFD is useful "in the capital project planning process as a road map to keep track of the original requirements, facilitate good communication across the hierarchy, and serve as a tool for evaluating project alternatives" (Ahmed et al. 2009).

There are also several studies that focus on QFD application during the design stage of the construction project (Mallon and Mulligan 1993, Huovila et al. 1997, Huovila and Nieminen 2001, Eldin and Hikle 2003, Haron and Khairudin 2012). Mallon and Mulligan's (1993) seminal work on the use of QFD in construction management underscored the utility of the QFD in the design stage of a hypothetical renovation project. According to Mallon and Mulligan (1993) "QFD is the most applicable technique for quality design and customer satisfaction subjects" compared to other approaches. In the same manner, Huovila et al. (1997) employed the QFD methodology in the design of an industrial building and found the QFD as a useful tool during the design stage. Eldin and Hikle (2003) carried out a pilot study of the use of the QFD in the preparation of a conceptual design of a large classroom for college students. Eldin and Hikle (2003) identified the customers' needs and the organization of the customers' requirements, developed the house of quality, and evaluated the initial designs. Findings of their study highlighted the usefulness of the QFD in engineering-construction projects by enabling the improvement of the communication process and the formulation of design decisions. Similarly, Haron and Khairudin (2012), used the QFD approach in improving the layout design of an apartment building in Malaysia. Haron and Khairudin (2012) conducted interviews with ten industry practitioners in identifying the favorite attributes for customer's requirement and in determining "the technical solutions for the layout."

However, there is a lack in studies that focus on the application of the QFD after the construction phase of a project, with the exception of the one conducted by Dikmen et al. (2005) which is a case study of the application of QFD in a housing project in Ankara, Turkey. Dikmen et al. (2005) used the QFD approach in determining the most suitable marketing strategy for the housing project, in facilitating decision making for upcoming projects, and in formulating a systematic procedure for developing a competitive advantage within the housing market. Findings of their case study suggest that QFD is useful during the marketing stage because it enables the determination of the suitable marketing strategy, helps identify competing alternatives, and promotes client satisfaction in upcoming projects. In addition, Dikmen et al. (2005) noted the different limitations of the QFD methodology which includes the following: its lack of comprehensiveness when it comes to the "budget, schedule, technology constraints of the project or other company specific constraints." They further recommended the use of a wider framework for the QFD methodology that will cover cost and schedule constraints.

3.4 Combination of the BSC and QFD in the Construction Industry

There are only a few studies which focus on the use of an integrated BSC and QFD approach in the construction industry. There were only three relevant studies found; these were the contributions of Burak (2006), Chen and Chou (2006), and Moussa (2017). Burak (2006) proposed a safety management framework for construction companies by combining the BSC and QFD approaches. Burak (2006) concluded that with the use of the integrated BSC and QFD framework, the following safety recommendations were generated: (1) Every construction company should cultivate a safety-conscious culture; (2) "effort spent on safety should not be seen as a cost increasing factor"; and (3) contractors must strategically manage safety by effectively planning and implementing safety-related issues. Burak (2006) also pointed out the effectiveness of the BSC in safety management through its ability to incorporate "the management responsibilities of planning, implementing and evaluating." In addition, Burak (2006) recommended the use of the QFD during the design stage to determine the safety goals "so that no unnecessary resources are later spent for the accomplishment of low value adding objectives."

In the same manner, Chen and Chou (2006) developed a framework for establishing the design requirements of an air cargo terminal with the combined use of the BSC and QFD methodology. With the use of the integrated BSC and QFD framework, Chen and Chou (2006) were able to identify the areas that needed improvement in the design of the air cargo terminal such as "the utilization, the availability and efficiency of material-handling equipment, the utilization and turnover rate of the storage positions and space, and the process operating efficiency." Chen and Chou (2006) concluded that an integrated BSC and QFD framework can help in designing an air cargo terminal which ensures the satisfaction of shareholders, customers, and employees alike.

Moussa (2017) developed an integrated BSC and QFD framework for addressing the financial perspective of the pavement management sector. Moussa (2017) concluded that his proposed framework can be used in pavement management in defining the four perspectives and their associated objectives, and subsequently rank them according to importance. As a result, companies belonging to the pavement management sector can prioritize their goals more effectively.

Table 3.1 Applications of an Integrated BSC and QFD

Source	Area of Application	Findings
Burak (2006)	Safety management	Highlighted BCS's ability to incorporate "the management responsibilities of planning, implementing and evaluating" (p.53). Recommended the use of the QFD during the design stage to determine safety goals.
Chen and Chou (2006)	Design requirements of an air cargo terminal	An integrated BSC and QFD framework can help in designing an air cargo terminal which ensures the satisfaction of shareholders, customers, and employees alike.
Moussa (2017)	Pavement Management	An integrated BSC and QFD framework can be used in pavement management in defining the four perspectives and their associated objectives, and subsequently rank them according to importance to help companies prioritize goals.

In light of the above discussion, the present study attempts to extend relevant research on the applicability of the BSC and the QFD into the less researched area of the construction industry by developing a framework of combined BSC and QFD for mitigating delays in the construction industry. The succeeding sections will delve on the methodology of the present study.

3.5 Conceptual Framework

A conceptual framework is "a process comprising of concepts and causal relationship between these concepts" (Sonson et al. 2017). Gratton and Jones (2003) explain that the conceptual framework "describes and explains the concepts to be used in the study, their relationships with each other, and how they are to be measured." The conceptual framework of this study, as shown in Figure 3.3, encompasses the four BSC perspectives: client perspective, financial perspective, contractor and project management team perspective, and innovation and learning prespective. As some authors have replaced the original BSC perspectives with their own to suit their studies (Jin et al. 2013, Sonson et al. 2017), the conceptual framework of this study replaces the original 'internal business process perspective' with contractor and project management team perspective, since most unjustified or inexcusable delays are largely contractor-dependent factors such as those involved in the availability of resources, proper organization, supervision and experience" (Gluzak and Lesniak 2015). In addition, contractor-related factors often result in severe delay outcomes that include time and cost overruns, being blacklisted by regulatory authorities, and client's loss of confidence (Kasimu and Abubakar, 2012).

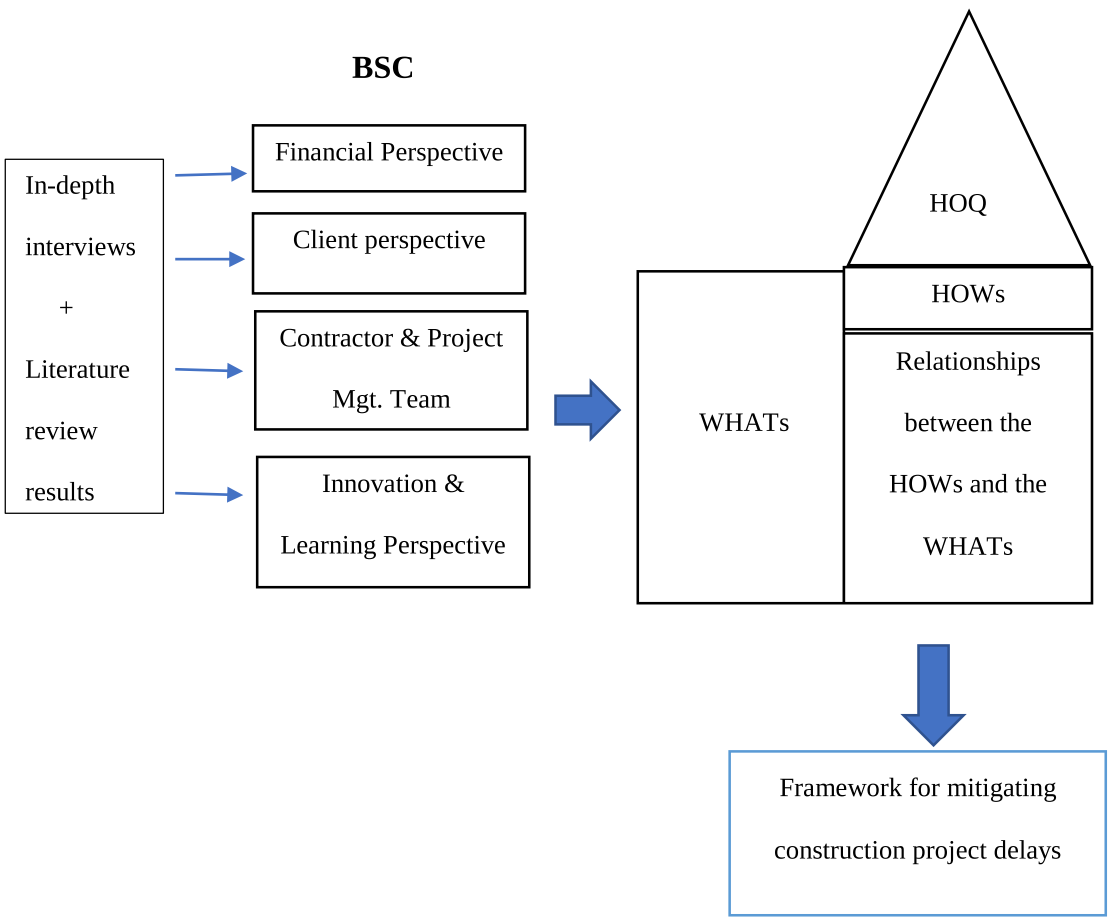

Figure 3.3 Conceptual Framework of the Project

As shown in Figure 3.3, in-depth interviews and literature review results were used to inform the identification of the BSC perspectives, which was carried out in the following manner: First, the financial objectives for construction organizations were established because of the premise that *any delay translates to added cost to the project*. This was followed by the establishment of the client, contractor and project management team, and learning and innovation perspectives which are considered as the *enablers* for mitigating construction project delays, because when they are fully implemented, delays can be avoided. Then, the financial objectives were linked with the enablers. The components of the four BSC perspectives are succinctly summarized below:

1. **Financial Perspective**: The financial perspective involves the provision of increased shareholder value through improved bottom line results (Chan 2009). As noted by Sonson at al. (2017), "construction organisations can use this perspective to demonstrate their financial accountability and stewardship through the production and validation of financial statements." In addition, several authors have documented that contractor's financial issues are one of the major causes of construction delays (Aibinu and Odeyinka 2006, Abd El-Razek et al. 2008, Kasimu and Abubakar 2012, Kikwasi 2012).

2. **Client Perspective**: Customer or client perspective is of outmost importance in construction projects because performance measurement and management (PMM) in construction is largely client driven (Sonson et al. 2017). Thus, it is important for construction companies to evaluate their client's requirements, increase customer value (Oyewobi et al. 2015), and improve their contractual relationship with clients (Sambasivan and Soon 2007). These actions often lead to "close customer relationships and high-quality in their operations" (Sonson 2017). In addition, clients can use a more

effective contract award procedure to ensure the selection of more capable contractors (Abdul-Rahman et al. 2006).

3. **Contractor and Project Management Team Perspective**: The contractor and project management team perspective encompass the integration and improvement of construction companies' internal efficiency (Sonson et al. 2017). Numerous authors have recommended measures for delay mitigation that focus on this perspective; these measures include: the use of predictive, preventive, and organisational or corrective measures (Chai et al. 2015), use of up-to-date technology (Abdul-Rahman et al. 2006, Zidane and Andersen 2018), simplification of administrative procedures, improvement of resource allocation, improvement of inter-disciplinary coordination, (Zidane and Andersen 2018), use of effective strategic planning initiatives (Faridi and El-Sayegh 2006), hiring of competent project team and highly- skilled laborers, allocation of sufficient resources at the design phase of the project (Abdul-Rahman et al. 2006), and improvement of planning and implementation of systematic control processes (Abdul-Rahman et al. 2006, Faridi and El-Sayegh 2006, Ng 2007).

4. **Innovation and Learning Perspective**: This perspective pertains to the premium placed by construction companies on their human resource development initiatives. Some of these initiatives include upgrading competencies and informatization (Yu et al. 2007), simplification of administrative procedures (Zidane and Andersen 2018), and use of lean principles (Asim et al. 2017), in order for construction companies to more effectively "manage their business and improve their performance and ability to adapt to change" (Sonson et al. 2017).

The four perspectives were then structured using the QFD approach, wherein the financial perspective constituted the HOWs, whilst the client, contractor, and project management team, and innovation learning perspectives constituted the

WHATs of the HOQ. The combined BSC and QFD approach served as the survey matrix for mitigating construction project delays which was subsequently administered to selected construction industry practitioners. Finally, their responses served as the basis of the proposed framework for mitigating construction project delays.

3.6 Approach to Theory Development

According to Awuzie and McDermott (2017), the importance of the research approach for any research undertaking cannot be undermined because the structure of a research design should be strongly anchored "upon the research approach adopted." Saunders et al. (2016) explained that the three key approaches to theory development are deductive, abductive, and inductive. The deductive approach involves moving "from general rule to a specific law-like inference and is usually used for theory testing" (Melkinovas 2018), whilst the abductive approach involves making inferences, "starting with observation of clue-like signs, which provide the basic notion for further research" (Melkinovas 2018) and thus, "enables the researcher's engagement in a back and forth movement between theory and data in a bid to develop new or modify existing theory" (Awuzie and McDermott 2017). Lastly, the inductive approach "involves moving from the particular to the general, as when making empirical observations about some phenomenon of interest and forming concepts and theories based on them" (Woiceshyn and Daellenbach 2018). The inductive approach, as explained by Melnikovas (2018), is typically used "in developing a theory or in fields with little researches on the topic."

The inductive approach to theory development was used in this project through the generation of empirical observations about construction project delays and developing an integrated BSC and QFD framework for mitigating construction project delay outcomes. According to Cavaye (1996), in the inductive approach, the basis for theory building is through statements about observed relationships. In the proposed framework, the relationships amongst the four BSC perspectives were identified and evaluated. In addition, in Mintzberg's (1979) form of inductive research, he explained that there are two parts to the inductive approach: detective work and the leap. Detective work involves not only data collection, but also the "analysis taking place" during the data collection process: "looking for patterns, commonalities, consistencies "(Cavaye 1996). On the other hand, the leap pertains to the examination of analytical meaning, which involves "generalization from and beyond the data to draw theoretical conclusion" (Cavaye 1996). In this project, the detective work entailed the identification of the components of the different BSC perspectives from the results of the in-depth interviews and review of related literature, and custom fitting them into the QFD structure. The leap, on the other hand, entailed the development of the integrated BSC and QFD framework, based on the generalizations made from results of the survey matrix.

This project did not use the deductive approach because it does not seek to test the applicability of an extant theory or framework in mitigating construction project delays. Instead, this project aims to propose a framework that can be used for mitigating construction project delays based on the integration of the BSC and QFD approaches. Similarly, this project did not use the abductive approach because it did not involve back and forth movement between theory and data. Rather, this project entailed the detective work and the leap that were used by Mintzberg (1979) in his inductive research.

3.7 Research Design

Research design has been defined as "a logical structure of the enquiry: it is a logical matter rather than a logistical one" ("What is a Research Design?" undated).

According to Ahktar (2016), research design can be regarded as “the structure of research. It is the “glue” that holds all of the elements in a research project together; in short, it is a plan of the proposed research work.” According to Ghauri (2005) the main types of research design are exploratory, descriptive, and experimental/causal. Similarly, Ahktar (2016) enumerated the following different types of research design: exploratory or formative, descriptive or formulative, explanatory or analytical, and experimental.

This project used the exploratory research design because it is applicable in studies where there is “very little existing research on the subject matter” and its main aim is to “identify the boundaries of the environment in which the problems, opportunities or situations of interest are likely to reside, and to identify the salient factors or variables that might be found there and be of relevance to the research” (van Wyk, undated). In terms of the application of the integrated BSC and QFD framework, there appears to be very little extant research undertaken, as only three studies are available in construction management literature: those conducted by Burak (2006) for safety management, Chen and Chou (2006) for the design requirements of an air cargo terminal, and Moussa (2017) for pavement management.

Furthermore, an exploratory research design is used for a more accurate investigation of a problem or “for developing a hypothesis” (Ahktar 2016). This project will extend extant research by examining more closely, the causes and outcomes of construction project delays and how to mitigate them. However, instead of developing a hypothesis, a framework for mitigating project delays is proposed.

3.8 Research Method

Saunders et al. (2016) explain that the researcher can choose from the following methodological choices: qualitative, quantitative or mixed methods. “Quantitative research methods involve numbers and mathematical operations, while qualitative methods imply the collection of a vast descriptive data" (Melkinovas 2018). On the other hand, mixed methods is an integrated approach that combine "elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the purposes of breadth and depth of understanding and corroboration" (Johnson et al. 2007). This project used the mixed methods approach in achieving its stated research aim due to the following reasons: Firstly, the mixed methods approach is consistent with the ontological and epistemological stance of pragmatism which regards research philosophy as "a continuum, rather than an option that stands in opposite positions" (Wahyuni 2012). It considers the objectivist (quantitative) and subjectivist (qualitative) viewpoints as being mutually inclusive. In this project, the quantitative method was used in the analysis of the survey matrix responses, whilst the qualitative method was used during the analysis of the interview transcripts. Secondly, the mixed-methods approach increases the level of rigor of the research findings (Greene 2007) through the triangulation of the research findings. In this project, qualitative data from the interviews were used to inform the construction of the survey matrix from which quantitative data were collected and analyzed. Finally, Riccucci (2010) highlights the suitability of the mixed -methods approach in applied fields due to the flexibility it offers in unravelling pragmatic, real-world problematical situations. Thus, the mixed-methods approach is well-suited for this project because it focuses on the mitigation of construction project delays, which is a practical enquiry relevant to construction management.

3.9 Data Collection and Analysis

3.9.1 Sample

This project used purposive sampling, which is circumscribed under the non-probability sampling technique, whereby the sample was “hand-picked for the research” (Denscombe 2007). It is suitable for “those situations where the researcher already knows something about the specific people or events and deliberately selects particular ones because they are seen as instances that are likely to produce the most valuable data” (Denscombe 2007). According to Thomas (2004), in purposive sampling, “where the researcher possesses sufficient knowledge, it may be possible to select one or a few units because they have characteristics relevant to the objectives of the study.” For this project, four construction industry practitioners were selected for the in-depth interviews for the identification of the components of the BSC. In the same manner, purposive sampling was used in selecting the sample for the survey matrix, which consisted of seventy construction industry practitioners. A key advantage of purposive sampling is that it allows the researcher to select people who can be considered critical for the research and who can help illuminate the research question or problem at hand. In addition, the use of purposive sampling for this project is not only economical, “but might also be informative in a way that conventional probability sampling cannot be” (Denscombe 2007).

3.9.2 Research Instrument

The research instrument for this project is a survey instrument which was developed using the QFD approach, wherein the financial perspective was used as the vertical matrix out- layer, while the enablers (client, contractor and project management team, and innovation and learning perspectives) served as the horizontal out-layer. The instrument development process involved the following: First, to rank the financial objectives based on their importance, a Likert -scale consisting of the following ranking scale was used: 'Very Important', 'Important', 'Moderately Important', 'Less Important', 'Not Important'. Next, to establish the relationships between the financial perspective and the enablers, a Likert -scale consisting of the following rating scale was used: 'strong relationship', 'medium relationship', 'low relationship', and 'no relationship'. The survey matrix questionnaire consisted of forty three Likert -scale items which was later distributed online to seventy construction industry practitioners through e-mail and face-to-face meetings with respondents.

3.9.3 Data Analysis

The collected data were gathered and analyzed using descriptive statistics. First, Cronbach's alpha was obtained for each item in the questionnaire in order to determine their reliability; that is, they measure what they intend to measure. In the same manner, the validity of the items of the survey questionnaire were determined by experts (expert judgment), who were construction industry professionals. Next, the average scores of all components of the financial perspective were obtained. In the same manner, the average scores of all components of the enablers (client, contractor and project management team, and innovation and learning perspectives) were calculated and were normalized with the weighted average scores of all components of the financial perspective. Figure 3.4 shows a bird's eye view of the methodology used in this project.

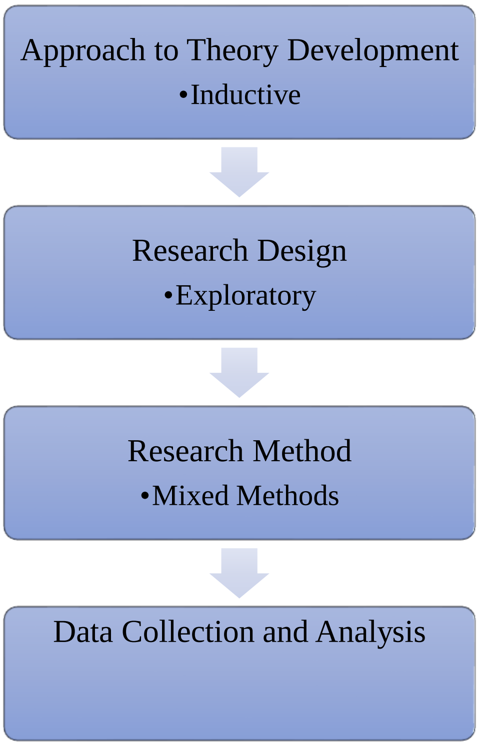

Figure 3.4 Diagram of the Project Methodology

3.10 Ethical Considerations

The following ethical considerations are relevant in this project: the use of human participants during the interviews and the survey, protection of the privacy and anonymity of the participants, the researcher/ participant relationship, and data storage. To address the first and second ethical considerations, the researcher ensured that the participants are free from any physical or psychological harm during their participation in this project. Furthermore, an informed written consent from each study participant was obtained prior to the conduct of the in-depth interviews and the administration of the survey questionnaire. The in-depth interviews were framed by a briefing before each interview started, and a debriefing afterwards. In addition, the researcher started off each interview with a brief explanation of the confidentiality and anonymity of the information that each interviewee will provide and their prerogative to withdraw at any stage of the investigation. In the same manner, an information package, consisting of a brief summary of the purpose of this project and the methodology, and their right to withdraw at any stage of the investigation, was emailed to each survey participant prior to the administration of the survey matrix questionnaire. To address the third ethical consideration of researcher/ participant relationship arising from the potential conflict between the desire to challenge to gain an opportunity to further explore the issues and the desire to collude with the participants during the interviews to 'keep things safe', a culture of openness was developed at the beginning of each in-depth interview, with the researcher emphasizing his openness to discussion during the entire process of inquiry or investigation. To address the fourth ethical consideration, all collected data were stored in a password-protected computer.

3.11 Conclusions

This chapter discussed the methodology used in this project. In particular, this chapter delved on the following: the conceptual framework, the research philosophy, the approach to theoretical development, the research design adopted, the data collection methods and analysis employed, and how the relevant ethical concerns were addressed. The results of the analysis of gathered data will be discussed in the next chapter.

Chapter 4 : Analysis, Results and Discussion

This chapter aims to present the results of the analysis of data obtained from the survey questionnaire. This chapter includes the following sections: The first section delves on the items of the questionnaire and their reliability. This is followed by the second section which shows the results of the analysis of data collected from the survey questionnaire. Lastly, the key findings drawn from results from the data analysis are presented.

4.1 The Survey Questionnaire

4.1.2 Items of the Survey Questionnaire

Items in the survey questionnaire consisted of the four BSC perspectives: financial, client, contractor and project management team, and innovation and learning.

4.1.2.1 Financial Perspective

The financial perspective included the following seven objectives:

1. Complete the project within the allocated budget.
2. Decrease overhead and operational costs.
3. Enhance reputation and hence gain more business opportunities.
4. Eliminate any additional costs due to late delivery of material and equipment.
5. Achieve early revenue and capital cost recovery.
6. Avoid penalties and liquidated damages.
7. Reduce cost due to rework.

4.1.2.2 Client Perspective

Items related to the client perspective included the following 15 objectives:

1. Prepare comprehensive tender document and process.
2. Ensure selection of the optimum bidder not only the lowest bidder.
3. Put in place comprehensive contract document.

4. Ensure comprehensive project control and monitoring systems for schedule, cost control and change order tracking.
5. Ensure robust QHSE management system and practices are in place.
6. Perform necessary soil investigation in advance.
7. Ensure quick access for contractors and subcontractors to site.
8. Promptly coordinate interface between client, project stakeholders, and contractor.
9. Ensure timely completion of design to avoid or minimize any changes during execution.
10. Include pre-approved vendor and subcontractor list in the contract to expedite material submittals and pre-qualifications.
11. Perform adequate project planning and scheduling.
12. Organize frequent internal project progress meeting.
13. Timely progress payments to the contractor.
14. Expedite decisions making process.
15. Enforce delay penalties and early completion incentive clauses.

4.1.2.3 Contractor and Project Management Team Perspective

Items related to contractor and project management team perspective included the following 14 objectives:

1. Ensure all submitted technical information is accurate for commencement of the work.
2. Ensure sufficient funding is in place at different milestone of the project.
3. Hire competent personnel for the project.
4. Allocate sufficient manpower for the project.
5. Ensure quick site mobilization process.

6. Select the optimum subcontractors and suppliers.
7. Ensure timely payment to subcontractors and suppliers.
8. Put in place appropriate plant and equipment management strategy.
9. Effectively plan, manage, and supervise site construction activities.
10. Put in place appropriate material management strategy.
11. Put in place comprehensive risk management plan.
12. Motivate labors through incentive programs, good standard accommodation camp, and recreation facilities.
13. Consider impact of seasonal weather conditions on performance and plan site activities accordingly.
14. Organize frequent project progress meeting between all project parties.

4.1.2.3 Innovation and Learning Perspective

Items related to innovation and learning perspective included the following 7 objectives:

1. Allow open communication and feedback approach between all parties.
2. Utilize electronic documentation systems review, approve documents and track document flow.
3. Increase productivity by using latest technology of construction tools and equipment as required.
4. Utilize electronic systems to track schedule and cost.
5. Re-sequencing work activities wherever possible without increasing resources.
6. Put in place knowledge management system to utilize previous project experience as applicable.
7. Provide training for project team to continuously upgrade their knowledge and to upskill labor.

Table 4.1 QFD Dimensions Filled with Construction Delay Mitigation Perspectives

	Financial Objectives						
	Complete the project within the allocated budget	Decrease overhead and operational costs	Enhance reputation and hence gain more business opportunities	Eliminate any additional cost due to late delivery of material and equipment	Achieve early revenue and capital cost recovery	Avoid penalties and liquidated damages	Reduce cost due to rework
Importance Rating of Objectives							
Prepare comprehensive tender document and process							
Ensure selection of the optimum bidder not only the lowest bidder							
Put in place comprehensive contract document							
Ensure comprehensive project control and monitoring systems for schedule, cost control and change order tracking							
Ensure robust QHSE management system and practices are in place							
Perform necessary soil investigation in advance							
Ensure quick access for contractors and subcontractors to site							
Promptly coordinate interface between client, project stakeholders, and contractor							
Ensure timely completion of design to avoid or minimize any changes during execution							
Include pre-approved vendor and subcontractor list in the contract to expedite material submittals and pre-qualifications							
perform adequate project planning and scheduling							
Organize frequent internal project progress meeting							
Timely progress payments to the contractor							
Expedite decisions making process							
Enforce delay penalties and early completion incentive clauses							

Table 4.1 (continued) QFD Dimensions Filled with Construction Delay Mitigation Perspectives

Ensure all submitted technical information is accurate for commencement of the work
Ensure sufficient funding is in place at different milestone of the project
Hire competent personnel for the project
Allocate sufficient manpower for the project
Ensure quick site mobilization process
Select the optimum subcontractors and suppliers
Ensure timely payment to subcontractors and suppliers
Put in place appropriate plant and equipment management strategy
Effectively Plan, manage and supervise site construction activities
Put in place appropriate material management strategy
Put in place comprehensive risk management plan
Motivate labors through incentive programs, good standard accommodation camp, and recreation facilities
Consider impact of seasonal weather conditions on performance and plan site activities accordingly
Organize frequent project progress meeting between all project parties
Allow open communication and feedback approach between all parties
Utilize electronic documentation systems review, approve documents and track document flow
Increase productivity by using latest technology of construction tools and equipment as required
Utilize electronic systems to track schedule and cost
Re-sequencing work activities wherever possible without increasing resources
Put in place knowledge management system to utilize previous project experience as applicable
Provide training for project team to continuously upgrade their knowledge and to upskill labor.

Items for the financial perspective were used for determining the importance of the financial objectives using the Likert-scale rating presented in Table 4.1 below. As shown in Table 4.1, a rating of ‘0’ means that the financial objective is ‘not important’; a rating of ‘1’ means that the financial objective is ‘less important’; a rating of ‘3’ means that the financial objective is ‘moderately important’; a rating of ‘5’ means that the financial objective is ‘important’; and a rating of ‘7’ means that the financial objective is ‘very important.’

Table 4.2 Likert-Scale Used for Rating the Importance of the Seven Financial Objectives

Objective Relative Importance	
7	Very Important
5	Important
3	Moderately Important
1	Less Important
0	Not Important

The relationship between the enablers (client, contractor and project management team, and innovation and learning perspectives) and the financial objectives were rated by the respondents using the following scale: ‘S’ for strong relationship, ‘M’ for medium relationship, ‘L’ for low relationship, and ‘empty’ for ‘no relationship’ (see Table 4.2).

Table 4.3 Rating Scale used for Indicating the Relationship between the Enablers and Financial Objectives

Relationship Between Enablers & Objectives	
Strong	S
Medium	M
Low	L
No Relation	Empty

4.1.3 Reliability of the Survey Questionnaire

Cronbach's alpha is a statistical tool that measures the similarity of responses provided by survey participants for similar questions (Sijtsma 2009). Cronbach's alpha was used to measure the internal consistency of the survey questionnaire; that is, the extent to which the items are associated or linked with one another (Sim and Wright 2000). Although a minimum value of 0.60 is considered acceptable (Sim and Wright 2000), a value of ≥ 0.70 is considered desirable (De Vellis 2003). Still, other researchers maintain that a value of ≥ 0.95 is needed to be able to establish survey reliability (Travakol and Dennick 2011). For the present study, a Cronbach's alpha score of >0.70 will be considered acceptable. As shown in Table 4.1, the items which correspond to the seven financial objectives in the questionnaire is therefore considered highly acceptable because the overall Cronbach's alpha value obtained was 0.989. Table 4.2 shows the overall Cronbach's alpha value of 0.989 obtained for the enablers (i.e. client perspective, contractor and project management team perspective, and innovation and learning perspective).

Table 4.4 Cronbach's alpha Values of the Financial Objectives

Factors	Number of Items	Cronbach's Alpha
Objective 1: Complete within the allocated budget	36	0.948
Objective 2: Decrease overhead and operational costs	36	0.945
Objective 3 Enhance reputation and hence gain more business opportunities	36	0.940
Objective 4 Eliminate any additional costs due to late delivery of material and equipment	36	0.939
Objective 5 Achieve early revenue and capital cost recovery	36	0.967
Objective 6 Avoid penalties and liquidated damages	36	0.964
Objective 7 Reduce costs due to rework	36	0.931
Overall	252	**0.989**

Table 4.5 Cronbach's alpha Values of the Enablers

Factors	Number of Items	Cronbach's Alpha
Client perspective	105	0.969
Contractor & project management team perspective	98	0.977
Innovation and learning perspective	49	0.962
Overall	252	0.989

4.2 Data Analysis

4.2.1 Average and Weighted Scores

The average score of each item was obtained using the average score equation below:

$$\bar{x} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}$$

Which can be expanded into:

$$\bar{x} = \frac{w_1 x_1 + w_2 x_2 + \cdots + w_n x_n}{w_1 + w_2 + \cdots + w_n}$$

Where W is the number of responses or response count, and X is the question scale for each response.

4.2.1.1 Average Scores, Weighted Scores and Ranking of the Objectives of the Financial Perspective

For instance, the average score of the financial objective 'complete the project within the allocated budget' was calculated using the above equation and is as follows:

[(60*7) + (9*5) + (1*3) + (0*1) + (0*0)] = 6.686/34.543 = 0.194 (see Table 4.6).

Table 4.6 Sample Score Calculation for Financial Objectives "Complete the project within the allocated budget"

Answer options	Scale	Count	%	Average score	Weighted average score
Very Important	7	60	86%		
Important	5	9	13%		
Moderately Important	3	1	1%	**6.686**	**0.194**
Less Important	1	0	0%		
Not Important	0	0	0%		

The average scores and weighted average scores of all financial objectives were then obtained using the same equation, enabling the researcher to rank the financial objectives based on their perceived importance (Table 4.7 and Figure 4.1). Thus, the most important financial objective is 'Complete the project within the allocated budget', followed by 'Avoid penalties and liquidated damages', followed by 'Enhance reputation and hence gain more business opportunities', followed by 'Decrease overhead and operational costs', followed by 'Achieve early revenue and capital cost recovery', followed by 'Eliminate any additional cost due to late delivery of material and equipment', and lastly, by 'Reduce cost due to rework.'

Table 4.7 Ranking of Financial Objectives based on Perceived Importance

Ranking	Description	Ave. Score	Weighted Score
1	Complete the project within the allocated budget	6.686	**0.194**
2	Avoid penalties and liquidated damages	5.343	**0.155**
3	Enhance reputation and hence gain more business opportunities	4.629	**0.134**
4	Decrease overhead and operational costs	4.600	**0.133**
5	Achieve early revenue and capital cost recovery	4.457	**0.129**
6	Eliminate any additional cost due to late delivery of material and equipment	4.414	**0.128**
7	Reduce cost due to rework	4.414	**0.128**
Sum of average score of financial objectives		**34.543**	**1.00**

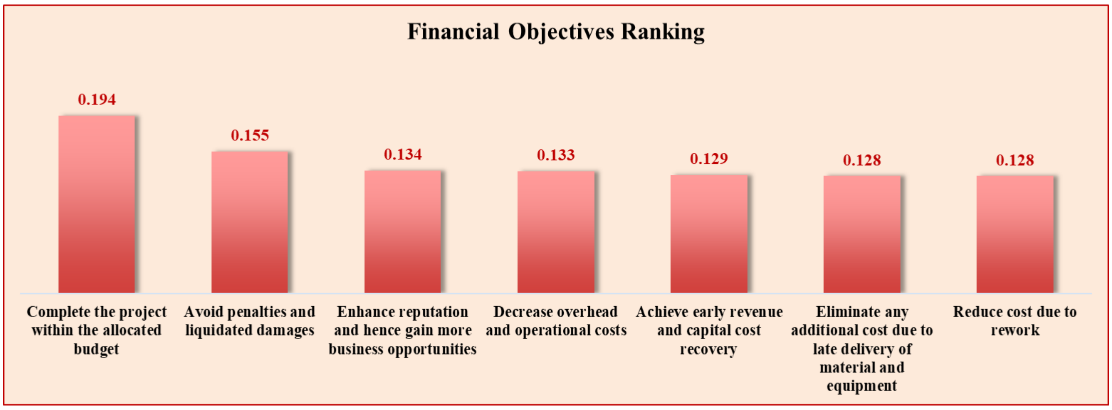

Figure 4.1 Ranking of Financial Objectives based on Perceived Importance

4.2.1.2 Overall Ranking of Enablers of Construction Delay Mitigation

To calculate the overall ranking of the enablers, first, the average of responses for each enablers against each financial objective is calculated, then it is normalized with the weighted average of the financial objectives. For instance, the average score of enabler 9 ‘Ensure timely completion of design to avoid or minimize any changes during project execution’ was calculated using the average score equation as follows:

[(58*5) + (11*3) + (0*1) + (1*0) + (0*0)] = 323/70 = 4.614

This process was repeated 7 times for each financial objective as shown in table 4.8.

Table 4.8 The average of responses for enabler 9 against each financial objectives

Enabler 9's relationship versus financial objectives							
Financial Objectives	1	2	3	4	5	6	7
Average score	4.614	3.471	2.929	3.543	3.500	3.586	4.343

This calculated average(s) were further normalized with the weighted average of the financial objectives as follow:

[(4.614*0.194) + (3.471*0.133) + (2.929*0.134) + (3.543*0.128) + (3.500*0.129) + (3.586*0.155) + (4.343*0.128)] = 3.762

Table 4.9 Sample calculation of normalization of average score for enabler 9

Financial Objectives	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Normalised average score of enabler**
weighted average scores for financial objectives	0.194	0.133	0.134	0.128	0.129	0.155	0.128	**3.762**
average score of enablers	4.614	3.471	2.929	3.543	3.500	3.586	4.343	

This process was repeated 36 times for each enabler. Table 4.10 shows the importance rating of the enablers of construction delay mitigation and their relationships with the 7 objectives of the financial perspective, as well as their overall rating.

Table 4.10 Importance Rating of the Objectives of the Enablers normalized with the Importance Rating of the Objectives of the Financial Perspective Showing the Overall rating of Each Enabler

			Financial Objectives							
			Complete the project within the allocated budget	Decrease overhead and operational costs	Enhance reputation and hence gain more business opportunities	Eliminate any additional cost due to late delivery of material and equipment	Achieve early revenue and capital cost recovery	Avoid penalties and liquidated damages	Reduce cost due to rework	**Importance Rating of Enablers**
Importance Rating of Objectives			6.686	4.600	4.629	4.414	4.457	5.343	4.414	
			0.194	**0.133**	**0.134**	**0.128**	**0.129**	**0.155**	**0.128**	
Enablers	Client perspective	Prepare comprehensive tender document and process	4.371	3.043	2.329	2.643	2.671	3.343	3.229	**3.175**
		Ensure selection of the optimum bidder not only the lowest bidder	4.157	2.457	3.014	2.314	2.729	3.643	3.114	**3.145**
		Put in place comprehensive contract document	4.286	2.871	2.329	3.114	2.929	3.814	3.357	**3.319**
		Ensure comprehensive project control and monitoring systems for schedule, cost control and change order tracking	4.557	3.343	2.686	4.086	3.586	3.986	3.514	**3.737**
		Ensure robust QHSE management system and practises are in place	2.914	2.000	4.157	1.457	2.157	2.786	2.543	**2.608**
		Perform necessary soil investigation in advance	2.886	1.671	1.486	1.586	1.857	1.814	2.743	**2.054**
		Ensure quick access for contractors and subcontractors to site	3.243	2.057	2.000	2.943	2.471	2.443	1.629	**2.451**
		Promptly coordinate interface between client, project Stakeholders, and contractor	3.829	2.686	3.243	3.529	2.914	3.200	3.357	**3.284**
		Ensure timely completion of design to avoid or minimize any changes during execution	4.614	3.471	2.929	3.543	3.500	3.586	4.343	**3.762**
		Include pre-approved vendor and subcontractor list in the contract to expedite material submittals and pre-qualifications	3.429	2.543	2.343	3.771	2.500	2.600	2.657	**2.862**
		perform adequate project planning and scheduling	4.343	3.371	3.029	4.229	3.500	4.071	3.443	**3.757**
		Organize frequent internal project progress meeting	3.343	2.229	2.557	3.057	2.500	2.957	3.057	**2.848**
		Timely progress payments to the contractor	3.914	2.729	3.486	3.200	3.057	3.314	1.729	**3.125**

Table 4.10 (continued) Importance Rating of the Objectives of the Enablers normalized with the Importance Rating of the Objectives of the Financial Perspective Showing the Overall rating of Each Enabler

Enablers	Contractor & project management team perspective	Expedite decisions making process	4.200	3.043	2.729	3.657	3.557	3.486	3.143	**3.451**
		Enforce delay penalties and early completion incentive clauses	3.014	2.129	2.243	2.857	2.529	3.457	2.043	**2.655**
		Ensure all submitted technical information is accurate for commencement of the work	3.800	2.600	2.857	3.529	3.143	3.414	4.071	**3.369**
		Ensure sufficient funding is in place at different milestone of the project	4.129	2.614	2.557	3.100	3.229	3.329	1.743	**3.040**
		Hire competent personnel for the project	4.214	3.257	3.829	2.971	3.057	3.329	4.057	**3.570**
		Allocate sufficient manpower for the project	4.186	3.029	3.057	2.657	2.957	3.257	2.871	**3.215**
		Ensure quick site mobilization process	3.657	2.314	2.386	2.571	2.686	3.171	1.686	**2.717**
		Select the optimum subcontractors and suppliers	4.114	3.143	3.386	3.557	3.200	3.486	3.757	**3.555**
		Ensure timely payment to subcontractors and suppliers	3.700	2.814	3.857	3.800	3.200	3.457	1.914	**3.286**
		Put in place appropriate plant and equipment management strategy	3.429	3.157	2.500	3.629	2.700	3.257	2.643	**3.073**
		Effectively Plan, manage and supervise site construction activities	4.200	3.357	3.500	3.400	3.186	3.871	4.086	**3.695**
		Put in place appropriate material management strategy	3.514	2.900	2.386	4.243	2.900	3.329	3.186	**3.224**
		Put in place comprehensive risk management plan	3.500	2.329	2.829	3.000	2.529	3.371	2.914	**2.970**
		Motivate labors through incentive programs, good standard accommodation camp, and recreation facilities	2.829	2.186	3.629	1.614	2.500	2.714	2.814	**2.633**
		Consider impact of seasonal weather conditions on performance and plan site activities accordingly	3.100	2.129	1.700	2.000	2.229	2.786	2.557	**2.412**
		Organize frequent project progress meeting between all project parties	3.486	1.971	2.743	2.657	2.429	2.671	3.186	**2.778**

Table 4.10 (continued) Importance Rating of the Objectives of the Enablers normalized with the Importance Rating of the Objectives of the Financial Perspective Showing the Overall rating of Each Enabler

Enablers	Innovation and learning perspective	Allow open communication and feedback approach between all parties	3.343	2.700	3.229	2.800	2.429	2.729	3.386	**2.965**
		Utilize electronic documentation systems review, approve documents and track document flow	3.271	3.114	2.529	2.371	2.157	2.600	2.614	**2.704**
		Increase productivity by using latest technology of construction tools and equipment as required	3.314	2.900	2.643	2.329	2.571	2.643	2.700	**2.765**
		Utilize electronic systems to track schedule and cost	3.486	2.929	2.671	2.671	2.914	3.157	2.229	**2.913**
		Re-sequencing work activities wherever possible without increasing resources	2.943	3.043	1.686	2.257	2.657	2.957	2.843	**2.653**
		Put in place knowledge management system to utilize previous project experience as applicable	3.414	2.814	3.000	2.329	2.614	2.886	3.500	**2.966**
		Provide training for project team to continuously upgrade their knowledge and to upskill labour.	3.186	2.700	3.514	1.857	2.243	2.671	3.729	**2.863**

As shown in Table 4.11 and Figure 4.2, the ten most important enablers of construction delay mitigation are as follows: (1) ‘Ensure timely completion of design to avoid or minimize any changes during execution and Perform adequate project planning and scheduling’ (client perspective); (2) ‘Ensure comprehensive project control and monitoring systems for schedule, cost control and change order tracking’ (client perspective); (3) ‘Effectively Plan, manage and supervise site construction activities’ (contractor and project management team perspective); (4) ‘Hire competent personnel for the project’(contractor and project management team perspective); (5) ‘Select the optimum subcontractors and suppliers’ (contractor and project management team perspective); (6) ‘Expedite decisions making process’ (client perspective); (7)

‘Ensure all submitted technical information is accurate for commencement of the work’ (contractor and project management team perspective); (8) ‘Put in place comprehensive contract document’ (client perspective); (9) ‘Ensure timely payment to subcontractors and suppliers’ (contractor and project management team perspective); and (10) ‘Promptly coordinate interface between client, project stakeholders, and contractor’ (client perspective).

Table 4.11 Overall ranking of enablers and financial objectives from highest to lowest

		Financial Objectives								
		Complete the project within the allocated budget	Avoid penalties and liquidated damages	Enhance reputation and hence gain more business opportunities	Decrease overhead and operational costs	Achieve early revenue and capital cost recovery	Eliminate any additional cost due to late delivery of material and equipment	Reduce cost due to rework	**Importance Rating of Enablers**	**Overall Enablers Ranking**
Importance Rating of Objectives		**6.686**	**5.343**	**4.629**	**4.600**	**4.457**	**4.414**	**4.414**		
		0.194	**0.155**	**0.134**	**0.133**	**0.129**	**0.128**	**0.128**		
Enablers	Ensure timely completion of design to avoid or minimize any changes during execution	4.614	3.586	2.929	3.471	3.500	3.543	4.343	**3.762**	**1**
	perform adequate project planning and scheduling	4.343	4.071	3.029	3.371	3.500	4.229	3.443	**3.757**	**2**
	Ensure comprehensive project control and monitoring systems for schedule, cost control and change order tracking	4.557	3.986	2.686	3.343	3.586	4.086	3.514	**3.737**	**3**
	Effectively Plan, manage and supervise site construction activities	4.200	3.871	3.500	3.357	3.186	3.400	4.086	**3.695**	**4**
	Hire competent personnel for the project	4.214	3.329	3.829	3.257	3.057	2.971	4.057	**3.570**	**5**
	Select the optimum subcontractors and suppliers	4.114	3.486	3.386	3.143	3.200	3.557	3.757	**3.555**	**6**
	Expedite decisions making process	4.200	3.486	2.729	3.043	3.557	3.657	3.143	**3.451**	**7**

Table 4.11 (continued) Overall ranking of enablers and financial objectives from highest to lowest

Enablers	Ensure all submitted technical information is accurate for commencement of the work	3.800	3.414	2.857	2.600	3.143	3.529	4.071	**3.369**	**8**
	Put in place comprehensive contract document	4.286	3.814	2.329	2.871	2.929	3.114	3.357	**3.319**	**9**
	Ensure timely payment to subcontractors and suppliers	3.700	3.457	3.857	2.814	3.200	3.800	1.914	**3.286**	**10**
	Promptly coordinate interface between client, project Stakeholders, and contractor	3.829	3.200	3.243	2.686	2.914	3.529	3.357	**3.284**	**11**
	Put in place appropriate material management strategy	3.514	3.329	2.386	2.900	2.900	4.243	3.186	**3.224**	**12**
	Allocate sufficient manpower for the project	4.186	3.257	3.057	3.029	2.957	2.657	2.871	**3.215**	**13**
	Prepare comprehensive tender document and process	4.371	3.343	2.329	3.043	2.671	2.643	3.229	**3.175**	**14**
	Ensure selection of the optimum bidder not only the lowest bidder	4.157	3.643	3.014	2.457	2.729	2.314	3.114	**3.145**	**15**
	Timely progress payments to the contractor	3.914	3.314	3.486	2.729	3.057	3.200	1.729	**3.125**	**16**
	Put in place appropriate plant and equipment management strategy	3.429	3.257	2.500	3.157	2.700	3.629	2.643	**3.073**	**17**
	Ensure sufficient funding is in place at different milestone of the project	4.129	3.329	2.557	2.614	3.229	3.100	1.743	**3.040**	**18**
	Put in place comprehensive risk management plan	3.500	3.371	2.829	2.329	2.529	3.000	2.914	**2.970**	**19**
	Allow open communication and feedback approach between all parties	3.343	2.729	3.229	2.700	2.429	2.800	3.386	**2.965**	**20**
	Put in place knowledge management system to utilize previous project experience as applicable	3.414	2.886	3.000	2.814	2.614	2.329	3.500	**2.966**	**21**
	Utilize electronic systems to track schedule and cost	3.486	3.157	2.671	2.929	2.914	2.671	2.229	**2.913**	**22**
	Include pre-approved vendor and subcontractor list in the contract to expedite material submittals and pre-qualifications	3.429	2.600	2.343	2.543	2.500	3.771	2.657	**2.862**	**23**
	Provide training for project team to continuously upgrade their knowledge and to upskill labor.	3.186	2.671	3.514	2.700	2.243	1.857	3.729	**2.863**	**24**

Table 4.11 (continued) Overall ranking of enablers and financial objectives from highest to lowest

Enablers	Organize frequent internal project progress meeting	3.343	2.957	2.557	2.229	2.500	3.057	3.057	**2.848**	**25**
	Organize frequent project progress meeting between all project parties	3.486	2.671	2.743	1.971	2.429	2.657	3.186	**2.778**	**26**
	Increase productivity by using latest technology of construction tools and equipment as required	3.314	2.643	2.643	2.900	2.571	2.329	2.700	**2.765**	**27**
	Ensure quick site mobilization process	3.657	3.171	2.386	2.314	2.686	2.571	1.686	**2.717**	**28**
	Utilize electronic documentation systems review, approve documents and track document flow	3.271	2.600	2.529	3.114	2.157	2.371	2.614	**2.704**	**29**
	Enforce delay penalties and early completion incentive clauses	3.014	3.457	2.243	2.129	2.529	2.857	2.043	**2.655**	**30**
	Re-sequencing work activities wherever possible without increasing resources	2.943	2.957	1.686	3.043	2.657	2.257	2.843	**2.653**	**31**
	Motivate laborers through incentive programs, good standard accommodation camp, and recreation facilities	2.829	2.714	3.629	2.186	2.500	1.614	2.814	**2.633**	**32**
	Ensure robust QHSE management system and practises are in place	2.914	2.786	4.157	2.000	2.157	1.457	2.543	**2.608**	**33**
	Ensure quick access for contractors and subcontractors to site	3.243	2.443	2.000	2.057	2.471	2.943	1.629	**2.451**	**34**
	Consider impact of seasonal weather conditions on performance and plan site activities accordingly	3.100	2.786	1.700	2.129	2.229	2.000	2.557	**2.412**	**35**
	Perform necessary soil investigation in advance	2.886	1.814	1.486	1.671	1.857	1.586	2.743	**2.054**	**36**

Table 4.12 Overall Ranking of Enablers of Construction Delay Mitigation and their prespectives

Overall Ranking	Enablers	Perspective
1	Ensure timely completion of design to avoid or minimize any changes during execution	Client
2	Perform adequate project planning and scheduling	Client
3	Ensure comprehensive project control and monitoring systems for schedule, cost control and change order tracking	Client
4	Effectively plan, manage and supervise site construction activities	Contractor &PMT
5	Hire competent personnel for the project	Contractor &PMT
6	Select the optimum subcontractors and suppliers	Contractor &PMT
7	Expedite decision making process	Client
8	Ensure all submitted technical information is accurate for commencement of the work	Contractor &PMT
9	Put in place comprehensive contract document	Client
10	Ensure timely payment to subcontractors and suppliers	Contractor &PMT
11	Promptly coordinate interface between client, project stakeholders, and contractor	Client
12	Put in place appropriate material management strategy	Contractor &PMT
13	Allocate sufficient manpower for the project	Contractor &PMT
14	Prepare comprehensive tender document and process	Client
15	Ensure selection of the optimum bidder not only the lowest bidder	Client
16	Timely progress payments to the contractor	Client
17	Put in place appropriate plant and equipment management strategy	Contractor &PMT
18	Ensure sufficient funding is in place at different milestone of the project	Contractor &PMT
19	Put in place comprehensive risk management plan	Contractor &PMT
20	Allow open communication and feedback approach between all parties	innovation & learning
21	Put in place knowledge management system to utilize previous project experience as applicable	innovation & learning
22	Utilize electronic systems to track schedule and cost	innovation & learning
23	Include pre-approved vendor and subcontractor list in the contract to expedite material submittals and pre-qualifications	Client
24	Provide training for project team to continuously upgrade their knowledge and to upskill labor.	innovation & learning
25	Organize frequent internal project progress meeting	Client
26	Organize frequent project progress meeting between all project parties	Contractor &PMT
27	Increase productivity by using latest technology of construction tools and equipment as required	innovation & learning
28	Ensure quick site mobilization process	Contractor &PMT
29	Utilize electronic documentation systems review, approve documents and track document flow	innovation & learning
30	Enforce delay penalties and early completion incentive clauses	Client
31	Re-Sequencing work activities wherever possible without increasing resources	innovation & learning
32	Motivate laborers through incentive programs, good standard accommodation camp, and recreation facilities	Contractor &PMT
33	Ensure robust QHSE management system and practices are in place	Client
34	Ensure quick access for contractors and subcontractors to site	Client
35	Consider impact of seasonal weather conditions on performance and plan site activities accordingly	Contractor &PMT
36	Perform necessary soil investigation in advance	Client

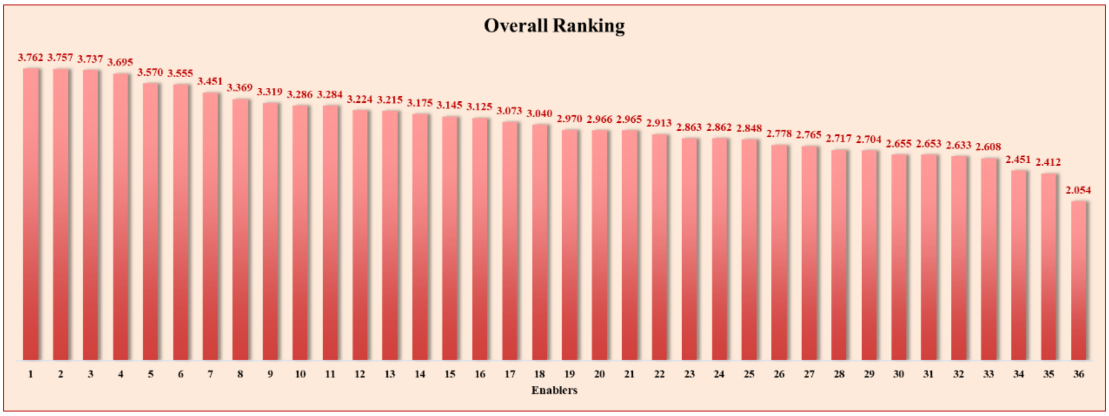

Figure 4.2 Overall Ranking of the Enablers of Construction Delay Mitigation

4.2.1.3 Average Scores, Weighted Scores, and Ranking of the Relationships between the Financial Objectives and the Client Perspective

The average formula was used to determine the average score of the relationship between the two different dimensions of the QFD: the objectives of the financial perspectives and the objectives of the enablers (i.e. client, contractor and project team management, and learning and innovation perspectives). For instance, the relationship between the objective of the financial perspective ‘complete the project within the allocated budget’ and the client perspective ‘ensure timely completion of design to avoid or minimize any changes during execution’ was rated by the respondents using the following scale: 1, 3, or 5, where "1" means weak, "3" means medium, and "5" means strong relationship. The average score obtained was 4.614. The average and weighted scores of the relationships of all objectives of the financial perspectives and the client perspectives as perceived by the survey respondents are shown in Table 4.10. The ranking of the weighted scores of the relationships of all objectives of the financial perspectives and the client perspectives are shown in Table 4.14 and Figure 4.3.

Table 4.13 Ranking of the Relationships between the Financial Objectives and the Client Perspective

Ranked Enablers	Ave. Score of Relationship to Obj.1 of Financial Perspective	Ave. Score of Relationship to Obj.2 of Financial Perspective	Ave. Score of Relationship to Obj.3 of Financial Perspective	Ave. Score of Relationship to Obj.4 of Financial Perspective	Ave. Score of Relationship to Obj.5 of Financial Perspective	Ave. Score of Relationship to Obj.6 of Financial Perspective	Ave. Score of Relationship to Obj.7 of Financial Perspective	Weighted Ave. Score
Ensure timely completion of design	4.614	3.471	2.929	3.543	3.500	3.59	4.34	**3.76**
Perform adequate project planning and scheduling	4.343	3.371	3.029	4.229	3.500	4.07	3.44	**3.76**
Ensure comprehensive project control and monitoring	4.557	3.343	2.686	4.086	3.586	3.99	3.51	**3.74**
Expedite decisions making process	4.200	3.043	2.729	3.657	3.557	3.49	3.14	**3.45**
Put in place comprehensive contract document	4.286	2.871	2.329	3.114	2.929	3.81	3.36	**3.32**
Promptly coordinate interface between client	3.829	2.686	3.243	3.529	2.914	3.20	3.36	**3.28**
Prepare comprehensive tender document and process	4.371	3.043	2.329	2.643	2.671	3.34	3.23	**3.18**
Ensure selection of the optimum bidder	4.157	2.457	3.014	2.314	2.729	3.64	3.11	**3.14**
Timely progress payments to the contractor	3.914	2.729	3.486	3.200	3.057	3.31	1.73	**3.12**
Include pre-approved vendor	3.429	2.543	2.343	3.771	2.500	2.60	2.66	**2.86**
Organize frequent internal project progress meeting	3.343	2.229	2.557	3.057	2.500	2.96	3.06	**2.85**
Enforce delay penalties and early completion incentive clauses	3.014	2.129	2.243	2.857	2.529	3.46	2.04	**2.65**
Ensure robust QHSE management system and practices are in place	2.914	2.000	4.157	1.457	2.157	2.79	2.54	**2.61**
Ensure quick access for contractors and subcontractors to site	3.243	2.057	2.000	2.943	2.471	2.44	1.63	**2.45**
Perform necessary soil investigation in advance	2.886	1.671	1.486	1.586	1.857	1.81	2.74	**2.05**

Table 4.14 Normalized Average Scores of the Objectives of the Client Perspectives Ranked from Highest to Lowest Values

Objectives of the Client Perspective	Normalized Average
Ensure timely completion of design to avoid or minimize any changes during execution	**3.76**
Perform adequate project planning and scheduling	**3.76**
Ensure comprehensive project control and monitoring systems for schedule, cost control and change order tracking	**3.74**
Expedite decision making process	**3.45**
Put in place comprehensive contract document	**3.32**
Promptly coordinate interface between client, project stakeholders, and contractor	**3.28**
Prepare comprehensive tender document and process	**3.18**
Ensure selection of the optimum bidder not only the lowest bidder	**3.14**
Timely progress payments to the contractor	**3.12**
Include pre-approved vendor and subcontractor list in the contract to expedite material submittals and pre-qualifications	**2.86**
Organize frequent internal project progress meeting	**2.85**
Enforce delay penalties and early completion incentive clauses	**2.65**
Ensure robust QHSE management system and practices are in place	**2.61**
Ensure quick access for contractors and subcontractors to site	**2.45**
Perform necessary soil investigation in advance	**2.05**

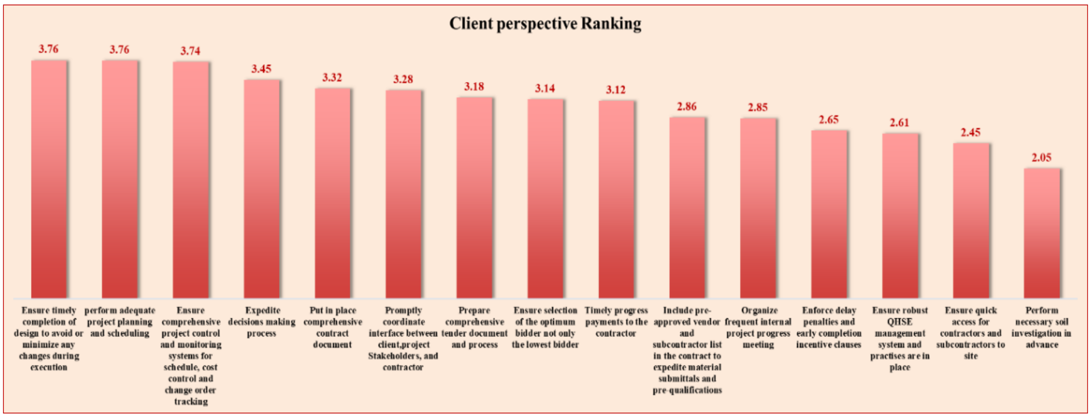

Figure 4.3 Weighted Average Scores of the Objectives of the Client Perspectives Ranked from Highest to Lowest Values

Thus, as shown in Table 4.13 and Figure 4.3 above, the 15 objectives of the client perspective normalized with the 7 objectives of the financial perspective include ‘Ensure timely completion of design to avoid or minimize any changes during execution’ as the highest-ranked objective with a weighted average score of 3.76, and ‘Perform necessary soil investigation in advance’ as the lowest-ranked objective with a weighted average score of 2.05.

4.2.1.4 Average Scores, Weighted Scores, and Ranking of the Relationships of the Objectives of the Financial Perspective and the Contractor and Project Management Team Perspective

The average score formula was used in obtaining the average and weighted scores of the objectives of the contractor and project management team perspective normalized with the objectives of the financial management perspective shown in Table 4.15.

Table 4.15 Ranking of the Relationships between the Financial Objectives and the Contractor and Project Management Team Perspective

	Ave. Score of Relationship to Obj.1 of Financial Perspective	Ave. Score of Relationship to Obj.2 of Financial Perspective	Ave. Score of Relationship to Obj.3 of Financial Perspective	Ave. Score of Relationship to Obj.4 of Financial Perspective	Ave. Score of Relationship to Obj.5 of Financial Perspective	Ave. Score of Relationship to Obj.6 of Financial Perspective	Ave. Score of Relationship to Obj.7 of Financial Perspective	Weighted Ave. Score
Effectively plan, manage and supervise site construction activities	4.200	3.357	3.500	3.400	3.186	3.87	4.09	**3.70**
Hire competent personnel for the project	4.214	3.257	3.829	2.971	3.057	3.33	4.06	**3.57**
Select the optimum subcontractors and suppliers	4.114	3.143	3.386	3.557	3.200	3.49	3.76	**3.56**
Ensure all submitted technical information is accurate for commencement of the work	3.800	2.600	2.857	3.529	3.143	3.41	4.07	**3.37**
Ensure timely payment to subcontractors and suppliers	3.700	2.814	3.857	3.800	3.200	3.46	1.91	**3.29**
Put in place appropriate material management strategy	3.514	2.900	2.386	4.243	2.900	3.33	3.19	**3.22**
Allocate sufficient manpower for the project	4.186	3.029	3.057	2.657	2.957	3.26	2.87	**3.21**
Put in place appropriate plant and equipment management strategy	3.429	3.157	2.500	3.629	2.700	3.26	2.64	**3.07**
Ensure sufficient funding is in place at different milestone of the project	4.129	2.614	2.557	3.100	3.229	3.33	1.74	**3.04**
Put in place comprehensive risk management plan	3.500	2.329	2.829	3.000	2.529	3.37	2.91	**2.97**
Organize frequent project progress meeting between all project parties	3.486	1.971	2.743	2.657	2.429	2.67	3.19	**2.78**
Ensure quick site mobilization process	3.657	2.314	2.386	2.571	2.686	3.17	1.69	**2.72**
Motivate labors through incentive programs, good standard accommodation camp, and recreation facilities	2.829	2.186	3.629	1.614	2.500	2.71	2.81	**2.63**
Consider impact of seasonal weather conditions on performance and plan site activities accordingly	3.100	2.129	1.700	2.000	2.229	2.79	2.56	**2.41**

The ranking of the weighted scores of the relationships of all objectives of the financial perspective and the contractor and project team management perspective are shown in Table 4.16 and Figure 4.4 below.

Table 4.16 Normalized Average Scores of the Objectives of the Contractor and Project Management Team Perspective Ranked from Highest to Lowest Values

Objectives of the Contractor and Project Management Team Perspective	Normalized Average
Effectively Plan, manage and supervise site construction activities	**3.70**
Hire competent personnel for the project	**3.57**
Select the optimum subcontractors and suppliers	**3.56**
Ensure all submitted technical information is accurate for commencement of the work	**3.37**
Ensure timely payment to subcontractors and suppliers	**3.29**
Put in place appropriate material management strategy	**3.22**
Allocate sufficient manpower for the project	**3.21**
Put in place appropriate plant and equipment management strategy	**3.07**
Ensure sufficient funding is in place at different milestone of the project	**3.04**
Put in place comprehensive risk management plan	**2.97**
Organize frequent project progress meeting between all project parties	**2.78**
Ensure quick site mobilization process	**2.72**
Motivate labors through incentive programs, good standard accommodation camp, and recreation facilities	**2.63**
Consider impact of seasonal weather conditions on performance and plan site activities accordingly	**2.41**

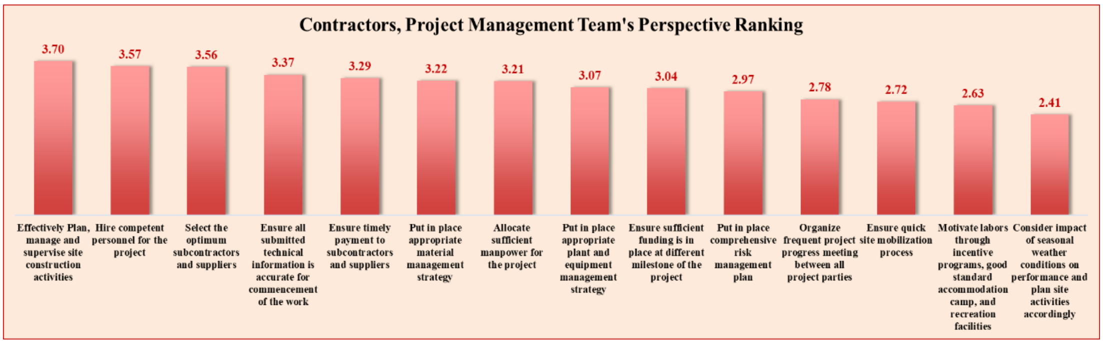

Figure 4.4 Contractor and Project Management Team’s Perspective Ranking

Thus, as shown in Table 4.14 and Figure 4.4 above, the 14 objectives of the contractor and project management team perspective normalized with the 7 objectives of the financial perspective include ‘Effectively Plan, manage and supervise site construction activities’ as the highest-ranked objective with a weighted average score of 3.70, and ‘Consider impact of seasonal weather conditions on performance and plan site activities’ as the lowest-ranked objective with a weighted average score of 2.41.

4.2.1.5 Average Scores, Weighted Scores, and Ranking of the Relationships of the Objectives of the Financial Perspective and the Innovation and Learning Perspective

In the same manner, the average score formula was used in obtaining the average and weighted scores of the objectives of the innovation and learning perspective. The values were normalized with the objectives of the financial management perspective shown in Table 4.17.

Table 4.17 Ranking of the Relationships between the Financial Objectives and the Innovation and Learning Perspective

	Ave. Score of Relationship to Obj.1 of Financial Perspective	Ave. Score of Relationship to Obj.2 of Financial Perspective	Ave. Score of Relationship to Obj.3 of Financial Perspective	Ave. Score of Relationship to Obj.4 of Financial Perspective	Ave. Score of Relationship to Obj.5 of Financial Perspective	Ave. Score of Relationship to Obj.6 of Financial Perspective	Ave. Score of Relationship to Obj.7 of Financial Perspective	Weighted Ave. Score
Put in place knowledge management system to utilize previous project experience as applicable	3.414	2.814	3.000	2.329	2.614	2.89	3.50	2.89
Allow open communication and feedback approach between all parties	3.343	2.700	3.229	2.800	2.429	2.73	3.39	2.73
Utilize electronic systems to track schedule and cost	3.486	2.929	2.671	2.671	2.914	3.16	2.23	3.16
Provide training for project team to continuously upgrade their knowledge and to upskill labour.	3.186	2.700	3.514	1.857	2.243	2.67	3.73	2.67
Increase productivity by using latest technology of construction tools and equipment as required	3.314	2.900	2.643	2.329	2.571	2.64	2.70	2.64
Utilize electronic documentation systems review, approve documents and track document flow	3.271	3.114	2.529	2.371	2.157	2.60	2.61	2.60
Re-Sequencing work activities wherever possible without increasing resources	2.943	3.043	1.686	2.257	2.657	2.96	2.84	2.96

The ranking of the weighted scores of the relationships of all objectives of the financial perspective and the innovation and learning perspective are shown in Table 4.18 Figure 4.5 below.

Table 4.18 Normalized Average Scores of the Objectives of the Innovation and Learning Perspective Ranked from Highest to Lowest Values

Objectives of the Innovation and Learning Perspective	Normalized Average
Put in place knowledge management system to utilize previous project experience as applicable	**2.97**
Allow open communication and feedback approach between all parties	**2.97**
Utilize electronic systems to track schedule and cost	**2.91**
Provide training for project team to continuously upgrade their knowledge and to upskill labor.	**2.86**
Increase productivity by using latest technology of construction tools and equipment as required	**2.76**
Utilize electronic documentation systems review, approve documents and track document flow	**2.70**
Re-Sequencing work activities wherever possible without increasing resources	**2.65**

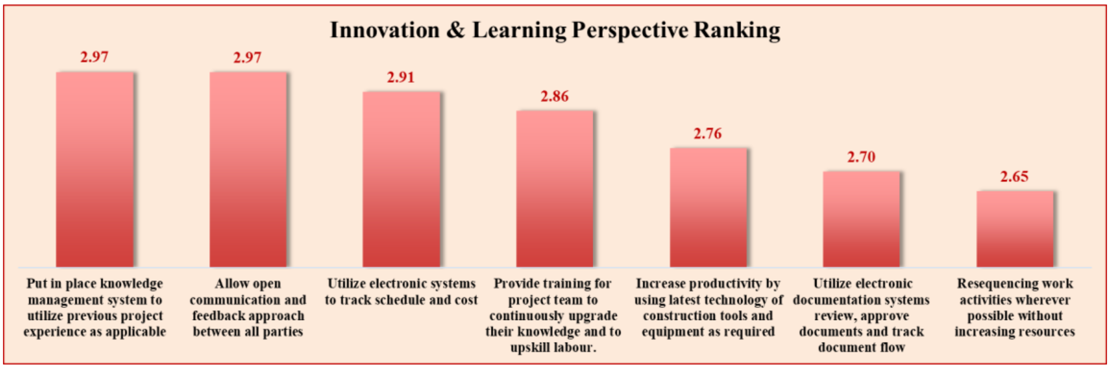

Figure 4.5 Ranking of the Objectives of Innovation and Learning Perspective

Thus, as shown in Table 4.15 and Figure 4.5 above, the 7 objectives of the innovation and learning perspective normalized with the 7 objectives of the financial perspective include ‘Put in place knowledge management system to utilize previous project experience as applicable’ as the highest-ranked objective with a weighted average score of ‘2.97’, and ‘Re-Sequencing work activities wherever possible without increasing resources' as the lowest-ranked objective with a weighted average score of 2.65.

4.3 Cause and Effect Analysis

Results of the data analysis reveal that the objectives of the different BSC perspectives are interrelated with one another, as evidenced by the responses of the survey participants when they were asked to rate the relationship between the objectives of the financial perspective and the objectives of the enablers (see Tables 4.10, 4.12, and 4.14). Furthermore, the house of quality illustrates that the 7 objectives of the financial perspective are closely linked with one another and are all unidirectional in terms of improvement (see Figure 4.6).

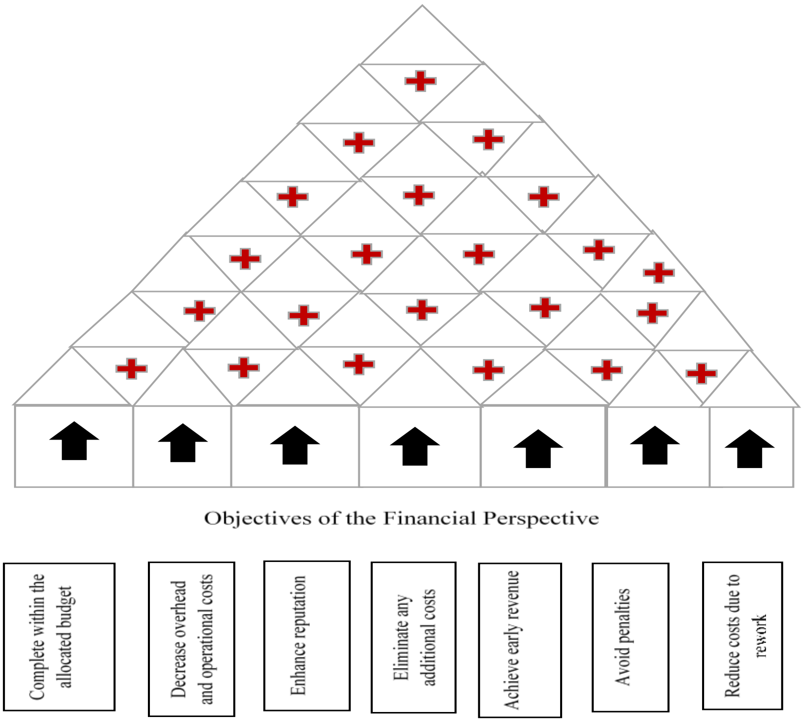

Figure 4.6 House of Quality of the Financial Perspective

To further demonstrate the interrelationships of the different objectives of the construction delay mitigation perspectives, cause and effect relationships amongst the four most important objectives of each perspective has been established and shown in the modified fishbone diagram below (see Figure 4.7). Thus, for the financial perspective, the top four most important objectives (see Table 4.7) were selected for the modified fish bone diagram. Similarly, the top four most important objectives of the client, contractor and project management team, and innovation and learning perspectives were selected (see Table 4.9).

As shown in Figure 4.7, an improvement in any given objective of the enablers of construction delay mitigation would lead to a corresponding improvement in any or all of the objectives of the financial perspective. For instance, the most important objective of the client perspective 'Ensure timely completion of design to avoid or minimize any changes during execution' would result in the improvement of all four objectives of the financial perspective, namely: 'Complete the project within the allocated budget', 'Avoid penalties and liquidated damages', 'Enhance reputation and hence gain more business opportunities', and 'Decrease overhead and operational costs'. In the same manner, an improvement in the second most important objective of the contractor and project management team perspective 'Hire competent personnel for the project' would result in the improvement of the aforementioned four objectives of the financial perspective.

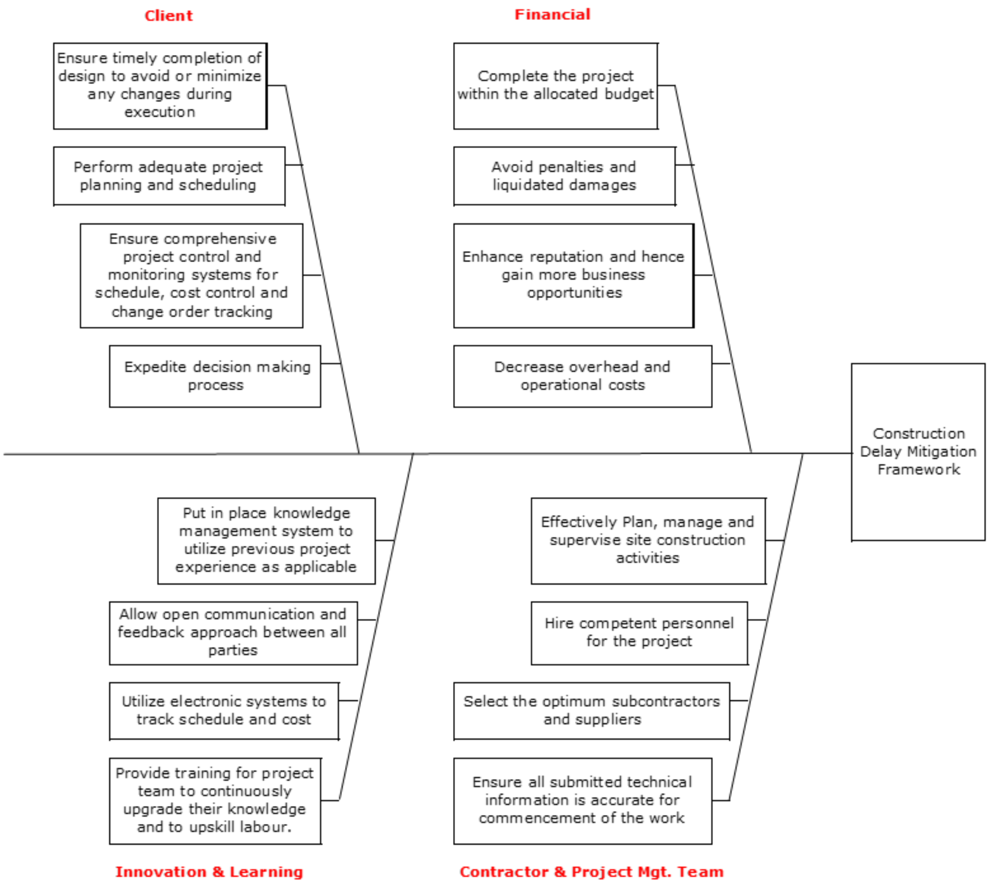

Figure 4.7 Modified Fishbone Diagram of the Objectives of Construction Delay Mitigation Perspective

Similarly, a modified cause and effect diagram illustrates the interrelationships of the objectives of the four construction delay mitigation perspectives (see Figure 4.8). The interrelationships amongst the objectives were determined through sound and rational judgment. As shown in Figure 4.8 for instance, the objective of the client perspective ‘Ensure timely completion of design to avoid or minimize any changes during execution’ is related to all four objectives of the financial perspective, namely: ‘Complete the project within the allocated budget’, ‘Avoid penalties and liquidated damages’, ‘Enhance reputation and hence gain more business opportunities’, and ‘Decrease overhead and operational costs’.

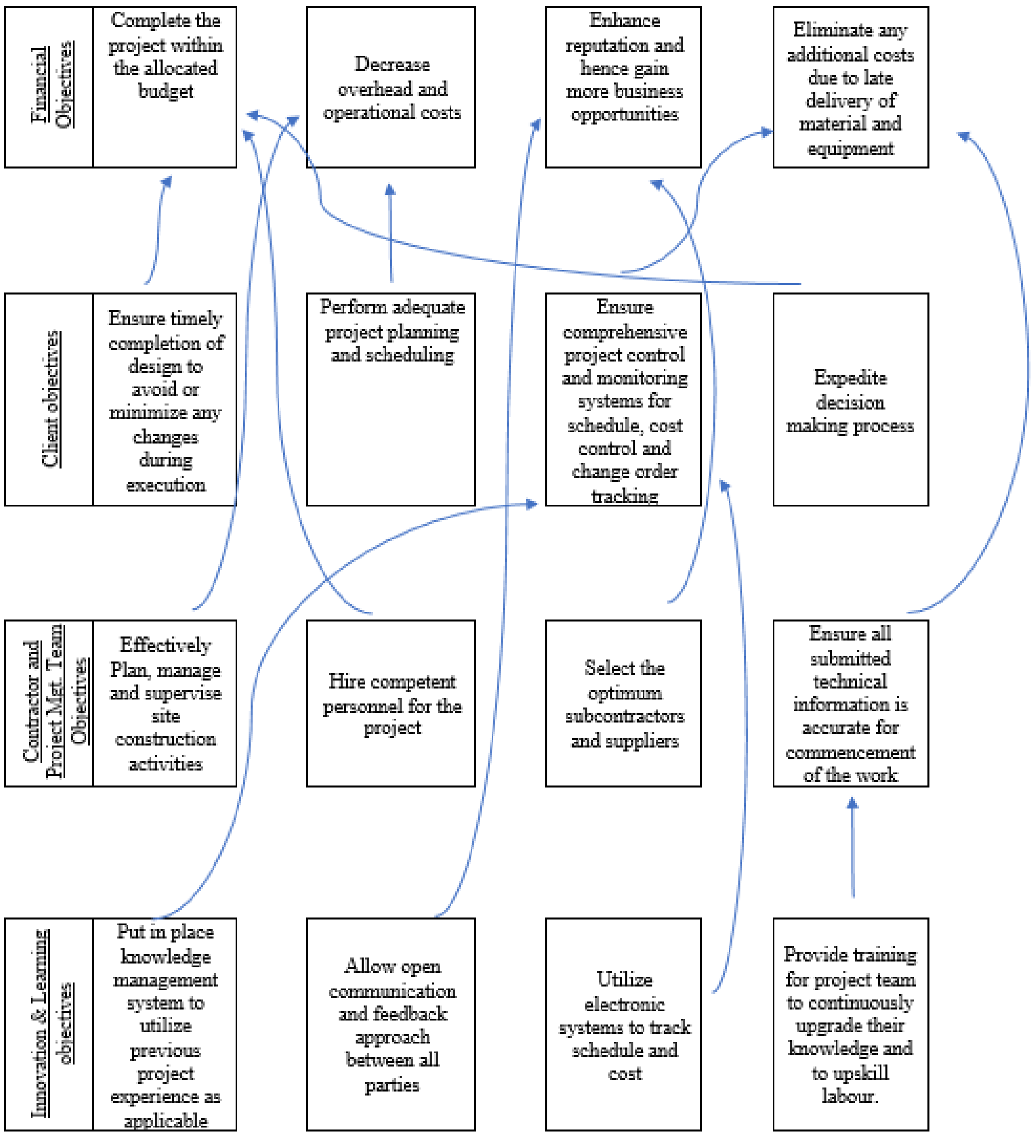

Figure 4.8 Cause and Effect Diagram of the Top Four Objectives of the Construction Delay Mitigation Perspectives

4.4 Discussion

The objectives of this study are: (1) to apply the BSC approach in mitigating construction project delays; (2) To identify the objectives of the financial perspective relevant to construction delays; (3) To apply the QFD approach in mitigating construction project delays; and (4) To identify the important factors that strongly influence the objectives of the financial perspective in mitigating construction project delays with the use of an integrated BSC and QFD approach.

To achieve the first objective and the second objective which is to apply the BSC approach in mitigating construction project delays, and to identify the objectives of the financial perspective relevant to construction delays respectively, interviews with construction industry practitioners and a review of related literature were conducted. The objectives of the financial perspective and the enablers' perspectives (i.e. client, contractor and project management team, and innovation and learning) were determined based on the results of the interviews and the literature review. In the same manner, the objectives of the financial perspective relevant to construction delays were identified using the interview and literature review results.

To achieve the third objective which is to apply the QFD approach in mitigating construction project delays, the financial perspective was used as the vertical matrix out- layer, while the enablers of delay mitigation (client, contractor and project management team, and innovation and learning perspectives) were used as the horizontal out-layer.

To achieve the fourth objective which is to identify the important factors that strongly influence the financial goals with the use of an integrated BSC and QFD approach, the relationships of the financial perspective and the enablers were then established using a Likert -scale consisting of the following rating scale: 'strong relationship', 'medium relationship', 'low relationship', and 'no relationship'. The top ten most important factors generated from the data analysis are as follows:

1. 'Ensure timely completion of design to avoid or minimize any changes during execution'; and 'Perform adequate project planning and scheduling' (client perspective)

2. ‘Ensure comprehensive project control and monitoring systems for schedule, cost control and change order tracking’ (client perspective).

3. ‘Effectively plan, manage and supervise site construction activities’, (contractor and project management team perspective).

4. ‘Hire competent personnel for the project’ (contractor and project management team perspective).

5. ‘Select the optimum subcontractors and suppliers’ (contractor and project management team perspective).

6. “Expedite decision making process” (client perspective).

7. Ensure all submitted technical information is accurate for commencement of the work (contractor and project management team perspective).

8. Put in place comprehensive contract document (client perspective).

9. Ensure timely payment to subcontractors and supplier (contractor and project management team perspective).

10. Promptly coordinate interface between client, project stakeholders, and contractor supplier (contractor and project management team perspective).

Table 4.16 shows the overall ranking of the significant factors that influence the objectives of the financial perspective. The importance of knowing these factors cannot be undermined, because they greatly affect the success of construction projects and thus, the construction industry as a whole. For instance, taking the most important owner/client factors into consideration, namely: ‘Ensure timely completion of design to avoid or minimize any changes during execution’; and ‘Perform adequate project planning and scheduling,’ would help reduce the transaction costs borne by the owners by minimizing the uncertainties associated with the project environment. The achievement of such client objectives would require ensuring that the engineering design is already complete and final prior to the bidding process, and that the project is efficiently managed. In the same manner, the most important contractor and project management team factors, such as: 'Effectively plan, manage and supervise site construction activities' and 'Hire competent personnel for the project' are critical to project success because these factors are associated with the actual production work involved in projects and in the effective management of project cost , schedule, and quality.

Therefore, knowledge of the most important factors or enablers that influence the financial perspective would subsequently result in the realization of the financial objectives such as: Completing the project within the allocated budget, avoiding penalties and liquidated damages, enhancing reputation and hence gaining more business opportunities, decreasing overhead and operational costs, achieving early revenue and capital cost recovery, eliminating any additional cost due to late delivery of material and equipment, and reducing cost due to rework. In turn, the realization of these financial objectives would result in successful construction projects, eventually leading to an energized and booming construction industry.

4.4.1 Comparison of Findings to the Findings of the Literature Review

Findings of this study indicate that the top ten most important factors that strongly influence the financial perspective in mitigating construction project delays are internal in nature; that is, they all belong to the client and the contractor and project management team perspectives. Such finding buttresses the findings from literature which highlight the strong influence of internal factors in mitigating construction project delays. For instance, Zidane and Andersen (2018b) identified the top ten universal delay factors in construction projects in 46 countries and concluded that those factors were all internal in nature. In the same manner, various authors have highlighted the predominance of client and contractor-related delay factors as the main causes of construction project delays (Odeh and Battaineh 2002, Frimpong et al. 2003, Lo et al. 2006, Alaghbari et al. 2007, Toor and Ogunlana 2008, Gonduz, et al. 2013, Gunduz and AbuHassan 2016, Zidane and Andersen 2018a).

Furthermore, findings of the present study support the findings in literature which highlight the predominance of internal factors as delay causes in developing countries such as Qatar (Odeh and Battaineh 2002, Frimpong et al. 2003, Alaghbari et al. 2007, Lo et al. 2006, Toor and Ogunlana 2008, Islam and Trigunarsyah 2017, Prasad et al. 2019). Results of the review identified the internal factors as largely comprised by client's change orders and contractor-related issues such as ineffective planning and project scheduling, inadequate experience, poor site management, and shortage of laborers, owner's interference, issues in monthly payments, slow and lackluster instruction by consultant, and material procurement (see Table 2.2).

In the same manner, findings of the present study support the findings in literature regarding the measures being implemented by construction industry professionals to mitigate the impacts of delay. For instance, findings of the present study indicate that the most important factors that strongly influence the financial perspective in mitigating construction project delays are both objectives of the client perspective: 'Ensure timely completion of design to avoid or minimize any changes during execution'; and 'Perform adequate project planning and scheduling.' These findings are similar to the mitigation measures found in the studies conducted by Prasad et al. (2019) which center on the importance of employing mitigation measures related to changes in design amongst others; and by Faridi and El-Sayegh (2006) and Rahman et al. (2006) which include mitigation measures aimed at improving planning and control processes, and using effective planning strategies.

Moreover, the present study identified the objectives of the financial perspective based on the results of the interviews and the literature review. The objectives of the financial perspective which were subsequently ranked in order of importance are all related to the aim of eliminating the possibility of cost overruns. Indeed, findings of review of prior literature from 1995 to 2013 (see Table 2.5) suggest that cost and time overruns were the most common effects of construction project delays in different countries around the world (Assaf et al. 1995, Nguyen et al. 2004, Assaf and Al-Hejji 2006, Aibinu and Odeyinka 2006, Sambasivan and Soon 2007, Alinaitwe et al. 2013).

4.4.2 Relation of Findings to Similar Studies

Findings of the literature review highlight the paucity in studies related to mitigation measures for construction project delays. Furthermore, majority of these studies offered largely prescriptive and generic mitigation measures (Mezher and Tawil 1998, Faridi and El-Sayegh 2006, Ng 2007, and Olawale and Sun 2010). Although Abdul-Rahman et al. (2006) were able to come up with an exhaustive list of mitigation measures that cover the project's entire lifecycle, they nevertheless failed to cover the important areas of consideration equally, which the current study refers to as the four BSC perspectives.

In addition, findings of the present study highlight the utility of the combined BSC and QFD framework in identifying the most important objectives of the financial perspective and the most important factors that influence the attainment of such objectives in mitigating construction project delays during the planning stage of the project. Thus, findings of the present study support the conclusions made by Burak (2006) who underscored the effectiveness of the QFD during the design stage of the construction project to avoid spending unnecessary resources in the attainment of unimportant objectives.

In the same manner, the present study buttresses the conclusions made by Moussa (2017) who developed an integrated BSC and QFD framework for identifying the four perspectives of the pavement management sector in Qatar. Moussa (2017) concluded that his proposed integrated BSC and QFD framework can be used in pavement management in defining the four perspectives and their associated objectives, and subsequently rank them according to importance. This will help companies belonging to the pavement management sector in prioritizing their goals more effectively, in the same manner that integrated the BSC and QFD framework proposed in the present study will help construction industry practitioners mitigate the effects of construction delays.

Chapter 5 : Conclusions and Recommendations

This chapter aims to discuss the conclusions and recommendations of the present study. The structure of this chapter is as follows: First, a succinct summary of the manner by which the aim of the study is achieved, and the associated challenges met by this researcher during the conduct of the research, are presented. This is followed by a brief discussion of the contribution of the present study to the academic field. Next, recommendations to the clients/owners, and contractor and project management team are presented. Finally, the limitations and recommendations for future research are discussed.

5.1 Summary

The present study aims to develop a combined Balanced Scorecard (BSC) and Quality Function Deployment (QFD) framework for mitigating construction delays during the construction stage of the project. To achieve this aim, the BSC approach was used in identifying the four perspectives for mitigating construction delays, and the QFD in ranking the enablers of delay mitigation based on their importance as perceived by construction industry professionals. The journey towards the achievement of the research aim and objectives, however, were not without challenges. The first challenge was accurately identifying the important factors that strongly influence the financial perspective in mitigating construction project delays due to the subjectivity of expert opinion. This challenge was however addressed by cross-checking the important factors identified through the interviews against the results of the review of related literature. The second challenge was recruiting the 70 survey participants, as it was not an easy task to find construction industry professionals who were willing to participate in the survey due to their busy schedules. To address this challenge, this researcher devoted a significant amount of time in carefully recruiting study participants.

5.2 Contribution of the Present Study to the Academic Field

The integrated BSC and QFD framework proposed in the present study enabled the identification and ranking of the objectives of the financial perspective and the enablers of construction delay mitigation. This will help construction industry professionals in prioritizing the enabling factors that influence the financial perspective, thereby helping them to focus on the achievement of the most important ones which subsequently results in efficiency ; that is, more tasks are accomplished with the use of less time and resources as the actions tend to be more narrowly focused on the achievement of the most important factors such as client and contractor -related factors, as opposed to the low-value adding factors. Moreover, findings of the present study highlight the utility of the integrated BSC and QFD framework in quantifying the strengths of association of the different objectives of the financial perspective and the enablers of construction delay mitigation. Thus, the proposed integrated BSC and QFD framework can serve as a systematic and structural approach for measuring the strength of influence of the enablers of delay mitigation against the financial perspective. Finally, the proposed framework can be considered a novel tool since this is the first integrated BSC and QFD framework for construction delay mitigation.

5.3 Recommendation to Clients/Owners

Owners are key stakeholders that directly influence project success. Due to such strong influence and based on the findings of this study, construction project clients/owners should ensure timely completion of design to avoid or minimize any changes during project execution. Indeed, design changes have been identified as one of the causes of delays (Zidane and Andersen 2018b). In addition, they should perform adequate project planning and scheduling and ensure that comprehensive project control and monitoring systems for schedule, cost control, and change order tracking are in place. They should also expedite the decision-making process in order to avoid delays. Lastly, they should put in place, comprehensive contract document and promptly coordinate interface between client, project stakeholders, and contractor. These recommendations will help ensure that rational approaches are adopted by the clients/owners during the planning and execution stages of the project which will help avoid delays. Since these recommendations are actually the objectives of the client perspective that significantly influence the financial perspective, it is clear that the use of the proposed framework is useful in generating a set of recommendations for key stakeholders such as the owners/clients, as well as the contractors and project management teams which is discussed in the succeeding section.

5.4 Recommendations to Contractors and Project Management Teams

Like the clients/owners, contractors and project management teams also strongly influence and thus, direct or control project success. Because they are key stakeholders of the project and based on the findings of this study, contractors and project management teams should effectively plan, manage, and supervise construction site activities. Moreover, contractors should hire competent personnel for the project and at the same time, select the optimum subcontractors and suppliers. These will help ensure that the best people are selected for the project management team and that their subcontractors and suppliers are highly dependable and reliable. In addition, contractors and project management teams must ensure that all submitted technical information are accurate for the commencement of work. They should also ensure timely payment to subcontractors and suppliers since failure to do so result in project delays.

5.3 Limitations and Recommendations for Future Research

One limitation is the small sample size (n=70), considering that the geographical context of the study is broad or universal, as opposed to being country-specific. Future research, therefore, should point toward gathering data that include the demographics of the study participants and recruiting a larger sample that is truly representative of all stakeholders. Furthermore, future research should include validation studies aimed at evaluating the effectiveness of the proposed framework in quantifying the strengths of association of the different objectives of the financial perspectives and the objectives of the perspectives of the enablers of construction delay mitigation.

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