



**An-Najah National University**  
**Faculty of Graduate Studies**

**QUALITY 4.0 FRAMEWORK IN THE  
CONSTRUCTION INDUSTRY IN  
PALESTINE**

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## **Dedication**

To my mother, to my father's soul,

To my husband Fadi for his support,

To my sons; Odai, Mohammad, Noor, and Omar and all my family,

To everyone who wished me well,

Thanks, and unlimited appreciation.

## **Acknowledgment**

In advance, 'thanks God', I want to start by thanking God Almighty, who has given me the power and patience to complete this thesis.

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This work would not be accomplished without the motivation and support of my family, and friends, I would like to extend my thanks for them. I also want to thank all of the participants from the Palestinian contracting sectors who answered the questionnaire and provided the necessary data.

Thank everyone.

And all thanks to everyone who contributed directly or indirectly to help me complete the thesis.


## Declaration

I, the undersigned, declare that I submitted the thesis entitled:

**QUALITY 4.0 FRAMEWORK IN THE CONSTRUCTION INDUSTRY IN  
PALESTINE**

I declare that the work provided in this thesis, unless otherwise referenced, is my own work, and is not been submitted elsewhere for any other degree or qualification.

Student's Name: Nasreen Abdel Hafeeth AL-Tuhul.

Signature: 

Date: 20/3/2023.

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# **QUALITY 4.0 FRAMEWORK IN THE CONSTRUCTION INDUSTRY IN PALESTINE**

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## **Abstract**

Many business sectors have been developed in the current rapidly evolving market while others are lagging behind this development such as the Construction Industry (CI). This study gives an overview for Quality 4.0 concept and investigates the relationship between Contract Management System (CMS) with Quality Management System (QMS) in presence of Quality 4.0 acceptance and implementation (Q4.0) as a mediating variable in the construction contracting companies working in West Bank in Palestine.

A conceptual literature-based framework was developed to connect between variables using exploratory research. Structured questionnaire was designed to collect data from a randomly selected sample; 95 responses from contracting Palestinian companies were gathered. Partial least squares structural equation modeling (PLS-SEM) using Smart-PLS software was used to analyze and assess the conceptual framework.

The results revealed that CMS and QMS are implemented at a high level in the targeted construction companies. Moreover, Q4.0 technological dimensions are highly accepted by these companies. It has been found that; Claims and Disputes Resolution (CDR), Communication and Relationship (CR), and Contract Risk Management (CRM) followed by financial issues are main contractual management dimensions to be developed in this industry.

Additionally, the results confirmed that CMS and Q4.0 have significant positive effect on quality management system. On the other hand, results showed that there is no significant impact of Q4.0 on CMS and no mediation effect of Q4.0 acceptance and implementation on the relationship between CMS and QMS. This study contributes in giving empirical evidence about the relationship between CMS, QMS, Q4.0 and recommends that other studies be done to assess the effect of other variables on QMS and to retest this model with in other industrial sectors with alarger sample size so that the results can be generalized.

**Keywords:** Contract Management System (CMS); Construction Industry (CI); Quality; Quality 4.0 (Q4.0); Quality Management System (QMS).

# **Chapter One**

## **Introduction and Literature Review**

### **1.1 Chapter Overview**

A comprehensive introduction is presented in this chapter and a general theoretical background and literature review for Q4.0 in the CI is provided. This chapter's sections are consisted of general background including the research's problem statement, the research's questions, the research's importance, the research's goals, the research hypotheses, and the structure of the thesis. In addition, this chapter discusses the literature review for the research topic to present a thorough and general knowledge and overview of peculiarities, contracting systems, and the quality management system in the CI. Furthermore, it discusses the Q4.0 concept in the CI; its dimensions, management practices, competencies, motivations, and challenges for adoption and implementation, environment and readiness, tools, and its relationship with sustainable performance. Additionally, the chapter discusses the framework of Q4.0 in the CI in Palestine and it's partially mediation effect on the relationship between an effective contracting system and an effective quality management system, and how to measure each variable in the proposed framework. The chapter also presents proposed hypothesis to be investigated through statistical analysis in the next chapters depending on the available related literature.

### **1.2 General Background**

The present business environment and industries have been witnessing remarkable developments and innovations due to rapid revolutions in technologies and globalization (Aslam et al., 2020), manufacturing industry is an example of these industries. Nevertheless, some industries such as the CI are facing challenges to adopt, implement, and emerge these technologies and innovations in their business environment in terms of cost, time, etc..., So activation of the role of innovation and excellent managing and controlling quality is a way to achieve good productivity and performance for such industries (Baur & Wee, 2015).

Quality management is the way and practices to reach 'quality', it is related to creating value for customers, it is a strategic and complex concept that can't be achieved without

the collaboration of all efforts at all organization levels (Knowles, 2011). The concept of quality has been changed, evolved and is expected to continue developing in the future (Wen et al., 2020). It also has been playing a crucial role in industries; following the quality systems lead to a high quality of origin. Fundamentally, that contributes to reducing maintenance costs and preserving the value of assets represented to stay competitive.

The construction industry is an industry in which deliverables are projects supervised by engineers all the time, each order, for each customer and different sites, it is associated with the building of houses, bridges, dams...etc (Ballard, 2005). The importance of the quality control system came to reduce the cost of establishments by avoiding the occurrence of errors as much as possible, by controlling all inputs to the CI, and imposing requirements for implementation according to technical codes and specifications (Mahamid, 2016). In construction, it is clear that the application of top management to quality specifications is important to the quality management system. However, there are many variances in the way in which contractors manage their projects, some of them are bounded by contracts to maintain legal and safe than seeking beyond the best approaches and give alternatives, other contractors are risk-takers and add value to the work, indeed, this requires a cooperative, partnership, and effective contracts that are the basis of quality application in CI.

The accomplishment of construction projects on time, within the budget, and the acceptable quality -mutually agreed upon in the signed contract between all contractual parties- is considered a success for any project; on the other hand, overruns in cost and being behind schedules weaken the project's performance. Contract in the CI is usually considered the most important success factor for any construction project where good performance is to comply with the provisions of the contract and the application of quality standards to achieve the desired outcomes.

Industries throughout the world are being pushed to accept new digital technologies generated through the fourth wave of industry and the digital transformation at its helmet. Although the construction sector is not at the forefront of this transformation and is a sophisticated industry due to its peculiarities apart from other industries, it is not excluded from this digital innovation (Jazzar et al., 2020). Despite that Industry 4.0 is real in

countries such as Germany, and several national strategies and policies have been developed to implement this concept in many countries such as Japan, France, and United States, Industry 4.0 technologies' availability and adoption are difficult for both industry representatives and countries (Da Silva et al., 2020). Quality 4.0 is an application of quality management aligned with industry 4.0, Quality 4.0 is the process of digitally monitoring, data collecting, and analyzing data in real-time. This helps companies effectively track quality issues, and predict maintenance requirements (Kupper et al., 2019).

In Palestine, as a developing region, there is a scarcity of empirical studies that enables innovation in project management practices (Ghaben & Jaaron, 2017). Additionally, many challenges and peculiarities are facing this industry and cause rework issues and wasting time, cost, and other resources accordingly. Work repetition is very expensive, and for that, it is necessary to establish quality control (QC) and quality assurance (QA) systems as a means to fulfill contractual needs. By applying quality techniques, knowledge, and skills for quality managers are needed to manage a successful project within the required cost, time and quality, to ensure achieving good results.

### **1.2.1 Problem Statement and the Research Questions**

Contract regime control and continuous quality improvements are tough in construction and resulted in many reworks and waste of time and costs issues; it is specified at the planning stage of each project and to be executed as contractually agreed. This makes relations with contractors complex and incorporative. This complexity and uncertainty are usually solved through subcontracting and variation orders during the execution stage. Furthermore, innovative studies are scarce in Palestine (Ghaben & Jaaron, 2017).

When the adversarial approach prevails over the customer's procurement function the project will suffer, and the role of quality management in the CI is clarified in the contract. To overcome this issue, emerging new digital technologies will make difference; these technologies should be mutually agreed upon and included in the signed contract. This procedure is highly adopted in services and manufacturing industries; however, adoption and implementation of this technology are faced with complex challenges in the construction industries (Edi, 2019), considering that these applications are expected to

increase integrity, reliability, and innovation between all contractual parties, and improve the performance and the quality of works accordingly (Emblemsvåg, 2020).

Many studies have been conducted in exploring the concept of total quality management system (TQM) while few ones have focused on embowering the road to (TQM) in the construction industry. An effective adoption of quality management system QMS and meeting international quality management standards in the construction industry is a way to achieve total quality management concept and integrate quality management into the technological processes.

In light of the presentation of the study problem, the main research questions raised by the study are summarized as follows:

1. What are the elements shaping the acceptance and implementation of digital technologies in the quality system in the construction projects in Palestine?
2. Do Quality 4.0 acceptance and implementation (Q4.0) mediate the relationship between an contract system (CMS) and an quality management system (QMS) in the construction projects in Palestine?
3. What kind of framework of Q4.0 is to be adopted and accepted in the construction industry in Palestine?
4. What is the level of implementation for CMS and QMS in the Palestinian contracting companies?

### **1.2.2 The Significance of Research**

Despite many examples of implementing Industry 4.0 in organizations in the literature, there is no general framework for implementing Industry 4.0 with a detailed timeline. Studies on ways to implement Industry 4.0 are still a current and unexplored area of research. The main objective of this study is to introduce the concept of the theoretical framework for Q4.0 adoption and implementation.

The importance of this study lies in the urgent importance of applying an effective quality management system in construction projects in Palestine because of the operational problems that appeared during the construction of these projects and the consequent waste of costs, disruption of projects, reduced lifespan of facilities and consequent economic and societal losses. Furthermore, the importance of discovering the elements of weakness

in the construction system in terms of the application of the quality assessment system 4.0 so that appropriate solutions are proposed to remedy the situation. The materials and methods will be described in sufficient detail to allow others to replicate and build upon the published results.

Therefore, this research will participate in finding solutions to remedy this situation and participate in lifting this important economic sector. Furthermore, this study helps decision-makers in the construction sector and the researchers in identifying and assessing the enabling factors to adopt and implement the Q4.0 concept.

### **1.2.3 Research Objectives**

Theoretically, this study contributes to explore the mediating role of quality4.0 acceptance and implementation in the relation between CMS and QMS in the construction sector in Palestine. Furthermore, the study presents a practical contribution and assesses decision-makers in the construction sector and researchers in identifying the enabling factors and framework to enhance the adoption of new digital technologies to be differentiated from other competitors; main other objectives are as follows:

1. To identify the elements shaping the acceptance and implementation of digital technologies in the quality system in the construction sector in Palestine.
2. To examine the role of Q4.0 in the relationship between contract management system CMS and quality management system QMS in the construction sector in Palestine.
3. To develop a framework of Quality 4.0 tailored to the CI in Palestine.
4. To measure the level of implementation of CMS and QMS in the Palesyinian contracting companies.

### **1.2.4 The Research Hypotheses**

The research will rely on several hypotheses to explore the roles of CMS and Q4.0 on QMS as follows

H1: Contracting management system (CMS) has a positive and significant impact (at a 5% significance level) on quality management system (QMS) in Palestine.

H2: Contracting management system (CMS) has a positive and significant impact (at a 5% significance level) on quality4.0 acceptance and implementation (Q4.0) in Palestine.

H3: Quality4.0 acceptance and implementation (Q4.0) has a positive and significant impact (at a 5% significance level) on (QMS) in Palestine.

H4: Quality4.0 Acceptance and Implementation (Q4.0) mediates the relationship between contracting management system (CMS) and quality management system (QMS) in Palestine (at a 5% significance level).

### **1.2.5 Thesis Structure**

This thesis is divided into four chapters as follows; Chapter one provides a comprehensive overview of the research, including the problem statement, hypothesis, objectives, and a comprehensive literature review of the research subject is provided. Also, it discusses the framework of quality 4.0 in the CI in Palestine and its partially mediation effect on the relationship between an effective contracting system and an effective quality management system, and how to measure each variable in the proposed framework. Chapter two gives a description of the methodology, research approaches, sampling techniques, and data collection methods followed in this research. Chapter three offers a data presentation, analysis, and testing of the hypotheses. Finally, chapter four gives a discussion of the statistical results, summary, conclusion for this study, limitations, and recommendations for future work.

### **1.3 Theoretical Background**

Quality management is critical in any industry's process since it ensures that products/services are reliable and meet the needs of customers (Yamada et al., 2013). It is a topic that's been widely discussed in the literature since the 1980s and 1990s, with a focus on nonconformity analysis, quality management philosophies like Total Quality Management (TQM), Lean Six Sigma, quality control and inspection tools and methodologies, and the impact of quality on company performance (Sahoo & Yadav, 2018). Traditional quality management approaches and technologies enable the discovery of faults and enhance decision-making, but with a delay in the corrective action. Furthermore, the rising model of mass production and mass customization introduces new challenges and complications to the manufacturing process (Aleksandrova et al., 2019).

One of the most important economic industries in the countries is the CI. Many industries and professionals are participating in construction, including designers, contractors,

consultants, and real estate developers- In light of the complexity of the common tasks and responsibilities of all parties, sources of errors and their occurrence possibility are increased. Therefore, this industry needs more quality managerial attention.

Contracts are the basis of quality in the CI; contractors to adhere with the technical specifications signed in the contract documents, so CMS is an essential controlling variable in quality evaluation in the CI.

The application of industry 4.0 tools is useful in the CI as it helps to estimate costs and reduce the time required to complete activities within a high-quality framework with a large profit rate, as well as improving future maintenance standards by referring to the data provided by these tools through electronic feedback (Antony et al., 2021).

Consequently, enhancing contracts and application of new technologies to the CI are expected to improve the level of quality in this vital industry.

#### **1.4 Construction Industry CI**

The construction industry in Palestine is the main factor for the success of the country's economy, as it is ramified everywhere, starting from residential houses, streets, hotels, hospitals, schools, universities, and others. The development of this industry leads to the development of other industries related to the CI, for example, concrete, wood, paving, and other industries, so with those challenges in the CI, it is imperative to follow an effective system that ensures the effectiveness of the quality of these industries (Hanan Ahmad Taha, 2010).

Generally, construction projects need to achieve the three basic elements in engineering project management; cost, time, and quality, for example, if the project is of high quality and completed in a short time, the cost will be high. This indicates that those elements are related to each other, that is, a high-quality project can be implemented if the budget and sufficient time are available to reach this scale. So, The CI needs an effective management system in terms of planning, scheduling, and monitoring project work within the framework of construction management.

In most CI projects, the owner's view is to obtain a project at a low cost and within a short period and at the same time a high-quality level, which makes contractors face

difficulties in achieving the desired quality of those projects. Hence, researchers have developed methodologies that improve the quality of the CI projects and their delivery as agreed in the contract (Da Silva et al., 2020).

Leong et al. (2014) conducted this study on one of the CI projects in Malaysia and studied the project performance index and the relationship between it and the quality management system to develop project performance. The results of the research indicate that the owner's satisfaction with the project's performance has a good relationship with improving quality management. The study activates the role of overarching quality management in the CI project.

Park & Yi (2021) adopted a certain research methodology to show the performance of the quality measure and the extent to which the CI was simulated, by comparing the project quality measure with the cost and time to complete the project based on a specific work plan. The researchers collected data and the study summarized the performance assessment of the quality characteristics of construction equipment and materials, operational skills, and job site planning and management. The researchers recommended the need to improve the efficiency of the performance of quality standards and to integrate them with management standards. Additionally, they stated that due to the complex developments in the world of the CI and new customer needs, the need of highly experienced and qualified project managers who can manage these projects correctly and effectively is raised.

Considering that, the CI still is facing many obstacles and complex challenges that need deep solutions. There is a lack of related studies to the CI in Palestine.

#### **1.4.1 Peculiarities of CI**

CI projects are unique compared to other industrial projects, and the most prominent characteristics of the CI according to Emblemståg (2020) and Koskela (1992) are shown in Table 1. According to Schalcher (2010) the CI is complex, the complexity is in its systems and processes starting from designing, walking through execution, and reaching finally maintenance stage, it consists of an unsystematic flow of processes that include many interrelated and dynamic subsystems; these systems are not following strict rules and processes, and they can be reordered and changed, new technologies and complex

mechanisms contribute to the consumption of various types of building materials, equipment, machinery, and factories. Additionally, the emergence of many major contracting companies, contractors, and subcontractors creates a spirit of competition among them, where each of them has an independent system in the formation of the organizational structure.

Construction is more complex compared to production projects in other industries. Each project in the CI is unique and distinct from the other project in terms of the nature and type of the project, for example, if two similar buildings are constructed on two different sites, the soil properties of each site are different from the other, so each project is different and unique from the other project.

This uniqueness has limited innovation in construction projects (Ghaben & Jaaron, 2017). Uniqueness may cause unforeseen conditions and internal uncertainty. The CI projects are characterized by the presence of regulatory bodies such as municipalities, the Ministry of Public Works and Housing, safety monitors, the town planning authority, rural and urban planning, etc., which work to control and monitor site works, as each body is independent of the other. This may cause external uncertainty and regular interventions (Hanan Ahmad Taha, 2010).

The CI sector in Palestine is classified as a means of support that enhances the economy; it has developed the contracting sector and put it at the forefront among other industries. Consequently, it improves the level of investment and creates multiple employment opportunities, and positively affects other sectors (Rashed & Othman, 2015). The CI is one of the most important industries that work to improve the infrastructure and economy in Palestine, but this industry faces some challenges as it lacks quality efficiency and lack of budget, where good management works to raise the level of efficiency within a reasonable budget and high-quality. Quality improvement has become a major challenge facing the CI that leads to the reduction of project costs and future maintenance costs within the framework of the construction project life cycle. Total Quality Management is considered one of the most important solutions that contribute to solving construction sector problems and project success (Syaj, 2015).

The CI needs man-power to execute the project work items within a safe environment predefined in the contract provisions, they should be highly qualified and skilled to ensure

the progress of work. However, this causes a wide variability in the productivity rate and project performance accordingly.

Furthermore, the CI - apart from other industries - consists of many stakeholders, mainly three main groups as follows:

1. The owner who is concerned with financing and financial matters to cover the needs of the project.
2. Engineers including civil engineers, architects, designers, and project managers, each of whom has a degree of experience in the CI to prepare plans, project scheduling, and perform supervision work during execution.
3. Contractors who concern with implementation work as stated in the plans.

**Table 1***CI peculiarities*

Peculiarity	Control Problems for process	Improvement problems for processes	Structural solutions	Control Operational solutions	Operational Enhancement for Improvement
Uniqueness and complexity	Absent prototype cycles, variations in customer input, coordination of uncertain activities.	No repetitions, so long-term improvements are a challenge.	Minimize the unique content in the project.	Clear requirements analysis, set up artificial cycles, buffer uncertain activities.	Cover a wider variety of needs by enhancing the flexibility of services and materials to, accumulate lessons learned from earlier projects
External and internal uncertainties (different sites)	weather uncertainty, flow interdependencies, variation of layouts, productivity variance (manual work)	Difficulty of transferring improvement in processes and skills between sites	Minimizing the site activities for any material flow	Reduction of external uncertainty using enclosures, detailed and continuous improvements and planning, hiring Multi skilled work labors.	Planning and risk analysis, enhancement systematized activities processes.
Varied organizations	Exchange of information through organization borders (disconnection).	Stimulating and improvement difficulties along organization limits.	Temporary organizational interfaces to be minimized.	Team cooperation during the project.	Integrate flows by cooperation and partnership.
External interventions	Delay in approval process.			Compression of approval cycle, Self-inspection.	

*Source: (Emblemsvåg, 2020; Koskela, 1992).*

Generally, complexity and uncertainty in the construction industries have resulted from, unique projects, site peculiarity, organizational issues, and intervention that causes a delay in approval (Emblemsvåg, 2020). According to Koskela (1992) Traditional design and execution, organization laws, and CI peculiarities are considered the cause of the most serious construction flow issues. As a result, these challenges require special attention.

#### **1.4.2 Contracting Management System (CMS) in CI**

The contracting sector is one of the most essential sectors in the CI in Palestine. The number of contractors and subcontractors has increased and they play an active role in the CI despite the political threats and the destruction it leaves behind, which affect inversely the number of workers, but in fact, the number of building contractors has been increased according to the Palestinian Contracting Union (PCU) online annual reports.

To ensure the success of the project in the CI, there must be an effective management system including an effective CMS, which consists of several contracting parties who, through this contract, can abide by all terms and conditions to achieve the objectives and outputs of the contract. The effective CMS also strengthens the working relationship and increases the team spirit within the project framework. The contract system (CS) continues for the entire period of project phases until completion and up to the final handover stage. The main purpose of the contract system is to activate the performance of the construction projects based on specific terms and conditions in the contract. Therefore, CS is of a high degree of quality to ensure the greatest possible benefit at the lowest costs and in a short period. CS has been activated to become comprehensive, the ideal mechanism for ensuring the sustainability of the relationship between contractors and customers, finding a balance between risks, material prices, and project work items, and improving quality performance during the implementation phase and ending with the project delivery phase throughout the life of the contract (Dmaidi et al., 2016).

The Traditional contracting way gives the chance to the incapable contractors to win tenders through the procurement process; the contractor will not finalize contractual works on the due date. Continued improvements to be affected because contractors will search to find the easiest solutions, not the best ones because the best solution in their opinion will cost more. When the contractor is unable to determine the financial risk

resulting from functional tests, high repair costs will become the customer's problem (Emblemsvåg, 2020). Customers and contractors have to discuss project problems to find the optimum solutions; their relationship should be smooth.

The contractor is a fundamental part in the CI project. He is the individual, company, or alliance of companies that work in the field of the CI and is classified by degrees as a first, second, third, fourth, and fifth class contractor. The contractor is registered in the list of the Palestinian Contractors Union, and in this case, he is considered a member of the union and his company bears a certain degree of classification. On this basis, projects are referred to his name according to the specialty classified, for example, building contractors, road contractors, water and sewage contractors, electromechanical networks contractors, and maintenance and public works contractors (Shweiki, 2013). In Palestine, to ensure that the terms of the contracts are applied correctly, you must refer to the general terms of contracts international federation for consulting engineers (FIDIC) clauses and abide by the general and special conditions included in the contract, as all (FIDIC) contracts contain instructions and provisions for construction projects to reduce risk. Some items that are not special and should not be modified, include the role of the supervising engineer in following up the work and evaluating the financial claims as to the owner's representative, the nature of the work environment, the delays in the project, and others (Bahij & Tuffaha, 2015).

Due to the difficult political conditions in Palestine; the contracting sector has not received sufficient development due to the restrictions imposed by the Zionist entity and this is causing many additional challenges such as the destruction of roads, sewage networks, and factories. Additionally, the Zionist entity is a stumbling block in importing and transporting building materials inside and outside Palestine, they imposed many restrictions on the movement of the project parties, including contractors, engineers, and workers.

Gunduz & Elsherbeny (2020) proposed a comprehensive construction contract management performance model from a sequential mixed methodology of qualitative and quantitative data collection and analysis. The model is to measure CMS performance, it consists of eleven major constructs affecting construction contract management. Namely; project governance and start-up, contract administration team, communication and

relationship management, quality and acceptance management, performance monitoring and reporting management, document and record management, financial management, changes and changes control management, claims and disputes resolution management, contract risk management, and contract closeout management. 93 indicators to measure these constructs, for example the construct G02-Team Management has six indicators namely; assignment of competent team, early assignment of team, clear responsibilities, training programs, regular performance assessment, and set performance dialogue for team, all detailed constructs and indicators are shown in Figure 1.

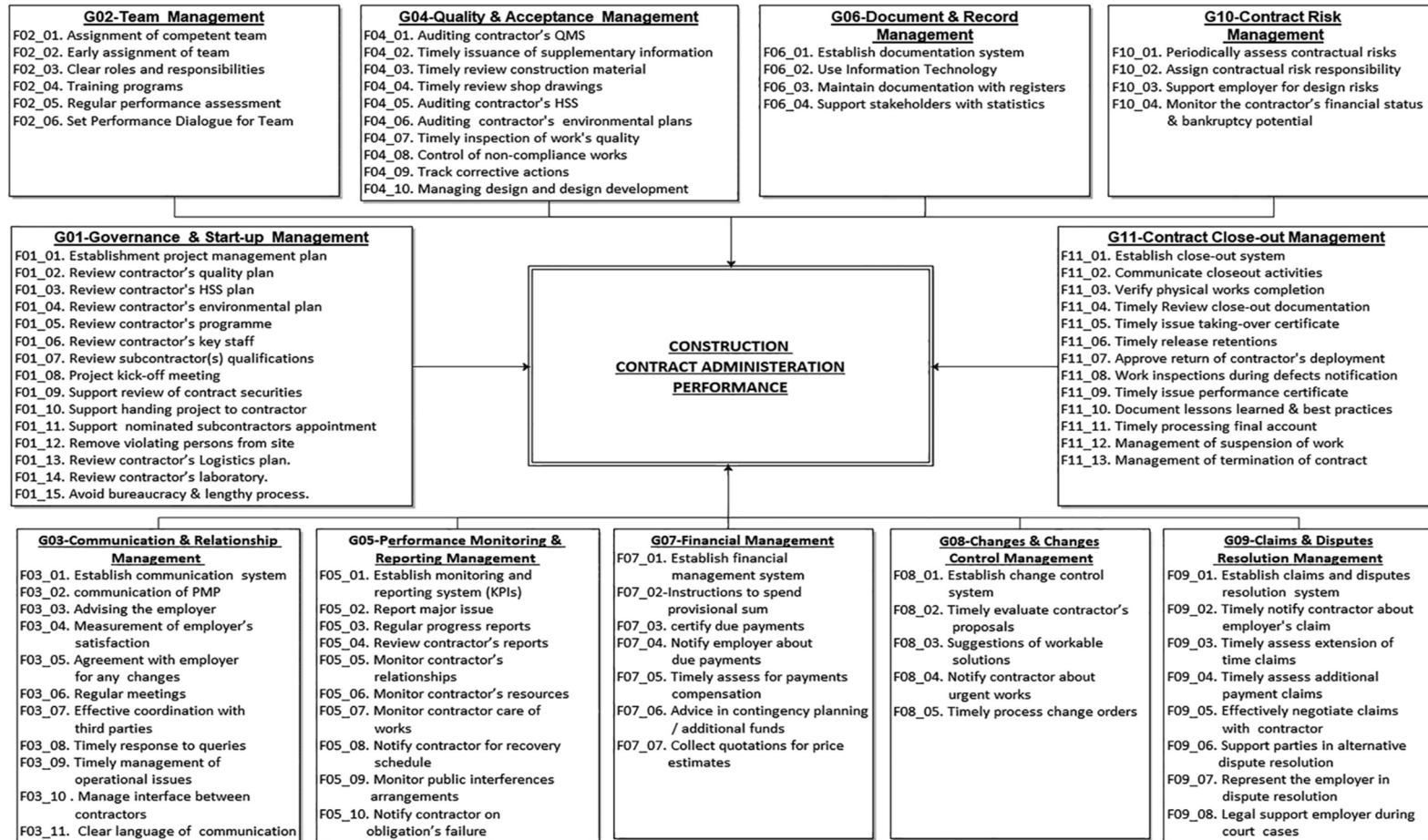
Herein, each two mutual and similar constructs; reporting and documentation constructs, quality and changes orders constructs, and project start up and close out constructs have been merged by the name of construct only; each merged construct includes six items; the first three ones are for the first indicator in the naming and the rest three items are for the second construct. Consequently, eight constructs are taken into consideration in this study with 33 related indicators as follows; performance monitoring, reporting & documentation (PMR), financial management (FM), claims & disputes resolution (CDR), quality & acceptance & Changes Control (QACC), communication & relationship (CR), contract risk management (CRM), project governance/ start-up & close-Out (PG), and contract administration team management (CAM).

In Palestine, as a developing country, many challenges face the construction contracting management systems CMS. According to Dmaldi et al. (2016) the main ten problems facing the contracting management system in the CI in Palestine from different construction stakeholder's perspectives; contractors, consultants, customers, institutions, and donor's points of view are:

- Intensive competition among contractors that causes very low prices,
- The policy of giving the bid to the lowest price rather than the most accurate one,
- Delayed payments by owners,
- Changeable value of currency exchange,
- Delay in decision-making by the owner,
- Projects are little in comparison to the number of contractors,
- The fluctuating cost of the construction materials as a result of inflation.

**Figure 1**

*Construction contract management performance*



*Note: Refer to (Gunduz & Elsherbeny, 2020)*

- The country's economic position is declining.
- Maneuvers by some contractors through the reduction in some prices on other items as, and
- Inconsistencies and conflicts exist in the tender document.

To achieve an effective contracting system these problems should be solved; as the contract is the main key driver in quality assurance in construction projects, quality improvements are not achievable without enhancement in the contractual regime. In any contract, legal and clear commercial issues are difficult to be changed, the focus will be on the project characterization of customers' requests such as how to confirm contractual quality, a functional test must be taken into account. Therefore, the delivery risk will be back to the customer.

Poor contract administration can result in disastrous consequences, a thorough assessment of the variable's influencing CMS is needed for each company to overcome complexities and challenges accompanied with construction CMS application and avoid risks. For that, continuous evaluation and lessons learned to be taken into consideration.

### **1.4.3 Quality Management System (QMS) in Construction**

Many researchers have conducted studies on the concept of quality management, and each of them has launched his definition of quality. Crosby & McGraw-Hill (1979) presented quality as "making a match between requirements and needs". This concept was taken and incorporated into the international quality standards ((ISO) 9001, 2008, also Idrus & Sodangi (2010) defined quality as part of the performance to achieve desired goals, they have argued on this topic and concluded that quality in the CI is a supportive force for bringing about conformance with prerequisites. On the other hand, the conducted research by March (2001) concluded that quality should be one of the most prominent standards of projects in the CI. Consequently, the quality standard expanded and became used in evaluating the performance of the CI projects to improve the project stages until its completion and delivery.

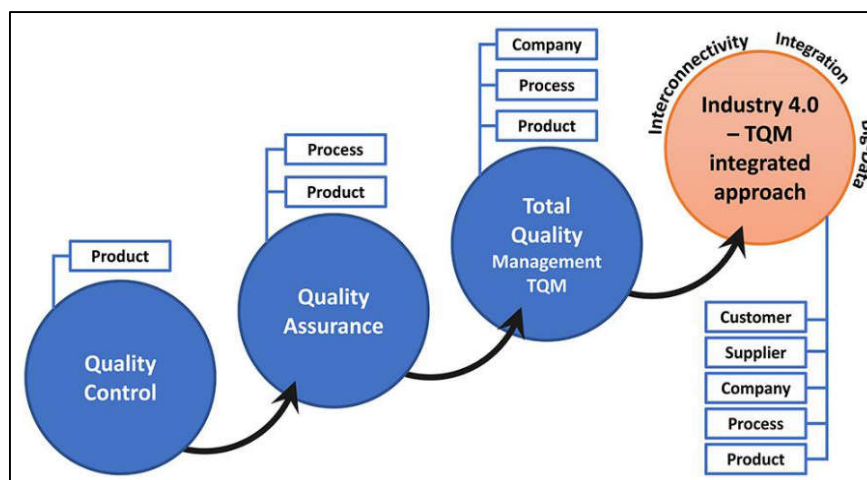
The quality of the construction works is the roadmap for any construction project, as it indicates the completion of the implementation stages according to the agreed terms in the scope of work, to meet the expectations of the owner and achieve high-quality results,

which ensures the success of the project. A quality system is considered effective if a strong management system is available to support the quality department and quality engineers in the organization, to be capable of improving quality standards. Syaj (2015) introduced the basic methods of quality management and summarized them in four stages inspection, quality control (QC), quality assurance (QA), and in addition to total quality management (TQM). She discussed in her research that the stages of total quality management and quality assurance contribute to improving the performance of the CI and ensuring that the project is free from problems and obstacles.

According to Esezobor (2016) elements of quality assurance (QA) are failure mode and effects analysis, quality systems development, comprehensive quality manual, quality planning and costs, improvement of non-production processes. Furthermore, the elements of total quality management (TQM) are policy deployment, involvement of suppliers and customer, team work, involvement of operations, performance measurement, and process management, Digitalized TQM in construction 4.0 according to Rifqi et al. (2021) is the future of quality which has been progressed through the past years as shown in Figure 2. Quality management contains many dimensions through which total quality management is reached in the CI, by developing the performance of workers, modernizing quality management programs, regulating relationships between project parties, and improving the quality of designs, which contributes to facilitating the process of cost estimation and achieving customer satisfaction.

**Figure 2**

*TQM framework in industry 4.0*



Source: (Rifqi et al., 2021)

Altayeb and Alhasanat (2014) studied critical success factors needed for the implementation of total quality management (TQM) in Palestine particularly, the Gaza strip. They concluded that the main factors shaping TQM are; leadership that represents approximately 5% of TQM, strategy and planning with 18%, customer satisfaction, process management, training issues, communications, and continuous improvements with approximate formulation 18%, 6%, 17%, 18%, and 18% respectively. Additionally, Rashed & Othman (2015) highlighted that in the construction industry; a successful implementation of TQM is resulted from the effective implementation of quality management systems QMS.

The International Organization for Standardization ISO introduced quality systems in March 1987 and the initial edition of the QMS standard, ISO 9000 was submitted on 1994, placed a strong emphasis on QA through preventative activities.

Later on, many versions have been submitted as the versions submitted in 2010 include; ISO 9000 (QMS principals and definitions); ISO 9001 (QMS needs); ISO 9004 (Management of organizational sustained success), and ISO 19011 (QMS audits guidance), Figure 3 is the structure on International Standard representation for ISO 9001:2015 in Plan-Do-Check-Act (PDCA); plan for the requirements (needs), check that it works, and act to correct any problems or improvement performance (Neyestani, 2017).

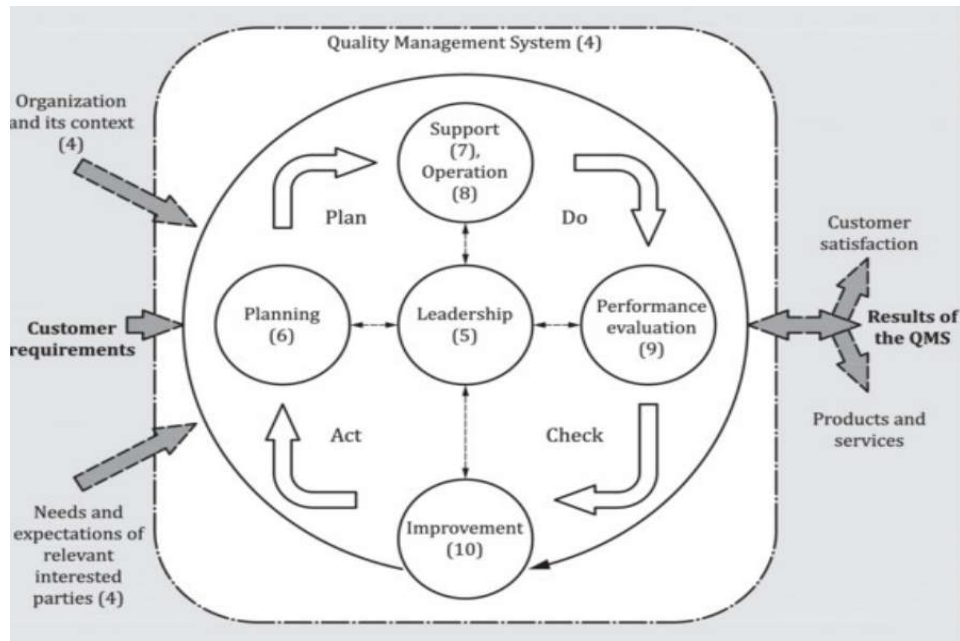
To get an effective and efficient QMS according to ISO 9001 certification, eight principals to be considered; customer focus (needs and service) who is the core of this process, clear and strong leadership, people involvement (workers and stakeholders), process approach including sequential and interactive processes and methodologies, systematical approach to management which will manage multiple processes together as a system, continuous improvement, factual approach of decision making, and mutually beneficial supplier relationships.

Öztaş et al. (2007) mentioned that QMS are using in several industries in Turkey. However, they are uncommon in the CI. Due to the nature of construction, several impediments make it difficult to deploy these systems successfully, and as a result, there is no objective way to measure the efficiency of these systems in the construction business. For Leong et al. (2014) and Neyestani (2017) a way to measure the effectiveness of Quality Management System QMS is the performance of the construction projects

through scope, cost, client satisfaction, time, and safety issues and could be measured according to Table 1 in appendix C.

**Figure 3**

*PDCA cycle of QMS structure on ISO representation for ISO 9001:2015*



Source:(Neyestani, 2017).

Many motives contribute to the adoption and implementation of ISO 9001 in the CI. According to researchers one of the most important of these motives is the ability to conduct an initial examination of building materials, assess the quality and know whether the materials and resources are good or not, as well as for workers and stakeholders where synergies can be created and motivation to ensure the workflow of these companies and their continuity of association with quality standards, which contributes to the development of competitive capabilities among the CI companies at present and in the future, by supporting training and management programs and adopting a computerized system that contains all the necessary data ensures resource optimization and performance efficiency, and customer and employee satisfaction towards the development of quality methodology and the creation of a large degree of participation among them, and taking the opinions of the company's workers for continuous improvement, which lead to project success (Santos & Millán, 2013).

During the study of Syaj (2015), it was clear that the performance of the CI companies in Palestine faces many challenges mainly, awarding the tender for the lowest price and not

efficiency, shortage of expertise in QM system, lack of qualifications and training programs needed to drive the improvement process. On the other hand, Idrus & Sodangi (2010) pointed out the need to expand the framework of the quality management system QMS to achieve high-quality results and the continuity of development and improvement for the CI companies.

In previous studies, dimensions of quality management in the CI was explored, many dimensions related to total quality management were concluded accordingly. For example, the dimension that includes the nature of the relationship between the owner and the contractor, in addition to the level of performance of operations that is based on improving decisions and following up the workflow to avoid problems. Consequently, achieving customer satisfaction and facilitating the selection and classification process for contractor and subcontractor to ensure TQM standards (Bakar et al., 2011). Quality dimensions provide product operational characteristics, materials, and features, as well as ensure the viability and durability of building materials for an extended period throughout the project lifecycle (Syaj, 2015).

### **1.5 Construction 4.0**

Industry 4.0, is a broad term consisting of a “confluence of trends and technologies” that are likely to reshape the way things are made (Baur & Wee, 2015). This term was firstly introduced in 2011 and aims to enable real-time communication between the physical and digital areas (Lee, 2015), many technologies have been cited within the literature that contribute to serving the Industry 4.0 concept (Aleksandrova et al., 2019; O’Donovan et al., 2019).

Construction 4.0 is the transformation of the CI from the traditional way of managing and performing works to a higher degree of digitalization through connecting virtual and real-world data (Craveiro et al., 2019). Soft competencies beyond technical expertise, in particular, communication skills are very important in this era (Kannan & Garad, 2021). The advent of Industry 4.0 has increasingly changed the way things are, due to the new advanced knowledge related to Industry 4.0. Many studies were prepared for digital transformation which to provide a comprehensive picture of the competencies currently required for production engineers.

The key drivers of construction 4.0 are the varied digital technologies and their interaction with one another, extant research has noted both the adoption of technologies and ideas from different sectors and dedicated technologies of the industry as significant drivers. Building Information Modeling BIM holds the central position and has become the fundamental necessity for the development industry's journey of making digital twins (Boton et al., 2021).

New technologies such as BIM- have been proven that can effectively solve and deal with quality issues and evolve QMS efficiency in the project life cycle. BIM is an important technology to improve the traditional ways of managing quality in the CI (Wang & Wei, 2020).

A key finding of Sawhney et al. (2020) study is that building information modeling BIM, which is a common data environment, forms the main basis for implementing the Building4.0 framework. In defining the Construction 4.0 framework, the study described its components and how the implementation to continue. The authors envision that by adopting Building 4.0, the industry can transform itself into a highly efficient, quality-centric, and secure industry that can successfully meet society's demands.

Boton et al. (2021) highlighted that, in previous few decades, the construction sector has witnessed a significant digital transformation, although the building information modeling (BIM) method is crucial to this shift, a growing number of technology techniques are appearing and being categorized under the term "Construction 4.0.". Construction 4.0's boundaries as a scientific field are far from being established. Nonetheless, a few literature studies describe its supporting technologies and define its meaning, but they do not give a comprehensive picture of the research activities.

In the CI, to achieve high-quality efficiency for the project, there must be an important element to consider, which is sustainable performance, according to all definitions of sustainability, current human needs must be met without impeding the requirements of future generations including social equality, environmental quality, and economic prosperity dimensions (Salameh, 2012).

As this concept has become widespread among various industries, there are some differences and views of some companies regarding policies and strategies for their

application, given that sustainability is a rather complex and built-in concept on value. Sustainable performance is included in all construction activities to achieve the required goals, as those goals are determined according to the priorities and needs of the project, which affects the mechanism for managing activities and delivering them on time. The terms quality and sustainable performance include everything related to construction work items on a large scale of all site works during the project life cycle. Therefore, many researchers have described sustainable performance as a broad and comprehensive stage for all CI activities to provide infrastructure services, to operate the work environment, and to achieve good economic feasibility within a high-quality frame (Tan et al., 2011).

Many challenges facing the sustainable practices in the CI about quality such as the challenge of having an organizational commitment to training sustainable practices on quality to achieve a clear strategy that ensures the sustainability of the construction performance according to what is contained in the contract and the challenge of materials procurement and delivery criteria (Esezobor, 2016).

Generally, the concept of sustainable performance has emerged to draw a roadmap for sustainability in construction projects. Eliminating the challenges facing the CI will reduce the pressure on construction companies to identify effective strategies to sustain the performance of construction activities, assess project quality and analyze the project life cycle while adhering to quality standards to provide a safe working environment. Through previous studies that were applied to the concept of sustainable performance and the quality of the CI, various principles were identified to achieve sustainable construction, including:

- 1- Implementation of the general framework of the concept of sustainability in a way that contributes to improving the approach to the CI, which meets the needs of the work environment and reduces risks.
- 2- Cooperation between the project parties and working as a team in the design, implementation, and maintenance work to meet the project needs and achieve customer satisfaction.
- 3- Evaluate the performance of the planning, construction, and maintenance phases within the project life cycle.
- 4- Establishing a balance when choosing the quality of building materials to reduce their environmental impacts throughout the life of the project.

5- Develop an acceptable budget to reduce future project costs, including maintenance and operation work.

The construction sector presents a barrier to a successful quality due to its peculiarities as mentioned earlier, it starts with how the designers gathered the owners' requirements and integrate them into the design of a unique and sustainable project (Klinc & Turk, 2019). However, Construction 4.0 is an effective way to sustainability.

Aleksandrova et al. (2019) mentioned that data might be obtained in real-time from not only machines and automated workplaces, but from also technical equipment, warehousing, and auxiliary systems. Artificial intelligence, as well as humans, can automate and control technological, processing, and auxiliary activities in the presence of adequate sensors to BIM.

### **1.6 Quality 4.0**

Q4.0 is a part of Construction 4.0 and is characterized as the digitalization of TQM and its effect on quality technology, processes, and individuals even as it is defined as the application of I4.0 technologies to quality. Q4.0 is described as the set of features that are needed to achieve a particular purpose.

In manufacturing industry, many studies discuss the role of quality 4.0 as Chiarini & Kumar (2021) who conduct this research to explore the dimensions of quality 4.0 in the Italian manufacturing industry, they conclude that three main dimensions shaping Q4.0. Namely:

- People including quality staff digital skills and top management,
- Process-based on Industry 4.0, based on ISO 9001, mapping of processes, automatic collection of data, data integration with other systems as Enterprise resource planning (ERP), and automatic documentation control,
- Technology includes predictive software and AI, communication between machines, and smart technologies for traceability, for the CI the most powerful technological tool is BIM.

When applying the concept of quality in CI projects, it is imperative to know the tools involved in industry technology, such as real-time control of project work completion, monitoring of all activities, and data evaluation thereof, as this will improve and ensure

quality. Previous studies presented some of these tools, the most important of which are the aforementioned BIM technology (Zhang et al., 2020), tracking and sensing systems, and feedback systems. Furthermore, Klinc & Turk (2019) highlighted that Cyber physical systems CPS are the main technological element of Industry 4.0; it refers to an automated, seamless link between the physical world and smart digital components that can perceive, guide, and govern the physical environment. You & Feng (2020) illustrated that the industry 4.0 technologies utilized in the construction sector based on an examination of the sector's features, this study provides a framework for a cyber-physical system to incorporate these technologies and enhance construction management and organization. Major components of the industry4.0 technological tools that will lead to construction 4.0 era and quality 4.0 accordingly are:

- Building Information Modeling (BIM); which has been developed from computer-aided design (CAD), is today a cutting-edge technology that supports a construction project's whole life cycle by offering a virtual model and pertinent building data and will be widely discussed in the section 1.7.2.1.
- Internet of Things (IoT); is a revolutionary technology that uses sensors, actuators, RFID, cameras, and laser scanners to connect physical items to the internet according to the established communication protocol such as GPS, Wi-Fi, and other gateways (Kang et al., 2017); it establishes ubiquitous connectivity between objects before sensing, identifying, and controlling the physical process. On a building site, many sensor types can be set up to track the progress of the work in real time.
- Cloud Computing is a new technology that may be utilized by computers, smartphones, and other communication devices using third-party data centers to send, store, and conduct computations (Birje et al., 2017). With on-demand access to a shared pool of resources, cloud computing has now evolved into a paradigm for Internet computing.
- Big Data; in the construction sector big data refers to the information produced during the stages of a building or structure's life cycle, including the phases of planning, design, tendering and bidding, construction, checking before acceptance, and operation management. The IoT such as data streams from sensors or RFID readers (Alam et al., 2017), and data from information systems such as BIM and other sources that are all used to create this data. Herein, Data mining that is the process of

obtaining valuable information from large amounts of data using a variety of techniques is very important.

- Machine Learning is a kind of artificial intelligence allows computers to mimic human learning and acquire information on their own by summarizing complicated occurrences; Practically speaking, machine learning is a technique for building prediction models from data (Alam et al., 2017).
- Intelligent Computing is a type of artificial intelligence that seeks to develop a system with autonomous thinking by imitating human thought or natural principles. It has several potential applications in the optimization issues facing the building industry (You & Feng, 2020).
- Reasoning Technology is a branch of decision support in the CI depending on finite knowledge rules and resulted in infinite solutions, Case-based reasoning is an artificial intelligence tool that uses a computer to simulates human analogous thinking (You & Wu, 2019).
- 3-D Reconstruction is description of the real state of works through logical mathematical model utilizing logical expressions of computers through the acquisition of depth data, preprocessing, and point cloud registration (Ma & Liu, 2018).
- Virtual and Augmented Reality is the use of computer technology, to give persons a unique merging with the outside world. To eliminate uncertainty; project members utilize virtual reality to view and understand technical difficulties to avoid risks associated with executing the works. VR may be utilized for risk assessment, spatial layout, lighting design, and landscaping during the design phase, as well as for construction scheme evaluation, construction scheduling, site layout, and process monitoring. BIM and VR combination will open up new opportunities for building an effective communication platform and central decision centers (Smith & Wong, 2022).
- Blockchain; is a network of computers that stores information, such as transactions or agreements. Once published, the information on the blockchain cannot be changed as it is kept chronologically, is viewable by a community of users and stakeholders, but is decentralized and not often administered by a central authority like a bank or a government. In construction, conjunction of BIM with Blockahain technology will facilitate planning, design, execution of works, payments, and control of the supply

chain and makes work environment effective, transparent, and sustainable (Penzes, 2019).

Many other technologies have been discussed in the extant literature and many researchers try to integrate the major technologies to shape industry 4.0 era in the construction sector. However, few studies discuss the integration of CPS in the CI. Fundamentally, the major technological components of industry 4.0 and quality 4.0 accordingly in the CI according to You & Feng (2020) are smart technologies including IoT gateways and devices, and digital ecosystem including central management and supportive technologies as BIM and the aforementioned ones.

Currently, there is a cloud-based platforms to manage quality in the CI such as 'Qualityze', these platforms improved planning and making decisions, provide higher level of employee engagement, simplified documentation, enhance customer satisfaction, and building strong relationships with suppliers and they facilitates the road to sustainability.

### **1.6.1 Smart Technologies (ST)**

Mechanical systems equipped with sensors, actuators, and preprogrammed controllers are included in smart technologies; enabling a structure to react to unexpected external loading circumstances. Knowledge of the mechanical system itself, embedded sensors, controlled devices, and driving electronics with integrated software is necessary to understand the concept of smart technologies (Holnicki-Szulc et al., 2008).

Smart technologies: including IoT devices on physical parts of the site, including unmanned aerial vehicle (UAV), sensors, and wearable devices connected to the internet and IoT gateway including global positioning system (GPS), Wi-Fi, Bluetooth, radio-frequency identification (RFID), ultra-wideband (UWB), and other gateways to enable the connectivity among devices among the network system. Hence, data and information transform smoothly and the work will be accomplished effectively.

### **1.6.1.1 Technological Devices (TD)**

Chiarini & Kumar (2021) highlighted that main objective of applying smart technologies are tractability and identification, they can greatly help businesses to identify and track their tools and products. The ISO 9001 standard specifically states that this is necessary. Companies must identify outputs as appropriate to maintain product conformance, and they must keep records of this information to allow product traceability, according to Clause 8.5.2 of ISO 9001 (ISO 2015a). Smart chips and RFID technology on goods and packaging is an excellent approach to track and identify goods as well as manage people. This makes it simpler to determine whether a product is nonconforming and where it is in the manufacturing cycle without humans' intervention.

As a result, companies can fully trace the production. Wireless sensors technology that sends and receives data from physical tags affixed to goods and components using radio frequency signals and other IoT gateways and used to:

- On-site and supply chain-wide real-time monitoring and control,
- Instantaneous communication, planning, and
- Decision-making using an integrated data platform.

In addition to smart chips, many technological devices mentioned in the literature can help in digital data gathering, tracking and monitoring mechanical equipment as cameras, barcodes, QR codes, and sensors. Automated data collection can provide centralized data storage with enhanced data security. It becomes feasible to perform data mining and analytics, which can enhance operations (Emblemsvåg, 2020).

### **1.6.1.2 Internet of Things (IoT)**

IoT connects the physical construction site such as workers, equipment, and materials with the cyber part to achieve the cyber– physical vertical integration. IoT gateways include GPS, Wi-Fi, RFID, UWB, and other gateways. IoT implementation needs good internet infrastructure to avoid interruptions of connectivity of the technological devices with the cloud where the cyber component is. The cloud offers platform as a service (for big data storage and analysis) and software as a service for applying software such as BIM, enterprise information system, and decision support system (DSS) (You & Feng, 2020). The cloud-based approach enables instant access to the CPS by all participants

using various devices to receive needed information. Furthermore, it eliminates their cognitive distinctions and encourages collaboration by allowing them to approach challenges from a shared perspective.

## **1.6.2 Digital Ecosystem**

You & Feng (2020) stated that digital ecosystem in the construction projects includes one or more from the aforementioned technologies. However, the major two components in the CI derived from reviewing the related literature are BIM software technology and central digital management system, these systems work effectively when accompanied with other supportive technologies as Blockchain, VR, AR, 3-D reconstruction, reasoning technology, and intelligent computing.

### **1.6.2.1 Building Information Modeling**

Building Information Modeling (BIM) is a process that involves the creation and representation of physical and functional aspects of buildings and is supported by a variety of tools, and technologies. Building information models are computer software that may be retrieved, transferred, or networked to enable effective decision-making management. Individuals, corporations, and government organizations use BIM software to plan, design, manage, and maintain buildings in a wide range of physical infrastructures including, water, electricity, gas, communication utilities, roads, trains, bridges, and bridges.

Through BIM technology, an accurate virtual structure of the facility is digitally created, which is used in the planning, design, and construction processes of the facility. BIM technology helps architects and engineers to imagine what will be built in a simulated environment through generating structure digital twin, to identify the nature of the expected problems and risks in terms of design, construction, and implementation, as well as for stakeholders whose role is enhanced within the project framework through BIM.

Azhar (2011) highlighted that BIM technology has witnessed a clear development in new buildings, but most of the current buildings in the CI in Palestine have not been maintained through BIM so far, as well as the research and studies conducted on BIM are limited. Previous studies showed the scarcity of BIM applications due to some challenges, most notably the inaccuracy of the information and its conversion from building data to

indicative data in existing buildings and the poor adaptation and relevance of that information to the needs of current buildings. BIM technology plays an effective role in creating a database of buildings; it is able to manage all information throughout the project life cycle.

BIM technology is able to determine geographic information, and site characteristics, estimate project cost quantities, construction materials quantities, and schedule project timeframes. Also, through this model, the entire project life cycle is indicated, and plans and specifications are defined smoothly. As a result, the project parties (owner, engineer, contractor, and subcontractor) can understand smoothly each other and achieve efficiency and accurate results for the CI project. Additionally, BIM is an efficient, risk-shifting, innovative, and sustainable strategic leverage tool (Cesarotti et al., 2014).

BIM technology has multiple uses as it can be applied for more than one purpose; building 3D models with ease, creating shop plans for building systems in the CI, calculating project quantities, estimating costs, and automatically adjusting them. Additionally, BIM can be used to follow up on the demand for materials needed for construction, follow the delivery schedule of all project work items, and can also be applied in the planning and maintenance stages. BIM is a simulation of the project as it includes three-dimensional structures for all project elements related to planning and design, implementation, and operation. The difference between BIM technology and traditional three-dimensional techniques is that three-dimensional is based on describing buildings by three-dimensional models such as heights; So that each model is checked and updated independently, this increases the probability of error rate occurrence due to the lack of continuous documentation. As well as, the nature of the data used is in the form of drawings such as circles, arcs, and lines, while in BIM technology the elements of the construction project are columns, walls, spaces, and others are digitalized to improve works quality at all project phases. BIM's major role is as following:

- Schematic design by analyzing and comparing different design models and combining project images with surrounding conditions
- Detailed design through animation, 3d interior and exterior structures, building performance level analysis, and structural design.
- Construction details through fabrication drawings, building element analysis, measurements, and 4D tabulation.

The uses of BIM have been developed, expanded, and become present in all phases of the project life cycle in terms of design, maintenance, and construction. BIM is based on storing data within a specific framework for reference when needed, which contributes to saving time and resources. By BIM, project members can analyze the existing land areas for the construction process, saving time and effort and performing other tasks. The project team can apply BIM technology to follow up the development of project work by following four-dimensional plans, following up and coordinating project meetings, updating information, and adjusting change orders. BIM helps in raising the efficiency and management of maintenance of existing buildings, preventing losses, organizing planning, and managing real estate operations.

BIM has many advantages for the owner, designer, and contractor, advantages of BIM include:

1. Acquiring accurate design through digital simulation.
2. Evaluating the performance of projects in the CI and following up on maintenance work.
3. Accurately estimating costs and ensuring no risk.
4. Reduction of change orders.
5. Follow up the supply chain and workflow within the site during the implementation of activities.
6. Monitor the safety of the project environment.
7. Apply value engineering and reduce risk.
8. Constant communication with the owner, designer, and workers.

When applying this technology and benefiting from BIM applications, the contractor can achieve a high percentage of profits, implement a high-quality project, in the least possible time and cost, and effectively manage safety directives (Azhar, 2011).

#### **1.6.2.2 Digital Centralized Management System (DCM)**

Fundamentally, This is the decision support system in the cloud with its other empowering systems as enterprise resource planning ERP for controlling day to day processes, project management system (You & Feng, 2020). These systems provide a thorough insight for the top management committee; including engineers, owners, and

other stakeholders, to optimize the design, perform intelligent scheduling, predict risks, evaluate faults, and upgrade maintenance strategy.

Karmakar & Delhi (2021) presents a layered model for the "world-view" of construction 4.0 and its key ingredients, it consists of physical layer, digital tools layer, data layer, and Digital Centralized Management CDM layer. In the CDM layer, the basic management data that governs all the project lifecycle from its initiation to grave exists. Data security and ownership concerns are abstracted from the physical layer and is transformed to this layer. This layer is very important in the witnessed current rapid developments in the space of Construction 4.0.

Herein, Human competences and other managerial pillars are very important in implementing Quality 4.0. Sony et al. (2020) mention important managerial components for Q4.0 successful adoption and implementation in organizations; Big data management skills, prescriptive analytics enhancement, effective vertical, horizontal, and end-to-end integration, applying Q4.0 for strategic advantage, leadership in Q4.0, training, organization culture, and top management support.

## **1.7 Hypotheses Development**

### **1.7.1 CMS and QMS**

Many researchers discussed types of contracts and their effect on the quality in the CI according to needs. The mechanism for determining needs is carried out by clients according to what is agreed upon in the contract of specifications and characteristics. Participation of all parties to the construction project in determining those requirements is very essential to ensure the achievement of a successful project and high quality that meets all requirements in a way that satisfies clients, and the constant concern to evaluate quality performance in the CI (Leong et al., 2014).

The findings of McNamara & Sepasgozar (2021) demonstrate that the discrepancy between stakeholders' understanding and actual practice was a contributing factor in executing agencies' inability to implement adequate contract management systems. Additionally, they highlight that the poor contract management process, the absence of effective project monitoring and assessment by executing agencies, as well as the hiring

of unqualified supervisory employees by contractors, can lead to poor quality of work and loss of money accordingly.

The studies testing the comprehensive view of the influence of contract management systems on the quality management systems in the CI are little and need to be investigated deeply in this important sector.

Hence, the following hypothesis is proposed:

H1: Contracting management system (CMS) has a positive and significant impact (at a 5% significance level) on quality management system QMS in Palestine.

### **1.7.2 CMS and Q4.0 Acceptance and Implementation**

Quality 4.0 emerges new technologies with traditional quality methods to arrive at new optimums in operational excellence, performance, and innovation (Aldag, 2018). In project based-industries, technologies of quality 4.0 must be confirmed by the customer in bids audit as a first step. Over time industry and the contractual regime become more difficult and this cause higher costs (Emblemsvåg, 2020). Intelligent contracts to solve this issue, it will result in an effective quality management system. Building Information Modeling (BIM) and blockchain are main technologies that have made important contributions to a wide range of contracting in CI, McNamara & Sepasgozar (2021) discussed the factors affecting successful construction through smart contract adoption - administration process- depending on BIM during the planning and delivering stages. The application of Q4.0 technologies and their introduction in CI projects contributes to focusing on transforming the tasks and work intended to be accomplished operationally related to the design and construction phases of the quality foundations to make Q4.0 widely applied within the framework of the whole company. Applying Q4.0 techniques and tools is to achieve the company's goals and policies, by adopting quality management and its role in digitally transforming the company and achieving balance in the stored data to ensure meeting project contractual requirements and customer satisfaction (Antony & Sony, 2021).

Hence, the following hypothesis is proposed:

H2: Contracting management system (CMS) has a positive and significant impact (at a 5% significance level) on quality4.0 acceptance and implementation (Q4.0) in Palestine.

### **1.7.3 Q4.0 and QMS**

The use of varied technologies in the CI often in conjunction with BIM was explored in extant literature. Some examples include but aren't limited to the employment of Virtual and Augmented Reality, Unmanned Aerial Vehicle (UAV) Systems, Internet of Things (IoT), Blockchain, Additive manufacturing, Laser Scanning technologies, and Radio Frequency Identifications (RFID) (Forcael et al., 2020). These technologies are augmented using various technologies such as Artificial Intelligence (AI), Machine Learning (ML), Big Data Analytics, and Cloud Computing and companies can reap huge quality benefits from applying these technologies.

Carvalho et al. (2021) analyzed the relationship between different quality management practices and new technologies in Industry 4.0, which may lead to better quality management. Through a literature review, this study worked to develop a table that links the relationship between quality management practices and Industry 4.0 technologies that improve quality. As future research, the authors highlight the importance of developing experimental and quantitative studies that demonstrate the impact of Industry 4.0 on quality management practices and the company's overall performance. Klinc & Turk (2019) addressed the benefits of applying digital technologies in CI like; saving money and time, improving quality, safety, collaboration and communication, sustainability, and improve the image of the company accordingly.

Hence, the following hypothesis is proposed:

H3: Quality4.0 acceptance and implementation (Q4.0) has a positive and significant impact (at a 5% significance level) on quality management system (QMS) in Palestine.

### **1.7.4 Q4.0 Acceptance and Implementation as a Mediator**

Quality 4.0 technology is characterized by containing several techniques that contribute to raising the quality of construction projects, linking them and making them a partial mediator with quality management development, such as artificial intelligence systems and building a giant digital database using special codes that help improve project stages, for example, quality design and planning is achieved by using a wide range of data that increases the ability to understand and know customer requirements comprehensively and efficiently.

Implementation and adoption of Q4.0 may be considered a successful step for all stages of the construction project and keeping pace with technological developments in control and sensing systems and predictive engineering. as it increases the efficiency of data analysis and evaluation throughout the life of the project within the framework of comprehensive quality standards (Sony et al., 2020).

The most important application of Q4.0 is predictive quality management creating a digital simulation of the project before starting execution using BIM technology. According to Musleh (2018) the awareness level of Palestinian engineers in the CI is ranging from high for civil and architectural engineers to moderate for others. Predictive quality will improve planning, scheduling, and documentation processes which will reflect in total quality management, reduce cost, achieving the requirements and satisfaction of all the project parties (Klinc & Turk, 2019; Martin et al., 2021).

Hence, the following hypothesis is proposed:

H4: Quality4.0 acceptance and implementation (Q4.0) mediates the relationship between contracting management system (CMS) and quality management system (QMS) in Palestine (at a 5% significance level).

### **1.8 Q4.0 in the CI in Palestine**

The construction sector in Palestine witnessed remarkable growth, but over time and according to the statistics (Palestinian Central Bureau of Statistics, 2006), the contribution of the construction sector to the GDP decreased to 2.5%, in light of the second intifada in Palestine. Considering that Palestine is a developing country, the CI faces many challenges and difficulties, such as the problems of scarcity of resources and waste of cost and time in addition to reworking issues due to a lack of skilled labor (Abu Zaiter, 2014), so it is necessary to find a way contributes to solving these problems and difficulties to lift the CI sector due to its important role in raising the economy of Palestine.

Several researchers have suggested applying the concept of Quality 4.0 so that, stakeholders in the construction sector can identify the factors needed to evaluate quality management and create communication between all parties to the project through the implementation of total quality management to raise competition among construction companies and meet project requirements and customer satisfaction (Altayeb & Alhasanat, 2014).

In Palestine, project quality management is very important, especially when the project is exposed to changes, whether internal or external, to provide the best solutions that help revive the national economy and make it stable under the political conditions of the country. Neglecting the implementation of total quality management in the CI in Palestine is leading to harm to the lives of Palestinians and their environment, and thus reflects negatively on the CI sector (Othman & Rashed, 2016). Quality management improvements need to be taken a place in the Palestinian CI. However, the identification and implementation of these improvements is complex due to the peculiarities of this industry. Theoretically, there are two possible ways of improvement to reach the desired effective quality management system QMS and effective quality management (TQM) accordingly; the first one is through the effective contracting management system CMS related to improving the contracts and the second way is through the mediation effect of Q4.0 acceptance and implementation in the relationship between CMS and QMS (Emblemsvåg, 2020).

Many motives contribute to adopt Q4.0 technology; the application of the concept of quality in the CI helps in the initial understanding of construction projects through the application of digital technologies that help to follow up, monitor activities, store data, and refer to it at any time and once problems occur. This will result in improving construction quality and achieving customer satisfaction, reducing errors and improving quality checks, and achieving comprehensive management of the quality system through modern sensor systems that work on quality control, and data management (Sony et al., 2021).

### **1.9 Conceptualization of the Proposed Model**

Previous studies showed many questions related to the future of quality in the CI and the extent of its development over time and about the development that taking place in the construction sector. To answer these questions and to address the challenges faced by the construction sector, as we mentioned earlier; it is necessary to define a framework for building quality called the Quality 4.0 framework. There are many ways and methods by which the Quality 4.0 framework is defined and improved, including focusing on services rather than products, ensuring value and quality within the market, and other ways.

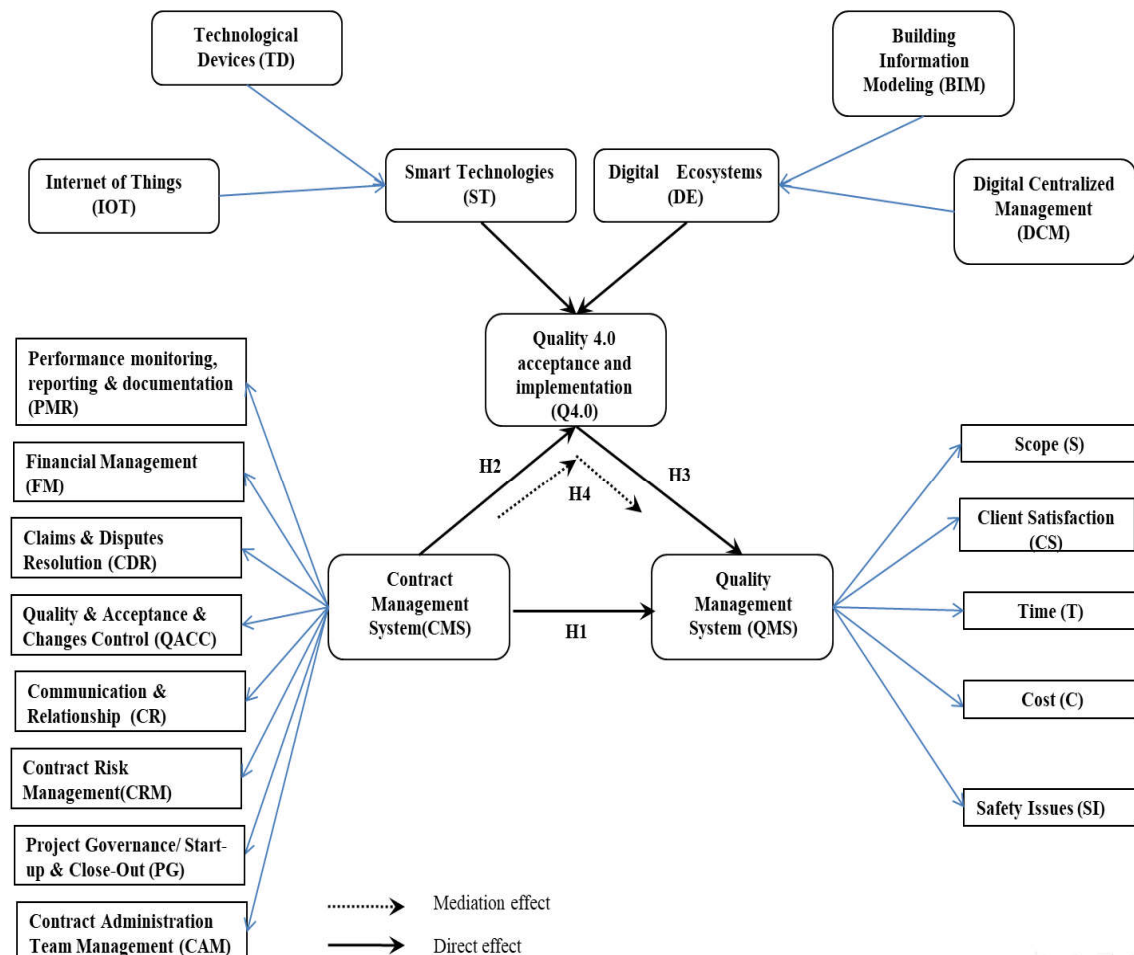
Several researchers emphasized this and suggested that it is necessary to change the concept of quality in the CI and transform it from a mere concept based on achieving customer satisfaction to a comprehensive framework that keeps pace with digital

developments and evaluates quality strategies to achieve flexibility and efficiency when delivering the project. Zonnenshain & Kenett (2020) suggested the necessity of dealing with the quality framework in the CI as a supportive force for the value of the project in the work of cost estimation and final delivery.

The proposed model in Figure 4 consists of three constructs Contracting Management System (CMS), Quality 4.0 acceptance and implementation (Q4.0), and Quality Management System (QMS). Each construct has some literature-based indicators and are mentioned in Table 1 appendix C. Figure 4 presents the proposed Conceptual framework for effective quality management system in the CI in Palestine.

**Figure 4**

*The Research Conceptual Framework*



## **Chapter Two**

### **Methodology**

#### **2.1 Chapter Overview**

The methodology in this research is discussed in this chapter. It includes research design, data collection, sample selection, questionnaire design, questionnaire distribution, knowledge of research content and reliability, and the method of data processing and analysis. There is a lack of information regarding the acceptance and implementation of quality 4.0 technology in the studies performed in the construction sector as mentioned in the literature review. Therefore, according to (Hair et al., 2011), exploratory research is the most suitable research design; this research approach is followed when little information about an issue or a problem is available and could be either qualitative or quantitative or mixed.

In this study, a mixed research approach will be used (qualitative and quantitative), to gain knowledge about the quality management systems, contracts, and factors affecting acceptance and implementation of Quality 4.0 in engineering project management.

A review of scientific papers was carried out using the main databases of the Web of Science (WoS), Scopus, and other publications using the web browser 'Google.com'. Mixed research approach is very powerful in deep understanding and interpretations of problems, it provides wide range of details (Amaratunga et al., 2002). In addition, choosing this approach helps in better refining the construct indicators chosen from literature to be more real in developing the questionnaire.

“The methodology section illustrates the procedure used to describe how to conduct the research, answer questionnaire questions, perform an experimental design, and discuss and analyze the results.” (Kallet, 2004).

#### **2.2 Research Types**

Based on Akhtar (2016) and Hair et al. (2011) researches are basically categorized into three main groups as follows:

- Exploratory research or formative research; usually used when little information is available and to formulate new relations between constructs and ideas.

- Descriptive research or statistical research; to describe specific topic, event, variable of interest and usually used in social and community issues and conducted through structured interviews, questionnaires and / or observations.
- Causal research or explanatory research explains how two occurrences are related; a causal connection states that a change in the independent construct (the cause) resulted in a change in the dependent construct (the effect) this type of researches is tested through an experimental research design under controlled conditions that are not changed along experiment execution.

In general, researchers frequently combine several research methods. For example, considering exploratory research, researchers used qualitative methods first before progressing to descriptive designs with quantitative methods. Finally, researchers have to choose the appropriate research type based on the research objectives and research questions.

### **2.3 Research Approach**

Fundamentally, research approach is divided into two main sections:

The first section: depends on the deduction method used for the inference that is followed in order to formulate theories and hypotheses, and then move on to the data. In this section of the approach, the relationship between all variables and the application of quantitative data should be clarified.

The second section: depends on the induction approach, through which the knowledge and understanding of behavior about things as well as the collection of qualitative data is performed (Herzog et al., 2019).

The research approach to be selected according to research questions. Creswell (2014) highlighted that the research approach includes plans, procedures, steps of assumptions, and collecting data process. Commonly, three research approaches to be used depending in the research questions and needed data; quantitative, qualitative, and mixed methods for numerical data, textual data, and both numerical and textual data respectively.

### **2.3.1 Quantitative Approach**

The quantitative method often focuses on gathering numerical data and using mathematical models to analyze data by academics (Williams, 2007). The quantitative method, according to Creswell (2014) is "a process for evaluating objective ideas through investigating the connection among variables". The researchers employ a deductive approach in this method, starting with the ability to verify theory using numerical data with statistical analyzing processes before being able to replicate and generalize the findings. Introduction, theory and literature review, methods, results, and discussion are the typical sections of a research report (Creswell, 2014).

Three major categories are used to classify the quantitative approach:

1. Descriptive research; two or more qualities are examined to see if they are connected through correlational research, development design, observational study, and survey research and using statistical analytic tools. Through cross-sectional or longitudinal research; the development design explores how the features of the study group may change through time. The researcher often uses open-ended or closed-ended approaches to collect data from respondents while observing these events as part of the observational study approach. Survey research is used to acquire data in the social sciences.
2. Experimental research: in this type of study, the effectiveness of the treatments is assessed. Experimental research examines the influence of treatment on outcomes.
3. Causal comparative research that examines the links between the independent and dependent variables, including 'causes and effects' research.

The quantitative stage of this study is based on confirming the resulting theoretical concepts by transforming them into seventeen variables to produce four testable hypotheses, and a confidence interval 95% was followed in order to determine and measure the proportions of the samples. Each theoretical concept was taken and turned into a question with answers obtained based on the five-point Likert scale, which are (1= Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree).

### **2.3.2 Qualitative Approach**

Qualitative research is related to discovering and understanding social or human problem and relationships, it depends on textual data. The inductive qualitative approach is usually used in this process, the data is gathered from the targeted population, general coding and themes are obtained, and then interpretation and generalization of the findings are applied (Creswell, 2014).

Several methods for conducting the qualitative research are addressed in the literature including:

- Case study research, that helps the researcher to develop a thorough investigation of a case, activity, process, or one or more persons (Creswell, 2014).
- Ethnography study is a cultural research; for studying behaviors and languages in relation to specific duration of time usually long (Creswell, 2014).
- Grounded theory study; a thorough, abstract theory of an event, procedure, or interaction is derived by the researcher and is based on the opinions of participants (Creswell, 2014).
- Phenomenological study that is defined as understanding humans' perceptions research according to a specific circumstances (Leedy & Ormrod, 2015).
- Content analysis study which is a thorough and methodical analysis of a certain piece of writing with the goal of spotting trends, generating themes, and/or discovering biases (Leedy & Ormrod, 2015).

### **2.3.3 Mixed Research Approach**

This study was based on following a variety of data collection methods, which include a mixture of quantitative and qualitative methods, where the sequential transformation strategy was followed, which contains two main steps in collecting data one after the other.

This study adopted the initially the qualitative method, then followed by the quantitative method, which was built in the first step. By following this strategy, the researcher can identify the problem from different points of view. Precisely, the sequential explanatory strategy was applied based on the collection and analysis of quantitative data in the initial stages. After that, qualitative data is collected and analyzed in the next stage, based on

the results obtained from the quantitative stage. This method is usually followed in order to analyze and interpret quantitative results, especially in the event of unexpected results from a quantitative study (Shweiki, 2013).

Based on the illustration of research types and approaches, and since there is a lack of data about the acceptance and adoption of quality 4.0 technologies and innovative techniques in the construction sector in studies conducted in Palestine; the exploratory research is the most suitable research design for this study. This type of research design gives a deep knowledge of business challenges and may be carried out as a qualitative or quantitative research technique (Hair et al., 2011). Furthermore, the conducted literature study helps in the structuring of the questionnaire used for data collecting and relationship research. In conclusion, exploratory research is the best approach of study for these kinds of investigations; hence, it was employed in this study. The deductive method with a quantitative approach is used for this study's objectives.

#### **2.4 Methodology of the Research**

Research's methodology refers to the overall approach the researcher employed to carry out the research by choosing a particular research approach, technique or mechanism for gathering data (Leedy & Ormrod, 2010). The three primary stages of performing research are formulation, execution, and analysis.

Hair et al. (2011) clarified that the problem of the study is identified during the formulation phase, which is then followed by a thorough review of the correspondent literature, the development of the questions of the research, and establishing of goals, defining the hypotheses, and forming the design of the study. The execution step includes method of choosing the sample, developing the data-gathering tool, starting the data collection process, and storing the collected data. The analytical phase entails the study and interpretation of data, the testing of hypotheses, and the development of conclusions and suggestions.

The flow chart of the study is presented in the methodology Figure 5, the methodology starts by defining the study's problem which needs investigating the role of CMS on QMS in the CI in Palestine and the effect of acceptance and implementation Q4.0 in enhancing quality issues in this relationship. After that, a through literature review related to these

three concepts has been conducted and the hypotheses have been developed accordingly. Consequently, quantitative research process is applied, starting by designing the literature-based questionnaire and validating it by the academic experts; the content of the questionnaire is validated through three experts review as shown in Table 3 Appendix C. After specifying the questionnaire, population that is the classified building construction contractors in Palestine the questionnaire is published electronically on doc's site (Google drive) on the internet and emails has been sent to the contractors according to Palestinian Contractors Union website.

## **2.5 Sampling Techniques**

The sampling procedure involves identifying the study population, selecting the sampling frame, selecting the sampling technique, determining the sample size, and carrying out the sampling plan. According to Hair et al. (2011), the sample is “a relatively small subset of the population”.

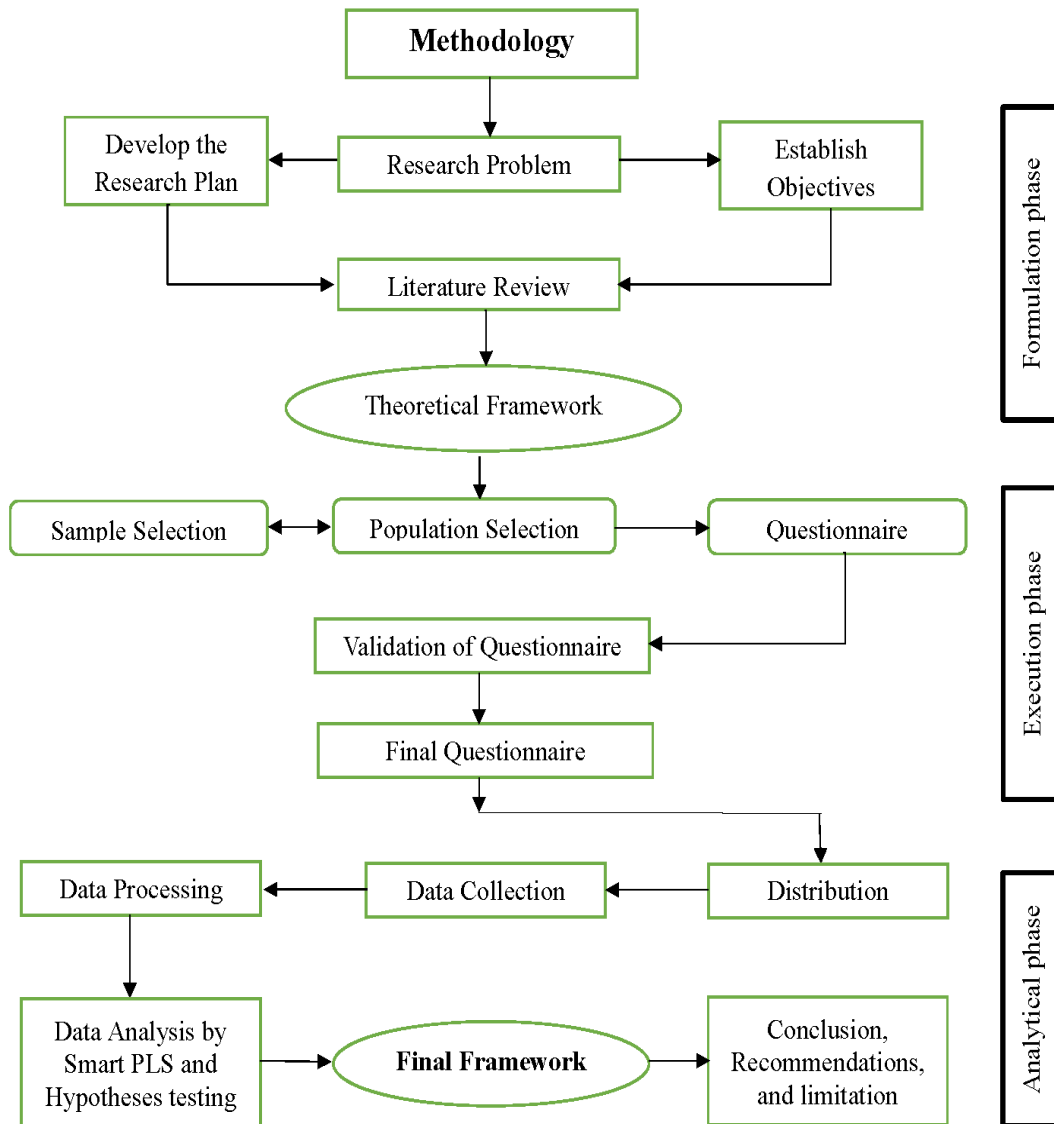
Evaluating the effect of CMS on QMS with Q4.0 acceptance and implementation as a mediator on this relationship in the CI in Palestine is the main objective of this research. Palestinian Contractors Union (PCU) is the general representative of Palestinian contractors and is a supportive member of CI projects, as it enhances the performance of construction contracting and its role in improving the efficiency of projects for the CI, encouraging investment in the construction industries and linking them directly with decision-makers. Furthermore, adherence to the conditions of practicing the contracting profession within the provisions of the contract system (Shweiki, 2013). The population of our study is the legally registered Palestinian building construction contractors. The stage of selecting the samples to be studied is one of the important stages in order to save time, effort and cost. In this study, the research sample consists of a group of managers and experts from contracting companies in Palestine.

According to PCU Website, the number of construction contractors legally registered and classified in Palestine is 336 contractors that represent the sampling frame of this study. Questionnaires were sent to all the population; 336 contractors via emails followed by phone calls; commonly, the targeted population list from which the sample is drawn is known as the sampling frame. The sample size that was gotten during approximately two months of data collection period was 95 firms (responses) of the total 336 building

classified construction-contracting members and they satisfied the population prerequisites of the study.

**Figure 5**

*Research Methodology Flow Chart*



Cohen (1992) recommended a sample size in PLS-SEM for a power of 80%, as indicated in Table 2 in Appendix C (Hair et al., 2011). The sample size in this study achieves 1% significance level with a minimum acceptable  $R^2$  of 0.25, since the maximum number of arrows pointing at a construct equal to five. As in such a study in quantitative research, the probability sampling approach is often utilized (Hair et al., 2011), and it is applied in this study,

To assure collecting a representative sample with the ability of generalization of results, a simple randomization method was used for each respondent. The three conditions of the random sample will be maintained to ensure fair representation of the respondent. These conditions are:

- Each respondent has the same chance (probability) being chosen.
- The sample size reflects the characteristics of the population, i.e. every respondent is selected from the same group.
- Each respondent will be selected independently of any other participant.

## **2.6 Development of Measurement and Questionnaire Design**

The capability of a research tool to measure what it is designed for is called validity. While consistency in outcomes when utilizing the same tool without altering the inputs is referred to as reliability (Leedy & Ormrod, 2010). The questionnaire was designed after specifying the main literature-based constructs in order to obtain accurate results, 64 items were generated. Appendix A and Appendix B include the questionnaires used in the study in English and Arabic respectively. All constructs have been operationalized as shown in appendix C Table 1.

To measure CMS; 33 items were selected according to Gunduz & Elsherbeny (2020); constructs are performance monitoring, reporting & documentation (PMR), financial management (FM), claims & disputes resolution (CDR), quality & acceptance & changes control (QACC), communication & relationship (CR), contract risk management(CRM), project governance/ start-up & close-Out (PG), and contract administration team management (CAM), with three items for each.

In order to evaluate QMS; 15 items were selected from the related literature; scope (S), client satisfaction (CS), time (T), cost (C), and safety issues (SI) with three items (Leong et al., 2014; Neyestani, 2017).

Additionally, Q4.0 acceptance and implementation is formulated through 16 items; technological devices on physical resources (TD), internet of things (IoT), building information modeling (BIM), digital centralized management (DCM), with four items each (Karmakar & Delhi, 2021; You & Feng, 2020).

The measurement scale was developed to be used to determine the value of variables and determine the level of importance. According to Hale & Wakefield (2012) and referring to Steven's measurement scales originally stated on 1946; the types of measurement scales are:

- Nominal Scale: The Nominal Scale is used to measure categorical data and numbers that appear as names and identifiers.
- Ordinal scale: This type shows an ordered and clear sequence of relationships.
- Interval scale: through which quantities are measured and contains equivalent units, and as it is an interval scale, the zero in it is just an additional point of measurement.
- Ratio scale: This scale is identical to the Interval scale, in that it represents quantity and equality of units, however this scale also has an absolute zero (ie there are no numbers below zero).

Five-point Likert scale is used in gathering data; where the respondent asked to score to what extent that they agree to the statements. The range of agreement are (1: Strongly disagree), (2: Disagree), (3: Neutral), (4: Agree), (5: Strongly Agree).

This study was based on the use of the interval scale, through the using of integers for this scale, in addition to the use of five-point Likert scale in order to measure the values and the degree of significance.

$$\text{Statistical agreement levels} = \frac{\text{Max.value} - \text{Min.value}}{\text{Max.value}} \quad \text{Equation (1)}$$

Statistical agreement levels =  $\frac{5-1}{5} = 0.8$ , the that has been used is as follow:

- |         |                               |                                      |
|---------|-------------------------------|--------------------------------------|
| Level 1 | for interval of mean 1-1.8    | is described as very low agreement,  |
| Level 2 | for interval of mean 1.81-2.6 | is described as low agreement,       |
| Level 3 | for interval of mean 2.61-3.4 | is described as neutral,             |
| Level 4 | for interval of mean 3.41-4.2 | is described as high agreement, and  |
| Level 5 | for interval of mean 4.21-5   | is described as very high agreement. |

## 2.7 Techniques of Data Analysis

The data collected from contracting companies is arranged in a suitable Excel sheet. Then the collected data was analyzed by:

- Statistical Package for the Social Sciences (SPSS) 22 software; it is to analyze the descriptive data gathered from the respondents, check the mean and standard deviation for each construct.

- Partial least squares structural equation modeling (PLS-SEM) was used to investigate the relationships of the study conceptual framework and test the proposed relationships accordingly. Smart PLS is one of the prominent software applications for Partial Least Squares Structural Equation Modeling (PLS-SEM) (Joseph F. Hair et al., 2013). The data was entered with the employment of first, second, and third order of constructs and the model was drawn through a repeated indicator strategy for each construct.

Through PLS algorithm calculations of the validity and reliability for all the indicators and the model were done and the results will be discussed and judged in chapter three using related tests threshold values. Additionally, bootstrapping analysis was performed to test the significance of all internal relationships and to assess the hypotheses if is supported or not.

Generally, two methodological elements for assessment models exist in Smart PLS, the assessment of the measurement model and the assessment of structural model. In the measurement model validity including convergent and discriminate validity, reliability, composite reliability, average variance extracted (AVE), Cronbach's alpha, and item loadings are evaluated.

On the other hand, the assessment of structural model includes evaluating  $R^2$  (the coefficient of determination),  $F^2$  (effect Size), GoF (goodness of fit Index), and path coefficients for testing the hypotheses. Additionally, the mediation effect of Q4.0 was assessed in the study.

## **Chapter Three**

### **Data Analysis and Results**

#### **3.1 Chapter Overview**

This chapter is an illustration of the results of the data analysis that was gathered through the published survey among building contracting companies in Palestine, descriptive and qualitative results were analyzed using SPSS software while quantitative data gathered through the questionnaire responses was analyzed using smart PLS software to check validity, reliability, and test the hypotheses of the study.

#### **3.2 Survey Response Analysis**

##### **3.2.1 Rates of the Responses**

Online questionnaire has been published and 95 responses were received, frequency analysis of the respondent's using SPSS is summarized in Table 2 below.

##### **3.2.2 Descriptive Analysis**

This analysis is to reveal the characteristics and distribution of the respondents and to show the properties of the contracting companies filled the questionnaire. The results show that, more than half of the responded sample is males respondents with percent of 64.2% while female respondents percentage is 35.8%, The results also show that 24.2% of respondents holding diploma certificate or less, almost half of sampled companies 52.6% holding bachelor degree, and the rest 23.2% respondents having higher education degree. In term of company experience, the results reveal that 17.9% of the companies involved in the questionnaire are with experience of less than five years whereas 30.5% are with experience between 5-15 years and the rest 51.6% are with company experience more than fifteen years.

**Table 2***Respondents profile summary*

No.	items	Option	Frequency	Percentage
1.	Gender	Male	61	64.2%
		Female	34	35.8%
		Total	95	100.0%
2.	Educational level	Diploma or less	23	24.2%
		Bachelor degree	50	52.6%
		Higher education	22	23.2%
		Total	95	100.0%
3.	Company experience	less than 5 Years	17	17.9%
		5-15 Years	29	30.5%
		More than 15 years	49	51.6%
		Total	95	100.0%
4.	Position	General manager/CEO	31	32.7%
		Construction engineer	38	40.0%
		Office engineer	12	12.6%
		Quality manager	4	4.2%
		Others	10	10.5%
		Total	95	100.0%
5.	Company classification	Contracting 1st	40	42.1%
		Contracting 2nd	30	31.6%
		Contracting 3rd	7	7.4%
		Contracting 4th	11	11.5%
		Contracting 5th	7	7.4%
		Total	95	100.0%
6.	Location	Jenin	18	18.9%
		Tullkarm	8	8.4%
		Nablus	29	30.5%
		Ramallah	18	18.9%
		Hebron	13	13.7%
		Bethlehem	4	4.2%
		Qalqilia	4	4.2%
		Jericho	1	1.1%
		Total	95	100.0%
7.	Employees number	1-9	8	8.4%
		10-19	14	14.7%
		20-50	28	29.5%
		More than 50	45	47.4%
		Total	95	100.0%
8.	Use quality management system	Currently uses	68	71.58%
		Plan to use within 12 months	12	12.63%
		Plan to use within more than 12 months	8	8.42%
		Currently, there are no plans to use	5	5.26%
		Not sure	2	2.11%
		Total	95	100.0%
9.	Having ISO9001/2008	Currently obtain	52	54.74%
		Plan to obtain within 12 months	22	23.16%
		Plan to obtain within more than 12 months	10	10.52%
		Currently, there are no plans to obtain	7	7.37%
		Not sure	4	4.21%
		Total	95	100.0%
10.	Number of contract employees	1 to 5	52	54.8%
		6 to 10	21	22.1%
		More than 10	22	23.2%
		Total	95	100.0%
11.	Technologies are included in the 'company's strategic planning	Yes	59	62.1%
		No	11	11.6%
		Not sure	25	26.3%
		Total	95	100.0%

The positions of the respondents are general manager, construction engineer, office engineer, quality engineer, and other positions such as administrative manager and financial manager with percentages of distribution 32.7%, 40%, 12.6%, 4.2%, 10.5% respectively. Referring to the contracting classification companies 42.1% of responded companies were classified first grade building company, 31.6% were second grade, whereas 7.4%, 11.5%, and 7.4% were third, fourth, and fifth grades respectively.

Geographical coverage of this study is limited in Palestine, the respondents' locations analysis reveals that 30.50% are from Nablus, while Jenin and Ramallah represent 37.8% of respondents' locations with 18.9% for each, and 8.4%, 13.7%, 1.1% for Tulkarem, Hebron, and Jericho respectively, while 4.2% of respondents' locations are from Bethlehem and the same percentage is for Qalqilya.

Out of 95 respondents, 45 firms have more than 50 employees with percent of 47.4%. On the other hand, 8.4% of firm's employee number was less than nine employees, 14.7% are with employee's number between 10-19, and 29.5% of the companies have employees from 20 to 50. Most respondents answered that their company use quality management system; 71.58% are currently use QMS, and 12.63% are planning to use within 12 months, while 8.42% are planning to use within more than 12 months, 5.26% have no plans to use QMS, and the rest are not sure of using QMS in their work environment.

54.74% of the respondents answered that they are currently have formal ISO-certificate such as ISO 9001/2008. Additionally, 23.16% are planning to obtain the ISO-certificate within 12 months, whereas 10.52% plan to get within more than 12 months, 7.37% and 4.21% have no plans to get and not sure of having ISO certificate respectively. Companies have less than five contract employees are with percent 54.8%, 22.1% and 23.2% have from 6-10 employees and more than 10 employees respectively. Additionally, 62.1% say that technologies are included in the company strategic planning on the other hand 11.6% answered that they are not included, while 26.3% are not sure of including these technologies in the strategic planning process.

In this study; five points Likert scale of equal intervals was utilized. Table 4 in Appendix C presents all descriptive analysis outcomes for the constructs and indicators used in this research. The arithmetic mean average and standard deviation of each factor's related questions in the questionnaire were calculated using the conceptual framework shown in

Figure 4 for each factor. To describe the distribution of the gathered data, descriptive analysis was performed. Table 3 below illustrates the mean and the standard deviation of each construct. All respondents showed positive attitude toward CMS indicators, Q4.0 indicators, and quality management system indicators as their mean is less than 2.5.

### **3.3 Questionnaires Analysis**

Partial Least Squares (PLS) approach was employed to analyze the quantitative data obtained from the questionnaire's responses by using Smart-PLS (v.4.0.8.5) software that is used to handle un-normalized data and small samples. Smart PLS is a friendly-use application utilizing Partial Least Squares (PLS) modeling method in the structural equation modeling (SEM) with graphical user interface. Smart-PLS analysis includes two major steps; The first one is the outer model assessment in order to find and assess the correlation between each latent variable and its related measures. The second element is the inner model that assesses the internal path relationship between latent variables. Herein, it had to be distinguished between two major categorical constructs; exogenous and endogenous ones; that are working as independent variables in the structural model and variables acting as dependent variables in an inner model respectively (Hair et al., 2011).

**Table 3***Means and standard deviations for indicators*

Item	Mean	Standard	Degree of
Performance monitoring, reporting & Financial Management (FM)	4.076	0.7822	High
Quality & Acceptance & Changes Control	3.898	0.8157	High
Project Governance/ Start-up & Close-Out	4.0025	0.8205	High
Contract Administration Team Management	3.979	0.7888	High
Technological Devices (TD)	3.9227	0.7757	High
Internet of Things (IoT)	3.8635	0.8715	High
Building Information Modeling (BIM)	3.5315	0.8560	High
Digital Centralized Management (DCM)	3.8527	0.8667	High
Scope (S)	3.6945	0.7950	High
Client Satisfaction (CS)	3.8	0.8157	High
Time (T)	3.6877	0.9077	High
Cost (C)	3.723	0.8263	High
Safety Issues (SI)	3.5437	0.8913	High
Contract Management System (CMS)	3.6737	0.8590	High
Quality 4.0 acceptance and implementation (Q4.0)	3.97564	0.79658	High
Quality Management System (QMS)	3.73555	0.8473	High
	3.68562	0.860	High

Furthermore, it should be distinguished between reflective and formative measurement models. Model A in the outer model using PLS-SEM or the reflective measurement model where the connected arrows are directed from the major construct towards its indicators means that the indicators of a construct represent the effects of applying the underlying construct. On the other hand, model B in the measurement using PLS-SEM or the formative measurement model where headed arrows are oriented towards the construct assumes that these indicators cause the construct; as a result, removing one indicator alters the construct's meaning since each indicator represents a different component of the main

construct. Both formative and reflective measurement models can be handled by the PLS-SEM application (Hair et al., 2011).

In this study, reflective indicators are used for CMS construct and its indicators; PMR, FM, QACC, PG, and CAM and for QMS construct and its indicators; S, C, T, CS, and SI. Additionally, reflective indicators are used for TD, IoT, BIM, and DCM; the second sub indicators for quality 4.0 and are used also for Q4.0 first indicators DE and ST to explore the components of Q4.0 acceptance and implementation construct.

The theoretical study model consists of 64 reflective items for 17 latent variables. However, 21 items were not valid for this study (reliability result from PLS-algorithm is less than the acceptable threshold 0.7 and were omitted from the model; three first order constructs were removed from the study accordingly. The omitted constructs are claims & disputes resolution (CDR), communication & relationship (CR), and contract risk management (CRM).

Consequently, the final study model consists of 43 reflective items for 14 latent variables as shown in Figure 1 in Appendix C. In this model, first, second, and third order constructs are used. Investigation of the relations between CMS as independent construct and QMS as dependent one, with Quality 4.0 acceptance and implementation as mediating variable is the main purpose of building the model. A mediation impact is used when a third construct is predicted to intermediate the relation between another two connected variables. Direct effect is the effect between the two major constructs (one arrow) while mediating effect (indirect) is a compound path consists of two or more direct effects (Hair et al., 2011). In this study, four hypotheses were investigated using Q4.0 acceptance and implementation as a partially mediating construct.

### **3.4 Measurement Model Assessment**

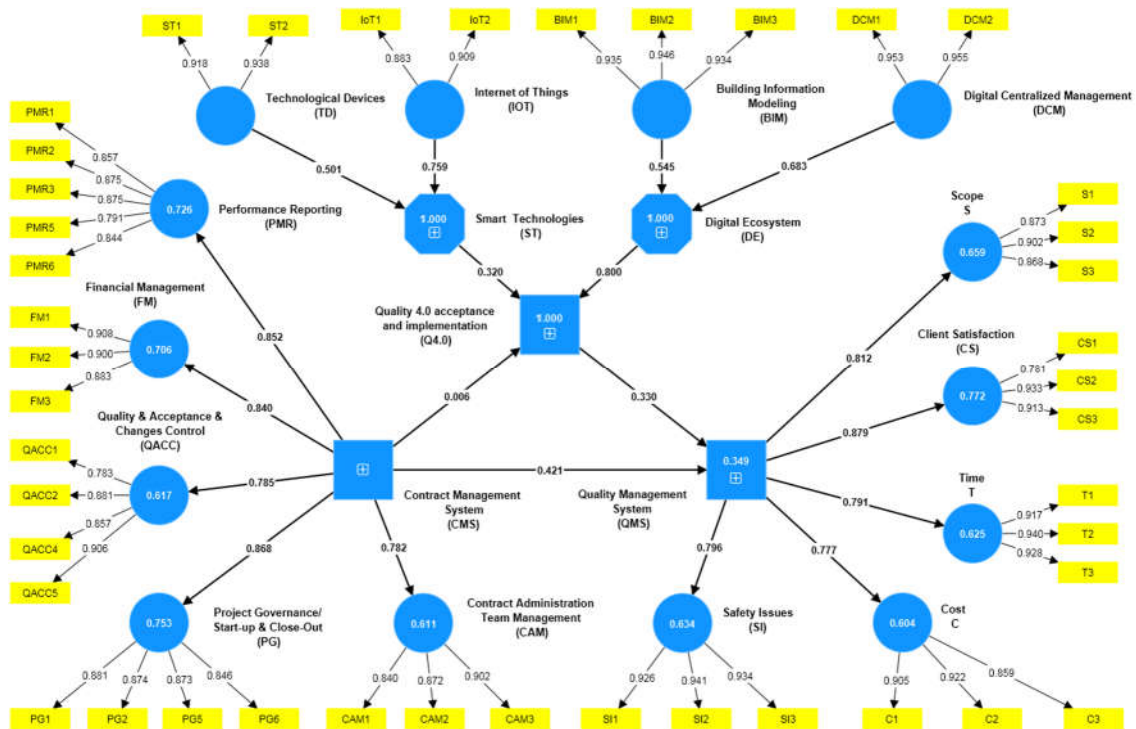
The construct's validity and reliability are evaluated as part of the measurement model. Validity assessment includes mainly two parts; convergent validity that is determined by assessing the variables' reliability, composite reliability, and extracted average variance (AVE), and the discriminant validity which is assessed through the Fornell-Larcker criteria, cross loadings, and the Heterotrait-Monotrait ratio (HTMT).

### 3.4.1 Convergent Validity

The degree to which a measure relates positively with the other measures of the same construct is known as the convergent validity. Identifying three tests is part of assessing convergent validity in reflective measurement models. Firstly, factor loadings that should be 0.708 or more (Hair et al., 2011); greater outer loading indicates that the items share many characteristics with a construct. As shown in Figure 6 below, all the outer loading are more than 0.708, so they comply with the first criteria of determining convergent validity.

**Figure 6**

*Research Measurement Model*



Secondly, Composite reliability results are checked to ensure the internal consistency and reliability; the values of reliability are within zero and one, the higher values of CR indicate greater reliability limits. The value of CR should be higher than 0.70 as stated by (Hair et al., 2011). As shown in Table 4 below all composite reliability values are more than 0.7's threshold; therefore, all constructs are reliable.

Thirdly, Average variance extracted (AVE) that is calculated through finding the mean value of the squared outer loading of the indicators for specific construct. The AVE limits

is to be greater than 0.50 that is, the variable accounts for higher than 50% of the variance of its measures (Hair et al., 2011).

**Table 4**

*Cronbach's Alpha , Composite Reliabilities And AVE values Of Constructs*

Variable	Indicators numbers	Cronbach's Alpha	Composite Reliability	AVE
BIM	3	0.932	0.933	0.88
C	3	0.876	0.887	0.80
CAM	3	0.841	0.845	2
CS	3	0.849	0.86	0.76
DCM	2	0.901	0.902	0.77
FM	3	0.879	0.882	2
IoT	2	0.755	0.763	0.91
PMR	5	0.903	0.906	0.80
PG	4	0.891	0.892	5
QACC	4	0.88	0.88	0.80
SI	3	0.927	0.928	3
S	3	0.856	0.857	0.72
TD	2	0.84	0.851	1
T	3	0.92	0.92	0.75

The values of AVE are shown in Table 4 for this study, values indicate good convergent validity. Additionally, A value higher than 0.7 is recommended for the traditional criterion in evaluating the internal consistency; Cronbach's alpha, the results are reported in Table 4 and indicates also a high internal consistency. Table 5 in Appendix C shows the constructs' reflective measurement properties.

### **3.4.2 Discriminant validity**

This test is employed to assess the uniqueness of a construct relative to other constructs (Hair et al., 2011). For assessing the discriminant validity; many tests are utilized including the cross loadings of the construct's indicators that had to be higher than all of

its loadings on other variables in the model. All cross loadings of model indicators are illustrated in Table 6 in Appendix C, and it is obvious that the cross loadings discriminant validity technique is supported.

Fornell-Larcker criterion is the second test used in investigating the discriminant validity of variables; this approach depends on comparing the AVE square root with the correlations of latent variable. Herein, AVE had to be greater than the highest correlation with other variables.

Table 5 shows the results of this test and reveals that Fornell-Larcker criteria to measure discriminant validity is confirmed.

**Table 5**

*Fornell-Larcker Criterion*

	BIM	C	CAM	CS	FM	DCM	IoT	PMR	PG	QACC	SI	S	TD	T
BIM	<b>0.938</b>	-	-	-	-	-	-	-	-	-	-	-	-	-
C	0.133	<b>0.896</b>	-	-	-	-	-	-	-	-	-	-	-	-
CAM	0.084	0.222	<b>0.872</b>	-	-	-	-	-	-	-	-	-	-	-
CS	0.316	0.657	0.309	<b>0.878</b>	-	-	-	-	-	-	-	-	-	-
FM	0.305	0.251	0.108	0.273	<b>0.954</b>	-	-	-	-	-	-	-	-	-
DCM	0.162	0.168	0.532	0.386	0.095	<b>0.897</b>	-	-	-	-	-	-	-	-
IoT	0.303	0.121	0.149	0.175	0.366	0.176	<b>0.896</b>	-	-	-	-	-	-	-
PMR	0.052	0.285	0.601	0.439	0.125	0.652	0.103	<b>0.849</b>	-	-	-	-	-	-
PG	0.022	0.263	0.59	0.476	0.126	0.65	0.114	0.712	<b>0.869</b>	-	-	-	-	-
QACC	0.042	0.126	0.533	0.328	0.091	0.643	0.212	0.537	0.61	<b>0.858</b>	-	-	-	-
SI	0.335	0.563	0.217	0.599	0.215	0.242	0.08	0.347	0.32	0.167	<b>0.934</b>	-	-	-
S	0.36	0.505	0.309	0.659	0.25	0.231	0.277	0.235	0.261	0.258	0.553	<b>0.881</b>	-	-
TD	0.12	0.175	0.398	0.17	0.315	0.244	0.219	0.103	0.132	0.193	0.092	0.255	<b>0.928</b>	-
T	0.109	0.522	0.337	0.591	0.141	0.34	0.241	0.353	0.374	0.171	0.562	0.573	0.179	<b>0.928</b>

Heterotrait-Monotrait ratio of correlations (HTMT) other criteria to assess the discriminant validity. HTMT ratio upper acceptable limit is 1 (Henseler et al., 2015). All HTMT values are listed in Table 6 are matching this limit (lower than 1) that means that the discriminant validity is supported, and this indicates a good reliability.

### 3.4.3 Formative Construct Discriminant Validity

Bootstrapping in PLS application is utilized to determine the importance of the constructs. Herein, it is necessary to confirm the formative model discriminant validity (i.e., Quality

4.0 acceptance and implementation construct). The critical t-values corresponds to significance level (SL) are 2.58 for a SL of 1%, 1.96 for SL of 5%, and 1.65 for a level of 10%. The t-values for each first and second order constructs are shown in Table 7.

**Table 6**

*Heterotrait-Monotrait Ratio (HTMT)*

	BIM	C	CAM	CS	DCM	FM	IoT	PMR	PG	QACC	SI	S	TD	T
BIM	-													
C	0.142	-												
CAM	0.093	0.252	-											
CS	0.35	0.762	0.365	-										
DCM	0.333	0.278	0.122	0.309	-									
FM	0.175	0.196	0.616	0.445	0.116	-								
IoT	0.357	0.178	0.182	0.216	0.443	0.214	-							
PMR	0.065	0.311	0.685	0.496	0.138	0.728	0.125	-						
PG	0.078	0.291	0.679	0.552	0.139	0.733	0.139	0.787	-					
QACC	0.074	0.141	0.615	0.379	0.103	0.726	0.257	0.595	0.682	-				
SI	0.36	0.626	0.242	0.674	0.234	0.265	0.095	0.375	0.35	0.191	-			
S	0.403	0.578	0.356	0.77	0.283	0.271	0.344	0.268	0.293	0.294	0.621	-		
TD	0.157	0.199	0.472	0.195	0.359	0.279	0.269	0.12	0.151	0.219	0.118	0.3	-	
T	0.126	0.577	0.381	0.667	0.155	0.373	0.289	0.384	0.412	0.185	0.608	0.644	0.203	-

Additionally, according to Hair et al. (2011) the Variance Inflation Factor (VIF) value is to check the collinearity of indicators and should be lower than 5 and that is demonstrated in this study and shown in Table 7 for formative indicators.

**Table 7**

*Weight, T- Values And Variance Inflation Factor (VIF) Values*

Third order construct	Second order construct	First order construct	Outer Weight	T-Value Second order	T-Value First order	VIF
Quality 4.0	ST	TD	0.300	1.371	1.87	2.209
		IoT	0.371		3.654	1.647
	DE	BIM	0.237	3.927	2.749	4.01
		DCM	0.388		3.108	3.22

### **3.5 Structural Model Assessment**

Structural model assessment is the next step followed validity and reliability assessment and used to examine relationships between constructs through PLS bootstrapping analysis as shown in Figure 7 through evaluating the coefficient of determination ( $R^2$ ), the effect size ( $F^2$ ), Goodness of fit index (GoF), and the significance of the path coefficients - hypotheses test.

#### **3.5.1 The Coefficient of Determination**

The most common measure employed to evaluate the structural model is the coefficient of determination ( $R^2$ ) that represents the model's predictive accuracy. Higher value of

( $R^2$ ) indicates higher level of predictive accuracy;  $R^2$  is ranging from zero to one.  $R^2$  value for endogenous latent variables depends on the model complexity when the values of  $R^2$  0.75, 0.50, or 0.25 the model predictive accuracy can be described as high, moderate, or weak respectively according to (Hair et al., 2011). The results reveal that  $R^2$  for dependent variable QMS equals 0.349, which is relatively good for new exploratory studies.

#### **3.5.2 The Effect Size ( $F^2$ )**

This test reflects the impact of removing specific exogenous variables on the dependent variables, and could be computed through subtracting  $R^2$  included from excluded and divide the outcome on  $1 - R^2$  included.

According to Cohen (1988) when the values of  $F^2$  equal to 0.02, 0.15, and 0.35, they indicate low, medium, and high effects of the independent constructs respectively.

Table 8 shows the effect size ( $F^2$ ) of CMS and Q4.0 on QMS construct.

#### **3.5.3 Goodness of Fit Index GoF**

The geometric mean of the average extracted variances (AVE) and the average  $R^2$  of the endogenous variables are used to compute GoF, which assesses the validity of the research model and measures the extend of relying on the study model. GoF equals square root of average  $R^2$  multiplied by average of AVE, GoF for this study =  $\sqrt{0.607 \times 0.817} = 0.704$

**Table 8***Coefficient of Determination and Effect Values*

Variable	R Square	R Square Adjusted	Result	F <sup>2</sup>	
				CMS	Q4.0
Quality Management System	0.349	0.335	Low to moderate	0.258 Medium effect	0.158 Medium effect
S	0.659	0.655	Moderate	-	-
CS	0.772	0.77	High	-	-
T	0.625	0.621	Moderate	-	-
C	0.604	0.6	Moderate	-	-
SI	0.634	0.63	Moderate	-	-

Wetzels et al. (2009) stated that there is no fit if the value of GoF is less than 0.1, there is a small fit if the GoF between 0.1 and 0.25, the fit is medium when GoF values between 0.25 and 0.36, and there is a large fit if GoF values larger than 0.36.

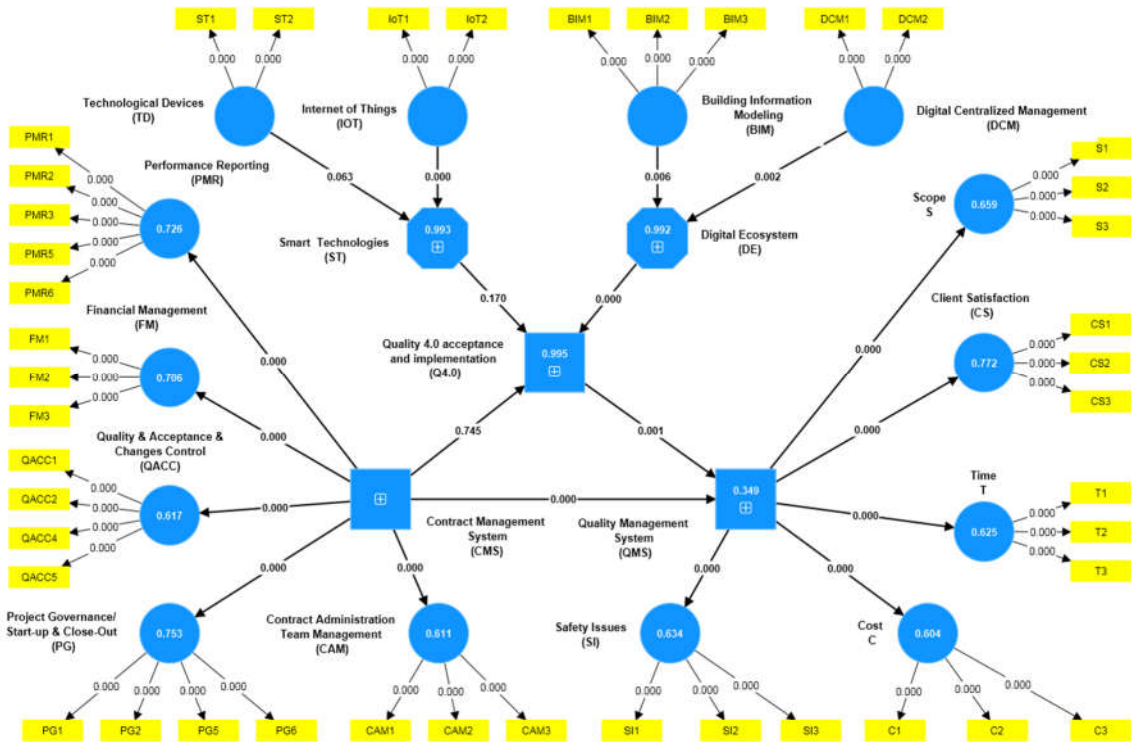
In this study, PLS model is with sufficient validity since the computed value of GOF is 0.704; greater than 0.36 as recommended by (Wetzels et al., 2009).

### 3.5.4 Path Coefficients Significance - Hypotheses Test

The structural model (testing relationships) was examined through firstly, running the PLS-SEM algorithm calculations. Herein, the path coefficient results were tested, these coefficients have values ranging from -1 to +1; strong positive relationships are associated with values close to +1 and strong negative relationships are accompanied with values close to -1. Secondly, running PLS-SEM bootstrapping for testing the significance of the relationships, PLS-SEM does not assume that the data are distributed normally. Therefore, this analytical method relies on the nonparametric bootstrap approach, which refers to using several subsamples in bootstrap samples. As advised by (Hair et al., 2011), 5000 subsamples to be employed in calculation of the bootstrapping algorithms. Results of the PLS bootstrapping running are shown in Figure 7. In addition, the results for T-values, P-values, and standard deviation values for direct relationships are illustrated in Table 9.

**Figure 7**

*PLS Bootstrapping Procedures*



As presented in Table 9 it is obvious that the relationship between CMS and QMS is positive and significant. Furthermore, results reveal a positive and significant relationship between Q4.0 Acceptance & Implementation and QMS and between DE and Q4.0. On the other hand, results show positive but not significant relationships between CMS and Q4.0 Acceptance & Implementation.

**Table 9**

*The Results Of Direct Relations*

Path	HYP.	Sample (β)	Standard Deviation (STDEV)	T-value	P-value	Result
CMS->QMS	H <sub>1</sub>	0.421	0.104	4.058	0.000	Supported
CMS->Q4.0 Acceptance & Implementation	H <sub>2</sub>	0.006	0.019	0.324	0.746	Not supported
Q4.0 Acceptance & Implementation -> QMS	H <sub>3</sub>	0.33	0.103	3.199	0.001	Supported

For all tables;  $\beta$  values refer to the correlation values results from PLS algorithm shown in Figure 6. From bootstrapping analysis,  $H_1$  results are ( $\beta = 0.421$ ,  $t = 4.058$ ,  $P\text{-value} = 0.000$ ) and  $H_3$  analysis results is ( $\beta = 0.33$ ,  $t = 3.199$ ,  $P\text{-value} = 0.001$ ) so it can concluded that these hypotheses are supported. On the other hand, the analysis results for  $H_2$  is ( $\beta = 0.006$ ,  $t = 0.324$ ,  $P\text{-value} = 0.746$ ), hence this hypothesis is not supported.

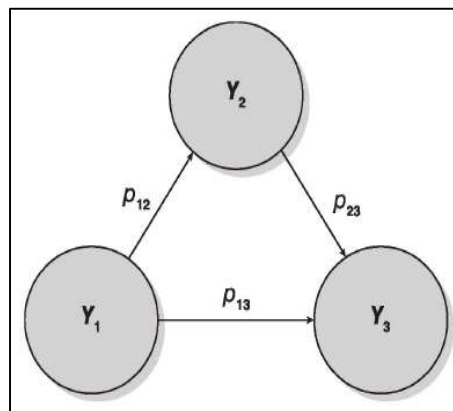
### 3.6 Mediating Effect Analysis

Hair et al. (2011) mentioned the model of general mediator as shown in Figure 8 and the process of mediator analysis PLS-SEM in Figure 9; for the analysis of mediation effects in the models.

Results from PLS algorithm calculations show that the direct effect between CMS and QMS is significant with values ( $\beta = 0.421$ ,  $t = 4.058$ ,  $P\text{-value} = 0.000$ ), so we will transfer to step two in the mediation analysis procedure, as shown in Figure 9, and including Q4.0 Acceptance and Implementation as a mediator to assess the significance of the indirect effect  $P_{12}$  and  $P_{23}$  as shown in Figure 8.

**Figure 8**

*The General Mediator Model*



Source: Hair et al. (2011), p.220.

Results show that this indirect effect is not significant with values ( $\beta = 0.002$ ,  $t = 0.273$ ,  $P\text{-value} = 0.785$ ), so there is no mediation effect of Q4.0 Acceptance and Implementation in the relation between CMS and QMS, Table 10 illustrates the indirect relation result. Hence, hypothesis  $H_4$  is not supported and there is no need to move to step three in the mediation analysis process.

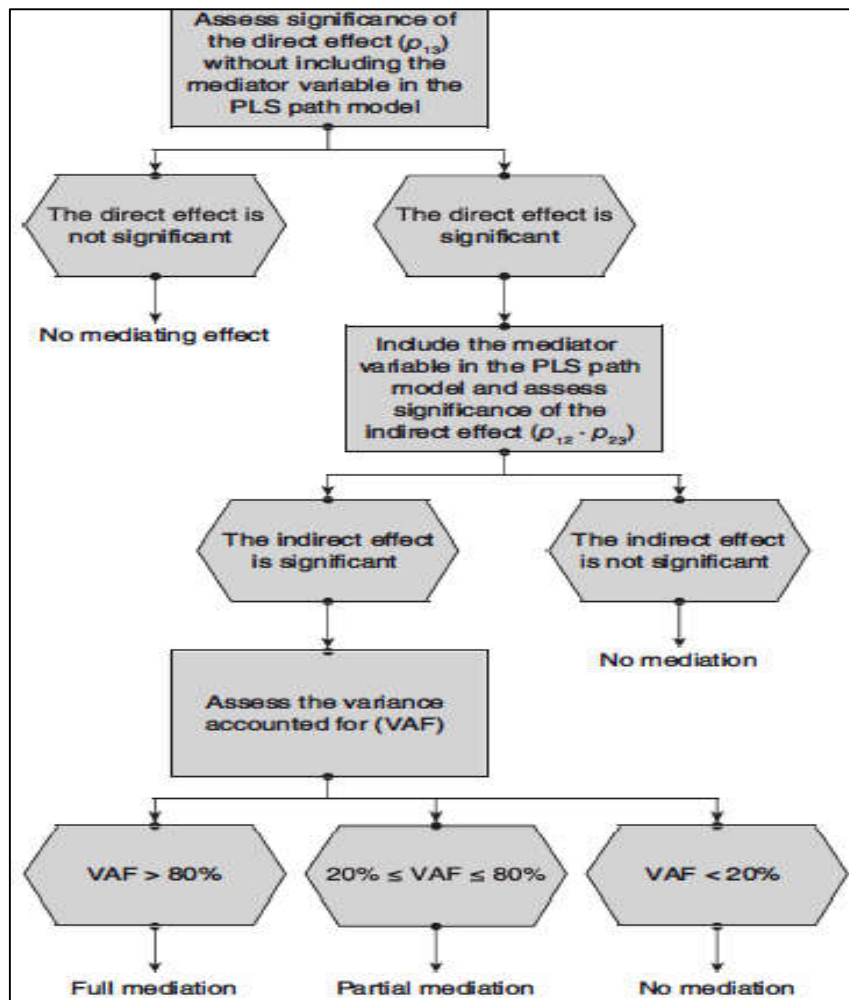
**Table 10**

*Indirect Relation (Mediation) Result*

Indirect Effects						
Path	Path No	Sample ( $\beta$ )	Standard Deviation (STDEV)	T-value	P-value	Result
CMS -> QMS						
Specific indirect effect	CMS -> P <sub>13</sub>	0.002	0.008	0.273	0.785	Not supported
Q4.0->QMS						

**Figure 9**

*The Mediator Analysis Process*



Source: Hair et al. (2011), p. 224.

## **Chapter Four**

### **Discussion, Conclusion and Recommendations**

#### **4.1 Chapter Overview**

Chapter four includes the discussion of the analysis results associated with CMS, Q4.0 acceptance and implementation, and QMS status in Palestinian contracting companies. Moreover, the chapter presents a discussion for the proposed hypotheses testing outcomes in addition to implications for the study theoretically and practically. Furthermore, this chapter illustrates and presents conclusions of the study, and some recommendations are highlighted for managers involved in the contracting companies. At the end of the chapter, the limitations of the study and recommendations for related future research orientation are presented.

#### **4.2 Results Discussion**

The respondent profile summary shown in Table 2 gives an illustration for the characteristics of responded sample; it reveals that most of the responders are males holding bachelor degree with experience more than 15 years, their positions are managers and construction engineers, and their companies have more than 50 employees with first-degree contracting classification. This means that the males tend to manage and work in the contracting companies in Palestine more than females due to the complexity and uniqueness of the contracting projects. Furthermore, their long experience and education, as responded, make them realize the importance of strategic planning and increase their tendency to adopt new technologies in their work, obtain ISO9001/2008, and use quality management systems in their work. On the other hand, more than half of the respondents have less than five contract employees that mean they are not investing too much on contractual issues so they need to pay more attention to contracts and hire more contract employees to strengthen contract regime and give more value for contractual work environment. Furthermore, the profile summary shows that despite the randomness of the sample collected through e-mails followed by phone call, most of the respondents are from the north of the West Bank.

The purpose of this study is to investigate the effect of CMS on QMS and explore the mediation effect of Q4.0 acceptance and implementation on the relation between CMS and QMS in Palestinian contracting companies.

After collecting and analyzing gathered data, invalid constructs have been omitted from the model and the final model is as shown in Figure 1 in appendix C, the omitted constructs are; claims & disputes resolution (CDR), communication & relationship (CR), and contract risk management (CRM). Additionally, the unreliable items have been omitted from the model; these items are for the implementation of Q4.0. Consequently, the proposed model still includes fourteen first-order constructs. For CMS, the variables are performance monitoring, reporting & documentation (PMR), financial management (FM), quality & acceptance & changes control (QACC), project governance/ start-up & closeout (PG), and contract administration team management (CAM).

Furthermore, Q4.0 includes the acceptance of technological devices on physical resources (TD), internet of things (IoT), building information modeling (BIM), digital centralized management (DCM)). In addition, QMS includes scope (S), client satisfaction (CS), time (T), cost (C), and safety issues (SI), In general, 43 items related to 14 first-order constructs still valid and reliable.

#### **4.2.1 Discussion of CMS in Palestine**

The analysis of gathered data for CMS reveals that claims and disputes resolution (CDR), communication and relationship (CR), and contract risk management (CRM) are invalid, and omitted from the final framework accordingly. 19 items of 33 in CMS are reliable.

The results indicate that the contractors, in general, highly agree on implementation of CMS with average value of 3.97564 in the scale of five (five equals absolute agreement). Precisely, all CMS indicators' agreement level in the surveyed contracting construction sector are ranging from 4.076 for performance monitoring, reporting & documentation (PMR) which is considered the most influential construct to the lowest agreement level 3.898 for financial management (FM). Furthermore, respondents are highly agreed on implementation of contract administration team management (CAM), quality and acceptance and changes (QACC), and project governance/ start-up and closeout (PG) with 3.9227, 4.0025, and 3.979 agreement levels respectively.

All of CMS agreement level is considered high. However, financial management requires more attention in establishing financial systems at earlier stages, notification about due payments, and assessing payments compensations in a timely basis. Dmaidi et al. (2016) mentioned main ten problems facing the CI in Palestine. These problems including financial ones need to be considered deeply to overcome challenges facing the CI in Palestine. Additionally, the management of claims & disputes resolution (CDR) construct, communication & relationship (CR), and contract risk management (CRM) at first step followed by financial issues need to be strengthened to reap a supportive contractual environment full of trust, collaboration, and transparency to get a successful project.

According to Bayliss et al. (2004) a partnership agreement promotes a "win-win" strategy that is one of the important pillars in CI development. However, as stated by the researcher, it is incompatible with the adversarial mentality that has historically characterized the construction business, the top management level's partnership dedication must be unwavering to overcome this issue and create collaborative environment, partnership implementation must start at the top and be given authority to senior management at the contract level. Senior management at that level is crucial in fostering a partnership attitude.

Partnership workshop, monthly review sessions, collection of control data will strengthen the partnership and communication relations, and promotes effective claims and disputes resolution. Consequently, risks will be managed effectively. Both contact parties must be committed to partnership and use a variety of strategies to inculcate, promote, and uphold the partnering spirit in order to support effective partnership. The incentive agreement and monthly review meetings are considered the best tools for putting the partnership strategy into practice and generate an effective contract management system. According to Singleton & Cormican (2013), investing in collaboration technology would be an important element in the future project's success in the CI.

In collaboration, contractors will participate in the design development utilizing construction collaborative technologies through a group of online utilities that work together to create a mutual unique interface between many interested parties. Facilitating engagement in creative procedures where they can freely communicate their knowledge,

expertise, ideas, and skills, ultimately delivering the best solution to meet their shared goal(s) while also creating a digitally auditable record of the people, data, and processes used in the delivery of solutions. Collaboration features includes commenting, measuring for cost estimations, discussion forms, and sharing drawings and details to facilitate quality management and preparing snag list. This collaboration will result in earlier and effective involvement in important decisions related to concept, executing, and maintenance issues. Furthermore, approval procedures and drawings revisions will be faster with fewer claims and better understanding through all involved parties and this will facilitate generating innovative and creative ideas and effective partnership accordingly.

Löfgren & Eriksson (2009) highlighted that joint activities between contractual parties in the CI positively affect collaboration and project performance accordingly through formulation of common goals, follow-up workshops, discussion/conflict resolution ladder, common project database, "open books" open accounting of costs, joint project office, team building activities, partnering facilitator, joint systematic risk management.

Political issues are generating additional risks in the Palestinian community that need special attention and further effective transparency and communication efforts. Enshassi et al. (2008) studied causes of claims in the CI in Palestine - Gaza strip- from owners' perspective and concluded that claims are resulted from mainly border restrictions (political issues), giving the contract to the lowest bidder, roadblocks, difficulty traveling between towns and governorates, involvement from locals during project execution, and an unanticipated rise in material costs. As a result, contractors prior to commencement any project need to study the risks accompanied with these claims and search for effective solutions at earlier stages.

In Palestine, the transforming of contracting relationship from its current legalistic approach to a relational one is very important and need more studies to go deeply in the contract clauses and search for effective ways of managing contacts through partnership and collaboration. Studies in contract management systems and evaluation are few in Palestine and the results revealed that most companies have less than five contract specialists. Therefore, contracting firms to exert more efforts in the implementation of CMS through investing in the training of the human resources on partnership, risk

management, claims and resolution management and collaboration approaches, increase the contract employee in the company, and enhance communications and partnership concept with other stakeholders to transfer the contract implementation level to a better influential one. The financial aspects and awareness are so essential to offer specific programs to assure effective implementation of CMS.

Results also revealed that there is a positive and significant relationship between CMS and QMS. Furthermore, results showed that CMS effect is not significant on Q4.0 acceptance and implementation. Herein, results can be understood within the construction contracting companies in Palestine; being a developing country is an additional complexity facing any development, the culture needs more efforts in order to become sufficiently mature to adopt new procedures and to secure needed resources to adopt new technologies. In general, enhancing trust between all contractual parties, transparency, risk sharing, and collaboration will improve contracts and companies will reap exceptional benefits accordingly.

#### **4.2.2 Discussion of Q4.0 in Palestine**

An important contribution of this study is the assessment of the level acceptance and implementation of Q4.0 in the Palestinian contracting companies. It also seeks to understand the relationships between CMS and Q4.0 on the one hand and Q4.0 and QMS on the other, as well as the expected mediation effect of Q4.0 between CMS and QMS.

In terms of Q4.0, the results that the acceptance level of Q4.0 among Palestinian contractors is high with a mean of 3.73555. Specifically, technological devices on physical resources (TD), internet of things (IoT), building information modeling (BIM), digital centralized management (DCM) is considered high with the mean of 3.8635, 3.5315, 3.8527, and 3.6945 respectively. Meanwhile, the internet of things (IoT) level of acceptance is the lowest with a mean of 3.5315. It is clear that acceptance of technological devices on physical resources (TD) and Building Information Modeling (BIM) are the most accepted parts of Q4.0, which indicates that companies are accepting the use of new technologies in the work environment, they accept to use BIM that is the future of work in CI in addition to high acceptance of TD in the work environment. Khader I. Y. Musleh (2018) highlighted that the Palestinian construction engineers are highly aware in BIM technology but the implementation needs more supportive efforts. These technologies

will contribute in solving the problems facing the CI and produce better communications through reduction of risks and increase of transparency. It is also obvious that construction companies need to evolve the work environment, the culture, and the management and accept using new technologies.

The results revealed that the infrastructure of the contracting companies is not ready to implement such technologies since all questions of implementation of Q4.0 technologies are omitted. Consequently, companies need more incentives and supportive infrastructure to gradual adoption of such technology; governments to exert more efforts for such developments. It is noted that smart technologies (ST) construct is not a significant factor from the Q4.0 variables used to measure Q4.0, therefore, more attention is required from companies and governments to strategically planning to utilize with the universal developments.

Furthermore, results demonstrate that managerial aspects such as implementing BIM and digital management systems such as ERP are much more influential than adoption of smart technologies, which has no significant relationship with Q4.0 acceptance and implementation; smart technologies including technological devices like sensors and RFID in addition to IoT technology are not significantly affect Q4.0. This result is not surprising due the environment of CI in Palestine, as developing country, and referring to the characteristics of the internet device and the Palestinian infrastructure as total. Furthermore, the topic of Q4.0 is relatively new and need more studies to clarify the concept and highlight the motivations and challenges for acceptance and implementation.

As indicated, there is no important relationship between CMS and Q4.0. Furthermore, there is a significant positive relation between Q4.0 and QMS, so this research demonstrated that there is no mediation relationship of Q4.0 between CMS and QMS and that can be explained in the context of the available Palestinian infrastructure as a developing and occupied country; there are many imposed restriction on the Palestinians imported technologies, internet device, materials, access ability...etc.

Previous studies like Syaj (2015) indicated the challenges facing the implementation of quality in the CI, the most important of which are lack of information about the quality management system, lack of expertise, poor performance of training programs, lack of awareness of the owner of the concept of quality, focus of stakeholders on earning short-

term profits, weak public safety programs, and lack of awareness of the concept of quality, follow-up and audit of plans before starting bids and comparing them with technical specifications, in addition to the delay in preparing building materials for the site, and the lack of clear laboratory specifications due to lack of budget. Most of the bids and tenders for construction projects are referred to the lowest-priced contractor and this is considered one of the challenges, so it is better to refer to the bid based on the accuracy of prices because of its great impact on quality, CI companies and offices in Palestine should apply the concept of total quality management by raising awareness of the importance of this system and its role in measuring quality performance and indicating the degree of weakness in project activities to reduce expected challenges.

Unfortunately, there are no studies for acceptance and implementation of Q4.0 in Palestine to compare with. In Palestine, as a developing region, there aren't many empirical studies supporting project management innovations (Ghaben & Jaaron, 2017).

#### **4.2.3 Discussion of QMS in Palestine**

Results demonstrated that there is a significant positive relation between CMS and QMS on its five performance dimensions: scope (S), client satisfaction (CS), time (T), cost (C), and safety issues (SI), as well as the same significant relationship between Q4.0 and QMS. Furthermore, the results revealed that the level of agreement on implementation QMS performance indicators was 3.68562 that is a high-level. In details the QMS indicators level of agreement for S, CS, T, C, and SI were 3.8, 3.6877, and 3.723, 3.5437, and 3.6737 respectively, which is considered high. Through these results from the contractor's point of view, it can be said that the management of contracts that improves the contracting systems and regime through enhancing the management of financial issues, communication and relationships, dispute resolving, and risks have significant role in improving the QMS performance.

For QMS, the results revealed that question; "The quality assurance process and project audits are effective "in scope construct was with average response 3.811 that is the highest average of the other ones followed by the question, "All employees are aware of quality improvements and understand the quality objectives" by an average of 3.821. While the average response rate for the question "outputs are tracked and measured, which

means areas of waste and duplication can be identified and eliminated" was 3.537 which is the lowest agreement level among QMS construct.

Practically, decision-makers and top managements in the construction contracting companies to enhance the role of tracking works and supporting the project performance taking into consideration through paying more attention to emerging new technologies in the work environment that will participate in solving this issue.

Referring to the results of QMS; particularly, the cost construct that has the lowest mean 3.5437 of among the QMS indicators. The other indicators are with average mean from 3.6737 and 3.8 and are considered high.

It should be noted that all previous studies discussed the dimensions of CMS, Q4.0, TQM, and QMS. However, no previous researches studied the relationships between these three constructs in a way to study upgrading quality management through Q4.0 technology dimensions adoption in the Palestinian contracting companies.

Mahamid (2016) study highlighted that the most serious factors that lead to rework in residential construction projects in Palestine is poor client-consultant and communication of client-contractor and this is in accordance with our study.

Rashed & Othman (2015) discussed critical issues affecting implementation of quality systems in Palestine; results show that skilled work force is in the front of these factors, Therefore, training programs to increase the skills and capabilities in implementing quality systems. They concluded that, the development of effective quality management would result in the successful implementation of TQM.

#### **4.2.4 Discussion of Hypothesis Testing**

Based on the hypotheses have been proposed in section 1.3; H<sub>1</sub>, H<sub>2</sub>, H<sub>3</sub>, and H<sub>4</sub>. The results demonstrate that there is an important and positive relation between CMS and QMS so H<sub>1</sub> is supported. This result is not surprising, the contract documents are the core of works` execution in CI and technical specifications formulate an essential part of these documents. In these specifications, the quality of the materials, the way of work execution, and technical instructions are specified and mutually agreed prior to any commencement of works, so the relationship between CMS and QMS is logically

significant and this is matching Gunduz & Elsherbeny (2020) and Emblemståg (2020) studies. Furthermore, The findings revealed a positive and significant relationship between Q4.0 acceptance and implementation and QMS; H<sub>3</sub> is supported; acceptance and adoption of Q4.0 technologies such as BIM, DCM and ST can be utilized and set up to track real time works and predict maintenance requirements so the occurrence of errors will be avoided and QMS will be effectively implemented and as a result the quality in the projects will be improved with higher employee engagement accordingly, and this result is matching Chiarini & Kumar (2021) and Javaid et al. (2021) studies.

The results of the relation between CMS and Q4.0 acceptance and implementation demonstrated that there is no significant correlation between them so H<sub>2</sub> is not supported and this result may be explained in the light of the current situation of the contracts and the missed partnership and collaboration; the contractors are only adhering with contract documents without searching for new ways to develop and facilitate tracking works and that is may be because of the peculiarities and challenges facing this industry including the political ones, financial issues, the existing poor infrastructure, and the missed training programs provided by PCU and Engineering Association on these new technologies.

Finally, the mediating effect proposed of Q4.0 acceptance and implementation on the relation between CMS and QMS in this study H<sub>4</sub> is not supported and this is not a surprising result since Q4.0 is a relatively new technology that needs more researches to highlight the advantages and risks accompanied with its implementation.

This study aimed to evaluate the mediation effect of Q4.0 acceptance and implementation on the relationship between CMS and QMS. As previously mentioned QMS was measured through the project overall performance indicators (Leong et al., 2014; Neyestani, 2017). When applying an effective QMS the performance of the project is expected to be developed, the works are expected to be executed in a short time, within the budget, with low and even no accidents, with a satisfied client, and with high quality and reach TQM.

### **4.3 Theoretical Implications**

The main theoretical contribution of this study is evaluating the mediation impact of Q4.0 acceptance and implementation in the relation between CMS and QMS and deepening the knowledge and understanding about these constructs, it provided a thorough image of these variables in the Palestinian construction contracting companies' context.

Previous studies discussed the relationship between CMS and QMS and the dimensions of these constructs. This study adds a third variable, which is Q4.0 acceptance and implementation, and conclude the benefits from the integration between them and emerging new technologies to enhance the level of QMS in construction contracting companies and reach integrated TQM. It presented a theoretical proof of the level of agreement on the indicators for CMS and Q4.0 acceptance, and QMS. Furthermore, the study tested the mediation effect of Q4.0 acceptance and implementation between CMS and QMS in Palestine that is the first study to address this topic in an integrative status in a developing country.

### **4.4 Practical Implications**

Practically, top management of the construction contracting companies should focus on reviewing the contract regime to increase partnership and collaboration, transparency, increase risk-sharing relationship between all parties, better governing of conflicts, and adopt effective regime's clauses in managing the financial issues. Moreover, focusing in emerging new technologies is excellent to achieve effective QMS in Palestine; BIM technology and centralizing the management through a central decision-making system with the enabling software such as enterprise resource planning (ERP) to control day-to-day processes, offer training programs, managing supply chain, and offer continual employee performance evaluation is to give eminent outcomes. Application of other technologies is not significant due to the peculiarity of the Palestinian community and the restrictions on the infrastructure due to political issues. All projects' stakeholders to work together and invest more in humans, processes, and technology to get a successful project and avoid the problems and risks.

## 4.5 Conclusions

Quality is a crucial strategic competitive element in the era of excellence; the concern of sustainable quality management that leads to sustainable performance is a concern worldwide. This leads the companies to think beyond borders in emerging new empowering technologies and tools to keep improving quality toward the fully tracked technological systems, processes, and human resources to grant relatively zero defects. Manufacturing and other industries have witnessed noticeable quality transformation and enhancements worldwide. However, construction industry is beyond these industries due to its peculiarities and varied environments.

This study is conducted to explore the impact of CMS on the company's quality management system QMS and to test the mediation effect of Q4.0 acceptance and implementation on the relationship between CMS and QMS in the context of Palestinian contracting construction companies. Furthermore, the study also measures the level of agreement of CMS indicators, Q4.0 acceptance and implementation and QMS. According to the results obtained from this study, Q4.0 acceptance and implementation and CMS explained 34.90% of the total effect of QMS. Additionally, the results indicate there is a statistically positive and significant relationship between the CMS and QMS and the CMS are implemented at a high level with a scale of 3.97564 demonstrating that if companies are involved in solving problems related to contractual issues, they will achieve more effective QMS.

It is demonstrated that CMS have an insignificant association with Q4.0 acceptance and implementation and the Q4.0 acceptance level is considered high with a scale of 3.73555, so emerging new technologies is accepted from the engineers and managers; this enables the organizations to plan strategically to a gradual transformation to the Quality 4.0 era and go towards eliminating waste and achieving desired contractual quality and client delight and reaching sustainability accordingly.

Fundamentally, specific dimensions of Q4.0 are accepted and significantly forming Q4.0 that are BIM technology and digitalized management systems like ERP, respondents confirm that digital management are much more essential than technology itself like sensors and IoT.

The construction industry managers have to recognize the value of emerging new technologies such as BIM on the aspects of quality management system and total quality management.

#### **4.6 Recommendations**

Although the systems of quality management concept is adopted in most countries, it stills immature in developing ones such as Palestine, and this can be explained through many reasons, including economic and political issues. Consequently, steps that would increase the benefit of enhancing the performance of quality management systems in organizations to be taken place such as:

- The PCU and Engineering Association are highly recommended to conduct training programs such as joint meetings, workshops, and seminars for contractors to improve regimes, quality, and adopt new technologies; as provide training in BIM for engineers that is the core of digital transformation in CI.
- Contractors are recommended to utilize the value of lessons learned from previous projects to avoid faults reoccurrence.
- Contractors are recommended to adopt strategic planning to gradually move toward developing the current work environment and overcome the all CI peculiarities and challenges.
- Contractors are encouraged to make serious efforts to establish an effective quality management system within their organizations including establishing a quality department within the organizational structure, hiring quality control engineers, and obtaining certifications in quality such as the ISO certificate.
- Contractors are advised to participate in empowering contract regime and their CMS by hiring contract specialists within organizational structure and take sufficient time to review contracts prior to commencement any works to advice owners and consultants about the conflict points and improvement approaches.
- Contractors are recommended implement an effective contracting management system to generate a rigid foundation of work process, communication, conflict resolving, and risk managing. As a result, effective total quality management will be achieved.
- Contractors are recommended to give a priority for developing capabilities of their employees to increase their ability to handle contractual issues, track supply chain

and quality, conduct instant communication, digitally making decisions, and increase their ability to deal with digital data through providing online or face-to-face training programs.

- Quality is not a contractual issue so contractors are recommended to adhere with quality management systems and enhance the value engineering process to avoid transferring risks to owners after project completion due to maintenance issues.
- Contractors are advised to adopt specific dimensions of the 4.0 technological era that would be able to lift the industry and not to be a burden; such as BIM and ERP software; these technologies will facilitate management of day to day activities and keep an instant follow up. Top management is also advised to pay more attention to the technological equipment and process that will facilitate work and add value.
- Activating the role of partnership, collaboration, and risk sharing with all contractual stakeholders through joint activities between contractual parties that include; mutual formulation of common goals, follow-up workshops, discussion of conflict resolution ladder, common project database, open accounting of costs, joint project office, team building activities, and joint systematic risk management.
- The Palestinian government is advised to introduce policies and plans to develop a supportive enabling infrastructure such as internet service.

#### **4.7 Limitations of Research**

This study has a few limitations. First, Q4.0 is a relatively new research topic and there is few ones done especially in the developing countries like Palestine. Second, information was gathered from construction contracting companies in Palestine, which is regarded as a small study population. As a result, the sample size was not large, making it wise to use caution when generalizing the findings. Third, the restrictions brought about by the political environment and the access limitations imposed on particular companies and resources. Fourth, the study is not demonstrated to be acceptable on other contracting companies rather than those classified in buildings construction.

#### **4.8 Research Directions**

This study served as a solid foundation for the beginning of additional research aimed at improving the quality in the construction industry. Work on gathering a broader sample of construction companies first. The same study may also be used in other subjects and

in other sectors such as manufacturing. Second, a replication of this study in additional developing nations verifies its findings. Thirdly, the influence of processes and people may be investigated as independent control variables that affect Q4.0 acceptance and adoption, CMS, and QMS. Fourth, it can examine how other factors, such as company environmental culture, play as mediators in the relationship between CMS and QMS to demonstrate their effect.

## List of Abbreviations

Abbreviation	Meaning
AVE	Average Value Extracted
BIM	Building Information Modeling
C	Cost
CAD	Computer-Aided Design
CAM	Contract Administration Team Management
CDR	Claims & Disputes Resolution
CI	Construction Industry
CMS	Contract Management System
CR	Communication & Relationship
CPS	Cyber Physical System
CRM	Contract Risk Management
CS	Client Satisfaction
DCM	Digital Centralized Management
DSS	Decision Support System
ERP	Enterprise Resource Planning
FIDIC	International Federation of Consulting Engineers
FM	Financial Management
GPS	Global Positioning System
ISO	International Organization for Standardization
IoT	Internet of Things
ISO	International Organization of Standards
ML	Machine Learning
PCU	Palestinian Contracting Union
PG	Project Governance
PLS-SEM	Partial Least Squares Structural Equation Modeling
PMR	Performance Monitoring, Reporting & Documentation
Q4.0	Quality 4.0
QA	Quality Assurance
QACC	Quality & Acceptance & Changes Control
QC	Quality Control
QMS	Quality Management System

RFID	Radio-Frequency Identification
S	Scope
SI	Safety Issues
SL	Significance Level
SPSS	Statistical Package for the Social Sciences
T	Time
TD	Technological Devices on physical Resources
TQM	Total Quality Management
UAV	Unmanned Aerial Vehicle
UWB	Ultra-Wide Band

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## Appendices

### Appendix A

#### Questionnaire in English



**An-Najah National University**  
**Faculty of Graduate Studies**  
**Engineering Management Program**

#### **Questionnaire about quality 4.0 framework in the Construction Industry in Palestine**

Dear respondent,

Thank you for your time in filling out this questionnaire. This study will target the construction contracting sector in Palestine, It aims to assess the *CMS* implementation, *quality 4.0* Q4.0 acceptance and implementation; that is a process of innovation and learning and the future of quality within industry 4.0 context and it is defined as the digitalization of Total Quality Management (TQM) using industry 4.0 technological tools, new management skills, and Building Information Modeling (BIM) software which links people, technology and processes to improve outcomes in building and construction at all 'projects' phases. Additionally, this survey aims to assess the *quality management system* and the relationships between all mentioned constructs in this vital sector of industry. The questionnaire is prepared for collecting information for scientific research to complete the requirements for getting a master's degree in engineering management at An-Najah National University.

The questionnaire includes two parts. The first one is to gather general information about the respondent, company, and the status of projects.

The second part consists of three sections. The first section aims to assess the degree to which contact management system are applied in construction companies in Palestine. The second one aims to assess the factors affecting the acceptance and implementation of Quality 4.0 technology in the CI in Palestine. Finally, The third section aims to measure the impact of applying an effective quality management system.

It will take 10 minutes to answer the questionnaire. Please read all parts carefully and choose the appropriate answer accurately and impartially, with full appreciation for your participation.

Regards,

Nasreen Abdelhafeeth Altuhul

Researcher, Master of Engineering Management

Email: Nasreen\_altuhul@yahoo.com

Mob +970-599-706753

**Part one: General information**

Please answer the following questions by putting an (X) in the answer that suits you.

1. **Gender;**                                     Male             Female
2. **Your education degree;**  
 Diploma or less             Bachelor degree             Higher education
3. **Your current position in the company;**  
 General manager/CEO     Construction engineer     Office engineer  
 Quality manager             other
4. **Your construction company classification;**

Degree	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>
Contracting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. **Company location;**  
 Jenin                     Tullkarm                     Nablus                     Ramallah  
 Jerusalem             Hebron                     Bethlehem             Salfit  
 Qalqilya             Jericho                     Tubas
6. **Number of employees in the company;**

- 1-9                       10-19                       20-50                       more than 50

**7. Company experience;**

- 0-less than 5 Years     5-15 Years     More than 15 years

**8. Does your company QMS in planning, supervising and executing projects?**

- Currently uses                       Currently, there are no plans to use  
 Plan to use within 12 months     Plan to use within more than 12 months  
 Not sure

**9. Does your company have a formal certificate related to quality management system such as ISO9001/2008?**

- Currently obtain                       Currently, there are no plans to obtain  
 Plan to obtain within 12 months     Plan to obtain within more than 12 months  
 Not sure

**10. Average number of contract employees working in the company is;**

- 1- 5                       6- 10                       more than 10

**11. Obtaining new technologies and software to manage projects (costs and timing) are included in the ' 'company's strategic planning;**

- Yes                       No                       Not sure

**Part two:**

**Section 1: Contact management system (CMS) assessment:**

CMS includes a set of policies and practices to execute the contracts, such as performance monitoring and reporting, financial management, claims and dispute resolution, document and record, quality and acceptance, communication and relationship, changes and changes control, project governance & start-up, Contract Administration Team Management, and contract close-out. This section aims to reveal to what degree the construction industries apply contract management systems. For each item, please choose to what extent that project contracts usually comply with the following items by marking the appropriate column with a (x) sign.

No.	Contract management system application	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Performance monitoring, reporting & documentation (PMR).					
1	Monitoring and reporting system (KPIs) are developed at earlier stages.					
2	Performance reports are in regular basis.					

3	Contractor's care of works is followed up.					
4	Documentation system is established and maintained.					
5	Information Technology is used in documentation.					
6	Stakeholders are provided with statistics.					
N <sup>o</sup>	Financial management (FM).	S	A	N	D	S
7	Financial management system is established at earlier stages.					
8	Owner is notified about due payments.					
9	Payments compensation are timely assessed.					
N <sup>o</sup>	Claims & disputes resolution (CDR).	S	A	N	D	S
10	Claims and disputes resolution systems are developed at earlier stages.					
11	Extension of time claims and additional payment claims are timely assessed.					
12	Support parties in alternative dispute resolution exists.					
N <sup>o</sup>	Quality acceptance & changes control (QACC).	S	A	N	D	S
13	Contractor's QMS is audited.					
14	Shop drawings and materials are timely reviewed.					
15	Work's quality is timely inspected.					
16	Change control system is established.					
17	Contractor's proposals are timely evaluated.					
18	Timely process change orders.					
N <sup>o</sup>	Communication & relationship (CR).	S	A	N	D	S
19	Communication system is established.					
20	Timely response to requests of information and queries.					
21	Regular meetings.					
N <sup>o</sup>	Contract risk management (CRM).	S	A	N	D	S
22	Periodically assess contractual risks.					
23	Contractual risk responsibility is assigned.					
24	Contractor's financial status is followed up.					
N <sup>o</sup>	Project governance / start-up and close out (PG).	Stron gly Agre	Agre e	Neut ral	Disa gree	Stron gly Disa
25	Project management plan is developed at earlier stages.					
26	Review contractor's key staff.					
27	Review subcontractor(s) qualifications.					
28	Close out system is establish.					
29	Document best practices and lessons learned.					
30	Final account and review the documentation of closing out is timely progressed.					
N <sup>o</sup>	Contract administration team management (CAM).	Stron gly Agre	Agre e	Neut ral	Disa gree	Stron gly Disa

31	Assignment of qualified team and regular performance assessment.					
32	Roles and responsibilities are clear.					
33	Regular training programs.					

## **Section 2: Quality 4.0 acceptance and Implementation**

Quality 4.0 acceptance and implementation (Q4.0) is affected through acceptance and use of many factors, This section aims to reveal to what degree engineers and the construction companies accept and are willing to implement Q 4.0. For each factor, please choose to what extent you agree the item expresses yourself and your company by marking the appropriate column with (x) sign.

No.	<b>Smart Technologies (ST)</b> Technological devices on physical resources (TD)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Employees in my company have a good understanding of how new technologies and devices can be utilized to support our business.					
2	I am willing to accept technologies in my work environment (sensors, drones, cameras, RFID ...etc.).					
3	Our top management is willing to take risks involved in implementing Q 4.0 smart technologies.					
4	Our top management has sufficient enabling resources to implement Q 4.0 new technologies.					
No.	<b>Internet of Things (IoT)</b>	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5	I am willing to accept the internet of things (IoT) to connect smart devices in the work environment to the internet.					
6	I accept receiving the necessary training to deal with the Internet of Things to support my company.					
7	My company is technically ready to transfer towards using smart technologies and utilize IoT.					
8	Wi-Fi, GPS, and other internet based gateways and infrastructures are supporting utilizing IoT.					
No.	<b>Digital Ecosystems</b> Building Information Modeling (BIM)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
9	I have no resistance to use BIM in my work.					

10	Technically, I can use new IT systems and digital based platforms according to user instructions manuals.					
11	Our company strategy focuses in emerging new digital technologies as BIM and establish new supportive policies accordingly.					
12	My company intends to provide proper training for BIM application.					
No.	<b>Digital Ecosystems</b> Digital Centralized Management (DCM)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13	Centralization of project's data will improve our work.					
14	My company accepts to engage all stakeholders in a digital system to facilitate communications and decision making.					
15	My company is willing to establish a central platform to manage work effectively.					
16	My company is ready to handle big data and use artificial intelligent and other supportive digital technologies.					

### Section 3: Quality management system (QMS)

Throughout the research "effectiveness of "QMS" is defined as meeting prescribed quality objectives of the company and specified requirements of ISO 9001:2000", It includes a systematic approach, documentation, guidance, and audit. This section reflects the expected outcomes when applying an effective quality management system from project's initiation stage until the closing out phase, by using five project performance indicators.

For each indicator, please choose to what extent you agree the item, in your opinion, is achieved in your work to measure effectiveness of QMS by marking the appropriate column with (x) sign.

No.	Quality management system	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Scope (S).					
1	All stakeholders are participating in continuous improvement.					
2	The quality assurance process and project audits are effective.					
3	All employees are aware of quality improvements and understand the quality objectives.					

No.		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Client satisfaction (CS).					
4	Increased business benefits.					
5	Reduced customer complaints.					
6	Increased customer loyalty.					
	Time (T).					
7	Effective communication that reduces delays.					
8	Well-managed supply chain.					
9	The project completion corresponds proposed implementation timeliness.					
	Cost (C).					
10	Efficient process management and resource usage that minimize costs.					
11	Business outputs are tracked and measured, which means areas of waste and duplication can be identified and eliminated.					
12	Realizing the defects earlier and are corrected at a lower cost.					
	Safety issues (SI).					
13	Low number of accidents and injuries during project implementation.					
14	Corrective actions are continuously taken.					
15	Almost no the fatalities occurs during the implementation of the project.					

Notes:

.....  
.....  
.....  
.....

Thank you

## Appendix B

### Questionnaire in Arabic



جامعة النجاح الوطنية

كلية الدراسات العليا

برنامج ماجستير الإدارة الهندسية

استبانة حول إطار عمل للجودة 4.0 في صناعة الانشاءات في فلسطين

عزيزي القارئ/ عزيزتي القارئة،

تحية طيبة،

تستهدف هذه الدراسة شركات المقاولات في فلسطين - الضفة الغربية والمتخصصة في مجال الأبنية حيث تقوم الباحثة بإجراء دراسة بعنوان: دراسة طرق تحسين نظام إدارة الجودة في المشاريع الإنشائية في فلسطين من خلال دراسة كفاءة نظام التعاقد وامكانية تطبيق الجودة 4.0 التي يتمحور الفكر الأساسي لها حول مواومة ممارسة إدارة الجودة مع القدرات الناشئة للصناعة 4.0 كاستخدام التكنولوجيا الحديثة مثل انترنت الاشياء والمجسات والواقع الافتراضي وغيرها بالإضافة إلى المحاكاة باستخدام النمذجة الشاملة BIM- Building Information Modeling وهي عملية توليد وإدارة بيانات المبنى خلال دورة حياته؛ تهدف الدراسة لدعم المنظمات في رحلتها نحو التميز ولتحقيق الأهداف المرجوة للأداء وزيادة فاعلية نظام إدارة الجودة للشركات الإنشائية العاملة في فلسطين. وقد تم اختيار شركتكم للمشاركة في هذه الدراسة بناءً على عينة عشوائية.

وتعد هذه الدراسة أكاديمية بحتة وسيتم استخدام البيانات التي تزودونها بها فقط لأغراض البحث العلمي وسوف تساعد في الحصول على فهم أفضل لآثار الجودة 4.0 واثار تحسين العقود على فعالية نظام ادارة الجودة للشركات الإنشائية العاملة في فلسطين.

تحتوي الاستبانة على اسئلة متخصصة يستطيع فقط صاحب الشركة، المدير العام للشركة، مدير الجودة أو الشخص (الأشخاص) المسؤول عن الجودة والبحث والتطوير في المؤسسة الخاصة بكم لذا يرجى من حضرتكم اخذ ذلك بعين

الاعتبار حين الإجابة عليها. ليس مطلوباً منكم أن تعرفوا عن أنفسكم وشركتكم وسوف يتم التعامل مع الإجابات بسرية تامة. وستكون متاحة فقط لأغراض البحث.

حسن تعاونكم في هذا البحث هو موضع تقدير كبير، وتأمل الباحثة أن تكون هذه الدراسة التي ستستغرق عشرة دقائق من وقتكم ذات أهمية بالنسبة لكم ولشركتكم، إذا كنت/م ترغب/ون في الحصول على نسخة من ملخص الدراسة، يرجى تضمين عنوانك/م في نهاية الاستبانة.

شكراً جزيلاً على وقتكم وتعاونكم البناء.

مع وافر الاحترام

الباحثة: نسرين الطحل

ماجستير الادارة الهندسية - جامعة النجاح الوطنية

جوال رقم 0599706753

أولاً: معلومات عامة

يرجى وضع إشارة (x) في المربع الذي ينطبق عليك:

(1) الجنس:  ذكر  انثى

(2) المؤهل العلمي:  دبلوم او اقل  بكالوريوس  دراسات عليا

(3) طبيعة عملك في الشركة:  المدير العام  مهندس الانشاءات  مهندس مكتب  مهندس الجودة  غير ذلك

(4) تصنيف الشركة في مجال الابنية هي مقاولات :

الدرجة	الاولى	الثانية	الثالثة	الرابعة	الخامسة
مقاولات	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

(5) المحافظة التي تتواجد فيها الشركة:  جنين  طولكرم  نابلس  رام الله والبيرة  القدس  الخليل  بيت لحم  سلفيت  قلقيلية  اريحا  طوباس.

(6) عدد الموظفين في الشركة:  من 1-9  من 10-19  من 20-50  اكثر من 50

(7) عدد سنوات خبرة الشركة:  أقل من 5 سنوات  من 5-15 سنة  اكثر من 15 سنة

8) هل تستخدم شركتك نظام إدارة الجودة في التخطيط والإشراف وتنفيذ المشاريع ؟

- تستخدم حالياً  لا يوجد خطط لاستخدامها حالياً  تخطط لاستخدامها خلال اثنا عشر شهراً  
 تخطط لاستخدامها خلال أكثر من اثنا عشر شهراً  غير متأكد

9) هل تمتلك شركتك شهادة رسمية متعلقة بنظام إدارة الجودة مثل ISO9001/2008؟

- تمتلك حالياً  لا يوجد خطط لامتلاكها حالياً  تخطط لامتلاكها خلال اثنا عشر شهراً  
 تخطط لامتلاكها خلال أكثر من اثنا عشر شهراً  غير متأكد

10) متوسط عدد موظفي العقود العاملين في الشركة هو:  أقل من 5  من 6-10  أكثر من 10

11) يتم تضمين الحصول على تقنيات وبرامج جديدة لإدارة المشاريع عند التخطيط الاستراتيجي للشركة

- نعم  لا  غير متأكد

ثانياً: يرجى وضع إشارة (x) في المربع الذي يتفق مع الوضع الحالي لشركتكم أمام كل فقرة من الفقرات الآتية

الجزء الأول: تطبيق عقود المشاريع الإنشائية في شركتكم

يتضمن نظام إدارة العقود مجموعة من السياسات والممارسات لتنفيذ هذه العقود ، مثل مراقبة الأداء وإعداد التقارير والإدارة المالية والمطالبات وتسوية المنازعات والتوثيق والجودة وقبول الأعمال والتواصل الفعال بين كافة اطراف العقد وادارة التغييرات وإدارة بدء المشروع وإدارة فريق التعاقد وإغلاق العقد عند الانتهاء من كافة الاعمال. يهدف هذا القسم إلى قياس درجة تطبيق الصناعات الإنشائية لأنظمة إدارة العقود، لكل عنصر يرجى اختيار إلى أي مدى تمتلك عقود المشروع عادةً للعناصر التالية عن طريق وضع علامة (x) على العمود المناسب.

م	الفقرة	موافق بشدة	موافق	محايد	معارض	معارض بشدة
<b>مراقبة الأداء وإعداد التقارير</b>						
1	يتم اعتماد نظام مراقبة ومعايير الاداء واعداد التقارير في المراحل الاولى لإعداد العقد.					
2	تقارير الأداء تصدر بموعدها وبطريقة منتظمة حسب العقد.					
3	يتم متابعة اعمال المقاول باستمرار.					
4	يوجد نظام متكامل للتوثيق وحفظ الملفات.					
5	نستخدم تكنولوجيا المعلومات في عملية التوثيق.					
6	يتم تزويد أصحاب المصلحة بالإحصائيات جميعها.					
<b>الإدارة المالية</b>						

م	الفقرة	موافق بشدة	موافق	محايد	معارض	معارض بشدة
7	يوجد نظام للإدارة المالية معتمد في مراحل مبكرة من التعاقد.					
8	يتم إخطار المالك عن المدفوعات المستحقة.					
9	تقيم الفواتير يتم في الوقت المناسب.					
<b>تسوية الدعاوى والنزاعات</b>						
10	يتم اعتماد أنظمة تسوية المطالبات والنزاعات في حال حصولها في مراحل مبكرة من التعاقد.					
11	تُقيم مطالبات تمديد الوقت ومطالبات الدفع الإضافية في الوقت المناسب.					
12	هناك دعم للأطراف في حل النزاع بطرق مختلفة.					
<b>الجودة وقبول الاعمال و ادارة التغييرات</b>						
13	نظام إدارة الجودة الخاص بالمقاول يتم تدقيقه واعتماده.					
14	تدقيق واعتماد المخططات التنفيذية والمواد في تتم الوقت المناسب.					
15	يتم فحص جودة العمل في الوقت المناسب.					
16	يوجد نظام لإدارة التغييرات بالمرحلة الأولى للتعاقد.					
17	يتم تقييم مقترحات المقاول في الوقت المناسب.					
18	تُعتمد أوامر التغيير في وقتها المناسب.					
<b>التواصل والعلاقة بين اصحاب المصلحة</b>						
19	يوجد نظام متكامل للتواصل بين كافة الاطراف.					
20	تتم الاستجابة في الوقت المناسب على جميع الاستفسارات.					
21	تُعقد اجتماعات منتظمة.					
<b>إدارة مخاطر العقود</b>						
22	تُقيم المخاطر التعاقدية بشكل دوري.					
23	يتم تحديد المسؤول عن المخاطر التعاقدية.					
24	متابعة الوضع المالي للمقاول باستمرار.					
<b>إدارة المشروع /بدء واغلاق العقد</b>						

م	الفقرة	موافق بشدة	موافق	محايد	معارض	معارض بشدة
25	يوجد خطة لإدارة المشروع في مراحل التعاقد الأولى.					
26	طاقم الموظفين الرئيسيين للمقاول يتم اعتماده.					
27	تتم مراجعة مؤهلات المقاول (المقاولين) من الباطن.					
28	يوجد نظام متكامل لإغلاق العقد.					
29	يتم توثيق أفضل الممارسات والدروس المستفادة.					
30	الحساب النهائي ومراجعة كافة الوثائق يتم في الوقت المناسب.					
<b>فريق إدارة التعاقد</b>						
31	فريق إدارة التعاقد مؤهل ويتم تقييم الاداء باستمرار.					
32	الأدوار والمسؤوليات واضحة للفريق.					
33	يتم اعتماد برامج تدريبية لفريق إدارة التعاقد بانتظام.					

#### الجزء الثاني: قبول وتطبيق الجودة 4.0 في شركتكم

يهدف هذا القسم إلى قياس الدرجة التي يرغب بها المهندسون والشركات الانشائية لقبول وتبني الجودة 4.0، يرجى اختيار إلى أي مدى توافق على أن العنصر يعبر عن نفسك من خلال وضع علامة (x) على العمود المناسب.

م	الفقرة	موافق بشدة	موافق	محايد	معارض	معارض بشدة
<b>نظام التكنولوجيا الذكية (ST) الأجهزة التكنولوجية على النظام المادي (TD)</b>						
1	يتمتع الموظفون في شركتي بفهم جيد لكيفية استخدام التقنيات والتكنولوجيا الجديدة لدعم أعمالنا.					
2	أنا على استعداد لقبول التقنيات المرافقة للتكنولوجيا الذكية في بيئة عملي (أجهزة الاستشعار ، الطائرات بدون طيار ، الذكاء الاصطناعي ، الواقع الافتراضي ... إلخ).					
3	إن إدارتنا العليا على استعداد لتحمل المخاطر التي ينطوي عليها تنفيذ تقنيات الجودة 4.0 الذكية.					
4	تمتلك إدارتنا العليا موارد كافية لتنفيذ تكنولوجيا الجودة 4.0 الجديدة.					
<b>انترنت الأشياء IoT</b>						

م	الفقرة	موافق بشدة	موافق	محايد	معارض	معارض بشدة
5	انا على استعداد لقبول انترنت الاشياء Iot لربط الاجهزة الذكية بالانترنت والتحكم بها.					
6	انا على استعداد لتلقي التدريب اللازم للتعامل مع انترنت الاشياء ودعم الشركة.					
7	شركتي مستعدة تقنياً للانتقال نحو استخدام إنترنت الأشياء.					
8	خدمة الانترنت والبنية التحتية للتكنولوجيا جيدة لتطبيق انترنت الاشياء.					
<b>الانظمة الرقمية</b>						
<b>نمذجة معلومات البناء BIM</b>						
9	ليس لدي اي اعتراض لاستخدام BIM في عملي.					
10	من الناحية الفنية ، يمكنني استخدام أنظمة تكنولوجيا المعلومات الجديدة.					
11	استراتيجيا- تنوي شركتنا ان تضع سياسات وقوانين لاستخدام BIM.					
12	ستقدم شركتي التدريب المناسب لتطبيق BIM.					
<b>الإدارة الرقمية المركزية (DCM)</b>						
13	مركزية بيانات المشروع من خلال منصات الانترنت سوف تسهل عملنا وتنظمه.					
14	تقبل شركتي إشراك جميع أصحاب المصلحة في نظام رقمي لتسهيل الاتصالات واتخاذ القرار.					
15	شركتي على استعداد لإنشاء منصة مركزية لإدارة العمل بفعالية.					
16	شركتي جاهزة للتعامل مع البيانات الضخمة واستخدام تقنيات التكنولوجيا الحديثة مثل الذكاء الاصطناعي.					

### الجزء الثالث: اثر تطبيق نظام إدارة الجودة الفعال بالمشاريع الانشائية

"فعالية" نظام إدارة الجودة " يعرف على أنه تحقيق أهداف الجودة للشركة والمتطلبات لشهادة الأيزو ISO 9001:2000 يعكس هذا القسم النتائج المتوقعة عند تطبيق نظام فعال لإدارة الجودة باستخدام خمسة مؤشرات للأداء. بالنسبة لكل مؤشر ، يرجى اختيار إلى أي مدى توافق على تحقق هذا البند برأيك، لقياس فعالية نظام إدارة الجودة عن طريق وضع علامة (x) على العمود المناسب.

م	الفقرة	موافق بشدة	موافق	محايد	معارض	معارض بشدة
<b>نطاق العمل</b>						
1	جميع أطراف المشروع تشارك في التحسين المستمر.					
2	تتم عملية تدقيق جودة المشاريع ومتابعتها بكفاءة.					
3	هناك وعي بتحسينات الجودة وفهم لأهداف الجودة من كافة الموظفين.					
<b>رضى العملاء</b>						
4	يزيد من الفوائد التجارية.					
5	يقلل من شكاوى العملاء.					
6	يزيد من ولاء العملاء.					
<b>الوقت</b>						
7	التواصل الفعال الذي يقلل من التأخير.					
8	الحد من التأخيرات من خلال الإدارة الفعالة لسلاسل الإمداد.					
9	اكتمال المشروع في الوقت المناسب المقترح للتنفيذ.					
<b>التكاليف</b>						
10	تخفيض المصروفات من خلال إدارة العمليات والموارد بكفاءة.					
11	يتم تتبع مخرجات الأعمال وقياسها، مما يعني أنه يمكن تحديد مناطق الهدر والازدواجية والقضاء عليها مبكراً.					
12	ندرك العيوب مبكراً فتقلل التكاليف.					
<b>السلامة العامة</b>						
13	تطبيق نظام إدارة الجودة الفعال يقلل عدد الحوادث والإصابات خلال تنفيذ المشروع.					
14	الاجراءات الوقائية والعلاجية يتم اتخاذها باستمرار لتفادي الحوادث.					
15	تقليل عدد اصابات العمل المميتة خلال تنفيذ المشروع.					

عذرا إذا كان لديكم اية ملاحظات اخرى يرجى اضافتها هنا

.....  
.....  
.....

مع بالغ شكري وتقديري لإجاباتكم على الفقرات كافة

## Appendix C

### Complementary Tables and Figures

**Table 1**

*Operationalisation Of Model Constructs*

Reflective constructs	Construct items	Adopted from
Performance monitoring, reporting & documentation (PMR)	<p>Monitoring and reporting system (KPIs) are developed at earlier stages.</p> <p>Performance reports are in regular basis.</p> <p>Contractor's care of works is followed up.</p> <p>Documentation system is established and maintained.</p> <p>Information Technology is used in documentation.</p> <p>Stakeholders are provided with statistics.</p>	(Gunduz & Elsherbeny, 2020)
Financial management (FM)	<p>Financial management system is established at earlier stages.</p> <p>Owner is notified about due payments.</p> <p>Payments compensation are timely assessed.</p>	(Gunduz & Elsherbeny, 2020)
Claims & disputes resolution (CDR)	<p>Claims and disputes resolution systems are developed at earlier stages.</p> <p>Extension of time claims and additional payment claims are timely assessed.</p> <p>Support parties in alternative dispute resolution exists.</p>	(Gunduz & Elsherbeny, 2020)
Quality acceptance & changes control (QACC)	<p>Contractor's QMS is audited.</p> <p>Shop drawings and materials are timely reviewed.</p> <p>Work's quality is timely inspected.</p> <p>Change control system is established.</p> <p>Contractor's proposals are timely evaluated.</p> <p>Timely process change orders.</p>	(Gunduz & Elsherbeny, 2020)
	<p>Communication system is established.</p>	

Communication & relationship (CR)	Timely response to requests of information and queries. Regular meetings.	(Gunduz & Elsherbeny, 2020)
Contract risk management (CRM)	Periodically assess contractual risks. Contractual risk responsibility is assigned. Contractor's financial status is followed up.	(Gunduz & Elsherbeny, 2020)
Project governance / start-up and close out (PG)	Project management plan is developed at earlier stages. Review contractor's key staff. Review subcontractor(s) qualifications. Close out system is establish. Document best practices and lessons learned. Final account and review the documentation of closing.	(Gunduz & Elsherbeny, 2020)
Contract administration team management (CAM)	Assignment of qualified team and regular performance assessment. Roles and responsibilities are clear. Regular training programs.	(Gunduz & Elsherbeny, 2020)
Technological devices on physical resources (TD)	Employees in my company have a good understanding of how new technologies and devices can be utilized to support our business. I am willing to accept technologies in my work environment (sensors, drones, cameras, RFID ...etc.). Our top management is willing to take risks involved in implementing Q 4.0 smart technologies. Our top management has sufficient enabling resources to implement Q 4.0 new technologies.	(Karmakar & Delhi, 2021; You & Feng, 2020)
Internet of Things (IoT)	I am willing to accept the internet of things (IoT) to connect smart devices in the work environment to the internet. I accept receiving the necessary training to deal with the Internet of Things to support my company.	(Karmakar & Delhi, 2021; You & Feng, 2020)

	<p>My company is technically ready to transfer towards using smart technologies and utilize IoT.</p> <p>Wi-Fi, GPS, and other internet based gateways and infrastructures are supporting utilizing IoT.</p>	
Building Information Modeling (BIM)	<p>I have no resistance to use BIM in my work. Technically, I can use new IT systems and digital based platforms according to user instructions manuals.</p> <p>Our company strategy focuses in emerging new digital technologies as BIM and establish new supportive policies accordingly.</p> <p>My company intends to provide proper training for BIM application.</p>	(Karmakar & Delhi, 2021; You & Feng, 2020)
Digital Centralized Management (DCM)	<p>Centralization of project's data will improve our work.</p> <p>My company accepts to engage all stakeholders in a digital system to facilitate communications and decision-making.</p> <p>My company is willing to establish a central platform to manage work effectively.</p> <p>My company is ready to handle big data and use artificial intelligent and other supportive digital technologies.</p>	(Karmakar & Delhi, 2021; You & Feng, 2020)
Scope (S)	<p>All stakeholders are participating in continuous improvement.</p> <p>The quality assurance process and project audits are effective.</p> <p>All employees are aware of quality improvements and understand the quality objectives.</p>	(Leong et al., 2014; Neyestani, 2017)
Client satisfaction (CS)	<p>Increased business benefits.</p> <p>Reduced customer complaints.</p> <p>Increased customer loyalty.</p>	(Leong et al., 2014; Neyestani, 2017)
Time (T)	<p>Effective communication that reduces delays.</p> <p>Well-managed supply chain.</p>	(Leong et al., 2014;

	The project completion corresponds proposed implementation timeliness.	Neyestani, 2017)
Cost (C)	Efficient process management and resource usage that minimize costs.  Business outputs are tracked and measured, which means areas of waste and duplication can be identified and eliminated.  Realizing the defects earlier and are corrected at a lower cost.	(Leong et al., 2014; Neyestani, 2017)
Safety issues (SI)	Low number of accidents and injuries during project implementation.  Corrective actions are continuously taken.  Almost no the fatalities occurs during the implementation of the project.	(Leong et al., 2014)

**Table 2**

*Sample Size Recommendations In PLS-SEM For A statistical Power of 80%*

Maximum Number of Arrows Pointing at a Construct	Significance Level											
	1%				5%				10%			
	Minimum R <sup>2</sup>				Minimum R <sup>2</sup>				Minimum R <sup>2</sup>			
	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75
2	158	75	47	38	110	52	33	26	88	41	26	21
3	176	84	53	42	124	59	38	30	100	48	30	25
4	191	91	58	46	137	65	42	33	111	53	34	27
5	205	98	62	50	147	70	45	36	120	58	37	30
6	217	103	66	53	157	75	48	39	128	62	40	32
7	228	109	69	56	166	80	51	41	136	66	42	35
8	238	114	73	59	174	84	54	44	143	69	45	37
9	247	119	76	62	181	88	57	46	150	73	47	39
10	256	123	79	64	189	91	59	48	156	76	49	41

*Note:* Refer to Hair et al. (2011), (P. 21).

**Table 3**

*Experts and Arbitrators Who Review the Questionnaire*

Number	Position
4	Teaching staff at An-Najah university
1	Teaching staff at Palestine Technical University – Kadoorie

**Table 4***Descriptive Analysis Of All Aspects Of The Questionnaire*

indicator	items	Mean	Standard deviation
PMR1	Monitoring and reporting system, (KPIs) are developed at earlier stages.	4.147	0.767
PMR2	Performance reports are in regular basis.	4.011	0.733
PMR3	Contractor's care of works is followed up.	4.137	0.776
PMR5	Information Technology is used in documentation.	4.032	0.876
PMR6	Stakeholders are provided with statistics.	4.053	0.759
FM1	Financial management system is established at earlier stages.	3.968	0.839
FM2	Owner is notified about due payments.	3.937	0.751
FM3	Payments compensation is timely assessed.	3.789	0.857
QACC1	Contractor's QMS is audited.	3.989	0.747
QACC2	Shop drawings and materials are timely reviewed.	3.789	0.893
QACC4	Change control system is established.	4.2	0.803
QACC5	Contractor's proposals are timely evaluated.	4.032	0.839
PG1	Project management plan is developed at earlier stages.	4.053	0.786
PG2	Review contractor's key staff.	3.968	0.801
PG5	Document best practices and lessons learned.	4.011	0.788
PG6	Final account and review the documentation of closing out is timely progressed.	3.884	0.78
CAM1	Assignment of qualified team and regular performance assessment.	4	0.665
CAM2	Roles and responsibilities are clear.	3.905	0.796
CAM3	Regular training programs.	3.863	0.866
TD1	Employees in my company have a good understanding of how new technologies and	3.874	0.849

	devices can be utilized to support our business.		
TD2	I am willing to accept technologies in my work environment (sensors, drones, cameras, RFID ...etc.).	3.853	0.894
IoT1	I am willing to accept the internet of things (IoT) to connect smart devices in the work environment to the internet.	3.505	0.857
IoT2	I accept receiving the necessary training to deal with the Internet of Things to support my company.	3.558	0.855
BIM1	I have no resistance to use BIM in my work.	3.863	0.841
BIM2	Technically, I can use new IT systems and digital based platforms according to user instructions manuals.	3.758	0.903
BIM3	Our company strategy focuses in emerging new digital technologies as BIM and establish new supportive policies accordingly.	3.937	0.856
DCM1	Centralization of project's data will improve our work.	3.726	0.787
DCM2	My company accepts to engage all stakeholders in a digital system to facilitate communications and decision making.	3.663	0.803
S1	All stakeholders are participating in continuous improvement.	3.768	0.827
S2	The quality assurance process and project audits are effective.	3.811	0.799
S3	All employees are aware of quality improvements and understand the quality objectives.	3.821	0.821
CS1	Increased business benefits.	3.663	0.854
CS2	Reduced customer complaints.	3.705	0.928
CS3	Increased customer loyalty.	3.695	0.941
T1	Effective communication that reduces delays.	3.737	0.823
T2	Well-managed supply chain.	3.758	0.855
T3	The project completion corresponds proposed implementation timeliness.	3.674	0.801

C1	Efficient process management and resource usage that minimize costs.	3.547	0.915
C2	Business outputs are tracked and measured, which means areas of waste and duplication can be identified and eliminated.	3.537	0.844
C3	Realizing the defects earlier and are corrected at a lower cost.	3.547	0.915
SI1	Low number of accidents and injuries during project implementation.	3.653	0.856
SI2	Corrective actions are continuously taken.	3.726	0.864
SI3	Almost no the fatalities occurs during the implementation of the project.	3.642	0.857

**Table 5**

*Reflective Constructs Measurement Properties.*

Reflective construct	Construct items	Items loading	Composite Reliability	AVE
Performance monitoring, reporting & documentation (PMR)	PMR1	0.857	0.906	0.721
	PMR2	0.875		
	PMR3	0.875		
	PMR5	0.791		
	PMR6	0.844		
Financial Management (FM)	FM1	0.908	0.882	0.805
	FM2	0.900		
	FM3	0.883		
Quality & Acceptance & Changes Control (QACC)	QACC1	0.783	0.88	0.736
	QACC2	0.881		
	QACC4	0.857		
	QACC5	0.906		
Project Governance/ Start-up & Close-Out (PG)	PG1	0.881	0.892	0.754
	PG2	0.874		
	PG5	0.873		
	PG6	0.846		
Contract Administration Team Management (CAM)	CAM1	0.840	0.845	0.760
	CAM2	0.872		
	CAM3	0.902		
Technological Devices (TD)	TD1	0.918	0.851	0.862
	TD2	0.938		

Internet of Things (IoT)	IoT1	0.883	0.763	0.803
	IoT2	0.909		
Building Information Modeling (BIM)	BIM1	0.935	0.933	0.880
	BIM2	0.946		
	BIM3	0.934		
Digital Centralized Management (DCM)	DCM1	0.953	0.902	0.910
	DCM2	0.955		
Scope (S)	S1	0.873	0.857	0.776
	S2	0.902		
	S3	0.868		
Cost (C)	C1	0.781	0.860	0.772
	C2	0.933		
	C3	0.913		
Time (T)	T1	0.917	0.920	0.862
	T2	0.940		
	T3	0.928		
Client Satisfaction (CS)	CS1	0.905	0.887	0.802
	CS2	0.922		
	CS3	0.859		
Safety Issues (SI)	SI1	0.926	0.928	0.872
	SI2	0.941		
	SI3	0.934		

**Table 6**

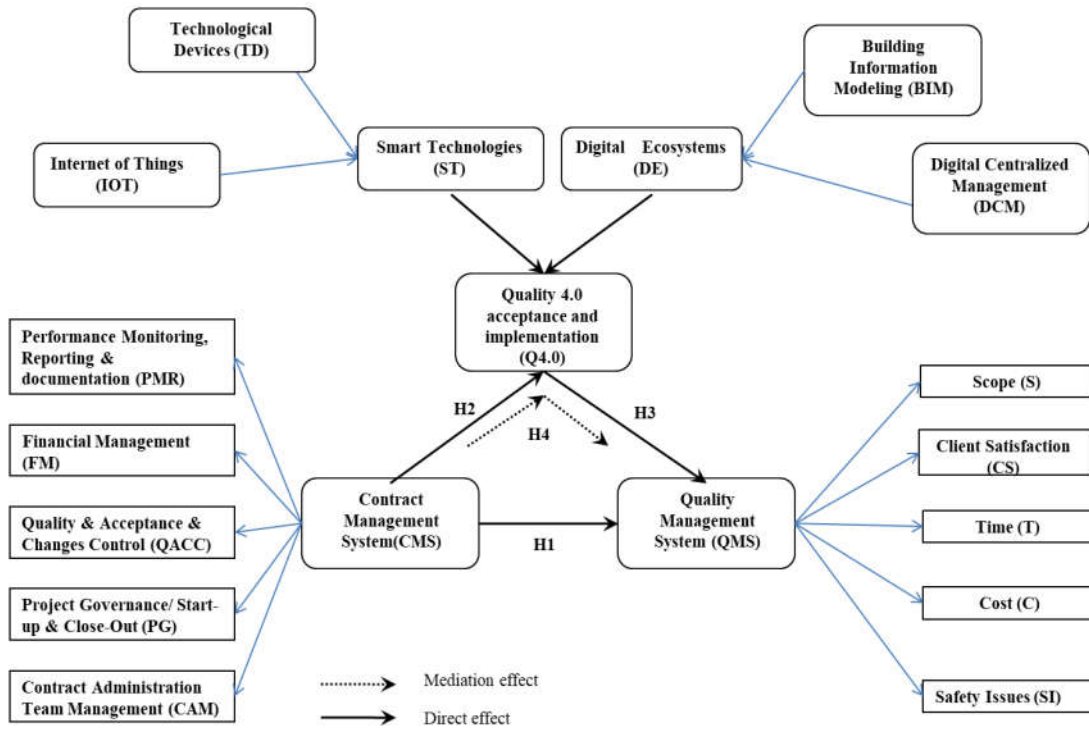
*Cross Loadings Discriminant Validity.*

Indicator variable															
	BIM	C	CAM	CS	FM	DCM	IoT	PMR	PG	QACC	SI	S	TD	T	
BIM1	<b>0.935</b>	0.106	0.019	0.246	0.115	0.688	0.253	0.011	0.033	0.004	0.283	0.28	0.047	0.005	
BIM2	<b>0.946</b>	0.156	0.104	0.315	0.163	0.738	0.287	0.091	0.063	0.033	0.351	0.364	0.103	0.182	
BIM3	<b>0.934</b>	0.112	0.112	0.327	0.177	0.695	0.311	0.041	0.028	0.087	0.307	0.368	0.189	0.123	
C1	0.08	<b>0.905</b>	0.125	0.602	0.04	0.169	0.041	0.178	0.137	0.023	0.515	0.39	0.101	0.391	
C2	0.182	<b>0.922</b>	0.258	0.655	0.252	0.303	0.192	0.324	0.308	0.217	0.508	0.542	0.209	0.534	
C3	0.085	<b>0.859</b>	0.203	0.496	0.142	0.191	0.159	0.252	0.248	0.079	0.492	0.41	0.151	0.467	
CAM1	0.039	0.145	<b>0.84</b>	0.23	0.439	0.041	0.146	0.508	0.516	0.428	0.145	0.179	0.302	0.255	
CAM2	0.092	0.18	<b>0.872</b>	0.292	0.441	0.164	0.132	0.547	0.502	0.45	0.151	0.278	0.356	0.239	
CAM3	0.086	0.249	<b>0.902</b>	0.284	0.507	0.142	0.115	0.516	0.526	0.511	0.265	0.342	0.379	0.382	
CS1	0.161	0.603	0.25	<b>0.781</b>	0.391	0.226	0.108	0.342	0.45	0.312	0.47	0.492	0.079	0.441	
CS2	0.305	0.57	0.307	<b>0.933</b>	0.35	0.373	0.175	0.432	0.402	0.295	0.57	0.63	0.178	0.565	
CS3	0.354	0.565	0.256	<b>0.913</b>	0.283	0.376	0.173	0.379	0.411	0.262	0.533	0.606	0.181	0.543	
FM1	0.219	0.273	0.509	0.462	<b>0.908</b>	0.229	0.134	0.667	0.595	0.567	0.3	0.295	0.281	0.389	

FM2	0.123	0.1	0.51	0.353	<b>0.9</b>	0.13	0.164	0.518	0.551	0.555	0.229	0.228	0.272	0.316
FM3	0.086	0.066	0.409	0.21	<b>0.883</b>	0.067	0.18	0.562	0.603	0.613	0.112	0.089	0.095	0.199
DCM1	0.293	0.194	0.103	0.222	0.117	<b>0.801</b>	0.381	0.13	0.114	0.116	0.182	0.221	0.256	0.118
DCM2	0.29	0.284	0.103	0.297	0.065	<b>0.82</b>	0.318	0.109	0.127	0.059	0.228	0.255	0.344	0.151
IoT1	0.228	0.106	0.058	0.145	0.108	0.34	<b>0.883</b>	0.079	0.107	0.135	0.067	0.234	0.13	0.218
IoT2	0.31	0.111	0.201	0.168	0.203	0.414	<b>0.909</b>	0.105	0.098	0.238	0.077	0.261	0.256	0.214
PMR1	0.04	0.198	0.476	0.293	0.529	0.085	0.126	<b>0.857</b>	0.589	0.439	0.21	0.157	0.01	0.201
PMR2	0.026	0.277	0.524	0.403	0.58	0.085	0.01	<b>0.875</b>	0.636	0.428	0.3	0.222	0.091	0.306
PMR3	0.015	0.305	0.617	0.444	0.555	0.087	0.142	<b>0.875</b>	0.689	0.527	0.339	0.248	0.162	0.353
PMR5	0.12	0.247	0.473	0.412	0.573	0.206	0.12	<b>0.791</b>	0.594	0.484	0.321	0.264	0.17	0.352
PMR6	0.018	0.165	0.439	0.294	0.528	0.047	0.034	<b>0.844</b>	0.49	0.39	0.295	0.087	0.003	0.272
PG1	0.105	0.17	0.555	0.383	0.532	0.163	0.163	0.634	<b>0.881</b>	0.487	0.245	0.228	0.153	0.268
PG2	0.018	0.233	0.468	0.401	0.555	0.062	0.062	0.604	<b>0.874</b>	0.556	0.259	0.194	0.065	0.306
PG5	0.044	0.267	0.594	0.433	0.606	0.094	0.096	0.615	<b>0.846</b>	0.595	0.301	0.282	0.181	0.369
PG6	0.101	0.159	0.465	0.347	0.653	0.119	0.151	0.525	0.583	<b>0.783</b>	0.231	0.203	0.225	0.234
QACC1	0.025	0.124	0.412	0.262	0.49	0.069	0.182	0.397	0.467	<b>0.881</b>	0.165	0.199	0.041	0.074
QACC2	0.025	0.076	0.465	0.24	0.499	0.057	0.212	0.427	0.492	<b>0.857</b>	0.049	0.235	0.212	0.096
QACC4	0.032	0.068	0.477	0.266	0.545	0.079	0.183	0.479	0.534	<b>0.906</b>	0.116	0.244	0.17	0.167
QACC5	0.305	0.54	0.139	0.53	0.1	0.27	0.042	0.233	0.198	0.029	<b>0.926</b>	0.521	0.033	0.495
SI1	0.317	0.487	0.267	0.57	0.287	0.297	0.086	0.345	0.378	0.244	<b>0.941</b>	0.552	0.084	0.542
SI2	0.317	0.552	0.198	0.576	0.283	0.378	0.096	0.389	0.315	0.185	<b>0.934</b>	0.477	0.137	0.537
SI3	0.304	0.493	0.165	0.54	0.07	0.305	0.231	0.079	0.095	0.135	0.468	<b>0.873</b>	0.229	0.491
S1	0.351	0.421	0.255	0.596	0.241	0.362	0.302	0.239	0.25	0.244	0.484	<b>0.902</b>	0.204	0.458
S2	0.297	0.422	0.387	0.602	0.292	0.343	0.2	0.295	0.337	0.297	0.509	<b>0.868</b>	0.241	0.562
S3	0.008	0.145	0.373	0.13	0.216	0.206	0.195	0.102	0.134	0.162	0.013	0.223	<b>0.918</b>	0.162
TD1	0.202	0.178	0.367	0.182	0.236	0.348	0.211	0.09	0.113	0.194	0.149	0.249	<b>0.938</b>	0.17
TD2	0.089	0.496	0.283	0.575	0.251	0.172	0.264	0.237	0.28	0.117	0.492	0.54	0.224	<b>0.917</b>
T1	0.125	0.448	0.305	0.554	0.38	0.171	0.218	0.359	0.383	0.155	0.566	0.546	0.15	<b>0.94</b>
T2	0.088	0.511	0.352	0.517	0.314	0.16	0.188	0.386	0.377	0.205	0.507	0.509	0.126	<b>0.928</b>
T3	<b>0.935</b>	0.106	0.019	0.246	0.115	0.688	0.253	0.011	0.033	0.004	0.283	0.28	0.047	0.005

**Figure 1**

*Final Conceptual Model*





جامعة النجاح الوطنية  
كلية الدراسات العليا

## إطار عمل للجودة (4.0) في صناعة الإنشاءات في فلسطين

إعداد

نسرين عبد الحفيظ محمد الطحل

إشراف

د. يحيى صالح

قدمت هذه الرسالة استكمالاً لمتطلبات الحصول على درجة الماجستير في الإدارة الهندسية، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس - فلسطين.

2023

## إطار عمل للجودة (4.0) في صناعة الانشاءات في فلسطين

إعداد

نسرين عبد الحفيظ محمد الطحل

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### الملخص

تهدف هذه الدراسة الى استكشاف العناصر الرئيسية المكونة للجوده 4.0 ومعرفة اثر تطبيق نظام إدارة العقود الفعال (CMS) على نظام إدارة الجودة (QMS) في ظل وجود قبول وتطبيق الجودة 4.0 (Q4.0) وتنفيذها كمتغير وسيط في شركات المقاولات الإنشائية في فلسطين.

ومن أجل تحقيق هدف الدراسة تم تطوير استبانة كأداة للدراسة الكمية مكونه من اربع فقرات لجمع البيانات حول المعلومات العامة للشركات وتطبيق العقود الإنشائية وقبول وتطبيق الجودة 4.0 وتطبيق نظام ادارة الجودة في الشركات الإنشائية بالضفة الغربية وذلك بعد ان تم تطوير نموذج بحثي للربط بين المتغيرات من خلال دراسة الادبيات السابقة. حيث تم جمع (95) استبانة من مديري ومهندسي الانشاءات في شركات المقاولات المستهدفة العاملة في فلسطين، وبناءً عليه تم تقييم نموذج البحث وتحليل الردود من خلال استخدام نمذجة المعادلات الهيكلية للمربعات الصغرى الجزئية (PLS-SEM) باستخدام برنامج Smart-PLS.

أشارت نتائج الدراسة إلى أن نظام إدارة العقود ونظام إدارة الجودة يتم تنفيذهما على مستوى مرتفع في شركات المقاولات في الضفة الغربية/فلسطين، وان هناك قبول بدرجة مرتفعة للأبعاد التكنولوجية ل (Q4.0) تحديدا نمذجة معلومات البناء (BIM) والإدارة المركزية الرقمية والتكنولوجيا الذكية، ومع ذلك تنفيذ جميع هذه التكنولوجيا غير مقبول حتى الآن بسبب خصوصية هذه الصناعة وتعقيدها وبسبب البنية التحتية غير الملائمة في فلسطين كونها دولة نامية، ولقد تبين من خلال النتائج أن حل المطالبات والنزاعات (CDR)، والتواصل

والعلاقة بين اصحاب المصلحة (CR)، وإدارة مخاطر العقود (CRM) بالدرجة الاولى متبوعة بالأمور المالية وترتيباتها بالدرجة الثانية من القضايا الإدارية التعاقدية الرئيسية التي يجب تطويرها في هذه الصناعة ولقد أكدت النتائج أن (CMS) و(Q4.0) لهما تأثير إيجابي كبير ومؤثر على نظام إدارة الجودة وكما أظهرت النتائج أنه لا توجد علاقة مؤثرة بين (CMS) و(Q4.0) ولا يوجد تأثير وسيط لقبول وتنفيذه (Q4.0) على العلاقة بين (CMS) و(QMS).

في ضوء نتائج الدراسة، تم التوصية بتدعيم العلاقات بين جميع أصحاب المصلحة تعاقدياً، فيما يتعلق بالتعاون والشراكة، وتقاسم المخاطر، إضافة الى ذلك اوصت الدراسة بتبني التخطيط الاستراتيجي لتبني التكنولوجيا الحديثة وادواتها تدريجياً، بما لا يؤثر سلباً على بيئة العمل والأنشطة، وعلى اتحاد المقاولين الفلسطيني ونقابة المهندسين اعتماد برامج تدريب مستمرة لتطوير الكوادر البشرية وتزويدهم بالتقنيات الحديثة، لأنهم عنصر مهم جداً و اساسي بأي عملية تغيير.

توفر الدراسة ونتائجها أيضاً فهماً عميقاً لمفاهيم نظام ادارة التعاقد وتكنولوجيا الجودة الرابعة ونظام ادارة الجودة. كما توصي الباحثة ومن خلال نتائج هذه الدراسة ان يتم تكرارها في قطاعات أخرى، ومع حجم عينة أكبر لتأكيد النتائج وادخال متغيرات وسيطة ومستقلة جديدة لزيادة كفاءة نظام ادارة الجودة وبالتالي تسهيل تحقيق ادارة الجودة الشاملة.

**الكلمات المفتاحية:** الجودة 4.0(Q4.0)، نظام إدارة العقود (CMS)، نظام إدارة الجودة (QMS)، الجودة، صناعة الانشاءات (CI).